Enclosure 1

Part B Permit Application for Renewal of the Los Alamos National Laboratory Hazardous Waste Facility Permit, Revision 1.0

Volume 2

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APPENDIX 4: OPEN DETONATION AND OPEN BURNING INFORMATION

The information provided in this appendix is submitted to address the applicable miscellaneous treatment unit application requirements of Title 40 of the Code of Federal Regulations (40 CFR) 270.23; Part 264, Subpart X; and Part 265, Subpart P not otherwise addressed within Sections 1 through 8 of the Permit Renewal Application. This appendix provides additional descriptions, where necessary, of the open detonation and open burning treatment units located at Los Alamos National Laboratory.

4.1. OPEN DETONATION AND OPEN BURNING UNITS AT LOS ALAMOS NATIONAL LABORATORY

Locations and site plans for the open detonation units located at Technical Area (TA) 36 and 39, and the open burning treatment unit located at TA-16 are included within Section 4.1, *Description of Open Detonation Treatment Units*, and 5.1, *Description of Open Burning Treatment Unit* of the Permit Renewal Application. Operations, authorized wastes, and waste handling information is included in Section 4.0, *Open Detonation Treatment* and Section 5.0, *Open Burning Treatment*. The following sections and supplemental documents provide specific information necessary to satisfy the requirements of 40 CFR 270.23(a-e), in a more detailed manner than within the main portions of the Permit Renewal Application. A summary of design capacities for the units are included in Table 4-1.

4.2. CONTAINMENT SYSTEMS

To meet the requirements at 40 CFR 270.15(a) and 264.175, the Permittees will ensure that secondary containment is provided as required. Existing storm water controls are discussed within Section 4.12.1 and 5.12.1, *Containment Systems*. Upgrades at all three units have been implemented since the previous applications to better ensure that migration of storm water from units is prevented to the extent possible. Specific information regarding the requirements of 40 CFR 264.601, the effectiveness and reliability of containment, confinement, and collection systems and structures that are utilized to protect human health and the environment at the open detonation and open burning units are evaluated in Sections 4.18 and 5.16, *Environmental Performance Standards*. Specific supplemental information associated with the evaluations used to ensure protection of human health and the environment, are discussed in Appendix Section 4.4, *Environmental Performance Standards*, and included as Supplements 4-2 through 4-16.

4.3. ALTERNATIVES ASSESSMENT

To provide justification for the continued use of the open detonation and open burning treatment technologies at the Los Alamos National Laboratory, an assessment was developed that explores waste minimization efforts, operational practice changes, alternative technologies, and process efficiencies that have occurred to decrease the amount and types of waste that require treatment through open detonation and open burning activities. The evaluation is included as Supplement 4-1, *Assessment of Alternatives for Open Detonation and Open Burning Activities*.

4.4. ENVIRONMENTAL PERFORMANCE STANDARDS

As referenced in Sections 4.18 and 5.16, *Environmental Performance Standards* of this permit application there were multiple evaluations and assessments that needed to be conducted in order to provide information as required by 40 CFR 264.601 to ensure protection of human health and the environment. Evaluations that were

developed/revised for this Permit Renewal Application are summarized in Sections 4.18 and 5.16 of the Permit Renewal Application and are included as follows:

- Supplement 4-2, *Open Detonation Unit Groundwater Monitoring and Surface Drainage Information*
- Supplement 4-3, *Hybrid Air Modeling Analysis and Ecological and Health Risk Assessment for Open Burning and Open Detonation Operations at Los Alamos National Laboratory*
- Supplement 4-4, *Air Sampling at Open Detonation Units*
- Supplement 4-5, *Soil Sampling Results Summary Report for the Open Detonation Unit at Technical Area (TA) 36-8*
- Supplement 4-6, *Soil Sampling Results Summary Report for the Open Detonation Unit at Technical Area (TA) 39-6*
- Supplement 4-7, *Open Detonation Unit at Technical Area 36 Human Health and Ecological Risk-Screening Assessments*
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- Supplement 4-9, *Revision of 2011 Open Detonation Risk Assessment*
- Supplement 4-10, *Predicting and Controlling Noise from Detonation Activities*
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- Supplement 4-12, *Air Sampling at Open Burning Treatment Unit*
- Supplement 4-13, *Thermal Measurements at the TA-16-388 Flash Pad*
- Supplement 4-14, *2018 Soil Sampling Results Summary Report For the Open Burning Unit at Technical Area (TA) 16-388 Flash Pad*
- Supplement 4-15, *Technical Area 16 - Open Burn/Open Detonation (OB/OD) Area - Technical Area 16-388 Flash Pad Human Health and Ecological Risk- Screening Assessments*
- Supplement 4-16, *Revision 1: Seismic Location Standards Evaluation for Three Open Burning/Open Detonation Locations under Consideration for Permitting under the Resource Conservation and Recovery Act at Los Alamos National Laboratory: Technical Areas 16, 36, and 39*

4.5. FACILITY LOCATION STANDARDS

At the request of the NMED-HWB, seismic location standard information for the three interim status units (TA-16-388 Flash Pad, TA-36-8, and TA-39-6) is included as part of the Permittees' response to a letter received from the NMED-HWB on January 25, 2022. The seismic investigation demonstrates that there has been no direct evidence observed for Holocene faulting within the noted radius of the facility. The report is included as Supplement 4-16, *Revision 1: Seismic Location Standards Evaluation for Three Open Burning/Open Detonation Locations under Consideration for Permitting under the Resource Conservation and Recovery Act at Los Alamos National Laboratory: Technical Areas 16, 36, and 39*.

Table 4-1
Open Burning and Open Detonation Hazardous Waste Management Unit Summary

Hazardous Waste Management Unit	Maximum Capacity	Type of Unit	Area
TA-16-388 Flash Pad	200 pounds per day (lbs/day)	Open burning	484 square feet (ft^2)
TA-36-8 "Minie"	2000 lbs/day	Open detonation	150,000 ft^2
TA-39-6 "Point 6"	1000 lbs/day	Open detonation	1,600 ft^2

Supplement 4-1

Assessment of Alternatives for Open Detonation and Open Burning Activities

Revised Supplement 4-1 2024 Alternative Technology (Alt Tech) Evaluation

Supporting the Los Alamos National Laboratory Part B Permit Application for Renewal of the LANL Hazardous Waste Facility Permit

May 2024

Los Alamos NATIONAL LABORATORY

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EXECUTIVE SUMMARY

In connection with its Part B Permit Application for Renewal of the Los Alamos National Laboratory Hazardous Waste Facility Permit submitted to the New Mexico Environment Department – Hazardous Waste Bureau (NMED-HWB), the Los Alamos National Laboratory (Laboratory or LANL) seeks to permit three thermal treatment interim status hazardous waste management units (HWMUs), namely TA-16-388 (Flash Pad), TA-36-8 (Minie Site), and TA-39-6 (Point 6) (collectively the Units). In support of obtaining permit coverage for the Laboratory's thermal treatment Units, the Laboratory submits this Revised Supplement 4-1 – 2024 Alternative Technology (Alt Tech) Evaluation. The Alt Tech Evaluation evaluates whether safe alternative technologies are available to treat some or all of the explosives waste treated at the Laboratory's thermal treatment Units.

The Laboratory's thermal treatment Units safely and compliantly treat the Laboratory's specialized explosives waste in a manner protective of human health and the environment. Specialized explosives waste, which is waste having the potential to detonate, is generated in small volumes in connection with the Laboratory's vital national security missions, including mission-critical specialized explosives research, development, testing, evaluation, and post-manufacture work. Specialized explosives waste is highly energetic, heterogenous, and potentially unstable and unpredictable. Its treatment presents unique safety, transportation, and environmental protection considerations.

The Laboratory implements processes and technologies at its thermal treatment Units that result in the safe, highly controlled, and environmentally protective thermal treatment of the Laboratory's specialized explosives waste. Each thermal treatment is designed to completely combust or consume the waste and to prevent potential air emissions and surface or groundwater contamination. Emissions are monitored and sampling occurs. The thermal treatment operations produce no secondary waste stream and effectively produce no byproducts, residuals, or emissions. Site studies confirm no environmental impact from the Laboratory's thermal treatment operations. Through proactive pollution prevention and waste minimization efforts, moreover, the Laboratory has been able to reduce its present-day generation of explosives waste by over 80%. The Laboratory's thermal treatment operations are safe, highly controlled, and protective of human health and the environment.

The Alt Tech Evaluation evaluates whether safe alternative technologies are available to treat the Laboratory's specialized explosives waste. Although the open burning (OB) and open detonation (OD) of hazardous waste is generally prohibited, EPA regulations allow for the OB/OD of "waste explosives." 40 C.F.R. § 265.382. Specifically, 40 C.F.R. § 265.382 provides that the "[o]pen burning or open detonation of hazardous waste is prohibited *except* for the open burning and detonation of waste explosives." Waste explosives "include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment." *Id.* Under this exemption, the OB/OD treatment of waste explosives may occur, but it must occur "in a manner that does not threaten human health or the environment." *Id*. An evaluation of potentially safe and available alternative technologies can inform the analysis of the appropriateness of the OB/OD treatment of waste explosives. *See* EPA 2022(b).

The Alt Tech Evaluation first describes the Laboratory's thermal treatment Units and addresses the thermal treatment conducted at the Units. The thermal treatment conducted at the Flash Pad *is, itself, an alternative technology to* the OB/OD of explosives waste. The Laboratory's thermal treatment operations are highly controlled, efficient, designed to completely combust or consume the waste, monitored and sampled, and right sized for the Laboratory's specialized explosives waste. The Laboratory's thermal treatment operations are *nothing like* stereotypical OB/OD operations, which lack the controls needed for the efficient and complete combustion of wastes and the ability to control and monitor emissions.

The Alt Tech Evaluation then addresses the site-specific factors that must be considered in evaluating any potential alternative technology. These factors are generally encompassed within the concepts of operational safety, monitorability, and toxic byproducts. Site-specific factors of particular importance are: (1) the Laboratory's generation and treatment of *specialized* explosives waste; (2) safety; (3) the Laboratory's national security mission and its unique explosives expertise; and (4) byproducts (and protection of human health and the environment).

The Laboratory generates, in small volumes, explosives waste that is highly energetic and heterogenous, and that is potentially unstable and unpredictable (*i.e.*, *specialized* explosives waste). The specialized explosives waste presents unique treatment and safety considerations. The specialized explosives waste *is* capable of detonation (it is D003 waste characteristic for reactivity), but its exact morphology and properties are difficult to discern. It is *not susceptible to conventional assumptions* about the treatment of explosives waste. The Laboratory's thermal treatment Units are specifically designed to address the unique risks posed by, and to safely treat, the specialized explosives waste. Whether an alternative to the Laboratory's thermal treatment of specialized explosives waste is safe and available requires careful analysis of the unique treatment and safety considerations presented by specialized explosives waste.

Safety is of preeminent importance to the Laboratory. Safety considerations impact acutely not only the treatment of specialized explosives waste, but also its generation, handling, storage, and transportation. An alternative technology is not safe if it cannot address the unique risks posed by and safely treat specialized explosives waste. But an alternative technology is also not safe if it materially increases the handling or storage of the specialized explosives waste, or if off-site transport to the alternative technology is prohibited.

Safety determinations are made by explosives safety experts. The Laboratory is a Federally Funded Research and Development Center (FFRDC) and National Security Laboratory with national security missions and specialized expertise related to the research, development, testing, and evaluation of explosives. The Laboratory also conducts work supporting the United States nuclear weapons stockpile, which includes specialized expertise in explosives peculiar to nuclear weapons. The Laboratory's explosives expertise is specialized, unique, and relevant to this Alt Tech Evaluation.

The Laboratory thermally treats its specialized explosives waste in a manner protective of human health and the environment. With respect to byproducts, the Laboratory's Flash Pad thermal treatment Unit fits only incongruously into the definition of an open burn or open detonation unit.[1] Stereotypical OB/OD units "lack the controls needed for the efficient and complete combustion of wastes and the ability to control and measure the emissions of combustion products." EPA 2022(b); *see also* 40 C.F.R. § 260.10. All the Laboratory's thermal treatment Units, however, possess numerous controls, are designed and/or operated to efficiently and completely combust or consume the waste, and monitor for emissions. Various potential alternative technologies, in contrast, generate potentially toxic byproducts and secondary waste streams.

After addressing these site-specific factors, potential alternative technologies are identified, and an initial screening is conducted. The Alt Tech Evaluation is conducted on a waste stream-by-waste stream, technology-by-technology basis. Through initial screening, alternative technologies that may be potentially applicable treatment options are evaluated in greater detail. This more detailed analysis

[1] To facilitate compliance and to ensure its thermal treatment operations are protective of human health and the environment, the Laboratory has *presumed* its thermal treatment operations constitute OB and/or OD. The Laboratory's thermal treatment operations, however, are more appropriately identified as an alternative technology to OB and/or OD. The Laboratory reserves its right to argue that its thermal treatment operations do not constitute OB and/or OD.

focusses on whether a particular alternative technology is safe and available, while considering site-specific factors.

The Alt Tech Evaluation concludes that, at present, there are no safe alternative technologies available to treat the Laboratory's specialized explosives waste. The Laboratory's specialized explosives waste is treated at the thermal treatment Units safely, compliantly, and in a manner protective of human health and the environment. The Laboratory remains committed to continuing its proactive approach to pollution prevention and waste minimization, and to analyzing in the future potential alternative technologies that may one day be proven to safely, effectively, and in an environmentally protective manner treat the Laboratory's specialized explosives waste, considering site-specific factors.

1 Introduction

Los Alamos National Laboratory, by and through the U.S. Department of Energy (DOE), including its field offices, the National Nuclear Security Administration (NNSA) Los Alamos Field Office (NA-LA) and the DOE Office of Environmental Management (DOE-EM) Los Alamos Field Office (EM-LA), Triad National Security, LLC (Triad), and Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (collectively, the Permittees) provide this *2024 Alternative Technology (Alt Tech) Evaluation* in support of the Part B Permit Application for Renewal of the Los Alamos National Laboratory Hazardous Waste Facility Permit submitted to the New Mexico Environment Department – Hazardous Waste Bureau (Permit Renewal Application).

The Laboratory is a Federally Funded Research and Development Center that has been operating for approximately 80 years in Northern New Mexico. Today, the Laboratory is a national security laboratory, as defined by 50 *United States Code* (U.S.C.) 2471, operated by a Management and Operating (M&O) contractor, Triad, on behalf of NNSA. The Laboratory is charged with missions related to high explosives research and development and, as an FFRDC, possesses special expertise in these materials. DOE also has a legacy waste remediation mission at LANL, which is executed by N3B on behalf of DOE-EM.

The Laboratory exists to support NNSA missions, which are established by law, including: (1) to enhance U.S. national security through the military application of nuclear energy; (2) to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile, including the ability to design, produce, and test, in order to meet national security requirements; (3) to promote international nuclear safety and nonproliferation; (4) to reduce global danger from weapons of mass destruction; and (5) to support U.S. leadership in science and technology. NNSA missions are carried out in a manner that is consistent with the principles of: (1) protecting the environment; (2) safeguarding the safety and health of the public and of the workforce; and (3) ensuring the security of the nuclear weapons, nuclear material, and classified information. The Laboratory also does work for other federal agencies and partners with a wide variety of other entities.

To achieve the Laboratory's national security-related missions, the Laboratory must generate a very small volume of specialized explosives waste. Specialized explosives waste is unique, heterogenous, highly energetic, potentially unstable, and possesses properties, morphologies, or characteristics that are difficult to discern and can be unpredictable. The specialized explosives waste is capable of detonation (it is D003 waste characteristic for reactivity), and, in fact, risks deflagration transition to detonation if heated and confined.

Specialized explosives waste is treated on site via thermal treatment, either through open burning (OB) or open detonation (OD).[2] The Laboratory currently conducts thermal treatment at the Flash Pad located at Technical Area (TA) 16-388 (Flash Pad), the OD unit at TA-36-8 (Minie Site), and the OD unit at TA-39-6 (Point 6). The Laboratory implements processes and technologies at its thermal treatment Units that result in the safe, highly controlled, and environmentally protective thermal treatment of the Laboratory's specialized explosives waste. Since 1980, these thermal treatment units at the Laboratory have operated under the interim status requirements of the New Mexico Hazardous Waste Act (HWA) and 40 CFR Part

[2] For simplicity, the Laboratory refers to its thermal treatment operations as open burning (OB) (Flash Pad) or open detonation (OD) (Minie Site and Point 6). However, the Laboratory's thermal treatment operations only incongruously fit the definition of OB and/or OD. Stereotypical OB/OD units "lack the controls needed for the efficient and complete combustion of wastes and the ability to control and measure the emissions of combustion products." EPA 2022(b); *see also* 40 C.F.R. § 260.10. The Laboratory's Units, however, possess numerous controls, are designed to efficiently and completely combust the waste, and monitor for emissions. Please *see also* n. 1.

265, Subpart P. Interim status is a designation given to facilities in existence before 1980. Interim status units must follow requirements that apply until issuance of a final permit or unit closure.

The Permit Renewal Application seeks to permit the thermal treatment Units under LANL's Hazardous Waste Facility Permit (Permit), consistent with 40 CFR Part 264, Subpart X. In seeking to permit the thermal treatment Units, the Laboratory has submitted supporting documents and analysis, including evaluations of alternatives to OB and OD. Permittees included an Alternatives Assessment with their June 2020 Permit Renewal Application.[3] After several rounds of review, comments, and responses, including a revised Alternatives Assessment submitted in May 2022, the NMED-HWB requested that the Laboratory provide a revised and integrated permit package in support of the Permit Renewal Application. This Revised Supplement 4-1 – 2024 Alternative Technology (Alt Tech) Evaluation is provided as part of the revised and integrated permit package for the Permit Renewal Application.

This Alt Tech Evaluation analyzes whether there are alternative treatment technologies that are safe and available to treat the specialized explosives waste treated at the Units. Although the OB/OD of hazardous waste is generally prohibited, EPA regulations allow for the OB/OD of "waste explosives." 40 C.F.R. § 265.382. Specifically, 40 C.F.R. § 265.382 provides that the "[o]pen burning or open detonation of hazardous waste is prohibited *except* for the open burning and detonation of waste explosives." Waste explosives "include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment." *Id.* Under this exemption, the OB/OD treatment of waste explosives may occur, but it must occur "in a manner that does not threaten human health or the environment." *Id*. An evaluation of potentially safe and available alternative technologies can inform the analysis of the appropriateness of the OB/OD treatment of waste explosives. *See* EPA 2022(b).

This Alt Tech Evaluation has been prepared consistent with applicable regulatory requirements and administrative guidance issued for permitting OB/OD units, including the permitting requirements of the HWA and 40 CFR Parts 264 and 265, comments received from NMED-HWB, and formal and informal administrative guidance issued by EPA (Tetra Tech 2002, EPA 2022a, EPA 2022b, EPA 2022c).

To identify potential Alt Tech that may be available to treat the explosives waste currently treated at the Units, the Permittees also considered the reports published in 2019 by EPA and the National Academies of Sciences, Engineering, and Medicine (NASEM) regarding the potential availability of Alt Tech for explosives waste, the EPA's September 12, 2023 Compendium of Alternative Technologies to Open Burning and Open Detonation of Energetic Hazardous Wastes (EPA Compendium), as well as other sources of information on technologies developed for the treatment of explosives waste (EPA 2019, EPA 2023, NASEM 2019,). This Alt Tech Evaluation considers potentially available alternative treatment technologies on a waste-stream by waste-stream, alternative technology-by-technology basis.

As an initial consideration in evaluating Alt Tech, the Laboratory assessed whether the waste requiring treatment is explosives waste characteristic for reactivity (D003). *See* 40 C.F.R. §§ 261.23(a)(6-8) (characteristic of reactivity); 265.382 (defining waste explosives to "include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment"). The Laboratory's detailed waste characterization for each waste stream confirms that the waste is explosives waste that has the potential to detonate and is characteristic for reactivity (D003 waste). Further, the Laboratory identified, where applicable, the potential contaminants of concern, the amount of each waste, its chemical composition, its hazardous waste code, net explosive weight, and U.S. Department of Transportation hazard class.

[3] Assessments and re-assessments of alternative treatment technologies previously submitted by LANL to NMED-HWB include evaluations completed in 2002, 2007, 2011, 2013, and 2020.

The Laboratory's explosives waste, moreover, is *specialized* explosives waste. The specialized explosives waste is unique, heterogenous, highly energetic, and potentially unstable. Its exact morphology and properties are difficult to discern and can be unpredictable. It presents deflagration transition to detonation risks when heated and confined. The specialized explosives waste is not susceptible to conventional assumptions about the treatment of explosives waste, and what technology can treat this specialized explosives waste safely and in an environmentally protective manner requires careful analysis. Prompt treatment of the specialized explosives waste at the Units, moreover, is necessary to avoid uncontrolled or unanticipated detonation.

The Laboratory then considered the following factors when evaluating Alt Tech, consistent with applicable regulatory requirements and recent administrative guidance, as more specifically described below:

- Operational safety;
- Monitorability;
- Toxic by-products;
- Site specific factors, including safety;
- Transportation hazard potential;[4]
- Offsite treatment options; and
- Availability/feasibility of a potential Alt Tech.

This Alt Tech Evaluation concludes that, at this time, there is no Alt Tech that is safe and available that can treat the Laboratory's specialized explosives waste streams. Continued thermal treatment at the Units is the only safe mode of treatment currently available. Ongoing thermal treatment at the Units is also the most environmentally protective treatment approach at this time. The thermal treatment operations produce no secondary hazardous waste stream and effectively produce no byproducts, residuals, or emissions. Site studies confirm no environmental impact from the Laboratory's thermal treatment operations. The conclusions of this Alt Tech Evaluation reflect the specialized nature of the Laboratory's explosives waste streams, site-specific operational and safety factors, and considerations related to the Laboratory's national security-related missions.

As a general matter, current Alt Techs that are utilized for conventional munitions disposal are not safe for the Laboratory's specialized explosives waste because, among other reasons, they necessitate increased waste storage periods and/or waste handling, and fail to account for the specialized nature of the Laboratory's explosives waste. Implementing such Alt Tech at the Laboratory would violate the cardinal rule of explosives safety, which is to limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives, consistent with safe and efficient operations (DOE 2021). The Alt Tech would introduce significant and unnecessary additional health and safety risks to workers, the public, facilities, and the environment. The Alt Techs are unable to safely treat, or are of uncertain efficacy in safely treating (*i.e.*, they are unproven), the Laboratory's specialized explosives waste. Such Alt Techs are also unproven in treating the Laboratory's specialized explosives waste streams in an environmentally more protective way and would generally create toxic byproducts or secondary waste streams.

[4] When considering any Alt Tech, an important consideration is that the Laboratory's specialized explosives waste that is treated at the Units must be treated onsite because, among other reasons, transportation of explosives waste with indeterminate characteristics offsite on public roadways is illegal under federal law, would pose a large risk to the public and the environment, and could present a significant national security risk.

Supporting the conclusions of this Alt Tech Evaluation, and as set forth in the Permit Renewal Application and further below, the Units treat the specialized explosives waste in a manner that ensures protection of human health and the environment. *See* 40 C.F.R. § 264.601. The Units are located, designed, constructed, operated, maintained, and will be closed in a manner that ensures protection of human health and the environment. *See* Permit Renewal Application, Sections 4 and 5. The Units are designed to achieve complete combustion and do not generate secondary hazardous waste streams or toxic by-products. Treatment at the Units is controlled and monitored, and is proven to be a safe, effective, and environmentally protective method of treatment.

2 LANL's National Security Missions and Specialized Explosives Waste

The Laboratory's national security-related missions include supporting the annual assessment of the United States' nuclear weapons stockpile. As one of three national security laboratories, pursuant to 50 U.S.C. § 2525, LANL is required to conduct such annual assessments. To fulfill this mandate, the Laboratory performs assessment activities, including modeling and testing of weapons components. Historically, the reliability and effectiveness of the nuclear weapons stockpile was assessed through underground testing of nuclear weapons, including at the Nevada Test Site. Modern assessment activities, including those performed by the Laboratory, allow the NNSA to evaluate the reliability and effectiveness of the nuclear weapons stockpile without having to conduct underground nuclear weapons testing.

The Laboratory also performs national security-related missions involving explosives development, characterization, testing, modeling, and simulation. One of the most crucial of these missions is the manufacturing of Pentaerythritol tetranitrate (PETN) Detonators. The PETN Detonator is a critical component of the United States' nuclear weapons stockpile, and LANL is unique in its creation of this Detonator. The Laboratory's PETN Detonator research includes breaching or insulting the PETN Detonator with various stimuli including electrical, chemical, mechanical, thermal, impact, shock, and laser interactions to determine if a specific breach or insult causes detonation. The Laboratory is also responsible for manufacturing certain precision high explosives and for performing a variety of scientific experiments on energetic, hazardous, and complex system and subsystem components at various high explosives firing sites at LANL. This includes research on explosives detection technology and improvised explosive device (IED) detection and defeat. These vital research activities can generate specialized high explosives waste streams.

LANL also performs research and development on high[5] explosives specifically developed for nuclear weapon system applications. LANL-designed high explosives are normally significantly more energetic and sensitive to insult than conventional explosives and are many orders of magnitude more violent than modern propellants. The explosives materials developed at LANL are often Polymer Bonded eXplosives (PBX) that are specifically formulated to meet requirements such as energy output (metal pushing ability), structural integrity, machinability, thermal stability, as well as improved application specific safety considerations. The development, fabrication, and testing of PBXs are the primary feeders of the Laboratory's specialized explosives waste streams. By design, due to their application in nuclear weapons

[5] Chemical explosives may be divided into the categories of low explosives and high explosives. Low explosives can burn rather quickly but react subsonically (rather than supersonically) and are designed to *deflagrate*. An example of a low explosive is the black powder contained in fireworks. High explosives react much, much faster at supersonic scales and are designed to *detonate*. (McDonough 2017) Under Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE) regulations, for storage purposes the three classes of explosives are considered high explosives, low explosives, and blasting agents. 27 CFR 555.202. There are significant differences, moreover, between types of high explosives and their applications.7

systems, these specific PBX explosives are highly energetic and cannot be treated safely in confined environments due to the potential for transition from deflagration to detonation if heated and confined.

The Laboratory's research and development work and national security-related missions described above generate small volumes of specialized explosives waste that are unique, heterogenous, highly energetic, potentially unstable, and possess properties, morphologies, or characteristics that are difficult to discern or can be unpredictable.[6] For example, research and development work involves intentionally damaging or insulting high explosives with impact, electrical discharge, or high temperature. Intentionally damaging or insulting high explosives may change their morphology, which may increase the sensitivity and alter other characteristics of the explosives materials. Therefore, while the characteristics of an explosives materials may be understood prior to damage or insult, once the material has been subjected to insult, it may not be possible to reliably predict the behavior of that material. Accordingly, assumptions regarding the applicability and availability of alternative treatment technologies based on studies performed on conventional munitions and explosives waste, such as the 2019 EPA and NASEM reports and EPA Compendium, do not directly inform alternative treatment decisions for the specialized and intentionally altered or insulted high explosives and associated waste that the Laboratory generates.

Similarly, LANL's responsibilities with respect to the United States' nuclear weapons stockpile involve both the surveillance of high explosives in deployed systems and the development of new high explosives with improved physical properties. The Laboratory regularly investigates new high explosives materials, new formulations, and new precursor materials. Improvements in the characteristics of high explosives may change the way the explosive behaves, such as an improvement to the resilience of the high explosives when exposed to insults like temperature, mechanical impulse, or electrical discharge. Therefore, because LANL's waste includes specialized high explosives, conclusions about the applicability and availability of alternative treatment technologies derived from studies performed on conventional munitions and explosives do not necessarily inform alternative treatment decisions for the specialized high explosives and associated wastes generated at LANL.

The 2019 EPA and 2019 NASEM reports on potential alternative treatment technologies for OB/OD focus on treatment of conventional munitions and explosives waste and do not consider the specialized and unique explosives waste generated at LANL. However, the conclusions of this Alt Tech Evaluation are consistent with these EPA and NASEM reports, as well as recent guidance, which recognize that OB/OD treatment will remain the only safe mode of treatment for certain types of explosives waste. For example, EPA's 2022 policy memorandum on OB/OD treatment of waste explosives acknowledges that OB/OD treatment "will still be needed to treat waste explosives that do not yet have other safe modes of treatment." (EPA 2022b). Similarly, the NASEM report recognizes that for certain wastes, based on site-specific factors, "[t]he capability for OB/OD will always be needed." (NASEM 2019). The EPA further acknowledges the continued viability of OB/OD for the treatment of certain types of highly energetic explosives waste, stating that "even though there are many alternative treatment technologies today . . . OB/OD will remain as the only option for certain energetic hazardous wastes until additional viable alternatives are developed or existing technologies are modified or improved upon." (EPA 2019).

Similarly, EPA's Compendium of Alternative Technologies to Open Burning and Open Detonation of Energetic Hazardous Wastes recognizes that a "technology that has been identified or implemented for a

[6] The specialized explosives waste has the potential to detonate and is characteristic for reactivity (D003 waste). Reference to indiscernible or difficult to determine characteristics of the specialized explosives waste does not change this. Rather, this recognizes that while the specialized explosives waste has the potential to detonate and is characteristic for reactivity, how, when, and under what conditions the specialized explosives waste will detonate can be indiscernible, difficult to determine, or unpredictable. This is a key consideration in evaluating whether any alternative technology is safe and available.

particular waste stream at one facility may not be suitable for another facility with a similar waste stream," and this is "more likely at Research, Development, Test, and Evaluation facilities where standard formulations may have been modified resulting in increased sensitivity and explosive risk and perform stress testing that reduces explosives and munitions stability." (EPA 2023).

The specialized explosives waste generated by LANL is the type of waste that, because of its highly energetic and unstable nature and other site-specific factors, must be treated on-site at the Units. There are no Alt Techs or combination of technologies available that are proven to safely treat LANL's specialized explosives waste streams. The Units are the only safe and proven mode of treatment available.

3 Conceptual Approach to the Laboratory's Specialized Explosives Waste Management

The Laboratory's overall explosives waste management approach is based on the following hierarchy of consideration:

1. **Pollution prevention** and **waste minimization activities** are first identified and implemented to the maximum extent practicable, to avoid generating waste in the first place. When feasible, based on safety concerns, programmatic effectiveness, and other factors, the Laboratory strives to eliminate and/or reduce the volume of explosives waste that must be treated and disposed. For further discussion of these efforts, please see Section 6.0.
2. Explosives waste is next reviewed waste stream-by-waste stream to **identify candidates for offsite treatment.** The Laboratory identifies wastes that can be safely and legally transported offsite to permitted facilities for treatment and disposal. LANL continually tries to identify new opportunities for safe and legal offsite shipment of waste for treatment. Many of the specialized explosives waste generated at the Laboratory are considered uncharacterized,[7] new waste explosives under U.S. Department of Transportation (DOT) regulations and DOE safety and control standards and cannot be legally transported offsite for treatment and disposal. For further discussion, please see Section 7.4.
3. Only when waste generation cannot be avoided and no safe and available offsite treatment option is identified, is onsite treatment required. While the Laboratory safely and effectively treats specialized explosives waste streams onsite, subject matter experts continually work to evaluate whether safe alternative technologies are available to treat the specialized explosives waste currently treated at the Units.

4 Description of the Laboratory's Thermal Treatment Units

Only those specialized explosives waste that must be generated by the Laboratory and that cannot be shipped offsite or treated by other means are treated at either the Flash Pad, located at TA-16-388, or the OD units, located at TA-36-8 and TA-39-6.[8] In other words, the Units only treat those wastes that must be generated and treated onsite. While treatment can occur throughout the year, with many treatments occurring, the overall treatment volumes even on an annual basis are small.

[7] "Uncharacterized" in this context means a material whose hazard classification cannot be determined within the meaning of 49 CFR § 171.8 and 49 CFR § 173.56 (*i.e.*, is unclassified and unapproved). This is not a reference to "uncharacterized" waste within the meaning of 40 CFR § 262.11 under RCRA.

[8] The TA-36-8 OD unit is known as the Minie Site, and the TA-39-6 OD unit is known as Point 6.

4.1 The Flash Pad (TA-16-388)

The Flash Pad is located in the northeast corner of TA-16. TA-16 is a security area that is situated on a broad mesa that is bounded on the north by Canon de Valle, on the south by State Road 4, and on the west by West Jemez Road (State Road 501) and the Santa Fe National Forest. TA-16 elevations range from approximately 7,700 ft. at the west to approximately 6,800 ft. at the lower east end. Topography is varied, ranging from steep canyon walls to sloping mesa tops. Access into the security area can be gained only through controlled entry stations by persons possessing an appropriate security clearance and site-specific training. Entry into the secured area is controlled.

The Flash Pad is located in a remote high explosives exclusion area within TA-16 that has additional access controls. Entry into the high explosives exclusion area is controlled through an industrial fence, with access granted through an access control station or a locked access gate. Such access is tied to the individual's badge credentials and if a person lacks the requisite credentials to access the area, access is denied.

The Flash Pad is an engineered thermal treatment unit that utilizes a concrete pad and propane enhanced controlled open oxidation. The Flash Pad consists of a 22 by 22 foot (ft.) concrete pad located within an area that provides secondary containment to prevent hazardous constituents from leaving the area. The Flash Pad has a concrete base that is 12 inches (in.) thick. The entire concrete pad is over a 45-mil Hypalon liner, which is six inches below grade underneath the bottom of the pad, and the liner extends out 2 ft. from the pad perimeter and curves up to ground level on all four sides. Hypalon is a chlorosulfonated polyethylene synthetic rubber, exhibiting resistance to ultraviolet light, heat, and many chemicals (*e.g.*, ozone and oxidizing chemicals).

Along the two sides and back of the Flash Pad's concrete pad, and inset 12 in., is a 3 ft. high, eight-inch-thick concrete wall that prevents any potential runoff from leaving the Flash Pad. The area around the Flash Pad is relatively level. The Flash Pad is equipped with a retractable steel cover, which covers the area when the Flash Pad is not in use. Three 5 ft. long forced air propane burners provide the heat source for treatment activities at the Flash Pad. A chain-link fence and brick retaining wall surround the Flash Pad.

Figure 1: Los Alamos National Laboratory engineered Flash Pad

The Flash Pad is used exclusively for the controlled treatment of the Laboratory's specialized explosives waste—it is not used for any other activities. Once waste is placed on the Flash Pad for treatment, operations are controlled and monitored remotely from a control building.

The quantity and configuration of the material to be treated at the Flash Pad determines the number of burners used. Temperature and time are controlled for efficient and complete combustion. The burners provide adequate heat to bring the material being flashed to a temperature sufficient to destroy the explosives material and maintains a temperature sufficient to prevent formation of incomplete combustion products for the duration of the treatment. This minimizes potential emissions from combustion (*see, e.g.,* LANL 2020l at p. 5). The treatment of explosives waste at the Flash Pad does not create any measurable or modeled toxic by-products (*see, e.g.,* LANL 2020k, LANL 2020l at p. 5).

Operations at the Flash Pad require post-treatment visual surveys of the area in and around the Flash Pad and post-burn covering of the Flash Pad. This practice minimizes the potential for precipitation contacting residuals, should they exist. Residuals are very uncommon, and should they occur consist of non-hazardous ash residuals. Any residuals identified during post-treatment visual surveys are cleaned up, binned, and then disposed of as New Mexico Special Waste. Post-burn covering of the Flash Pad further reduces the chance of any residual migration off the Flash Pad.

Conservative air modeling conducted for the Flash Pad concluded that no ambient air-quality standards are exceed. Calculated air-concentration results were compared to the air-quality standards and the appropriate human health screening levels, where available, and the predicted impacts are all below the appropriate screening levels. Additionally, predicted soil deposition (over a 10-year period) demonstrates that added impacts to soil concentrations are less than the human health and ecological screening levels. Air monitoring conducted in 2011 and 2022 indicate the operations monitored did not exceed any appropriate state or federal levels specified for the analytes monitored.

In 2022 and 2023, at the Flash Pad, the average quantity per treatment was approximately 40 lbs. Most treatment events are conducted in the morning when the wind is generally at its lowest. Technical standards prohibit more than one planned treatment in a twenty-four hour period. Most treatment events at the Flash Pad are conducted in a single treatment that is approximately 60 minutes or less. In 2022 and 2023, the Laboratory conducted a total of 80 and 84 treatments, respectively, at the Flash Pad.

An application of the Flash Pad is when explosive material has become entrained within the interstitials of fabrication machines that are used to machine high explosives into necessary forms. To safely recycle the metal from these machines, the Laboratory must first "flash" (or burn) off any residual explosives waste particles. Some single steel components treated in this manner can weigh up to 2000 lbs. and measure 5 x 4 x 3 ft. Without flashing, small volumes of residual high explosives material would prevent the Laboratory from recycling many tons of steel. Because it is able to flash, the Laboratory has recycled over 100,000 lbs. of steel after treatment at the Flash Pad in the past few years alone.

4.2 The TA-36-8 OD Unit (Minie Site)

TA-36 contains the TA-36-8 OD unit (Minie Site), several other firing sites used in research activities, and supporting offices where research is conducted with various types of explosives. Located in the east central portion of the Laboratory, TA-36 is spread over several mesa tops between a branch of Pajarito Canyon to the north and Water Canyon to the south. Mesa-top elevations at TA-36 range from approximately 6,380 to 7,120 ft. above mean sea level.

The Minie Site is used primarily for non-waste-related experimental test detonations. The Minie Site is only occasionally used to treat specialized explosives waste. The TA-36-8 OD unit is located in the southern portion of TA-36. The unit consists of an irregularly shaped area near Building TA-36-8, which is the control building. The Minie Site is a sandy area that measures approximately 500 ft. east to west and 300 ft. north to south. The western portion is relatively flat; the eastern portion is concave to minimize fragment dispersion.

The Minie Site has a maximum treatment capacity of 2,000 lbs. of explosives waste per detonation and an annual treatment limit of 15,000 lbs. Waste treatments at the Minie Site are by design complete detonations. Explosives material is destroyed and there are no measured or modeled toxic byproducts. Operations require post-detonation visual surveys as soon as practical for any materials not consumed by detonation, which minimizes the potential for precipitation contacting any residuals that could ever be present.

The Minie Site is located in a remote, security-controlled location within TA-36. Entry is controlled through an industrial fence with access granted through an access control station or a locked access gate. Access into the security area through the fence can only be gained by persons possessing an appropriate security clearance and site-specific training. Entry into the secured area is controlled via a combination of an entry station that is manned by security personnel or by badge readers on gates 24 hours per day. Unescorted access to the area is granted only to persons possessing appropriate security clearance and meeting site-specific training requirements. Visitors must check in at the appropriate access control station to be added to the site-specific badge-reader system to gain access to the area.

4.3 The TA-39-6 OD Unit (Point 6)

TA-39 contains the TA-39-6 OD unit (Point 6) and other explosives testing sites. TA-39 is located in the southern portion of the Laboratory and includes much of the mesa between Water Canyon to the north and Ancho Canyon to the south.

Point 6 is only occasionally used to treat specialized explosives waste. The Point 6 site is used primarily for non-waste-related experimental test detonations. Point 6 is located near Control Building 6 and is a relatively flat, sand covered area that measures approximately 40 by 40 ft. in a canyon bottom. Steep canyon walls rise 100 ft. or more in the immediate vicinity of Point 6 and, along with a retaining wall that has been installed, form a rough semi-circle around the unit. Point 6 is used to treat only explosives waste. Point 6 is used to open air detonate waste-excess explosives and explosive-contaminated combustible waste. Experiments conducted at this firing site are designed to expend all high explosives in the device. Waste treatments are by design complete detonations. Explosives materials is destroyed and there are no measured or modeled toxic byproducts.

Point 6 has a maximum treatment capacity of 1,000 lbs. of explosives waste per detonation and an annual treatment limit of 15,000 lbs.

Point 6 is located in a remote, security-controlled location within TA-39. Entry is controlled through an industrial fence with access granted through an access control station or a locked access gate. Access into the security area through the fence can only be gained by persons possessing an appropriate security clearance and site-specific training. Entry into the secured area is controlled via a combination of an entry station that is manned by LANL security personnel or by badge readers on gates 24 hours per day. Unescorted access to the area is granted only to persons possessing appropriate security clearance and meeting site-specific training requirements. Visitors must check in at the appropriate access control station to be added to the site-specific badge-reader system to gain access to the area.

5 Waste Streams Treated at the Thermal Treatment Units

This section describes the waste streams treated at the Laboratory's Units and provides a summary of the historic and current quantities of waste treated by the Units.

Each waste stream described in this Section and treated at the Units meets the definition of waste explosives under 40 CFR § 265.382. Each waste stream exhibits characteristics of reactivity, as defined in 40 CFR § 261.23, and is capable of detonation or explosive reaction if subjected to a strong initiating source or if heated under confinement. Each thermal treatment of the specialized explosives waste removes the characteristic of reactivity, and any other hazardous characteristic or constituent.

As discussed in greater detail in Section 7.2, the Laboratory's specialized explosives waste streams are generated from national security related missions addressing specialized high explosives. The specialized explosives waste is unique, heterogenous, highly energetic, and, under some conditions, potentially unstable. Furthermore, unlike facilities that generate and treat conventional munitions and explosives materials, LANL's explosives waste streams often have indeterminate morphologies and properties. The Laboratory's ongoing cutting-edge scientific research and development work involves both development of new explosives materials and intentionally damaging or insulting explosives materials. This research and development work results in the generation of specialized explosives waste with complex behaviors and indeterminate morphologies and properties.

5.1 Waste Streams Treated at the Flash Pad

The specialized explosives waste streams treated at the Flash Pad consist of the following:

- Explosives machining waste – This waste stream consists of explosives machining chips, and some filters, filter solids, and water that result primarily from the filtration of water used during the machining activities. Cloth filters, plastic bags, and wrapping are sometimes present in the waste.

- Over the past 5 years, this waste stream constitutes 29 to 51% of the total waste treated, with an average of 80%, through flashing.
- Potential explosives in this waste stream include: PETN; Cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX); Octahydro, 1,3,5,7-tetranitro; 1,3,5,7-tetrazocine (HMX); plastic-bonded explosives (PBX's or LX's); 4,4-diamino-3,3-azoxyfurazan (DAAF); 2,4,6-trinitrotoluene (TNT); Comp B; triamino trinitrobenzene (TATB); Baratol (including TNT and barium nitrate); and Cyclotol (a mixture of RDX and TNT).
- Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, Barium, Lead, and 2,4-Dinitrotoluene.
- Potential EPA hazardous waste codes include D003, D005, D008, and D030.

- Explosives-contaminated combustible debris – This waste stream includes explosives-contaminated debris generated in research laboratories and processing operations. Debris can involve filters removed from laboratories or processing bays, or may contain very small amounts of solvent. The most common solvents used are ethanol and acetone.
  - Over the past 5 years, this waste stream constitutes 90 to 32% of the total waste treated, with an average of 6.8%, through flashing.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, Cyclotol, Octol, TATB, DAAF, 2,6-Bis(picrylamino)-3,5-dinitropyridine (PYX), TNT, PBXs, and LXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene, spent halogenated solvents, and spent non-halogenated solvents.
  - Potential EPA hazardous waste codes include: D001, D003, D018, D022, D028, D029, D030, D035, D040, F001, F002, F003, F004, and F005.
- Explosives contaminated noncombustible debris – Most often this waste stream consists of metal equipment or sand/carbon from water filtration activities or maintenance and decommissioning and demolition activities. When metal, this waste stream is typically recycled after treatment when treated by flashing. This waste stream consists of explosives-contaminated equipment, including discarded, noncombustible equipment; debris from firing sites; noncombustible material from decommissioning and demolition activities; and material from explosives processing areas such as carbon or sand from filtering processes.
  - Over the past ten years, this waste stream constitutes <1 to 58% of the total waste treated, with an average of 11%, through flashing.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, PYX, Nitroguanidine (NQ), Nitrocellulose, PBXs, LXs, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal (a mixture of TNT and aluminum), and Baratol.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, Barium, Lead, Silver, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene, spent halogenated solvents, and spent non-halogenated solvents.
  - Potential EPA hazardous waste codes include: D003, D005, D008, D011, D018, D022, D028, D029, D030, D035, D040, F001, F002, F003, F004, and F005.
- Excess explosives – This waste stream includes either large or small (*i.e.*, laboratory-scale) amounts of excess explosives. Explosives may be in the form of flakes, granules, crystals,

powders, pressings, plastic bonded, putties, rubberized solids, or extrudable solids. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances.

  - This waste stream constitutes <1% of the total waste treated through flashing and has not been treated since 2014.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, PYX, NQ, Nitrocellulose, PBX's and LX's, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, and Baratol.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Barium, and 2,4-Dinitrotoluene.
  - Potential EPA hazardous waste codes include: D001, D003, D005, D030.

- Explosives-contaminated solvent waste – This waste stream consists of dimethyl sulfoxide (DMSO) containing dissolved explosives.
  - This waste stream constitutes 0 to <1% of the total waste treated through flashing and has not been treated since 2008.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, PBXs, and LXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity and 2,4-Dinitrotoluene.
  - Potential EPA hazardous waste codes include: D003 and D030.

Additional information and discussion regarding the waste streams treated at the Flash Pad is available within Permittees' revised Waste Analysis Plan. *See* Permit Renewal Application, Revised Supplement 1-3, Permittees' Proposed Changes to Attachment C, Waste Analysis Plan.

The Flash Pad generates no secondary hazardous waste stream. At the conclusion of flashing operations there is only ash residuals, whose waste stream is non-hazardous and disposed of as New Mexico Special Waste in a solid waste landfill (*see*, *e.g.*, LANL 202k, LANL 2020l). Recent waste stream profiles for ash shipped offsite has been provided in Attachment 1. The waste stream profiles demonstrated that most waste generated by the treatment process is non-hazardous and the lesser quantity of hazardous waste is due to metal (barium) toxicity, that burning of the waste does not destroy.

5.1.1 Historic and Current Waste Treatment Volumes for the Flash Pad

The quantities of specialized explosives waste treated at the Flash Pad are small, especially when compared to quantities treated at other sites or from historic sites (*see* DOD 2021, noting that at DOD's 34 locations, from 2014 to 2017 approximately 17,000,000 lbs. of explosives waste were treated per year, which equates to an average to 500,000 lbs. per site each year. Since 2013, LANL has treated only about 0.5% of this amount per year on average). **Table 5-1** lists, by waste stream, the quantities of explosives waste treated at the Flash Pad from 2013 to 2023.

The Laboratory has worked hard to achieve a high degree of pollution prevention and waste minimization (see Section 6) through the years. These efforts have resulted in the reduced generation of each of the waste streams described above, by eliminating some activities that generated portions of the waste streams and/or through substitution, segregation, or other waste minimization activities. In the past

decade, the Laboratory reduced treatment volumes at the Flash Pad by nearly 80% as compared with historic operations.

From 1996 to 2000, annual treatment volumes for the waste streams treated at the Flash Pad were on average 10,833 lbs. per year (excluding non-combustible materials). Since 2013, the Flash Pad has treated an average of approximately 2,250 lbs. per year, which represents an approximately 80% reduction. Although the Laboratory has reduced treatment volumes at the Flash Pad, mission requirements may result in fluctuations in the amount of specialized explosives waste treated at the Flash Pad in the future.

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Table 5-1 Annual Amount of Explosives Waste Treated at the Flash Pad from 2013-2023 by Waste Stream, *in pounds (lbs.)* (with approximate % of yearly total noted)

	Explosives Machining Waste	Explosives-Contaminated Combustible Debris	Explosives Contaminated Noncombustible Debris		Excess Explosives[3]	Explosives-Contaminated Solvents[4]	Total (lbs.)
			Metal[1]	Sand[2]			
2013	**2,283** (99.5%)	**11** (0.48%)	**5** (0.02%)	0	0	0	**2,299**
2014	**935** (97%)	0	**4** (0.04%)	0	**21** (2.2%)	0	**960**
2015	**1,665** (90%)	0	0	**195** (10%)	0	0	**1,860**
2016	**1,465** (88%)	**71** (4%)	**3** (0.2%)	**130** (7.8%)	0	0	**1,669**
2017	**1,671** (96%)	**30** (2%)	**32** (2%)	0	0	0	**1,733**
2018	**1,538** (97%)	**29** (2%)	**21** (1%)	0	0	0	**1,588**
2019	**1,130** (88.6%)	**10** (0.8%)	**36** (2.8%)	**100** (7.8%)	0	0	**1,276**
2020	**1,670** (41%)	**10** (0.2%)	**31** (0.8%)	**2,400** (58%)	0	0	**4,111**
2021	**2,113** (67%)	**810** (26%)	**58** (2%)	**170** (5%)	0	0	**3,152**
2022	**2,110** (53.5%)	**1,306** (33.1%)	**7** (0.2%)	**520** (13.2%)	0	0	**3,943**
2023	**1,190** (55%)	**24** (1%)	**27** (1.25%)	**920** (42.5%)	0	0	**2,161**

[1] The weight listed is the weight (in lbs.) of the estimated explosives content that is suspected to contaminate the equipment not the total weight of the equipment or debris in the case of noncombustible metals. Only the explosive is being treated, therefore, it is what is counted and represents the number of times noncombustible debris was treated during the year.

[2] Sand is no longer reused and is sent offsite as waste; therefore, the total weight of sand and explosives is included in the quantity of waste treated, instead of only the estimated explosives content.

[3] Generation rates of this waste stream are significantly decreased due to identification of alternative beneficial uses for excess explosives.

[4] This waste stream has largely been eliminated from being generated due to improvements in processes that must be treated as explosives waste and can be shipped offsite for disposal.

5.2 Waste Streams Treated by Open Detonation

The waste streams treated at the Laboratory by OD consist of the following:

- Excess explosives – This waste stream includes either large or small (*i.e.*, laboratory-scale) amounts of excess explosives. Explosives may be in the form of flakes, granules, crystals, powders, pressings, plastic bonded, putties, rubberized solids, or extrudable solids. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances.

- Over the past ten years, this waste stream constitutes 71 to 95% of the total waste, with an average of 83% treated through open detonation.
- Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, 2,6-Bis[picrylamino]-3, PYX, NQ, Nitrocellulose, PBX's and LX's, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, and Baratol.
- Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Barium, and 2,4-Dinitrotoluene.
- Potential EPA hazardous waste codes include: D001, D003, D005, D030.

- Explosives-contaminated combustible debris – This waste stream includes heterogeneous explosives-contaminated debris generated in research laboratories, processing areas, and prep rooms. Debris may include trace amounts of solvents. Other materials that may be present in this waste stream include plastic pieces, bags, fiber cloth, wrapping, and tubing; weigh boats; latex or nitrile gloves; glass or plastic vials; cardboard and paper; fiberboard containers; paper cleaning wipes, rags, and swabs. Metal constituents may include aluminum, stainless steel, steel, brass, and copper. Small quantities of solvents such as ethanol, acetone methanol, ethyl acetate, and toluene may also be present.
  - Over the past ten years, this waste stream constitutes 0 to 29% of the total waste treated through open detonation.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, Cyclotol, Octol, TATB, DAAF, PYX, TNT, PBXs, and LXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene, spent halogenated solvents, and spent non-halogenated solvents.
  - Potential EPA hazardous waste codes include: D001, D003, D018, D022, D028, D029, D030, D035, D040, F001, F002, F003, F004, and F005.
- Detonators, initiators, mild detonating fuses, and blasting caps – This waste stream includes detonators, initiators, and/or mild detonating fuses containing explosives. Explosives may be in metal or plastic casings and may contain lead- based primaries or be in a lead sheath. Typically, nitromethane is used as fuel for treatment activities. This waste stream may include manufactured articles removed from fire protection systems.
  - This waste stream constitutes approximately 1 to 2% of the total waste treated through open detonation.
  - Potential explosives in this waste stream include: PETN, HMX, RDX, TATB, lead azide, lead styphnate, and PBXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity and Lead.
  - Potential EPA hazardous waste codes include: D003 and D008.
- Shaped charges and test assemblies – This waste stream includes shaped charges consisting of cores of explosives with metal sheaths or metal liners or high explosives test assemblies consisting of explosives in plastic or metal holders. Assemblies may contain lead or silver metal. This waste stream may include manufactured articles removed from fire protection systems.

- This waste stream constitutes approximately 1 to 2% of the total waste treated through open detonation.
- Potential explosives in this waste stream include: PETN, RDX, HMX, PBXs, and LXs.
- Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, Lead, Silver, 2,4-Dinitrotoluene.
- Potential EPA hazardous waste codes include: D003, D008, D011, and D030.

- Projectiles and munitions larger than 0.50 caliber – This waste stream includes projectiles and munitions larger than 0.50 caliber (0.50-inch diameter). This waste stream may include manufactured articles removed from fire protection systems.
  - This waste stream constitutes approximately 1 to 2% of the total waste treated through open detonation.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity and Lead.
  - Potential explosives in this waste stream include: munitions/projectiles.
  - Potential EPA hazardous waste codes include: D003 and D008.
- Pressing Molds – This waste stream includes adiprene (urethane) pressing molds contaminated with explosives.
  - This waste stream constitutes approximately 1-2% of the total waste treated through open detonation.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, 2,4-Dinotrotoluene.
  - Potential explosives in this waste stream include: TNT.
  - Potential EPA hazardous waste codes include: D003 and D030.

Additional information and discussion regarding the waste streams treated by OD at LANL is available within the revised Waste Analysis Plan submitted in support of the Permittees' Permit Renewal Application. *See* Permit Renewal Application, Revised Supplement 1-3, Permittees' Proposed Changes to Attachment C, Waste Analysis Plan.

5.2.1 Historic and Current Waste Treatment Volumes for Wastes Treated by OD

Table 5-2 lists, by waste stream, the quantities of specialized explosives waste treated at the Laboratory's OD units for the past decade, from 2013 through 2022. Pollution prevention and waste minimization activities, *see* Section 6, have reduced the routine generation of each of the waste streams by eliminating some activities that generated portions of the waste streams and/or through substitution, segregation, or other waste minimization practices.

As shown in **Table 5-2**, the Laboratory's treatment activities at the OD units have decreased significantly over the last several years. This reduction is due to pollution prevention and waste minimization measures, including the beneficial reuse of materials for other mission requirements. The Laboratory has not performed OD treatments since 2014, however, mission requirements may result in fluctuations in the amount of specialized explosives waste treated at the Minie Site or at Point 6 in the future. To ensure that LANL can execute its mission and as mission needs change, both the TA-36-9 and TA-39-6 OD units must continue to be available either under interim status or as permitted units.

Table 5-2 Cumulative Amounts of Explosives Waste Treated at the OD Units from 2013-2023 by Waste Stream, *in pounds (lbs.)* (with approximate % of yearly total noted)

	Individual units annual amount excess explosives[1]		Individual units annual amount explosives contaminated debris[2]		Individual units annual amount black powder or gunpowder[3]		**Treatment annual totals (per OD unit)**		Cumulative annual total amounts (in lbs.)
	TA-36-8	TA-39-6	TA-36-8	TA-39-6	TA-36-8	TA-39-6	TA-36-8	TA-39-6	
2013	274 (72.9%)	82 (21.8%)	0	0	20 (5.3%)	0	294	82	376
2014	5 (71%)	0	2 (29%)	0	0	0	7	0	7
2015	-	-	-	-	-	-	-	-	0
2016	-	-	-	-	-	-	-	-	0
2017	-	-	-	-	-	-	-	-	0
2018	-	-	-	-	-	-	-	-	0
2019	-	-	-	-	-	-	-	-	0
2020	-	-	-	-	-	-	-	-	0
2021	-	-	-	-	-	-	-	-	0
2022	-	-	-	-	-	-	-	-	0
2023	-	-	-	-	-	-	-	-	0

[1] This waste stream has been significantly decreased in generation rates due to identification of alternative use.

[2] This waste has been significantly decreased due to process improvements that decrease the quantity and rate of generation of this type of waste.

[3] This waste stream has been eliminated.

Note: The waste streams representing (1) detonators, initiators, mild detonating fuses, and blasting caps; (2) shaped charges and test assemblies; (3) projectiles and munitions larger than 0.50 caliber; and (4) pressing molds have not been treated in this timeframe, but are preserved due to potential for future generation.

6 The Laboratory's Proactive Pollution Prevention and Waste Minimization

The first step in assuring the Laboratory is conducting safe and effective thermal treatment at the Units is to avoid waste generation whenever possible. As such, the first step in the Laboratory's waste management conceptual approach is to identify and implement waste minimization activities to the maximum extent practicable.

Waste minimization requires implementation of processes, practices, and procedures to reduce the volume of explosives and explosives contaminated waste that must be managed as hazardous waste. Through the years, the Laboratory has made considerable effort to eliminate or minimize wastes, or beneficially reuse materials that would otherwise be treated/disposed as wastes. Operations and waste management personnel rigorously apply waste minimization principles to significantly reduce the quantity of explosives waste treated at the Units. Some specific pollution prevention practices and waste reduction efforts applicable to the waste steams treated at the Units are discussed below.

6.1 Pollution Prevention Practices and Waste Minimization Efforts Implemented at LANL

Waste generators and waste professionals at the Laboratory work continuously to improve the management of regulated and non-regulated wastes. With respect to wastes treated at the Units, waste minimization is achieved by implementing the following pollution prevention and waste minimization practices:

- **Robust site-wide pollution prevention program and services**. The goal of the Laboratory's pollution prevention efforts is to reduce or eliminate waste whenever possible. However, when waste elimination is not possible, the Laboratory reduces potential adverse environmental impacts by treating waste to reduce its toxicity, segregating waste (separating it into different types) to reduce its overall volume, and disposing of waste in a responsible manner. The Laboratory's pollution prevention program provides a number of services, including:
  - opportunity assessments, which systematically evaluate existing processes and provide solutions to eliminate or reduce waste;
  - engineering and technical support to individuals or operations that generate waste;
  - funding for innovative projects that eliminate or substantially reduce waste or conserve natural resources;
  - recognition of individuals and projects that exemplify the goals of the program;
  - communicating pollution prevention success stories and best practices; and
  - facilitating process improvements to avoid or reduce the generation of waste.
- **Robust site-wide Environmental Management System (EMS).** The Laboratory's EMS is certified under ISO Standard 14001, and it provides a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvement, and measuring results. The EMS covers every program at the Laboratory and examines means by which a program impacts the environment.
- **Carefully assessing potential waste**. Policies and procedures at LANL require generators of explosives contaminated combustible debris to carefully assess whether wastes generated from production and research activities are hazardous waste. Segregating explosives contaminated debris from non-detonable contaminated debris ensures minimization of combustible debris that must be treated onsite.
- **Updating work approaches to minimize waste generation.** Explosives parts can be pressed into their near final shapes using previously unavailable isostatic presses, which have reduced the amount of explosives machining wastes generated. New technology allows for pressing a cone directly, so that the shape requires only minimal finishing through machining, thereby minimizing machining wastes.
- **Identifying beneficial uses for materials.** Alternative uses are found for explosive pieces that do not meet quality specifications, rather than treating them as waste. Furthermore, the operation of a solvent recovery system for the process generating the highest quantity of explosives contaminated solvents treated onsite. After recovery, the recovered and purified solvents are reused in experimental processes rather than disposed.
- **Shipping offsite whenever possible.** Explosives contaminated oils and solvents that are contaminated with less than 25% explosives are shipped offsite for treatment and disposal. Contaminated oils and solvents with less than 25% explosives in solution are not considered an

explosive hazard (DOE 2019). In addition, although the Laboratory does not currently generate bulk propellants and munitions containing propellants, if generated, they would be shipped to an offsite facility for treatment and disposal.

- **Employing other modes of treatment for equipment whenever possible.** Excess explosives processing equipment resulting from decommissioning or maintenance activities that is potentially contaminated with explosives is steam cleaned or pressure washed instead of being treated with flashing when safe to do so. Water generated as part of the process is sent to the High Explosives Wastewater Treatment Facility. In addition, when safe to do so, plastics are steam cleaned and disposed of or recycled offsite as non-hazardous waste.
- **Managing the operational footprint to minimize potential contamination.** Explosives machining operations, as well as most explosives pressing operations, have been consolidated into one building, thereby reducing the potential for explosives contamination at many locations.
- **Utilizing the appropriate thermal treatment options to minimize impacts.** Highly contaminated molds that cannot be steam cleaned are treated by OD rather than flashing because the products of combustion are more complete due to the higher temperature and pressure present during OD reactions.
- **Managing inventory.** Implementation of a centralized explosive inventory system that is available to all explosives custodians provides the opportunity for owners and users to search a common inventory system for in-stock explosives materials before ordering new materials. The explosive inventory system further reduces unnecessary explosives waste.
- **Employing technological solutions whenever feasible.** The implementation of mercury/explosives separation technology has reduced the amount of toxicity in waste streams and of excess explosives contaminated wastes.

In addition, the Laboratory systematically and successfully applies pollution prevention principles to reduce the toxicity of the explosives waste streams and the amounts of excess explosives and explosives contaminated waste treated onsite. These principles have been demonstrated with the reuse of machining sludge and the reduction of overall treatment at the OD units.

6.2 Anticipated Waste Generation Practices and the Laboratory's Commitment to Continual Improvement

The Laboratory's waste minimization efforts have significantly reduced the quantity of waste that is treated onsite at the Units. Current onsite waste treatment activities at the Units are less than in the past because of careful evaluation of waste generating practices. From 2013 through 2022, the Laboratory has treated an average of approximately 2,259 lbs. per year at the Flash Pad and 38 lbs. per year by OD. The Laboratory anticipates that future waste treatment quantities will remain at, or be less than, the current quantities. However, risk reduction efforts or changes in mission requirements at LANL may increase the overall amounts of waste needing treatment in specific years and may increase the annual quantity of waste to be thermally treated in the future.

Explosive inventory reduction efforts at the Laboratory will continue to reduce the explosives waste inventory. These efforts have included the increased shipment of explosives offsite for disposal where safe and lawful, as well as onsite reuse and onsite treatment of excess explosives as necessary. Explosives are only treated at the Units when other options have not proved safe or available. Although mission requirements will continue to drive the use of thermal treatment, the Laboratory remains committed to continuously improving its approaches to pollution prevention, waste minimization, and safe and effective waste treatment.

7 General and Site-Specific Factors Relevant to Consideration of Alt Tech at LANL

7.1 EPA General Criteria for Alt Tech Evaluations

EPA regulations authorize the permitting of open burning and open detonation units for the treatment of waste explosives. Waste explosives means "waste which has the potential to detonate and bulk military propellants which cannot be safely disposed of through other modes of treatment."[9]

EPA has interpreted this regulation as authorizing the permitting and operation of OB/OD units where no alternative mode of treatment is *safe* and *available* (EPA 2022b, EPA 2022c). For determining whether a technology is safe, EPA has provided that the following factors should be considered:

- **Operational safety** – whether the technology creates unreasonable risk of injury (*i.e.*, by substantially increasing the likelihood of unintentional explosion) to personnel operating the unit.
- **Monitorability** – whether the technology must be monitorable both in terms of operational controls and effluents/emissions resulting from treatment operations to ensure protection of human health and the environment.
- **Toxic by-products** – whether the technology must be able to treat any toxic by-products to levels that are protective of human health and the environment before release (EPA 2022c).

In addition, EPA Region III Draft Guidance for the permitting and operation of OB/OD treatment units states that the selection and appropriateness of OB/OD treatment should be based upon the following factors: (1) site specific safety; (2) transportation hazard potential; (3) offsite treatment options; and (4) feasibility of Alt Tech considerations (EPA 2002). EPA provides that to identify whether alternative technologies are available, the 2019 EPA and NASEM reports on Alt Tech should be considered, as well as other sources of information on technologies that have been developed to date for certain waste streams (EPA 2022b, EPA 2022c).

The 2019 EPA and NASEM reports focus on Alt Tech available for treating conventional munitions, which are different types of explosives waste streams than the Laboratory's specialized explosives waste. As discussed below, the Laboratory's explosives waste are associated with nuclear weapons applications. Significantly, the 2019 EPA and NASEM reports both acknowledge that there are circumstances and types of energetic waste that necessitate the continued use of OB/OD treatment based upon safety hazards and other site-specific feasibility factors (EPA 2019, NASEM 2019). Section 7.2 discusses such LANL-specific factors relevant to the consideration of Alt Tech for the specialized explosives waste treated at the thermal treatment Units.

Additionally, EPA's Compendium of Alternative Technologies to Open Burning and Open Detonation of Energetic Hazardous Wastes includes about 130 pages of matrixes that summarize key aspects of alternative OB/OD technologies, based on a review of 37 reference documents (EPA 2023). The facilities and waste types covered by the EPA Compendium focus on conventional munitions and ordnance wastes. The wastes include complete assemblies (*e.g.*, projectiles, ammunition, grenades, rockets, mines, flares, *etc*.) and components of assemblies' items (*e.g.*, rocket motors, charges, detonators, detonating cord, fuses, primers, blasting caps, warheads, *etc*.). The vast majority of the treatment technologies included in the EPA Compendium can be classified as either contained burn units (potential alternatives for open

[9] 40 CFR § 265.382 ("Open burning of hazardous waste is prohibited **except for the open burning and detonation of waste explosives**.") (emphasis added).

burning) or contained detonation units (potential alternatives for open detonation).[10] Contained burn and contained detonation units are addressed in Section 8 of this Alt Tech Evaluation.

The EPA Compendium does not identify technologies applicable to the unique wastes generated by LANL. Significantly, as the EPA Compendium recognizes, the selection of appropriate alternative technologies is facility-specific and waste-specific. The EPA Compendium also recognizes that the alternative technologies may not be applicable to unique and sensitive waste streams, such as those generated at research and development facilities. As the EPA Compendium states: "A technology that has been identified or implemented for a particular waste stream at one facility may not be suitable for another facility with a similar waste stream. This may be encountered across all OB/OD facilities, and more likely at Research, Development, Test, and Evaluation facilities where standard formulations may have been modified resulting in increased sensitivity and explosive risk and perform stress testing that reduces explosives and munitions stability." (EPA 2023).

7.2 Site-Specific Considerations

7.2.1 *The Laboratory Utilizes Operational Safety Controls*

In support of national defense, DOE has an active role in research and development of explosive formulations, explosives synthesis, charge geometry, and explosive assemblies. DOE and operating organizations maintain explosives safety standards that fully address potential risks. Maintaining worker and public safety is paramount in all DOE explosives handling operations.

The most important consideration when managing explosives waste streams is to minimize or eliminate, if possible, the danger and exposure to workers and the public from accidental ignition of the waste. At the Laboratory, all work activities associated with explosives and other energetic materials are carefully controlled, and safety is maintained through compliance with the requirements outlined in the *DOE Standard for Explosives Safety* (DOE 2021).

Site-specific safety and security are important concerns in every decision to treat explosives waste on- or offsite at LANL. Each onsite waste treatment activity at LANL is carefully planned to minimize worker exposure and handling of explosives. Personnel trained in explosives handling and familiar with the explosives' characteristics conduct the onsite waste treatment operations. This reduces the potential for compromising the energetic material and reduces the likelihood of serious injury or death. LANL explosives waste streams vary widely in form and constituents. Onsite explosives professionals are familiar with the specific types of explosives waste generated at LANL, the processes that generate them, and the processes for treating them. This includes familiarity with the unique, complex, and difficult to discern properties or attributes of the specialized explosives waste, and how to address and treat them.

Additionally, operational restrictions self-imposed by the Laboratory during thermal treatment operations further provide for safe treatment of waste and reduce the effects to human health and the environment. As discussed in Sections 7.4 and 7.5, the Units are designed to achieve complete combustion and prevent

[10] Such units are referred to by various names. Contained Burn Technologies: contained burn chamber; static kiln, contained thermal treatment chamber; international thermal convection system; contained burn chamber in static burn/static firing configuration; rotary kiln incinerator; decineration; thermal convection system; car bottom furnace. Contained Detonation Technologies: controlled detonation chamber, static detonation chamber; static kiln incinerator, contained thermal treatment chamber; controlled detonation chamber (transportable).

potential air, groundwater, or other environmental impacts. Routine thermal treatment operations occur only during daylight hours (*i.e.*, one hour after sunrise or one hour before sunset) and in appropriate weather conditions, which are checked before any waste treatment operation. Transportation of, or routine operations with, explosives waste at the Units may not occur during the following severe conditions:

- Lightning within a six-mile radius;
- Bounding conditions as detailed in the LANL Fire Danger Matrix maintained by emergency operations personnel at the Facility;
- Icy roads (for transport);
- During precipitation events;
- Any time winds are greater than 20 miles per hour and winds that are greater than 10 miles per hour in drier weather conditions, such as in the spring and summer seasons when fire danger rating is deemed to be "Very High" or "Extreme."

Site-specific safety concerns are critically important in the Laboratory's decisions regarding waste storage. Explosives waste must be stored for a time to accumulate sufficient quantities for treatment or disposal, whether on- or offsite. Rigorous administrative processes are used to maintain explosives safety at LANL. Specific safety procedures address the precautions routinely taken in order to ensure compliance with established explosives weight limits in each explosives work area, in order to prevent overloading a facility or area. The Laboratory has used multiple generator accumulation locations for explosives waste in smaller quantities to prevent propagation of accidental explosions.

Any decision to further increase the types or quantities of explosives waste streams shipped offsite, or to adopt other onsite treatment technologies, would require additional storage areas and/or longer-term storage of explosives waste streams. These factors would increase site-specific and operational safety risks at LANL. Any increase in site-specific safety risks at the Laboratory is not acceptable. Therefore, the additional safety hazards due to requiring additional storage and handling must be considered when evaluating Alt Tech.

7.2.2 *LANL's Specialized High Explosives Waste Streams Are Unique*

The Laboratory's specialized explosives, and the associated waste streams, are specific to explosives used *in nuclear weapons applications*, and associated research and development activities, which directly informs assumptions about the applicability and availability of Alt Tech options. These specialized explosives are different from explosives used in conventional munitions in important ways. The Laboratory's research and development of high explosives have led to a unique, specialized assortment of very high-performance explosives with very high detonation velocities, high energy content, and efficient energy conversion and release.

LANL performs research and development on explosives specifically developed for nuclear weapon systems. The explosive materials are PBXs and are specifically formulated to meet requirements such as structural integrity, machinability, and thermal stability, as well as improved safety characteristics. Development, fabrication, and testing of PBXs are the primary feeders for the Laboratory's explosives waste streams. These explosives wastes generated at the Laboratory possess unique and potentially unpredictable properties. Furthermore, the research and development activities performed on PBX explosives include tests and experiments that intentionally detonate these explosives or subject them to insults, such as thermal or mechanical environments. Insulting explosives in this manner can change their sensitivity; thus, any remaining explosives waste is unique, has difficult to discern properties, and is potentially in a less safe or unstable condition, and is not susceptible to certain kinds of treatment.

Therefore, even when the Laboratory receives a commercial explosive or an explosive from another facility (where that facility may be able to implement an Alt Tech option for some of its explosives waste streams), it does not follow that LANL would be able to implement the same (or any) Alt Tech.

The Laboratory's specialized high explosives waste cannot be treated in a confined environment due to the potential for detonation. The *burning* of a high explosive is known as *deflagration*, which is simply a combustion process that can take place in a time scale from seconds to milliseconds (10^{-3} seconds). The *detonation* process is significantly more violent and rapid and takes place as a molecular chain reaction which travels many times faster than the speed of sound, measured in microseconds (10^{-6} seconds), and results in very high energy. The specialized explosives used at the Laboratory transition from deflagration to detonation when exposed to an open flame in a confined environment. Critical to the application of alternative technologies to treat LANL's specialized high explosives waste is the propensity and potential for detonation if confined and brought to an elevated temperature. Temperature plus confinement of modern high explosives results in detonation (Leininger 2020).

LANL also maintains and develops a portion of the United States' nuclear stockpile. Safety of these nuclear weapons is a responsibility that often involves surveillance of the high explosives in deployed systems and development of high explosives with improved physical properties. Surveillance involves the physical inspection of weapons systems, including the high explosives, and sometimes requires investigations to understand issues that are observed, for example aging of high explosives that results in requirements no longer being met. Such a situation is addressed by development of improvements to the high explosives themselves. New high explosives formulations are researched, investigated, and developed at LANL, and subsequent improvements in characteristics of the high explosives may result in changing the way the explosive behaves, such as an improvement to the resilience of the high explosives when exposed to insults like temperature or shock.

In addition to working with high explosives materials to generate specialized high explosives and unique high explosives waste, LANL intentionally damages, or insults, high explosives as part of its research and development work. Insulting or damaging high explosives materials changes the morphology of the material and the morphology impacts the sensitivity of the high explosives. Insulted or damaged explosives are defined as Storage Compatibility Group L in the *DOE Standard for Explosive Safety* (DOE 2021). Group L also includes experimental explosives, explosives of temporary interests, newly synthesized compounds, and new mixtures, all of which the Laboratory generates (DOE 2021).

Prior to insult, the high explosives materials may be well understood, but once the morphology of a high explosives has been changed it is not possible to reliably predict the behavior of the material. This is an important consideration in the context of assumptions about the availability of Alt Techs for treating the Laboratory's explosives waste. The explosives waste streams generated at LANL are unique, constantly changing, and heterogeneous. Therefore, studies performed on munitions wastes or other conventional types of explosives waste, such as the 2019 EPA and 2019 NASEM reports and EPA Compendium, cannot directly inform whether Alt Techs are available that can safely treat the Laboratory's explosives waste.

Uncontrolled and unanticipated detonation of the Laboratory's specialized high explosives waste would present exceptional health and safety risks to workers, the public, facilities, and the environment. These risks are mitigated through treatment of the waste at the Laboratory's thermal treatment Units, which provide for treatment in an unconfined environment, while minimizing waste storage periods and waste handling.

7.2.3 *The Thermal Treatment Units Treat Small Volumes of Specialized Explosives Waste in a Highly Controlled Manner*

The Units treat, in a designed and highly controlled manner, the limited and discrete quantities of specialized explosives waste that the Laboratory must generate to fulfill its research, development, and national security–related missions. The Units are designed to treat the Laboratory's specialized explosives waste streams. The Units do not treat any other types of wastes, such as large-scale or conventional munitions . The Units are geographically isolated, access restricted, and are not continuously operated. The Units are designed to enhance safety and to protect human health and the environment. The Units efficiently and completely combust the specialized explosives waste and do not generate secondary hazardous waste streams or any measurable or modeled toxic by-products.

Data Sheet 7-1 and **Data Sheet 7-2** provide a summary of the current treatment technology used at the Laboratory, for the Flash Pad and the TA-36-8 (Minie Site) and TA-39-6 (Point 6) OD units. The thermal treatment conducted at the Units is, itself, an alternative technology to the OB/OD of explosives waste. The Laboratory's thermal treatment operations are highly controlled, efficient, designed to completely combust or consume the waste, monitored and sampled, and right sized for the Laboratory's specialized explosives waste. The data sheets present an organized and detailed rationale for why these current treatment approaches are utilized, in a manner that allows for comparison with **Data Sheet 8-1** through **Data Sheet 8-17** provided below in Section 8, in the discussion of the Alt Tech Evaluation process.

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Data Sheet 7-1. Existing Treatment Technology: Flash Pad

Existing Treatment Technology: Flash Pad (OB)		
Flash Pad Technology Description	Flashing or burning explosives waste destroys waste by self-sustained combustion after being ignited or by controlled burning using supplemental fuel in an open environment. The Flash Pad is designed to attain temperatures that result in the complete combustion and decomposition of the explosives waste stream and byproducts. This technology best serves waste generated during machining of explosives, excess explosive powders and pieces, explosive contaminated combustible wastes, laboratory samples of experimental explosives, and large pieces of equipment that must be flashed prior to shipment offsite for recycle or disposal.	
Treatment Type	OB	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – All**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Applicable to combustible wastes and small quantities of explosives waste.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**No**
	Revision to CWA – NPDES:	**No**
	Other:	
Safety Risk Considerations	Specific training for operators and explosives safety personnel are required and the area must be secured. The burn is monitored remotely through cameras. Specific operating parameters are invoked for open burning to assure the safety of personnel and protect human health and the environment.	
Human Health and Environmental Impact Considerations	Residual ash is contained within the lined burn area, collected, and analyzed for hazardous constituents; generally disposed as non-hazardous. Secondary thermal treatment provided if necessary. Air emissions include CO, CO_2, H_2O, NO & N_2; little or no secondary combustion products due to short residence time. The Flash Pad is subject to ongoing LANL environmental monitoring programs.	
Energy Resource Demands of Operation	Heat generated by oxidation of combustible wastes and supplemental fuel (propane).	
Secondary Waste Streams Generated by Technology	Residual ash is analyzed for hazardous constituents (none are present and the residual ash can be disposed of as NM special waste). Expected emissions are CO, CO_2, H_2O, NO_2, N_2, and little to no secondary combustion products due to short residence time.	
Operations/Treatment Capability Uncertainty	Proven technology.	
Relative Cost Range	*Capital:* No change.	
	Operations and MTCE: No change.	

Data Sheet 7-2. Existing Treatment Technology: TA-36-8 and TA-39-6 Open Detonation Units

Existing Treatment Technology: TA-36-8 and TA-39-6 Open Detonation Units		
TA-36-8 and TA-39-6 OD Technology Description:	Open detonation involves the detonation of explosives waste in an open air environment. Detonation treatment is designed to achieve complete consumption of the waste stream and byproducts. This technology is best suited for small or large pieces of explosives. OD is especially appropriate for aged explosive material with difficult to predict properties because OD requires a minimum of moving and handling, and avoids explosive concerns associated with technologies that require waste containment.	
Treatment Type	OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**Yes – All**
Principal/Treatment Capability Limitations	Applicable to explosives waste; not suitable for combustible waste.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**No**
	Revision to CWA – NPDES:	**No**
	Other:	
Safety Risk Considerations	Larger detonations for explosives pieces that are greater than the capacity of a confined detonation chamber. This requires less handling for workers. Also, the explosive would not have to be size-reduced prior to treatment by OD. LANL conducts detonations from a remote location inside the control building following specific operating procedures for OD to assure the safety of human health and the environment.	
Human Health and Environmental Impact Considerations	CO_2, H_2O, and N_2 emissions. OD units are subject to ongoing LANL environmental monitoring programs.	
Energy Resource Demands of Operation	Energy provided by waste explosives being treated; supplemental fuel is not required.	
Secondary Waste Streams Generated by Technology	Process effluents include metal fragments, CO_2, H_2O, and N_2.	
Operations/Treatment Capability Uncertainty	Proven technology	
Relative Cost Range:	*Capital:* No change.	
	Operations and MTCE: No change.	

7.2.4 *The Thermal Treatment Units Safely Treat Specialized Explosives Waste Streams Without Generating Toxic By Products Generated by Alternative Technologies*

The Laboratory's thermal treatment Units are located, designed, constructed, operated, and maintained in a manner that ensures protection of human health and the environment. *See* Permit Renewal Application, Sections 4 and 5. The safety of the Units has been proven through extensive data and analysis.

The Flash Pad is designed and operated to achieve the complete combustion of explosives waste materials and no measurable or modeled toxic by-products (*see*, *e.g.*, LANL 2020k). Thermal treatment analysis demonstrates that specialized explosives waste is fully treated in the Flash Pad (*see* LANL 2020l). The analysis shows that the temperatures attained at the unit exceed 1500°F within 60 seconds of the start of the burn and temperatures above 1500°F (>2000°F routinely) are maintained continuously for the duration of the burn (often 60 minutes) while the propane burners are in operation. These temperatures result in complete decomposition of the explosives waste streams and potential toxic byproducts, including dioxins and furan congeners, which are destroyed at temperatures above 1400°F (Kulkarni 2008, LANL 2020l at p.5).

The Laboratory's Flash Pad is a modern, engineered approach to open burning. The Flash Pad uses propane enhanced controlled burning that by design achieves complete combustion and prevents potential air emissions and constituent migration to groundwater due to the Flash Pad's design (including advanced liner, secondary containment, and storm water controls). The Flash Pad provides the right-sized treatment unit for LANL's heterogeneous explosives waste streams. *See* Permit Renewal Application, Section 5.1.2.

The Laboratory's OD units have also been designed to achieve complete consumption and prevent potential air emissions and groundwater contamination. PBX explosives, like those used at LANL, fully detonate leaving little or no residual constituents when initiated with correct shock inputs. When performing an open detonation treatment of specialized explosives waste at LANL, the high explosive is configured in such a manner to ensure shock transmission from an in-contact initiation system. Such a system involves a detonator and a new pristine high explosive that is applied to the specialized explosives waste. Controlled initiation ensures complete consumption of the waste material regardless of any indiscernible properties of the waste.

To further address concerns about the potential release of toxic contaminates, the explosives waste streams treated at the Units have been carefully assessed to ensure metal contents are minimized to the extent possible (as a component of a combustible waste) and to ensure that materials that may release toxic contaminants are not included within the waste stream. The materials currently prohibited from open burning at LANL include: radiological constituents; biologic or chemical warfare weaponry; small arms ammunition up to 50 calibers; beryllium; ammonium perchlorate; polyvinyl chloride (PVC); small control boxes or electronic equipment; blasting caps, electric detonators, explosives units containing electric detonators, and mild detonating fuse arrays.

The Laboratory's Units have been shown to be effective treatment technologies for the specialized explosives waste streams generated from LANL's explosives research and development and national security-related missions.

7.2.5 *The Thermal Treatment Units Do Not Pose a Threat to Human Health or the Environment*

The Laboratory performs environmental monitoring specific to each of the Units. This monitoring spans several years and is ongoing. Results from this enduring environmental monitoring demonstrates that the Units do not pose a threat to either human health or the environment. *See* Permit Renewal Application, Sections 4.18 and 5.16. There are no discernable adverse impacts to small mammals and avian populations proximate to the Units, to soils in any manner that would pose risk to residents or workers (including cancer risks), or to the air, surface, or groundwater.

For example, small mammal population and chemical concentration research finds that analyzed constituents in whole body field mice samples are either not detected or are detected below reference and

screening levels (Fresquez 2011, Fresquez *et al*. 2013). Similarly, ongoing decadal avian population monitoring indicates that the Units have no negative effect on bird populations (Hathcock & Fair 2013, Hathcock 2014, Hathcock 2015, Hathcock *et al*. 2017, Hathcock *et al*. 2018, Hathcock *et al*. 2019, Sanchez *et al*. 2020, Rodriguez & Abeyta 2021, Gadeck & Velardi 2021, Gadek Velardi & Abeyta 2022, Mason et. al. 2023). Studies include ongoing monitoring of nest eggs, specifically for impacts from dioxins and furans among other metals. Over approximately a decade, no adverse impacts from operating the Units have been found (Gaulker & Stanek 2019, Gaulker & Stanek 2020, Gaulker & Stanek 2021, Gaulker & Stanek 2022, Gaulker & Stanek 2023, Mason et. al. 2023).

Small mammals and avian populations would be expected to demonstrate impacts if the operation of the Units were adversely impacting the environment as these populations are most proximate to the Units. The lack of impacts on the receptors most proximate to the Units means that inferences about impacts to receptors much further away from the Units are not be supported.

Multiple years of soil monitoring also serve to assess and support understanding of the current status of soil chemical concentrations at the Units. Soil monitoring conducted prior to each application for the Units utilized risk assessment guidance from the New Mexico Environment Department (NMED). Risk assessments for the Units resulted in human health risk calculations indicating no risk to residents and workers from exposure to soils.

Human health cumulative cancer risk and noncancer screening level Hazard Indices for hypothetical residents and industrial workers are also below threshold levels. Additionally, after application of site-specific population area use factors and low-effect factors, ecological risk assessments conclude that there is likely no risk to ecological receptors. Impact to the vegetative or invertebrate soil fauna community (plants and earthworms) is not expected to occur due to intended use and bare ground. Avian and mammalian population information indicates that neither birds nor mammals are adversely affected (*see, e.g.,* LANL 2020f, LANL 2020g, LANL 2020n).

Extensive air modeling also demonstrates that operation of the Units is not predicted to result in exceedances of applicable human health and ecological screening levels. Predicted soil deposition (over a 10-year period) also demonstrates that impacts to soil concentrations are less than human health and ecological screening levels (*see* LANL 2020c, LANL 2020k). Atmospheric monitoring efforts supplement and reinforce this modeling and analyses. Each sample is collected downwind of the Units and is analyzed for metals and dioxins/furans. The results are then compared to acute air-inhalation exposure concentration screening levels, where screening levels could be identified. As with past monitoring efforts, more recent monitoring results support that there are no dioxins or furan compounds detected within air samples. Comparisons of metals detected within the samples are also below acute inhalation-exposure screening levels (*see* LANL 2020c, Green & Allen 2011).

Finally, institutional monitoring is conducted at LANL for storm water, groundwater, and air. Monitoring networks are located across the Laboratory and are designed to inform the conditions of water and air as described in the Annual Site Environment Report (ASER). Results of all site monitoring indicate and support that there is no adverse effect to human health and the environment due to operation of the Units (*see, e.g.,* LANL 2020c, LANL 2020k).

7.2.6 *As a National Security Laboratory, Requirements for Implementing Potential Alt Tech that Could Meet Screening Criteria May Impact Availability for LANL*

Even when there may be an Alt Tech that is potentially available, and even where the Laboratory can secure any necessary waivers or federal approvals to implement a specific Alt Tech, vendors themselves

may not prioritize federal research and development facilities such as LANL. These considerations are not hypothetical in nature. The Laboratory faces challenges with vendor and product availability and approval in many commercial products, as do all federal research and development facilities.

7.3 Specific Transportation and Storage Considerations & Restrictions

Sections 5 and 6 describe the composition of the Laboratory's explosives waste streams and efforts to avoid or minimize the generation of these wastes to the maximum extent practicable. The remaining wastes must be treated or disposed of in accordance with applicable requirements. As described in Section 3, the second step in LANL's waste management conceptual approach is to review the remaining explosives waste, on a waste stream-by-waste stream basis, to identify candidate wastes that could be safely transported offsite to permitted facilities for treatment and disposal.

Most of the Laboratory's wastes can be safely and securely shipped offsite. For the Laboratory's specialized explosives waste, which is subject to greater shipping limitations, ongoing review occurs to identify additional opportunities for increased offsite shipment where feasible and where it can be done safely. This is complicated by the fact that as energetic materials age or are subjected to testing, the resulting explosives waste may develop properties that are unpredictable. For this reason, the Laboratory's explosives waste that are aged, sensitive, or otherwise-unstable and cannot be stabilized are legally prohibited from transportation on public roadways, in accordance with DOT regulations. *See* 49 CFR § 173.53.

When stabilized through desensitization, or another process, to lower the sensitivity, energy output, and flame temperature of the composition, the Laboratory's explosives waste can be transported on public roadways and, whenever possible and practical, this is LANL's practice. For those explosives waste that cannot be stabilized for offsite transportation because the transportation hazard potential is too great or is legally prohibited, the wastes are accumulated onsite in compliance with generator accumulation requirements until they can be safely and effectively treated. For these explosives waste, storage and handling hazards are minimized by performing treatment onsite at the Units as often as needed to avoid accumulating excess waste inventory and exceeding the work areas' explosives safety limits.

7.3.1 Transportation Safety and DOT Transportation Requirements

Shipments of numerous types of hazardous materials (including explosives) on public roads pose hazards and risks for both public and worker safety. Because of this, the DOT and States have imposed restrictions and prohibitions on transport of explosives and explosives waste. Some waste streams generated at the Laboratory cannot be legally or safely transported on public roadways to offsite commercial facilities. Explosives waste streams that cannot be safely transported on public roadways are those that cannot be properly stabilized or that do not meet offsite facilities' waste acceptance criteria. In some cases, noncombustible debris contaminated with explosives cannot be released from the Laboratory's explosives areas without being flashed.

DOT specifies explosives transportation requirements within the hazardous materials requirements in Title 49 of the Code of Federal Regulations. The list of "Forbidden Explosives" under 49 CFR § 173.54 that may not be offered for transport or transported includes:

- New explosives[11] that have not been examined, classified, and approved for transport;

[11] New explosives include explosives that have not been previously produced, or those that have been previously produced, but whose formulation, design, or process has been changed so as to alter any of the properties of the explosive. *See* 40 CFR § 173.56.

- Explosives containing chlorates either as an ammonium salt or an acidic substance;
- Damaged packages or articles;
- Propellants that are unstable, condemned or deteriorated;
- Explosives specifically forbidden in the Table of Hazardous Materials (49 CFR § 172.101); and
- Explosives that fail to pass specified sensitivity, stability and burning tests.

In addition, each of the Laboratory's explosives waste streams that have not been previously shipped offsite must be tested, classified, and assigned proper shipping names and an EX-ID number[12] by the DOT Associate Administrator in accordance with DOT requirements in 49 CFR § 173.56 through § 173.58 to transport explosives waste on public roads or highways. Any explosives waste streams that fail the required testing series cannot be assigned numbers or transported to commercial facilities. There is currently a substantial backlog of new explosives document requests pending review by the DOT Associate Administrator's office. Review of new requests may take several years.[13]

To the maximum extent possible, the Laboratory ships offsite for treatment its explosives waste. Only that waste that cannot be shipped offsite is treated at the Units. None of the Laboratory's specialized explosives waste currently treated at the Units may be shipped offsite. None of the specialized explosives waste have been examined, classified, and approved for transport. Further complicating any approval for transport is the unique nature of the specialized explosives waste, and the complex morphology, properties, and potential unpredictability of the explosives waste. Certain of the specialized explosives waste streams, moreover, contain explosives materials that are prohibited from transport.

If the Laboratory were required to hold its specialized explosives waste to complete this lengthy process, rather than safely and effectively treating it at the Units, additional onsite storage and handling of explosives waste would be required.[14] This additional onsite storage and handling of explosives waste would pose a serious risk to both the environment and human health. The potential for degradation of explosives during the extended storage period would result in unnecessary additional risk to workers and the environment. This does not limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives. In addition to the shipping considerations described above, explosives that present export complications pursuant to 22 CFR §§ 120-130 cannot be shipped offsite for treatment. Furthermore, all explosives contaminated noncombustible debris that cannot be steam cleaned must undergo treatment per Section 18 of the DOE Explosives Safety Standard (DOE 2021).

Therefore, because of the transportation, storage, and handling hazards, the Laboratory will need to maintain onsite explosives waste treatment capability to safely disposition specialized explosives waste.

[12] An EX-ID number is issued by DOT to identify an explosive that has been tested and classified by DOT (49 CFR § 171.8 and 49 CFR § 173.56).

[13] Also problematic is that the changed nature of stored explosives material through the lengthy DOT process could result in a never-ending "do loop" where the authorization, once received, may no longer be utilized for the aged material, so the explosives waste would have to be stored for an ever longer period as new authorizations are pursued with DOT.

[14] The potential need to stockpile explosives waste to meet minimum treatment quantity requirements for transporting waste to offsite treatment facilities, likewise, would result in unnecessary additional risk to workers and the environment.

7.3.2 Federal Requirements for Transfer of Weapons Materials and Explosive Material to Commercial Facilities

Federal security and property requirements for classified waste and military munitions (as applicable) add to the complexity of handling, transport, and treatment of explosives waste generated at LANL. Many of the Laboratory's explosives waste streams that require thermal treatment, when unreacted, may contain classified components or features. These components or features complicate the Laboratory's ability to transport an explosives hazardous waste offsite and add to the transportation hazard. Some explosives waste-items may be controlled property according to DOE or U.S. Department of Defense (DoD) requirements and may not be eligible for release to an offsite disposal facility, even for purposes of destruction. Likewise, offsite treatment may be entirely prohibited or may be significantly delayed due to prohibitions and restrictions on transportation of that waste to an offsite facility.

7.4 Offsite Treatment Considerations

The Laboratory maintains the capability to ship certain explosives waste offsite to RCRA-permitted commercial treatment facilities. Whenever feasible, the Laboratory ships permissible bulk propellants, munitions containing propellants, and excess explosives to offsite facilities for treatment, storage, and disposal. In order to make these shipments, the waste must meet the offsite facility's waste acceptance criteria (WAC) and the waste must be able to be safely and legally transported.

The majority of the Laboratory's explosives waste, however, cannot be safely transported and stored offsite. In order to be sent to an offsite permitted commercial treatment, storage, and disposal facility (TSDF), any explosives waste candidates must meet the following requirements:

- The TSDF's WAC must comply with applicable Land Disposal Restriction (LDR) requirements;
- DOE requirements which prohibit the transportation offsite of experimental explosives, explosives of temporary interests, newly synthesized compounds, and new mixtures, all of which the Laboratory generates;
- DOT requirements which prohibit the transportation of new and/or uncharacterized[15] explosives waste;[16] and
- Federal requirements for transfer of weapons materials and explosive materials to commercial facilities, including security and property requirements for classified waste and military munitions (as applicable).

Offsite treatment decreases the overall quantity of explosives waste that must be treated onsite at the Units. However, explosives waste awaiting shipment must be accumulated and stored onsite until the treatment facility approves the waste shipments which, as noted above, is a significant site-specific safety consideration.

[15] "Uncharacterized" in this context means a material whose hazard classification cannot be determined within the meaning of 49 CFR § 171.8 and 49 CFR § 173.56 (*i.e.*, is unclassified and unapproved). This is not a reference to "uncharacterized" waste within the meaning of 40 CFR § 262.11 under RCRA.

[16] In addition to the DOT requirements and restrictions discussed in Sections 7 and 8, the DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) recently terminated Explosive (EX) classification approvals for dozens of previously approved shippers of explosives waste, further restricting the options for shipment of explosives waste to offsite TSDFs. *See* PHMSA, Hazardous Materials: Notification of Termination of Certain Explosive Classification Approvals Due to Non-Compliance with the UN Model Regulation Test Series 6(d) Requirements, 88 Fed. Reg. 38935 (June 14, 2023).

7.4.1 Offsite Facilities' Waste Acceptance Criteria and Acceptance Process

Offsite commercial TSDFs establish criteria to ensure that explosives waste streams accepted for disposition meet the facility's individual RCRA permit requirements and can be safely handled and properly treated by the facility (*i.e.*, to ensure compliance with applicable LDR standards). Requests for treatment and disposal must include documentation that confirms compliance with the facility's WAC, including a description of the physical form, chemical constituents, EPA Hazardous Waste Numbers (EPA HW No.), DOT Proper Shipping Name (PSN), and explosive ID number.

Shipments of the Laboratory's explosives waste offsite are also subject to the availability of appropriate storage and treatment capacity at the receiving facility. Wastes cannot be transported until shipments are approved by the receiving facility. The elapsed time between submitting a request for transport and receiving authorization to ship can sometimes be significant (*e.g.*, up to six months).

7.4.2 Current Offsite Treatment Options

Options for waste treatment offsite are limited because explosives waste streams that are considered detonable, or have the capability of exploding, require a special permit to be shipped as non-regulated waste. Furthermore, operations at offsite treatment facilities may not be as controlled as the treatment that occurs at the Units. There are currently three commercial facilities capable of accepting and/or treating some of the explosives waste streams generated at the Laboratory, including:

- the Clean Harbors, Colfax Facility;
- the General Dynamics Ordnance and Tactical Systems, Main Office and Disposal Facility;
- and the Veolia ES Technical Solutions-Trade Waste Incineration (Veolia-TWI).

At this time, the Laboratory will typically send explosive-contaminated waste streams to Veolia-TWI and Clean Harbors, Colfax Facility.

The Clean Harbors, Colfax Facility, located in Colfax, Louisiana, consists of twenty separate treatment units (40 CFR Part 264, Subpart X, Thermal Treatment Units) with the capability of treating reactive (D003) characteristic hazardous wastes through OB processes. The facility is capable of treating up to 480,000 lbs. of explosives waste annually and has the capability of storing up to 50,000 lbs. of explosives (Clean Harbors 2023). In 2023, the Louisiana Department of Environmental Quality released a preliminary draft RCRA renewal permit for Clean Harbors that would result in the cessation of OB treatment. While Clean Harbors is confident that it can implement Alt Tech to continue at least some amount of treatment of explosives waste (Clean Harbors 2023), the timeline for implementation and what explosives waste will be able to be processed at this facility in the future remains uncertain.

The General Dynamics Ordnance and Tactical Systems facility, located in Joplin, Missouri, consists of two RCRA Part B permitted and maximum achievable control technology (MACT) compliant incinerators (one of which is a rotary kiln incinerator) and a car bottom furnace (General Dynamics 2023).

Veolia-TWI, located in Sauget, Illinois, consists of three permitted treatment units (two fixed hearth thermal treatment units and one rotary kiln thermal treatment unit) with the capability of treating explosives waste that has been properly characterized; provided that the waste does not contain any prohibited wastes as listed within the facility permit (Veolia 2023). The facility includes a magazine that is used to store up to 100,000 lbs. of Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE) low

explosives. The facility has no capability to store BATF high explosives or detonators, but it can process them.

7.4.3 Public and Worker Safety Issues with Offsite Treatment

Each of the offsite facilities currently available is located at some distance from the Laboratory. Clean Harbors, Colfax Facility is located 842 miles east of LANL; General Dynamics Ordnance and Tactical Systems, Carthage, is located approximately 800 miles east of LANL; and Veolia-Trade Waste Incineration Facility is located 1,084 miles northeast of LANL. Transportation of waste from the Laboratory to any of these facilities would be via motor carrier over public roads.

Transportation of explosives by motor carrier occurs nationwide on a daily basis, but not without risk to the public. In contrast, the public has limited contact with or access to explosives transported for onsite treatment at the Units. By treating onsite, the Laboratory can control the transportation of the waste by controlling the traffic in the area, the speed at which it can travel, and can limit the area within which the waste is moved. Treatment of waste onsite decreases the potential for the public to be exposed to these hazards.

Onsite treatment of the Laboratory's explosives waste also decreases the handling of waste required by workers. Packaging and transport for onsite treatment are conducted by explosives personnel that have experience handling the specific wastes generated at LANL, including those that are not in pristine condition, have been subjected to damage, and/or are generated from unique processes. Shipment to offsite facilities increases the number of persons handling these explosives and requires that explosives waste be handled at the receiving facility by personnel who are less knowledgeable and experienced with these particular explosives waste streams.

In addition, offsite transportation increases offsite human and environmental impact along the transportation route, the overall carbon emissions from transport vehicles, and the increased risk of transportation incidents, theft, or diversion.

Most TSDFs require a minimum volume per shipment, as specified in the facility's WAC. Quantities of explosives waste streams generated at the Laboratory have been generally decreasing with the implementation of pollution prevention and waste reduction initiatives; however, generation rates are not consistent because they are based on programmatic activities that vary from year to year. Coupling minimum shipment volumes with generally decreasing explosives waste generation results in increased storage time for explosives waste. The Laboratory's explosives waste treated onsite at the Units, by contrast, is currently treated within days or weeks of generation.

Without the treatment capabilities at the Units, any shippable wastes would have to be accumulated until the minimum volume accepted by an offsite treatment facility was reached or a lesser quantity for transport can be brokered with the receiving facility (*see* Sections 7.2 and 7.3 for additional discussion on the hazards of increased storage). Explosives may deteriorate or become unsuitable for transport while waiting for disposal approval. The inability to promptly remove and dispose of excess, aging, or insulted explosives and minimize time and amounts in storage unnecessarily exposes workers to greater hazards.

7.4.4 National Security Considerations for Offsite Treatment

As part of its national security mission, the Laboratory will continue to develop explosive formulations and assemblies that may be related to threat reduction, homeland security, and enhanced security projects. At times of heightened security risk, shipment of certain explosives waste that are candidates for offsite shipment can be prohibited because of the increased risk of transportation-related incidents, theft, or

diversion. In the wrong hands, the Laboratory's explosives waste would not only present a risk of detonation and immediate physical harm to the public, but the waste itself could reveal highly classified information related to the United States' nuclear weapons programs and related research and development. These national security concerns must be considered when considering whether Alt Techs are available to safely treat the explosives waste treated at the Units.

7.4.5 Summary of Offsite Treatment Considerations

Although the Laboratory has worked to increase the amounts and types of explosives waste streams shipped offsite for treatment and disposal and further to reduce the overall quantity of explosives waste treated onsite, increased offsite treatment and disposal is not safe or available at this time. LANL employs offsite treatment whenever practicable. However, options for increased offsite treatment are often limited and the following factors are considered:

- DOE Explosives Safety requirements prohibit the transportation offsite of experimental explosives, explosives of temporary interests, newly synthesized compounds, and new mixtures, all of which the Laboratory generates;
- DOT regulations prohibit the transportation of new and/or uncharacterized[17] explosives waste;
- Explosives may deteriorate or become unsuitable for transport while waiting for disposal approval, presenting site-specific safety considerations;
- Additional storage and handling requirements would pose increased safety and environmental risk and increased permitting liability risk;
- Offsite transportation of LANL's explosives waste can raise national security concerns; and
- Under any scenario involving offsite shipment, the Units must still be able to continue onsite treatment to treat explosives waste having no safe or available alternative, non-shippable explosives waste, and classified wastes, including noncombustible debris wastes that cannot be shipped offsite for disposal without prior treatment.

8 Assessment of Alternative Treatment Technologies

This section describes the Laboratory's Alt Tech Evaluation process, which is utilized to determine whether any Alt Tech may be available that could safely treat the Laboratory's explosives waste currently treated at the thermal treatment Units. This analysis is performed consistent with the approach outlined in EPA's 2022 OB/OD policy memo (EPA 2022b), EPA's December 2022 webinar presentation (EPA 2022c), and EPA Region III Draft Guidance (Tetra Tech 2002). The steps involved in this approach include:

1. **Alt Tech Identification**. Identify Alt Techs that could potentially be used to treat the Laboratory's explosives waste streams in lieu of the current thermal treatment at the Units.
2. **Initial Screening of Identified Alt Tech.** Screen each candidate Alt Tech for its potential applicability to treat the Laboratory's explosives waste streams, conducting the analysis on a waste stream by waste stream basis.

[17] "Uncharacterized" in this context means a material whose hazard classification cannot be determined within the meaning of 49 CFR § 171.8 and 49 CFR § 173.56 (*i.e.*, is unclassified and unapproved). This is not a reference to "uncharacterized" waste within the meaning of 40 CFR § 262.11 under RCRA.

3. **Detailed Screening of Potentially Applicable Alt Tech**. Perform more detailed evaluation for any potentially applicable Alt Tech, including evaluating site-specific safety factors and proven availability, and conducting the analysis on a waste stream by waste stream basis. Then, if any Alt Tech meets these thresholds, also consider other criteria suggested by guidance and experience.

As part of the considerations of various Alt Techs, the ability to implement any potentially applicable Alt Tech at the Laboratory is an important consideration. As discussed above, to ship the Laboratory's explosives waste offsite, the shipment must conform to both DOE Explosives Safety requirements and DOT regulations. Accordingly, LANL may only ship explosives waste offsite if it has obtained at least the following three types of approvals for such explosives waste shipments:

1. DOT-EX Number for the shipment;

2. DOT Special Permit; or

3. Approved Interim Hazard Classification (IHC).

A significant portion of the specialized explosives waste that the Laboratory treats at the Flash Pad consists of the following types of waste: (1) machining waste; (2) laboratory waste, such as contaminated gloves, wipes, cotton swabs, and weigh boats from chemistry operations; and (3) high explosives wastewater filters and nylon socks (*see* Section 5). These waste types are difficult—if not impossible—to evaluate and classify in accordance with DOE Explosives Safety Standards and DOT Transportation Standards for sensitivity or other physical/mechanical/performance properties, as their shape and form vary, making such evaluations constantly changing. Additionally, such wastes are not homogenous, which further complicates the ability to conduct the necessary DOE Explosives Safety Standards and DOT Transportation Standards assessments to obtain the requisite approval to ship such wastes offsite.

To ensure the safety of workers, drivers, and the general public from hazards, the transportation requirements in 49 CFR Part 173 mandate that all hazardous materials undergo specific testing and analysis and be approved on a case-by-case basis. For explosives, the Laboratory must submit data based on UN Series 1-6 tests. Unfortunately, due to the lack of a consistent form for machining waste and inadequate quantities of laboratory waste, discussed below, the Laboratory does not meet the material and packaging requirements for the UN Series tests.

Machining waste from high explosives machining operations is generally mixed with water at varying levels of dilution, and chips of varying high explosives and sizes suspend and/or dissolve in the water. Accordingly, this machining slurry waste is not homogenous; its dilution varies depending on the amount of water in the slurry; and its high explosive chemical constituents vary depending on the types of high explosives or mixes of high explosives (*e.g.*, PBX, 9501, 9502, *etc*.) contained in the slurry waste from the given high explosive machining that created the waste in the first instance. These varying factors can drastically change the sensitivity of the high explosives waste and, therefore, make it difficult, if not impossible, to conduct the necessary analysis to determine if such waste could meet DOT and DOE requirements for safe offsite shipment and treatment. Consequently, it is unlikely that machining waste would ever be eligible for shipment offsite.

Regarding lab waste, LANL relies on acceptable generator knowledge to determine if this waste stream is detonable. Once a generator determines that waste is detonable, it is unlikely that the Laboratory could obtain the necessary approval to send the waste offsite for treatment. Similar to the machining waste described in the preceding paragraph, this waste stream is not homogenous. It would be difficult or impossible to conduct the necessary analysis to determine whether such waste could be eligible for shipment offsite. Additionally, some of this waste stream may contain unique high explosives waste

created at LANL for which the sensitivity or other physical/mechanical/performance properties would be unknown for purposes of DOE and DOT analysis. Thus, it would be unlikely that the Laboratory could obtain the necessary approvals to ship this waste stream offsite.

High explosives wastewater filters and nylon socks would similarly not likely be approved for shipment for offsite treatment, as these wastes are also not homogenous. Because these filters/nylon socks can be entrained with a variety of high explosives materials, it would be difficult, or impossible, to conduct the required analysis to obtain a DOT-Ex Number, DOT Special Permit, or IHC to ship this waste offsite.

As noted throughout EPA guidance, an Alt Tech must be shown to be safe and available. The Laboratory's specialized explosives waste are often unique, potentially unstable, and possess difficult to discern morphologies and properties. They are unlike the known explosives waste treated at other facilities, such as ordinance, munitions, rocket motors, and igniters. The Laboratory's specialized explosives waste often cannot be legally transported offsite for treatment under DOT and DOE restrictions. Furthermore, the Laboratory's national security mission means that even if offsite transport could be done safely, national security concerns may preclude such transport. For these reasons, any Alt Tech for the explosives waste treated at the Units, that can safely treat the Laboratory's specialized explosives waste streams, would have to be installed onsite.[18]

8.1 Step One: Alt Tech Identification

Alternatives to OB/OD have been researched for nearly three decades, primarily by the DoD military munitions community in support of global demilitarization efforts. Most research on Alt Tech has been oriented toward the disposition of excess military munitions due to the volumes of unwanted excess munitions stockpiled at DoD facilities throughout the world and the cleanup of firing ranges. Waste munitions consist primarily of encased weapons, such as rockets, missiles, bombs, mortar rounds, artillery ammunition, grenades, cluster munitions, and land mines. Technology development has focused mainly on production-scale demilitarization activities, with little consideration of specialized explosives waste from high explosives research and development activities.

To exercise due diligence in considering all possible alternatives, the Laboratory sought to obtain information from all likely sources concerning candidate Alt Techs, including those focused more on demilitarization of waste munitions. Publicly available information was collected and reviewed from the national and global demilitarization communities, including from organizations such as the Defense Technical Information Center (DTIC 2019), the DoD facilities and programs recent reviews of alternatives (*see, e.g.*, NAVAIR 2004, NASEM 2019, EPA 2019, EPA 2023, JOCG 2010, JOCG 2011, ETSCP 2006, SERDP 2023); and from private industry (Eldorado 2023, Dynasafe 2023, General Dynamics 2023). The Laboratory considered each candidate Alt Tech for its state of development and for its applicability to treat the Laboratory's explosives waste streams.

During initial screening, candidate Alt Techs were evaluated to eliminate methods or technologies that are: inapplicable to the Laboratory's explosives waste streams; those that are pre- or post-processing steps in a treatment train rather than primary treatment processes; and those that have not been demonstrated to be effective for treating the types of explosives waste streams generated at the Laboratory. Therefore, treatment technologies that were identified as pre-treatment, mitigation methods, or *in-situ* techniques

[18] The Laboratory recognizes that, in the future, there may be treatment options that involve permitted mobile treatment units. At this time, however, there are no mobile treatment units that are safe and available to treat the specialized explosives waste generated by the Laboratory, nor are there any such units available in New Mexico for thermal treatment of any type of explosives waste. Mobile treatment units, moreover, may present unique security concerns for the Laboratory.

were screened out from identified candidate Alt Techs. The rationale for this screening approach is described further below:

> **Demilitarization/pre-treatment methods.** Demilitarization/pre-treatment methods are not applicable to the Laboratory's explosives waste. Demilitarization focuses on reclaiming and recovering the explosives from munitions for sale or reuse, and on disassembling surplus military equipment for recycling and disposal. At the Laboratory, explosives encased in metal or plastic comprise an extremely small amount of LANL's explosives waste stream and cannot be recovered or reclaimed for sale or reuse.

> **Mitigation technologies.** Mitigation technologies do not destroy the explosive, but rather mitigate effects of the primary treatment activity taking place. For example, foam may be used with OD to prevent fragment dispersal and mitigate the sound of the destruction technology (*i.e.*, sometimes, earth fill has been placed atop an OD shot for this purpose). As such, mitigation technologies are not Alt Tech. While mitigation technologies are not themselves Alt Tech, the Laboratory does investigate and apply these technologies as applicable.

> ***In-situ* technologies**. *In-situ* technologies, such as biodegradation, are applied to environmental media (soils and groundwater) as part of remedial actions. As such, while important for the role they provide, they are not applicable as Alt Tech for the Laboratory's explosives waste streams, which do not include explosives-contaminated environmental media.

After the initial screening, the Laboratory compiled a list of seventeen Alt Techs that could potentially treat the Laboratory's explosives waste to meet LDRs and that should go through additional screening.

The potentially applicable Alt Techs identified for further evaluation are listed in **Table 8-1**. These Alt Techs include potential alternatives for both the Flash Pad and the OD units. Some listed Alt Techs are potential alternatives for only the Flash Pad, such as a contaminated waste processor, cryofracture, flashing furnace, open detonation, and oxidation (cerium-catalyzed). Other Alt Techs are potential alternatives for only the OD units, such as cryogenic cutting, hydromilling, liquid ammonia extraction, and open burning.

Data sheets for each Alt Tech option are included below, at **Data Sheet 8-1** to **Data Sheet 8-17**. These data sheets are structured to provide a comparison against the data sheets for the Flash Pad and OD units, at **Data Sheet 7-1** and **Data Sheet 7-2**. The data sheets provided below explain in greater detail each Alt Tech and related considerations for each technology.

It should be noted that **Table 8-1** does not list OB as an alternative to the Flash Pad or OD as an alternative to the Laboratory's OD units, since the table includes only other Alt Techs to these proven technologies. However, the Laboratory's Flash Pad is nothing like stereotypical open burning operations, which lack the controls needed for the efficient and complete combustion of wastes and the ability to control and monitor emissions. The Flash Pad could reasonably be considered an alternative to the kind of OB technology used by others, which exhibit a less controlled process.

As described above in Sections 5 and 7, the Laboratory's customized Flash Pad system uses controlled propane-fueled flames to rapidly oxidize energetic waste streams and minimize environmental impacts. Similarly, OD at the Laboratory is tailored to each unique energetic waste stream managed using that technology. Also not shown in **Table 8-1** are modifications to the Laboratory's current treatment

technologies, such as collection hoods or structures to collect a portion of any air emissions for possible subsequent treatment. Such add-on technologies could be considered in the future, if measurable adverse environmental effects of operating the Units are identified.

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Table 8-1 Alt Tech Candidate List

	Candidate Alt Tech	Potential Alternative For	Alt Tech Description
1	**Case Opening**	OB, OD	Case opening involves a variety of techniques to separate a munitions' body (projectile) from the cartridge case. The remaining energetic material will need to be treated and/or destroyed using alternative technologies.
2	**Chemical Conversion**	OB, OD	Chemical conversion involves using processes such as solvent extraction and solvolytic extraction to convert recovered explosives and propellants to other products. This technology can only treat specific types of explosives waste based upon the specific chemical makeup of the explosive. Extraction technologies frequently create a secondary hazardous waste stream consisting of organic solvents.
3	**Co-firing in Boilers**	OB, OD	Co-firing in boilers can be utilized for explosives that can be desensitized so that they can be co-fired with traditional fuels in commercial boilers for heating. For co-firing in boilers to be effective, the explosives waste must be soluble in fuel oil #2.
4	**Contained Burn (#1), at a Confined Burn Facility**	OB, OD	Contained burn at a confined burn facility consists of treating explosives contaminated wastes in blast-reinforced chambers. In some cases, additional fuel (such as kerosene) must be added to the waste stream. The combustion gases are contained and processed through air emissions control equipment. This treatment is frequently used by the military to destroy small caliber ammunition and bulk explosives. Small-scale confined burn facilities are currently in use by law enforcement agencies nationwide. The waste is ignited using a squib and allowed to burn of its own accord.
5	**Contained Burn (#2), Energetic-Contaminated Waste**	OB, OD	Energetic-contaminated waste technology is designed for wastes contaminated with small amounts of explosive material. It is similar to contained burning, but is targeted more toward burning combustible wastes contaminated with explosives rather than ammunition or bulk explosives. It is used mostly for combustible wastes (*e.g.*, rags, gloves, wipes, plastic, etc.) that are contaminated with small amounts of explosives. Because there is no controlled fuel supply or "controlled flame device," a contained burn unit may be permitted as a miscellaneous unit under RCRA Subpart X, rather than being permitted as an incinerator. Waste is ignited using a squib and is allowed to burn of its own accord, with the aid of added fuel (*e.g.*, kerosene) in some cases.
6	**Contained Detonation**	OB, OD	Contained detonation involves the detonation of waste inside a steel chamber constructed to dampen the blast. After burning reactions are suppressed to protect the integrity of the chamber. Particulates are filtered from the detonation gases. This technology is best suited for small pieces of explosives, and residuals may transform into toxic or more complex compounds than those created when treating the same waste by OB or OD.

	Candidate Alt Tech	Potential Alternative For	Alt Tech Description
7	**Contaminated Waste Processor**	OB	A contaminated waste processor (CWP) consists of a car bottom furnace that treats contaminated combustible waste, such as rags, gloves, wipes, fiber drums, pallets, plastic, coveralls, *etc*. Typically, the CWP is capable of batch or continuous feed operations.
8	**Cryofracture**	OB	The cryofracture process is used to cool ferrous munition bodies below their embrittlement temperature and allow the munitions to be fractured in a hydraulic press. This process allows access to and segregation of the energetics so they can be treated by thermal destruction. This technology is suitable for size reduction prior to a thermal treatment.
9	**Cryogenic cutting**	OD	Cryogenic cutting technology uses liquid nitrogen that is pressurized and then ejected through a small orifice at high velocities. The system includes a cryogenic fluid supply system, a pressurization system, a temperature control system, a nozzle system, a recovery system, and a manipulation system. This treatment is effective as a pre-treatment to cut through casings for the purpose of removing the casing from the explosive prior to treatment; however, a static charge can build up under certain circumstances and is a safety concern. Secondary materials spray is an additional waste stream.
10	**Flashing Furnace**	OB	A flashing furnace thermally decontaminates metal parts with explosive contamination. Up to 10,000 lbs. of contaminated metal can be flashed per hour. The furnace can be installed in a fixed location or can be trailer mounted for field applications. This technology is enclosed and has a controlled flame device.
11	**Incinerator, Fluidized Bed**	OB, OD	A fluidized bed incineration is an enclosed incinerator that utilizes the injection of explosives waste into a turbulent bed of hot sand, created by forced air. Emissions are filtered prior to release to the environment. This treatment technology is only effective for certain liquids, slurries, and powders with low organic content. The powders must be homogeneous in size.
12	**Incinerator, Plasma Arc**	OB, OD	A plasma arc incineration uses molten slag (*i.e.*, soil with iron fluxing agent) which destroys organic compounds. The technology encapsulates inorganic toxic solid wastes in the molten slag and when hardened is disposed. Emissions are filtered prior to release to the atmosphere. This is an enclosed alternative to incineration that can be utilized for explosives waste that are high in organic compounds (*e.g.*, paint, solvents).

	Candidate Alt Tech	Potential Alternative For	Alt Tech Description
13	**Incinerator, Rotary Kiln**	OB, OD	A rotary kiln incineration is an enclosed incinerator treatment technology. The rotary kiln slowly moves waste from one end to the other and waste detonates or combusts within the chamber; therefore, only small amounts of explosives waste can be treated at one time. Emissions are filtered prior to release to the atmosphere. Small explosive items with casings (<40 grams of select energetic material) can also be treated with this technology. Uniform explosives waste streams are treated most efficiently.
14	**Hydromilling**	OD	Hydromilling of explosives waste uses high pressure water jets to "cut" through the material. This is a pre-treatment technology that is not conducive for experimental and specialized explosives waste streams with indeterminate characteristics. A secondary hazardous waste stream of water and explosives is created by this process.
15	**Liquid Ammonia Extraction**	OD	Liquid ammonia extraction uses propellant, explosive fuel, and oxidizer ingredients to extract, separate, and recover the explosive using liquid ammonia. This treatment method can treat explosives waste that has a plastic binder associated with the waste in a limited capacity.
16	**Oxidation, Cerium-catalyzed**	OB	Cerium-catalyzed electrochemical oxidation operates at atmospheric pressure and can convert organic hazardous waste materials into carbon dioxide and water. This technology is used to treat organic pumpable fluids.
17	**Oxidation, Base Hydrolysis**	OB, OD	Base hydrolysis oxidation heats waste to mild temperatures (90 to 150 ˚C) and usually elevated pressures (200 lbs. per square in. gauge) with a strong base (pH>12). The explosives waste is converted to water-soluble, non-energetic products. The resulting solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation.

8.2 Step Two: Initial Screening of Identified Alt Tech (Candidate Alt Tech)

EPA guidance suggests evaluating Alt Tech on a waste stream by waste stream basis. **Table 8-2** is based on the revised Waste Analysis Plan submitted in support of the Permittees' Permit Renewal Application (*see* Permit Renewal Application, Revised Supplement 1-3, Permittees' Proposed Changes to Attachment C, Waste Analysis Plan). This table lists the nine categories of explosives waste streams generated by the Laboratory and correspond to the categories of wastes described in Sections 5.1 and 5.2 above.

The categories of explosives waste streams listed in **Table 8-2** are broad. As discussed above, each explosives waste stream produced at the Laboratory can contain a combination of explosives including specific high explosives, some of which are only generally described in the table. Also shown in **Table 8-2** are the typical and maximum loads currently treated, a description of the typical and maximum physical size of the waste stream, known hazardous contaminants present in the waste stream, and other materials typically contained in the waste stream.

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Table 8-2 Detailed Information Concerning Waste Streams Treated at the Units

	Waste Stream	Waste Stream Description	% of Total Waste Treated[1]	Max. Explosive Load (lbs.)	Max. Waste Volume (cubic ft.)	Potential Explosives[2]	Potential Hazardous Constituents	Other Potential Materials
1	Explosives machining waste	Explosives machining chips, filters, filter solids, and water	74%	200 (OB)	~50	Pentaerythritol tetranitrate (PETN), Cyclo-1,3,5-trimethylene-2,4,6- trinitramine (RDX), Octahydro, 1,3,5,7-tetranitro, 1,3,5,7- tetrazocine (HMX), plastic-bonded explosives (PBXs or LXs), 4,4-diamino-3,3- azoxyfurazan (DAAF), 2,4,6- trinitrotoluene (TNT), Comp B, and triamino trinitrobenzene (TATB), Baratol, Cyclotol	Barium, Lead, 2,4-Dinitrotoluene	Plastic bags
2	Excess explosives	Large or small (*i.e.*, laboratory-scale) amounts of excess explosives. Explosives may be in the form of flakes, granules, crystals, powders, pressings, plastic bonded, putties, rubberized solids, or extrudable solids. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances.	11%	200 (OB) 2,000 (OD)	~0.5	HMX, RDX, PETN, TATB, DAAF, (2,6- Bis[picrylamino]-3,5- dinitropyridine (PYX), Nitroguanidine (NQ), Nitrocellulose, PBXs and LXs, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, Baratol	Barium, 2,4-Dinitrotoluene	Plastic bags, plastic wrapping, plastic casings, cardboard, paper, paper bags, and/or fiberboard containers. Small potential for aluminum, stainless steel, steel, and/or copper.

	Waste Stream	Waste Stream Description	% of Total Waste Treated[1]	Max. Explosive Load (lbs.)	Max. Waste Volume (cubic ft.)	Potential Explosives[2]	Potential Hazardous Constituents	Other Potential Materials
3	Explosives-contaminated combustible debris	Explosives-contaminated combustible debris generated in research laboratories and processing operations. Debris can involve filters removed from laboratories or processing bays or may contain very small amounts of solvent. The most common solvents used are ethanol and acetone.	6%	200 (OB) <55 (OD)	~10	HMX, RDX, PETN, Cyclotol, Octol, TATB, DAAF, PYX, TNT, PBXs, and LXs	Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4- Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene	Plastic bags, plastic wrapping, weigh boats, gloves, vials, cardboard, paper, paper bags, fiberboard containers, kimwipes, rags, swabs, flasks, watch glasses, tubing, and/or rods. Possible aluminum, stainless steel, steel, and/or copper. When solvents are present, may contain trace amounts of ethanol, acetone, methanol, ethyl acetate, toluene, cyclohexanone, benzene, chloroform, 1,2-dichloroethane, 1,2-dichloroethylene, methyl ethyl ketone, or trichloroethylene. Noncombustible portions of waste are minimized as much as possible.
4	Explosives-contaminated solvent waste	Dimethyl sulfoxide (DMSO) containing dissolved explosives	<1%	200 (OB)	NA	HMX, RDX, PETN, TATB, DAAF, PBXs, and LXs	2,4-Dinitrotoluene	
5	Explosives-contaminated noncombustible debris	Explosives-contaminated equipment including discarded, noncombustible equipment; debris from firing sites; noncombustible material from decommissioning and demolition activities; and material from explosives processing areas such as carbon or sand from filtering processes	9%	200 (OB) <55 (OD)	~10	HMX, RDX, PETN, TATB, DAAF, PYX, NQ, Nitrocellulose, PBXs, LXs, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, Baratol	Barium, Lead, Silver, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene	Noncombustible material may include glass, ceramic, or metal piping or equipment. Rarely when solvents are present, they may include trace amounts of ethanol, acetone, methanol, ethyl acetate, toluene, cyclohexanone, benzene, chloroform, 1,2- dichloroethane, 1,2-dichloroethylene, methyl ethyl ketone, or trichloroethylene.

	Waste Stream	Waste Stream Description	% of Total Waste Treated[1]	Max. Explosive Load (lbs.)	Max. Waste Volume (cubic ft.)	Potential Explosives[2]	Potential Hazardous Constituents	Other Potential Materials
6	Detonators, initiators, and mild detonating fuses	Detonators, initiators, and/or mild detonating fuses containing explosives. Explosives may be in metal or plastic casings and may contain lead-based primaries or be in a lead sheath. Typically nitromethane is used as fuel for treatment activities. This waste stream may include manufactured articles removed from fire protection systems.	<1%	<55 (OD)		PETN, HMX, RDX, TATB, lead azide, lead styphnate, PBXs	Lead	Plastic bags, plastic wrapping, cardboard, paper, paper bags, and/or fiberboard containers. Aluminum, lead, stainless steel, steel, or copper may be present.
7	Shaped charges and test assemblies	Shaped charges consisting of cores of explosives with metal sheaths or metal liners or high-explosives test assemblies consisting of explosives in plastic or metal holders. Assemblies may contain lead or silver metal.	<1%	<55 (OD)		PETN, RDX, HMX, PBXs, and LXs	Lead, Silver, 2,4-Dinitrotoluene	Plastic components, plastic bags, plastic wrapping, cardboard, paper, paper bags, and/or fiberboard containers. Aluminum, copper, lead, stainless steel, brass, and/or copper may be present.
8	Projectiles and munitions larger than 0.50 caliber	Projectiles and munitions larger than 0.50 caliber	<1%	<55 (OD)		Munitions/ projectiles	Lead	Plastic bags, plastic wrapping, fiberglass, cardboard, paper, fiberboard drums, lead, brass, steel, stainless steel, copper, depleted uranium, and/or aluminum.
9	Pressing molds	Adiprene (urethane) pressing molds contaminated with explosives	<1%	<55 (OD)		TNT	2,4-Dinotrotoluene	Adiprene, plastic bags, plastic wrapping, cardboard, paper, and/or paper bags.

[1] The average for Table 8-2 include information for the 2005-2022 period of OB/OD combined, compared to the averages reflected Tables 5-1 and 5-2 (which provide annual averages for OB and OD separately). Total percentage may not add to 100% due to rounding.

[2] Potential explosives do not include all of the possible explosives that may be treated at the unit, only those currently expected to be treated as part of the waste stream. The nature of LANL's work produces new high explosives that are described only generally here. Note also that explosives in many waste streams have been insulted or are otherwise rendered unstable (unable to be transported offsite safely).

The initial screening of seventeen identified Alt Techs evaluates whether any of these candidate Alt Techs have the potential ability to treat each explosives waste stream generated, or potentially generated, at the Laboratory. This screening is summarized in **Table 8-3**. The Laboratory's specialized explosives waste streams are not approved by DOT to be transported offsite and, therefore, must be treated onsite. So, if an Alt Tech were proven to be safe for treating one or more of the Laboratory's explosives waste streams and it were available, then implementation of that Alt Tech would require onsite installation.

The majority of the identified Alt Techs in **Table 8-3** through initial screening are not applicable (noted with a dash) to the categories of explosives waste streams generated at the Laboratory. Eight Alt Techs are *potentially able* (or potentially applicable, noted with **PA**) to possibly treat at least some portion of each of the Laboratory's nine waste streams treated at the Units. Of these eight Alt Techs that may be potentially able to treat, two have limitations concerning the size of treatable wastes (small portions only) and two have limitations as to the form of the waste (powder only). Three candidate Alt Techs are shown as having unknown applicability (noted with *Unknown*) with respect to applicability to two of the Laboratory's explosives waste stream categories.

Providing further basis for the summary provided in **Table 8-3**, data sheets for each identified Alt Tech are also given. **Data Sheet 8-1** through **Data Sheet 8-17** appear at the end of this Section 8.2. These data sheets provide additional discussion of each candidate Alt Tech. The data sheets also provide more detailed rationale for why a given Alt Tech is potentially applicable, or not, as a candidate for treating the Laboratory's explosives waste streams.

The majority of the candidate Alt Techs listed in **Table 8-3** were developed for conventional munitions or waste streams associated with the production and/or demilitarization of conventional munitions. The explosives waste associated with conventional munitions are different than the explosives waste associated with nuclear weapons applications and research. While a few of these Alt Techs may *theoretically* have the potential to be adapted to treat the Laboratory's specialized explosives waste, the technologies have not been tested or proven with such waste streams. Thus, significant technology development and testing would be necessary to evaluate whether such Alt Techs could be effective, or whether modifications would be necessary to safely treat the Laboratory's specialized explosives waste streams.

The Alt Tech Evaluation is further complicated by the fact that the specialized explosives waste that LANL generates from its research, development, and national security missions are of varying composition and nature, as opposed to conventional energetics associated with conventional munitions. The explosives waste associated with conventional munitions are far more homogeneous in nature than found in any of the Laboratory's nine explosives waste streams. Indeed, if an Alt Tech were developed and tested for a current explosives waste stream generated by the Laboratory, because of the changing nature of the Laboratory's operations and missions, there is no certainty that it would be possible to use that Alt Tech into the future on a changed explosives waste. Technology evaluation, technology development, and testing for the LANL explosives waste streams currently generated may not be applicable to future waste streams.

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Table 8-3 Initial Screening of Candidate Alt Tech for Potential Ability (or Potential Applicability, PA) to Treat the Laboratory's Specialized Explosives Waste

Waste Stream:	1. Explosives machining waste	2. Excess explosives	3. Explosives-contaminated combustible debris	4. Explosives-contaminated solvent waste	5. Explosives-contaminated noncombustible debris	6. Detonators, initiators, and mild detonating fuses	7. Shaped charges and test assemblies	8. Projectiles and munitions (> 0.50 caliber)	9. Pressing molds
Waste Must Be Treated Onsite Only? **(Yes or No)**	Yes (PBX)	Yes (PBX)	Yes (PBX)	Yes (PBX)	Yes (PBX)	Yes	Yes (PBX)	Yes	Yes
Treated at the LANL Flash Pad?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	-	-	-	-
Treated at the LANL OD Units?	-	**Yes**	-	-	-	**Yes**	**Yes**	**Yes**	**Yes**
Alt Tech Candidate and the <u>Potential Ability</u> ("PA") to Treat LANL Waste Streams Nos. 1 through 9									
Case Opening	-	-	-	-	-	-	-	*Unknown*	-
Chemical Conversion	-	-	-	-	-	-	-	-	-
Co-firing in Boilers	-	-	-	-	-	-	-	-	-
Contained Burn (#1), at a Confined Burn Facility	-	**PA (small quantities only)**	-	-	-	-	-	-	-
Contained Burn (#2), Energetic-Contaminated Waste	-	-	**PA**	-	-	-	-	-	-
Contained Detonation	-	**PA**	**PA (small debris only)**	-	-	-	-	-	-
Contaminated Waste Processor	-	-	**PA**	-	-	-	-	-	-
Cryofracture	-	-	-	-	-	-	-	-	-
Cryogenic cutting	-	-	-	-	-	-	-	-	-

Waste Stream:	1. Explosives machining waste	2. Excess explosives	3. Explosives-contaminated combustible debris	4. Explosives-contaminated solvent waste	5. Explosives-contaminated noncombustible debris	6. Detonators, initiators, and mild detonating fuses	7. Shaped charges and test assemblies	8. Projectiles and munitions (> 0.50 caliber)	9. Pressing molds
Flashing Furnace	-	-	-	-	**PA**	-	-	-	-
Incinerator, Fluidized Bed	**PA (powdered only)**	-	-	-	-	-	-	-	-
Incinerator, Plasma Arc	-	-	-	**PA**	-	-	-	-	-
Incinerator, Rotary Kiln	**PA (powdered only)**	-	-	-	-	-	-	-	-
Hydromilling	-	-	-	-	-	-	-	-	-
Liquid Ammonia Extraction	-	-	-	-	-	-	-	*Unknown*	-
Oxidation, Cerium-catalyzed	-	-	-	*Unknown*	-	-	-	-	-
Oxidation, Base Hydrolysis	-	-	-	-	-	-	-	-	-

Data Sheet 8-1. Treatment Technology: Case Opening

Identified Candidate: Case Opening		
Description	Case opening involves a variety of techniques to separate a munitions' body (projectile) from the cartridge case. The remaining energetic material removed from the case will need to be treated and/or destroyed using alternative technologies.	
Treatment Type	**Pre-treatment.** Removed energetic requires subsequent treatment by alternative method, *e.g.*, OB/OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Only used for treating thinned-and thick cased munitions. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	No
	Revision to CWA – NPDES:	May generate wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-2. Alt Tech: Chemical Conversion

Identified Alt Tech Candidate: Chemical Conversion		
Alt Tech Description	Chemical conversion involves using processes such as solvent extraction and solvolytic extraction to convert recovered explosives and propellants to other products. This technology can only treat specific types of explosives waste based upon the specific chemical makeup of the explosive.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Requires chemical solvents; creates a secondary waste stream that would require additional treatment, storage, or disposal at a permitted hazardous waste facility. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	Yes, assuming chemical conversion chamber is vented
	Revision to CWA – NPDES:	May generate cooling water and/or wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units. Extraction technologies frequently create a secondary hazardous waste stream consisting of organic solvents.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-3. Alt Tech: Co-firing in Boilers

Identified Alt Tech Candidate: Co-firing in Boilers		
Alt Tech Description	Co-firing in boilers can be utilized for explosives that can be desensitized so that they can be co-fired with traditional fuels in commercial boilers for heating. The explosive must be soluble in fuel oil #2.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Limited to explosives that are soluble in Fuel Oil #2. Not suitable for any explosives waste treated at Units, because they are not soluble in oil.	
Permits Required	*RCRA Part B*	**Yes**
	Revision to CAA Title V	**Yes**, emissions from boiler fuel combustion
	Revision to CWA – NPDES	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other	Modification of air permits for existing commercial boilers
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-4. Alt Tech: Contained Burn (#1), at a Confined Facility

Identified Alt Tech Candidate: Contained Burn (#1), at a Confined Facility		
Alt Tech Description	Contained burn at a confined burn facility consists of explosives contaminated wastes that are treated in blast-reinforced chambers. In some cases, additional fuel (such as kerosene) must be added to the waste stream. The combustion gases are contained and processed through air emissions control equipment. This treatment is frequently used by the military to destroy small caliber ammunition and bulk explosives. Small-scale confined burn facilities are currently in use by law enforcement agencies nationwide. The waste is ignited using a squib and allowed to burn of its own accord.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~7%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (~50%); would require treatment in small batches**
Principal/Treatment Capability Limitations	Potentially applicable to small caliber munitions and small quantities of some excess explosives.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. With explosives waste possessing indeterminate characteristics or that was insulted, a contained burn is an unacceptable risk to personnel. There is no controlled flame to ensure complete detonation or burn of the explosive, and typically no capability to view if the explosive has been fully treated prior to opening the chamber. Unit increases the potential for catastrophic failure (explosion) when compared to current treatment technique.	
Human Health and Environmental Impact Considerations	Combustion and waste degradation gases emitted from air pollution control equipment.	
Energy Resource Demands of Operation	Requires supplemental fuel for contained burn chamber. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include scrubber waste and baghouse dust. Process effluents include emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters. Emissions scrubbing system must be designed to capture dioxins/furans that may be generated during the process, as the temperature is not controlled. Periodic replacement of air pollution control system components such as cloth bags and filter media.	
Operations/Treatment Capability Uncertainty	Limited to small caliber munitions and small quantities of some excess explosives.	
Relative Cost Range	*Capital:* + Construction of blast chambers, air pollution control equipment. Cost is very high considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: + O&M of air pollution control equipment; supplemental fuel cost; management, treatment & disposal of secondary waste streams; employee training for contained burn facility. Must include costs for existing LANL OB/OD activities, as blast chamber can potentially handle only a small portion of LANL energetic wastes.	

Data Sheet 8-5. Alt Tech: Contained Burn (#2), Energetic-Contaminated Waste

Identified Alt Tech Candidate: Co-firing in Boilers		
Alt Tech Description	Energetic-contaminated waste technology is designed for wastes contaminated with small amounts of explosive material. It is similar to contained burning, but is *targeted more toward burning combustible wastes contaminated* with explosives rather than ammunition or bulk explosives. It is used mostly for combustible wastes (*e.g.*, rags, gloves, wipes, plastic, *etc*.) that are contaminated with small amounts of explosives. Because there is no controlled fuel supply or "controlled flame device", a contained burn unit may be permitted as a miscellaneous unit under RCRA Subpart X, rather than being permitted as an incinerator. This waste is ignited using a squib and is allowed to burn of its own accord, with the aid of added fuel (*e.g.*, kerosene) in some cases.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (<1%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (<1%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated combustible debris, which is an exceptionally small fraction of explosives waste treated at Units	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers.	
Human Health and Environmental Impact Considerations	Combustion and waste degradation gases emitted from air pollution control equipment.	
Energy Resource Demands of Operation	Requires fuel for ignition only. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams may include scrubber waste and bag house dust. Process effluents include emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters. Emissions scrubbing system must be designed to capture dioxins/furans that may be generated during the process, as the temperature is not controlled. Periodic replacement of air pollution control system components such as cloth bags and filter media. Due to absence of supplemental fuel throughout the burn, residual waste (ash) may require supplemental treatment.	
Operations/Treatment Capability Uncertainty	Limited to a very small fraction of LANL energetic wastes. Due to absence of supplemental fuel throughout the burn, residual waste (ash) may require supplemental treatment.	
Relative Cost Range	*Capital:* + Construction of contained burn chambers, air pollution control equipment. Cost is very high considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: + O&M of air pollution control equipment; management, treatment & disposal of secondary waste streams; employee training for contained burn facility. Must include costs for existing LANL OB/OD activities, as contained burn chamber can potentially handle only a very small fraction of LANL energetic wastes.	

Data Sheet 8-6. Alt Tech: Contained Detonation

Identified Alt Tech Candidate: Contained Detonation		
Alt Tech Description	Contained detonation involves the detonation of explosives waste inside a steel chamber constructed to dampen the blast. After burning reactions are suppressed to protect the integrity of the chamber. Particulates are filtered from the detonation gases. This technology is best suited for small pieces of explosives, and residuals may transform into toxic or more complex compounds than those created when treating the same waste by OB or OD.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~5%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (~50%)**
Principal/Treatment Capability Limitations	Limited to small bulk explosives and combustible debris Limited lifetime on number of detonations the chamber can treat Chamber becomes difficult to dispose of as hazardous waste	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Large pieces of explosives may require size reduction prior to treatment in order to meet the operating capacity of the unit. This requires more handling by the worker and subsequent safety concerns. There is a potential for catastrophic failure.	
Human Health and Environmental Impact Considerations	Air emissions *(e.g.*, CO_2, H_2O and N_2) from detonation chamber. Metal fragments (contained near unit).	
Energy Resource Demands of Operation	May require supplemental fuel for detonation chamber. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	The secondary waste stream consists of ash and fragments. Process effluents include metal fragments, pulverized gravel, air pollution control unit residue, major burn emissions including CO, CO_2, H_2O, NO_x, N_2; secondary combustion products due to residence time; and limited lifetime of chamber with replacement required and disposal of used chamber.	
Operations/Treatment Capability Uncertainty	Limited to a fraction of LANL energetic wastes.	
Relative Cost Range	*Capital:* + Construction of contained burn chambers, air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: + O&M of air pollution control equipment; management, treatment & disposal of secondary waste streams; employee training for contained detonation facility. Must include costs for existing LANL OB/OD activities, as contained detonation chamber can potentially handle only a small portion of LANL energetic wastes.	

Data Sheet 8-7. Alt Tech: Contaminated Waste Processor

Identified Alt Tech Candidate: Contaminated Waste Processor (CWP)		
Alt Tech Description	A CWP consists of a car bottom furnace that treats (*i.e.*, combusts/oxidizes) contaminated combustible waste, such as rags, gloves, wipes, fiber drums, pallets, plastic, coveralls, *etc*. CWPs may operate in batch or continuous feed modes.	
Treatment Type	OB Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (<1%)**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated combustible debris and residues, which comprise an exceptionally small fraction of the LANL OB/OD waste stream.	
Permits Required	*RCRA Part B:*	Subpart O
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from combustion of fuel and waste.	
Energy Resource Demands of Operation	CWP is typically heated via fuel combustion. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash, baghouse particulate and scrubber residues. Process effluents are emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters.	
Operations/Treatment Capability Uncertainty	Only proven for limited waste types; potentially applicable to some explosives-contaminated combustible debris and residues.	
Relative Cost Range	*Capital:* ++ Construction of CWP and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a very small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of CWP and air pollution control equipment; fuel for CWP; employee training for CWP. Must include costs for existing LANL OB/OD activities, as CWP can potentially handle only a very small fraction of LANL energetic wastes.	

Data Sheet 8-8. Treatment Technology: Cryofracture

Identified Candidate: Cryofracture		
Description	Cryofracture process is used to cool ferrous munition bodies below their embrittlement temperature and allow the munitions to be fractured in a hydraulic press. This process allows access to the energetics so they can be subsequently treated by thermal destruction. This technology is suitable for size reduction prior to a thermal treatment. This treatment method has mostly been used for projectile explosives and is not suitable for explosive materials at LANL.	
Treatment Type	**Pretreatment method**, removed material requires treatment by OB	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Energetics contained in ferrous munitions bodies. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-9. Treatment Technology: Cryogenic Cutting

Identified Candidate: Cryogenic Cutting		
Description	Cryogenic cutting technology uses liquid nitrogen that is pressurized and then ejected through a small orifice at high velocities. The system includes a cryogenic fluid supply system, a pressurization system, a temperature control system, a nozzle system, a recovery system, and a manipulation system. This treatment is effective as a pre-treatment to cut through casings for the purpose of removing the casing from the explosive prior to treatment; however, a static charge can build up under certain circumstances and is a safety concern. This treatment method is not suitable for explosive materials at LANL.	
Treatment Type	**Pre-treatment**, removed material requires treatment by OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Not applicable to any LANL OB/OD waste streams	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units. Secondary materials spray is an additional waste stream.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-10. Alt Tech: Flashing Furnace

Identified Alt Tech Candidate: Flashing Furnace		
Alt Tech Description	A flashing furnace thermally decontaminates metal parts with explosive contamination. Up to 10,000 lbs. of contaminated metal can be flashed per hour. The furnace can be installed in a fixed location or can be trailer mounted for field applications. Because this technology is enclosed and has a controlled flame device, permitting of the unit may require adherence to 40 CFR 264, Subpart O (incinerator) requirements.	
Treatment Type	OB Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~3%)**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated noncombustible debris, typically metal, which is a very small fraction of the LANL OB waste stream	
Permits Required	*RCRA Part B:*	Need for Subpart X permit questioned. Maybe – Subpart O
	Revision to CAA Title V:	40 CFR 264, Subpart O (incinerator) requirements
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	If the unit is mobile, precautions will have to be in place to ensure that fuel can be located at each specific location within the explosives area. Increased waste handling by workers. Trained personnel would be required to conduct treatment activities. In addition, use of mobile unit within LANL HE exclusion area may present additional site-specific safety concerns. Roads within LANL will not accommodate large mobile unit, and presence of HE storage magazines would create additional risks to workers.	
Human Health and Environmental Impact Considerations	Emissions from fuel combustion and waste flashing – CO, CO_2, H_2O, NO_2, N_2.	
Energy Resource Demands of Operation	Requires fuel to heat flash furnace. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	The secondary waste streams include explosives contaminated non-combustible debris. Expected emissions are CO, CO_2, H_2O, NO_x, N_2, and little to no secondary combustion products due to short residence. Residual ash is not expected.	
Operations/Treatment Capability Uncertainty	Limited to a very small fraction of LANL energetic wastes – *i.e.*, explosives-contaminated noncombustible debris, typically metal.	
Relative Cost Range	*Capital:* ++ Construction of flash furnace facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of flash furnace and air pollution control equipment; fuel for flash furnace; employee training for flash furnace. Must include costs for existing LANL OB/OD activities, as CWP can potentially handle only a very small fraction of LANL energetic wastes. Must include costs for existing LANL OB/OD activities, as flashing furnace can only treat a portion of LANL energetic wastes.	

Data Sheet 8-11. Alt Tech: Incinerator, Fluidized Bed

Identified Alt Tech Candidate: Incinerator, Fluidized Bed		
Alt Tech Description	A fluidized bed incineration is an enclosed incinerator that utilizes the injection of explosives waste into a turbulent bed of hot sand, created by forced air. Emissions are filtered prior to release to the environment. This process is limited to liquids, slurries, and powders with low organic content. The powders must be homogeneous in size.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~70%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (<1%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives machining waste (powdered only) Limited to treating powders, liquids and slurries Cannot treat most bulk explosives or noncombustible debris	
Permits Required	*RCRA Part B:*	Yes – Subpart O
	Revision to CAA Title V:	Yes
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from heat (combustion) source Requires power for operation of air emissions collection and treatment system	
Energy Resource Demands of Operation	Energy source (*e.g.*, fuel combustion, electricity) required to heat fluidized bed	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash and scrubber residues; periodic replacement of fluidized bed media.	
Operations/Treatment Capability Uncertainty	Limited to a fraction of LANL energetic wastes.	
Relative Cost Range	*Capital:* ++ Construction of fluidized bed incinerator facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a fraction of LANL energetic wastes	
	Operations and MTCE: ++ Operation of fluidized bed incinerator and air pollution control equipment; fuel for incinerator; treatment & disposal of secondary waste streams; employee training for fluidized bed incinerator facility. Must include costs for existing LANL OB/OD activities, as fluidized bed incinerator can potentially treat only a portion of LANL energetic wastes.	

Data Sheet 8-12. Alt Tech: Incinerator, Plasma Arc

Identified Alt Tech Candidate: Incinerator, Plasma Arc		
Alt Tech Description	A plasma arc incineration uses molten slag (*i.e.*, soil with iron fluxing agent) which destroys organic compounds. The technology encapsulates inorganic toxic solid wastes in the molten slag and when hardened is disposed. Emissions are filtered prior to release to the atmosphere. This is an enclosed alternative to incineration that can be utilized for explosive wastes that are high in organic compounds (*e.g.*, paint, solvents).	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~5%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (~50%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated solvents Limited to bulk explosives and solvent waste	
Permits Required	*RCRA Part B:*	**Yes** – Subpart O
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from heat (combustion) source.	
Energy Resource Demands of Operation	Energy source (*e.g.*, fuel combustion, electricity) required to heat plasma arc furnace Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash, scrubber residue, and slag.	
Operations/Treatment Capability Uncertainty	Limited to a small fraction of LANL energetic wastes.	
Relative Cost Range	*Capital:* ++ Construction of plasma incinerator facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of plasma arc incinerator facility and air pollution control equipment; fuel for incinerator treatment & disposal of secondary waste streams (*e.g.*, slag); employee training for plasma arc facility. Must include costs for existing LANL OB/OD activities, as plasma arc incinerator can potentially treat only a portion of LANL energetic wastes.	

Data Sheet 8-13. Alt Tech: Incinerator, Rotary Kiln

Identified Alt Tech Candidate: Incinerator, Rotary Kiln		
Alt Tech Description	A rotary kiln incineration is an enclosed incinerator treatment technology. The rotary kiln slowly moves waste from one end to the other and waste detonates or combusts within the heated chamber; therefore, only small amounts of explosives waste can be treated at one time. Emissions are treated (*i.e.*, filtered and/or neutralized) prior to release to the atmosphere. Small explosive items with casings (<40 grams energetic material) can also be treated with this technology. Uniform explosives waste streams are treated most efficiently.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~95%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (<1%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives machining waste (powdered only) Limited types and amounts of explosives that can be treated at one time Cannot treat most bulk explosives or noncombustible debris	
Permits Required	*RCRA Part B:*	**Yes** – Subpart O
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from combustion of fuel and waste routed through air pollution control equipment – *e.g.*, particulate collection and scrubbing.	
Energy Resource Demands of Operation	Kiln is typically heated via fuel combustion. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash, baghouse particulate and scrubber residues. Process effluents are emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters.	
Operations/Treatment Capability Uncertainty	Proven for limited waste types.	
Relative Cost Range	*Capital:* ++ Construction of rotary kiln incinerator facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a portion of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of rotary kiln incinerator facility and air pollution control equipment; fuel for incinerator treatment & disposal of secondary waste streams; employee training for rotary kiln incinerator. Must include costs for existing LANL OB/OD activities, as rotary kiln incinerator can potentially treat only a portion of LANL energetic wastes.	

Data Sheet 8-14. Treatment Technology: Hydromilling

Identified Candidate: Hydromilling		
Description	Hydromilling of explosives waste uses high pressure water jets to "cut" through the material. This is a pre-treatment technology that is not conducive for experimental explosives waste streams.	
Treatment Type	**Pre-treatment**; removed material requires treatment by OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units.	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units.	
Secondary Waste Streams Generated by Technology	NA – A secondary hazardous waste stream of water and explosives is created by this process.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units.	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units.	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units.	

Data Sheet 8-15. Alt Tech: Liquid Ammonia Extraction

Identified Alt Tech Candidate: Liquid Ammonia Extraction		
Alt Tech Description	Liquid ammonia extraction uses propellant, explosive fuel and oxidizer ingredients to extract, separate, and recover the explosive using liquid ammonia. This treatment method can treat explosives waste that have a plastic binder associated with the waste in a limited capacity.	
Treatment Type	OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Used only for treatment of explosives waste that have a plastic binder. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units.	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units.	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units.	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units.	

Data Sheet 8-16. Alt Tech: Oxidation, Cerium-catalyzed

Identified Alt Tech Candidate: Oxidation, Cerium-catalyzed		
Alt Tech Description	Cerium-catalyzed electrochemical oxidation operates at atmospheric pressure and can convert organic hazardous waste materials into carbon dioxide and water. This technology is used to treat organic pumpable fluids.	
Treatment Type	OB Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Applicability limited to pumpable organic fluids. Not applicable to the explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**; produces oxidation emissions.
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units.	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units.	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units. Cesium catalyst requires periodic replacement; spent catalyst subject to offsite treatment/disposal.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units.	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units.	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units.	

Data Sheet 8-17. Treatment Technology: Oxidation, Base Hydrolysis

Identified Candidate: Oxidation, Base Hydrolysis		
Alt Tech Description	Base hydrolysis oxidation heats waste to mild temperatures (90 to 150 ˚C) and usually elevated pressures (200 lbs. per square in. gauge) with a strong base (pH>12). The explosives waste is converted to water-soluble, non-energetic products. The resulting solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation.	
Treatment Type	**Pre-treatment** OD Alternative; additional treatment of resulting solution is required	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**Yes – Partial (~25%)**
Principal/Treatment Capability Limitations	Limited to organic waste streams with no plastic, which comprise a small fraction of the LANL OD waste stream	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**, emissions from oxidation chamber and heat (combustion) source
	Revision to CWA – NPDES:	**Yes**, generates cooling water and/or wastewater subject to treatment and/or discharge permitting
	Other:	Supplemental treatment – *e.g.*, bioremediation, supercritical water extraction – likely requires additional permitting; general and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers increases risks associated with handling strong base (pH>12) and high pressure equipment. Supplemental treatment – *e.g.*, bioremediation, supercritical water extraction – may pose additional risks.	
Human Health and Environmental Impact Considerations	Varies depending upon supplemental treatment method – *e.g.*, bioremediation, supercritical water extraction	
Energy Resource Demands of Operation	Energy (fuel or electricity) required to heat aqueous base-reaction vessel.	
Secondary Waste Streams Generated by Technology	Aqueous solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation. Emissions from fuel combustion.	
Operations/Treatment Capability Uncertainty	Has not been employed for LANL's unique energetic wastes. Therefore treatability studies would be required.	
Relative Cost Range	*Capital:* ++ Base hydrolysis treatment system equipment, plus supplemental treatment system equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of base hydrolysis treatment facility and air pollution control equipment; chemicals; transportation to and operation of supplemental treatment system; treatment & disposal of secondary waste streams; employee training for base hydrolysis system. Must include costs for existing LANL OB/OD activities, as base hydrolysis treatment can potentially treat only a portion of LANL energetic wastes.	

8.3 Step Three: Further Screening of Potentially Applicable Alt Techs

After performing an initial screening for candidate Alt Techs, the next step is to take the potentially applicable (PA) Alt Techs that may be candidates for treating at least some portion of the Laboratory's explosives waste and conduct a more detailed evaluation.

Only the eight potentially applicable Alt Techs that passed initial screening received more detailed screening. This more detailed screening of remaining potentially applicable Alt Techs is shown in **Table 8-4** to **Table 8-8**. The criteria used for the more detailed screening in **Table 8-4** are those emphasized by EPA (EPA 2022b, EPA 2022c). Safety and availability are considered *threshold screening criteria*. If an Alt Tech, or multiple Alt Techs, meet the threshold screening criteria of safety and availability, then additional criteria may be considered to assist with evaluation and decision-making.

As a threshold matter, an Alt Tech must, first, be safe to use, as determined by explosives safety experts and considering site-specific factors. Safe includes operational safety, monitorability, and environmental protection (produces no toxic by-products). To be a viable option, the operational safety for a given Alt Tech must be either greater, or at least neutral, compared to current operations. If an Alt Tech is determined to be safe for use at the Laboratory, the next threshold evaluation criterion in the detailed screening is availability of the Alt Tech.

None of the potentially applicable Alt Techs meet the threshold screening criteria for the Laboratory's explosives waste. It must be noted that even if one or all of the potentially applicable Alt Techs met the threshold screening criteria, which they fail to do, only some portions of the Laboratory's explosives waste would be able to be treated by these Alt Techs. In other words, the Laboratory's thermal treatment Units would still be required to operate even if all the Alt Techs met the threshold screening criteria and each could be implemented.

Table 8-4 addresses threshold screening criteria for each explosives waste stream currently treated at the Units. In summary, none of the potential Alt Tech candidates have been developed and demonstrated for the Laboratory's specialized explosives waste streams. Significant research and development efforts would be required to support the customized demonstration, development, design, and construction of potentially applicable Alt Techs. At this time, no proven technology is currently available that could safely treat the explosives waste stream currently treated at the Laboratory's Units.

If, however, an Alt Tech were determined to meet the threshold screening criteria and was both safe and available for use at the Laboratory, the remaining screening criteria would be further considered. These additional criteria are intended to help select among multiple safe and available Alt Techs. In the future, these remaining criteria may be applied to provide a deeper evaluation:

- throughput (*i.e.*, treatment) capacity of the Alt Tech;
- energy consumption of the Alt Tech;
- water consumption of the Alt Tech;
- air impacts and wastewater generation and discharges for the Alt Tech;
- reliability, maintainability, and cost.

At the Laboratory, considering the very low quantities of specialized explosives waste treated at the thermal treatment Units, and the Laboratory's ability to treat specialized explosives waste streams safely, efficiently, and with no adverse effect on human health or the environment (*i.e.*, lack of a demonstrated harmful environmental impact from operation of the Units), it is highly questionable whether these additional criterion would favor consideration of some other alternative technology, even if it were to be proven safe and available. Considering the nature of the Laboratory's research, development, and national security missions, and that the composition and characteristics of its specialized explosives waste streams are constantly evolving and changing, moreover,

even if an alternative technology were determined to be capable of handling a current waste stream, that is no guarantee that the alternative technology could treat future permutations of that waste stream. The Laboratory's thermal treatment operations are highly controlled, safe, efficient, designed, and operated to completely combust or consume the waste, monitored and sampled, and right sized for the Laboratory's specialized explosives waste. No alternative, even if safe and available, possesses a similar mix of safety, efficiency, and human health and environmental protectiveness.

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Table 8-4. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives Machining Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
1. Explosives Machining Waste (wet only with filter socks)	**Incinerator, Fluidized Bed**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more handling of energetic and potentially unstable waste than current LANL practices, so **increases safety concerns**. Injection of potentially unstable energetic waste into an enclosed fluidized bed incinerator **poses safety** concerns. Considerable operator training required. Confinement of explosives within the fluidized bed could lead to a buildup of residual pressure from breakdown products generated within the system – a **potential explosion hazard**.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fluidized bed heat source. Secondary waste streams include ash, scrubber residues and baghouse dust. Periodic replacement of fluidized bed media, scrubber solution and baghouse bags. Contaminated wastewaters also generated.
		Is Technology Proven Effective & Available?		**No.** Fluidized bed incineration has not been proven for the Laboratory's specialized explosives waste. **No.** Fluidized bed incineration is not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized fluidized bed incineration system for LANL's explosives machining waste. Uncertain application if waste composition were to change.
	Incinerator, Rotary Kiln	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (rotary kiln incinerator) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by incinerator heat source. Secondary waste streams include ash, scrubber residues and baghouse dust. Periodic replacement of fluidized bed media, scrubber solution, and baghouse bags. Contaminated wastewaters.
		Is Technology Proven & Available?		**No.** Rotary kiln incineration has not been proven for the Laboratory's specialized explosives waste. **No.** Rotary kiln incineration is not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized rotary kiln incineration system for LANL's explosives machining waste. Uncertain application if waste composition were to change.

Table 8-5. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Excess Explosives Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
Excess explosives (small quantities only)	**Contained Burn (#1), at a Confined Burn Facility**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (confined burn facility) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by contained burns system heat source and supplemental fuel (if required). Secondary waste streams include ash, scrubber residues and baghouse dust. Periodic replacement of scrubber solution and bags for baghouse. Contaminated wastewaters.
		Is Alt Tech Proven Effective & Available?		**No.** Contained burn treatment has not been proven for LANL's specialized explosives waste. **No.** Contained burn treatment systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained burn treatment system for small quantities of LANL's excess explosives. Uncertain application if waste composition were to change.
	Contained Detonation	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (containment system) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Air emissions from waste detonation. Scrubber residues and baghouse dust from air emissions control system. Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) from supplemental fuel, if used. Toxic byproducts may be generated due to confinement and associated residence time. Periodic decontamination of containment system will generate decontamination wastes (*e.g.*, wastewater, solvents).
		Is Alt Tech Proven Effective & Available?		**No.** Contained detonation has not been proven for LANL's specialized explosives waste. **No.** Contained detonation systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained detonation system for small quantities of LANL's excess explosives. Uncertain application if waste composition were to change.

Table 8-6. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives-Contaminated Combustible Debris Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
3. Explosives-contaminated combustible debris (small debris only)	**Contained Burn (#2), Energetic-Contaminated Waste**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (contained burn system) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fuel used for ignition. Secondary waste streams may include ash, scrubber waste and baghouse dust, decontamination wastewaters. Emissions scrubbing system must be designed to capture dioxins/furans that may be generated during the process, as the temperature is not controlled.
		Is Technology Proven Effective & Available?		**No.** Contained burn treatment has not been proven for LANL's specialized explosives waste. **No.** Contained burn treatment systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained burn treatment system for LANL's explosives-contaminated combustible debris (small debris only). Uncertain application if waste composition were to change.
	Contained Detonation	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (contained detonation system) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Secondary waste streams may include ash and fragments. Air emissions control system (if employed) wastes include scrubber waste and baghouse dust.
		Is Technology Proven Effective & Available?		**No.** Contained detonation has not been proven for LANL's specialized explosives waste. **No.** Contained detonation systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained detonation system for LANL's explosives-contaminated combustible debris (small debris only). Uncertain application if waste composition changes.
	Contaminated Waste Processor	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (contaminated waste processor) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fuel used for contaminated waste processor car bottom furnace. Secondary waste streams include ash, baghouse dust, scrubber wastes and wastewater.
		Is Technology Proven Effective & Available?		**No.** Contaminated waste processing has not been proven for LANL's specialized explosives waste. **No.** Contaminated waste processing systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained detonation system for LANL's explosives-contaminated combustible debris (small debris only). Uncertain application if waste composition changes.

Table 8-7. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives-Contaminated Solvent Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
4. Explosives-contaminated solvent waste	**Incinerator, Plasma Arc**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (plasma arc incinerator) also so **increases safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO2, H2O, NO2, N2 and others) generated by fuel used to provide heat to the plasma arc incinerator. Secondary waste streams include ash, molten slag and scrubber wastes.
		Is Technology Proven Effective & Available?		**No.** Plasma arc incineration has not been proven for LANL's specialized explosives waste. **No.** Plasma arc incineration systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized plasma arc incineration system for LANL's explosive contaminated solvent waste. Uncertain application if waste composition changes.

Table 8-8. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives-Contaminated Noncombustible Debris Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
5. Explosives-contaminated noncombustible debris	**Flashing Furnace**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (flashing furnace) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fuel used to provide heat to the flashing furnace. Secondary waste streams include residual metals parts and scrubber wastes.
		Is Technology Proven Effective & Available?		**No.** Flashing furnace treatment has not been proven for LANL's specialized explosives waste. **No.** Flashing furnace systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design and construction of a customized flashing furnace system for LANL's explosive-contaminated non-combustible debris. Uncertain application if waste composition changes.

8.4 Alt Tech Evaluation Supports Continued Operation of the Flash Pad and OD Units

The Alt Tech Evaluation process identified seventeen candidate Alt Techs. After an initial screening, the Alt Tech Evaluation process eliminated nine of the identified candidate Alt Techs and focused additional screening on eight potentially applicable Alt Techs. The additional screening was focused on the threshold criteria, which consider whether potentially applicable Alt Techs are both safe and available, considering site-specific factors. All potentially applicable Alt Techs fail to meet the threshold criteria of safe and available.

Based on the Alt Tech Evaluation, it is not appropriate nor feasible to transition from the Laboratory's use of the thermal treatment Units. There are no safe and available Alt Techs available for any of the Laboratory's specialized explosives waste streams. Even if all of the potentially applicable Alt Techs were to become both safe and available, and even if the additional screening criteria were to weigh in favor of their adoption, implementation of the Alt Techs would still not alleviate the need for the thermal treatment Units to continue to treat significant portions of the Laboratory's specialized explosives waste.

The Laboratory's thermal treatment Units continue to be the only safe and available mode of treatment for the Laboratory's specialized explosives waste. The thermal treatment Units treat the waste safely, efficiently, and in a manner protective of human health and the environment. With its continued commitment to pollution prevention and waste minimization, the Laboratory will continue to minimize explosives waste and to evaluate alternative treatment technologies. However, onsite treatment at the thermal treatment Units continues to be the only safe and available mode of treatment.

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9 Conclusions

To achieve its scientific research and development and national security-related missions, the Laboratory develops specialized high explosives and also intentionally alters and insults explosives materials. These mission critical activities generate small volumes of specialized explosives waste. This specialized explosives waste is unique, heterogenous, highly energetic, potentially unstable, and often possesses indeterminate properties and characteristics. The properties and expected behaviors of the Laboratory's explosives waste streams, moreover, are constantly changing in nature.

The Laboratory's specialized explosives waste is dissimilar from the homogenous conventional munitions and waste explosives generated at other facilities. Studies performed by EPA and NASEM on potential Alt Tech for OB/OD focus on treatment of conventional munitions and waste explosives, and do not consider the specialized, intentionally altered, and insulted explosives and associated waste generated at LANL (EPA 2019, EPA 2023, NASEM 2019). Therefore, these studies do not provide a sound basis to inform Alt Tech decisions for the Laboratory's specialized explosives waste.

The Laboratory safely, efficiently, and in a manner protective of human health and the environment treats its specialized explosives waste at the Units . The Units treat, in a specifically designed and highly controlled manner, the limited and discrete quantities of specialized explosives waste that the Laboratory must generate to fulfill its research, development, and national security–related missions. The Units are designed to achieve efficient and complete combustion of the waste, and they do not generate secondary hazardous waste streams or any measurable or modeled toxic by-products. The Units have been shown to be safe and effective treatment technologies for the Laboratory's specialized explosives waste.

The Units are protective of human health and the environment. Environmental monitoring specific to the Units has demonstrated that they do not pose a threat to either human health or the environment. Notably, risk-screening assessments of the Units' operations demonstrate that there is no unacceptable risk to either human health or ecological receptors from the operations (LANL 2020f, LANL 2020g).

The Units also provide a "right-sized treatment unit" for the varying specialized explosives waste streams requiring treatment. The Units allow for prompt treatment of the Laboratory's specialized explosives waste streams, which increases safety by minimizing worker exposure and onsite storage needs, and also avoids the increased risks caused by transport of explosives waste. The Units can also address the unique risks posed by the specialized explosives waste, and can adapt to changes in the specialized waste's composition or size.

The Laboratory's Flash Pad is a modern, controlled approach to open burning, and it should be considered a safe and effective Alt Tech to conventional open burning. The Flash Pad utilizes propane-enhanced controlled open oxidation and other controls to achieve complete combustion without generating toxic by-products. The Laboratory's OD units are also designed and operated to achieve complete consumption without generating toxic by-products. Additional controls and monitoring at the Units furthers their safe and environmentally protective operations.

This Alt Tech Evaluation analyzed whether Alt Techs are available that can safely treat the specialized explosives waste streams currently treated at the Laboratory's thermal treatment Units. As detailed in Sections 7 and 8, there are no Alt Techs available that have been proven capable of safely treating the specialized explosives waste streams currently treated at the Units. The Units are the only proven safe mode of treatment available. The Units are protective of human health and the environment. EPA

regulations allow for the OB/OD of waste explosives. 40 C.F.R. § 265.382. Where there are no safe and available alternatives, it is appropriate to continue to use OB/OD for waste explosives. EPA 2022(b).

This conclusion is predicated on a robust analysis of the factors considered in an Alt Tech evaluation, including operational safety, monitorability, and toxic by-products. This conclusion also reflects the specialized nature of the explosives waste that the Laboratory generates, site-specific operational and safety factors, and considerations related to LANL's national security-related missions. Transportation of the Laboratory's specialized explosives waste offsite on public roadways, moreover, is not allowed or authorized under federal law (*see* 49 CFR § 173.53), would pose a significant risk to the public and the environment, and could present a national security risk.

Furthermore, given the highly energetic and heterogenous and potentially unstable and unpredictable nature of the Laboratory's explosives waste streams, the potential for degradation of explosives materials and unanticipated detonation exists during storage and handling. Therefore, any treatment technology that requires additional onsite storage and handling is necessarily unsafe because it introduces significant and unnecessary additional health and safety risks to workers, the public, facilities, and the environment. Each of the potentially applicable alternative treatment technologies analyzed in Section 8 and **Table 8-4** of this Alt Tech Evaluation would require increased waste storage periods and/or waste handling, resulting in increased health, safety, and environmental risks.

Section 6 of this Alt Tech Evaluation describes the Laboratory's proactive pollution prevention and waste minimization efforts, operational practice changes, and process efficiencies. These processes have enabled the Laboratory to significantly decrease the overall volume of explosives waste generated by roughly 80% during routine operations. These efforts are effective and are continuing, but they also cannot eliminate the need for continued thermal treatment at the Units into the foreseeable future.

For all of these reasons, and for those reasons previously submitted to the NMED, continued operation of the Laboratory's thermal treatment Units is the only safe and available treatment option for the Laboratory's specialized explosives waste at this time.

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11 Acronyms and Abbreviations

Acronym	Definition
ASER	Annual Site Environment Report
BATFE	Bureau of Alcohol, Tobacco, Firearms and Explosives
CFR	Code of Federal Regulations
CWP	contaminated waste processor
DAAF	4,4- diamino-3,3-azoxyfurazan
DOE	U.S. Department of Energy
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
EMS	Environmental Management System
EWI	El Dorado Engineering Explosive Waste Incinerator
EPA	U.S. Environmental Protection Agency
ETSCP	Environmental Security Technology Certification Program
FFRDC	Federally Funded Research and Development Center

Acronym	Definition
HMX	1,3,5,7-tetrazocine
HWA	New Mexico Hazardous Waste Act
IED	improvised explosive device
IHC	Interim Hazard Classification
JOCG	Joint Ordinance Commanders Group
LDR	Land Disposal Restriction
LANL	Los Alamos National Laboratory
MACT	maximum achievable control technology
N3B	Newport News Nuclear BWXT-Los Alamos, LLC
NASEM	National Academies of Sciences, Engineering, and Medicine
NAVAIR	Naval Air Systems Command
NMED-HWB	New Mexico Environment Department-Hazardous Waste Bureau
NNSA	National Nuclear Security Administration
NQ	Nitroguanidine
OB	Open Burning
OD	Open Detonation
PBX	Plastic Bonded eXplosives
PETN	Pentaerythritol tetranitrate
PHMSA	Pipeline and Hazardous Materials Safety Administration
PSN	Proper Shipping Name
PVC	polyvinyl chloride
PYX	2,6-Bis(picrylamino)-3,5-dinitropyridine
RCRA	Resource Conservation and Recovery Act
RDX	Cyclo-1,3,5-trimethylene-2,4,6-trinitramine
SERDP	Strategic Environmental Research and Development Program
TA	Technical Area
TATB	triamino trinitrobenzene
TNT	2,4,6- trinitrotoluene
TSDF	treatment, storage, and disposal facilities
WAC	waste acceptance criteria

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 1 – Waste Stream Profiles for Ash/Sand Residue

.

WASTE PROFILE FORM
COVER SHEET

44544
APPROVED

Waste Stream ID:	44544
WPF ID (Legacy):	
Waste Stream Name:	ASH FROM BURNING GROUND TREATMENT OPERATIONS.
Expiration Date:	09/18/2020
Waste Type:	Hazardous Waste
Radiological Type:	Non Radioactive
RCRA Category:	RCRA Solid Hazardous
Ancillary Types:	
Primary Composition:	Other [Describe]
Composition (other):	Ash
EPA Codes:	D007
Waste Acceptance:	
EPA Form Code:	W303
	Inorganic Solids: Ash (from any type of burning of hazardous waste)
EPA Source Code:	G19
	Other Intermittent Events or Processes: Other one-time or intermittent processes (specify in comments)

Waste Generation Estimates

YEAR	VOLUME
2021	15.00 gal
2020	15.00 gal
2019	15.00 gal
2018	15.00 gal
2017	5.00 gal

WASTE PROFILE FORM

Reference Number

WCATS ID	Legacy WPF ID
44544	

Generator's Z Number	Waste Generator's Name *(print)*	WMC's Z Number	WMC's Name *(print)*		Generator's Phone
313872	HANSON, DARREN	169004	GONZALES, PAUL		5056675527
Generator's Mail Stop	**Waste Generating Group**	**Waste Stream Technical Area**	**Building**	**Room**	**WMC Phone**
D471	J-8	16	000441	N/A	5056658812

Waste Accumulation *(check only one)*

- ☑ Satellite Accumulation Area — Site No: 6509
- ☐ Less-than-90 Days Storage Area — Site No:
- ☐ TSDF — Site No:
- ☐ Universal Waste Storage Area — Site No:
- ☐ Used Oil for Recycle — Site No:

ER Use Only

- ☐ ER Site — SWMU/AOC No.

- ☐ PCBs Storage Area — Site No:
- ☐ NM Special Waste — Site No:
- ☐ Rad Staging Area — Site No:
- ☐ Rad Storage Area — Site No:
- ☐ None of the Above — Site No:
- ☐ Central Accumulation Area — Site No:

Method of Characterization *(check as many as apply)*

☑ Chemical/Physical Analysis	☑ Attached	Sample No: Event 11418 RFA 3947 Burn Site
☑ Acceptable Knowledge Documentation	☑ Attached	Documentation No: HE burning operations at 16-388
☐ PCB Analysis	☐ Attached	Sample No:
☐ Radiological Analysis	☐ Attached	Sample No:
☐ Material Safety Data Sheet (MSDS)	☐ Attached	

Section 1 - Waste Prevention/Minimization *(answer all questions)*

Can hazard segregation, elimination, or material substitution be used?	☐ Yes *(provide comments)*	☑ No	
Can any of the materials in the waste stream be recycled or reused?	☐ Yes *(provide comments)*	☑ No	
Has waste minimization been incorporated into procedures or other process controls?	☑ Yes	☐ No *(provide comments)*	
Can this waste be generated outside a RCA?	☐ Yes *(provide comments)*	☐ No	☑ N/A

Comments:

Section 2 - Chemical and Physical Information

Waste Type *(check only one)*

- ☐ Unused/Unspent Chemical
- ☑ Process Waste/Spent Chemical/Other

Radiological Information

Was Waste generated in a RCA?

- ☐ Yes ☑ No
- ☑ Non-radioactive
- ☐ Radioactive - Low Level
- ☐ Radioactive - Transuranic

Waste Destination *(check one)*

- ☐ SWWS
- ☐ RLWTF
- ☐ RLWTP
- ☐ TA-16/HE
- ☐ NTS

Classified Information

- ☑ Unclassified
- ☐ Classified/Sensitive

Waste Category *(check all that apply)*

- ☑ Inorganic
- ☐ Organic
- ☐ Solvent (see instructions)
- ☐ Degreaser (see instructions)
- ☐ Dioxin
- ☐ Electroplating
- ☑ Treated Hazardous Waste or Residue
- ☐ No-Longer Contained-In
- ☑ Explosive Process
- ☐ Infectious/Medical
- ☐ Biological
- ☐ Beryllium
- ☐ Empty Container (see instructions)
- ☐ Battery (see instructions)

Asbestos

- ☐ Friable
- ☐ Non-Friable

PCB Source Concentration

- ☐ PCB < 50 ppm
- ☐ PCB >= 50 - < 500 ppm
- ☐ PCB >= 500 ppm
- ☐ Hazardous Waste Contaminated Soil
- ☐ Untreated Hazardous Debris
- ☐ Commercial Solid Waste
- ☐ Other [Describe]

Other:

Waste Source *(check only one)*

Waste Source A

- ☐ Decon
- ☐ Materials Processing/Production
- ☐ Research/Development/Testing
- ☐ Scheduled Maintenance
- ☐ Housekeeping - Routine
- ☐ Spill Cleanup - Routine
- ☐ Sampling - Routine Monitoring
- ☑ Other (describe)

Waste Source B

- ☐ Abatement
- ☐ Construction/Upgrades
- ☐ Demolition
- ☐ Decon/Decom
- ☐ Investigative Derived
- ☐ Orphan/Legacy
- ☐ Remediation/Restoration
- ☐ Repacking (secondary)
- ☐ Unscheduled Maintenance
- ☐ Housekeeping (non-routine)
- ☐ Spill Cleanup (non-routine)
- ☐ Non-Petroleum Tanks
- ☐ Petroleum Tanks
- ☐ Other (describe)

Other: Treatment

Waste Matrix *(check only one)*

Gas

- ☐ ≤1.5 Atmospheres Pressure
- ☐ >1.5 Atmospheres Pressure
- ☐ Liquified Compressed Gas

Liquid

- ☐ Aqueous
- ☐ Non-Aqueous
- ☐ Suspended Solids/Aqueous
- ☐ Suspended Solids/Non-Aqueous

Solid

- ☑ Powder/Ash/Dust
- ☐ Solid
- ☐ Sludge
- ☐ Absorbed/Solidified Liquid
- ☐ Debris

Matrix Type *(check only one)*

- ☐ Homogeneous
- ☑ Heterogeneous

Estimate Annual Volume (m^3):

Section 3 - Process and Waste Description

Process Description:
ASH from Burning Ground treatment operations. Ash is generated from the treatment of materials that containe or could potentially containe detonable amounts of high explosives (HE). Once treated, all HE is incinerated. Waste is non-explosive, therefore non-RCRA-D003 reactive and non-DOT Hazard Class 1 explosive.

The 16-388 flash pad is outfitted with electronically ignited propane burners and no longer use benzene, toluene or kerosene as an ignition source. The propane burners efficiently render explosive residues to a non-explosive, non-RCRA reactive state.

Waste Description:
Waste will consist of Ash from Burning Ground operations.

Section 4 - Characteristics

Ignitability *(check only one)*	**Corrosivity** *(check only one)* (pH)	**Reactivity** *(check as many as apply)*	**Boiling Point** *(check only one)*
☐ < 73 F (< 22.8 C)	☐ <= 2.0	☐ RCRA Unstable	☐ <= 95 F (<= 35 C)
☐ 73 - 99 F (22.8 - 37.2 C)	☐ 2.1 - 4.0	☐ Water Reactive	☐ >95 F (> 35 C)
☐ 100 - 139 F (37.8 - 59.4 C)	☐ 4.1 - 6.0	☐ Cyanide Bearing	☑ Not Applicable
☐ 140 - 200 F (60.0 - 99.3 C)	☐ 6.1 - 9.0	☐ Sulfide Bearing	
☐ > 200 (> 99.3 C)	☐ 9.1 - 12.4	☐ Pyrophoric	
☐ EPA Ignitable - Non-liquid	☐ >= 12.5	☐ Shock Sensitive	
☐ DOT Flammable Gas	☐ Liquid Corrosive to Steel	☐ Explosive [Specify DOT Div.]	
☐ DOT Oxidizer	☑ Non-aqueous	☑ Non-Reactive	
☑ Not Ignitable			

	Characterization Method				Concentration of Contaminants		
Identify for all contaminants listed	**AK**	**TCLP**	**Total**	**None or Non-detect**	**Contaminant present at Minimum**	**Maxiumum**	**Regulatory Limit**
Toxicity Characteristic Metals					(10,000 ppm = 1%)		
Arsenic	☐	☐	☑	☐	0.001 to	42.1 ppm	5.0 ppm
Barium	☐	☐	☑	☐	0.01 to	136 ppm	100.0 ppm
Cadmium	☐	☐	☑	☑	to	ppm	1.0 ppm
Chromium	☐	☐	☑	☐	0.1 to	1110 ppm	5.0 ppm
Lead	☐	☐	☑	☑	to	ppm	5.0 ppm
Mercury	☐	☐	☑	☑	to	ppm	0.2 ppm
Selenium	☐	☐	☑	☐	0.0001 to	0.368 ppm	1.0 ppm
Silver	☐	☐	☑	☑	to	ppm	5.0 ppm
Toxicity Characteristic Organics							
Benzene	☑	☐	☐	☑	to	ppm	0.5 ppm
Carbon tetrachloride	☑	☐	☐	☑	to	ppm	0.5 ppm
Chlorobenzene	☑	☐	☐	☑	to	ppm	100.0 ppm
Chloroform	☑	☐	☐	☑	to	ppm	6.0 ppm
Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
p-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
m-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
o-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
1,4-Dichlorobenzene	☑	☐	☐	☑	to	ppm	7.5 ppm
1,2-Dichloroethane	☑	☐	☐	☑	to	ppm	0.5 ppm
1,1-Dichloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
2,4-Dinitrotoluene	☑	☐	☐	☑	to	ppm	0.13 ppm
Hexachlorobenzene	☑	☐	☐	☑	to	ppm	0.13 ppm
Hexachlorobutadiene	☑	☐	☐	☑	to	ppm	0.5 ppm
Hexachloroethane	☑	☐	☐	☑	to	ppm	3.0 ppm
Methyl ethyl ketone	☑	☐	☐	☑	to	ppm	200.0 ppm
Nitrobenzene	☑	☐	☐	☑	to	ppm	2.0 ppm
Pentachlorophenol	☑	☐	☐	☑	to	ppm	100.0 ppm
Pyridine	☑	☐	☐	☑	to	ppm	5.0 ppm
Tetrachloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
Trichloroethylene	☑	☐	☐	☑	to	ppm	0.5 ppm
2,4,6-Trichlorophenol	☑	☐	☐	☑	to	ppm	2.0 ppm
2,4,5-Trichlorophenol	☑	☐	☐	☑	to	ppm	400.0 ppm
Vinyl chloride	☑	☐	☐	☑	to	ppm	0.2 ppm
Herbicides and Pesticides							
Chlordane	☑	☐	☐	☑	to	ppm	0.03 ppm
2,4-D	☑	☐	☐	☑	to	ppm	10.0 ppm
Endrin	☑	☐	☐	☑	to	ppm	0.02 ppm
Heptachlor (& its epoxide)	☑	☐	☐	☑	to	ppm	0.008 ppm
Lindane (gamma-BHC)	☑	☐	☐	☑	to	ppm	0.4 ppm
Methoxychlor	☑	☐	☐	☑	to	ppm	10.0 ppm
2,4,5-TP (Silvex)	☑	☐	☐	☑	to	ppm	1.0 ppm
Toxaphene	☑	☐	☐	☑	to	ppm	0.5 ppm

Section 5 - Additional Constituents and Contaminants

Additional Constituents and Contaminants. Please account for 100% of waste. Range should be given within guidelines of individual constituents. List all other constients (including inerts) not identified above and attach any applicable analysis. No chemical formula allowed in this field. Continue in Section 3 Additional information as necessary. CAS numbers are needed for all chemical constituents, for material without a CAS number, enter "No CAS Number".

CAS No.	Name of constituent	Minimum (ppm)		Maximum (ppm)
-----	Ash	1000000	to	1000000
7429-90-5	Aluminum	0.1	to	1970
7440-41-7	Beryllium	0.0001	to	0.0325
7440-70-2	Calcium	1	to	22900
7440-48-4	Cobalt	0.01	to	418
7440-50-8	Copper	0.01	to	498
7439-89-6	Iron	10	to	168000
7440-09-7	Potassium	0.01	to	101
7439-95-4	Magnesium	0.01	to	894
7439-96-5	Manganese	0.1	to	2230
7440-23-5	Sodium	0.01	to	499
7440-02-0	Nickel	1	to	32400
7440-36-0	Antimony	0.001	to	86
7440-62-2	Vanadium	0.001	to	30.6
7440-66-6	Zinc	0.01	to	670
	Total of max. ranges of this section and page 2			123.20 in %

Additional Information

If additional information is available on the chemical, physical, or radiological character of the waste not covered on this form, provide it below

No compatibility issues. The waste is compatible with High Density Polythylene (HDPE) containers.

Per the data, the ash waste failed for Chromium and will be managed as hazardous waste (SAA site ID 6509)

Section 6 - Work Control Documentation

Do the procedures for this process cover how to manage this waste? ☑ Yes ☐ No *(provide comments)*

Do the procedures for this process address controls to prevent changes to waste constituents and concentrations or addition or removal of waste to/from containers? ☑ Yes ☐ No *(provide comments)*

Comments:

Section 7 - Packaging and Storage Control

Describe how the waste will be packaged in according to the applicable WAC.

DOT compliant container

No compatibility issues. The waste is compatible with High Density Polythylene (HDPE) containers

Identify the storage management controls that will be used for this waste stream: *(check all that apply)*

☐ Tamper Indication Devices ☐ Limited use locks with log-in for waste ☑ Locked cabinet or building ☐ Other (describe)

Section 8 - Waste Certification Statements

☑ Waste appears to meet WAC attachment for: HAZ

☐ Waste stream needs exception/exemption for treatment, storage, or disposal.

☐ Waste does not meet the criteria for any known TSDF. (DOE approval is required. Contact the office of the Principle Associate Director for Weapons Programs [PADWP] for assistance.)

Waste Generator Certification: Based on my knowledge of the waste and/or chemical/physical analysis, I certify that the waste characterization information on this form is correct and that it meets the requirements of the applicable waste acceptance criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: *JOHN MORRIS (109712)* Date: *09/18/17 12:53 PM*

Waste Management Approval: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *JEFFREY LEE (217511)* Date: *09/18/17 12:54 PM*

RCRA Review: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *ANDY ELICIO (118692)* Date: *09/18/17 01:06 PM*

Attachment 4 - LDR and UHC

Identify category and presence of any constituents listed below *(equal to or above limit)*.

Non-Wastewater/Wastewater Category *(check only one)*

☑ Non Wastewater ☐ Wastewater [as defined by 40 CFR 268.2(f)] ☐ Lab Pack [40 CFR 268.2(f)] **Sign Certification #1**

Notifications and Certifications - Check the appilcable boxes

Generator Requirements:

☐ This shipment contains hazardous waste contaminated soil that does not meet treatment standards **Sign Certification #2**
☐ This shipment contains untreated hazardous debris to be treated to 40 CFR 268.45 treatment standards **(No certification)**
☐ Hazardous wastes (except soil) meeting treatment standards at point of generation **Sign Certification #3**
☐ Hazardous wastes contaminated soil meeting treatment standards at point of generation **Sign Certification #4**

TSDF or Generator Treatment:

☐ TSDF treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #5**
☐ Generator treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #6**
☐ Hazardous wastes contaminated soil treated to 40 CFR 268.49 **Sign Certification #7**
☐ Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS **Sign Certification #8**
☑ Wastes or residues from characteristic hazardous waste treatment not meeting UTS **Sign Certification #9**
☐ Other TSDF wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #10**
☐ Other generator wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #11**

Notification of Underlying Hazardous Constituents

(Check the applicable underlying constituents above the concentration levels for D001 through D043 characterstic wastes only)

☐ ***No Underlying Hazardous Constituents in this waste stream.***

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Acenaphthene	83-32-9	0.059	3.4	34.0
☐	Acenaphthylene	208-96-8	0.059	3.4	34.0
☐	Acetone	67-64-1	0.28	160.0	1600.0
☐	Acetonitrile	75-05-8	5.6	38.0	380.0
☐	Acetophenone	98-86-2	0.01	9.7	97.0
☐	2-Acetylaminofluorene	53-96-3	0.059	140.0	1400.0
☐	Acrolein	107-02-8	0.29	N/A	N/A
☐	Acrylamide	79-06-1	19.0	23.0	230.0
☐	Acrylonitrile	107-13-1	0.24	84.0	840.0
☐	Aldicarb sulfone	1646-88-4	0.056	0.28	2.8
☐	Aldrin	309-00-2	0.021	0.066	0.66
☐	4-Aminobiphenyl	92-67-1	0.13	N/A	N/A
☐	Aniline	62-53-3	0.81	14.0	140.0
☐	o-Anisidine	90-04-0	0.01	0.66	6.6
☐	Anthracene	120-12-7	0.059	3.4	34.0
☐	Aramite	140-57-8	0.36	N/A	N/A
☐	alpha-BHC	319-84-6	0.00014	0.066	0.66
☐	beta-BHC	319-85-7	0.00014	0.066	0.66
☐	delta-BHC	319-86-8	0.023	0.066	0.66
☐	Barban	101-27-9	0.056	1.4	14.0
☐	Bendiocarb	22781-23-3	0.056	1.4	14.0
☐	Benomyl	17804-35-2	0.056	1.4	14.0
☐	Benz[a]anthracene	56-55-3	0.059	3.4	34.0
☐	Benzal chloride	98-87-3	0.055	6.0	60.0
☐	Benzene	71-43-2	0.14	10.0	100.0
☐	Benzo(b)fluoranthene	205-99-2	0.11	6.8	68.0
☐	Benzo[a]pyrene	50-32-8	0.061	3.4	34.0
☐	Benzo[ghi]perylene	191-24-2	0.0055	1.8	18.0
☐	Benzo[k]fluoranthene	207-08-9	0.11	6.8	68.0
☐	Bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	72.0
☐	Bis(2-chloroethyl) ether	111-44-4	0.033	6.0	60.0
☐	Bis(2-chloroisopropyl) ether	39638-32-9	0.055	7.2	72.0
☐	Bis(2-ethylhexyl) phthalate	117-81-7	0.28	28.0	280.0
☐	Bromodichloromethane	75-27-4	0.35	15.0	150.0
☐	Bromomethane	74-83-9	0.11	15.0	150.0
☐	4-Bromophenyl phenyl ether	101-55-3	0.055	15.0	150.0
☐	n-Butyl alchohol	71-36-3	5.6	2.6	26.0
☐	Butyl benzyl phthalate	85-68-7	0.017	28.0	280.0
☐	Butylate	2008-41-5	0.042	1.4	14.0
☐	Carbaryl	63-25-2	0.006	0.14	1.4

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Carbendazim	10605-21-7	0.056	1.4	14.0
☐	Carbofuran	1563-66-2	0.006	0.14	1.4
☐	Carbofuran phenol	1563-38-8	0.056	1.4	14.0
☐	Carbon disulfide	75-15-0	3.8	4.8	48.0
☐	Carbon tetrachloride	56-23-5	0.057	6.0	60.0
☐	Carbosulfan	55285-14-8	0.028	1.4	14.0
☐	Chlordane	57-74-9	0.0033	0.26	2.6
☐	p-Chloro-m-cresol	59-50-7	0.018	14.0	140.0
☐	p-Chloroaniline	106-47-8	0.46	16.0	160.0
☐	Chlorobenzene	108-90-7	0.057	6.0	60.0
☐	Chlorobenzilate	510-15-6	0.1	N/A	N/A
☐	Chlorodibromomethane	124-48-1	0.057	15.0	150.0
☐	Chloroethane	75-00-3	0.27	6.0	60.0
☐	2-Chloroethyl vinyl ether	110-75-8	0.062	N/A	N/A
☐	Chloroform	67-66-3	0.046	6.0	60.0
☐	Chloromethane	74-87-3	0.19	30.0	300.0
☐	2-Chloronaphthalene	91-58-7	0.055	5.6	56.0
☐	2-Chlorophenol	95-57-8	0.044	5.7	57.0
☐	Chloroprene	126-99-8	0.057	0.28	2.8
☐	3-Chloropropylene	107-05-1	0.036	30.0	300.0
☐	Chrysene	218-01-9	0.059	3.4	34.0
☐	p-Cresidine	120-71-8	0.01	0.66	6.6
☐	m-Cresol	108-39-4	0.77	5.6	56.0
☐	o-Cresol	95-48-7	0.11	5.6	56.0
☐	p-Cresol	106-44-5	0.77	5.6	56.0
☐	m-Cumenyl methylcarbamate	64-00-6	0.056	1.4	14.0
☐	Cyanide (Amenable)	57-12-5*	0.86	30.0	300.0
☐	Cyanide (Total)	57-12-5	1.2	590.0	5900.0
☐	Cyclohexanone	108-94-1	0.36	0.75	7.5
☐	2,4-D	94-75-7	0.72	10.0	100.0
☐	o,p'-DDD	53-19-0	0.023	0.087	0.87
☐	p,p'-DDD	72-54-8	0.023	0.087	0.87
☐	o,p'-DDE	3424-82-6	0.031	0.087	0.87
☐	p,p'-DDE	72-55-9	0.031	0.087	0.87
☐	o,p'-DDT	789-02-6	0.0039	0.087	0.87
☐	p,p'-DDT	50-29-3	0.0039	0.087	0.87
☐	Di-n-butyl phthalate	84-74-2	0.057	28.0	280.0
☐	Di-n-octyl phthalate	117-84-0	0.017	28.0	280.0
☐	Di-n-propylnitrosamine	621-64-7	0.4	14.0	140.0
☐	Dibenz[a,h]anthracene	53-70-3	0.055	8.2	82.0
☐	Dibenzo[a,e]pyrene	192-65-4	0.061	N/A	N/A
☐	1,2-Dibromo-3-chloropropane	96-12-8	0.11	15.0	150.0
☐	1,2-Dibromoethane	106-93-4	0.028	15.0	150.0
☐	Dibromomethane	74-95-3	0.11	15.0	150.0
☐	1,4-Dichlorobenzene	106-46-7	0.09	6.0	60.0
☐	m-Dichlorobenzene	541-73-1	0.036	6.0	60.0
☐	o-Dichlorobenzene	95-50-1	0.088	6.0	60.0
☐	Dichlorodifluoromethane	75-71-8	0.23	7.2	72.0
☐	1,1-Dichloroethane	75-34-3	0.059	6.0	60.0
☐	1,2-Dichloroethane	107-06-2	0.21	6.0	60.0
☐	1,1-Dichloroethylene	75-35-4	0.025	6.0	60.0
☐	trans-1,2-Dichloroethylene	156-60-5	0.054	30.0	300.0
☐	2,4-Dichlorophenol	120-83-2	0.044	14.0	140.0
☐	2,6-Dichlorophenol	87-65-0	0.044	14.0	140.0
☐	1,2-Dichloropropane	78-87-5	0.85	18.0	180.0
☐	trans-1,3-Dichloropropene	10061-02-6	0.036	18.0	180.0
☐	cis-1,3-Dichloropropylene	10061-01-5	0.036	18.0	180.0
☐	Dieldrin	60-57-1	0.017	0.13	1.3
☐	Diethyl phthalate	84-66-2	0.2	28.0	280.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Dimethyl phthalate	131-11-3	0.047	28.0	280.0
☐	p-Dimethylaminoazobenzene	60-11-7	0.13	N/A	N/A
☐	2,4-Dimethylphenol	105-67-9	0.036	14.0	140.0
☐	4,6-Dinitro-o-cresol	534-52-1	0.28	160.0	1600.0
☐	1,4-Dinitrobenzene	100-25-4	0.32	2.3	23.0
☐	2,4-Dinitrophenol	51-28-5	0.12	160.0	1600.0
☐	2,4-Dinitrotoluene	121-14-2	0.32	140.0	1400.0
☐	2,6-Dinitrotoluene	606-20-2	0.55	28.0	280.0
☐	Dinoseb	88-85-7	0.066	2.5	25.0
☐	1,4-Dioxane	123-91-1	12.0	170.0	1700.0
☐	Diphenylamine	122-39-4	0.92	13.0	130.0
☐	1,2-Diphenylhydrazine	122-66-7	0.087	N/A	N/A
☐	Disulfoton	298-04-4	0.017	6.2	62.0
☐	Dithiocarbamates (total)	WCATS-001	0.028	28.0	280.0
☐	EPTC	759-94-4	0.042	1.4	14.0
☐	Endosulfan I	959-98-8	0.023	0.066	0.66
☐	Endosulfan II	33213-65-9	0.029	0.13	1.3
☐	Endosulfan sulfate	1031-07-8	0.029	0.13	1.3
☐	Endrin	72-20-8	0.0028	0.13	1.3
☐	Endrin aldehyde	7421-93-4	0.025	0.13	1.3
☐	Ethyl acetate	141-78-6	0.34	33.0	330.0
☐	Ethyl benzene	100-41-4	0.057	10.0	100.0
☐	Ethyl ether	60-29-7	0.12	160.0	1600.0
☐	Ethyl methacrylate	97-63-2	0.14	160.0	1600.0
☐	Ethylene oxide	75-21-8	0.12	N/A	N/A
☐	Famphur	52-85-7	0.017	15.0	150.0
☐	Fluoranthene	206-44-0	0.068	3.4	34.0
☐	Fluorene	86-73-7	0.059	3.4	34.0
☐	Fluoride	16984-48-8	35.0	N/A	N/A
☐	Formetanate hydrochloride	23422-53-9	0.056	1.4	14.0
☐	Heptachlor (& its epoxide)	76-44-8	0.0012	0.066	0.66
☐	Heptachlor epoxide	1024-57-3	0.016	0.066	0.66
☐	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	0.025
☐	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	0.025
☐	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	0.025
☐	Hexachlorobenzene	118-74-1	0.055	10.0	100.0
☐	Hexachlorobutadiene	87-68-3	0.055	5.6	56.0
☐	Hexachlorocyclopentadiene	77-47-4	0.057	2.4	24.0
☐	Hexachloroethane	67-72-1	0.055	30.0	300.0
☐	Hexachloropropene	1888-71-7	0.035	30.0	300.0
☐	HxCDDs (All Hexachlorodibenzo-p-dioxins)	34465-46-8	0.000063	0.001	0.01
☐	HxCDFs (All Hexachlorodibenzo-furans)	55684-94-1	0.000063	0.001	0.01
☐	Indeno[1,2,3-cd]pyrene	193-39-5	0.0055	3.4	34.0
☐	Iodomethane	74-88-4	0.19	65.0	650.0
☐	Isobutyl alcohol	78-83-1	5.6	170.0	1700.0
☐	Isodrin	465-73-6	0.021	0.066	0.66
☐	Isosafrole	120-58-1	0.081	2.6	26.0
☐	Kepone	143-50-0	0.0011	0.13	1.3
☐	Lindane (gamma-BHC)	58-89-9	0.0017	0.066	0.66
☐	Mercury (Retort Residues)	7439-97-6*	N/A	0.2	2.0
☐	Methacrylonitrile	126-98-7	0.24	84.0	840.0
☐	Methanol	67-56-1	5.6	0.75	7.5
☐	Methapyrilene	91-80-5	0.081	1.5	15.0
☐	Methiocarb	2032-65-7	0.056	1.4	14.0
☐	Methomyl	16752-77-5	0.028	0.14	1.4
☐	Methoxychlor	72-43-5	0.25	0.18	1.8
☐	Methyl ethyl ketone	78-93-3	0.28	36.0	360.0
☐	Methyl isobutyl ketone	108-10-1	0.14	33.0	330.0
☐	Methyl methacrylate	80-62-6	0.14	160.0	1600.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Methyl methanesulfonate	66-27-3	0.018	N/A	N/A
☐	Methyl parathion	298-00-0	0.014	4.6	46.0
☐	3-Methylcholanthrene	56-49-5	0.0055	15.0	150.0
☐	4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.5	30.0	300.0
☐	Methylene chloride	75-09-2	0.089	30.0	300.0
☐	Metolcarb	1129-41-5	0.056	1.4	14.0
☐	Mexacarbate	315-18-4	0.056	1.4	14.0
☐	Molinate	2212-67-1	0.042	1.4	14.0
☐	N-Nitroso-di-n-butylamine	924-16-3	0.4	17.0	170.0
☐	N-Nitrosodiethylamine	55-18-5	0.4	28.0	280.0
☐	N-Nitrosodimethylamine	62-75-9	0.4	2.3	23.0
☐	N-Nitrosodiphenylamine	86-30-6	0.92	13.0	130.0
☐	N-Nitrosomethylethylamine	10595-95-6	0.4	2.3	23.0
☐	N-Nitrosomorpholine	59-89-2	0.4	2.3	23.0
☐	N-Nitrosopiperidine	100-75-4	0.013	35.0	350.0
☐	N-Nitrosopyrrolidine	930-55-2	0.013	35.0	350.0
☐	Naphthalene	91-20-3	0.059	5.6	56.0
☐	2-Naphthylamine	91-59-8	0.52	N/A	N/A
☐	5-Nitro-o-toluidine	99-55-8	0.32	28.0	280.0
☐	o-Nitroaniline	88-74-4	0.27	14.0	140.0
☐	p-Nitroaniline	100-01-6	0.028	28.0	280.0
☐	Nitrobenzene	98-95-3	0.068	14.0	140.0
☐	o-Nitrophenol	88-75-5	0.028	13.0	130.0
☐	p-Nitrophenol	100-02-7	0.12	29.0	290.0
☐	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	0.05
☐	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	0.05
☐	Oxamyl	23135-22-0	0.056	0.28	2.8
☐	Parathion	56-38-2	0.014	4.6	46.0
☐	PeCDDs (All Pentachlorodibenzo-p-dioxins)	36088-22-9	0.000063	0.001	0.01
☐	PeCDFs (All Pentachlorodibenzo-furans)	30402-15-4	0.000035	0.001	0.01
☐	Pebulate	1114-71-2	0.042	1.4	14.0
☐	Pentachlorobenzene	608-93-5	0.055	10.0	100.0
☐	Pentachloroethane	76-01-7	0.055	6.0	60.0
☐	Pentachloronitrobenzene	82-68-8	0.055	4.8	48.0
☐	Pentachlorophenol	87-86-5	0.089	7.4	74.0
☐	Phenacetin	62-44-2	0.081	16.0	160.0
☐	Phenanthrene	85-01-8	0.059	5.6	56.0
☐	Phenol	108-95-2	0.039	6.2	62.0
☐	1,3-Phenylenediamine	108-45-2	N/A	N/A	N/A
☐	o-Phenylenediamine	95-54-5	N/A	N/A	N/A
☐	Phorate	298-02-2	0.021	4.6	46.0
☐	Phthalic acid	100-21-0	0.055	28.0	280.0
☐	Phthalic anhydride	85-44-9	0.055	28.0	280.0
☐	Physostigmine	57-47-6	0.056	1.4	14.0
☐	Physostigmine salicylate	57-64-7	0.056	1.4	14.0
☐	Promecarb	2631-37-0	0.056	1.4	14.0
☐	Pronamide	23950-58-5	0.093	1.5	15.0
☐	Propanenitrile	107-12-0	0.24	360.0	3600.0
☐	Propham	122-42-9	0.056	1.4	14.0
☐	Propoxur	114-26-1	0.056	1.4	14.0
☐	Prosulfocarb	52888-80-9	0.042	1.4	14.0
☐	Pyrene	129-00-0	0.067	8.2	82.0
☐	Pyridine	110-86-1	0.014	16.0	160.0
☐	Safrole	94-59-7	0.081	22.0	220.0
☐	Sulfide	18496-25-8	14.0	N/A	N/A
☐	2,4,5-T	93-76-5	0.72	7.9	79.0
☐	TCDDs (All Tetrachlorodi-benzo-p-dioxins)	41903-57-5	0.000063	0.001	0.01
☐	TCDFs (All Tetrachlorodibenzofurans)	30402-14-3	0.000063	0.001	0.01
☐	2,4,5-TP (Silvex)	93-72-1	0.72	7.9	79.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14.0	140.0
☐	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6.0	60.0
☐	1,1,2,2-Tetrachloroethane	79-34-5	0.057	6.0	60.0
☐	Tetrachloroethylene	127-18-4	0.056	6.0	60.0
☐	2,3,4,6-Tetrachlorophenol	58-90-2	0.03	7.4	74.0
☐	Thiodicarb	59669-26-0	0.019	1.4	14.0
☐	Thiophanate-methyl	23564-05-8	0.056	1.4	14.0
☐	Toluene	108-88-3	0.08	10.0	100.0
☐	Total PCBs (Polychlorinated biphenyls)	1336-36-3	0.1	10.0	100.0
☐	Toxaphene	8001-35-2	0.0095	2.6	26.0
☐	Triallate	2303-17-5	0.042	1.4	14.0
☐	Tribromomethane	75-25-2	0.63	15.0	150.0
☐	2,4,6-Tribromophenol	118-79-6	0.035	7.4	74.0
☐	1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	0.057	30.0	300.0
☐	1,2,4-Trichlorobenzene	120-82-1	0.055	19.0	190.0
☐	1,1,1-Trichloroethane	71-55-6	0.054	6.0	60.0
☐	1,1,2-Trichloroethane	79-00-5	0.054	6.0	60.0
☐	Trichloroethylene	79-01-6	0.054	6.0	60.0
☐	Trichloromonofluoromethane (R11)	75-69-4	0.02	30.0	300.0
☐	2,4,5-Trichlorophenol	95-95-4	0.18	7.4	74.0
☐	2,4,6-Trichlorophenol	88-06-2	0.035	7.4	74.0
☐	1,2,3-Trichloropropane	96-18-4	0.85	30.0	300.0
☐	Triethylamine	121-44-8	0.081	1.5	15.0
☐	Tris(2,3-dibromopropyl) phosphate	126-72-7	0.11	0.1	1.0
☐	Vernolate	1929-77-7	0.042	1.4	14.0
☐	Vinyl chloride	75-01-4	0.27	6.0	60.0
☐	Xylene	1330-20-7	0.32	30.0	300.0
☐	2,4-Xylidine	95-68-1	0.01	0.66	6.6
☑	Antimony	7440-36-0	1.9	1.15	11.5
☐	Arsenic	7440-38-2	1.4	5.0	50.0
☐	Barium	7440-39-3	1.2	21.0	210.0
☐	Beryllium	7440-41-7	0.82	1.22	12.2
☐	Cadmium	7440-43-9	0.69	0.11	1.1
☑	Chromium	7440-47-3	2.77	0.6	6.0
☐	Lead	7439-92-1	0.69	0.75	7.5
☐	Mercury	7439-97-6	0.15	0.025	0.25
☑	Nickel	7440-02-0	3.98	11.0	110.0
☐	Selenium	7782-49-2	0.82	5.7	57.0
☐	Silver	7440-22-4	0.43	0.14	1.4
☐	Thallium	7440-28-0	1.4	0.2	2.0
☐	Vanadium	7440-62-2	4.3	1.6	16.0
☐	Zinc	7440-66-6	2.61	4.3	43.0

Notifications/Certifications #9

WPF # _____

Wastes or residues from characteristic hazardous waste treatment not meeting UTS

I certify under penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification. Based on my inquiry of those individuals immediately responsible for obtain this information, I believe that the treatment process has been operated and maintained properly so as to comply with the treatment standards in 40 CFR 268.40 without impremissible dilution of the prohibited waste. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

JEFFREY LEE (217511)
Authorized Signature

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.40 or 268.49 to remove the hazardous characteristic. This decharacterized waste contains underlying hazardous constituents that require further treatment to meet treatment standards. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

JEFFREY LEE (217511)
Authorized Signature

Attachment 1 - Additional Radionuclides

Please list the supplimentary radionuclides and their concentration values.

WASTE PROFILE FORM
COVER SHEET

49597
APPROVED

Waste Characterization Information

Waste Stream ID:	49597
WPF ID (Legacy):	
Waste Stream Name:	ASH
Expiration Date:	09/21/2023
Waste Type:	New Mexico Special Waste
Radiological Type:	Non Radioactive
RCRA Category:	RCRA Solid Non-hazardous
Ancillary Types:	TREATED FORMERLY CHARACTERISTIC HAZARDOUS WASTE
Primary Composition:	Other [Describe]
Composition (other):	ash
EPA Codes:	
Waste Acceptance:	
EPA Form Code:	NA
	Not Applicable: Not Applicable
EPA Source Code:	NA
	Not Applicable: Not Applicable

Waste Generation Estimates

YEAR	VOLUME
2024	0.00 CM
2023	0.00 gal
2022	0.00 gal
2021	220.00 gal

WASTE PROFILE FORM

Reference Number

WCATS ID	Legacy WPF ID
49597	

Generator's Z Number	Waste Generator's Name *(print)*	WMC's Z Number	WMC's Name *(print)*		Generator's Phone
317357	BAILON, JESSE	169004	GONZALES, PAUL		5056673133
Generator's Mail Stop	**Waste Generating Group**	**Waste Stream Technical Area**	**Building**	**Room**	**WMC Phone**
C936	M-8	16	000441		5056658812

Waste Accumulation *(check only one)*

- ☐ Satellite Accumulation Area — Site No: _____
- ☐ Less-than-90 Days Storage Area — Site No: _____
- ☐ TSDF — Site No: _____
- ☐ Universal Waste Storage Area — Site No: _____
- ☐ Used Oil for Recycle — Site No: _____

ER Use Only

- ☐ ER Site — SWMU/AOC No. _____

- ☐ PCBs Storage Area — Site No: _____
- ☑ NM Special Waste — Site No: 6614
- ☐ Rad Staging Area — Site No: _____
- ☐ Rad Storage Area — Site No: _____
- ☐ None of the Above — Site No: _____
- ☐ Central Accumulation Area — Site No: _____

Method of Characterization *(check as many as apply)*

☑ Chemical/Physical Analysis	☑ Attached	Sample No: 1 & 2
☐ Material Safety Data Sheet (MSDS)	☐ Attached	
☐ Radiological Analysis	☐ Attached	Sample No: _____
☐ Acceptable Knowledge Documentation	☐ Attached	Documentation No: _____
☐ PCB Analysis	☐ Attached	Sample No: _____

Section 1 - Waste Prevention/Minimization *(answer all questions)*

Can hazard segregation, elimination, or material substitution be used?	☐ Yes *(provide comments)*	☑ No	
Can any of the materials in the waste stream be recycled or reused?	☐ Yes *(provide comments)*	☑ No	
Has waste minimization been incorporated into procedures or other process controls?	☑ Yes	☐ No *(provide comments)*	
Can this waste be generated outside a RCA?	☐ Yes *(provide comments)*	☐ No	☑ N/A

Comments:

Section 2 - Chemical and Physical Information

Waste Type *(check only one)*

- ☐ Unused/Unspent Chemical
- ☑ Process Waste/Spent Chemical/Other

Radiological Information

Was Waste generated in a RCA?

- ☐ Yes ☑ No
- ☑ Non-radioactive
- ☐ Radioactive - Low Level
- ☐ Radioactive - Transuranic

Waste Destination *(check one)*

- ☐ SWWS
- ☐ RLWTF
- ☐ RLWTP
- ☐ TA-16/HE
- ☐ NTS

Classified Information

- ☑ Unclassified
- ☐ Classified/Sensitive

Waste Category *(check all that apply)*

- ☑ Inorganic
- ☑ Organic
- ☐ Solvent (see instructions)
- ☐ Degreaser (see instructions)
- ☐ Dioxin
- ☐ Electroplating
- ☐ Treated Hazardous Waste or Residue
- ☐ No-Longer Contained-In
- ☑ Explosive Process
- ☐ Infectious/Medical
- ☐ Biological
- ☐ Beryllium
- ☐ Empty Container (see instructions)
- ☐ Battery (see instructions)

Asbestos

- ☐ Friable
- ☐ Non-Friable

PCB Source Concentration

- ☐ PCB < 50 ppm
- ☐ PCB >= 50 - < 500 ppm
- ☐ PCB >= 500 ppm
- ☐ Hazardous Waste Contaminated Soil
- ☐ Untreated Hazardous Debris
- ☐ Commercial Solid Waste
- ☐ Other [Describe]

Other:

Waste Source *(check only one)*

Waste Source A

- ☑ Decon
- ☐ Materials Processing/Production
- ☐ Research/Development/Testing
- ☐ Scheduled Maintenance
- ☐ Housekeeping - Routine
- ☐ Spill Cleanup - Routine
- ☐ Sampling - Routine Monitoring
- ☐ Other (describe)

Waste Source B

- ☐ Abatement
- ☐ Construction/Upgrades
- ☐ Demolition
- ☐ Decon/Decom
- ☐ Investigative Derived
- ☐ Orphan/Legacy
- ☐ Remediation/Restoration
- ☐ Repacking (secondary)
- ☐ Unscheduled Maintenance
- ☐ Housekeeping (non-routine)
- ☐ Spill Cleanup (non-routine)
- ☐ Non-Petroleum Tanks
- ☐ Petroleum Tanks
- ☐ Other (describe)

Other:

Waste Matrix *(check only one)*

Gas

- ☐ ≤1.5 Atmospheres Pressure
- ☐ >1.5 Atmospheres Pressure
- ☐ Liquified Compressed Gas

Liquid

- ☐ Aqueous
- ☐ Non-Aqueous
- ☐ Suspended Solids/Aqueous
- ☐ Suspended Solids/Non-Aqueous

Solid

- ☐ Powder/Ash/Dust
- ☑ Solid
- ☐ Sludge
- ☐ Absorbed/Solidified Liquid
- ☐ Debris

Matrix Type *(check only one)*

- ☑ Homogeneous
- ☐ Heterogeneous

Estimate Annual Volume (m^3):

0.8328

Section 3 - Process and Waste Description

Process Description:
Ash from the TA-16 flash pad from flash pad. Sand had previously tested positive to containing HE prior to flashing.

Waste Description:
Treated sand with trace metals.

Section 4 - Characteristics

Ignitability *(check only one)*	**Corrosivity** *(check only one)* (pH)	**Reactivity** *(check as many as apply)*	**Boiling Point** *(check only one)*
☐ < 73 F (< 22.8 C)	☐ <= 2.0	☐ RCRA Unstable	☐ <= 95 F (<= 35 C)
☐ 73 - 99 F (22.8 - 37.2 C)	☐ 2.1 - 4.0	☐ Water Reactive	☐ >95 F (> 35 C)
☐ 100 - 139 F (37.8 - 59.4 C)	☐ 4.1 - 6.0	☐ Cyanide Bearing	☑ Not Applicable
☐ 140 - 200 F (60.0 - 99.3 C)	☐ 6.1 - 9.0	☐ Sulfide Bearing	
☐ > 200 (> 99.3 C)	☐ 9.1 - 12.4	☐ Pyrophoric	
☐ EPA Ignitable - Non-liquid	☐ >= 12.5	☐ Shock Sensitive	
☐ DOT Flammable Gas	☐ Liquid Corrosive to Steel	☐ Explosive [Specify DOT Div.]	
☐ DOT Oxidizer	☑ Non-aqueous	☑ Non-Reactive	
☑ Not Ignitable			

	Characterization Method				Concentration of Contaminants		
				None or	Contaminant present at		
Identify for all contaminants listed	**AK**	**TCLP**	**Total**	**Non-detect**	**Minimum**	**Maxiumum**	**Regulatory Limit**
Toxicity Characteristic Metals					(10,000 ppm = 1%)		
Arsenic	☐	☑	☐	☑	to	ppm	5.0 ppm
Barium	☐	☑	☐	☐	0 to	27.3 ppm	100.0 ppm
Cadmium	☐	☑	☐	☐	0 to	0.00682 ppm	1.0 ppm
Chromium	☐	☑	☐	☑	to	ppm	5.0 ppm
Lead	☐	☑	☐	☐	0 to	0.948 ppm	5.0 ppm
Mercury	☐	☑	☐	☑	to	ppm	0.2 ppm
Selenium	☐	☑	☐	☐	0 to	0.562 ppm	1.0 ppm
Silver	☐	☑	☐	☑	to	ppm	5.0 ppm
Toxicity Characteristic Organics							
Benzene	☐	☐	☑	☑	to	ppm	0.5 ppm
Carbon tetrachloride	☐	☐	☑	☑	to	ppm	0.5 ppm
Chlorobenzene	☐	☐	☑	☑	to	ppm	100.0 ppm
Chloroform	☐	☐	☑	☑	to	ppm	6.0 ppm
Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
p-Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
m-Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
o-Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
1,4-Dichlorobenzene	☐	☐	☑	☑	to	ppm	7.5 ppm
1,2-Dichloroethane	☐	☐	☑	☑	to	ppm	0.5 ppm
1,1-Dichloroethylene	☐	☐	☑	☑	to	ppm	0.7 ppm
2,4-Dinitrotoluene	☐	☐	☑	☑	to	ppm	0.13 ppm
Hexachlorobenzene	☐	☐	☑	☑	to	ppm	0.13 ppm
Hexachlorobutadiene	☐	☐	☑	☑	to	ppm	0.5 ppm
Hexachloroethane	☐	☐	☑	☑	to	ppm	3.0 ppm
Methyl ethyl ketone	☐	☐	☑	☐	0 to	0.0001815 ppm	200.0 ppm
Nitrobenzene	☐	☐	☑	☑	to	ppm	2.0 ppm
Pentachlorophenol	☐	☐	☑	☑	to	ppm	100.0 ppm
Pyridine	☐	☐	☑	☑	to	ppm	5.0 ppm
Tetrachloroethylene	☐	☐	☑	☑	to	ppm	0.7 ppm
Trichloroethylene	☐	☐	☑	☑	to	ppm	0.5 ppm
2,4,6-Trichlorophenol	☐	☐	☑	☑	to	ppm	2.0 ppm
2,4,5-Trichlorophenol	☐	☐	☑	☑	to	ppm	400.0 ppm
Vinyl chloride	☐	☐	☑	☑	to	ppm	0.2 ppm
Herbicides and Pesticides							
Chlordane	☑	☐	☐	☑	to	ppm	0.03 ppm
2,4-D	☑	☐	☐	☑	to	ppm	10.0 ppm
Endrin	☑	☐	☐	☑	to	ppm	0.02 ppm
Heptachlor (& its epoxide)	☑	☐	☐	☑	to	ppm	0.008 ppm
Lindane (gamma-BHC)	☑	☐	☐	☑	to	ppm	0.4 ppm
Methoxychlor	☑	☐	☐	☑	to	ppm	10.0 ppm
2,4,5-TP (Silvex)	☑	☐	☐	☑	to	ppm	1.0 ppm
Toxaphene	☑	☐	☐	☑	to	ppm	0.5 ppm

Section 5 - Additional Constituents and Contaminants

Additional Constituents and Contaminants. Please account for 100% of waste. Range should be given within guidelines of individual constituents. List all other constients (including inerts) not identified above and attach any applicable analysis. No chemical formula allowed in this field. Continue in Section 3 Additional information as necessary. CAS numbers are needed for all chemical constituents, for material without a CAS number, enter "No CAS Number".

CAS No.	Name of constituent	Minimum (ppm)		Maximum (ppm)
67-64-1	Acetone	0	to	0.05
117-81-7	Bis(2-ethylhexyl) phthalate	0	to	0.0151
-----	Butanone[2-]	0	to	0.00363
84-74-2	Di-n-butyl phthalate	0	to	0.0762
75-09-2	Methylene chloride	0	to	0.01
-----	Ash	950000	to	1000000
	Total of max. ranges of this section and page 2			100.00 in %

Additional Information

If additional information is available on the chemical, physical, or radiological character of the waste not covered on this form, provide it below

Methylene chloride, acetone and MEK detectes are not from a known or suspected usage as solvents.

Section 6 - Work Control Documentation

Do the procedures for this process cover how to manage this waste? ☑ Yes ☐ No *(provide comments)*

Do the procedures for this process address controls to prevent changes to waste constituents and concentrations or addition or removal of waste to/from containers? ☑ Yes ☐ No *(provide comments)*

Comments:

Section 7 - Packaging and Storage Control

Describe how the waste will be packaged in according to the applicable WAC.

Waste will be packaged into a compatible DOT approved poly drums.

Waste is compatible with itself

Identify the storage management controls that will be used for this waste stream: *(check all that apply)*

☑ Tamper Indication Devices ☐ Limited use locks with log-in for waste ☑ Locked cabinet or building ☐ Other (describe)

Section 8 - Waste Certification Statements

☑ Waste appears to meet WAC attachment for: NMSW

☐ Waste stream needs exception/exemption for treatment, storage, or disposal.

☐ Waste does not meet the criteria for any known TSDF. (DOE approval is required. Contact the office of the Principle Associate Director for Weapons Programs [PADWP] for assistance.)

Waste Generator Certification: Based on my knowledge of the waste and/or chemical/physical analysis, I certify that the waste characterization information on this form is correct and that it meets the requirements of the applicable waste acceptance criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: *JESSE BAILON (317357)* Date: *09/21/21 08:37 AM*

Waste Management Approval: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *PAUL GONZALES (169004)* Date: *09/22/21 10:08 AM*

RCRA Review: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *ROBERT MOLTER (239137)* Date: *09/22/21 10:58 AM*

Attachment 4 - LDR and UHC

Identify category and presence of any constituents listed below *(equal to or above limit)*.

Non-Wastewater/Wastewater Category *(check only one)*

☐ Non Wastewater ☐ Wastewater [as defined by 40 CFR 268.2(f)] ☐ Lab Pack [40 CFR 268.2(f)] **Sign Certification #1**

Notifications and Certifications - Check the appilcable boxes

Generator Requirements:

☐ This shipment contains hazardous waste contaminated soil that does not meet treatment standards **Sign Certification #2**
☐ This shipment contains untreated hazardous debris to be treated to 40 CFR 268.45 treatment standards **(No certification)**
☐ Hazardous wastes (except soil) meeting treatment standards at point of generation **Sign Certification #3**
☐ Hazardous wastes contaminated soil meeting treatment standards at point of generation **Sign Certification #4**

TSDF or Generator Treatment:

☐ TSDF treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #5**
☐ Generator treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #6**
☐ Hazardous wastes contaminated soil treated to 40 CFR 268.49 **Sign Certification #7**
☐ Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS **Sign Certification #8**
☑ Wastes or residues from characteristic hazardous waste treatment not meeting UTS **Sign Certification #9**
☐ Other TSDF wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #10**
☐ Other generator wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #11**

Notification of Underlying Hazardous Constituents

(Check the applicable underlying constituents above the concentration levels for D001 through D043 characterstic wastes only)

☐ ***No Underlying Hazardous Constituents in this waste stream.***

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Acenaphthene	83-32-9	0.059	3.4	34.0
☐	Acenaphthylene	208-96-8	0.059	3.4	34.0
☐	Acetone	67-64-1	0.28	160.0	1600.0
☐	Acetonitrile	75-05-8	5.6	38.0	380.0
☐	Acetophenone	98-86-2	0.01	9.7	97.0
☐	2-Acetylaminofluorene	53-96-3	0.059	140.0	1400.0
☐	Acrolein	107-02-8	0.29	N/A	N/A
☐	Acrylamide	79-06-1	19.0	23.0	230.0
☐	Acrylonitrile	107-13-1	0.24	84.0	840.0
☐	Aldicarb sulfone	1646-88-4	0.056	0.28	2.8
☐	Aldrin	309-00-2	0.021	0.066	0.66
☐	4-Aminobiphenyl	92-67-1	0.13	N/A	N/A
☐	Aniline	62-53-3	0.81	14.0	140.0
☐	o-Anisidine	90-04-0	0.01	0.66	6.6
☐	Anthracene	120-12-7	0.059	3.4	34.0
☐	Aramite	140-57-8	0.36	N/A	N/A
☐	alpha-BHC	319-84-6	0.00014	0.066	0.66
☐	beta-BHC	319-85-7	0.00014	0.066	0.66
☐	delta-BHC	319-86-8	0.023	0.066	0.66
☐	Barban	101-27-9	0.056	1.4	14.0
☐	Bendiocarb	22781-23-3	0.056	1.4	14.0
☐	Benomyl	17804-35-2	0.056	1.4	14.0
☐	Benz[a]anthracene	56-55-3	0.059	3.4	34.0
☐	Benzal chloride	98-87-3	0.055	6.0	60.0
☐	Benzene	71-43-2	0.14	10.0	100.0
☐	Benzo(b)fluoranthene	205-99-2	0.11	6.8	68.0
☐	Benzo[a]pyrene	50-32-8	0.061	3.4	34.0
☐	Benzo[ghi]perylene	191-24-2	0.0055	1.8	18.0
☐	Benzo[k]fluoranthene	207-08-9	0.11	6.8	68.0
☐	Bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	72.0
☐	Bis(2-chloroethyl) ether	111-44-4	0.033	6.0	60.0
☐	Bis(2-chloroisopropyl) ether	39638-32-9	0.055	7.2	72.0
☐	Bis(2-ethylhexyl) phthalate	117-81-7	0.28	28.0	280.0
☐	Bromodichloromethane	75-27-4	0.35	15.0	150.0
☐	Bromomethane	74-83-9	0.11	15.0	150.0
☐	4-Bromophenyl phenyl ether	101-55-3	0.055	15.0	150.0
☐	n-Butyl alchohol	71-36-3	5.6	2.6	26.0
☐	Butyl benzyl phthalate	85-68-7	0.017	28.0	280.0
☐	Butylate	2008-41-5	0.042	1.4	14.0
☐	Carbaryl	63-25-2	0.006	0.14	1.4

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Carbendazim	10605-21-7	0.056	1.4	14.0
☐	Carbofuran	1563-66-2	0.006	0.14	1.4
☐	Carbofuran phenol	1563-38-8	0.056	1.4	14.0
☐	Carbon disulfide	75-15-0	3.8	4.8	48.0
☐	Carbon tetrachloride	56-23-5	0.057	6.0	60.0
☐	Carbosulfan	55285-14-8	0.028	1.4	14.0
☐	Chlordane	57-74-9	0.0033	0.26	2.6
☐	p-Chloro-m-cresol	59-50-7	0.018	14.0	140.0
☐	p-Chloroaniline	106-47-8	0.46	16.0	160.0
☐	Chlorobenzene	108-90-7	0.057	6.0	60.0
☐	Chlorobenzilate	510-15-6	0.1	N/A	N/A
☐	Chlorodibromomethane	124-48-1	0.057	15.0	150.0
☐	Chloroethane	75-00-3	0.27	6.0	60.0
☐	2-Chloroethyl vinyl ether	110-75-8	0.062	N/A	N/A
☐	Chloroform	67-66-3	0.046	6.0	60.0
☐	Chloromethane	74-87-3	0.19	30.0	300.0
☐	2-Chloronaphthalene	91-58-7	0.055	5.6	56.0
☐	2-Chlorophenol	95-57-8	0.044	5.7	57.0
☐	Chloroprene	126-99-8	0.057	0.28	2.8
☐	3-Chloropropylene	107-05-1	0.036	30.0	300.0
☐	Chrysene	218-01-9	0.059	3.4	34.0
☐	p-Cresidine	120-71-8	0.01	0.66	6.6
☐	m-Cresol	108-39-4	0.77	5.6	56.0
☐	o-Cresol	95-48-7	0.11	5.6	56.0
☐	p-Cresol	106-44-5	0.77	5.6	56.0
☐	m-Cumenyl methylcarbamate	64-00-6	0.056	1.4	14.0
☐	Cyanide (Amenable)	57-12-5*	0.86	30.0	300.0
☐	Cyanide (Total)	57-12-5	1.2	590.0	5900.0
☐	Cyclohexanone	108-94-1	0.36	0.75	7.5
☐	2,4-D	94-75-7	0.72	10.0	100.0
☐	o,p'-DDD	53-19-0	0.023	0.087	0.87
☐	p,p'-DDD	72-54-8	0.023	0.087	0.87
☐	o,p'-DDE	3424-82-6	0.031	0.087	0.87
☐	p,p'-DDE	72-55-9	0.031	0.087	0.87
☐	o,p'-DDT	789-02-6	0.0039	0.087	0.87
☐	p,p'-DDT	50-29-3	0.0039	0.087	0.87
☐	Di-n-butyl phthalate	84-74-2	0.057	28.0	280.0
☐	Di-n-octyl phthalate	117-84-0	0.017	28.0	280.0
☐	Di-n-propylnitrosamine	621-64-7	0.4	14.0	140.0
☐	Dibenz[a,h]anthracene	53-70-3	0.055	8.2	82.0
☐	Dibenzo[a,e]pyrene	192-65-4	0.061	N/A	N/A
☐	1,2-Dibromo-3-chloropropane	96-12-8	0.11	15.0	150.0
☐	1,2-Dibromoethane	106-93-4	0.028	15.0	150.0
☐	Dibromomethane	74-95-3	0.11	15.0	150.0
☐	1,4-Dichlorobenzene	106-46-7	0.09	6.0	60.0
☐	m-Dichlorobenzene	541-73-1	0.036	6.0	60.0
☐	o-Dichlorobenzene	95-50-1	0.088	6.0	60.0
☐	Dichlorodifluoromethane	75-71-8	0.23	7.2	72.0
☐	1,1-Dichloroethane	75-34-3	0.059	6.0	60.0
☐	1,2-Dichloroethane	107-06-2	0.21	6.0	60.0
☐	1,1-Dichloroethylene	75-35-4	0.025	6.0	60.0
☐	trans-1,2-Dichloroethylene	156-60-5	0.054	30.0	300.0
☐	2,4-Dichlorophenol	120-83-2	0.044	14.0	140.0
☐	2,6-Dichlorophenol	87-65-0	0.044	14.0	140.0
☐	1,2-Dichloropropane	78-87-5	0.85	18.0	180.0
☐	trans-1,3-Dichloropropene	10061-02-6	0.036	18.0	180.0
☐	cis-1,3-Dichloropropylene	10061-01-5	0.036	18.0	180.0
☐	Dieldrin	60-57-1	0.017	0.13	1.3
☐	Diethyl phthalate	84-66-2	0.2	28.0	280.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Dimethyl phthalate	131-11-3	0.047	28.0	280.0
☐	p-Dimethylaminoazobenzene	60-11-7	0.13	N/A	N/A
☐	2,4-Dimethylphenol	105-67-9	0.036	14.0	140.0
☐	4,6-Dinitro-o-cresol	534-52-1	0.28	160.0	1600.0
☐	1,4-Dinitrobenzene	100-25-4	0.32	2.3	23.0
☐	2,4-Dinitrophenol	51-28-5	0.12	160.0	1600.0
☐	2,4-Dinitrotoluene	121-14-2	0.32	140.0	1400.0
☐	2,6-Dinitrotoluene	606-20-2	0.55	28.0	280.0
☐	Dinoseb	88-85-7	0.066	2.5	25.0
☐	1,4-Dioxane	123-91-1	12.0	170.0	1700.0
☐	Diphenylamine	122-39-4	0.92	13.0	130.0
☐	1,2-Diphenylhydrazine	122-66-7	0.087	N/A	N/A
☐	Disulfoton	298-04-4	0.017	6.2	62.0
☐	Dithiocarbamates (total)	WCATS-001	0.028	28.0	280.0
☐	EPTC	759-94-4	0.042	1.4	14.0
☐	Endosulfan I	959-98-8	0.023	0.066	0.66
☐	Endosulfan II	33213-65-9	0.029	0.13	1.3
☐	Endosulfan sulfate	1031-07-8	0.029	0.13	1.3
☐	Endrin	72-20-8	0.0028	0.13	1.3
☐	Endrin aldehyde	7421-93-4	0.025	0.13	1.3
☐	Ethyl acetate	141-78-6	0.34	33.0	330.0
☐	Ethyl benzene	100-41-4	0.057	10.0	100.0
☐	Ethyl ether	60-29-7	0.12	160.0	1600.0
☐	Ethyl methacrylate	97-63-2	0.14	160.0	1600.0
☐	Ethylene oxide	75-21-8	0.12	N/A	N/A
☐	Famphur	52-85-7	0.017	15.0	150.0
☐	Fluoranthene	206-44-0	0.068	3.4	34.0
☐	Fluorene	86-73-7	0.059	3.4	34.0
☐	Fluoride	16984-48-8	35.0	N/A	N/A
☐	Formetanate hydrochloride	23422-53-9	0.056	1.4	14.0
☐	Heptachlor (& its epoxide)	76-44-8	0.0012	0.066	0.66
☐	Heptachlor epoxide	1024-57-3	0.016	0.066	0.66
☐	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	0.025
☐	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	0.025
☐	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	0.025
☐	Hexachlorobenzene	118-74-1	0.055	10.0	100.0
☐	Hexachlorobutadiene	87-68-3	0.055	5.6	56.0
☐	Hexachlorocyclopentadiene	77-47-4	0.057	2.4	24.0
☐	Hexachloroethane	67-72-1	0.055	30.0	300.0
☐	Hexachloropropene	1888-71-7	0.035	30.0	300.0
☐	HxCDDs (All Hexachlorodibenzo-p-dioxins)	34465-46-8	0.000063	0.001	0.01
☐	HxCDFs (All Hexachlorodibenzo-furans)	55684-94-1	0.000063	0.001	0.01
☐	Indeno[1,2,3-cd]pyrene	193-39-5	0.0055	3.4	34.0
☐	Iodomethane	74-88-4	0.19	65.0	650.0
☐	Isobutyl alcohol	78-83-1	5.6	170.0	1700.0
☐	Isodrin	465-73-6	0.021	0.066	0.66
☐	Isosafrole	120-58-1	0.081	2.6	26.0
☐	Kepone	143-50-0	0.0011	0.13	1.3
☐	Lindane (gamma-BHC)	58-89-9	0.0017	0.066	0.66
☐	Mercury (Retort Residues)	7439-97-6*	N/A	0.2	2.0
☐	Methacrylonitrile	126-98-7	0.24	84.0	840.0
☐	Methanol	67-56-1	5.6	0.75	7.5
☐	Methapyrilene	91-80-5	0.081	1.5	15.0
☐	Methiocarb	2032-65-7	0.056	1.4	14.0
☐	Methomyl	16752-77-5	0.028	0.14	1.4
☐	Methoxychlor	72-43-5	0.25	0.18	1.8
☐	Methyl ethyl ketone	78-93-3	0.28	36.0	360.0
☐	Methyl isobutyl ketone	108-10-1	0.14	33.0	330.0
☐	Methyl methacrylate	80-62-6	0.14	160.0	1600.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Methyl methanesulfonate	66-27-3	0.018	N/A	N/A
☐	Methyl parathion	298-00-0	0.014	4.6	46.0
☐	3-Methylcholanthrene	56-49-5	0.0055	15.0	150.0
☐	4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.5	30.0	300.0
☐	Methylene chloride	75-09-2	0.089	30.0	300.0
☐	Metolcarb	1129-41-5	0.056	1.4	14.0
☐	Mexacarbate	315-18-4	0.056	1.4	14.0
☐	Molinate	2212-67-1	0.042	1.4	14.0
☐	N-Nitroso-di-n-butylamine	924-16-3	0.4	17.0	170.0
☐	N-Nitrosodiethylamine	55-18-5	0.4	28.0	280.0
☐	N-Nitrosodimethylamine	62-75-9	0.4	2.3	23.0
☐	N-Nitrosodiphenylamine	86-30-6	0.92	13.0	130.0
☐	N-Nitrosomethylethylamine	10595-95-6	0.4	2.3	23.0
☐	N-Nitrosomorpholine	59-89-2	0.4	2.3	23.0
☐	N-Nitrosopiperidine	100-75-4	0.013	35.0	350.0
☐	N-Nitrosopyrrolidine	930-55-2	0.013	35.0	350.0
☐	Naphthalene	91-20-3	0.059	5.6	56.0
☐	2-Naphthylamine	91-59-8	0.52	N/A	N/A
☐	5-Nitro-o-toluidine	99-55-8	0.32	28.0	280.0
☐	o-Nitroaniline	88-74-4	0.27	14.0	140.0
☐	p-Nitroaniline	100-01-6	0.028	28.0	280.0
☐	Nitrobenzene	98-95-3	0.068	14.0	140.0
☐	o-Nitrophenol	88-75-5	0.028	13.0	130.0
☐	p-Nitrophenol	100-02-7	0.12	29.0	290.0
☐	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	0.05
☐	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	0.05
☐	Oxamyl	23135-22-0	0.056	0.28	2.8
☐	Parathion	56-38-2	0.014	4.6	46.0
☐	PeCDDs (All Pentachlorodibenzo-p-dioxins)	36088-22-9	0.000063	0.001	0.01
☐	PeCDFs (All Pentachlorodibenzo-furans)	30402-15-4	0.000035	0.001	0.01
☐	Pebulate	1114-71-2	0.042	1.4	14.0
☐	Pentachlorobenzene	608-93-5	0.055	10.0	100.0
☐	Pentachloroethane	76-01-7	0.055	6.0	60.0
☐	Pentachloronitrobenzene	82-68-8	0.055	4.8	48.0
☐	Pentachlorophenol	87-86-5	0.089	7.4	74.0
☐	Phenacetin	62-44-2	0.081	16.0	160.0
☐	Phenanthrene	85-01-8	0.059	5.6	56.0
☐	Phenol	108-95-2	0.039	6.2	62.0
☐	1,3-Phenylenediamine	108-45-2	N/A	N/A	N/A
☐	o-Phenylenediamine	95-54-5	N/A	N/A	N/A
☐	Phorate	298-02-2	0.021	4.6	46.0
☐	Phthalic acid	100-21-0	0.055	28.0	280.0
☐	Phthalic anhydride	85-44-9	0.055	28.0	280.0
☐	Physostigmine	57-47-6	0.056	1.4	14.0
☐	Physostigmine salicylate	57-64-7	0.056	1.4	14.0
☐	Promecarb	2631-37-0	0.056	1.4	14.0
☐	Pronamide	23950-58-5	0.093	1.5	15.0
☐	Propanenitrile	107-12-0	0.24	360.0	3600.0
☐	Propham	122-42-9	0.056	1.4	14.0
☐	Propoxur	114-26-1	0.056	1.4	14.0
☐	Prosulfocarb	52888-80-9	0.042	1.4	14.0
☐	Pyrene	129-00-0	0.067	8.2	82.0
☐	Pyridine	110-86-1	0.014	16.0	160.0
☐	Safrole	94-59-7	0.081	22.0	220.0
☐	Sulfide	18496-25-8	14.0	N/A	N/A
☐	2,4,5-T	93-76-5	0.72	7.9	79.0
☐	TCDDs (All Tetrachlorodi-benzo-p-dioxins)	41903-57-5	0.000063	0.001	0.01
☐	TCDFs (All Tetrachlorodibenzofurans)	30402-14-3	0.000063	0.001	0.01
☐	2,4,5-TP (Silvex)	93-72-1	0.72	7.9	79.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14.0	140.0
☐	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6.0	60.0
☐	1,1,2,2-Tetrachloroethane	79-34-5	0.057	6.0	60.0
☐	Tetrachloroethylene	127-18-4	0.056	6.0	60.0
☐	2,3,4,6-Tetrachlorophenol	58-90-2	0.03	7.4	74.0
☐	Thiodicarb	59669-26-0	0.019	1.4	14.0
☐	Thiophanate-methyl	23564-05-8	0.056	1.4	14.0
☐	Toluene	108-88-3	0.08	10.0	100.0
☐	Total PCBs (Polychlorinated biphenyls)	1336-36-3	0.1	10.0	100.0
☐	Toxaphene	8001-35-2	0.0095	2.6	26.0
☐	Triallate	2303-17-5	0.042	1.4	14.0
☐	Tribromomethane	75-25-2	0.63	15.0	150.0
☐	2,4,6-Tribromophenol	118-79-6	0.035	7.4	74.0
☐	1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	0.057	30.0	300.0
☐	1,2,4-Trichlorobenzene	120-82-1	0.055	19.0	190.0
☐	1,1,1-Trichloroethane	71-55-6	0.054	6.0	60.0
☐	1,1,2-Trichloroethane	79-00-5	0.054	6.0	60.0
☐	Trichloroethylene	79-01-6	0.054	6.0	60.0
☐	Trichloromonofluoromethane (R11)	75-69-4	0.02	30.0	300.0
☐	2,4,5-Trichlorophenol	95-95-4	0.18	7.4	74.0
☐	2,4,6-Trichlorophenol	88-06-2	0.035	7.4	74.0
☐	1,2,3-Trichloropropane	96-18-4	0.85	30.0	300.0
☐	Triethylamine	121-44-8	0.081	1.5	15.0
☐	Tris(2,3-dibromopropyl) phosphate	126-72-7	0.11	0.1	1.0
☐	Vernolate	1929-77-7	0.042	1.4	14.0
☐	Vinyl chloride	75-01-4	0.27	6.0	60.0
☐	Xylene	1330-20-7	0.32	30.0	300.0
☐	2,4-Xylidine	95-68-1	0.01	0.66	6.6
☐	Antimony	7440-36-0	1.9	1.15	11.5
☐	Arsenic	7440-38-2	1.4	5.0	50.0
☐	Barium	7440-39-3	1.2	21.0	210.0
☐	Beryllium	7440-41-7	0.82	1.22	12.2
☐	Cadmium	7440-43-9	0.69	0.11	1.1
☐	Chromium	7440-47-3	2.77	0.6	6.0
☐	Lead	7439-92-1	0.69	0.75	7.5
☐	Mercury	7439-97-6	0.15	0.025	0.25
☐	Nickel	7440-02-0	3.98	11.0	110.0
☐	Selenium	7782-49-2	0.82	5.7	57.0
☐	Silver	7440-22-4	0.43	0.14	1.4
☐	Thallium	7440-28-0	1.4	0.2	2.0
☐	Vanadium	7440-62-2	4.3	1.6	16.0
☐	Zinc	7440-66-6	2.61	4.3	43.0

Notifications/Certifications #9

WPF # _____

Wastes or residues from characteristic hazardous waste treatment not meeting UTS

I certify under penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification. Based on my inquiry of those individuals immediately responsible for obtain this information, I believe that the treatment process has been operated and maintained properly so as to comply with the treatment standards in 40 CFR 268.40 without impremissible dilution of the prohibited waste. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

ROBERT MOLTER (239137)
Authorized Signature

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.40 or 268.49 to remove the hazardous characteristic. This decharacterized waste contains underlying hazardous constituents that require further treatment to meet treatment standards. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

ROBERT MOLTER (239137)
Authorized Signature

Attachment 1 - Additional Radionuclides

Please list the supplimentary radionuclides and their concentration values.

WASTE PROFILE FORM
COVER SHEET

52250
APPROVED

Waste Characterization Information

Waste Stream ID:	52250
WPF ID (Legacy):	
Waste Stream Name:	ASH II
Expiration Date:	11/17/2023
Waste Type:	New Mexico Special Waste
Radiological Type:	Non Radioactive
RCRA Category:	RCRA Solid Non-hazardous
Ancillary Types:	TREATED FORMERLY CHARACTERISTIC HAZARDOUS WASTE
Primary Composition:	Other [Describe]
Composition (other):	Ash
EPA Codes:	
Waste Acceptance:	
EPA Form Code:	NA
	Not Applicable: Not Applicable
EPA Source Code:	NA
	Not Applicable: Not Applicable

Waste Generation Estimates

YEAR	VOLUME
2024	500.00 gal
2023	500.00 gal
2022	500.00 gal

Los Alamos NATIONAL LABORATORY EST.1943

WASTE PROFILE FORM

Reference Number

WCATS ID	Legacy WPF ID
52250	

Generator's Z Number	Waste Generator's Name *(print)*	WMC's Z Number	WMC's Name *(print)*		Generator's Phone
317357	BAILON, JESSE	169004	GONZALES, PAUL		5056673133
Generator's Mail Stop	**Waste Generating Group**	**Waste Stream Technical Area**	**Building**	**Room**	**WMC Phone**
C936	M-8	16	000441		5056658812

Waste Accumulation *(check only one)*

- ☐ Satellite Accumulation Area — Site No: _____
- ☐ Less-than-90 Days Storage Area — Site No: _____
- ☐ TSDF — Site No: _____
- ☐ Universal Waste Storage Area — Site No: _____
- ☐ Used Oil for Recycle — Site No: _____

ER Use Only

- ☐ ER Site — SWMU/AOC No. _____

- ☐ PCBs Storage Area — Site No: _____
- ☑ NM Special Waste — Site No: 6614
- ☐ Rad Staging Area — Site No: _____
- ☐ Rad Storage Area — Site No: _____
- ☐ None of the Above — Site No: _____
- ☐ Central Accumulation Area — Site No: _____

Method of Characterization *(check as many as apply)*

☑ Chemical/Physical Analysis	☑ Attached	Sample No: 1
☐ Radiological Analysis	☐ Attached	Sample No: _____
☐ Acceptable Knowledge Documentation	☐ Attached	Documentation No: _____
☐ PCB Analysis	☐ Attached	Sample No: _____
☐ Material Safety Data Sheet (MSDS)	☐ Attached	

Section 1 - Waste Prevention/Minimization *(answer all questions)*

Can hazard segregation, elimination, or material substitution be used?	☐ Yes *(provide comments)*	☑ No	
Can any of the materials in the waste stream be recycled or reused?	☐ Yes *(provide comments)*	☑ No	
Has waste minimization been incorporated into procedures or other process controls?	☑ Yes	☐ No *(provide comments)*	
Can this waste be generated outside a RCA?	☐ Yes *(provide comments)*	☐ No	☑ N/A

Comments:

Section 2 - Chemical and Physical Information

Waste Type *(check only one)*

- ☐ Unused/Unspent Chemical
- ☑ Process Waste/Spent Chemical/Other

Radiological Information

Was Waste generated in a RCA?

- ☐ Yes ☑ No
- ☑ Non-radioactive
- ☐ Radioactive - Low Level
- ☐ Radioactive - Transuranic

Waste Destination *(check one)*

- ☐ SWWS
- ☐ RLWTF
- ☐ RLWTP
- ☐ TA-16/HE
- ☐ NTS

Classified Information

- ☑ Unclassified
- ☐ Classified/Sensitive

Waste Category *(check all that apply)*

- ☑ Inorganic
- ☑ Organic
- ☐ Solvent (see instructions)
- ☐ Degreaser (see instructions)
- ☐ Dioxin
- ☐ Electroplating
- ☑ Treated Hazardous Waste or Residue
- ☐ No-Longer Contained-In
- ☑ Explosive Process
- ☐ Infectious/Medical
- ☐ Biological
- ☐ Beryllium
- ☐ Empty Container (see instructions)
- ☐ Battery (see instructions)

Asbestos

- ☐ Friable
- ☐ Non-Friable

PCB Source Concentration

- ☐ PCB < 50 ppm
- ☐ PCB >= 50 - < 500 ppm
- ☐ PCB >= 500 ppm
- ☐ Hazardous Waste Contaminated Soil
- ☐ Untreated Hazardous Debris
- ☐ Commercial Solid Waste
- ☐ Other [Describe]

Other:

Waste Source *(check only one)*

Waste Source A

- ☑ Decon
- ☐ Materials Processing/Production
- ☐ Research/Development/Testing
- ☐ Scheduled Maintenance
- ☐ Housekeeping - Routine
- ☐ Spill Cleanup - Routine
- ☐ Sampling - Routine Monitoring
- ☐ Other (describe)

Waste Source B

- ☐ Abatement
- ☐ Construction/Upgrades
- ☐ Demolition
- ☐ Decon/Decom
- ☐ Investigative Derived
- ☐ Orphan/Legacy
- ☐ Remediation/Restoration
- ☐ Repacking (secondary)
- ☐ Unscheduled Maintenance
- ☐ Housekeeping (non-routine)
- ☐ Spill Cleanup (non-routine)
- ☐ Non-Petroleum Tanks
- ☐ Petroleum Tanks
- ☐ Other (describe)

Other:

Waste Matrix *(check only one)*

Gas

- ☐ ≤1.5 Atmospheres Pressure
- ☐ >1.5 Atmospheres Pressure
- ☐ Liquified Compressed Gas

Liquid

- ☐ Aqueous
- ☐ Non-Aqueous
- ☐ Suspended Solids/Aqueous
- ☐ Suspended Solids/Non-Aqueous

Solid

- ☐ Powder/Ash/Dust
- ☑ Solid
- ☐ Sludge
- ☐ Absorbed/Solidified Liquid
- ☐ Debris

Matrix Type *(check only one)*

- ☑ Homogeneous
- ☐ Heterogeneous

Estimate Annual Volume (m^3):

1.8927

Section 3 - Process and Waste Description

Process Description:
Waste is generated from treatment waste with High Explosive (HE) at the TA-16 flash pad.

Waste Description:
Ash as a result from treated HE waste with trace metals and non-detonable amounts of high explosives.

Section 4 - Characteristics

Ignitability *(check only one)*	**Corrosivity** *(check only one)* (pH)	**Reactivity** *(check as many as apply)*	**Boiling Point** *(check only one)*
☐ < 73 F (< 22.8 C)	☐ <= 2.0	☐ RCRA Unstable	☐ <= 95 F (<= 35 C)
☐ 73 - 99 F (22.8 - 37.2 C)	☐ 2.1 - 4.0	☐ Water Reactive	☐ >95 F (> 35 C)
☐ 100 - 139 F (37.8 - 59.4 C)	☐ 4.1 - 6.0	☐ Cyanide Bearing	☑ Not Applicable
☐ 140 - 200 F (60.0 - 99.3 C)	☐ 6.1 - 9.0	☐ Sulfide Bearing	
☐ > 200 (> 99.3 C)	☐ 9.1 - 12.4	☐ Pyrophoric	
☐ EPA Ignitable - Non-liquid	☐ >= 12.5	☐ Shock Sensitive	
☐ DOT Flammable Gas	☐ Liquid Corrosive to Steel	☐ Explosive [Specify DOT Div.]	
☐ DOT Oxidizer	☑ Non-aqueous	☑ Non-Reactive	
☑ Not Ignitable			

	Characterization Method				Concentration of Contaminants		
				None or	Contaminant present at		
Identify for all contaminants listed	**AK**	**TCLP**	**Total**	**Non-detect**	**Minimum**	**Maxiumum**	**Regulatory Limit**
Toxicity Characteristic Metals					(10,000 ppm = 1%)		
Arsenic	☐	☑	☐	☐	0 to	0.026 ppm	5.0 ppm
Barium	☐	☑	☐	☐	0 to	10.9 ppm	100.0 ppm
Cadmium	☐	☑	☐	☐	0 to	0.00309 ppm	1.0 ppm
Chromium	☐	☑	☐	☑	to	ppm	5.0 ppm
Lead	☐	☑	☐	☐	0 to	0.0136 ppm	5.0 ppm
Mercury	☐	☑	☐	☑	to	ppm	0.2 ppm
Selenium	☐	☑	☐	☑	to	ppm	1.0 ppm
Silver	☐	☑	☐	☑	to	ppm	5.0 ppm
Toxicity Characteristic Organics							
Benzene	☑	☐	☐	☑	to	ppm	0.5 ppm
Carbon tetrachloride	☑	☐	☐	☑	to	ppm	0.5 ppm
Chlorobenzene	☑	☐	☐	☑	to	ppm	100.0 ppm
Chloroform	☑	☐	☐	☑	to	ppm	6.0 ppm
Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
p-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
m-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
o-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
1,4-Dichlorobenzene	☑	☐	☐	☑	to	ppm	7.5 ppm
1,2-Dichloroethane	☑	☐	☐	☑	to	ppm	0.5 ppm
1,1-Dichloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
2,4-Dinitrotoluene	☐	☑	☐	☑	to	ppm	0.13 ppm
Hexachlorobenzene	☑	☐	☐	☑	to	ppm	0.13 ppm
Hexachlorobutadiene	☑	☐	☐	☑	to	ppm	0.5 ppm
Hexachloroethane	☑	☐	☐	☑	to	ppm	3.0 ppm
Methyl ethyl ketone	☑	☐	☐	☑	to	ppm	200.0 ppm
Nitrobenzene	☐	☑	☐	☑	to	ppm	2.0 ppm
Pentachlorophenol	☑	☐	☐	☑	to	ppm	100.0 ppm
Pyridine	☑	☐	☐	☑	to	ppm	5.0 ppm
Tetrachloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
Trichloroethylene	☑	☐	☐	☑	to	ppm	0.5 ppm
2,4,6-Trichlorophenol	☑	☐	☐	☑	to	ppm	2.0 ppm
2,4,5-Trichlorophenol	☑	☐	☐	☑	to	ppm	400.0 ppm
Vinyl chloride	☑	☐	☐	☑	to	ppm	0.2 ppm
Herbicides and Pesticides							
Chlordane	☑	☐	☐	☑	to	ppm	0.03 ppm
2,4-D	☑	☐	☐	☑	to	ppm	10.0 ppm
Endrin	☑	☐	☐	☑	to	ppm	0.02 ppm
Heptachlor (& its epoxide)	☑	☐	☐	☑	to	ppm	0.008 ppm
Lindane (gamma-BHC)	☑	☐	☐	☑	to	ppm	0.4 ppm
Methoxychlor	☑	☐	☐	☑	to	ppm	10.0 ppm
2,4,5-TP (Silvex)	☑	☐	☐	☑	to	ppm	1.0 ppm
Toxaphene	☑	☐	☐	☑	to	ppm	0.5 ppm

Section 5 - Additional Constituents and Contaminants

Additional Constituents and Contaminants. Please account for 100% of waste. Range should be given within guidelines of individual constituents. List all other constients (including inerts) not identified above and attach any applicable analysis. No chemical formula allowed in this field. Continue in Section 3 Additional information as necessary. CAS numbers are needed for all chemical constituents, for material without a CAS number, enter "No CAS Number".

CAS No.	Name of constituent	Minimum (ppm)		Maximum (ppm)
-----	Ash	990000	to	1000000
2691-41-0	HMX	0	to	75.2
121-82-4	RDX	0	to	2.63
-----	TATB	0	to	5.64
	Total of max. ranges of this section and page 2			100.01 in %

Additional Information

If additional information is available on the chemical, physical, or radiological character of the waste not covered on this form, provide it below

HE in this waste stream is non detonable and will not carry a D003 waste code.

Section 6 - Work Control Documentation

Do the procedures for this process cover how to manage this waste? ☑ Yes ☐ No *(provide comments)*

Do the procedures for this process address controls to prevent changes to waste constituents and concentrations or addition or removal of waste to/from containers? ☑ Yes ☐ No *(provide comments)*

Comments:

Section 7 - Packaging and Storage Control

Describe how the waste will be packaged in according to the applicable WAC.

Waste will be packaged into a compatible DOT approved poly drums.

Waste is compatible with itself

Identify the storage management controls that will be used for this waste stream: *(check all that apply)*

☑ Tamper Indication Devices ☐ Limited use locks with log-in for waste ☐ Locked cabinet or building ☐ Other (describe)

Section 8 - Waste Certification Statements

☑ Waste appears to meet WAC attachment for: NMSW

☐ Waste stream needs exception/exemption for treatment, storage, or disposal.

☐ Waste does not meet the criteria for any known TSDF. (DOE approval is required. Contact the office of the Principle Associate Director for Weapons Programs [PADWP] for assistance.)

Waste Generator Certification: Based on my knowledge of the waste and/or chemical/physical analysis, I certify that the waste characterization information on this form is correct and that it meets the requirements of the applicable waste acceptance criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: *JESSE BAILON (317357)* Date: *11/17/22 04:08 PM*

Waste Management Approval: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *PAUL GONZALES (169004)* Date: *11/17/22 04:09 PM*

RCRA Review: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *ANDY ELICIO (118692)* Date: *11/17/22 04:14 PM*

Attachment 4 - LDR and UHC

Identify category and presence of any constituents listed below *(equal to or above limit)*.

Non-Wastewater/Wastewater Category *(check only one)*

☑ Non Wastewater ☐ Wastewater [as defined by 40 CFR 268.2(f)] ☐ Lab Pack [40 CFR 268.2(f)] **Sign Certification #1**

Notifications and Certifications - Check the appilcable boxes

Generator Requirements:

☐ This shipment contains hazardous waste contaminated soil that does not meet treatment standards **Sign Certification #2**
☐ This shipment contains untreated hazardous debris to be treated to 40 CFR 268.45 treatment standards **(No certification)**
☐ Hazardous wastes (except soil) meeting treatment standards at point of generation **Sign Certification #3**
☐ Hazardous wastes contaminated soil meeting treatment standards at point of generation **Sign Certification #4**

TSDF or Generator Treatment:

☐ TSDF treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #5**
☐ Generator treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #6**
☐ Hazardous wastes contaminated soil treated to 40 CFR 268.49 **Sign Certification #7**
☑ Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS **Sign Certification #8**
☐ Wastes or residues from characteristic hazardous waste treatment not meeting UTS **Sign Certification #9**
☐ Other TSDF wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #10**
☐ Other generator wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #11**

Notification of Underlying Hazardous Constituents

(Check the applicable underlying constituents above the concentration levels for D001 through D043 characterstic wastes only)

☑ ***No Underlying Hazardous Constituents in this waste stream.***

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Acenaphthene	83-32-9	0.059	3.4	34.0
☐	Acenaphthylene	208-96-8	0.059	3.4	34.0
☐	Acetone	67-64-1	0.28	160.0	1600.0
☐	Acetonitrile	75-05-8	5.6	38.0	380.0
☐	Acetophenone	98-86-2	0.01	9.7	97.0
☐	2-Acetylaminofluorene	53-96-3	0.059	140.0	1400.0
☐	Acrolein	107-02-8	0.29	N/A	N/A
☐	Acrylamide	79-06-1	19.0	23.0	230.0
☐	Acrylonitrile	107-13-1	0.24	84.0	840.0
☐	Aldicarb sulfone	1646-88-4	0.056	0.28	2.8
☐	Aldrin	309-00-2	0.021	0.066	0.66
☐	4-Aminobiphenyl	92-67-1	0.13	N/A	N/A
☐	Aniline	62-53-3	0.81	14.0	140.0
☐	o-Anisidine	90-04-0	0.01	0.66	6.6
☐	Anthracene	120-12-7	0.059	3.4	34.0
☐	Aramite	140-57-8	0.36	N/A	N/A
☐	alpha-BHC	319-84-6	0.00014	0.066	0.66
☐	beta-BHC	319-85-7	0.00014	0.066	0.66
☐	delta-BHC	319-86-8	0.023	0.066	0.66
☐	Barban	101-27-9	0.056	1.4	14.0
☐	Bendiocarb	22781-23-3	0.056	1.4	14.0
☐	Benomyl	17804-35-2	0.056	1.4	14.0
☐	Benz[a]anthracene	56-55-3	0.059	3.4	34.0
☐	Benzal chloride	98-87-3	0.055	6.0	60.0
☐	Benzene	71-43-2	0.14	10.0	100.0
☐	Benzo(b)fluoranthene	205-99-2	0.11	6.8	68.0
☐	Benzo[a]pyrene	50-32-8	0.061	3.4	34.0
☐	Benzo[ghi]perylene	191-24-2	0.0055	1.8	18.0
☐	Benzo[k]fluoranthene	207-08-9	0.11	6.8	68.0
☐	Bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	72.0
☐	Bis(2-chloroethyl) ether	111-44-4	0.033	6.0	60.0
☐	Bis(2-chloroisopropyl) ether	39638-32-9	0.055	7.2	72.0
☐	Bis(2-ethylhexyl) phthalate	117-81-7	0.28	28.0	280.0
☐	Bromodichloromethane	75-27-4	0.35	15.0	150.0
☐	Bromomethane	74-83-9	0.11	15.0	150.0
☐	4-Bromophenyl phenyl ether	101-55-3	0.055	15.0	150.0
☐	n-Butyl alchohol	71-36-3	5.6	2.6	26.0
☐	Butyl benzyl phthalate	85-68-7	0.017	28.0	280.0
☐	Butylate	2008-41-5	0.042	1.4	14.0
☐	Carbaryl	63-25-2	0.006	0.14	1.4

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Carbendazim	10605-21-7	0.056	1.4	14.0
☐	Carbofuran	1563-66-2	0.006	0.14	1.4
☐	Carbofuran phenol	1563-38-8	0.056	1.4	14.0
☐	Carbon disulfide	75-15-0	3.8	4.8	48.0
☐	Carbon tetrachloride	56-23-5	0.057	6.0	60.0
☐	Carbosulfan	55285-14-8	0.028	1.4	14.0
☐	Chlordane	57-74-9	0.0033	0.26	2.6
☐	p-Chloro-m-cresol	59-50-7	0.018	14.0	140.0
☐	p-Chloroaniline	106-47-8	0.46	16.0	160.0
☐	Chlorobenzene	108-90-7	0.057	6.0	60.0
☐	Chlorobenzilate	510-15-6	0.1	N/A	N/A
☐	Chlorodibromomethane	124-48-1	0.057	15.0	150.0
☐	Chloroethane	75-00-3	0.27	6.0	60.0
☐	2-Chloroethyl vinyl ether	110-75-8	0.062	N/A	N/A
☐	Chloroform	67-66-3	0.046	6.0	60.0
☐	Chloromethane	74-87-3	0.19	30.0	300.0
☐	2-Chloronaphthalene	91-58-7	0.055	5.6	56.0
☐	2-Chlorophenol	95-57-8	0.044	5.7	57.0
☐	Chloroprene	126-99-8	0.057	0.28	2.8
☐	3-Chloropropylene	107-05-1	0.036	30.0	300.0
☐	Chrysene	218-01-9	0.059	3.4	34.0
☐	p-Cresidine	120-71-8	0.01	0.66	6.6
☐	m-Cresol	108-39-4	0.77	5.6	56.0
☐	o-Cresol	95-48-7	0.11	5.6	56.0
☐	p-Cresol	106-44-5	0.77	5.6	56.0
☐	m-Cumenyl methylcarbamate	64-00-6	0.056	1.4	14.0
☐	Cyanide (Amenable)	57-12-5*	0.86	30.0	300.0
☐	Cyanide (Total)	57-12-5	1.2	590.0	5900.0
☐	Cyclohexanone	108-94-1	0.36	0.75	7.5
☐	2,4-D	94-75-7	0.72	10.0	100.0
☐	o,p'-DDD	53-19-0	0.023	0.087	0.87
☐	p,p'-DDD	72-54-8	0.023	0.087	0.87
☐	o,p'-DDE	3424-82-6	0.031	0.087	0.87
☐	p,p'-DDE	72-55-9	0.031	0.087	0.87
☐	o,p'-DDT	789-02-6	0.0039	0.087	0.87
☐	p,p'-DDT	50-29-3	0.0039	0.087	0.87
☐	Di-n-butyl phthalate	84-74-2	0.057	28.0	280.0
☐	Di-n-octyl phthalate	117-84-0	0.017	28.0	280.0
☐	Di-n-propylnitrosamine	621-64-7	0.4	14.0	140.0
☐	Dibenz[a,h]anthracene	53-70-3	0.055	8.2	82.0
☐	Dibenzo[a,e]pyrene	192-65-4	0.061	N/A	N/A
☐	1,2-Dibromo-3-chloropropane	96-12-8	0.11	15.0	150.0
☐	1,2-Dibromoethane	106-93-4	0.028	15.0	150.0
☐	Dibromomethane	74-95-3	0.11	15.0	150.0
☐	1,4-Dichlorobenzene	106-46-7	0.09	6.0	60.0
☐	m-Dichlorobenzene	541-73-1	0.036	6.0	60.0
☐	o-Dichlorobenzene	95-50-1	0.088	6.0	60.0
☐	Dichlorodifluoromethane	75-71-8	0.23	7.2	72.0
☐	1,1-Dichloroethane	75-34-3	0.059	6.0	60.0
☐	1,2-Dichloroethane	107-06-2	0.21	6.0	60.0
☐	1,1-Dichloroethylene	75-35-4	0.025	6.0	60.0
☐	trans-1,2-Dichloroethylene	156-60-5	0.054	30.0	300.0
☐	2,4-Dichlorophenol	120-83-2	0.044	14.0	140.0
☐	2,6-Dichlorophenol	87-65-0	0.044	14.0	140.0
☐	1,2-Dichloropropane	78-87-5	0.85	18.0	180.0
☐	trans-1,3-Dichloropropene	10061-02-6	0.036	18.0	180.0
☐	cis-1,3-Dichloropropylene	10061-01-5	0.036	18.0	180.0
☐	Dieldrin	60-57-1	0.017	0.13	1.3
☐	Diethyl phthalate	84-66-2	0.2	28.0	280.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Dimethyl phthalate	131-11-3	0.047	28.0	280.0
☐	p-Dimethylaminoazobenzene	60-11-7	0.13	N/A	N/A
☐	2,4-Dimethylphenol	105-67-9	0.036	14.0	140.0
☐	4,6-Dinitro-o-cresol	534-52-1	0.28	160.0	1600.0
☐	1,4-Dinitrobenzene	100-25-4	0.32	2.3	23.0
☐	2,4-Dinitrophenol	51-28-5	0.12	160.0	1600.0
☐	2,4-Dinitrotoluene	121-14-2	0.32	140.0	1400.0
☐	2,6-Dinitrotoluene	606-20-2	0.55	28.0	280.0
☐	Dinoseb	88-85-7	0.066	2.5	25.0
☐	1,4-Dioxane	123-91-1	12.0	170.0	1700.0
☐	Diphenylamine	122-39-4	0.92	13.0	130.0
☐	1,2-Diphenylhydrazine	122-66-7	0.087	N/A	N/A
☐	Disulfoton	298-04-4	0.017	6.2	62.0
☐	Dithiocarbamates (total)	WCATS-001	0.028	28.0	280.0
☐	EPTC	759-94-4	0.042	1.4	14.0
☐	Endosulfan I	959-98-8	0.023	0.066	0.66
☐	Endosulfan II	33213-65-9	0.029	0.13	1.3
☐	Endosulfan sulfate	1031-07-8	0.029	0.13	1.3
☐	Endrin	72-20-8	0.0028	0.13	1.3
☐	Endrin aldehyde	7421-93-4	0.025	0.13	1.3
☐	Ethyl acetate	141-78-6	0.34	33.0	330.0
☐	Ethyl benzene	100-41-4	0.057	10.0	100.0
☐	Ethyl ether	60-29-7	0.12	160.0	1600.0
☐	Ethyl methacrylate	97-63-2	0.14	160.0	1600.0
☐	Ethylene oxide	75-21-8	0.12	N/A	N/A
☐	Famphur	52-85-7	0.017	15.0	150.0
☐	Fluoranthene	206-44-0	0.068	3.4	34.0
☐	Fluorene	86-73-7	0.059	3.4	34.0
☐	Fluoride	16984-48-8	35.0	N/A	N/A
☐	Formetanate hydrochloride	23422-53-9	0.056	1.4	14.0
☐	Heptachlor (& its epoxide)	76-44-8	0.0012	0.066	0.66
☐	Heptachlor epoxide	1024-57-3	0.016	0.066	0.66
☐	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	0.025
☐	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	0.025
☐	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	0.025
☐	Hexachlorobenzene	118-74-1	0.055	10.0	100.0
☐	Hexachlorobutadiene	87-68-3	0.055	5.6	56.0
☐	Hexachlorocyclopentadiene	77-47-4	0.057	2.4	24.0
☐	Hexachloroethane	67-72-1	0.055	30.0	300.0
☐	Hexachloropropene	1888-71-7	0.035	30.0	300.0
☐	HxCDDs (All Hexachlorodibenzo-p-dioxins)	34465-46-8	0.000063	0.001	0.01
☐	HxCDFs (All Hexachlorodibenzo-furans)	55684-94-1	0.000063	0.001	0.01
☐	Indeno[1,2,3-cd]pyrene	193-39-5	0.0055	3.4	34.0
☐	Iodomethane	74-88-4	0.19	65.0	650.0
☐	Isobutyl alcohol	78-83-1	5.6	170.0	1700.0
☐	Isodrin	465-73-6	0.021	0.066	0.66
☐	Isosafrole	120-58-1	0.081	2.6	26.0
☐	Kepone	143-50-0	0.0011	0.13	1.3
☐	Lindane (gamma-BHC)	58-89-9	0.0017	0.066	0.66
☐	Mercury (Retort Residues)	7439-97-6*	N/A	0.2	2.0
☐	Methacrylonitrile	126-98-7	0.24	84.0	840.0
☐	Methanol	67-56-1	5.6	0.75	7.5
☐	Methapyrilene	91-80-5	0.081	1.5	15.0
☐	Methiocarb	2032-65-7	0.056	1.4	14.0
☐	Methomyl	16752-77-5	0.028	0.14	1.4
☐	Methoxychlor	72-43-5	0.25	0.18	1.8
☐	Methyl ethyl ketone	78-93-3	0.28	36.0	360.0
☐	Methyl isobutyl ketone	108-10-1	0.14	33.0	330.0
☐	Methyl methacrylate	80-62-6	0.14	160.0	1600.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Methyl methanesulfonate	66-27-3	0.018	N/A	N/A
☐	Methyl parathion	298-00-0	0.014	4.6	46.0
☐	3-Methylcholanthrene	56-49-5	0.0055	15.0	150.0
☐	4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.5	30.0	300.0
☐	Methylene chloride	75-09-2	0.089	30.0	300.0
☐	Metolcarb	1129-41-5	0.056	1.4	14.0
☐	Mexacarbate	315-18-4	0.056	1.4	14.0
☐	Molinate	2212-67-1	0.042	1.4	14.0
☐	N-Nitroso-di-n-butylamine	924-16-3	0.4	17.0	170.0
☐	N-Nitrosodiethylamine	55-18-5	0.4	28.0	280.0
☐	N-Nitrosodimethylamine	62-75-9	0.4	2.3	23.0
☐	N-Nitrosodiphenylamine	86-30-6	0.92	13.0	130.0
☐	N-Nitrosomethylethylamine	10595-95-6	0.4	2.3	23.0
☐	N-Nitrosomorpholine	59-89-2	0.4	2.3	23.0
☐	N-Nitrosopiperidine	100-75-4	0.013	35.0	350.0
☐	N-Nitrosopyrrolidine	930-55-2	0.013	35.0	350.0
☐	Naphthalene	91-20-3	0.059	5.6	56.0
☐	2-Naphthylamine	91-59-8	0.52	N/A	N/A
☐	5-Nitro-o-toluidine	99-55-8	0.32	28.0	280.0
☐	o-Nitroaniline	88-74-4	0.27	14.0	140.0
☐	p-Nitroaniline	100-01-6	0.028	28.0	280.0
☐	Nitrobenzene	98-95-3	0.068	14.0	140.0
☐	o-Nitrophenol	88-75-5	0.028	13.0	130.0
☐	p-Nitrophenol	100-02-7	0.12	29.0	290.0
☐	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	0.05
☐	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	0.05
☐	Oxamyl	23135-22-0	0.056	0.28	2.8
☐	Parathion	56-38-2	0.014	4.6	46.0
☐	PeCDDs (All Pentachlorodibenzo-p-dioxins)	36088-22-9	0.000063	0.001	0.01
☐	PeCDFs (All Pentachlorodibenzo-furans)	30402-15-4	0.000035	0.001	0.01
☐	Pebulate	1114-71-2	0.042	1.4	14.0
☐	Pentachlorobenzene	608-93-5	0.055	10.0	100.0
☐	Pentachloroethane	76-01-7	0.055	6.0	60.0
☐	Pentachloronitrobenzene	82-68-8	0.055	4.8	48.0
☐	Pentachlorophenol	87-86-5	0.089	7.4	74.0
☐	Phenacetin	62-44-2	0.081	16.0	160.0
☐	Phenanthrene	85-01-8	0.059	5.6	56.0
☐	Phenol	108-95-2	0.039	6.2	62.0
☐	1,3-Phenylenediamine	108-45-2	N/A	N/A	N/A
☐	o-Phenylenediamine	95-54-5	N/A	N/A	N/A
☐	Phorate	298-02-2	0.021	4.6	46.0
☐	Phthalic acid	100-21-0	0.055	28.0	280.0
☐	Phthalic anhydride	85-44-9	0.055	28.0	280.0
☐	Physostigmine	57-47-6	0.056	1.4	14.0
☐	Physostigmine salicylate	57-64-7	0.056	1.4	14.0
☐	Promecarb	2631-37-0	0.056	1.4	14.0
☐	Pronamide	23950-58-5	0.093	1.5	15.0
☐	Propanenitrile	107-12-0	0.24	360.0	3600.0
☐	Propham	122-42-9	0.056	1.4	14.0
☐	Propoxur	114-26-1	0.056	1.4	14.0
☐	Prosulfocarb	52888-80-9	0.042	1.4	14.0
☐	Pyrene	129-00-0	0.067	8.2	82.0
☐	Pyridine	110-86-1	0.014	16.0	160.0
☐	Safrole	94-59-7	0.081	22.0	220.0
☐	Sulfide	18496-25-8	14.0	N/A	N/A
☐	2,4,5-T	93-76-5	0.72	7.9	79.0
☐	TCDDs (All Tetrachlorodi-benzo-p-dioxins)	41903-57-5	0.000063	0.001	0.01
☐	TCDFs (All Tetrachlorodibenzofurans)	30402-14-3	0.000063	0.001	0.01
☐	2,4,5-TP (Silvex)	93-72-1	0.72	7.9	79.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14.0	140.0
☐	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6.0	60.0
☐	1,1,2,2-Tetrachloroethane	79-34-5	0.057	6.0	60.0
☐	Tetrachloroethylene	127-18-4	0.056	6.0	60.0
☐	2,3,4,6-Tetrachlorophenol	58-90-2	0.03	7.4	74.0
☐	Thiodicarb	59669-26-0	0.019	1.4	14.0
☐	Thiophanate-methyl	23564-05-8	0.056	1.4	14.0
☐	Toluene	108-88-3	0.08	10.0	100.0
☐	Total PCBs (Polychlorinated biphenyls)	1336-36-3	0.1	10.0	100.0
☐	Toxaphene	8001-35-2	0.0095	2.6	26.0
☐	Triallate	2303-17-5	0.042	1.4	14.0
☐	Tribromomethane	75-25-2	0.63	15.0	150.0
☐	2,4,6-Tribromophenol	118-79-6	0.035	7.4	74.0
☐	1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	0.057	30.0	300.0
☐	1,2,4-Trichlorobenzene	120-82-1	0.055	19.0	190.0
☐	1,1,1-Trichloroethane	71-55-6	0.054	6.0	60.0
☐	1,1,2-Trichloroethane	79-00-5	0.054	6.0	60.0
☐	Trichloroethylene	79-01-6	0.054	6.0	60.0
☐	Trichloromonofluoromethane (R11)	75-69-4	0.02	30.0	300.0
☐	2,4,5-Trichlorophenol	95-95-4	0.18	7.4	74.0
☐	2,4,6-Trichlorophenol	88-06-2	0.035	7.4	74.0
☐	1,2,3-Trichloropropane	96-18-4	0.85	30.0	300.0
☐	Triethylamine	121-44-8	0.081	1.5	15.0
☐	Tris(2,3-dibromopropyl) phosphate	126-72-7	0.11	0.1	1.0
☐	Vernolate	1929-77-7	0.042	1.4	14.0
☐	Vinyl chloride	75-01-4	0.27	6.0	60.0
☐	Xylene	1330-20-7	0.32	30.0	300.0
☐	2,4-Xylidine	95-68-1	0.01	0.66	6.6
☐	Antimony	7440-36-0	1.9	1.15	11.5
☐	Arsenic	7440-38-2	1.4	5.0	50.0
☐	Barium	7440-39-3	1.2	21.0	210.0
☐	Beryllium	7440-41-7	0.82	1.22	12.2
☐	Cadmium	7440-43-9	0.69	0.11	1.1
☐	Chromium	7440-47-3	2.77	0.6	6.0
☐	Lead	7439-92-1	0.69	0.75	7.5
☐	Mercury	7439-97-6	0.15	0.025	0.25
☐	Nickel	7440-02-0	3.98	11.0	110.0
☐	Selenium	7782-49-2	0.82	5.7	57.0
☐	Silver	7440-22-4	0.43	0.14	1.4
☐	Thallium	7440-28-0	1.4	0.2	2.0
☐	Vanadium	7440-62-2	4.3	1.6	16.0
☐	Zinc	7440-66-6	2.61	4.3	43.0

Notifications/Certifications #8

WPF # _____

Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.40 to remove the hazardous characteristic and that underlying hazardous constituents, as defined in 268.2(i) have been treated on-site to meet the 268.48 universal treatment standards. I am aware that there are significant penalties for submitting a false certification, including the possibility of fine and imprisonment.

PAUL GONZALES (169004)
Authorized Signature

I certify under the penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification. Based on my inquiry of those individuals immediately responsible for obtaining this information, I believe that the treatment process has been operated and maintained properly so as to comply with the treatment standards specified in 40 CFR 268.40 without impermissible dilution of the prohibited waste. I am aware that there are signficant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

PAUL GONZALES (169004)
Authorized Signature

Attachment 1 - Additional Radionuclides

Please list the supplimentary radionuclides and their concentration values.

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 2 – Leininger 2020

High Explosives Report:

Leininger, L.D., *et al.*, May 2020. *IHE Material and IHE Subassembly Qualification Test Description and Criteria*, Vol. 14.7.

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IHE Material and IHE Subassembly Qualification Test Description and Criteria

May 14, 2020
Version 14.7

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LLNL-TR-679331 LA-UR-15-29238 (version 13.5)	November 17, 2015 (Updated June 7, 2016)	Initial Release
LLNL-TR-679331-REV-1 LA-UR-15-29238 (version 14.7)	May 14, 2020	• Test details of the Deflagration to Detonation Transition (DDT) experiment specified. • High temperature Shock to Detonation (SDT) experiment temperature setpoint from DDT high temperature experiment, instead of from an additional cookoff test. • No substantive changes to the Skid Test • Number of Bullet Tests reduced from 6 to 3 for each of 2 bullet types. • No substantive changes to IHE Subassembly Definitions

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Insensitive High Explosive (IHE) Materials and Subassemblies

As defined in Chapter 16 of the DOE Explosive Safety Standard (DOE-STD-1212), IHE Materials are mass-detonable explosives that are so insensitive that the probability of accidental initiation or transition from burning to detonation is negligible. The test series to qualify an IHE material contains the following elements:

1. Deflagration-to-Detonation Transition (DDT)
2. Shock-to-Detonation Transition (SDT)
3. Skid Test
4. Bullet Test

For explosives that do not meet the qualification criteria of an IHE material, there is a test series to qualify as an IHE subassembly in a smaller, weapon-system relevant, configuration. The IHE Subassembly Qualification Test Series contains the following elements:

1. DDT of individual subassembly materials in relevant, conservative, scales to application
2. SDT material test of the main charge only
3. Skid Test
4. Multiple Bullet Impact Test

The first section of this document defines the DDT, SDT, Skid, and Bullet tests that comprise the IHE Material Qualification Test Series.

The second section of this document describes the tests that are required for the IHE Subassembly Qualification Test Series. These tests are described in more general terms, as some details will depend on the configuration and materials of the specific IHE subassembly being tested.

The qualification and approval process described herein is limited to the Department of Energy (DOE) and nuclear weapons applications.

These definitions were approved by vote of the DOE/NNSA Explosive Safety Committee in May 2016 and are required for any new material or subassembly proposed that is not already noted as approved in DOE-STD-1212.

Section 1

IHE Material Qualification Test Series

2.1 Deflagration-to-Detonation Experiment

1.1.1 Introduction

The purpose of the deflagration-to-detonation test is to demonstrate that an IHE material will not undergo deflagration-to-detonation transition (DDT) under stockpile relevant conditions of scale, confinement, and material condition. Inherent in this test design is the assumption that ignition does occur, with onset of deflagration. The test design will incorporate large margins and replicates to account for the stochastic nature of DDT events.

1.1.2 Underlying Physics

DDT in condensed-phase, inhomogeneous, explosives is a significantly more complex process than shock-to-detonation transition (SDT), comprising a number of distinct steps:

1. Ignition of reaction.
2. Conductive burning, in which the ignition front advances by thermal conduction.
3. Convective burning, in which the ignition front advances by penetration of hot, gaseous, products.
4. Compaction of the unreacted explosive ahead of the ignition front by pressurization due to the reaction products, choking off the convective process.
5. Downstream plug formation.
6. Shock formation at the downstream plug boundary.
7. SDT

This process is dependent on:

1. Decomposition chemistry and kinetics: intrinsic properties that control pre-ignition decomposition, which affect the degree of porosity developed at elevated temperature prior to ignition and, consequently, the compaction characteristics of the material. They also determine deflagration rate as a function of pressure; faster favors reaction build up and shorter run-to-detonation distances.

2. Mechanical properties: rate-dependent intensive intrinsic properties that control deflagration rate as a function of accessible surface area via strain-rate-dependent fracture properties, and also determine compaction and plug formation.

This combination of complex factors puts a quantitative understanding of the phenomenon beyond our current modeling capabilities but, since we understand the trends arising from each factor, we can bound the problem by experimental exploration of worst-case scenarios with a limited number of replicates.

Accordingly, the proposed DDT test is highly conservative in terms of the external (to the explosive) parameters of importance, specifically confinement and charge size. The metric is the absence of transition to detonation in a charge size and geometry that permits a significantly longer run distance, and which is subject to much stronger and more massive confinement, than any configuration of relevance to a nuclear weapon.

1.1.3 DDT Test Configuration and Diagnostics

A representative apparatus is shown in Figure 1, and described as follows:

- Heavily confined explosive samples with long run length.
    - Confinement is provided by a thick-walled steel cylinder (yield strength of the steel to be ~36 ksi (or larger); should be widely-available commercially:
        - 3 inch nominal internal diameter,
        - 2 inch wall thickness, and
        - ~40 inches long to accommodate explosive column, head space, and end caps
    - Both ends are sealed with threaded end caps. End cap shall be 2 inches thick in the axial direction and 1.5 inch thick in the radial direction. Length of thread engagement shall be 4 inches. If threaded end caps are undesirable, alternate closure hardware may be used instead, provided confinement is demonstrated to be equivalent (if alternate end cap design is employed, justification demonstrating confinement equivalence must be approved by the DOE/NNSA IHE Qualification Update Group).
    - One end cap possesses an igniter system, typically comprised of a hot-wire embedded in pyrotechnic. The gap between the ignitor and the explosive column should not exceed ¼ inch to ensure the system can reliably ignite deflagration in the explosive; failure to ignite the explosive does not constitute a “passing”. In the event that the igniter fails to ignite deflagration in the explosive, re-ignition may be attempted on the assembly.
    - The other end cap possesses a vent hole; ~1/8 inch diameter. This vent hole permits slow gas products to escape, avoiding quasi-static pre-pressurization of the tube, but is too small of a diameter to provide significant venting when cookoff occurs (a choked flow condition is attained when the explosive deflagrates).
    - Length of the explosive column is 36 inches and shorter than the bore length, to leave an initial axial ullage of ~1/2 ± 0.1 inch. This ullage allows for thermal expansion of the explosive column, permitting porosity to develop that might increase the likelihood of DDT. Alternate ullage lengths are permissible if they meet the intent.

  - Additional penetrations of the tube are permissible (e.g. for internal thermocouple or pressure diagnostics) provided they do not compromise the mechanical confinement of the tube. If postmortem analysis reveals failure of confinement at the feedthrough location, the validity of the test confinement must be justified.

- Externally heated tube with external temperatures recorded during the long-duration thermal heating of the assembly, at a rate ≥ 0.25 Hz (the temperature rise during dynamic event does not need to be resolved).
- Test may be executed with tube in any orientation (horizontal, igniter on top, igniter on bottom). If the test is oriented with the igniter on top, care must be taken that explosive successfully ignites even if internal slumping takes place during the thermal conditioning and there is a gap between the ignitor system and the explosive column.
- Two material states examined are (1) typical charge density and (2) surrogate damaged material utilizing pressing prills (molding powder) of the candidate material.
    1. Consolidated explosive can be in the form of multiple stacked uniaxially pressed pellets, provided the pellet density is within ±1% of production density material. The diametral clearance between explosive pellets and bore at ambient temperature shall be small enough so that thermal expansion during heating develops an interference fit once the explosive reaches 10°C below the critical temperature for the experiment, with consideration given to the Coefficient of Thermal Expansion (CTE) of the explosive being tested. This interference fit prevents gas flow between the explosive and the wall of the tube, so burning will progress through the bulk explosive and not at the edges.
    2. Pressing prills (molding powder) shall be loaded into the bore via "pouring" with no additional packing pressure applied. This assembly method will achieve a "pour density" test configuration, which constitutes the lowest handling density of material and a worse-case scenario with regards to surface area available for deflagration. Pour density attained shall be reported as part of the test record and will be calculated from the mass of the material used and the nominal volume of the bore.
- The IHE candidate material is evaluated in two configurations:
    1. In one configuration, the explosive self-ignites from heating, similar to a cookoff test. (Although the igniter system is not required for this test configuration, any through holes in the non-vented cap end of the tube shall be plugged.). This configuration is used to establish a "critical temperature", T_c.
    2. In a second configuration, after reaching a set elevated temperature, which is slightly below the established critical temperature, deflagration is ignited by a donor pyrotechnic.
- Diagnostics:
    - External tube temperatures (e.g. thermocouples).
    - Post-reaction examination of the confinement tube, particularly fragment size distribution.
    - Velocimetry (e.g. PDV) on the tube wall close to the vented end to quantify the presence (or lack of) detonation at the end of the tube. PDV diagnostics may be optional if the occurrence of DDT can be successfully ascertained by comparison with deliberately-detonated tubes (e.g. postmortem analysis of fragments).

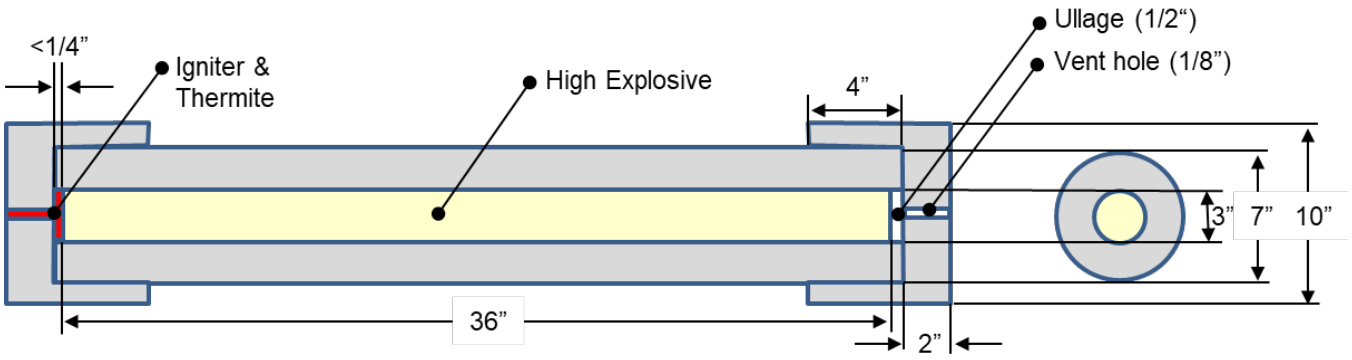

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Figure 1: Conceptual configuration of IHE Deflagration-to-Detonation Transition (DDT) IHE experiment.

1.1.3.1 Test Conditions

First test series (slow cook-off ensures ignition at the center of the charge):

- Production density explosive is heated ~20˚C/hr until self-ignition occurs. Intent of heating rate is to achieve no more than 10˚C radial temperature difference.
- The control location for temperature shall be a measurement of the external surface of the central tube, at the midpoint of the long dimension of the tube. The temperature measurement will not be in contact with a heating element, shall be adequately insulated from ambient air conditions, and adhered to the metal to ensure that the measurement accurately represents the surface temperature of the tube.
- The temperature of this control thermocouple when explosion occurs will be designated Tc (critical temperature) for the purpose of this experiment. It is understood that this critical temperature is not directly indicative of the explosive temperature necessary to induce self-ignition, but rather as a fiducial reference for conducting subsequent experiments. Designating a critical temperature using exterior thermocouples provides a test method that avoids the challenge of diagnosing internal temperatures without compromising the confinement of the assembly.
- This test configuration is identically repeated twice more for a total of three tests. The lowest Tc obtained of the three tests is used as the Tc for subsequent testing.
- External temperature difference is measured along the length of the central tube and shall not exceed 10 ˚C during heating.

Second test series:

- Production density explosive is heated at the same ramp rate of ~20˚C/hr to 10˚C below Tc, then promptly ignited with a pyrotechnic composition.
- If the final recorded temperature is higher than 10˚C below Tc, the test remains valid; the final recorded temperature must be ≥ [Tc-10˚C].

Third test series:

- Pour density molding powder is tested identically (heated at ~20˚C/hr to 10˚C below Tc, then promptly ignited with a pyrotechnic composition).
- If the final recorded temperature is higher than 10˚C below Tc, the test remains valid; the final recorded temperature must be ≥ [Tc-10˚C].

1.1.3.2 Number of Tests

Three tests at each test series (9 total). As mentioned above, all three repeats of the first configuration are performed first in order to determine the lowest Tc; that Tc is used for the remaining two series. The purpose of the triplicate execution of the second and third configurations is to establish a measure of statistical repeatability. If substantive variations in test outcome are observed—even if no test exhibits DDT—the validity of the test series must be reviewed by the DOE/NNSA IHE Qualification Update Group.

1.1.3.3 Quantity of Explosive Required

- ~8 kg per production density explosive test.
- ~5 kg per molding powder explosive test.
- ~63 kg for nine tests.

1.1.3.4 Criteria for Qualifying as IHE

No development of a detonation wave within the tube length in any test as confirmed by post-test examination of the tube and/or by fielding velocimetry.

- If velocimetry diagnostics are not fielded, two additional deliberate detonation tests must be performed to provide a baseline against which to compare the qualification test results. One tube is deliberately detonated with production-density explosive, the other with the pour density molding powder. For both tests, a section of central tube ≥ 1 ft long (otherwise with the same bore diameter and wall thickness) will be filled at one end with 6 inches of explosive material. A detonator and booster will be placed in contact with the inside surface of the explosive fill and deliberately detonated. No end caps are required. The failure morphology of the tube obtained from these deliberate detonation baseline tests can be used in comparison with the qualification testing to establish whether detonation occurred.

OR

- Absence of DDT may be diagnosed with velocimetry data.

2.2 Shock-to-Detonation Experiment

1.2.1 Introduction

The purpose of the shock-to-detonation experiment is to demonstrate that the IHE will not undergo shock-to-detonation transition (SDT) under a defined shock stimulus at ambient temperature, which differentiates the SDT behavior of IHEs from the SDT behavior of Conventional High Explosives (CHEs). Note that any explosive, IHE or CHE, must undergo SDT at some shock stimulus for a nuclear weapon to function as designed.

In addition to the defined ambient-temperature shock stimulus, an additional SDT experiment is required at high temperature, to show that the explosive is not excessively sensitized by exposure to high-temperature conditions.

The ambient-temperature threshold shock stimulus was developed based on consideration of the shock sensitivity of a set of CHEs and currently recognized IHEs (Gresshoff, 2018). Figure 2 shows the shock sensitivity of CHEs and IHEs represented as a threshold SDT pressure as a function of shock duration.

Figure 2 is based on run-to-detonation, or Pop-Plot, data for TATB-based (LX-17, PBX 9502, and UF-TATB) and HMX-based (LX-04, PBX 9501, LX-07-2, and LX-10) high explosives scaled to the shock initiation threshold based on short-pulse initiation data for LX-17 and LX-04 (Gresshoff, 2018). There is some uncertainty in this scaling; however, the shock duration for the SDT threshold was chosen with this in mind and was necessary as the run-to-detonation distance is unknown for a future candidate IHE. As pressure is decreased, the shock duration required for SDT increases until a pressure is reached where there is no SDT regardless of the shock duration. HMX and TATB cut-offs are estimated at ~1.5 and ~7.5 GPa respectively for the HEs evaluated in this study and published in the literature. It is expected that SDT does not occur below these pressures, even for very long shocks. The figure indicates the SDT criterion for a sustained shockwave (3 μs duration) is 3.5 GPa.

Previous work on IHE Qualification of TATB (PBX 9502, LX-17, and UF-TATB) show data from Pantex Plant (Slape, 1984) which suggest that IHE qualification with the No. 8 Blasting Cap detonator was performed on both molding powder and “compacted” parts at nominal density. Although it was never written in DOE-STD-1212 (which prescribes TB 700-2 protocol for transportation and storage with molding powder), this history suggests a precedence for short-duration, high pressure, Taylor wave-type, loading of pressed parts as a component of the material definition. Hydrocode calculations of the Pantex Modified NOL Card Gap test showed that the upper limit of output for a Taylor wave into Explosive D is approximately 5.3 GPa. The lower limit of duration available for a gas gun flyer plate design is approximately 0.5 μs duration (cap duration is expected to be longer, but a Taylor wave). Therefore, the criterion for short pulse shockwave is prescribed to be 5.3 GPa at 0.5 μs and noted on Figure 2.

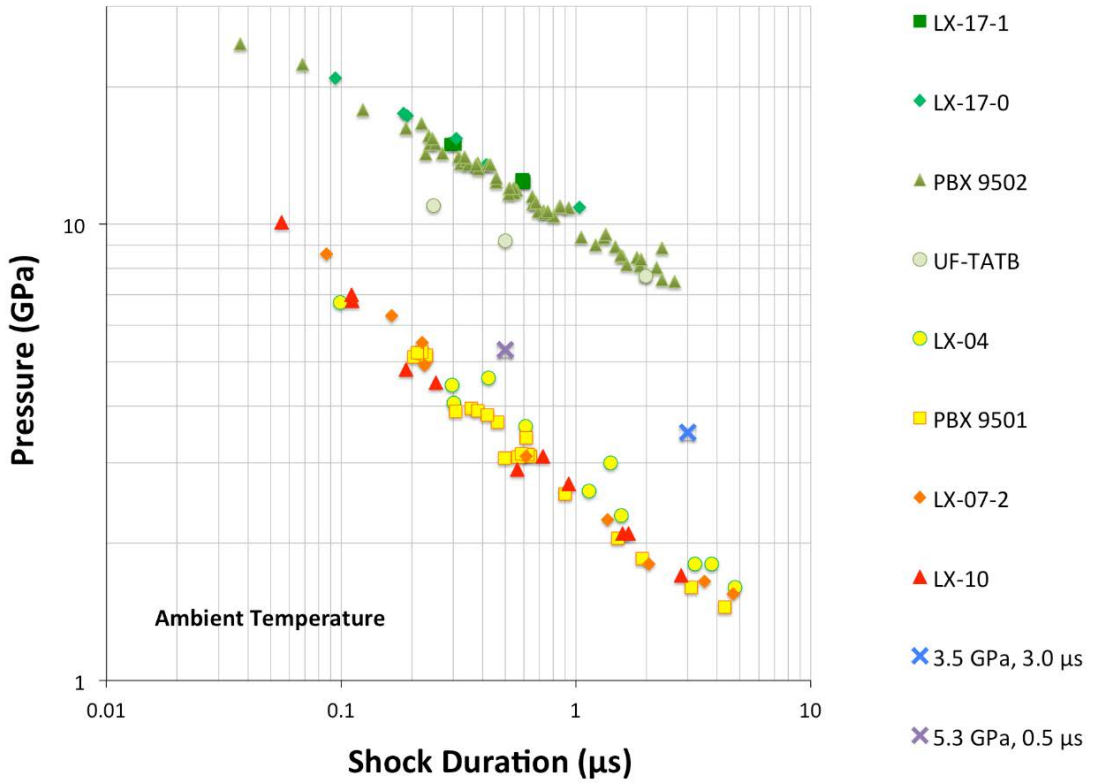


Figure 2. Shock sensitivity of several DOE explosives scaled from Pop-Plot data, showing the separation in behavior between IHEs and CHEs. The TATB-based IHEs (LX-17, PBX 9502, and UF-TATB) form a family with significantly lower shock sensitivity than the HMX-based CHEs (LX-04, PBX 9501, LX-07, and LX-10). The SDT criterion for IHEs is no evidence of detonation for a log-pulse (3 µs duration) of 3.5 GPa and a short-pulse (0.5 µs duration) of 5.3 GPa.

A second experimental series is required to evaluate SDT at high temperature. Virtually all known explosives are sensitized to SDT at high temperatures. It is important that the degree of sensitization to shock not be so high that the heated explosive represents a severe SDT hazard. The hazard is likely worse at the highest temperature where the explosive will survive, and the risk is that the explosive is extremely shock sensitive (e.g. an explosive that passes that SDT criteria at ambient, but recovers primary-like shock sensitivity at high temperatures is undesirable). The shock criterion for a heated test is substantially lower than criterion for the ambient temperature test. High-temperature shock sensitivity data for some IHEs and CHEs are shown in Figure 3 (Gresshoff, 2018). Because short-pulse data is not widely known for HEs at temperature, the data in the graph is still in the standard “Pop-Plot” format revealing pressure and run distance to detonation.

Also shown in Figure 3 is the new IHE criterion for high-temperature shock sensitivity – absence of shock-to-detonation transition with a 1.5 GPa shock sustained for at least 3 µs. The high-temperature testing must be done at a temperature that involves the effect of phase changes or other physical changes. For this reason, the test temperature is defined as the temperature 10°C below that which the explosive is expected to thermally explode, which will be a worst-case test for thermal sensitization.

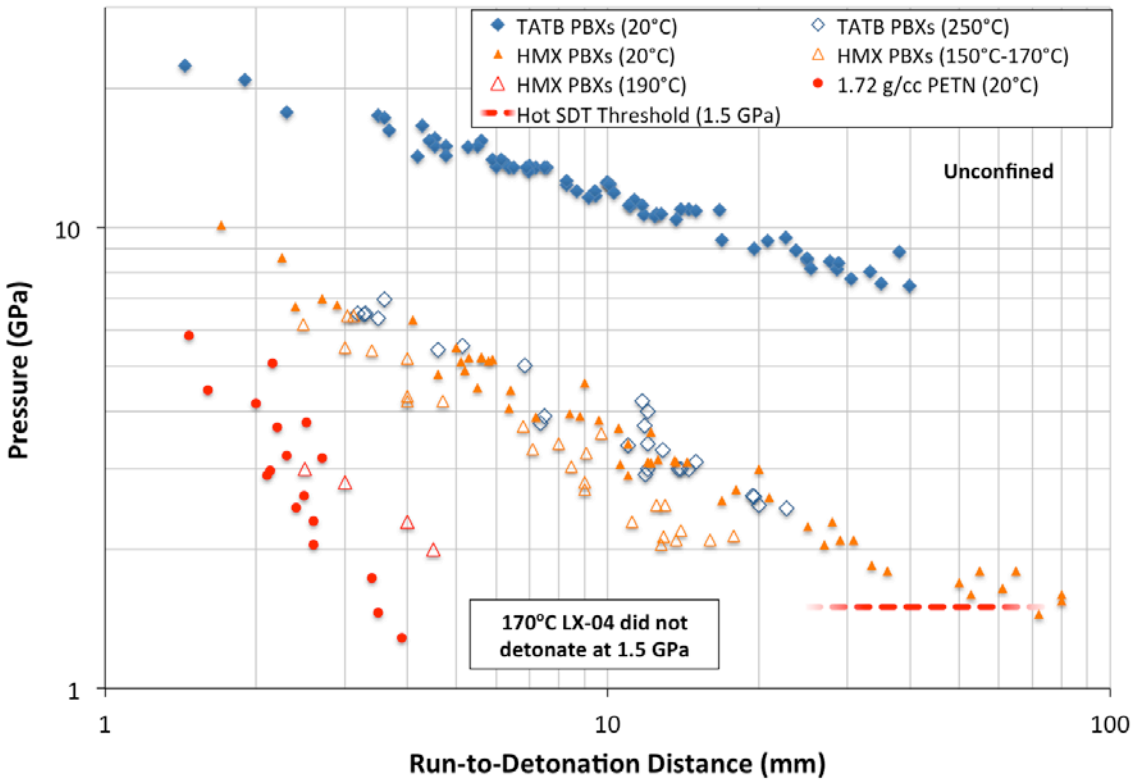


Figure 3. Shock sensitivity of several DOE explosives at high temperatures. The elevated-temperature SDT criterion of 1.5 GPa is shown as a dotted line as run-to-detonation distance is unknown in future candidate IHEs.

1.2.2 Underlying Physics

In the accepted understanding of shock-to-detonation transition (SDT) in composite solid explosives, interaction of the shock front with voids, interfaces, or other irregularities in the solid results in development of localized hot spots. If the shock is sufficiently strong and long-lasting, these hot spots react, coalesce, and release chemical energy fast enough to accelerate the shock wave until it forms a detonation. If the shock is too low in magnitude or duration, the hot spots may not react, or may quench before coalescing, and transition to detonation does not occur.

In addition to shock magnitude and duration, other factors are very important in SDT. The shock duration determines the time until a rarefaction from the rear of the sample reduces the shock pressure and may quench the reaction. Rarefaction waves from the side of explosive samples will have a similar effect, with the rarefaction penetrating farther from the edge as the shock travels from the impact surface. Shocks driven by small-diameter impactors similarly have rarefaction waves from the side that will quench the reaction. Therefore, size of explosive sample and diameter of the impactor driving the shock wave are important. If the shock is not planar or is not parallel to the explosive surface, these interactions are even more complex. If the shock wave at a surface is reflected back into the sample by a higher-impedance material, this also may have a strong effect on the SDT response.

To make the IHE test for SDT as unambiguous and reproducible as possible, it is specified as a 1-dimensional planar shock input with long duration. The explosive sample diameter and length are specified to avoid the effect of rarefactions from the side, while also allowing enough distance for the shock to run before side rarefactions come into play.

The propagation rate of the shock or reaction front provides a clear delineation between an unreacted shock and a detonation wave. Diagnostics are embedded in the explosive sample to measure either pressure or particle velocity, *in situ*, and measure if the shock wave is building to a detonation or is failing. The use of such diagnostics is an important element of these tests, as a reacting shock wave that may not have reached detonation conditions is a quite different response than an unreacted, or failing, shock front.

Sensitization of explosives at high temperature is driven by physical transformations in the explosive. For TATB plastic-bonded explosives, the shock sensitivity at 250°C is caused by the irreversible ratchet growth with formation of additional voids that sensitize the explosive to shock; when TATB explosives are physically confined, the shock sensitivity is significantly reduced. For HMX plastic-bonded explosives, the shock sensitivity is only slightly increased by heating to 150°C; the large increase in sensitivity at 190°C is caused by the beta-to-delta phase transition in HMX with the resultant formation of additional voids. To evaluate a candidate IHE, testing must be done at a sufficiently high temperature to include the effect of phase changes or other physical changes. The worst-case conditions are those in which the explosive is heated just below the temperature at which it will thermally decompose. This temperature is dependent on the thermal stability of the explosive, and on the configuration (e.g., size) of the explosive sample, and therefore the test temperature cannot be defined *a priori*. Instead, it is defined as the temperature 10°C below that at which the explosive will thermally explode in a relevant configuration.

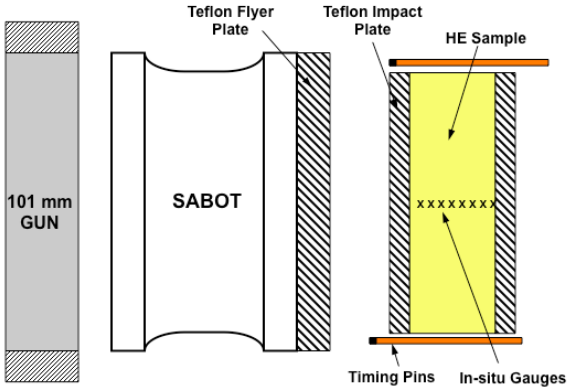
1.2.3 SDT Test Configuration and Diagnostics

- Use gun to achieve reproducible 1-D planar shock into sample.
- Ambient temperature test:
    - 3.5 GPa, >3.0 μs
    - 5.3 GPa, >0.5 μs
- High temperature test:
    - Explosive is heated at a ramp rate of ~20˚C/hr to a set point of [Tc-10 ˚C], where Tc is the temperature determined in the DDT cook-off test as measured on the boundary of the sample.
    - 1.5 GPa, >3.0 μs
- Explosive sample diameter and length sufficient to ensure 1-D shock:
    - diameter: ~60-90 mm (~2.5-4 inches).
    - length: ~30-45 mm (~1-1.5 inches).
- Explosive density: within the production range for the application.

- Diagnostics:
  - Embedded gauges (pressure or particle velocity) at several distances from the shock front.
  - Other standard diagnostics to measure impact velocity.
- To achieve shock pressures and durations for the 1D collision of a teflon impactor (2.15 g/cc, C_o=2.08 mm/μs, S_1=1.62) on an LX-17 IHE sample (1.9 g/cc, C_o=2.5 mm/μs, S_1=2.1) at room temperature (configuration shown in Figure 4):
  - 3.5 GPa for 3 μs:

    6 mm thick flyer at 1 km/s
  - 5.3 GPa for 0.5 μs:

    1 mm thick flyer at 1.5 km/s



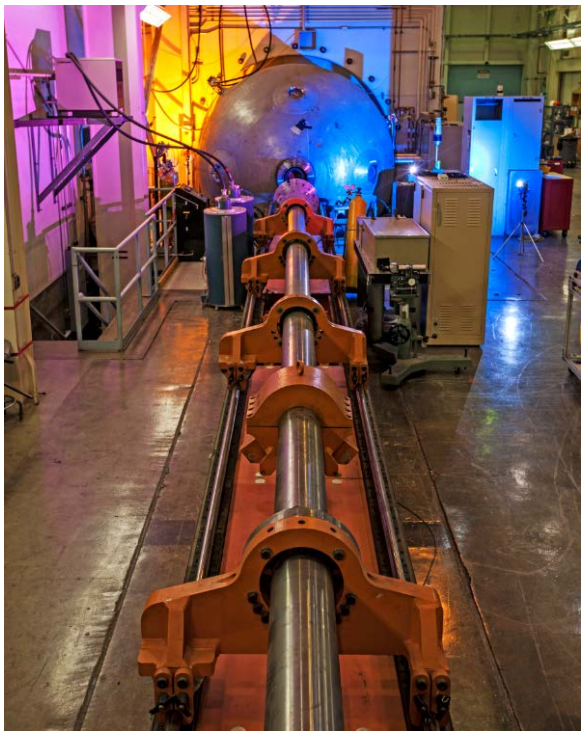


Figure 4. Example of SDT test configuration in the 100 mm gun at LLNL's High Explosive Application Facility (HEAF). Other similar configurations will give the same type of data and are equally acceptable. Elevated-temperature shock tests require heaters and thermocouples integrated into the target assembly.

1.2.3.1 Test Conditions

- Temperature
  - Ambient temperature: ~ 25°C.

    - High temperature: 10°C below the thermal explosion temperature for the explosive from the DDT cook-off experiment.
- Shock input to explosive with symmetric flyer/impact surface.
- Embedded diagnostics.

1.2.3.2 Number of Tests

- Three replicate tests at each temperature.

1.2.3.3 Quantity of Explosive Required

- ~600 g per test.
- ~1,800 g for three tests at each temperature.
- ~3.6 kg total.

1.2.3.4 Criteria for Qualifying as IHE

- No development of detonation wave in the explosive as shock progresses through the sample.
- Reaction wave, if any, is failing as the end of the sample is approached, as shown by the pressure or particle velocity gauges.

2.3 Skid Test

1.3.1 Introduction

The purpose of the skid test is to show that bare billets of explosive will not react with significant violence when subjected to a very severe drop environment, far worse than is anticipated in any actual handling accident.

For this test, which is a worker safety test, the acceptance criteria are based on worker safety concerns rather than detonation. As described below, the worst-case response for an explosive that has passed the skid test is non-violent explosive reaction.

The pendulum apparatus used in this skid test was first developed by Los Alamos National Laboratory in 2013 (Parker et al., 2020) and was conceived and designed to capture the underlying physics of reaction which had only previously been observed in "outlier data" as reported from the standard skid tests (Slape, 1984; Garrow, 2015). The new pendulum configuration allows exquisite control of the strike surface location, angle, and drop height such that potential reaction can be imaged to quantify the hazard and the experiment is highly repeatable. The apparatus has been designed to provide equivalent loading to the previously used vertical free-fall apparatus, with improved diagnostics.

1.3.2 Underlying Physics

The physical mechanisms governing explosive response in the skid test are very complex. Impacts such as those encountered from any conceivable drop height are incapable of driving a shock-to-detonation response. Ignition and deflagration is the worst possible outcome. The initial impact of an explosive causes compression and/or fracture with simultaneous conversion of mechanical energy to heat by frictional heating, which is generally grit-mediated. If the thermal energy is sufficient to ignite the explosive, and depending on the surface area that is produced by the fracture that may then become incorporated into the reaction, the ensuing response may range from a few points of light, to a rapid deflagration, to a detonation. If the DDT test described previously has been successfully completed before the skid test is executed, then the most violent response of a detonation is not possible, and the worst case is a rapid deflagration.

1.3.3 Skid Test Configuration and Diagnostics

- Pendulum skid impact test based on the new LANL Skid Test apparatus (Parker et al., 2020) shown in Figure 5
- Hemispherical sample, 28 cm diameter, of production density explosive
- Target surface will be gritty glass or steel.
    - Grit particles must be loose or weakly bonded such that they break free during impact.
    - Level of grit (silica sand, mean diameter ~600 μm) should be sufficient to cover the strike surface, while still providing space between grit (typical coverage: areal density ~$2x10^5$ particles/m^2) (Heatwole et al, 2015)
- Diagnostics: High-speed video side-on to impact plane and through target plate if transparent

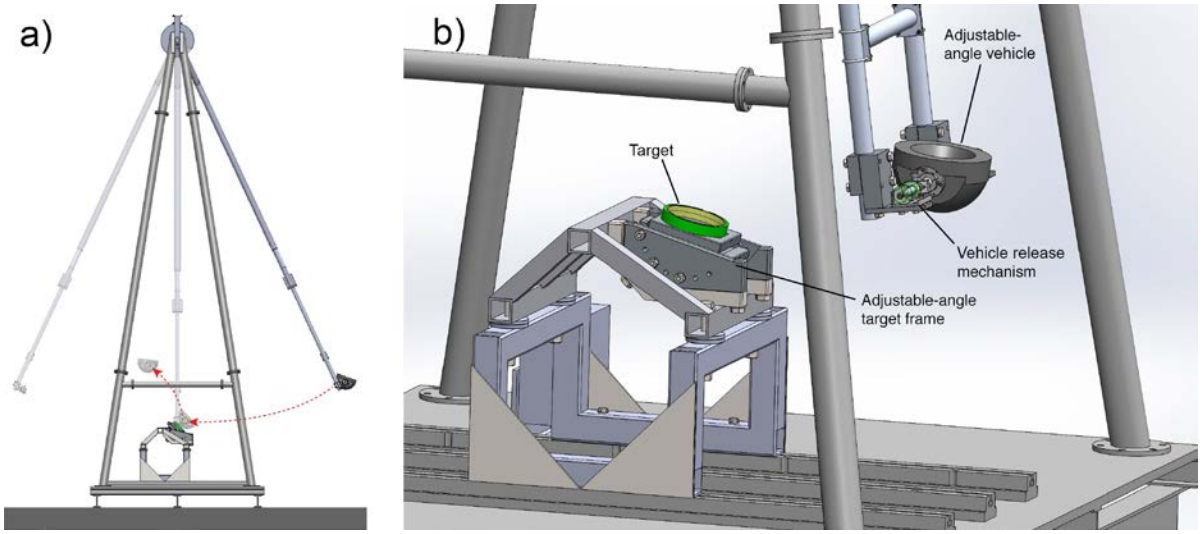


Figure 5. Pendulum skid impact test based on the new LANL Skid Test apparatus. (a) arm length = 15 ft (b) hemispherical charge rests in cradle, free to escape (bounce) upon contact with target.

1.3.3.1 Test Conditions

- Initial test configuration: Production machined hemisphere at ambient temperature
- Impact angle of 45˚
- Initial equivalent drop height of 12 ft. "Equivalent drop height" is the height at which the pendulum must be released in order to achieve an impact velocity that is equal to the impact velocity attained during vertical free-fall, i.e. $v = \sqrt{(2gh)}$. A 12 ft drop is a representative yet conservative worse-case height for handling accident scenarios involving workers manipulating a bare charge.

1.3.3.2 Number of Tests

- Three at 12 foot-equivalent drop height.

1.3.3.3 Quantity of Explosive Required

- ~10 kg per hemispherical charge.
- ~30 kg for three tests.

1.3.3.4 Criteria for Qualifying as IHE in the Skid Test

Reaction criteria (Note: These levels have been modified from levels in the original skid test which ranged from "0" for “no reaction” to "6" for “full detonation” (Garrow, 2015)). Image panels of the various reactions are shown in Figure 10 from Parker, et al. (2020):

- Reaction 0 is acceptable:
  - No visible smoke. No scorching of explosive surface. Video may show glowing abrasive particles from target surface.
- Reaction 1 is acceptable:
  - Visible smoke. Non-propagating, luminous ignition sites may be visible. Scorching of the explosive surface. No luminous flames are visible in high-speed videography from a side view.
- Reaction 2 is not acceptable:
  - Propagating, luminous flames are visible from high-speed videography. Postmortem examination reveals partial or complete disintegration of the explosive contact surface due to cracking induced by explosive reaction.

- The above criteria apply regardless of fracture of the explosive test object.
  - Occurrence of Reaction 2, or reaction violence exceeding Reaction 2, in any of the tests performed in the series, including tests where the charge fractured, disqualify the material as an IHE.

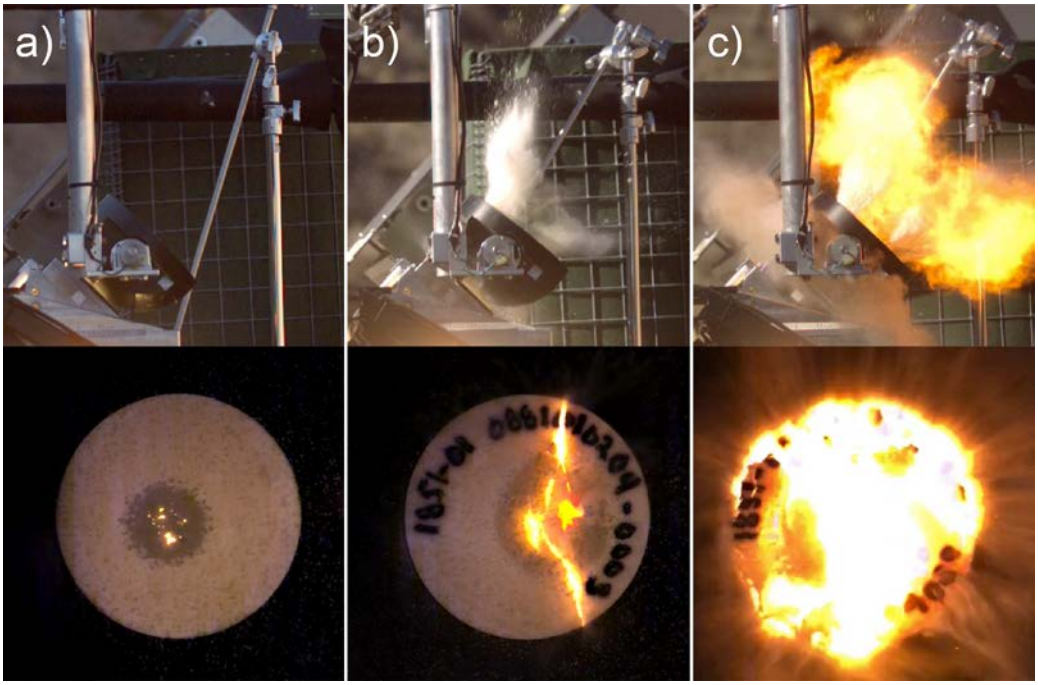


Figure 6. Examples of skid test reaction levels with a smaller, scaled, explosive charge. Three image pairs showing synchronous views from the side and through transparent impact surfaces: (a) Reaction 1, non-propagating luminous ignition sites, (b) Reaction 2, flame propagation into cracks, no fireball, and (c) Reaction 2, flame propagation and fireball.

2.4 Bullet Test

1.4.1 Introduction

The purpose of the bullet test is to show that an IHE does not react violently when impacted by a bullet under the conditions described below. This is a demonstration that the IHE is relatively unreactive to this type of stimulus and is not intended to prove that the IHE will not react to any sort of bullet or related stimulus. The ammunition selected is representative of threats to which the IHE will be exposed during its lifecycle but does not represent the worst possible case. The configuration represents the likely worst-case path of least resistance. Figure 10 shows an example of the response from this test for both HMX-based and TATB-based explosives.

1.4.2 Underlying Physics

Explosive response to the impact from a bullet is very complex. Typically, the bullet does not impart a shock to the explosive in such a way to cause shock-to-detonation transition, but instead provides input of mechanical and thermal energy to the explosive. The mechanical energy of the bullet impacting and tearing through the explosive is converted to thermal energy by the thermomechanical response of the explosive, and thermal energy from the hot bullet is deposited as the bullet travels through. This thermal energy may cause the explosive to ignite, and then may eventually lead to an explosion.

The mechanical response of the explosive is dependent on its configuration and confinement. The experimental configuration shown in Figure 7 offers a geometry somewhat representative of IHEs in their intended applications.

1.4.3 Bullet Test Configuration and Diagnostics

The test configuration is shown in Figure 7.

- Explosive sample is contained in a steel fixture with steel front and back plates.
- Bullets are shown in Figure 8 and Figure 9, and are 50 caliber, armor piercing, and military ball rounds.
- Bullet enters the sample through the front plate and exits through a plate-foam-plate stack-up.
- Diagnostics:
    - Include a method to measure the bullet velocity.
    - High-speed imaging to observe the target response for at least 10 seconds.

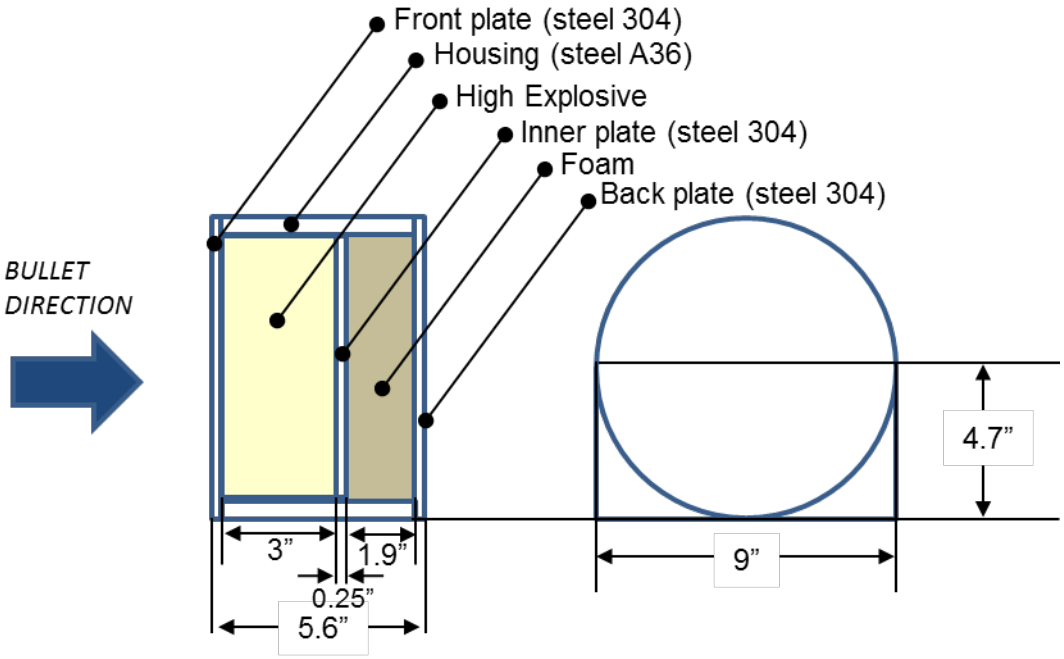
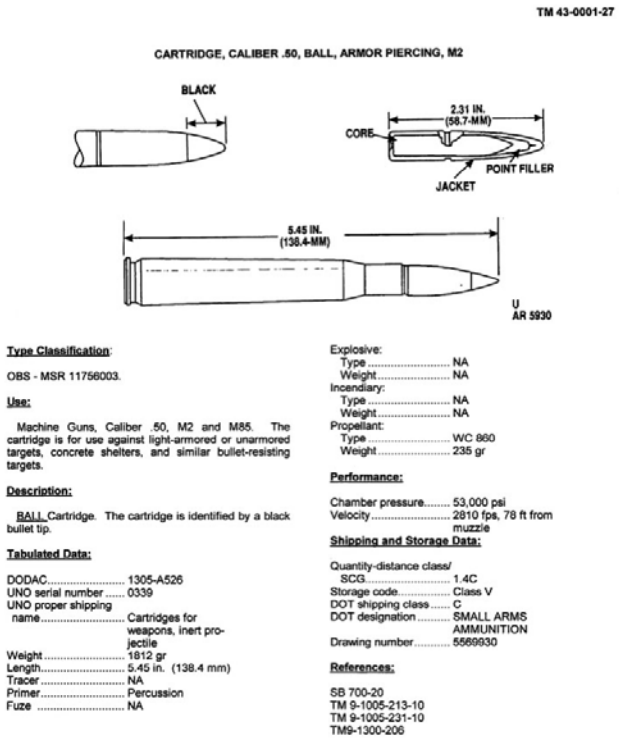


Figure 7. Conceptual configuration of IHE Qualification Bullet Test



TM 43-0001-27

CARTRIDGE, CALIBER .50, BALL, ARMOR PIERCING, M2

Type Classification:

OBS - MSR 11756003.

Use:

Machine Guns, Caliber .50, M2 and M85. The cartridge is for use against light-armored or unarmored targets, concrete shelters, and similar bullet-resisting targets.

Description:

BALL Cartridge. The cartridge is identified by a black bullet tip.

Tabulated Data:

DODAC	1305-A526
UNO serial number	0339
UNO proper shipping name	Cartridges for weapons, inert projectile
Weight	1812 gr
Length	5.45 in. (138.4 mm)
Tracer	NA
Primer	Percussion
Fuze	NA
Explosive:	
Type	NA
Weight	NA
Incendiary:	
Type	NA
Weight	NA
Propellant:	
Type	WC 860
Weight	235 gr

Performance:

Chamber pressure	53,000 psi
Velocity	2810 fps, 78 ft from muzzle

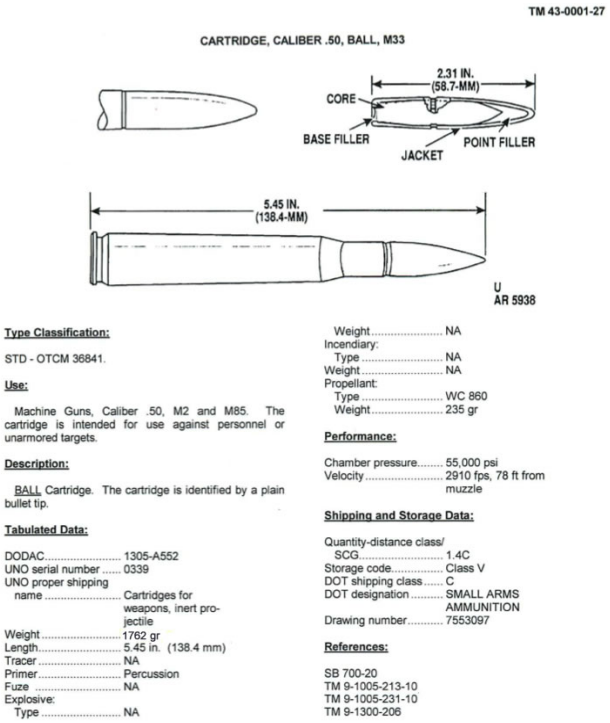
Shipping and Storage Data:

Quantity-distance class/ SCG	1.4C
Storage code	Class V
DOT shipping class	C
DOT designation	SMALL ARMS AMMUNITION
Drawing number	5569930

References:

SB 700-20
TM 9-1005-213-10
TM 9-1005-231-10
TM9-1300-206

Figure 8. 50-caliber armor piercing round.



TM 43-0001-27

CARTRIDGE, CALIBER .50, BALL, M33

Type Classification:

STD - OTCM 36841.

Use:

Machine Guns, Caliber .50, M2 and M85. The cartridge is intended for use against personnel or unarmored targets.

Description:

BALL Cartridge. The cartridge is identified by a plain bullet tip.

Tabulated Data:

DODAC	1305-A552
UNO serial number	0339
UNO proper shipping name	Cartridges for weapons, inert projectile
Weight	1762 gr
Length	5.45 in. (138.4 mm)
Tracer	NA
Primer	Percussion
Fuze	NA
Explosive:	
Type	NA
Weight	NA
Incendiary:	
Type	NA
Weight	NA
Propellant:	
Type	WC 860
Weight	235 gr

Performance:

Chamber pressure	55,000 psi
Velocity	2910 fps, 78 ft from muzzle

Shipping and Storage Data:

Quantity-distance class/ SCG	1.4C
Storage code	Class V
DOT shipping class	C
DOT designation	SMALL ARMS AMMUNITION
Drawing number	7553097

References:

SB 700-20
TM 9-1005-213-10
TM 9-1005-231-10
TM 9-1300-206

Figure 9. 50-caliber ball round.

1.4.3.1 Test Conditions

- Ammunition: 50 caliber armor piercing and 50 caliber military ball round.
- Muzzle velocity: standard for each type.
- One bullet per test.
- Explosive sample:
    - Diameter: ~8 inches (200 mm).
    - Thickness: ~ 3inches (75 mm).
    - Density: within the specified range for the application.
        - Main charges are generally 96-98% TMD.
        - Boosters are generally 92-95% TMD.

1.4.3.2 Number of Tests

- Three replicates with each bullet type (six tests total).

1.4.3.3 Quantity of Explosive Required

- ~ 4500 g per test.
- ~ 27 kg total.

1.4.3.4 Criteria for Qualifying as IHE

- Burn: smoke and/ or visible light is acceptable, burning reaction can completely consume material. Assembly may be distorted, and surfaces blackened. Any level of damage beyond that is a failure. If the assembly is fragmented, that is a failure.
- Panels of pass and fail are in Figure 10.

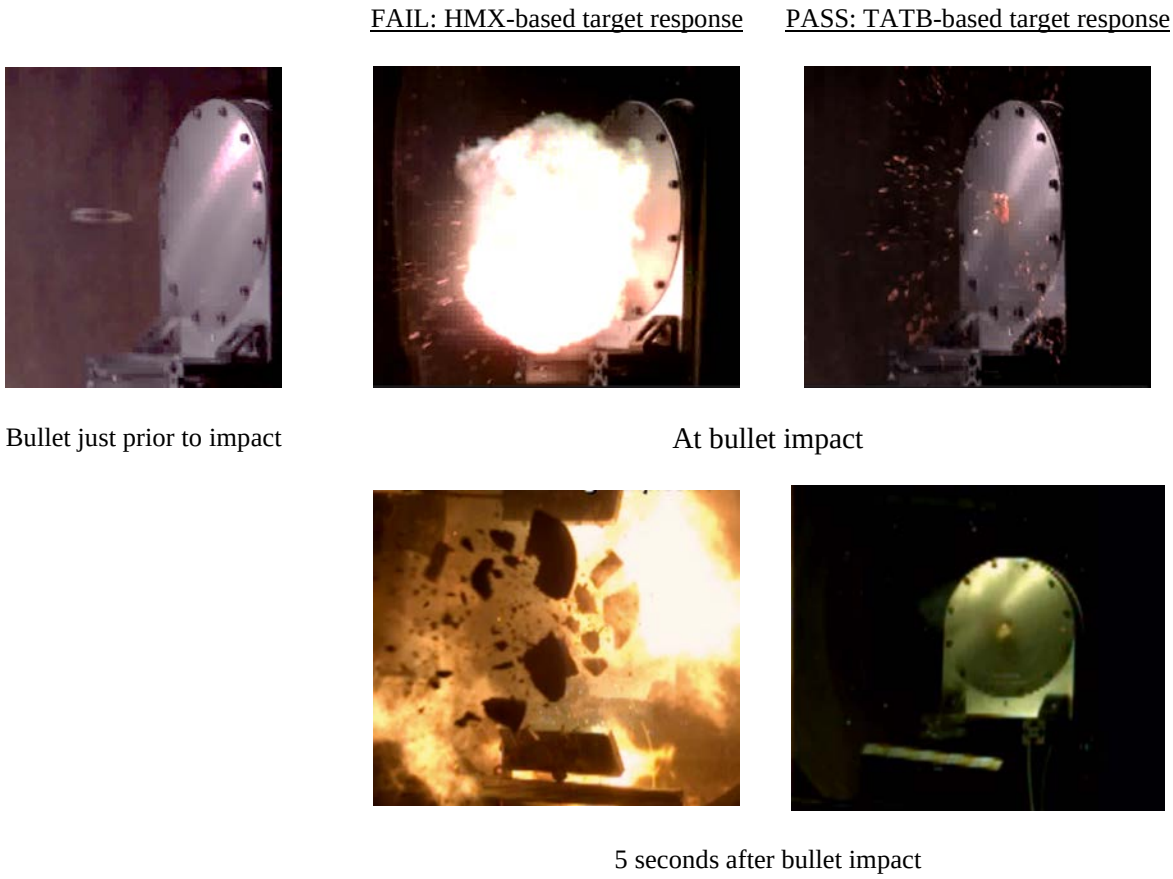


Figure 10. The bullet impact test distinguishes between the reaction violence of an HMX-based explosive and TATB-based explosive to the impact with a 50 caliber armor-piercing round. In this case, the HMX-based explosive fails to meet the IHE criteria. The visible light/reaction at impact is acceptable, however the violent disassembly of the undetonated HE constitutes a failure.

Section 2

IHE Subassembly Qualification Test Series

This section outlines a general plan to qualify IHE subassemblies that contain explosives that are not qualified as IHE materials. In general, this will occur when it is desired to have an IHE subassembly that consists of a main charge of IHE qualified materials with CHE boosters and/or detonators. However, it is also possible that the main charge be a material that has not passed the IHE material qualification tests outlined in Section 1, provided it qualifies to the same criteria at a system-relevant scale (as described herein), and it passes the SDT criterion for an IHE material at both ambient and heated conditions.

While this document provides an outline of the expectations for IHE subassembly qualification, this is an outline to aid in the development of a test plan for approval by the DOE/NNSA Explosives Safety Committee in consultation with the DOE/NNSA IHE Qualification Update Group. DOE-STD-1212, Chapter 16, Section 16.6 “IHE Subassembly Qualification Process” outlines the procedure for submitting a test plan, committee review procedures, and submission requirements. The test plan must consider worst-case configurations for testing.

2.1 Deflagration-to-Detonation Transition Experiment

For cases where the main charge is composed of IHE qualified materials, using booster, detonator, or other materials that are not IHE, it is a requirement to demonstrate that the materials that are not IHE cannot undergo DDT on a scale that is conservative to its relevant application in the subassembly.

For cases where it is desired to use a main charge that is not an IHE qualified material, but is smaller than was imagined in the material definition from the previous section, the main charge material must also be subjected to and pass a DDT test at the scale of use plus a conservative margin of scale and confinement consistent with the IHE materials test scale outlined in Section 1.1.

Each non-IHE material to be used shall be qualified by testing it in a scaled version of the DDT test. Each material will be tested in this configuration in a scale that is the actual scale of use plus a conservative margin in dimensions and confinement. All materials in the subassembly must pass this test individually for the subassembly to qualify as an IHE subassembly. No evidence of DDT may be observed in any test. Three replications of each test are required.

2.2 Shock-to-Detonation Transition Experiment – Main charge only

In order for the subassembly to qualify as an IHE subassembly, the main charge material must pass the identical SDT test as described in Section 1.2, for both ambient and heated configurations, with the same criteria for a passing result. Booster and detonator materials are not subjected to the SDT criteria to be consistent with previous test requirements.

2.3 Skid Test

Skid testing will be performed as above in Section 2.3, except that the assembly will be dropped for impact in the worst possible configuration - on the booster surrounded by main charge material consistent with the actual weapon configuration, with or without detonators. Three tests are required with drops at 45 degrees from 12 ft, with no observation of violent reaction (based on criteria described in Section1.3.3).

2.4 Multiple Bullet Impact Test

Bullet testing will be performed on the assembly, and in this case, the configuration of the target material will be designed to present a worst-case, path of attack, for the weapon subassembly. The test specimen geometry may or may not be the same as described in Section 2.4. If the path of attack includes a booster, then that booster must be included in the test. Threat is a three-round burst of NATO-7.62 mm (0.3 inches) ammunition. The passing criterion is to exhibit no violent reaction (based on criteria described in Section 1.4.3.4) when subjected to the threat. Three replicate tests are required.

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CHEMICAL CONCENTRATIONS IN FIELD MICE COLLECTED FROM OPEN-DETONATION FIRING SITES TA-36 MINIE AND TA-39 POINT 6 AT LOS ALAMOS NATIONAL LABORATORY

P.R. Fresquez

ABSTRACT

Field mice (mostly *Peromyscus* spp.) were collected at two open-detonation (high explosive) firing sites—Minie at Technical Area (TA) 36 and Point 6 at TA-39—at Los Alamos National Laboratory in August of 2010 and in February of 2011 for chemical analysis. Samples of whole body field mice from both sites were analyzed for target analyte list elements (mostly metals), dioxin/furans, polychlorinated biphenyl congeners, high explosives, and perchlorate. In addition, uranium isotopes were analyzed in a composite sample collected from TA-36 Minie. In general, all constituents, with the exception of lead at TA-39 Point 6, in whole body field mice samples collected from these two open-detonation firing sites were either not detected or they were detected below regional statistical reference levels (99% confidence level), biota dose screening levels, and/or soil ecological chemical screening levels. The amount of lead in field mice tissue collected from TA-39 Point 6 was higher than regional background, and some lead levels in the soil were higher than the ecological screening level for the field mouse; however, these levels are not expected to affect the viability of the populations over the site as a whole.

INTRODUCTION

Small mammal mark-recapture studies were conducted at Los Alamos National Laboratory (LANL) at two open-detonation high explosive research and development firing sites—Minie at Technical Area (TA) 36 and Point 6 at TA-39—during August of 2010 (Bennett and Robinson 2011). The purpose of the mark-recapture studies was to evaluate the small mammal (field mice) species occurrence and population abundance at the open-detonation firing sites when compared to an undeveloped (control) site. Based on population abundance, species diversity and composition, sex ratios, and weights, the open-detonation firing sites do not appear to be adversely affecting small mammal population dynamics when compared to the undeveloped background site.

On the final day of trapping for the population study at the two detonation sites in 2010, all animals were euthanized and submitted for chemical analysis to investigate the

concentrations of various chemicals, particularly dioxin and furans, associated with open-detonation activities at LANL. Additional samples for chemical analyses were collected at both firing sites in February 2011. This chemical uptake analysis was conducted to gather information on the potential impact that the open-detonation operations conducted at TA-36 Minie and TA-39 Point 6 may have historically had on the sites. Field mice are effective indicators of contaminant presence due to their feeding and activity habits (i.e., burrowing) (Arthur et al. 1987), and at LANL they are used as the biota (radionuclide) dose (McNaughton 2006) and (chemical) uptake (Fresquez et al. 2010) models for terrestrial mammals because they have the smallest home range (~100 m^2).

METHODOLOGY

Site Descriptions

LANL is situated in northern New Mexico on the Pajarito Plateau (Figure 1), a series of finger-like mesas speared by east-to-west-oriented canyons. The mesa tops slope eastward from approximately 2377 m (7800 ft) to 1890 m (6200 ft). The surrounding land is largely undeveloped, including large tracts held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, and San Ildefonso Pueblo.

The firing sites are in remote locations and specialize in experimental studies of the dynamic properties of high explosive materials under high-pressure and temperature conditions. The facilities that make up the explosives testing operations are used primarily for research, development, test operations, and detonator development and testing related to the US Department of Energy Stockpile Stewardship Program (DOE 2008).

TA-36 Minie (Solid Waste Management Unit [SWMU] 36-004[c]) is located near the head of Fence Canyon (Figure 2). TA-39 Point 6 (SWMU 39-004[c]) is located in the bottom of Ancho Canyon (Figure 3). Both of the firing sites involved within this study have been in use since the 1950s. The vegetation consists of piñon (*Pinus edulis* Engelm.)

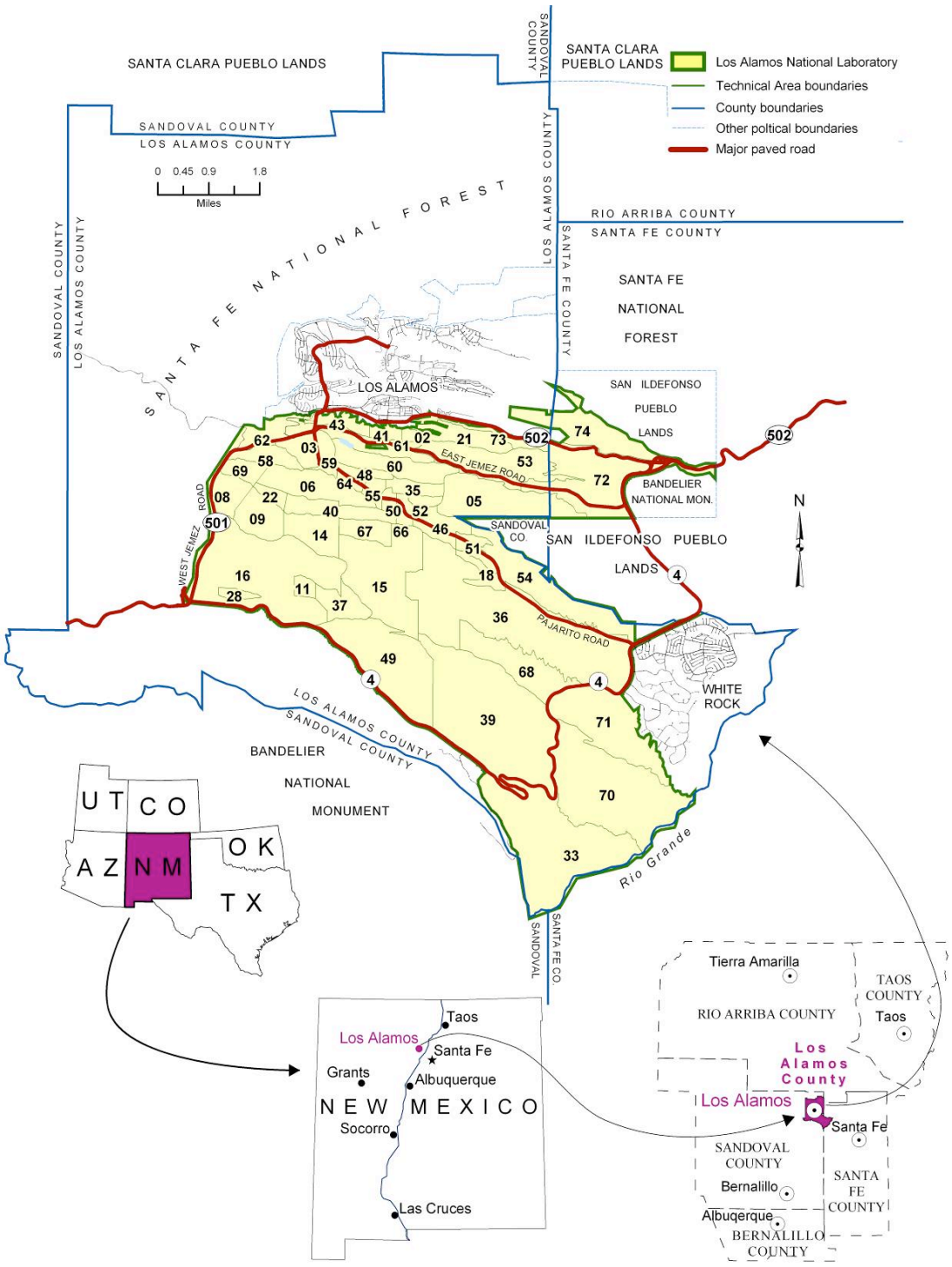

Figure 1. Location of Los Alamos National Laboratory (from Bennett and Robinson 2011)

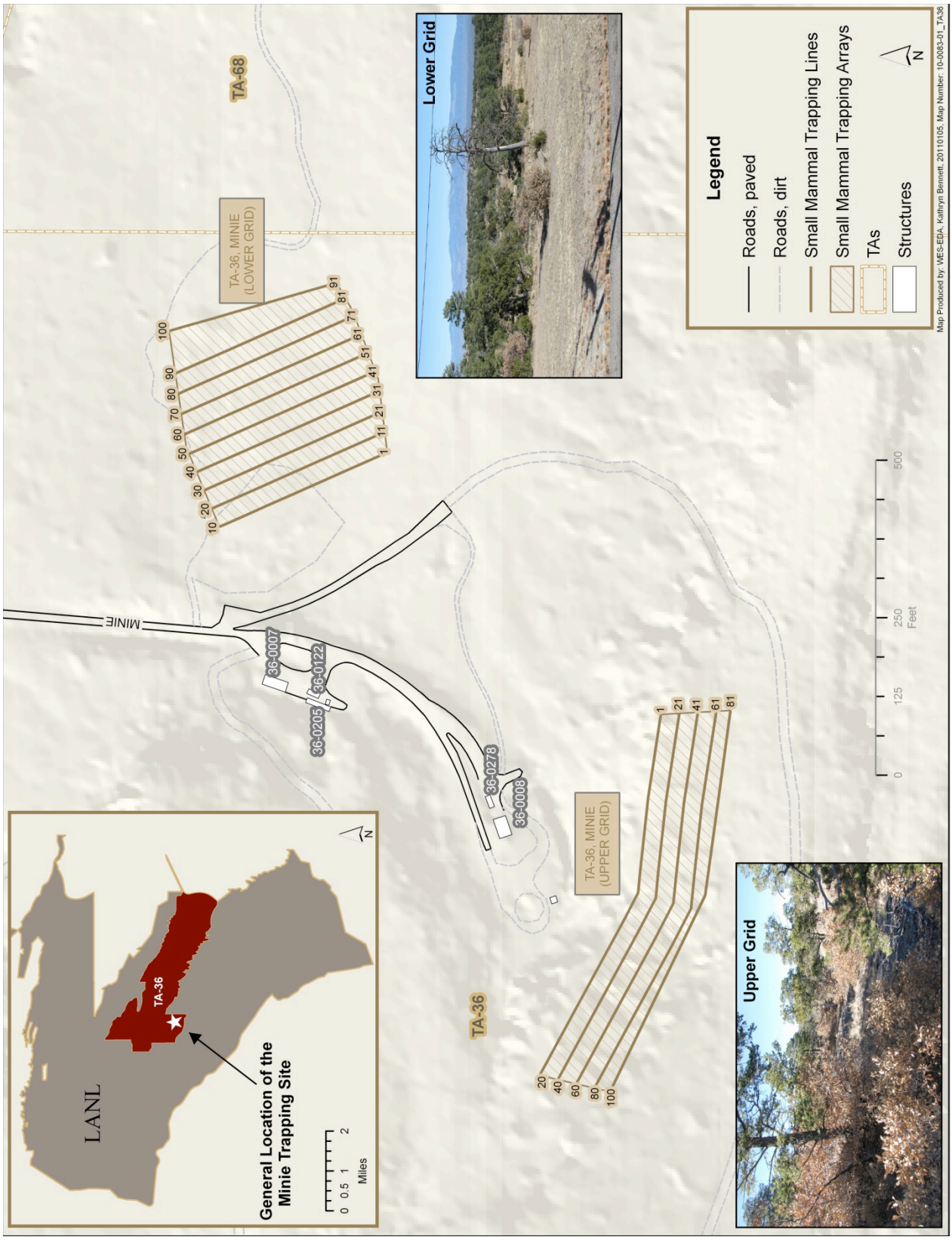

Figure 2. TA-36 Minie trapping location (from Bennett and Robinson 2011)

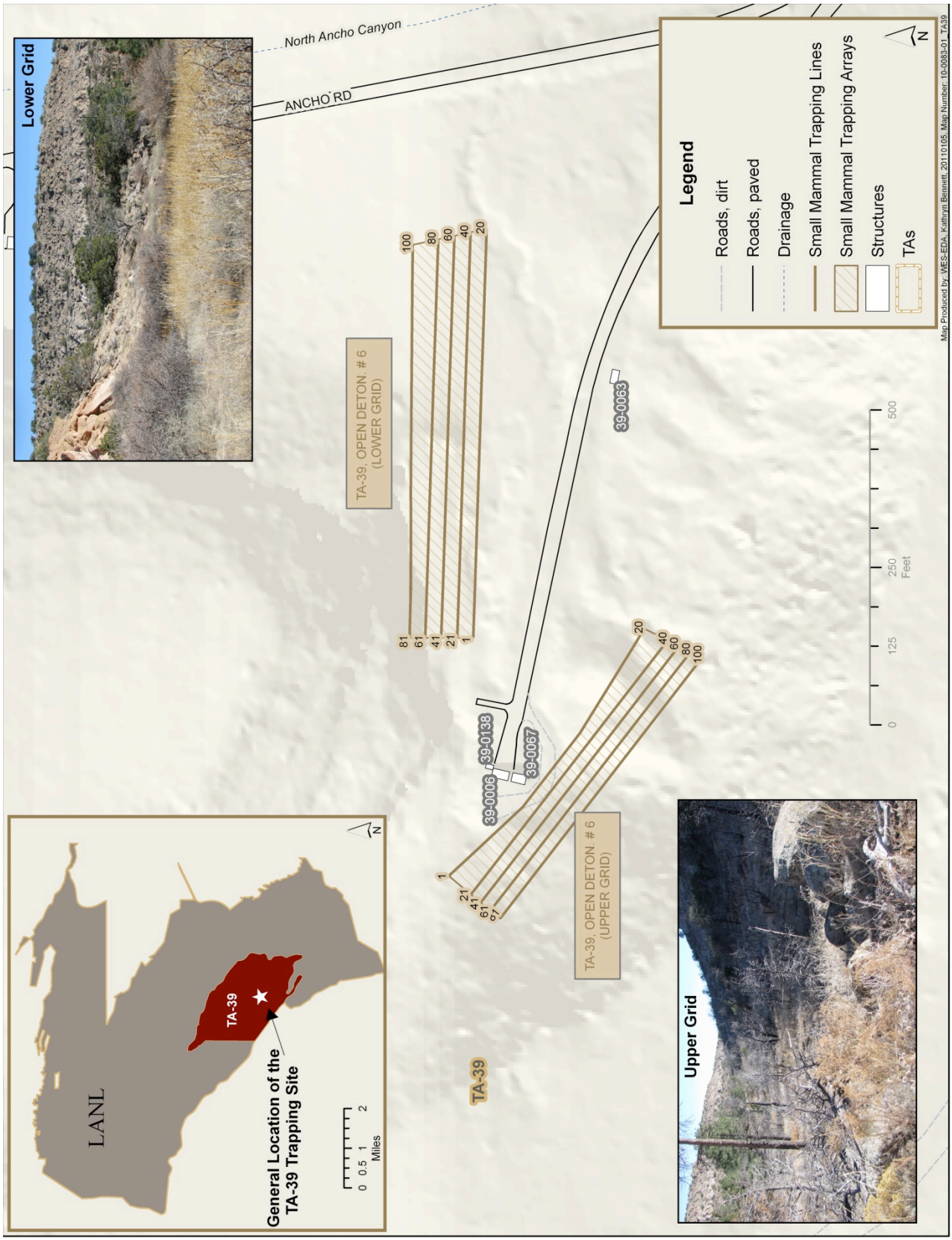

Figure 3. TA-39 Point 6 trapping location (from Bennett and Robinson 2011)

-(*Juniperus monosperma* [Englem.] Sarg.) with interspersed ponderosa pine (*Pinus ponderosa* C. Lawson) and gambel oak (*Quercus gambelii* Nutt.).

Small Mammal Trapping

Trapping grids, for the population study, were set up at TA-36 Minie and TA-39 Point 6 (see Figures 2 and 3). Each firing site was assigned two grids—lower and upper—with grid configuration based on topography of each site. The lower grids consisted of 10 lines of 10 traps with spacing of 10 m per trap and 10 m between each line, and these grids were situated downgradient of the firing site. The upper grids consisted of five lines of 20 traps with spacing of 10 m per trap and 10 m between each line, and these grids were situated adjacent and upgradient to the firing site. Each grid had 100 traps.

Trapping at each location took place over four consecutive nights. Traps were baited in the late afternoon with a molasses-coated horse feed and checked early each morning. Animals were collected and taken to a central location for processing. At the processing location, field mice were identified to species, weighed, sexed, and measured (total body, tail, hind foot, and ear). These data can be found in Bennett and Robinson (2011). Each animal was ear tagged and released. On the final day of trapping in 2010, all animals were euthanized, placed in double zip lock bags, and stored in a freezer at 4 degrees C. Additional samples for chemical analysis were collected in February 2011. All sample information can be found in the Appendix; the most common sample consisted of deer mice (*Peromyscus maniculatus*).

Captured mouse being weighed.

ALS (formally Paragon Analytics) Group analyzed the field mice (whole body) samples collected from TA-36 (Minie) for uranium-234, uranium-235, and uranium-238; and for target analyte list (TAL) elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury) from both sites. Polychlorinated biphenyls (PCBs) (congeners, homologs, and totals) and dioxin/furans in whole body field mice from both sites were analyzed by Cape Fear Analytical Laboratory, Inc., and General Engineering Laboratories analyzed the samples for high explosives and perchlorate.

Biota Comparison Levels

Radionuclides and chemical concentrations in biota from Laboratory areas are first compared to regional statistical reference levels (RSRLs). RSRLs, which represent natural and fallout levels, are the upper-level background concentrations (mean plus three standard deviations = 99% confidence level) for radionuclides and chemicals calculated from biota that was collected from regional locations away from the influence of the Laboratory (over nine miles away) (DOE 1991). For radionuclides, TAL elements, high explosives, dioxin/furans, perchlorate, and PCBs in whole body field mice, RSRLs can be found in Fresquez (2009, 2011).

If the levels of radionuclides in field mice collected from potentially impacted areas are higher than the RSRLs, the concentrations are compared to (tissue) screening levels (SLs) and then to standards. Biota SLs were set at 10% (0.01-rad/day) of the standard for terrestrial animals (0.1-rad/day) (DOE 2002) by the dose assessment team at the Laboratory to identify the potential contaminants of concern (McNaughton 2006).

There are no regulatory SLs for chemicals in tissues of biota; so if chemicals in biota are higher than the RSRLs then the chemical concentration in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2010). ESLs are LANL derived and are designed to reflect the concentration of a chemical in the soil that is not expected to produce any adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on soil (i.e., they are the

concentrations that are protective of ecological receptors under chronic exposure conditions).

RESULTS

TA-36 Minie

a. Uranium Isotopes. The concentration of uranium-238 in a composite whole body field mouse sample (n = 5 subsamples) was the only uranium isotope out of the three that was detected in higher amounts than the RSRL (Table 1). The amount of uranium-238, however, was two orders of magnitude below the biota dose screening level. Based on the isotopic distribution of uranum-234 and uranium-238, the source of uranium was depleted uranium.

Table 1. Uranium isotopes (pCi/g ash) in a composite whole body field mouse sample (n = 5) collected from TA-36 Minie in 2010. (Bold values are higher than 3TPU and the RSRL.)

Radionuclide[a]	Sample #3214	3TPU[b]	RSRL[c]	SL[d]
Uranium-234	0.066	0.025	0.11	46
Uranium-235/236	0.0055	0.0069	0.0092	46
Uranium-238	**0.261** DU[e]	0.072	0.098	46

[a]Method was by alpha spectrometry.
[b]Values are the total propagated uncertainty at the 99% confidence level.
[c]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2009).
[d]Screening Level is based on 0.01 rad/day.
[e]DU = depleted uranium based on the distribution of U-234 to U238.
Sample #SFB-10-11-3214 contained five mice—three from the upper grid and two from the lower grid.

b. TAL Elements. Most TAL elements in field mice (n = 3) collected from TA-36 Minie were below RSRLs (Table 2). The only two elements that were higher than the RSRLs were barium in two out of the three samples and lead in three out of the three samples. However, based on the highest concentration of barium in the soil at TA-36 Minie (204 mg/kg) (Vigil-Holterman and Juarez 2011a), the level was below the ESL of 1800 mg/kg for the field mouse (LANL 2010). Similarly, the highest lead concentration detected in soil at TA-36 Minie was 44 mg/kg (Vigil-Holterman and Juarez 2011a) and is lower than the ESL for the field mouse of 120 mg/kg (LANL 2010).

Table 2. TAL elements (mg/kg wet) in whole body field mice collected from TA-36 Minie and TA-39 Point 6 in 2010. (Bold values are higher than the RSRL.)

	TA-36 OD Minie			TA-39 OD Point 6			
Element[a]	**3202/U[d]**	**3203/L**	**3204/U**	**3215/L**	**3216/U**	**3217/L**	**RSRL[b]**
Aluminum	6.0	13	8.9	11	17	13	73
Barium	**5.6**	3.6	**5.8**	**8.6**	**5.2**	2.0	5.1
Beryllium[c]	0.00065	0.0015	0.00095	0.00090	0.00085	0.00075	0.016
Calcium	6800	6000	7700	8000	8100	7000	12624
Chromium	0.21	0.23	0.32	0.23	0.37	0.26	0.40
Cobalt	0.021	0.023	0.016	0.018	0.025	0.015	0.072
Copper	2.6	1.9	1.8	2.6	2.0	1.5	6.2
Iron	40	52	57	53	59	53	140
Magnesium	200	270	230	270	220	160	544
Manganese	0.94	1.7	0.94	1.5	1.2	0.97	7.6
Nickel	0.042	0.083	0.035	0.046	0.057	0.074	0.11
Potassium	2600	2600	2900	2400	2900	1700	3677
Sodium	1300	1000	1300	1100	1200	860	1920
Vanadium	0.0076	0.024	0.0064	0.013	0.027	0.015	0.14
Zinc	35	77	100	35	36	83	119
Antimony	0.034	0.084	0.030	0.043	0.066	0.12	0.17
Arsenic	0.0076	0.014	0.011	0.0060	0.0093	0.010	0.089
Cadmium	0.035	0.0039	0.0071	0.0020	0.010	0.015	0.039
Lead	**0.50**	**0.66**	**0.99**	**3.0**	**1.0**	**0.82**	0.49
Selenium	0.32	0.27	0.28	0.27	0.34	**0.42**	0.40
Silver	0.00087	0.0014	0.0010	0.00081	0.00087	0.0012	0.020
Thallium	0.0012	0.0020	0.0018	0.0027	0.0023	0.0027	0.0055
Mercury	0.0047	0.0017	0.0037	0.0013	0.0042	0.0017	0.013

[a]Al to Zn by method SW6010B and analyzed by inductively coupled plasma; Sb to Tl by method SW6020B and analyzed by inductively coupled plasma mass spectroscopy; Hg by method SW7471 and analyzed by cold vapor atomic adsorption.
[b]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2009).
[c]All U flagged undetected (<minimum detection limit [MDL]) TAL elements were reported as one-half the MDL; all B flagged estimated values (>MDL but <RL) were reported.
[d]Sample number/grid location (U = upper, L = lower)

c. Dioxin and Furans. There were no dioxin or furan concentrations that were detected above the standard quantification limit (SQL) (i.e., reporting level) in any of the eight whole body field mouse samples (Table 3).

d. High Explosives and Perchlorate. There were no detections of high explosives above the SQL in any of the four whole body field mice samples at TA-36 Minie (Table 4). Similarly, all field mouse samples (n = 4) contained perchlorate concentrations below the RSRL.

e. Polychlorinated Biphenyls. Total PCBs in three of the five whole body field mice samples collected from TA-36 Minie were slightly higher than the RSRL calculated from non-urban sites (undisturbed grasslands) but quite lower than the RSRL estimated from field mice collected near an urban waste transfer station in Española, NM (Table 5). Nevertheless, the highest PCB amounts detected in soil at TA-36 Minie (Aroclor 1248 = 0.0054 mg/kg, Aroclor 1254 = 0.0036 mg/kg, and Aroclor 1260 = 0.021 mg/kg) (Vigil-Holterman and Juarez 2011a) were all below the ESLs for the deer mouse (Aroclor 1248 = 0.014 mg/kg, Aroclor 1254 = 0.88 mg/kg, and Aroclor 1260 = 20 mg/kg) (LANL 2010).

TA-39 Point 6

a. TAL Elements. Most TAL elements in whole body field mice from TA-39 Point 6 (n = 3) were below or similar to the RSRLs (see Table 2). As in field mice from TA-36 Minie, the only two TAL elements that were found to be higher than the RSRLs were barium in two of the three samples and lead in all three samples. Based on the highest barium concentration in soil at TA-39 Point 6 measured in 1995 (302 mg/kg) (LANL PRS Database) and in 2010 (99 mg/kg) (Vigil-Holterman and Juarez 2011b), the levels are well below the ESL of 1800 mg/kg for field mice (LANL 2010). Conversely, the highest lead concentrations detected in soil at TA-39 Point 6 in 1995 (978 mg/kg) (LANL PRS Database) and in 2010 (375 mg/kg) (Vigil-Holterman and Juarez 2011b) were higher than the ESL of 120 mg/kg (LANL 2010). Undoubtedly, the highest lead concentrations in soil at TA-39 Point 6 were probably associated with samples collected on or near the firing pad; however, based on the average soil lead concentration from two sampling

Table 3. Dioxin and furan concentrations (pg/g wet) in whole body field mice samples collected from TA-36 Minie in 2010/11.

	Aug-10										Feb-11					
Dioxin/Furan[a]	3205/L[bc]	Lab Q	3206/L	Lab Q	3207/U	Lab Q	3208/U	Lab Q	3209/U	Lab Q	5081/L	Lab Q	5083/L	Lab Q	5085/L	Lab Q
Dioxins																
Tetrachlorodibenzodioxin[2,3,7,8-]	0.175	U	0.501	U	0.173	U	0.482	U	0.535	U	0.084	U	0.0668	U	0.0734	U
Tetrachlorodibenzodioxins (Total)	0.175	U	0.501	U	0.173	U	0.482	U	0.535	U	0.084	U	0.0668	U	0.0734	U
Pentachlorodibenzodioxin[1,2,3,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Pentachlorodibenzodioxins (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxins (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	1.04	J	0.474	U	0.478	U	0.726	U	0.622	J	0.42	U	0.334	U	0.367	U
Heptachlorodibenzodioxins (Total)	4.6	J	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.412	J
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.59	J	1.67	J	0.956	U	1.45	U	1.61	J	0.896	J	0.668	U	1.25	J
Furans																
Tetrachlorodibenzofuran[2,3,7,8-]	0.165	J	0.258	J	0.222	J	0.311	J	0.359	J	0.257	J	0.156	J	0.211	J
Tetrachlorodibenzofurans (Totals)	0.379	J	0.493	J	0.468	J	0.311	J	0.698	J	0.464	J	0.289	J	0.188	J
Pentachlorodibenzofuran[1,2,3,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Pentachlorodibenzofuran[2,3,4,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Pentachlorodibenzofurans (Totals)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofuran[1,2,3,7,8,9-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U

Table 3 (cont.)

	Aug-10										Feb-11					
Furans (cont.)	**3205/L[bc]**	**Lab Q**	**3206/L**	**Lab Q**	**3207/U**	**Lab Q**	**3208/U**	**Lab Q**	**3209/U**	**Lab Q**	**5081/L**	**Lab Q**	**5083/L**	**Lab Q**	**5085/L**	**Lab Q**
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofurans (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzofurans (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.992	U	0.949	U	0.956	U	1.45	U	1.11	U	0.84	U	0.668	U	0.734	U

[a]Method blank corrected data.
[b]Sample number/grid location (U = upper, L = lower).
[c]Results as related to the Laboratory Qualifier: Result followed by a blank space is a Detected value = result was above the reporting limit (RL); Result followed by a U is an Undetected value = result was below the minimum detectable level (MDL) (Shown); Result followed by a J is an Estimated value = result was above the MDL but below the RL.

Table 4. High explosives (µg/kg wet) and perchlorate (mg/kg wet) in whole body field mice collected from TA-36 Minie and TA-39 Point 6 in 2010. (Bold values are higher than the RSRL.)

		TA-36 OD Minie				TA-39 OD Site 6		
High Explosives/Perchlorate	**RL[a]**	**3210/U[b]**	**3211/L**	**3212/L**	**3213/U**	**3221/L**	**3222/U**	**RSRL[c]**
2,4-Diamino-6-nitrotoluene	2000	U[d]	U	U	U	U	U	
2,6-Diamino-4-nitrotoluene	2000	U	U	U	U	U	U	
3,5-Dinitroaniline	1000	U	U	U	U	U	U	
Amino-2,6-dinitrotoluene[4-]	500	U	U	U	U	U	U	
Amino-4,6-dinitrotoluene[2-]	500	U	U	U	U	U	U	
Dinitrobenzene[1,3-]	500	U	U	U	U	U	U	
Dinitrotoluene[2,4-]	500	U	U	U	U	U	U	
Dinitrotoluene[2,6-]	500	U	U	U	U	U	U	
HMX	500	U	U	U	U	U	U	
Nitrobenzene	500	U	U	U	U	U	U	
Nitrotoluene[2-]	500	U	U	U	U	U	U	
Nitrotoluene[3-]	500	U	U	U	U	U	U	
Nitrotoluene[4-]	500	U	U	U	U	U	U	
PETN	1000	U	U	U	U	U	U	
RDX	500	U	U	U	U	U	U	
TATB	1000	U	U	U	U	U	U	
Tetryl	500	U	U	U	U	U	U	
Trinitrobenzene[1,3,5-]	500	U	U	U	U	U	U	
Trinitrotoluene[2,4,6-]	500	U	U	U	U	U	U	
Tris (o-cresyl) phosphate	1000	U	U	U	U	U	U	
Perchlorate	0.0040	0.028	0.012	0.012	0.096	0.12	0.088	0.19

[a]Reporting level (standard quantification limit).
[b]Sample number/grid location (U = upper, L = lower).
[c]Regional Statistical Reference Level; this is the upper-level background concentration (mean + 3 SD) based on data from Fresquez (2011).
[d]Laboratory Qualifier. (Detected) = result was above the reporting limit (RL); U (Undetected) = result was below the minimum detectable level (MDL); J (Estimated) = result was above the MDL but below the RL.

Table 5. Polychlorinated biphenyl (PCB) homologs and totals (pg/g wet) in whole body field mice collected from TA-36 Minie in 2010/2011. (Total PCBs highlighted in bold are higher than the RSRL.)

	Aug-10				Feb-11						RSRL[c]	
PCB Homolog/Total	3205/L[ab]	Lab Q	3206/L	Lab Q	5080/L	Lab Q	5084/L	Lab Q	5082/L	Lab Q	Non-Urban	Urban
Total monoCB	5.62	U	5.69	U	6.76	U	5.36	U	5.1	U		
Total diCB	5.62	U	5.69	U	6.76	U	5.36	U	5.1	U		
Total triCB	26.3		5.69	U	6.76	U	5.36	U	5.1	U		
Total tetraCB	5.62	U	5.69	U	6.76	U	5.36	U	5.1	U		
Total pentaCB	73.8		93.2		19.7		36.8		15.2			
Total hexaCB	1140		1860		147		443		82.1			
Total heptaCB	1500		4120		163		428		88.4			
Total octaCB	540		1850		48.2		164		11.4			
Total nonaCB	130		146		6.76	U	12		5.1	U		
Total decaCB	66.2		30.1		6.76	U	5.36	U	5.1	U		
Total PCB	3470		8100		378		1080		197		885	28000

[a]Sample number/grid location (U = upper, L = lower).
[b]Result as related to Laboratory Qualifiers: Result followed by a blank space is a Detected value = result was above the standard quantification limit (SQL); Result followed by a U is an Undetected value = result was below the minimum detectable level (MDL) (shown); Result followed by a J is an Estimated value = result was above the MDL but below the SQL.
[c]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2011).

periods over the entire site, the amount (82 mg/kg; n = 57) (LANL PRS Database, Vigil-Holterman and Juarez 2011b) was lower than the ESL for field mice.

b. Dioxin and Furans. Out of the six field mice samples collected in August of 2010 and February of 2011, only one sample and for only one compound, pentachlorodibenzofuran [2,3,4,7,8-], was detected above the SQL (Table 6). The amount (5.26 pg/g wet weight), however, was just above the reporting limit of 4.8 pg/g wet weight, and there were no detections of this compound above the reporting limit in soil samples collected from the site (Vigil-Holterman and Juarez 2011b); thus, these data in the tissue of one field mouse sample out of six may be a false positive.

c. High Explosives and Perchlorate. There were no detections of high explosives above the SQLs in any of the field mice samples (n = 2) collected at TA-39 Point 6 (see Table 4). Similarly, the amounts of perchlorate (n = 2) were below the RSRL.

d. Polychlorinated Biphenyls. Two out of five whole body field mouse samples collected from TA-39 Point 6 were higher in total PCBs than either of the RSRLs (Table 7). These two samples were collected from the upper grid, which is closer to the firing site, as compared to the other three samples being collected at the lower grid, which is further away. Nevertheless, the highest PCB amounts detected in soil at TA-39 Point 6 (Aroclor 1254 = 0.042 mg/kg and Aroclor 1260 = 0.018 mg/kg) (Vigil-Holterman and Juarez 2011b) were still below the ESLs for the deer mouse (Aroclor 1254 = 0.88 mg/kg and Aroclor 1260 = 20 mg/kg) (LANL 2010).

CONCLUSIONS

The tissues of the biota collected from TA-36 Minie indicated that analyzed concentrations were below the RSRLs or applicable SLs or soil comparisons. Similarly, at TA-39 Point 6, with the exception of lead, there were no detections of inorganic and organic chemicals in whole body tissues of field mice above RSRLs or applicable SLs or soil comparisons. Additionally, average lead concentrations over the TA-39 Point 6 site indicate that the site as a whole is not above ESLs for the field mouse. In conclusion, none of whole body tissue concentrations within the samples collected from TA-36 Minie or from TA-39 Point 6 appear to significantly impact the field mice population. In fact,

Table 6. Dioxin and furan concentrations (pg/g wet) in whole body field mice samples collected from TA-39 Point 6 in 2010/2011.

	Aug-10						Feb-11					
Dioxin/Furan[a]	**3218/L[b,c]**	**Lab Q**	**3219/U**	**Lab Q**	**3220/U**	**Lab Q**	**5548/L**	**Lab Q**	**5550/L**	**Lab Q**	**5552/L**	**Lab Q**
Dioxins												
Tetrachlorodibenzodioxin[2,3,7,8-]	0.442	U	0.287	U	0.245	U	0.081	U	0.0845	U	0.0692	U
Tetrachlorodibenzodioxins (Total)	0.442	U	0.287	U	0.245	U	0.081	U	0.0845	U	0.0692	U
Pentachlorodibenzodioxin[1,2,3,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Pentachlorodibenzodioxins (Total)	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxins (Total)	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.487	U	1.1	J	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzodioxins (Total)	0.487	U	1.1	J	0.495	U	0.405	U	0.402	U	0.346	U
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.07	J	2.06	J	1.03	J	0.81	U	0.803	U	0.728	J
Furans												
Tetrachlorodibenzofuran[2,3,7,8-]	0.345	J	0.323	J	0.655	J	0.177	J	0.169	J	0.208	J
Tetrachlorodibenzofurans (Totals)	0.633	J	0.434	J	0.655	J	0.499	J	0.492	J	0.421	J
Pentachlorodibenzofuran[1,2,3,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Pentachlorodibenzofuran[2,3,4,7,8-]	0.489	J	**5.26**		0.773	J	0.405	U	0.402	U	0.346	U
Pentachlorodibenzofurans (Totals)	0.489	J	**5.26**		0.773	J	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofuran[1,2,3,7,8,9-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U

Table 6 (cont.)

	Aug-10						Feb-11					
Furans (cont.)	**3218/L[b,c]**	**Lab Q**	**3219/U**	**Lab Q**	**3220/U**	**Lab Q**	**5548/L**	**Lab Q**	**5550/L**	**Lab Q**	**5552/L**	**Lab Q**
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.487	U	0.571	J	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofurans (Total)	0.487	U	0.571	J	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzofurans (Total)	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.974	U	0.968	U	0.989	U	0.81	U	0.803	U	0.692	U

[a]Method blank corrected data.
[b]Sample number/grid location (U = upper, L = lower).
[c]Results as related to the Laboratory Qualifier: Result followed by a blank space (Detected) = result was above the reporting limit (RL); Result followed by a U (Undetected) = result was below the minimum detectable level (MDL) (Shown); Result followed by an J (Estimated) = result was above the MDL but below the RL.

Table 7. Polychlorinated biphenyl (PCB) homologs and totals (pg/g wet) in whole body field mice collected from TA-39 Point 6 in 2010/2011. (Total PCBs highlighted in bold are higher than the RSRL.)

	Aug-10				Feb-11						RSRL[c]	
PCB Homolog/Total	3219/U[ab]	Lab Q	3220/U	Lab Q	5549/L	Lab Q	5551/L	Lab Q	5553/L	Lab Q	Non-Urban	Urban
Total monoCB	4.77	U	3.42	U	5.99	U	5.97	U	5.6	U		
Total diCB	4.77	U	3.42	U	5.99		5.97	U	5.6			
Total triCB	5.06	B	49.8		5.99		5.97		5.6			
Total tetraCB	9.72	B	41.5	B	5.99		5.97		5.6			
Total pentaCB	3370		12100		65.1		34		5.6			
Total hexaCB	44900		16400		471		189		65.9			
Total heptaCB	9820		4070		313		71.7		39.2			
Total octaCB	1020		802		130		33.2		10.7			
Total nonaCB	86.2		90.1		19.3		5.97	U	5.6	U		
Total decaCB	8.58		3.42	U	5.99	U	5.97	U	5.6	U		
Total PCB	**59300**		**33600**		998		328		116		857	28000

[a]Sample number/grid location (U = upper, L = lower).
[b]Result as related to Laboratory Qualifiers: Result followed by a blank space is a Detected value = result was above the standard quantification limit (SQL); Result followed by a U is an Undetected value = result was below the minimum detectable level (MDL) (shown); Result followed by a J is an Estimated value = result was above the MDL but below the SQL.
[c]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2011).
B = blank corrected.

Bennett and Robinson (2011) reported that the populations from these two detonation sites were similar to an undisturbed background location.

We acknowledge that the sample numbers for chemical analysis in some cases may be small and recommend more sampling over time.

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APPENDIX

Information on field mice collected at open-detonation firing sites TA-36 Minie and TA-39 Point 6

							Constituents Analyzed			
TA	**Species Name**	**Ear Tag #**	**Date Collected**	**Weight (g)**	**Sample #**	**Grid Location**	**Uranium Isotopes**	**Dioxin/ Furans**	**PCB Congeners**	**HE/ Perchlorate**	**TAL Elements**
					SFB10-11-						
36	REME	4033	8/13/10	20	3202	Upper					X
36	PEMA	4040	8/13/10	10.5	3203	Lower					X
36	PEMA	2	8/13/10	17	3204	Upper					X
36	PEMA	4029	8/10/10	17	3205	Lower		X	X		
36	PEMA	4028	8/13/10	17.5	3206	Lower		X	X		
36	REME	4036	8/13/10	11	3207	Upper		X			
36	REME	3	8/13/10	7	3208	Upper		X			
36	REME	4034	8/13/10	8.5	3209	Upper		X			
36	REME		8/10/10	14.5	3210	Upper				X	
36	PETR	1	8/13/10	25	3211	Lower				X	
36	PETR	4027	8/13/10	34	3212	Lower				X	
36	PEMA	4037	8/13/10	19	3213	Upper				X	
36	4 PEMA 1 NEME	4043, 4032, 4030, 4035, 4048	8/13/10	Composite	3214	3U, 2L	X				
					MICE36-11-						
36	PETR		2/17/11	10	5080	Lower			X		
36	PEMA		2/15/11	15	5084	Lower			X		
36	PEBO		2/15/11	19	5085	Lower		X			
36	REME		2/17/11	11.5	5081	Lower		X			
36	PEMA		2/17/11	17	5082	Lower			X		
36	PEMA		2/17/11	15.5	5083	Lower		X			

39	PEMA	4098	8/26/10	16.5	3215	Lower					X
39	PEBO	2602	8/26/10	19.5	3216	Upper					X
39	PEMA	4085	8/26/10	27	3217	Lower					X
39	PEMA	2603	8/26/10	10.5	3218	Lower	X				
39	PEMA	4080	8/23/10	17	3219	Upper	X	X			
39	PEMA	4083	8/26/10	25	3220	Upper	X	X			
39	PEMA	4090	8/26/10	15.5	3221	Lower			X		
39	PEMA	4082	8/26/10	12.5	3222	Upper			X		
39	PEMA		2/24/11	12.5	MICE39-11-5550	Lower	X				
39	PEMA		3/1/11	19	5553	Lower		X			
39	PEMA		2/23/11	17	5549	Lower		X			
39	PEMA		2/23/11	12	5548	Lower	X				
39	PEMA		2/24/11	16	5551	Lower		X			
39	PEMA		2/24/11	13.5	5552	Lower	X				

PEMA = deer mouse (*Peromyscus maniculatus*)
PETR = pinyon mouse (*Peromyscus truei*)
REME = western harvest mouse (*Reithrodontomys megalotis*)
PEBO = brush mouse (*Peromyscus boylii*)
NEME = Mexican wood rat (*Neotoma mexicana*)
Sample Coordinates:

TA-36, upper grid (X = 1631558 and Y = 1756103) and lower grid (X = 1632355 and Y = 1756697)
TA-39, upper grid (X = 1636020 and Y = 1746329) and lower grid (X = 1636562 and Y = 1746542)

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Attachment 4 – Fresquez *et al.* 2013

Environmental Report:

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Title:	**CHEMICAL CONCENTRATIONS IN FIELD MICE/VOLES COLLECTED FROM AN OPEN-BURN SITE AT TECHNICAL AREA 16 AT LOS ALAMOS NATIONAL LABORATORY: REVISION 1**
Author(s):	P.R. Fresquez, L. Hansen, and C. Hathcock
Intended for:	Report

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PREFACE

The purpose of this revision was to increase the data base for small mammal collections at the TA-16 burning grounds. In addition to inorganic elements and dioxin/furan concentrations in field mice/voles collected in 2011, the population parameters of field mice around the TA-16 burn ground site were estimated and samples were analyzed for polychlorinated biphenyls, high explosives, and perchlorate.

CHEMICAL CONCENTRATIONS IN FIELD MICE/VOLES COLLECTED FROM AN OPEN-BURN SITE AT TECHNICAL AREA 16 AT LOS ALAMOS NATIONAL LABORATORY: REVISION 1

P.R. Fresquez, L. Hansen, and C. Hathcock

ABSTRACT

Field mice and voles were collected around an open-burn (high-explosive waste) site, TA-16-388 (flash pad), at Technical Area 16 at Los Alamos National Laboratory in March of 2011 for the analysis of 23 target analyte list (TAL) elements (mostly metals) and 17 dioxin/furan chemicals. In July of 2012, small mammal community and population parameters were estimated across the site, and samples were analyzed for polychlorinated biphenyl's (PCBs), high explosives (HEs), and perchlorate. All TAL elements in whole-body field mouse samples (n=3) were either similar to regional statistical reference levels (RSRLs) or below ecological screening levels. Dioxins and furans (n=6) and HEs (n=2) were not detected in any of the whole-body field mouse/vole samples. Perchlorate concentrations (n=2) were below the RSRL. One out of the two small mammal samples contained PCB Arochlor-1260 above non-urban RSRLs; the amount, however, was similar to the urban RSRL. There was no adverse effect of burning ground operations on local small mammal populations.

INTRODUCTION

Two open-burn treatment units (burn units), the TA-16-388 Flash Pad and the TA-16-399 Burn Tray, located at Technical Area 16 (TA-16) at Los Alamos National Laboratory (LANL or the Laboratory), are used for the destruction of high explosives (HE), HE machining wastes, and wastes contaminated with HE (LANL 2003) **(Figures 1 and 2)**. The burn units have been in operation since the late 1950s and have been authorized to operate under an interim basis by the State of New Mexico since 1980. Currently, the Laboratory is in the process of applying for a hazardous waste permit for the open-burning treatment of HE wastes at TA-16. The public has voiced concern about potential effects from releases of chemicals, particularly dioxins and furans on the surrounding environment (New Mexico Environment Department [NMED] 2010).

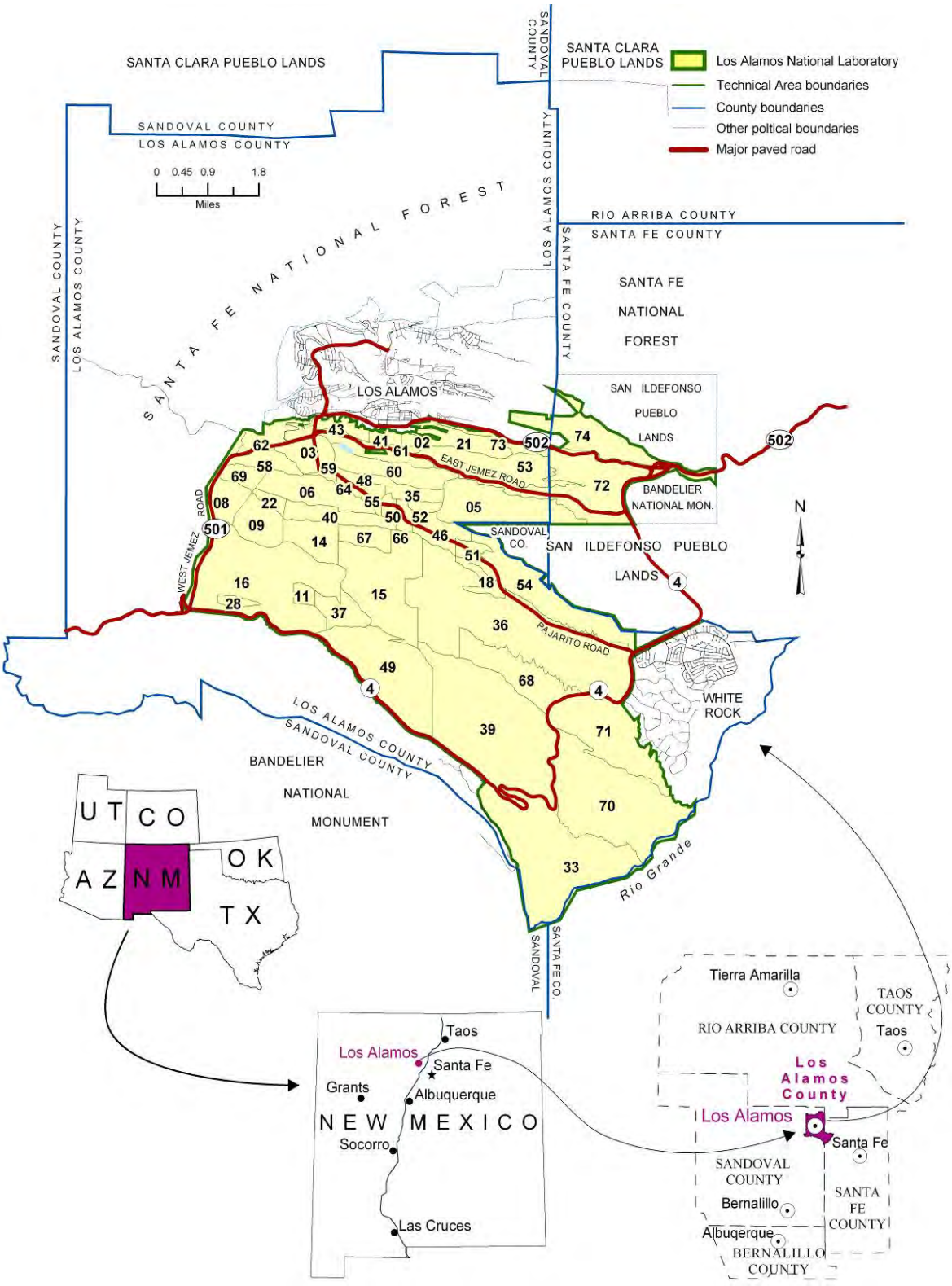

Figure 1. Location of Los Alamos National Laboratory**.**

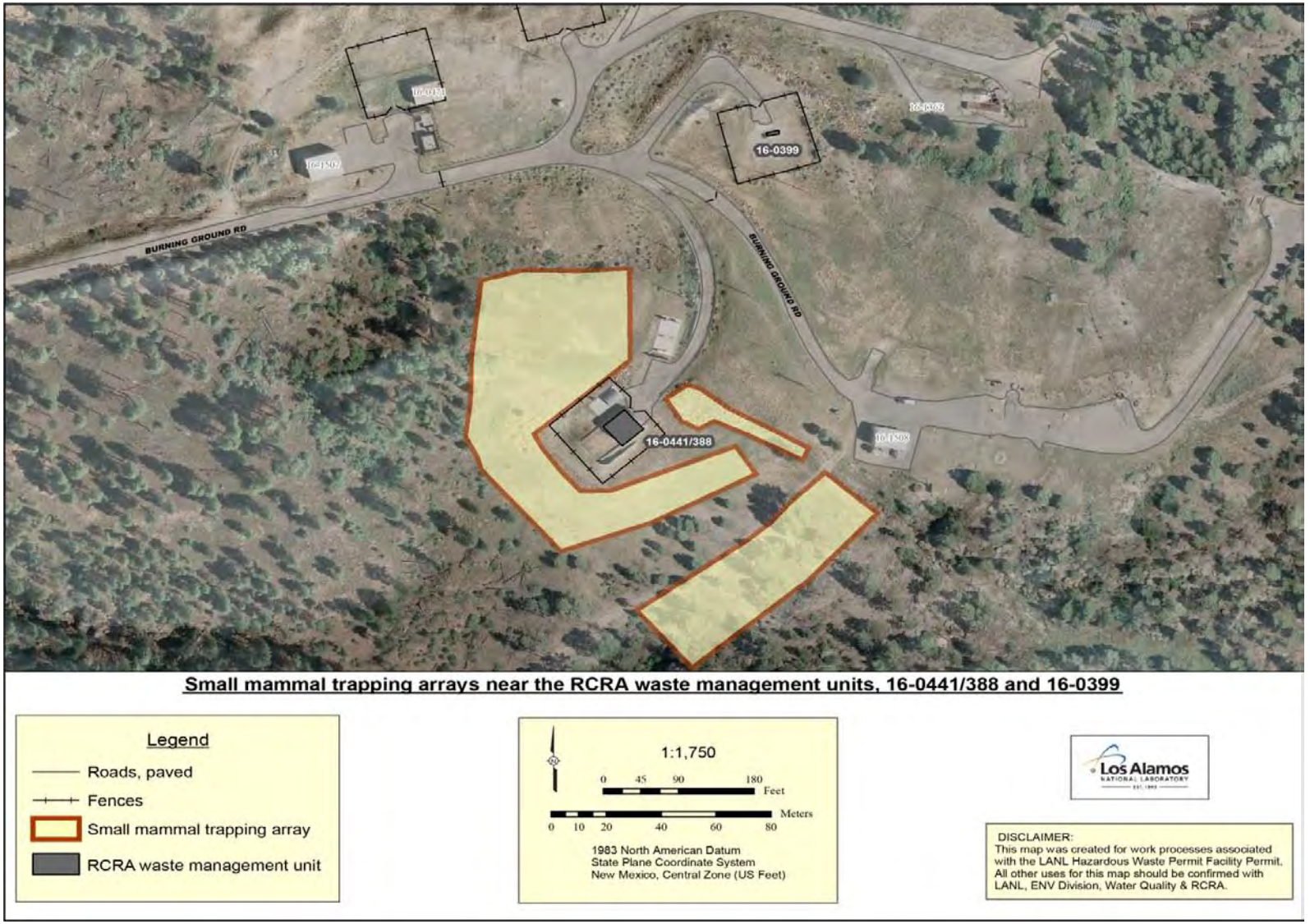

Figure 2. Location of burn units (referred to as the RCRA waste management units) and sampling arrays at TA-16 in 2011.

An analysis of Resource Conservation and Recovery Act (RCRA) metals and dioxin/furan chemicals in soil samples (n=37) collected in proximity to the two burn units at TA-16 showed that some elements like barium, cadmium, and silver were detected above background and each sample contained from 3 to 17 dioxin/furan chemicals. The human health and ecological risk analyses concluded that no risks to human or ecological receptors above acceptance thresholds are present at the site (LANL 2010a).

The purpose of the present study was to gain more information on any food-chain transfer of the chemicals of potential ecological concern at the burn units to a low-trophic-level animal receptor (e.g., field mice) to verify the results of the ecological risk analysis. In general, field mice are effective biomonitors because of their ease of collection, feeding habits (e.g., omnivore), limited home range, and association with the soil (e.g., burrowing) (Arthur et al. 1987, Talmage and Walton 1991, Smith et al., 2002). At LANL, field mice are used as the biota (radionuclide) dose (McNaughton 2006) and chemical (Fresquez et al. 2010) uptake models for terrestrial mammals because they have the smallest home range (0.089 to 1.5 acres) (Wood et al. 2010).

METHODOLOGY

Site Description

The Laboratory is situated in northern New Mexico on the Pajarito Plateau, a series of fingerlike mesas separated by east-to-west-oriented canyons. The mesa tops slope eastward from approximately 2377 m (7800 ft) to 1890 m (6200 ft). The surrounding land is largely undeveloped, including large tracts held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, and San Ildefonso Pueblo. The open-burn sites are located in a remote location at TA-16 and vegetation consist of mostly ponderosa pine (*Pinus ponderosa* C. Lawson), gambel oak (*Quercus gambelii* Nutt) and open field grasses.

Small Mammal Trapping

2011 Study. Large snap traps were set in three arrays (north/west/south, east, and southeast) around the most often used burn unit, TA-16-388 (Flash Pad), in March-April 2011 **(Figure 2)**. Traps were baited in the late afternoon with molasses-coated oat bait and checked early each morning. A total of nine field mice/voles were collected over the sampling period; three samples were used for target analyte list (TAL) analysis, and six samples were used for dioxin/furan

analysis. The samples for TAL analysis were each placed in double ziplock bags, whereas the dioxin/furan samples were each placed into 250-mL amber glass jars. All samples were secured with chain-of-custody tape, transported in an ice cooler, and stored in a freezer until they were submitted to the Laboratory's Sample Management Office. Samples consisted of deer mice (*Peromyscus maniculatus*) (PEMA), brush mice (*Peromyscus boylii*) (PEBO), and long-tailed voles (*Microtus longicaudus*) (MILO) (Appendix A).

ALS Group (formerly Paragon Analytics) analyzed the whole-body (carcass plus pelt) field mouse samples for TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury). Seventeen dioxin/furan congeners in whole-body field mice/voles were analyzed by Cape Fear Analytical, LLC.

2012 Study. Small mammal trapping was conducted near TA-16-399 (Flash Pad) on July 2-3, using Sherman live traps. The objective of the sampling was to evaluate the status of the small mammal community and to collect samples for the analysis of polychlorinated biphenyls (PCBs), high explosives (HEs), and perchlorate. A trap web was set up with 12 spokes and 10 traps per spoke (Parmenter et al. 2003) **(Figure 3)**. Traps were baited on July 2nd, and checked on July 3rd. Six samples were collected, processed, and submitted similar to the 2011 study, but for organic chemical analyses.

Measures of abundance (captures per 100 trap nights), species richness, and species diversity for all captured animals; and average weight, male:female sex ratios; and indicators of reproductive activity (presence of pregnant females or juveniles) for the two most commonly trapped species, PEBO and PEMA, were determined. A comparison of these metrics to results from 21 other locations sampled between 2001 and 2010 on or near LANL using Sherman live traps during summer time periods (July through September) was conducted. Comparison trapping locations ranged from mesa tops to canyon bottoms and from pinyon-juniper to riparian, ponderosa pine, and mixed conifer habitats. Box and whisker plots were plotted for the number of captures per 100 trap nights, the species' sex ratios, the species' average nonpregnant adult weights, and community diversity, as indexed by Shannon' H metric (Shannon 1948). Sex ratios were not

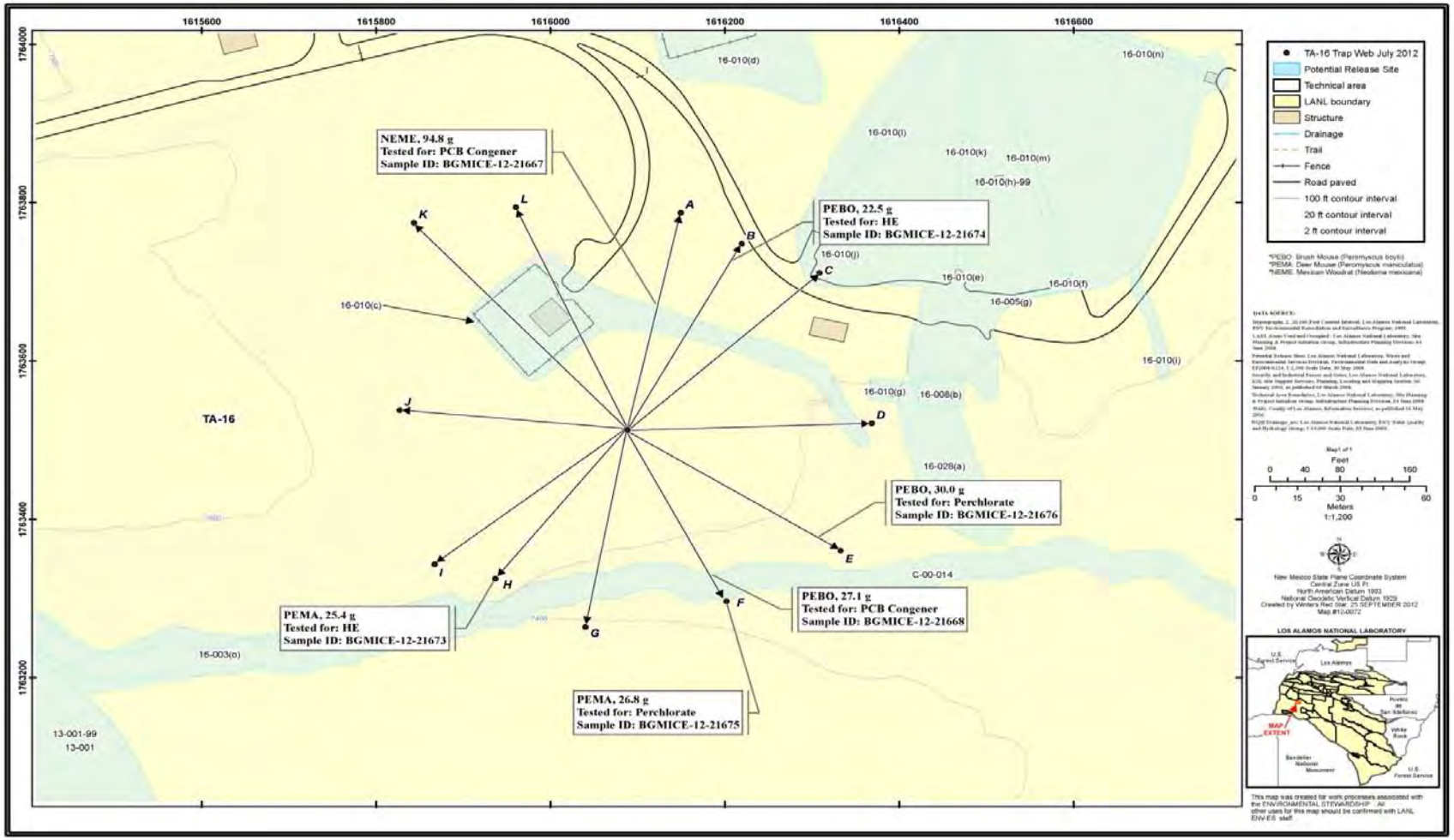

Figure 3. Map of the trapping web used to sample small mammals at the TA-16 burning grounds during July 2012. NEME = *Neotoma Mexicana*; PEBO = *Peromyscus boylii*; PEMA = *Peromyscus maniculatus*; PCB = polychlorinated biphenyl; HE = high explosives.

calculated if only one gender was captured in the trapping effort. The box and whisker plots represent the minimum value, the 25th percentile, the median, the 75th percentile, and the maximum value.

Biota Comparison Levels

Chemical concentrations in field mice/voles from Laboratory areas are first compared with regional statistical reference levels (RSRLs). RSRLs, which represent natural and fallout levels of chemicals, are the upper-level bounds of background concentrations (mean plus three standard deviations = 99% confidence level) calculated from field mice that were collected from regional locations away from the influence of the Laboratory (over 9 miles away) (U. S. Department of Energy [DOE] 1991). For TAL elements, dioxins/furans, PCBs, and perchlorate in whole-body field mice, RSRLs can be found in Fresquez (2009, 2011a). HEs are not naturally produced or commonly released, so the small mammals collected from regional locations should not contain these chemicals.

There are no regulatory screening levels for chemicals in tissues of field mice, so if chemicals in field mice are higher than the RSRLs, then the average chemical concentration in the soil at the place of collection is compared with ecological screening levels (ESLs) (LANL 2010b). ESLs are derived by the Laboratory from the literature and are designed to reflect the concentration of a chemical in the soil that is not expected to produce any adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on soil (i.e., they are the concentrations that are protective of ecological receptors under chronic exposure conditions).

RESULTS

2011 Study: Of the 23 TAL elements, barium, nickel, and cadmium were the only chemicals in whole-body field mice collected from around a burn unit at TA-16 (TA-16-388) that were detected in higher concentrations than the RSRLs in two or more samples **(Table 1)**. (Note that barium and cadmium were also detected above background concentrations in soil samples.) Nickel and cadmium in whole-body field mice were just above the RSRLs, whereas barium was substantially higher (15 to 27 mg/kg) than the field mouse RSRL (5.1 mg/kg). Nevertheless, the average concentration of barium in soil (519 mg/kg) from across the site (n=32) (LANL 2010a) was still below the ESL of 1800 mg/kg for the field mouse (LANL 2010b). Dioxins and furans

Table 1. TAL Elements (mg/kg wet) in Whole-Body Field Mice Collected from Burn Site at TA-16 in 2011.

Element[a]	9125[b] (brush mouse)	9131 (deer mouse)	9132 (deer mouse)	RSRL[c]
Aluminum	11	21	14	73
Barium	**15**	**27**	**22**	5.1
Beryllium[d]	0.0022	0.0019	0.0023	0.016
Calcium	11000	10000	11000	12624
Chromium	0.22	0.23	0.23	0.40
Cobalt	0.035	0.049	0.048	0.072
Copper	2.8	3.4	3.8	6.2
Iron	61	84	79	140
Magnesium	280	300	360	544
Manganese	3.1	2.6	2.4	7.6
Nickel	**0.14**	**0.12**	**0.18**	0.11
Potassium	2800	2700	2700	3677
Sodium	1300	1200	1200	1920
Vanadium	0.029	0.052	0.036	0.14
Zinc	23	23	25	119
Antimony	0.032	0.041	0.057	0.17
Arsenic	0.026	0.028	0.022	0.089
Cadmium	**0.048**	**0.040**	0.035	0.039
Lead	**0.59**	0.49	0.19	0.49
Selenium	0.29	0.39	0.39	0.40
Silver	0.0085	0.0068	0.0076	0.020
Thallium	0.0018	0.0017	0.0018	0.0055
Mercury	0.012	0.0081	0.0023	0.013

Note: Bold values are higher than the RSRL.
[a]Al to Zn by method SW6010B and analyzed by the inductively coupled plasma (ICP) technique; Sb to Tl by method SW6020B and analyzed by ICP/mass spectrometry; Hg by method SW7471 and analyzed by cold vapor atomic absorption.
[b]Sample number.
[c]The RSRL is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez 2009.
[d]All U flagged undetected (<method detection limit [MDL]) TAL elements were reported as one-half the MDL; all B flagged estimated values (>MDL but <reporting limit) were reported.

Table 2. Dioxin and Furan Concentrations (pg/g wet) in Whole-Body Field Mouse/Vole Samples Collected from Open-Burn Site TA-16 in 2011.

Dioxins/Furans[a]	9126[b] (MILO)	RQ[c]	9127 (MILO)	RQ	9128 (MILO)	RQ	9129 (MILO)	RQ	9130 (PEMA)	RQ	9133 (PEMA)	RQ
Dioxins												
Tetrachlorodibenzodioxin[2,3,7,8-]	0.0847	U	0.0843	U	0.084	U	0.0831	U	0.134	J	0.0837	U
Tetrachlorodibenzodioxins (Total)	0.0847	U	0.0843	U	0.084	U	0.0831	U	0.134	J	0.0837	U
Pentachlorodibenzodioxin[1,2,3,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.791	J	0.418	U
Pentachlorodibenzodioxins (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.791	J	0.418	U
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.46	J	0.418	U
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.734	J	0.418	U
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzodioxins (Total)	0.423	U	0.422	U	0.42	U	0.416	U	1.19	J	0.418	U
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	1.97	J	0.418	U
Heptachlorodibenzodioxins (Total)	0.423	U	0.422	U	0.42	U	0.416	U	2.87	J	0.418	U
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	0.847	U	0.843	U	1.7	J	0.831	U	7.73	J	0.837	U

Table 2. Continued.

Dioxins/Furans[a]	9126[b]	RQ[c]	9127	RQ	9128	RQ	9129	RQ	9130	RQ	9133	RQ
Furans												
Tetrachlorodibenzofuran[2,3,7,8-]	0.246	U	0.268	U	0.282	U	0.299	U	0.197	U	0.244	U
Tetrachlorodibenzofurans (Total)	0.442	J	0.449	J	0.282	U	0.519	J	0.197	U	0.395	J
Pentachlorodibenzofuran[1,2,3,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Pentachlorodibenzofuran[2,3,4,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Pentachlorodibenzofurans (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[1,2,3,7,8,9-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.776	J	0.418	U
Hexachlorodibenzofurans (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.776	J	0.418	U
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.753	J	0.418	U
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Heptachlorodibenzofurans (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.753	J	0.418	U
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.847	U	0.843	U	0.84	U	0.831	U	0.836	U	0.837	U

[a]Method was by 8290; blank corrected data.
[b]Sample number.
[c]Results as related to the reporting qualifier (RQ). Result followed by a blank space is a detected value = result was above the standard quantification limit (SQL); result followed by a U is an undetected value = result was below the method detection limit (MDL) (shown); result followed by a J is an estimated value = result was above the MDL but below the SQL.

were not detected above the analytical limit of quantification (detection limit) in any of the whole-body field mice/voles collected around the burn site, TA-16-388, at TA-16 **(Table 2)**. These data are similar to other dioxin/furan field-mouse uptake studies at the local (Fresquez 2011b) and national (Krouskop et al., 1991) levels and suggest that dioxins and furans, at least in the parts per trillion range (pg/g) in soil under natural field conditions, are not significantly assimilated, either by ingestion and/or by surface contact modes, to field mice/voles; possibly because of the adsorption of the chemical to soil surfaces or because of oxidation/reduction changes.

2012 Study: Trapped animals included one Mexican woodrat (*Neotoma mexicana*) (NEMA), three brush mice (PEBO) and two deer mice (PEMA). This resulted in a species richness of three, a capture rate of 4.2 animals per 100 trap nights, and a species diversity of 1.01. Species richness was within the range of normally observed results for LANL trapping efforts **(Figure 4)**. Captures per 100 trap nights and species diversity values were in the middle 50 percent of the data values for all trapping locations **(Figures 5 and 6)**.

Only two adult male PEMA were captured, so no pregnant females or juveniles were recorded for that species. There was evidence of reproduction in the captured PEBO **(Figure 7)**. Male:female sex ratios for PEBO at TA-16 were in the middle 50 percent of the data values for all trapping locations **(Figure 4)**. Average nonpregnant adult weights at the TA-16 burning grounds were above the 75th percentile for all species/gender combinations captured, and for PEBO and PEMA males, they were the highest values recorded at any of the LANL trapping locations **(Figure 8)**.

There were no HEs detected in any of the field mice collected around the burn unit and the perchlorate concentrations were similar to the RSRL **(Table 3).** One out of the two small mammals (brush mouse>wood rat) collected was higher in PCBs than the RSRL for undisturbed (non-urban) sites **(Table 4)**. PCB concentrations differ between small mammal species and may be attributed to differences in habitat use and foraging strategies (Johnson et al., 1996, Smith et al., 2006). Nevertheless, the highest PCB amount recorded (26,500 pg/g) was still similar to PCBs in field mice collected from around the perimeter of a public waste (garbage) transfer station (28,000 pg/g) (Fresquez 2011) and was far below the average (whole-body) amount (2.3E06 pg/g) that resulted in population alterations by decreasing reproductive capability and changes in liver, spleen, and adrenal function in field mice (Battey et al., 1990).

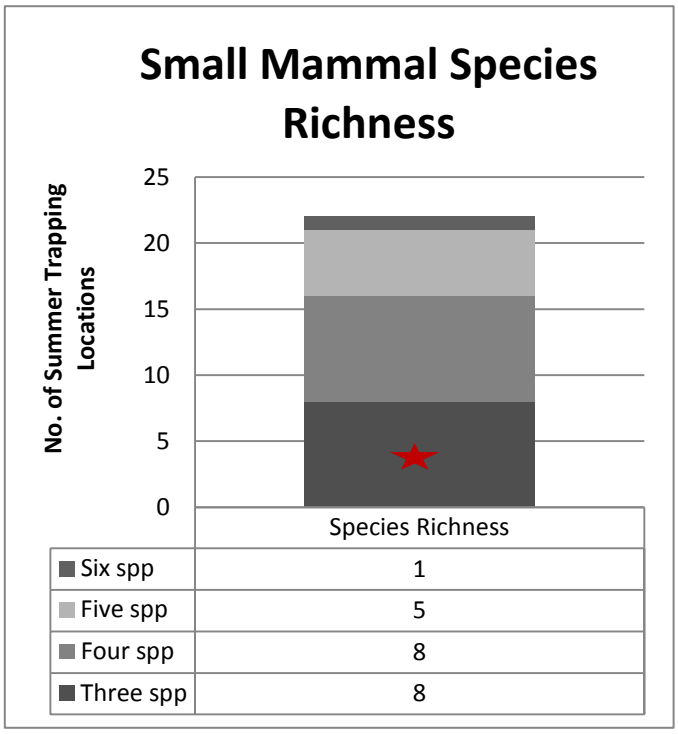

Figure 4. Species richness of small mammal communities sampled at LANL during summer between 2001 and 2012. The red star indicates the sampled species richness of three at the TA-16 burning grounds.

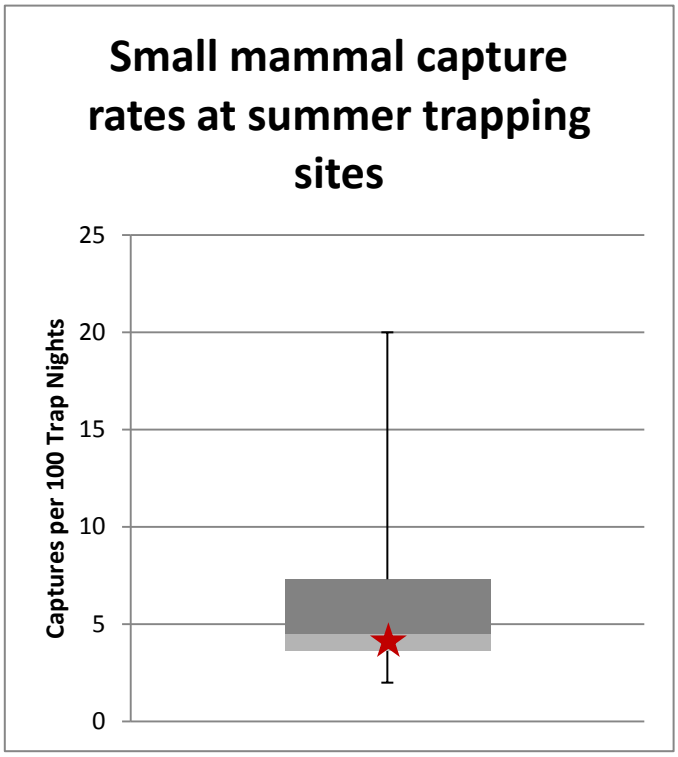

Figure 5. Capture rates of small mammal communities sampled at LANL during summer between 2001 and 2012. The red star indicates the sampled capture rate of 4.2 captures per 100 trap nights at the TA-16 burning grounds.

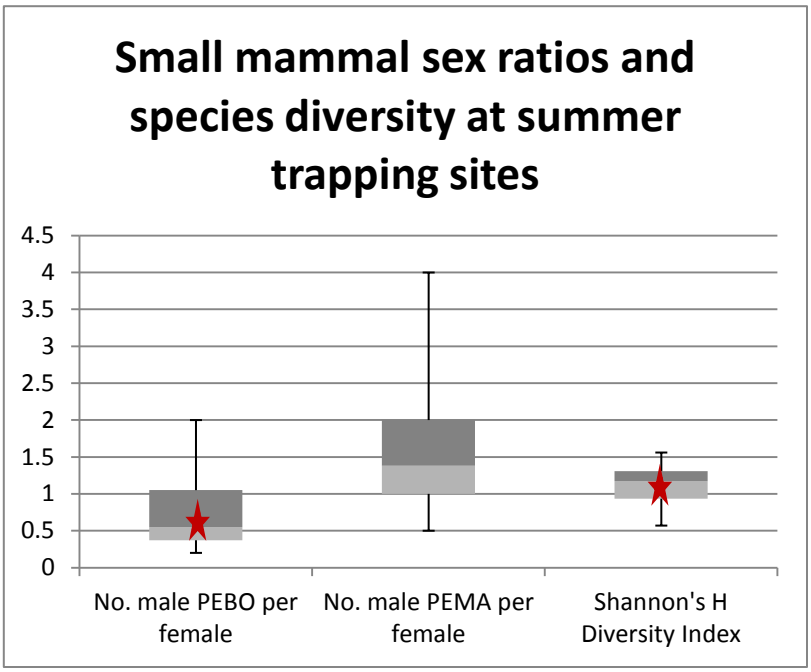

Figure 6. Sex ratios (males per female) and species diversity (Shannon's H index) for small mammals sampled at LANL during summer between 2001 and 2012. The red star indicates the sampled values at the TA-16 burning grounds of 0.5 male PEBO (*P. boylii*) per female, and a Shannon's H value of 1.01. No female PEMA (*P. maniculatus*) were captured, so no sex ratio was calculated for that species during this trapping effort.

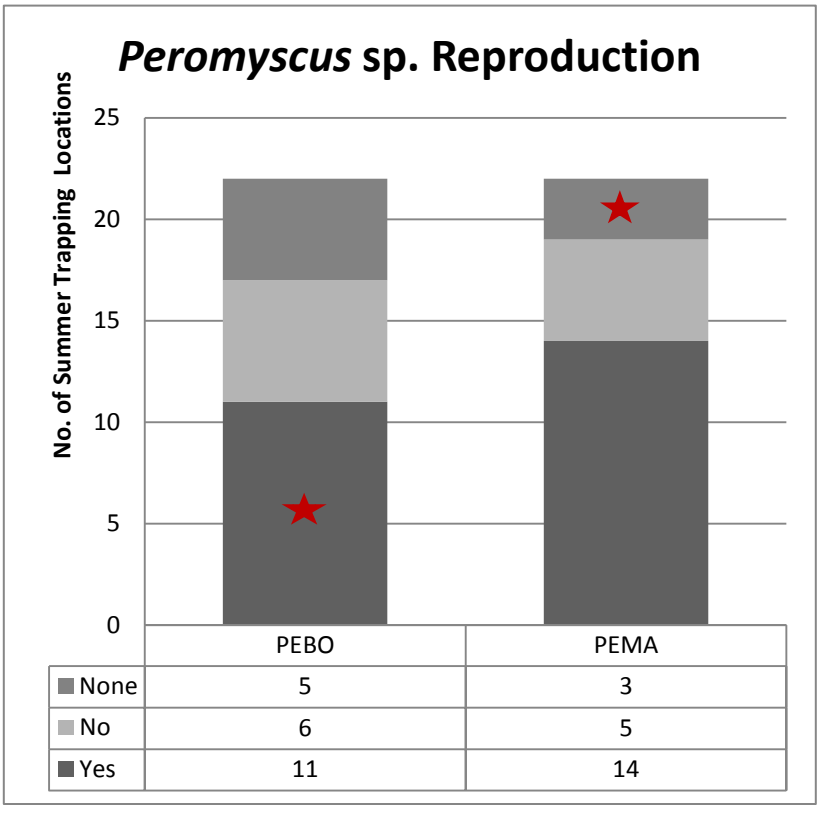

Figure 7. Evidence of reproduction (pregnant females or juveniles) in PEBO (*P. boylii*) and PEMA (*P. maniculatus*) populations sampled at LANL during summer between 2001 and 2012. Yes indicates the presence of either pregnant females or juveniles; No indicates only nonpregnant adult females present; and, None means that no adult females or juveniles of that species were captured. The red star indicates the sampling results at the TA-16 burning grounds of "Yes" for PEBO and "None" for PEMA.

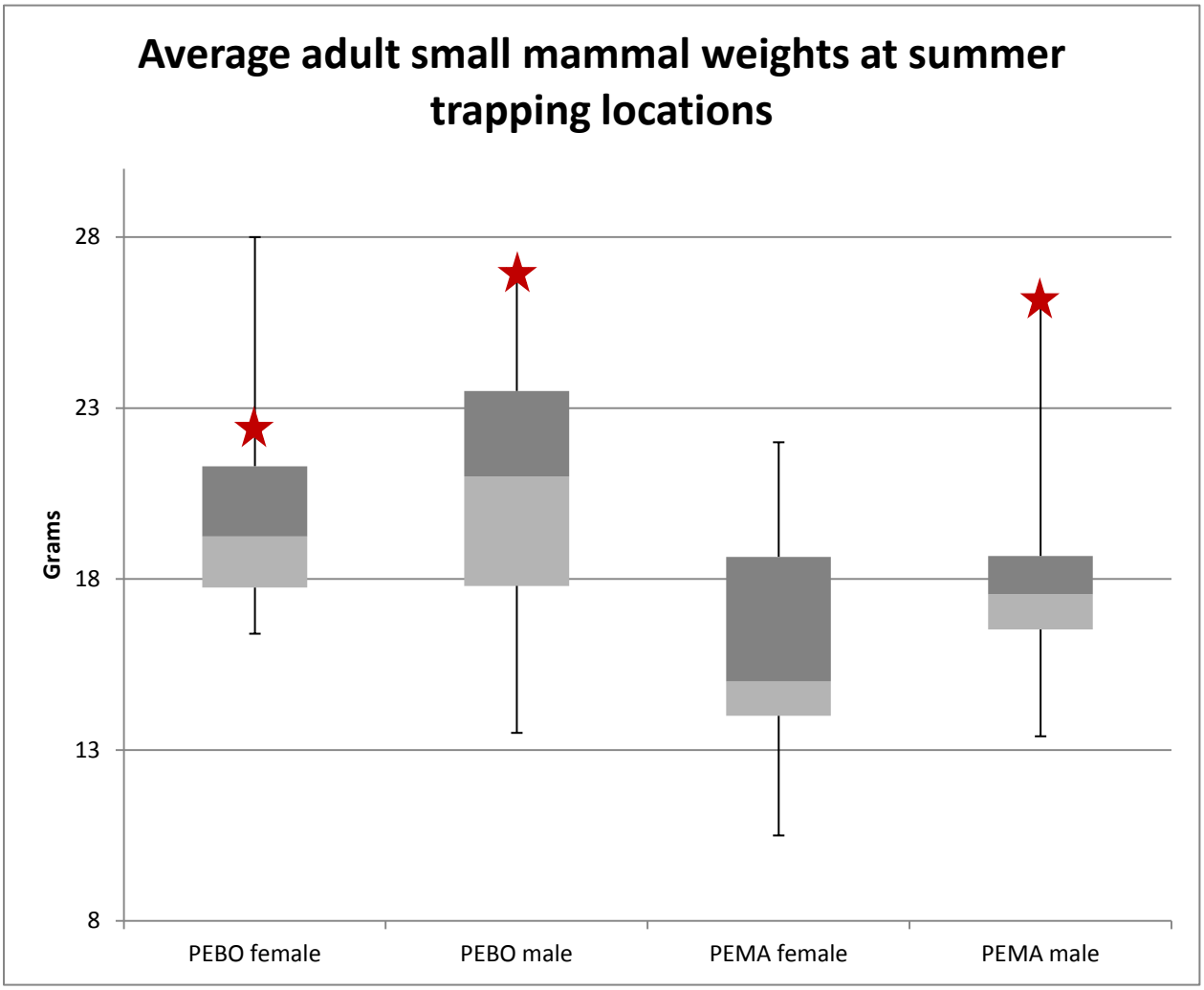

Figure 8. Average weight of adult nonpregnant female and of male PEBO (*P. boylii)* and PEMA (*P. maniculatus)* sampled at LANL during summer between 2001 and 2012. The red star indicates the sampling results at the TA-16 burning grounds of 22.5 g for female PEBO, 27.1 g for male PEBO, and 26.1 g for male PEMA. No female PEMA were captured during this trapping effort.

Table 3. High explosive concentrations (µg/kg wet) and perchlorate (mg/kg wet) in whole body field mice samples collected from TA-16 in 2012.

High Explosive/Perchlorate	12-21673[a] (deer mouse)	12-21674[a] (brush mouse)	
Trinitrotoluene[2,4,6-]	U	U	
Dinitrotoluene[2,4-]	U	U	
RDX	U	U	
Amino-2,6-dinitrotoluene[4-]	U	U	
HMX	U	U	
TATB	U	U	
Amino-4,6-dinitrotoluene[2-]	U	U	
Tetryl	U	U	
2,6-Diamino-4-nitrotoluene	U	U	
Dinitrotoluene[2,6-]	U	U	
3,5-Dinitroaniline	U	U	
2,4-Diamino-6-nitrotoluene	U	U	
PETN	U	U	
Tris (o-cresyl) phosphate	U	U	
Nitrotoluene[2-]	U	U	
Nitrobenzene	U	U	
Nitrotoluene[3-]	U	U	
Trinitrobenzene[1,3,5-]	U	U	
Dinitrobenzene[1,3-]	U	U	
Nitrotoluene[4-]	U	U	
	12-21675[a] (deer mouse)	**12-21676[a] (brush mouse)**	**RSRL[b]**
Perchlorate	0.0216	0.0032	0.19

[a]Sample number.
[b]Regional Statistical Reference Level; this is the upper-level background concentration (mean + 3 SD) based on data from Fresquez 2011a.

U (Undetected)=result was below the minimum detectable level.

Table 4. Polychlorinated biphenyl (PCB) homologs and totals (pg/g wet) in whole body field rat/mice collected from TA-16 in 2012.

PCB Homolog/Total[a]	12-21667[b] (wood rat)	12-21668[b] (brush mouse)	RSRL[c] Non-Urban	RSRL[c] Urban
Mono PCBs	0	0		
Di PCBs	0	0		
Tri PCBs	0	0		
Tetra PCBs	0	0		
Penta PCBs	23	1600		
Hexa PCBs	263	11100		
Hepta PCBs	146	10400		
Octa PCBs	91	2760		
Nona PCBs	7.5	511		
Deca PCB	0	49		
Total PCBs	531	26500	885	28000

[a]Method was by 1668A; blank corrected data.

[b]Sample number

[c]Regional Statistical Reference Level is the mean plus three standard deviations (99% confidence level) from Fresquez 2011a.

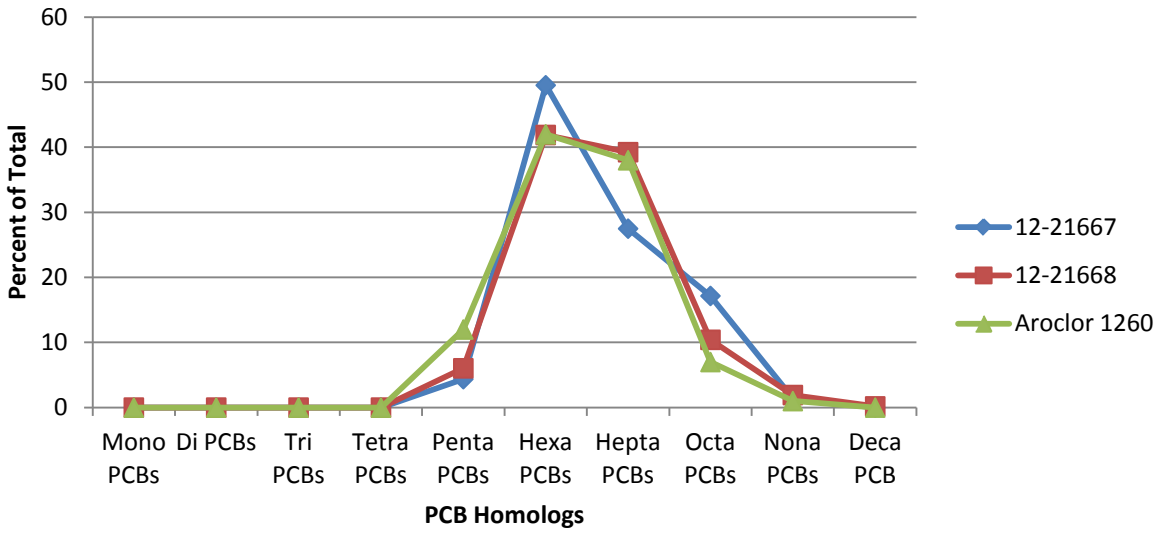

Figure 9. PCB homolog distribution of whole-body field wood rat (#21667)/brush mouse (#21668) samples collected from the TA-16 burning grounds in 2012 compared with Arochlor-1260.

The PCB homolog distribution of the field (brush) mouse collected near the TA-16 burn unit overlaps the distribution pattern of Archlor-1260 almost perfectly **(Figure 9)**.

Overall, both inorganic and organic data from whole-body field mice/voles collected at the burn unit site at TA-16 support the results of the ecological risk assessment conducted for this site. These data support the conclusion that there is no adverse effect of burn unit operations on local small mammal populations.

ACKNOWLEDGMENTS

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APPENDIX A: Sample Information

Species	Array Location	Sample Number	Date Collected	Weight (grams)	TAL	Dioxins/ Furans	PCBs	HE	Perchlorate
PEMA[a]	N/W/S	MICEBURN-11-9133	3/17/11	21		X[b]			
PEMA	N/W/S	9132	3/17/11	13.5	X				
PEMA	SE	9131	3/18/11	16.5	X				
PEMA	N/W/S	9130	3/22/11	19.5		X			
MILO	N/W/S	9129	3/22/11	24		X			
MILO	N/W/S	9128	3/23/11	21.5		X			
MILO	N/W/S	9127	3/24/11	20.5		X			
MILO	N/W/S	9126	3/24/11	21		X			
PEBO	SE	9125	4/1/11	15	X				
NEME	A	BG-MICE-12-21667	7/3/12	94.8			X		
PEBO	B	21674	7/3/12	23.5				X	
PEBO	E	21676	7/3/12	30					X
PEBO	F	21668	7/3/12	27.1			X		
PEMA	F	21675	7/3/12	26.8					X
PEMA	H	21673	7/3/12	25.4				X	

Note: Coordinates are as follows: X = 1615893.65 and Y = 1763660.03.
[a]PEMA = Deer mouse (*Peromyscus maniculatus*), MILO = Long-tailed vole (*Microtus longicaudus*), PEBO = Brush mouse (*Peromyscus boylii*), NEME=Mexican wood rat.
[b]X = Analyzed.

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 5 – Hathcock & Fair 2013

Environmental Report:

Hathcock, C.D. and J.M. Fair, 2013. *Avian Monitoring at the TA 36 Minie Site, TA-39 Point 6 Site, and TA 16 Burn Ground*. LA-UR-13-27825.

Title:	**Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Grounds**
Author(s):	Charles D. Hathcock and Jeanne M. Fair Environmental Protection Division
Intended for:	RCRA Permitting Team and External

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year monitoring program for migratory birds in Fiscal Year (FY) 2013 to monitor avifauna at two open detonation sites and one open burn site at LANL. The objectives of this on-going study are to monitor patterns and trends of bird abundance and diversity over time at these sites. LANS biologists completed the first year of this effort in 2013.

Three surveys were completed at each of the study sites at the Technical Area (TA)-36 Minie Site, the TA-39 Point 6, and the TA-16 Burn Grounds between May and July 2013. A total of 590 birds representing 55 species were recorded. Of the 55 species detected at the three study sites, 54 are protected under the Migratory Bird Treaty Act (MBTA).

Results indicate that the avian abundance and diversity at the three study sites were comparable to or greater than that of the control sites. Continued monitoring will produce trends over time in avian abundance and diversity that can be compared to local, regional, and national data.

Introduction

As part of the Resource Conservation and Recovery Act (RCRA) permitting process for two open detonation sites, the TA-36 Minie Site and TA-39 Point 6, and one open burn site, the TA-16 Burn Grounds, at LANL, an avian monitoring program was started in 2013. The goal was to monitor avian use of the habitat surrounding the open detonation and open burning sites and compare their use to other locations at LANL in the same habitat type. Comparisons were made to control sites which have been surveyed since 2011 (Hathcock et al. 2011; Hathcock and Keller 2012).

LANS biologists used standard point count methodology to record avian density and diversity along transects in the three study sites during the summer of 2013. Summer surveys provide information about what migratory birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years, as they provide trend data, which can be compared with regional and national changes in bird populations, changes in the natural environment at LANL, and LANL operations.

Methods

Field Methods

Point count surveys along a transect were chosen as the most rigorous method to monitor patterns of bird abundance and richness, and population trends, in habitats found at two open detonation sites and one open burning site at LANL. This method is already used around LANL at other locations for long-term monitoring. The surveys were conducted along transects in the forested, undeveloped land surrounding the study sites (Figures 1 – 3). The habitat types around the sites are pinyon-juniper woodland (PJ) for the sites at TA-36 and -39 and mixed conifer forest (MC) for the site at TA-16. These habitat descriptions are based on the 1/4 hectare physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study

sites were compared to control sites at LANL. The control sites (Figure 4) are monitored annually in ongoing surveys conducted at LANL since 2011 as described in Hathcock and Keller (2012). The PJ study sites at TA-36 and -39 are similar to the PJ control sites at TA-70 and -71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at the TA-16 Burn Grounds is similar in elevation, and overstory vegetation, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present in the control sites.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1st – August 15. Ideally the breeding bird surveys should take place in the 2nd week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys.

- Each survey consists of nine points along the transect, ~ 250 m apart
- At each point of the survey the surveyor will look and listen for 5 minutes, noting any birds encountered. The distance for observations is considered as an "unlimited-distance circular plot"; however, noting the distance to each bird out to 100 meters should be done. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, any birds encountered that have not otherwise been counted from a previous point or future point should also be noted. It should not be the intent for the surveyor to dawdle between points looking for additional birds.
- Surveys should not be conducted during rain events or wind greater than 25 kph.
- Any bird(s) encountered will be recorded on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- The "NOTES" section should be used for indicating any potentially important aspects of the survey that may affect the data. Examples include: excess noise from nearby equipment and vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

Statistical Methods

Summary statistics are compiled to look at trends in avian abundance and diversity between the three study sites and the control sites. To compare relative abundances between years and with control sites, the "birds per hour" was calculated for each site. This was calculated by taking the total number of birds per habitat type and dividing by the total number of minutes surveyed. Then this number is multiplied by 60 to get the number of birds per hour.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine species diversity by location and habitat type. This diversity index is a popular measure in ecology that is used to describe the species richness in a community. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1\ (p_i\ (\ln\ (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

Another useful measure is the Shannon's equitability estimate (E_H) (Shannon 1948) which is a measure of evenness in the population. This measures the evenness with which individuals are divided among the taxa present. This measure ranges from 0 to 1 where one represents a completely even community in which all species' abundances are equal. The Shannon's E_H is calculated using the following formula:

$E_H = H/\ln S$

Where S is species count, ln is the natural log, and *H* is the Shannon's diversity index.

To compare indices, a bootstrapping technique is used where two samples, A and B, are pooled. Then 1,000 random pairs of samples (Ai and Bi) are taken from this pool, with the same numbers of individuals as in the original two samples. For each replicate pair, the diversity indices div(Ai) and div(Bi) are computed. The number of times |div(Ai)-div(Bi)| exceeds or equals |div(A)-div(B)| indicates the probability that the observed difference could have occurred by random sampling from one parent population as estimated by the pooled sample. A small probability value less than 0.05 indicates a significant difference in the diversity index between the two samples. The diversity indices and the bootstrap comparisons between indices were completed using the PAST statistical software (Hammer et al. 2001).

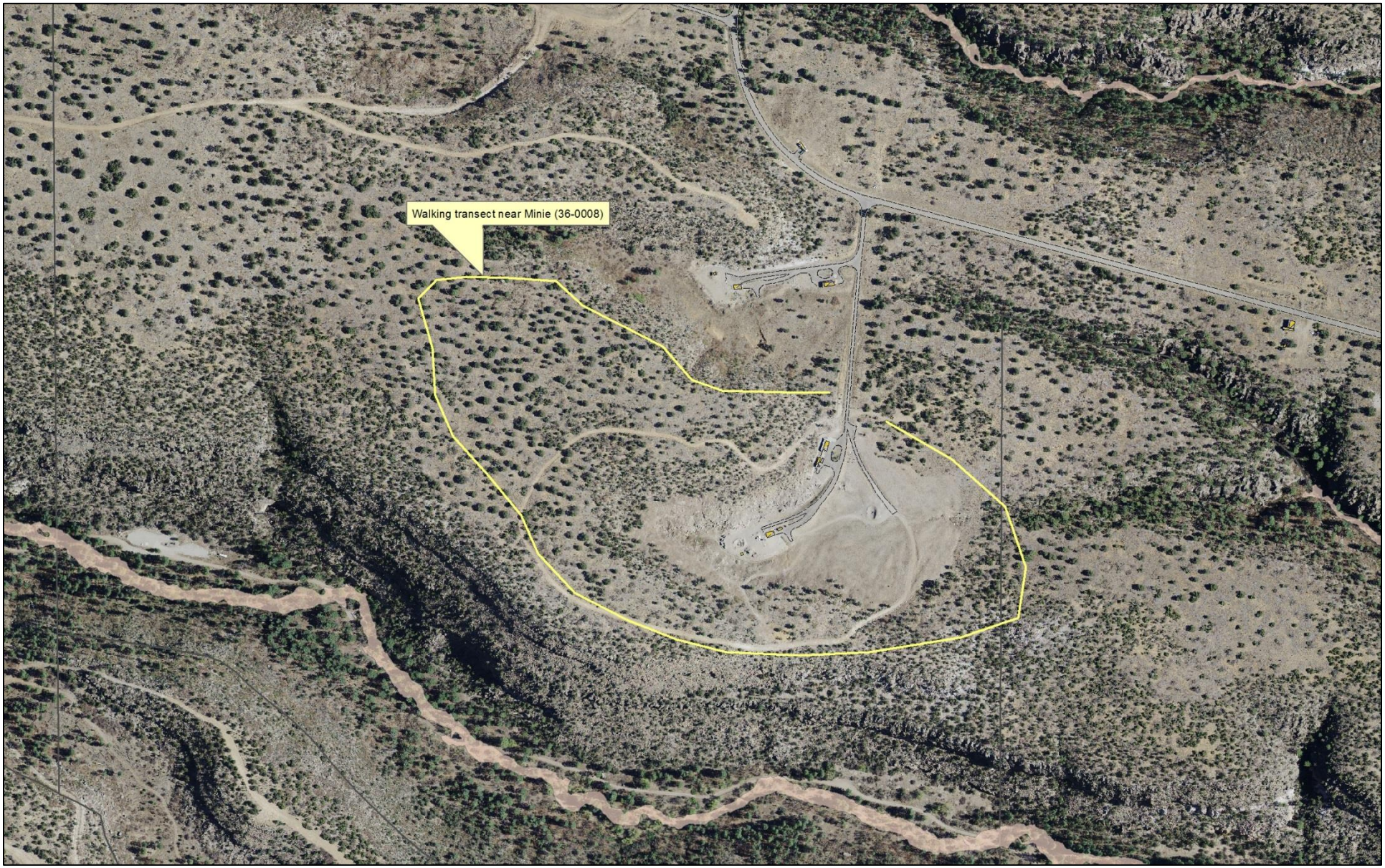

Figure 1. Field Working Map for the Transect Around the TA-36 Minie Site.

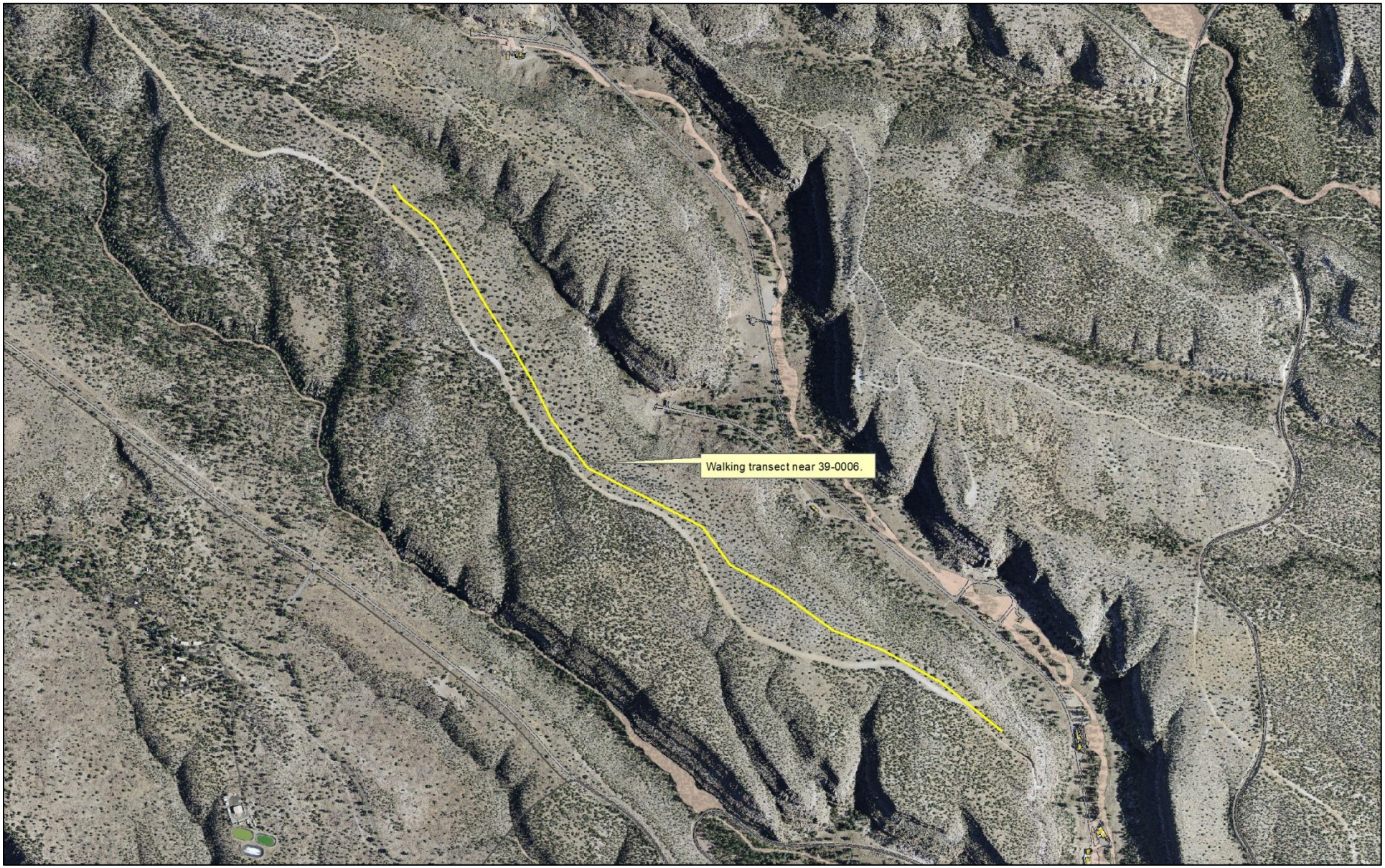

Figure 2. Field Working Map for the Transect Around the TA-39 Point 6.

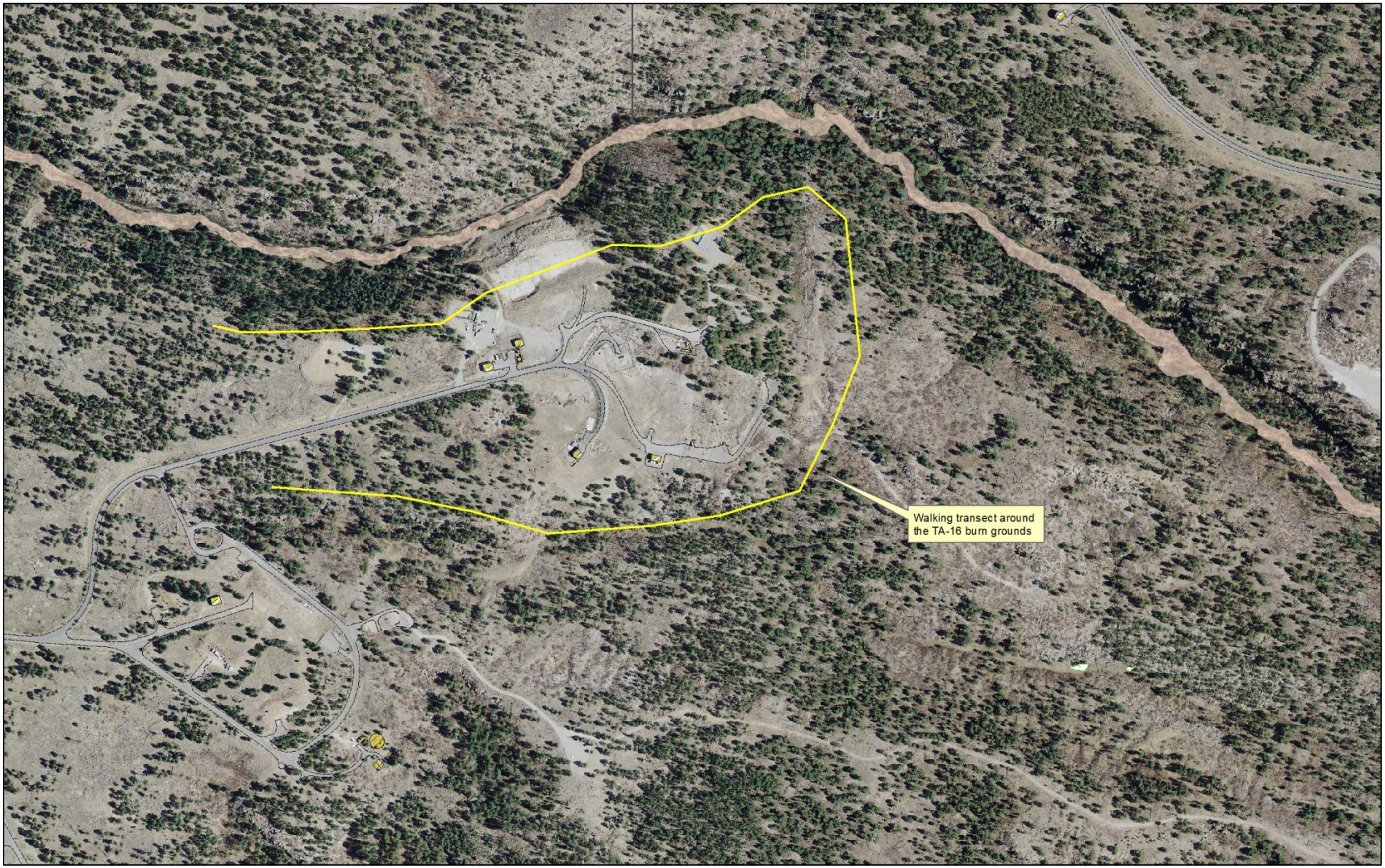

Figure3. Field Working Map for the Transect Around the TA-16 Burn Grounds.

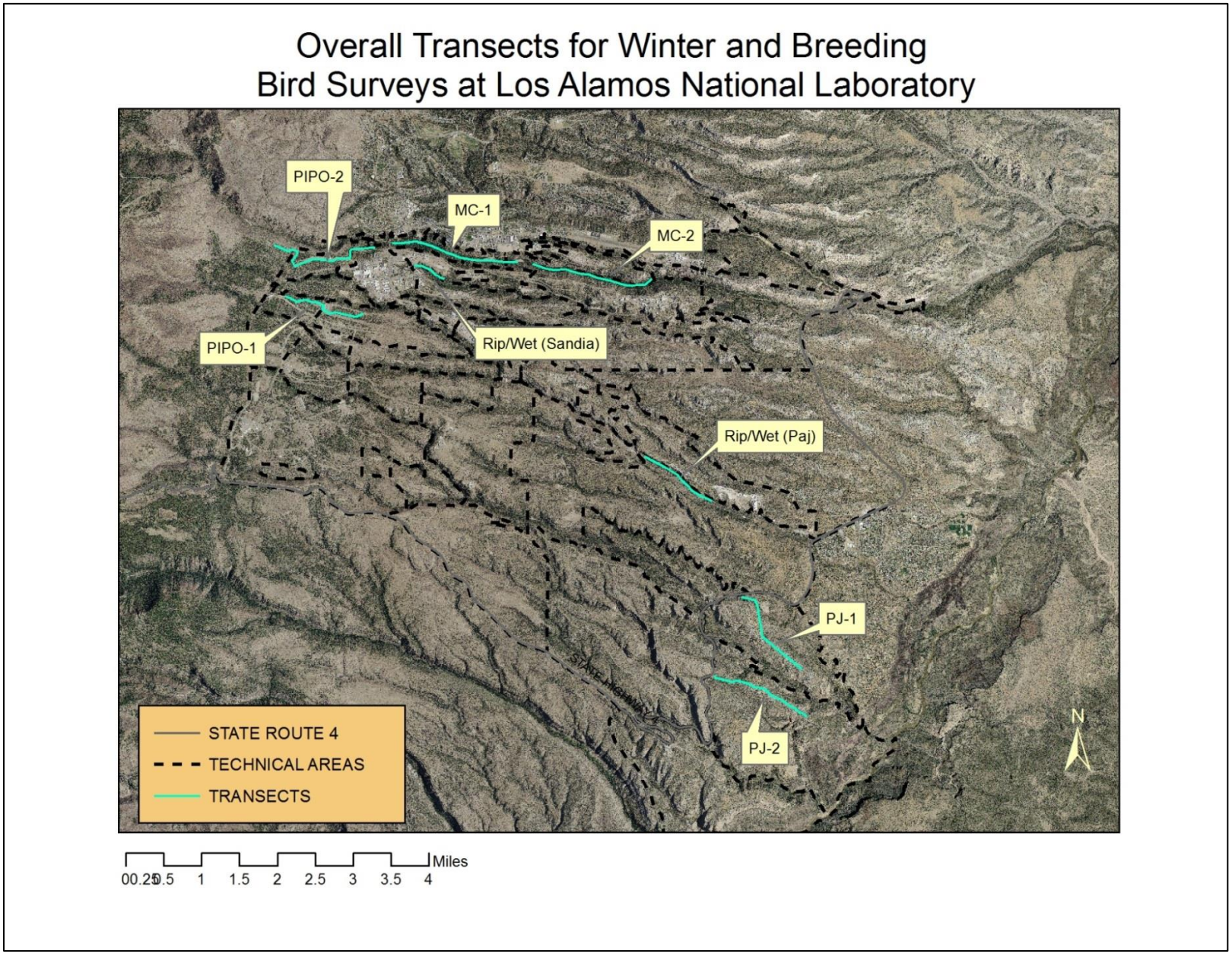

Figure 4. Control Transects from Ongoing Avian Monitoring Around LANL (Hathcock and Keller 2012). MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland, Rip/Wet: Riparian / Wetland.

Results and Discussion

Three surveys were completed at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Grounds between May and July 2013. A total of 590 birds representing 55 species were recorded. The ten most common species at these three sites were the House Finch, Spotted Towhee, Western Bluebird, Mourning Dove, Ash-throated Flycatcher, Pine Siskin, Western Wood-Pewee, Juniper Titmouse, Gray Flycatcher, and Plumbeous Vireo. A full account of the 2013 data is detailed in Table 1.

Table 1. Birds Recorded at the Three Study Sites in 2013.

Species Name	TA-36 Minie Site (PJ Habitat)	TA-16 Burn Grounds (MC Habitat)	TA-39 Point 6 (PJ Habitat)
Acorn Woodpecker		5	
American Kestrel			1
American Robin	1	7	1
Ash-throated Flycatcher	11	3	19
Audubon's Warbler		6	
Bewick's Wren	4		3
Black-chinned Hummingbird		1	3
Black-headed Grosbeak	1		
Black-throated Gray Warbler			5
Blue-gray Gnatcatcher	3		2
Broad-tailed Hummingbird	2	5	3
Brown Creeper		1	
Brown-headed Cowbird	1	4	
Bushtit			2
Canyon Towhee	2	1	1
Chipping Sparrow	3	1	6
Common Nighthawk	6		5
Common Raven	2	5	1
Cooper's Hawk		1	
Cordilleran Flycatcher		5	
Dark-eyed Junco		6	
Eurasian Collared-Dove	3		
Evening Grosbeak	3	5	
Grace's Warbler		6	
Gray Flycatcher	12		10
Great Horned Owl			1
Green-tailed Towhee	3		1
Hairy Woodpecker		1	

Hammond's Flycatcher		8	
House Finch	16	16	21
House Wren		1	
Juniper Titmouse	12		11
Lesser Goldfinch	2	3	4
Mountain Chickadee	5	5	
Mourning Dove	17	4	13
Pine Siskin	10	12	6
Plumbeous Vireo	10	11	1
Pygmy Nuthatch		11	
Red-shafted Flicker	3	3	3
Rock Wren	3	1	7
Say's Phoebe	2	1	2
Spotted Towhee	17	11	12
Steller's Jay		3	
Townsend's Solitaire	1		
Turkey Vulture		1	
Violet-green Swallow			6
Virginia's Warbler		17	
Warbling Vireo		2	
Western Bluebird	15	20	5
Western Kingbird	6		7
Western Scrub-Jay	5	1	8
Western Tanager		2	
Western Wood-Pewee	10	15	
White-breasted Nuthatch	1	9	
White-winged Dove	1		7
Grand Total	**193**	**220**	**177**

The bird surveys were analyzed to determine the "birds per hour", which is a measure of relative abundance, for each of the three study sites as well as the control sites of the comparable habitat type (Figure 5). The birds per hour were similar between the three study sites and the associated control sites. The TA-16 Burn Grounds site was slightly lower in bird per hour than the MC control sites, but not significantly lower ($t_{3,1}$=3.506, p = 0.07). Error bars were calculated for the control sites since multiple years of data were available. The birds per hour for the TA-16 Burn Grounds was within 2 standard deviations of the mean of the MC control sites (Figure 5). The TA-36 Minie Site and TA-39 Point 6 were very similar to the PJ control sites ($t_{3,1}$=0.717, p = 0.54 and $t_{3,1}$=1.274, p = 0.33).

As described in the next section, the diversity and evenness of the avian community at the TA-16 Burn Grounds were not significantly different than the MC control sites. One possible reason for the lower birds per hour measurement, albeit not significantly lower, at the TA-16 Burn Grounds

was related to the control sites that were used. Selecting a control site is one of the fundamental issues when designing an ecological study. In this study the control sites are based on previous and ongoing work at LANL, and the two control sites for the MC habitat are located along the bottom of Los Alamos Canyon. The birds per hour can be slightly different when MC on a mesa-top, such as the TA-16 Burn Grounds, is compared with similar habitat in the bottom of a canyon. There are also species of birds, such as the Common Raven, that are seen in high numbers in Los Alamos Canyon due to close proximity to the townsite.

The 2013 results indicate that the relative abundance of the bird communities at the three study sites were not significantly different than the control sites.

The Shannon's diversity indices are detailed in Table 2. The TA-16 Burn Grounds showed the largest diversity of bird species, which was expected since it is primarily MC habitat. A bootstrapping technique using 1,000 permutations was used to compare the diversity indices.

Compared to the control sites, the diversity and evenness of the TA-16 Burn Grounds were not significantly different than both the 2013 data ($p=0.53$ and 0.57) and the pooled data from 2011-2013 ($p=0.11$ and 0.17).

Compared to the control sites, the diversity of the TA-36 Minie Site was not significantly different than the 2013 data ($p=0.38$) and the pooled data ($p=0.66$). However, the evenness of the TA-36 Minie Site was significantly larger than the control sites for both the 2013 data as well as the pooled data ($p=0.001$ and 0.003).

Compared to the control sites, the diversity at TA-39 Point 6 was significantly larger than the 2013 data ($p=0.03$) and larger than the pooled data, but not significantly ($p=0.13$). The evenness of the TA-39 Point 6 was significantly larger than the control sites for both the 2013 data as well as the pooled data ($p=0.003$ and 0.017).

These results indicate that the bird diversity and evenness of the avian communities at the study sites are comparable to or greater than the control sites, with some being significantly greater. This indicates a healthy avian population at the study sites.

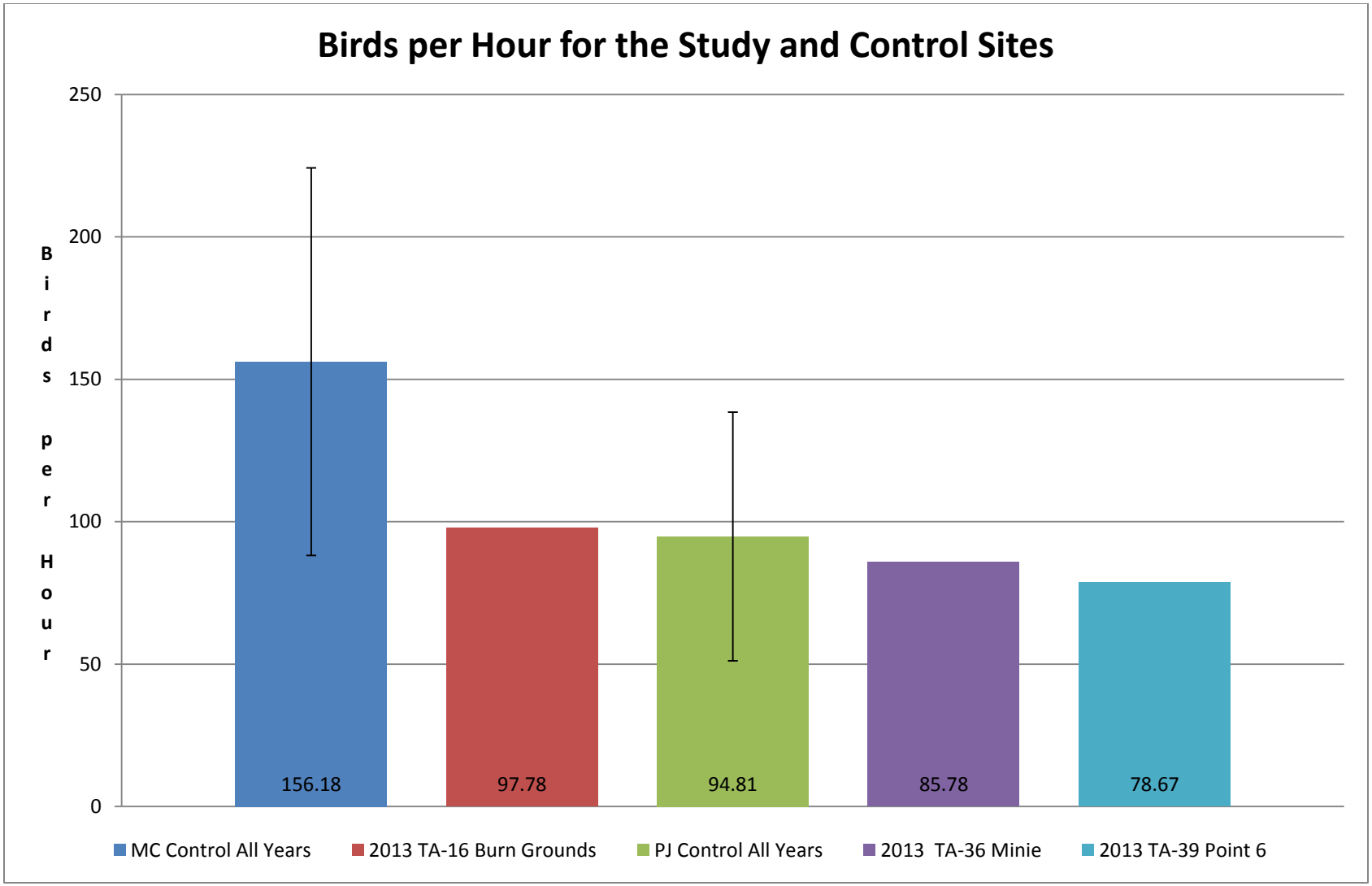

Figure 5. Birds per Hour for the Study and Control Sites. Error Bars are +/- 2 Standard Deviations. MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

Table 2. Shannon Values for the Study Sites and Control Sites; Statistically Significant Results are Bolded. MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

Transect Name	Diversity Index (H)	2013 PJ Control Sites Diversity Index (H)	All Years PJ Control Sites Diversity Index (H)	2013 MC Control Sites Diversity Index (H)	All Years MC Control Sites Diversity Index (H)
TA-36 Minie Site (PJ)	2.942	2.832	2.878		
TA-39 Point 6 (PJ)	3.09	**2.832 (p=0.03)**	2.878		
TA-16 Burn Grounds (MC)	3.304			3.383	3.501
Transect Name	Equitability Index (EH)	2013 PJ Control Sites Equitability Index (EH)	All Years PJ Control Sites Equitability Index (EH)	2013 MC Control Sites Equitability Index (EH)	All Years MC Control Sites Equitability Index (EH)
TA-36 Minie Site (PJ)	0.729	**0.5143 (p=0.001)**	**0.4805 (p=0.003)**		
TA-39 Point 6 (PJ)	0.709	**0.5143 (p=0.003)**	**0.4805 (p=0.017)**		
TA-16 Burn Grounds (MC)	0.6983			0.6269	0.6269

In addition to supporting federally protected species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for understanding migratory bird conservation. Of the 55 species detected at the three study sites, 54 are protected under the MBTA. Additionally, two of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980. Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three study sites are on the top 100 list. These two species are the Virginia's Warbler and Grace's Warbler.

Avian Nestbox Network

In 1997, an avian nestbox monitoring network was established on LANL, Los Alamos County land, and U.S. Forest Service land to investigate the health and condition of cavity-nesting bird populations on the Pajarito Plateau. The purpose of this study was to evaluate the magnitude and sources of ecological risks from contaminants and other environmental stressors for cavity-nesting birds at LANL. The main objective was to evaluate the ecological and physiological costs of exposure to various contaminants at LANL and their potential impact on population processes. In 2011, nestboxes were added to the TA-36 Minie Site and TA-39 Point 6 to investigate any potential impacts to cavity-nesting birds (Figures 6 and 7).

On Sept 17th 2012, the Environmental Protection Division received notification from the Waste Facilities Operations Facility Operations Director of potential fire suppression/tree removal activities near archaeological sites near the TA-36 Minie firing site. Nestboxes were removed from trees as part of the fuels mitigation activities. These nestboxes were replaced for the 2013 breeding season and monitoring resumed at TA-36 Minie Site for the summer breeding season. However, the habitat was significantly impacted in the area around TA-36 Minie Site by the removal of trees.

Due to the drought and the lower elevation of the nestboxes at TA-39 Point 6, no birds nested in the nestboxes in 2013. However, TA-36 Minie Site had two nests in the nestboxes in 2013. There was one Mountain Bluebird nest that hatched four eggs and one Western Bluebird nest that presumably hatched and fledged nestlings. Due to the extreme drought conditions in 2013, field work was under fire restrictions and nestboxes were not checked until July 1st, thus all baseline monitoring measurements were not collected. Due to the small sample size, no statistical comparisons can be made at this time to the over 500 nestboxes located throughout LANL and the Pajarito Plateau. However, due to the dry summer of 2013, most locations in the avian nestbox network had a decrease in hatching and fledgling success. For example, the percent of eggs hatched in 2013 was 68.12% compared to all previous years hatching success of 77-95%. Fledgling success was 67.55%, which in our study is highly dependent on elevation of the location. However, there are not noticeable differences in the four nests total that have hatched in the last two years at the TA-36 Minie Site, with a 100% hatch and fledge rate.

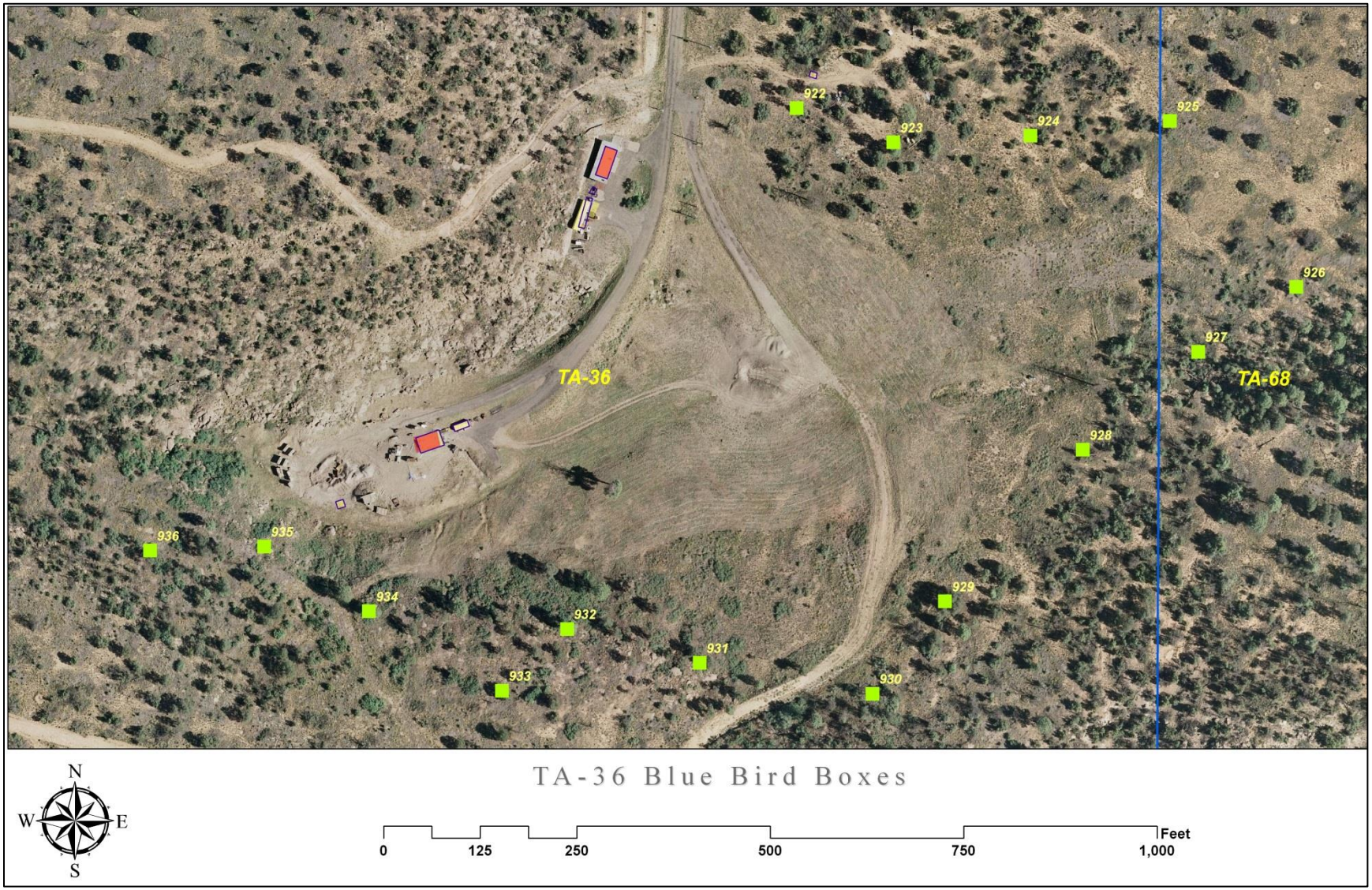

Figure 6. Avian Nestboxes Located at TA-36 Minie Site.

Figure 7. Avian Nestboxes Located at TA-39 Point 6.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the MBTA, and allow LANL to contribute to national goals in avian conservation monitoring and research.

Acknowledgments

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October 2014

Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year monitoring program for migratory birds in 2013 to monitor avifauna at two open detonation sites and one open burn site at LANL. The objectives of this on-going study are to monitor patterns and trends of bird abundance and diversity over time at these sites. LANS biologists completed the second year of this effort in 2014.

Three surveys were completed at each of the study sites at the Technical Area (TA) 36 Minie Site, the TA-39 Point 6, and the TA-16 Burn Ground between May and July 2014. A total of 588 birds representing 54 species were recorded. Of the 54 species detected at the three study sites, all but one is protected under the Migratory Bird Treaty Act (MBTA).

Results from 2014 indicate that the avian abundance and diversity at the three study sites were comparable to or significantly greater than that of the control sites. Continued monitoring will produce trends over time in avian abundance and diversity that can be compared to local, regional, and national data.

Introduction

As part of the Resource Conservation and Recovery Act permitting process at LANL for two open detonation sites, the TA-36 Minie Site and TA-39 Point 6, and one open burn site, the TA-16 Burn Ground, an avian monitoring program was started in 2013 (Hathcock and Fair 2013). The goal was to monitor avian use of the habitat surrounding the open detonation and open burning sites and compare their use to other locations at LANL in the same habitat type. Comparisons were made to control sites which have been surveyed since 2011 (Hathcock et al. 2011; Hathcock and Keller 2012).

LANS biologists used standard point count methodology to record avian density and diversity along transects in the three study sites and associated control sites during the summer of 2014. Summer surveys provide information about what migratory birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with regional and national trends in bird populations. They also can be correlated to changes in the natural environment at LANL.

Methods

Field Methods

Point count surveys along a transect were chosen as the most rigorous method to monitor patterns of bird abundance and richness in habitats found at two open detonation sites and one

open burning site at LANL. This method is already used at other LANL locations for long-term monitoring. The surveys were conducted along transects in the forested, undeveloped land surrounding the study sites (Figures 1–3). The habitat types around the sites are pinyon-juniper woodland (PJ) for the sites at TA-36 and TA-39 and mixed conifer forest (MC) for the site at TA-16. These habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study sites were compared to control sites at LANL. The control sites (Figure 4) are monitored annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock and Keller (2012). The PJ study sites at TA-36 and TA-39 are similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at the TA-16 Burn Ground is similar in elevation and overstory vegetation to the MC control sites, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon in TA-43, TA-2, and TA-21. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present at the control sites.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1st through August 15. Ideally the breeding bird surveys should take place the second week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys.

- Each survey consists of nine points along the transect, ~ 250 m apart
- At each point of the survey the surveyor will look and listen for 5 minutes, noting any birds encountered. The distance for observations is considered as an “unlimited-distance circular plot”; however, noting the distance to each bird out to 100 m should be done. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, any birds encountered that have not otherwise been counted from a previous point or future point should also be noted. The surveyor’s main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Surveys should not be conducted during rain events or wind greater than 25 kph.
- All birds encountered will be recorded on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- The “NOTES” section should be used for indicating any potentially important aspects of the survey that may affect the data. Examples include: excess noise from nearby equipment and

vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

Statistical Methods

The data were summarized to look at trends in avian abundance and diversity for the three study sites and the control sites. To compare relative abundances between years and sites, the "birds per hour" was calculated for each site. This was calculated by taking the total number of birds detected per survey and dividing by the total number of minutes surveyed. The result is multiplied by 60 to get the number of birds per hour.

The means of the study sites and control sites were compared using the Mann-Whitney U non-parametric two sample test. The data were not normally distributed thus the non-parametric test was used. Probability levels at 0.05 or less were considered significant.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine avian community diversity by location and habitat type. This diversity index is a popular measure in ecology. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1\ (p_i\ (\ln\ (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

Another useful measure is the Shannon's equitability estimate (E_H) (Shannon 1948) which is a measure of evenness in the population. This measures the evenness with which individuals are divided among the taxa present. This measure ranges from 0 to 1 where one represents a completely even community in which all species' abundances are equal. The Shannon's E_H is calculated using the following formula:

$E_H = H/\ln S$

Where S is species count, ln is the natural log, and *H* is the Shannon's diversity index.

To compare indices, a bootstrapping technique was used and probability levels at 0.05 or less were considered significant. A general description of the technique is where two samples, A and B, are pooled. Then 1,000 random pairs of samples (Ai and Bi) are taken from this pool, with the same numbers of individuals as in the original two samples. For each replicate pair, the diversity indices div(Ai) and div(Bi) are computed. The number of times |div(Ai)-div(Bi)| exceeds or equals |div(A)-div(B)| indicates the probability that the observed difference could have occurred by random sampling from one parent population as estimated by the pooled sample. A small probability value less than 0.05 indicates a significant difference in the diversity index between the two samples. The diversity indices and the bootstrap comparisons between indices were computed using the PAST statistical software (Hammer et al. 2001).

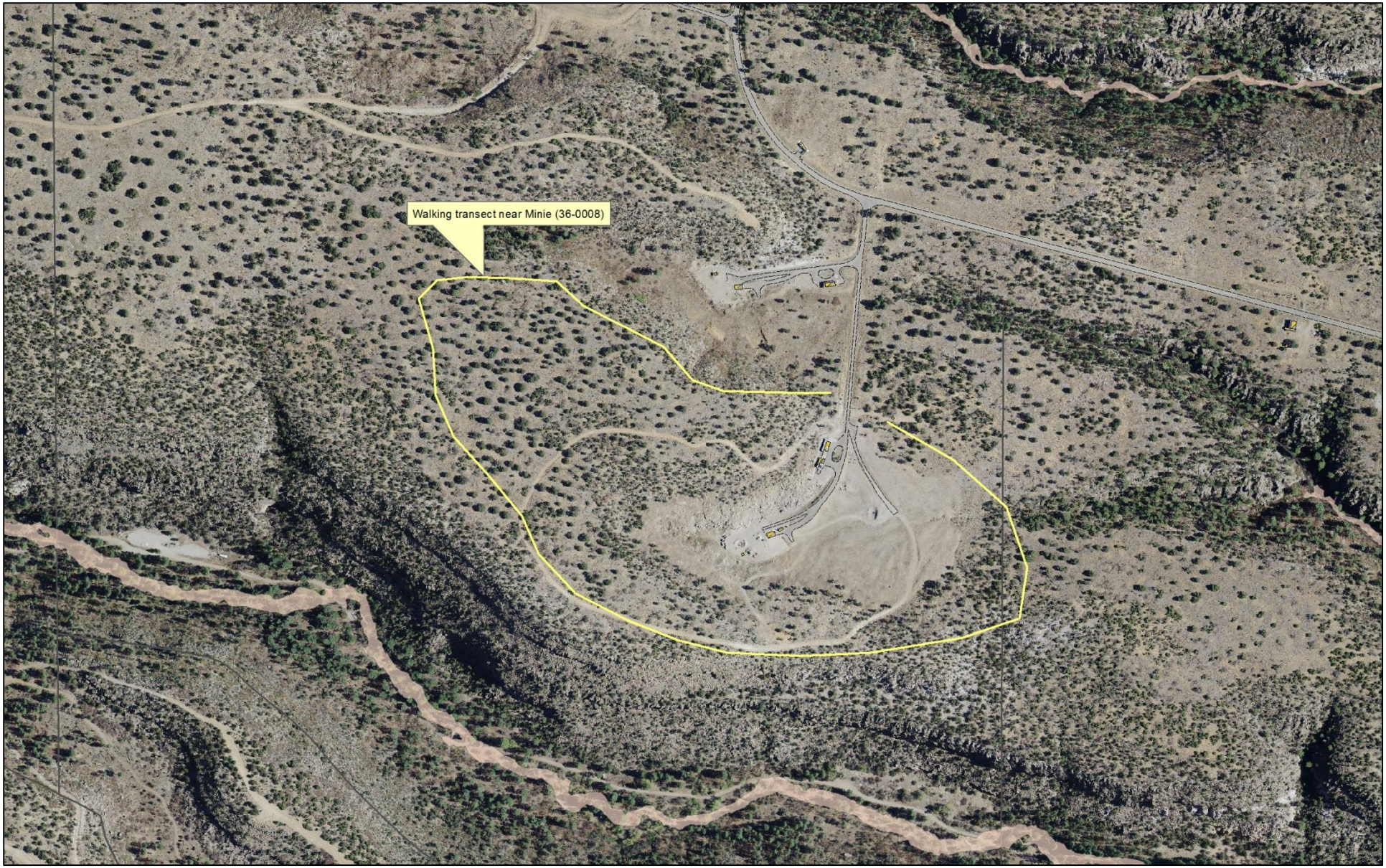

Figure 1. Field working map for the transect around the TA-36 Minie Site.

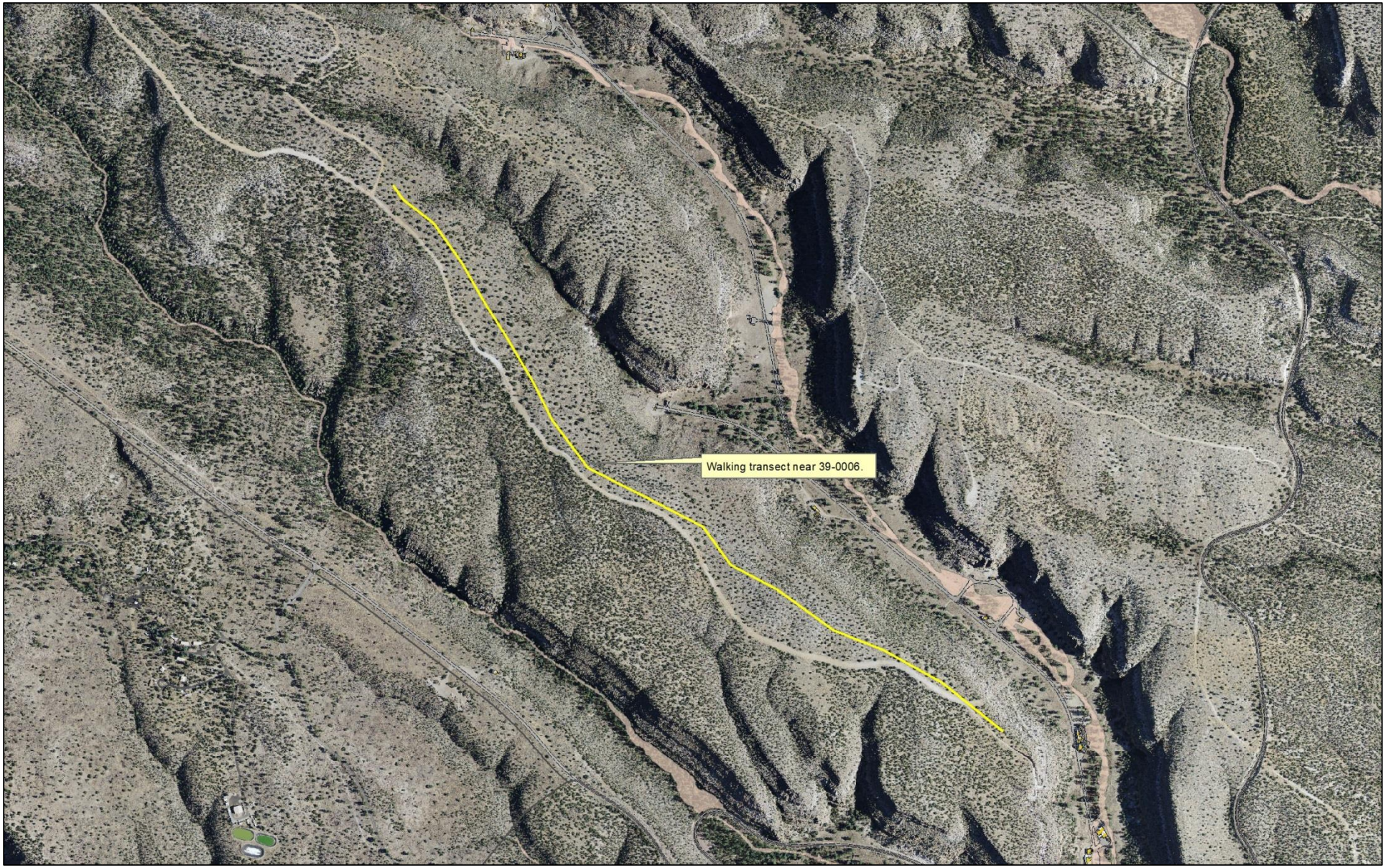

Figure 2. Field working map for the transect around the TA-39 Point 6.

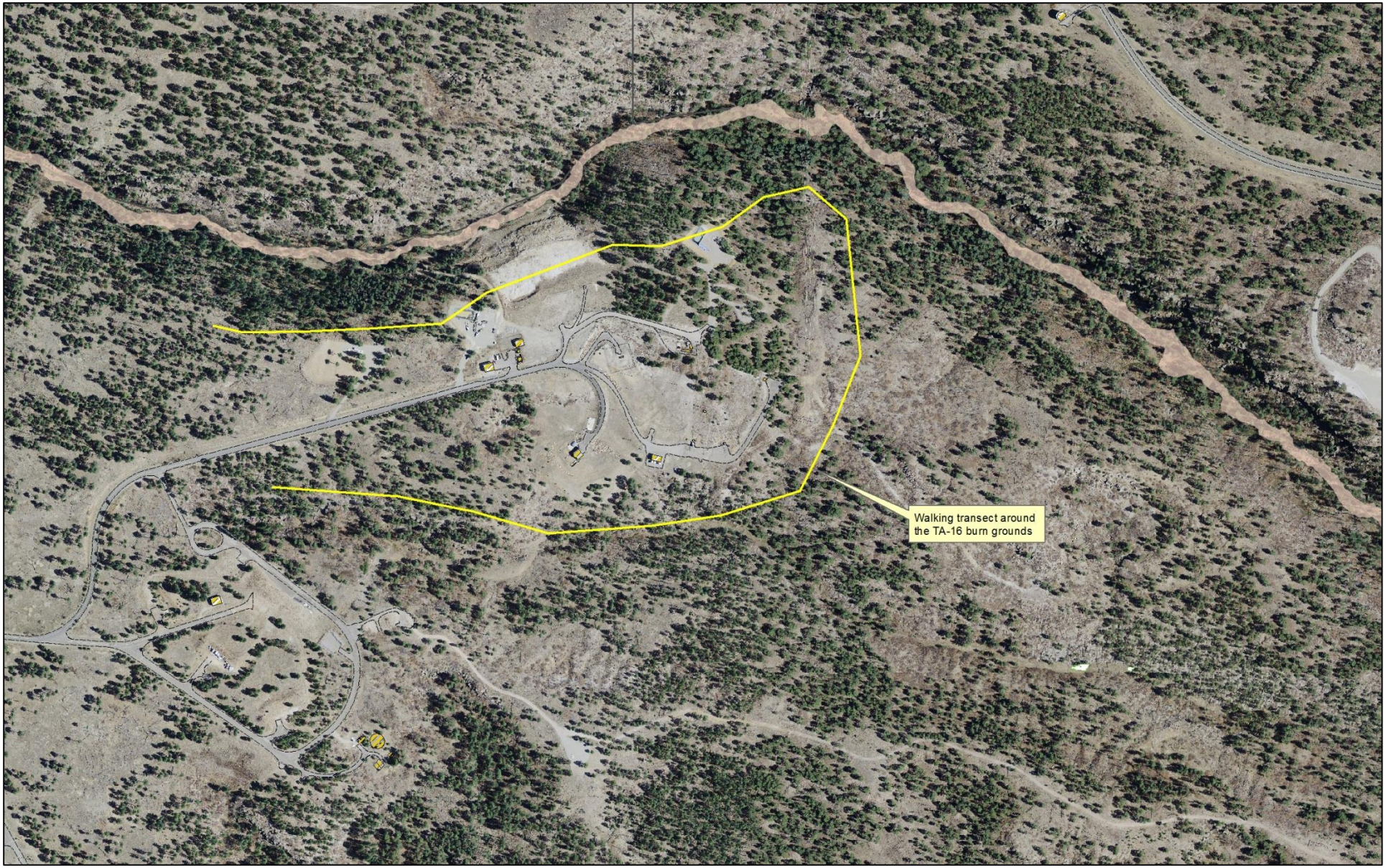

Figure3. Field working map for the transect around the TA-16 Burn Ground.

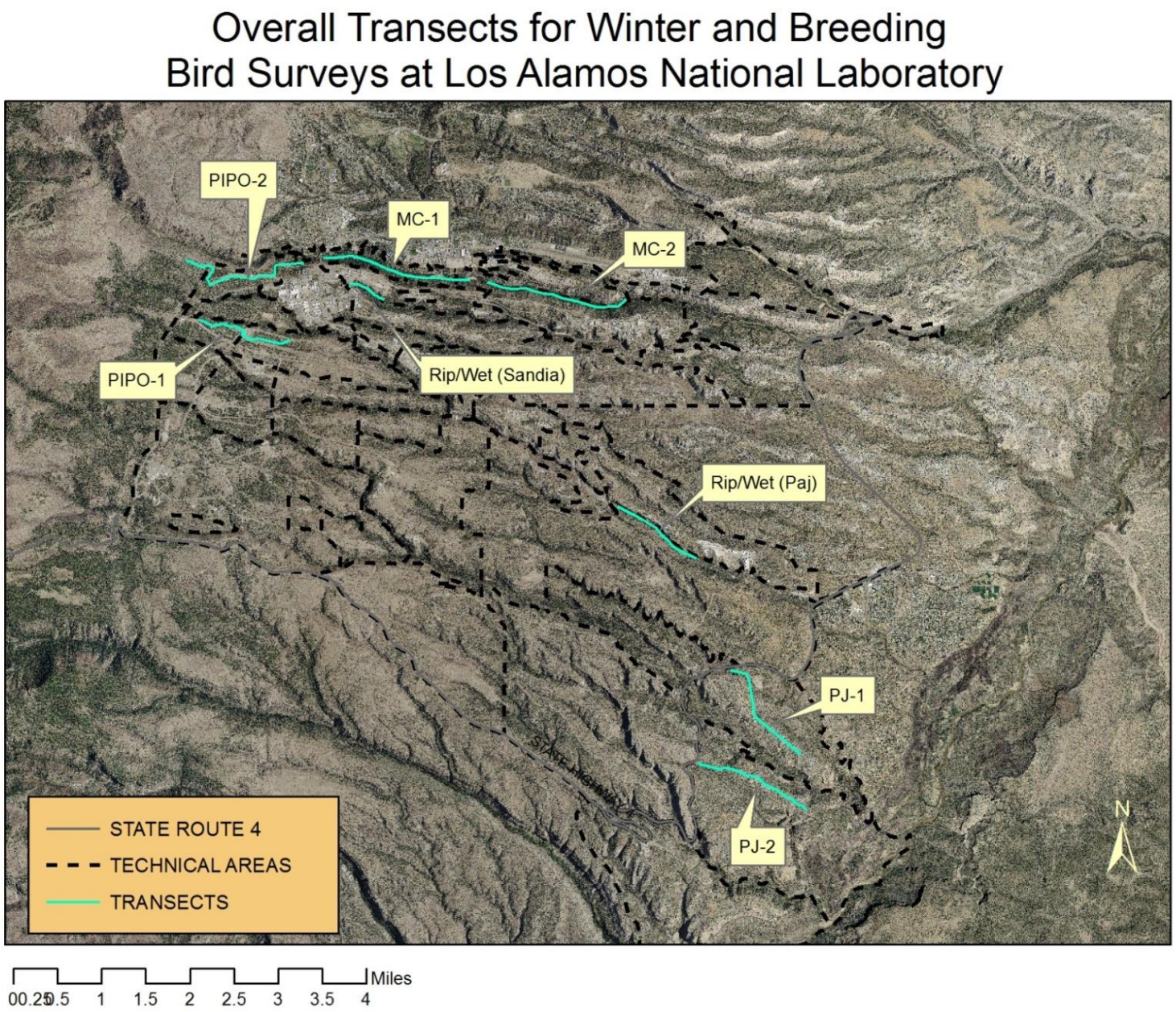

Figure 4. Control transects from ongoing avian monitoring around LANL (Hathcock and Keller 2012).
MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland, Rip/Wet: Riparian / Wetland.

Results and Discussion

Three surveys were completed at each of the three study sites and the associated control sites between May and July 2014. A total of 588 birds representing 54 species were recorded at the three study sites. A full account of the 2013–2014 data is detailed in Table 1.

The bird surveys were analyzed to determine the birds per hour, which is a measure of relative abundance, for each of the three study sites as well as the control sites of the comparable habitat type (Figure 5). The mean birds per hour at the TA-16 Burn Ground site was slightly lower than the MC control sites, but not significantly lower (Mann-Whitney U: Z = -1.0371, p = 0.30). The TA-36 Minie Site and TA-39 Point 6 birds per hour means were slightly higher that the PJ control sites, but not significantly higher (Mann-Whitney U: Z = 0.7913, p = 0.43 and Z = 1.0787, p = 0.28). The mean values with error bars corresponding to +/- 1 standard deviation for both years are represented in Figure 5. The 2014 results indicate that the relative abundance of the bird communities at the three study sites was not significantly different than the control sites.

In the first year of the study, the mean birds per hour at the TA-16 Burn Ground was significantly lower than the MC Control sites (Mann-Whitney U: Z = -2.2132, p = .026), but the difference lessened and was no longer significant in 2014. The mean birds per hour at the TA-16 Burn Ground were similar between years, but the control site numbers dropped in 2014.

The Shannon's diversity indices are detailed in Table 2. The TA-16 Burn Ground showed the largest diversity of bird species, which was expected since it is primarily MC habitat, which is known to be more diverse than PJ from past studies (Hathcock and Keller 2012).

Compared to the MC control sites, the diversity and evenness of the TA-16 Burn Ground were not significantly different (p=0.24 and 0.26).

Compared to the PJ control sites, the diversity of the TA-36 Minie Site was not significantly different (p=0.15); however, the evenness of the TA-36 Minie Site was significantly larger than the PJ control sites (p=0.024).

Compared to the PJ control sites, the diversity at TA-39 Point 6 was not significantly different (p=0.38); however, the evenness of the TA-39 Point 6 was significantly larger than the PJ control sites (p=0.12).

These results indicate that the bird diversity and evenness of the avian communities at the study sites are comparable to or greater than the control sites, with some being significantly greater. This suggests a healthy avian population at the study sites.

Table 1. Birds Recorded at the Three Study Sites in 2013–2014

Species	2013	2014	2013	2014	2013	2014
	TA-36	TA-36	TA-39	TA-39	TA-16	TA-16
	Pinyon-Juniper Woodland		Pinyon-Juniper Woodland		Mixed Conifer Forest	
Acorn Woodpecker					5	
American Kestrel			1			
American Robin	1	1	1	1	7	
Ash-throated Flycatcher	11	5	19	11	3	5
Audubon's Warbler		2			6	5
Bewick's Wren	4	8	3	10		
Black-chinned Hummingbird		1	3	2	1	
Black-headed Grosbeak	1	3		2		
Black-throated Gray Warbler			5	6		
Blue-gray Gnatcatcher	3	14	2			6
Broad-tailed Hummingbird	2	1	3	1	5	11
Brown Creeper					1	
Brown-headed Cowbird	1				4	1
Bushtit		2	2	14		
Canyon Towhee	2		1	1	1	
Chipping Sparrow	3	16	6	6	1	5
Clark's Nutcracker						4
Common Nighthawk	6		5	1		
Common Raven	2	5	1		5	6
Cooper's Hawk					1	
Cordilleran Flycatcher					5	10
Dark-eyed Junco					6	2
Downy Woodpecker						1
Eurasian Collared-Dove	3					
Evening Grosbeak	3				5	
Grace's Warbler					6	4
Great Horned Owl		3	1			
Green-tailed Towhee	3	1	1			
Hairy Woodpecker					1	1
Hammond's Flycatcher					8	9
Hermit Thrush						4
House Finch	16	17	21	4	16	2

Species	2013 TA-36 Pinyon-Juniper Woodland	2014 TA-36 Pinyon-Juniper Woodland	2013 TA-39 Pinyon-Juniper Woodland	2014 TA-39 Pinyon-Juniper Woodland	2013 TA-16 Mixed Conifer Forest	2014 TA-16 Mixed Conifer Forest
House Wren					1	1
Juniper Titmouse	12		11	13		
Lesser Goldfinch	2	6	4	12	3	
Mountain Bluebird		2		4		
Mountain Chickadee	5	2			5	8
Mourning Dove	17	17	13	22	4	
Northern Mockingbird				1		
Pine Siskin	10	2	6		12	4
Plumbeous Vireo	10	10	1		11	16
Pygmy Nuthatch					11	13
Red Crossbill				2		2
Red-shafted Flicker	3	1	3	2	3	4
Rock Wren	3	3	7	10	1	2
Say's Phoebe	2	1	2	1	1	
Spotted Towhee	17	8	12	6	11	18
Steller's Jay					3	2
Townsend's Solitaire	1					
Turkey Vulture					1	
Violet-green Swallow		5	6	4		2
Virginia's Warbler					17	11
Warbling Vireo					2	9
Western Bluebird	15	11	5	19	20	20
Western Kingbird	6	13	7	6		
Western Scrub-Jay	5	1	8	10	1	
Western Tanager		2		2	2	3
Western Wood-Pewee	10	8		4	15	10
White-breasted Nuthatch	1	4			9	8
White-throated Swift				1		
White-winged Dove	1	5	7	5		
Grand Total	193	186	177	193	220	209

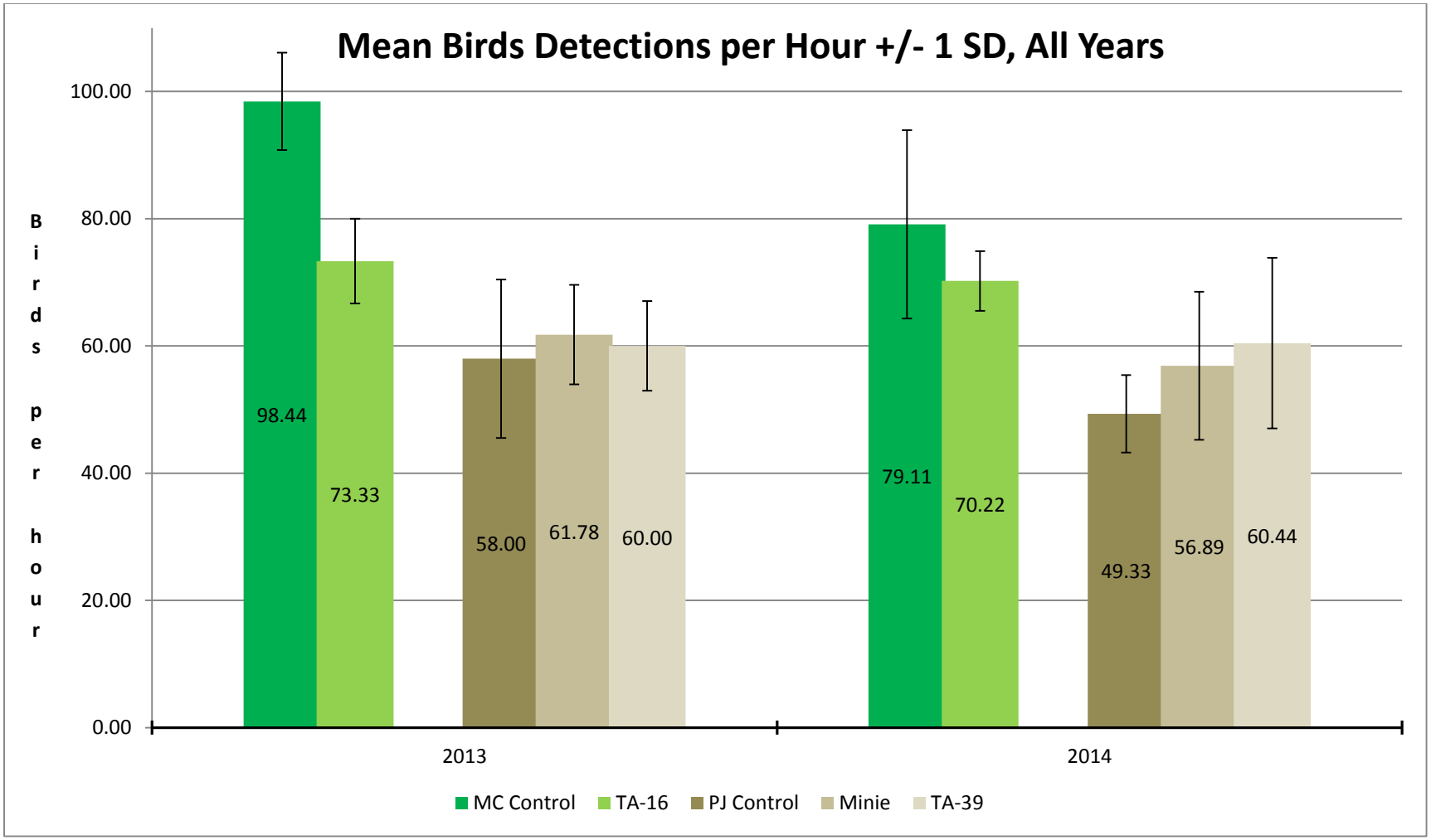

Figure 5. Birds per hour for the study and control sites. Error bars are +/- 1 standard deviation.
MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

Table 2. Shannon Values for the Study Sites and Control Sites; Statistically Significant Results are Bolded.

Transect Name	Diversity Index (H)	2014 PJ Control Sites Diversity Index (H)	2014 MC Control Sites Diversity Index (H)
TA-36 Minie Site (PJ)	3.141	2.99	
TA-39 Point 6 (PJ)	3.073	2.99	
TA-16 Burn Ground (MC)	3.207		3.327
Transect Name	Equitability Index (EH)	2014 PJ Control Sites Equitability Index (EH)	2014 MC Control Sites Equitability Index (EH)
TA-36 Minie Site (PJ)	**0.7009 (p=0.024)**	0.5525	
TA-39 Point 6 (PJ)	**0.6967 (p=0.012)**	0.5525	
TA-16 Burn Ground (MC)	0.679		0.7487

MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

In addition to supporting federally protected species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 54 species detected at the three study sites, all but one are protected under the MBTA. Additionally, three of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those three species are the Pinyon Jay, Juniper Titmouse, and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980. Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Three species detected at the three study sites are on the top 100 list. These three species are the Pinyon Jay, Virginia's Warbler, and Grace's Warbler.

Avian Nestbox Network

In 1997, an avian nestbox monitoring network was established on LANL, County of Los Alamos land, and U.S. Forest Service land to investigate the health and condition of cavity-nesting bird populations on the Pajarito Plateau. The purpose of this study was to evaluate the magnitude and sources of ecological risks from past LANL releases and other environmental stressors for cavity-nesting birds. The main objective was to evaluate the ecological and physiological costs of exposure to various constituents at LANL and their potential impact on population processes. In 2011, nestboxes were added to the TA-36 Minie Site and TA-39 Point 6 to investigate any potential impacts to cavity-nesting birds (Figures 6 and 7). Only data from the target species are reported herein, Western and Mountain Bluebirds and the Ash-throated Flycatcher.

During the 2014 nesting season, 15 nestboxes at TA-36 and 12 nestboxes at TA-39 were actively monitored. At TA-36, 10 nests were found and 4 of the nests fledged young successfully. This was an occupancy rate of 66% with a 40% success rate. Two of the nests were inhabited by Mountain Bluebirds and the other eight nests were inhabited by Western Bluebirds.

At TA-39, two nests were found and one of the nests fledged young successfully. This was an occupancy rate of 16%. One nest was inhabited by a Western Bluebird and the other was inhabited by an Ash-throated Flycatcher. Nearby nestboxes in lower Ancho Canyon also had low occupancy rates.

The overall avian nestbox network had 627 nestboxes in 2014 that were actively monitored. There were 126 active nests found and 87 of those nests fledged young successfully. This was an overall occupancy rate of 20% with a 69% success rate.

The occupancy and success rates at TA-36 were similar to the results in the overall network. More years of data are needed to begin to look at the results in a more robust manner.

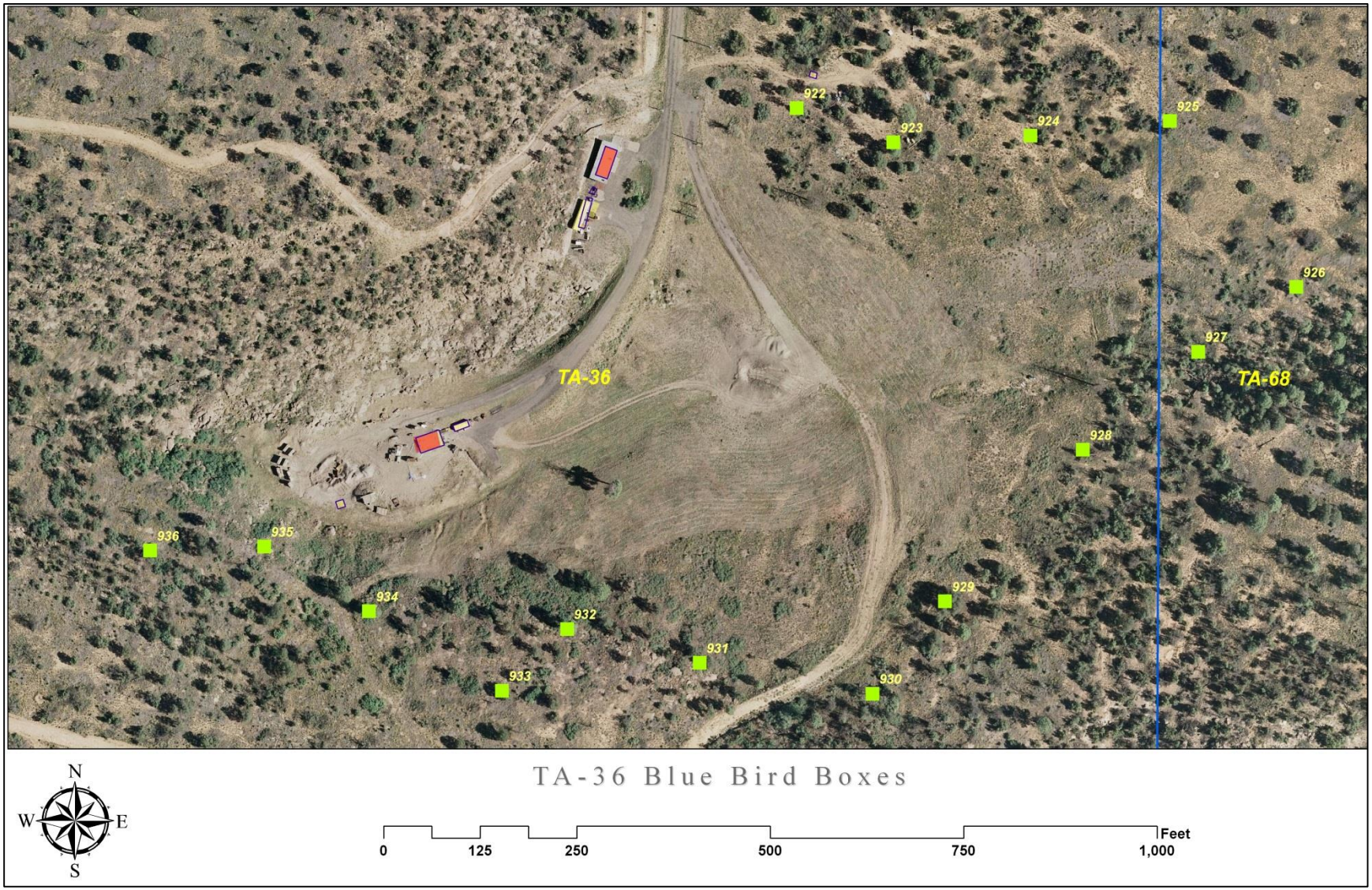

Figure 6. Avian nestboxes located at TA-36 Minie Site.

Figure 7. Avian nestboxes located at TA-39 Point 6.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the MBTA, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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October 2015

Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory

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Prepared for: U.S. Department of Energy, National Nuclear Security Administration,
Los Alamos Field Office

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna at two open detonation sites and one open burn site at LANL. Results from these efforts are compared among years and to avifauna monitoring conducted at other areas across LANL. The objectives of this study are to determine whether LANL firing site operations impact bird abundance or diversity. LANS biologists completed the third year of this effort in 2015.

Three avian point count surveys were completed at each of the study sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2015. A total of 881 birds representing 55 species were recorded at the study sites. All of the 55 species detected at the three study sites are protected under the Migratory Bird Treaty Act (MBTA). Three avian point count surveys were also completed at each of the control sites between May and July 2015.

The data were analyzed to determine abundance using an estimate of birds detected per hour, and to calculate the species diversity. The number of birds detected in three different feeding guilds were compared to examine functional community differences among areas.

Results from 2015 monitoring indicate a general increase in bird abundance across LANL. This is likely indicative of effects from greater precipitation in the winter of 2014 into the spring and early summer of 2015. Precipitation drives habitat suitability which can potentially drive animal populations using the addition resources. The link between moisture and habitat quality for a migratory bird indicates that the availability of high-quality habitats is dynamic due to variation in precipitation among seasons and years (Smith et al. 2010). There were no significant differences in bird abundance when comparing the three study sites to their respective controls. The species diversity indices at Minie site and TA-39 were not significantly different than their controls in 2015. The TA-16 burn ground bird diversity was significantly lower ($p < 0.01$) than its mixed conifer (MC) control, with 12 fewer species present. Also, there were no significant differences in the mean number of birds per feeding guild when comparing the three study sites to their respective controls in 2015.

In addition to avian point counts, nestboxes were monitored around all three study sites. These data are compared to the avian nestbox monitoring network, which was established in 1997 to investigate the occupancy rates and reproductive success of cavity-nesting bird populations. In 2015 there was an overall occupancy rate of 40% with a 66% success rate for the avian nestbox network at LANL. The percent occupancy and nest success were higher at both Minie site and TA-16, suggesting that the firing site operations are not negatively affecting nest success. Further study is needed at TA-39 because only one of 12 nestboxes at TA-39 was occupied. There may be an issue with nestbox placement at TA-39 and this issue will be investigated further in 2016. Continued monitoring will produce data that can be compared to local, regional, and national trends over time.

Introduction

As part of the Resource Conservation and Recovery Act permitting process at LANL for two open detonation sites (TA-36 Minie site and TA-39 point 6), and one open burn site, (TA-16 burn ground), an avian monitoring program was started at these locations in 2013 (Hathcock and Fair 2013). The goal is to compare avian abundance, diversity, and productivity at these sites to other locations at LANL of the same habitat type. Comparisons are made to control sites that have been surveyed since 2011 (Hathcock et al. 2011).

LANS biologists used standard point count methodology to record avian abundance and diversity along transects at the three study sites and associated control sites during the summer of 2015. Summer surveys provide information about what birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with regional and national trends in bird populations. They also can be correlated to changes in the natural environment at LANL.

In addition to avian point counts, nestboxes are monitored around all three study sites to investigate any potential impacts to occupancy rates and productivity of cavity-nesting birds. These data are compared to the LANL avian nestbox monitoring network, which was established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the study sites (Figures 1–3). The habitat types around the sites are pinyon-juniper (PJ) for the sites at TA-36 and TA-39 and MC at TA-16. These habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study sites were compared to control sites at LANL of the same habitat type. The control sites (Figure 4) are monitored annually in ongoing surveys that have been conducted at LANL since 2010 as described in Hathcock et al. (2011). Each habitat type control contains two replicate transects that are monitored in the same way as the study sites with the same number of points and during the same time periods. In each survey month, all study site and control site transects are randomized and surveyed following the random order.

The PJ study sites at TA-36 and TA-39 are similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at the TA-16 burn ground is similar in elevation and overstory vegetation to the MC control sites, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon in TA-43, TA-2, and TA-21. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present at the control sites.

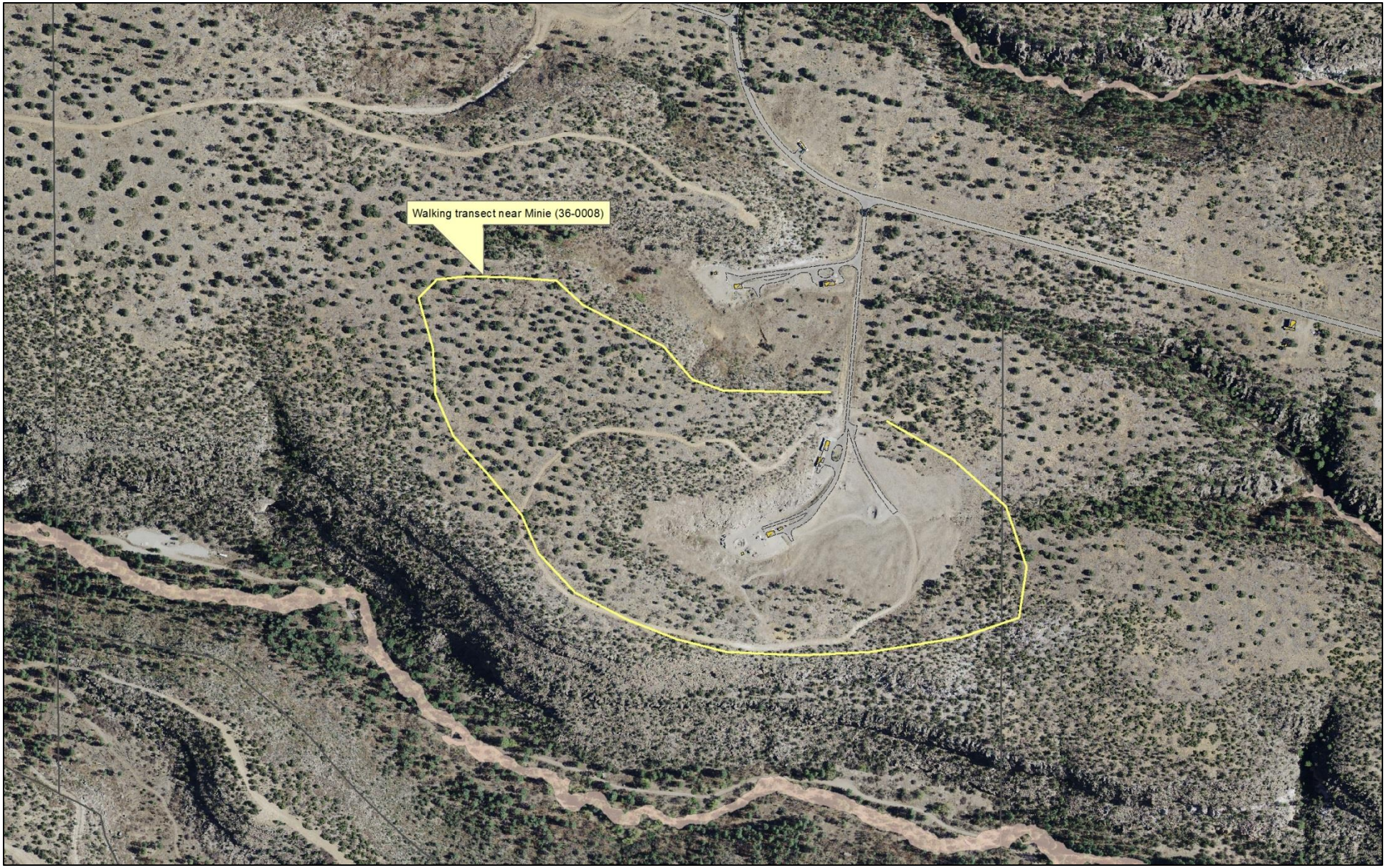

Figure 1. Field working map for the breeding bird survey transect around the TA-36 Minie site.

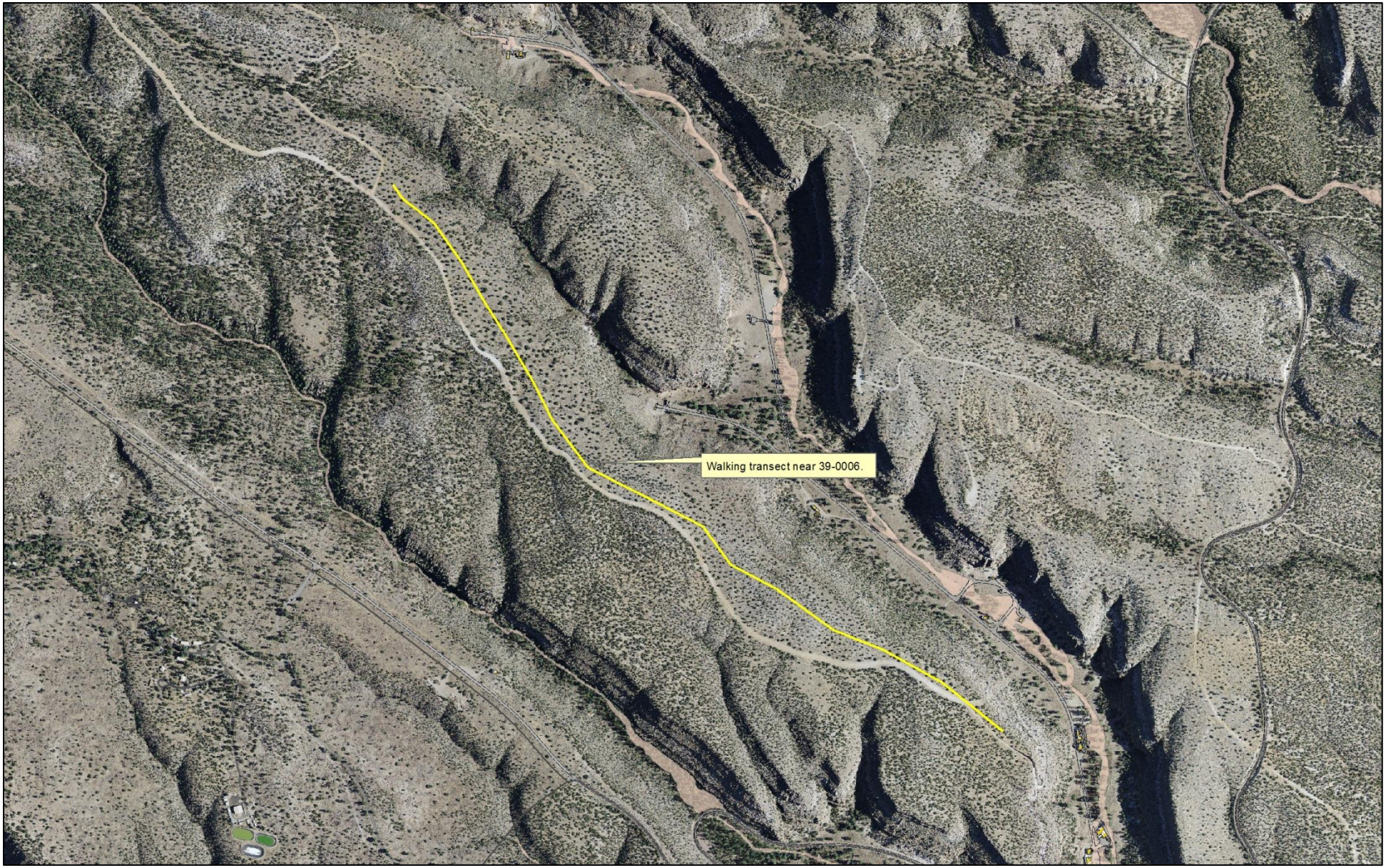

Figure 2. Field working map for the breeding bird survey transect around the TA-39 point 6.

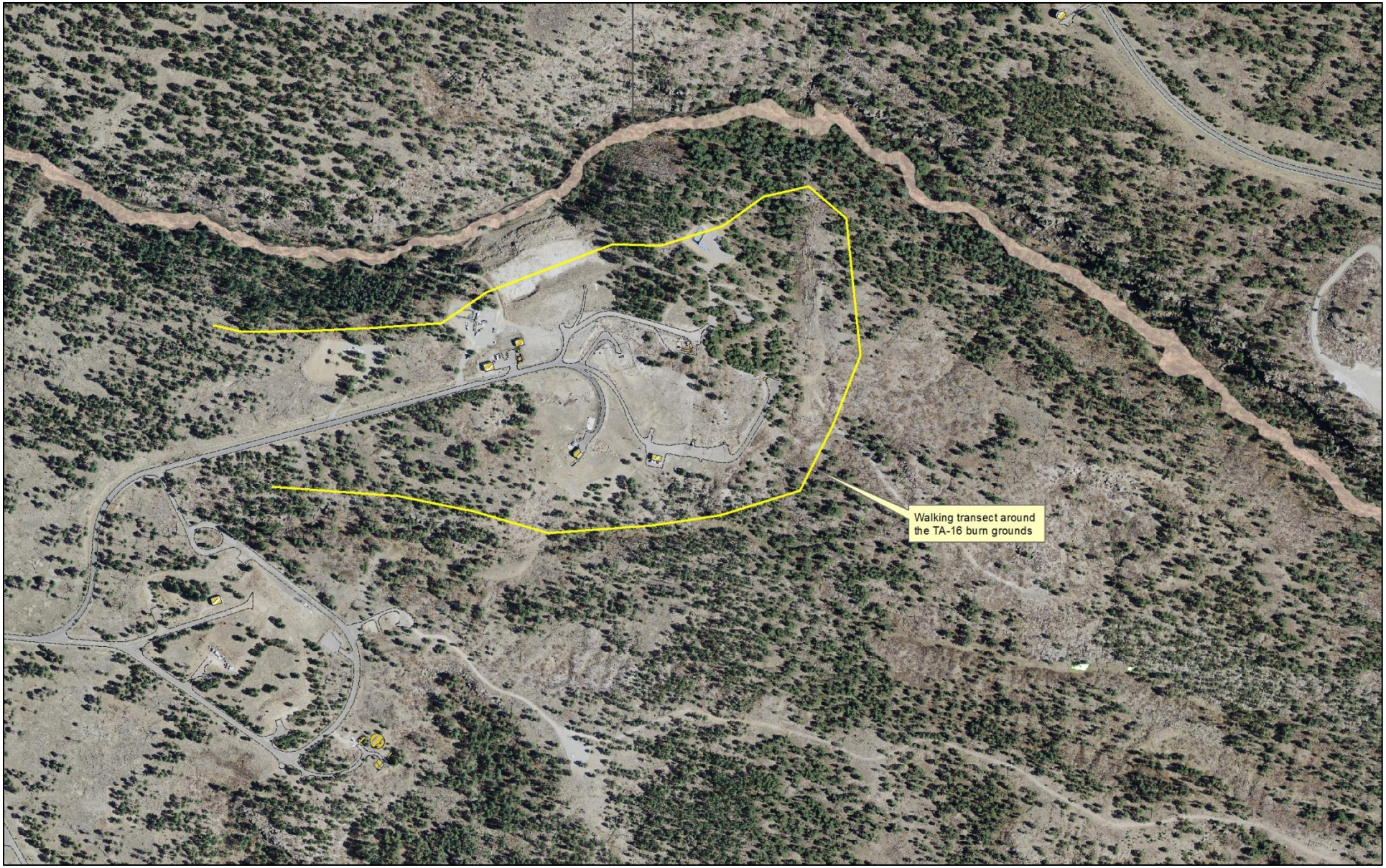

Figure 3. Field working map for the breeding bird survey transect around the TA-16 burn ground.

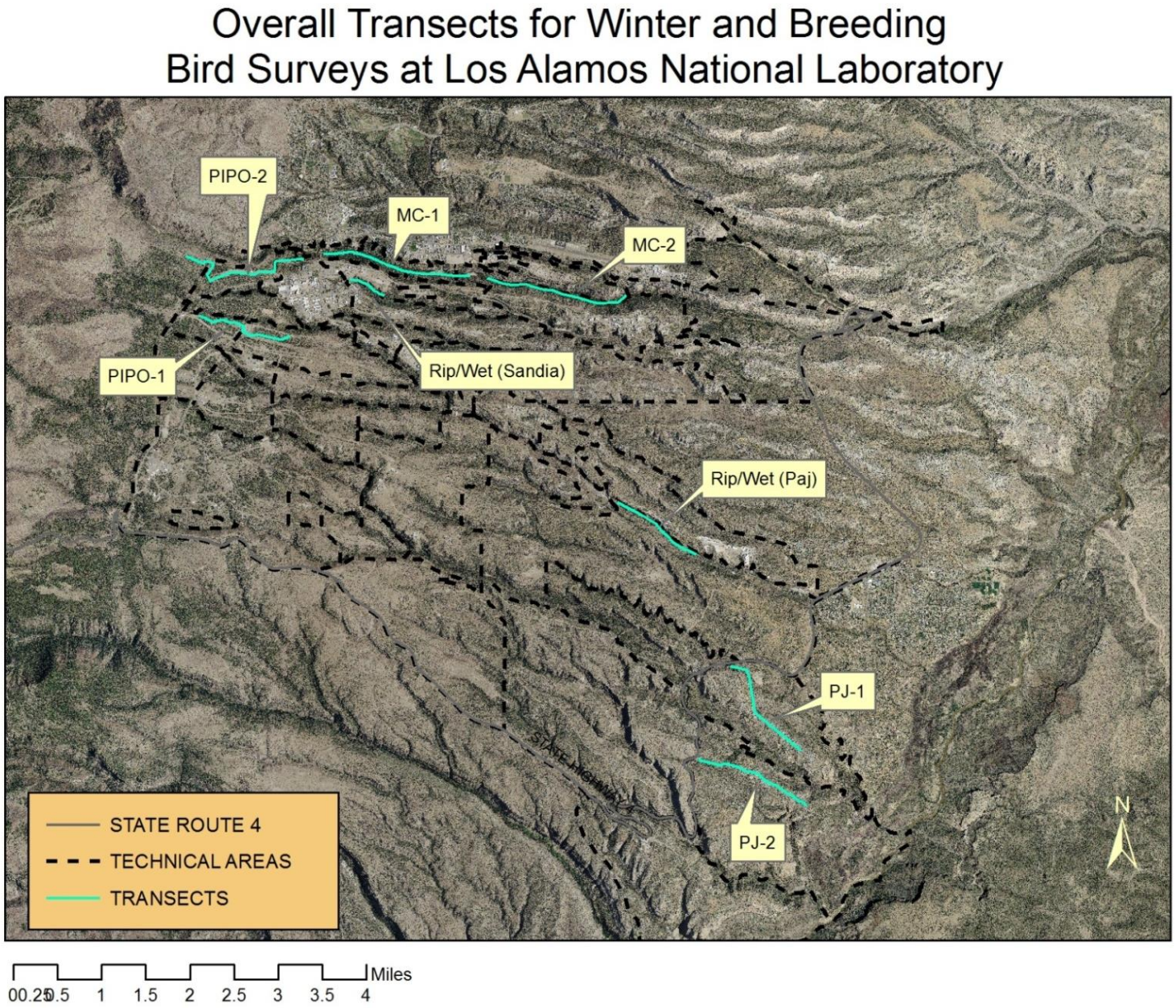

Figure 4. Control transects from ongoing avian monitoring around LANL.

MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland, Rip/Wet: Riparian / Wetland.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1 through August 15. Ideally the breeding bird surveys should take place the second week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along the transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an "unlimited-distance circular plot"; however, the distance to each bird out to 100 m should be noted. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, any birds encountered that have not otherwise been counted from a previous point or future point should also be noted. The surveyor's main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Surveys should not be conducted during rain events or wind greater than 15 mph.
- All birds encountered will be recorded on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- The "NOTES" section should be used for indicating any potentially important aspects of the survey that may affect the data. Examples include: excess noise from nearby equipment and vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to the TA-36 Minie site and TA-39 point 6 (Figures 5 and 6) and in 2015 nestboxes were added to the TA-16 burn ground (Figure 7). Data from the three study sites are compared to the overall avian nestbox network at LANL that was established in 1997.

Nestboxes are monitored every 1 to 2 weeks for active nests. When an active nest is found it is monitored more closely to determine whether the nest fails or successfully fledges young.

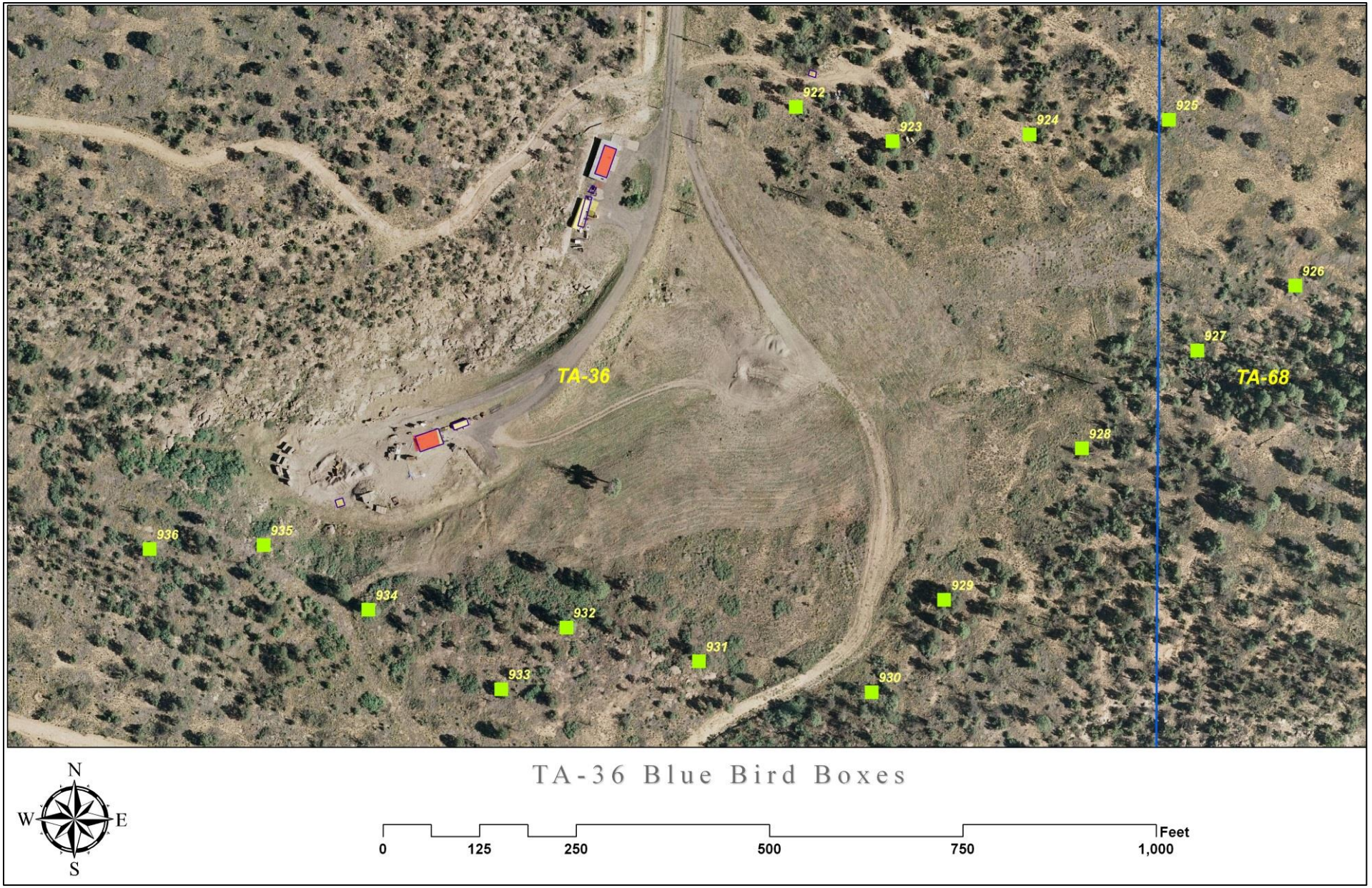

Figure 5. Avian nestboxes located at TA-36 Minie site.

Figure 6. Avian nestboxes located at TA-39 point 6.

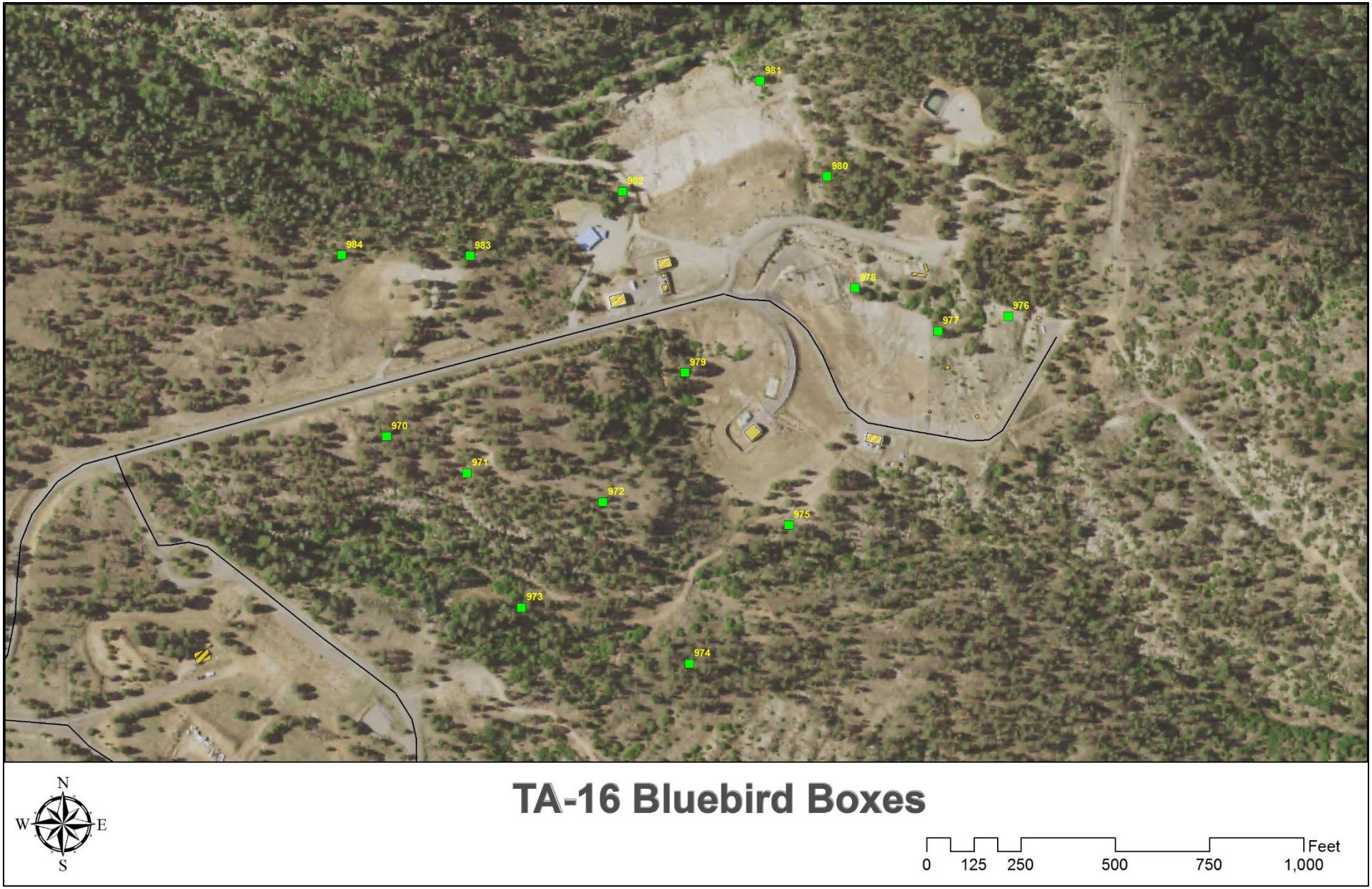

Figure 7. Avian nestboxes located at the TA-16 burn ground.

Statistical Methods

The data were summarized to look at trends in avian abundance and diversity for the three study sites and the control sites. To compare relative abundances between years and sites, the birds per hour (BPH) was calculated for each site by taking the total number of birds detected per survey and dividing by the total number of minutes surveyed. The result is multiplied by 60 to get the BPH. The BPH of the study sites and control sites were compared using the Mann-Whitney U non-parametric two sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine avian diversity for the study and control sites. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1 (p_i (\ln (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

To compare indices, a Shannon *t* test was used. As described in Magurran (1988), the variance of *H* is determined, which then allows the determination of the *t* value and degrees of freedom. Probability values of 0.05 or less indicated a significant difference in *H* between the two samples. The diversity indices and Shannon's *t* test were computed using PAST version 3.08 statistical software (Hammer et al. 2001).

Birds were categorized into feeding guilds based on the work of De Graaf et al. (1985). For food type, they did not necessarily include all foods taken by each species, only the major food items (20% of diet during a given period).

- Carnivore: vertebrates
- Crustaceovore: crustaceans
- Frugivore: fruits
- Granivore: nuts
- Herbivore: plants (leaves, stems, roots)
- Insectivore: insects
- Moltuscovore: mollusks
- Omnivore: a variety of foods including both animal and plant foods (the less common food group makes up 10% of diet)
- Piscivore: fish
- Vermivore: sandworms, earthworms, etc.

The guilds were customized to account for some bird species being split since the publication. Other changes were made to make it more suited to this study. All woodpeckers were changed from frugivores to omnivores; vermivores (American Robins in this study) were changed to omnivores; hummingbirds were changed from omnivores to nectarivores; Cassin's and House finches were changed from frugivores to granivores. Nectarivores and carnivores were dropped from the analysis due to low samples sizes, leaving granivores, insectivores, and omnivores for this report. The mean number of birds and standard deviation were calculated for each feeding guild. The means of the study sites and control sites were compared using the Mann-Whitney U non-parametric two sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant. All significant values in tables are bolded and shaded gray.

The control sites have been operated since 2011. The full datatset for the control sites was summarized for the point count surveys (2011–2015) and the Shannon's diversity index (Appendix 2).

Occupancy rate and nest success rate of the nestboxes at the three study sites and in the overall network were calculated. For any single site or overall, the number of active nestboxes divided by the total number of nestboxes is the occupancy rate. Similarly, the number of nestboxes that successfully fledged young divided by the number of active nestboxes is the nest success rate.

Results and Discussion

Three surveys were completed at each of the three study sites and the associated control sites between May and July 2015. A total of 881 birds representing 55 species were recorded at the three study sites. A full account of the 2013–2014 data is detailed in Appendix 1.

The mean BPH abundance values with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figure 8. The BPH was compared between study sites and their control site for each year using the Mann-Whitney U non-parametric two sample test (Table 1). These results indicate that in 2014 and 2015 the relative abundance of the bird communities at each of the study sites was similar to its respective control site. There was one significant difference in 2013 between the MC control site and the TA-16 burn ground ($p = 0.02$). This has been explained in earlier reports as being related to access restrictions in the first year of the study for this site.

Table 1. Comparisons of BPH between study sites and control sites among years.

Years	MC Control to TA-16	PJ Control to TA-39	PJ Control to Minie Site
2013	**Z = -2.2039 (p = 0.02)**	Z = -0.1313 (p = 0.89)	Z = 0.3889 (p = 0.69)
2014	Z = -1.6852 (p = 0.09)	Z = -0.3889 (p = 0.69)	Z = 1.1818 (p = 0.23)
2015	Z = 0.1291 (p = 0.89)	Z = -0.1296 (p = 0.89)	Z = 0.3939 (p = 0.69)

Note: statistically significant results are shaded.

Additionally, the mean BPH was compared between years for each site using the Mann-Whitney U non-parametric two sample test (Table 2). These results suggest that the relative abundance of bird communities at all three study sites remained similar over the years. The PJ control site does indicate that 2015 was significantly greater that the first two years of this study ($p = 0.008$ and $p = 0.004$). However, as noted in Figure 8, all sites had higher BPH values in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in BPH are attributed to the increased precipitation. Links between moisture and habitat quality for a migratory bird have been documented (Smith et al. 2010) and may be a causal factor. The data suggest that LANL operations are not negatively affecting the bird abundances at the three study sites.

Table 2. Comparisons of mean BPH between years and among sites.

Sites	2013 to 2014	2013 to 2015	2014 to 2015
MC Control	Z = 1.3659 (p = 0.17)	Z = -0.4010 (p = 0.68)	Z = -1.2855 (p = 0.19)
TA-16	Z = 0.8729 (p = 0.38)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)
PJ Control	Z = 0.6439 (p = 0.51)	**Z = -2.6514 (p = 0.008)**	**Z = -2.8121 (p = 0.004)**
TA-39	Z = 0.4364 (p = 0.66)	Z = -1.7457 (p = 0.08)	Z = -0.4364 (p = 0.66)
Minie Site	Z = 0.2214 (p = 1.0)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)

Note: statistically significant results are shaded.

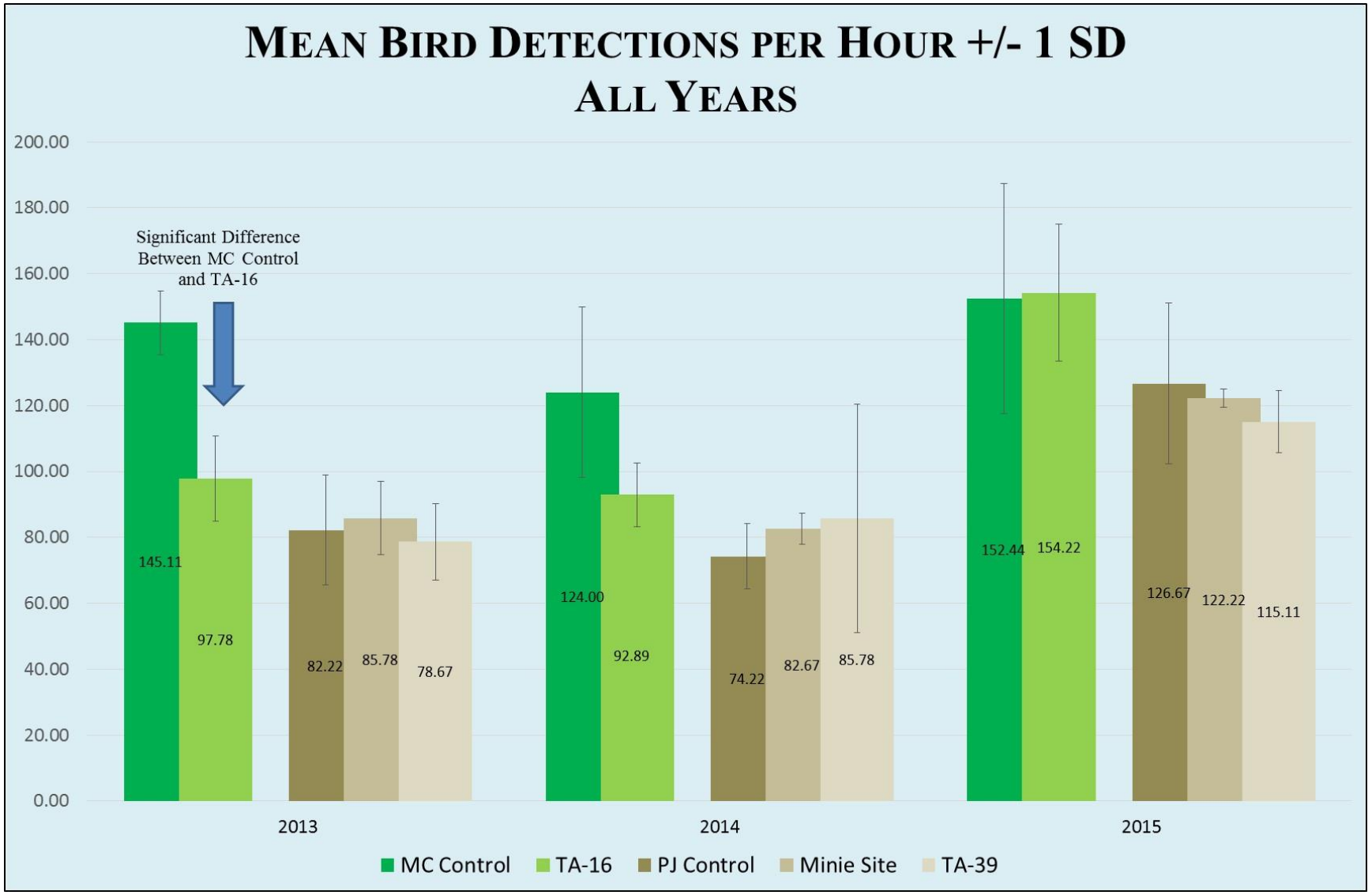

Figure 8. Birds per hour for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

The species diversity was determined using the Shannon's diversity index for each of the three study sites as well as the control sites of the comparable habitat type. The Shannon's diversity values for each site by year are represented in Figure 9. The bird diversity was compared between study sites and their control site for each year using the Shannon *t* test (Table 3).

Table 3. Shannon values for the study sites and control sites.

Years	MC Control to TA-16	PJ Control to Minie Site	PJ Control to TA-39
2013	t = 1.4194, df = 376 (p = 0.15)	**t = 2.9717, df = 510 (p < 0.01)**	**t = -2.3053, df 466 (p = 0.02)**
2014	t = 1.9235, df 412 (p = 0.06)	t = 1.8716, df = 455 (p = 0.06)	t = -1.0396, df = 477 (p = 0.29)
2015	**t = 4.4626, df = 653 (p < 0.01)**	t = 0.52699, df = 663 (p = 0.59)	t = 0.21662, df = 482 (p = 0.82)

Note: statistically significant results are shaded.

These results indicate that in 2013 the bird diversities in the PJ control sites were significantly less than Minie site ($p < 0.01$) and TA-39 ($p = 0.02$) trending toward similarity in following years. The results also indicate that in 2015 the bird diversity at the TA-16 burn ground was significantly lower ($p < 0.01$) than the MC control. This is contrary to the previously reported BPH data for the TA-16 burn grounds (Figure 5). The lower diversity value is due to 12 fewer species being present at the TA-16 burn grounds compared to the MC controls. Hathcock and Fair (2013) discussed this issue and attributed it to the fact that the MC control sites were in a canyon bottom closer to the townsite compared to the TA-16 burn grounds being on a mesa top.

This lower diversity value warranted further analysis. The Shannon's diversity values were determined for the ponderosa pine control sites. These control sites have not been used in this study because when this study began in 2013, the TA-16 burn ground was considered to be a MC habitat. This habitat does contain some components of a ponderosa pine forest. The Shannon's diversity value in 2015 for the ponderosa pine control was 3.161 which is a better fit to the data than the MC control. The Shannon t test was used to compare the 2015 diversity values from the TA-16 burn ground and the ponderosa pine control. These two sites were not significantly different ($t = 1.2603$, $df = 689$, $p = 0.20$). This is more speculative at this point and will be examined more extensively in the future. A significant difference in one year is not a trend. The data suggest that LANL operations are not negatively affecting bird diversity at the Minie site and TA-39, and more study is needed at the TA-16 burn ground.

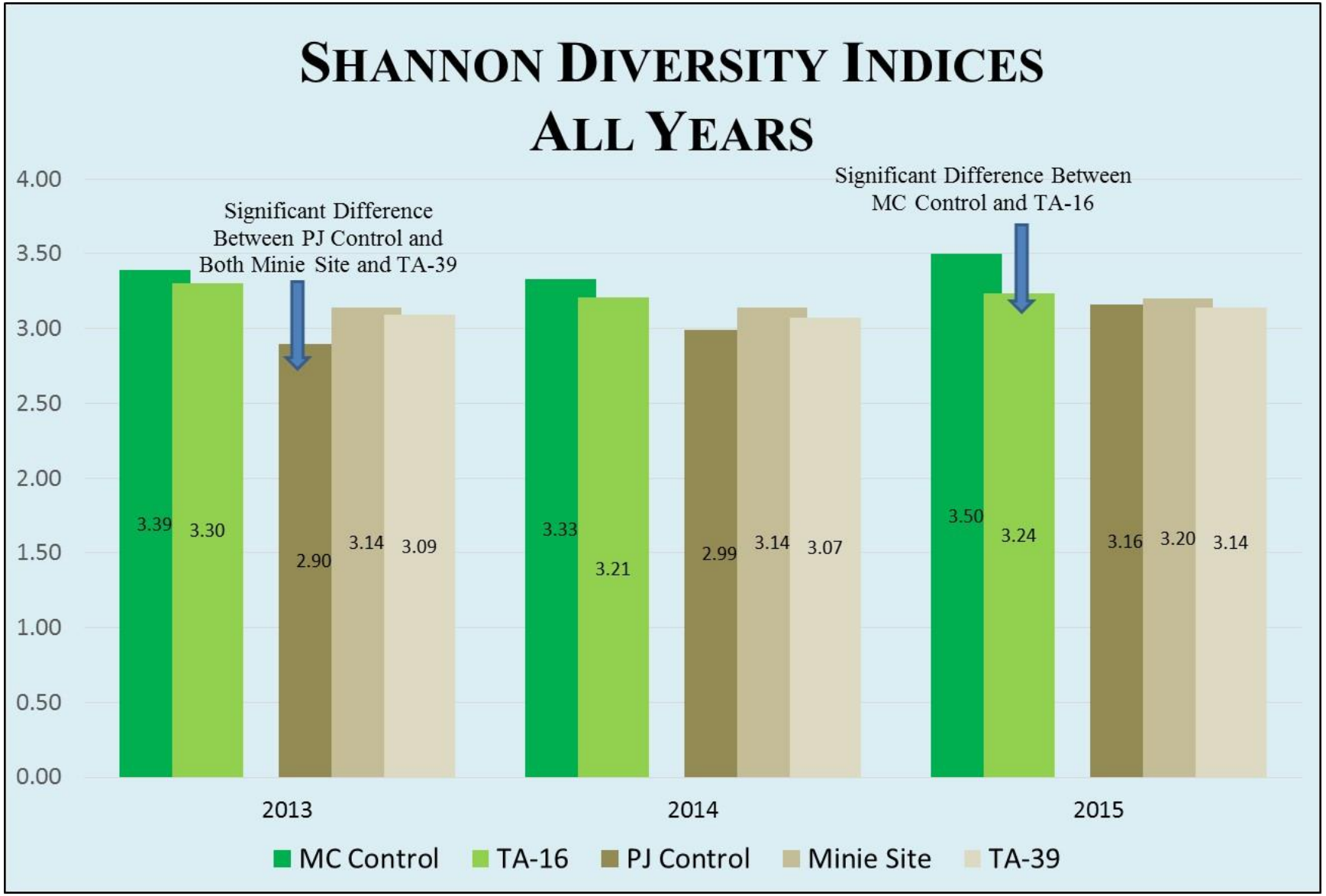

Figure 9. Shannon's diversity indices for the study and control sites.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat.

A new analysis was conducted in 2015 for this study. Bird species were categorized into feeding guilds based on the work of De Graaf et al. (1985). Only granivores, insectivores, and omnivores are presented in this report. The mean number of birds for these three feeding guilds with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figures 10–12. Insectivores have consistently been the largest feeding guild, followed by the omnivores and the granivores.

The mean number of birds were compared between years and among feeding guilds by study site using the Mann-Whitney U non-parametric two sample test (Table 4). These results indicate that there were no significant differences in feeding guilds between years for all three study sites. The control sites were analyzed similarly (Table 5) and trends very generally indicate that the mean numbers dropped slightly from 2013 to 2014 and then were highest in 2015. This fits well with the precipitation discussion earlier with the BPH differences.

A final analysis was performed to test for significant differences between study sites and their control site by feeding guild for each year using the Mann-Whitney U non-parametric two sample test (Table 6). There was one significant difference between the MC control site and the TA-16 burn ground ($p = 0.01$) with regard to omnivores. As discussed earlier, access limitations in 2013 may have affected the number of birds recorded. The significant differences disappeared in subsequent years. There were also significantly greater numbers of insectivores at Minie site compared to its control in 2013 and 2014.

Feeding guilds are also useful to monitor for habitat changes. From Figure 10 it is apparent that granivores are more prevalent in PJ habitats compared to MC. The opposite is seen in Figure 11 as insectivores are much higher in MC habitat than PJ. The omnivores are more evenly distributed among both habitats (Figure 12) which is indicative of their generalist nature, although the MC habitat does still have higher numbers of these birds.

During the 2015 nesting season, 15 nestboxes each at Minie site and TA-16, and 12 nestboxes at TA-39 were actively monitored. The overall avian nestbox network without the three study sites contained 653 nestboxes in 2015. Of those, 263 contained active nests and 174 of those nests fledged young successfully. This was an overall occupancy rate of 40% with a 66% success rate.

At Minie site, 14 nests were found and 9 of the nests fledged young successfully. Only 10 nestboxes were used, but 4 of those nestboxes had a second clutch. This was an occupancy rate of 66% with a 64% success rate.

At TA-39, only one nest was found and it successfully fledged young. This was an occupancy rate of 8%. These nestboxes at TA-39 will be relocated in 2016. The firing site at TA-39 is in a small narrow canyon and the nestboxes will be moved a little further out to a more open area to increase nesting attractiveness. The number of nestboxes in 2016 will also increase to 15 to be consistent.

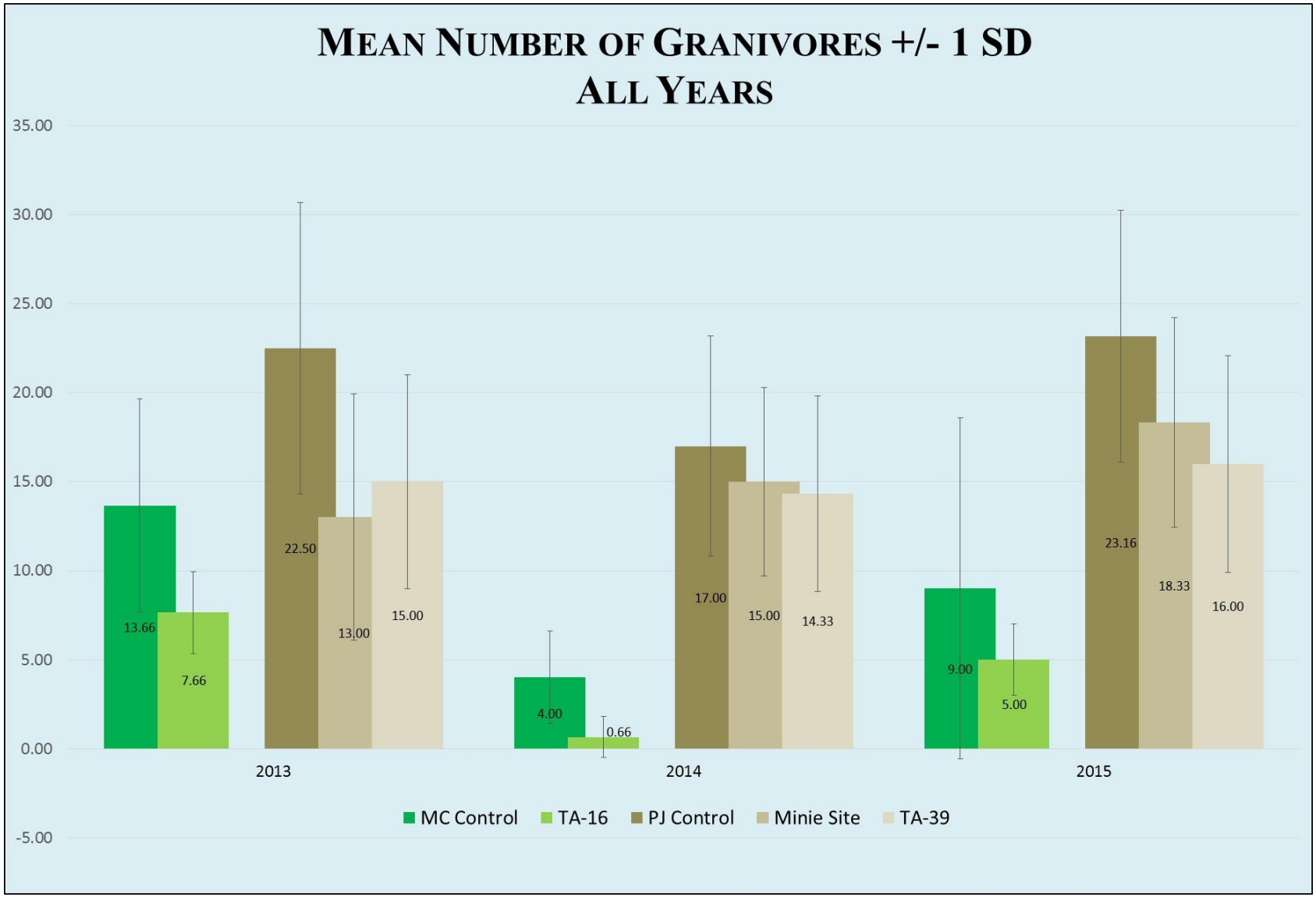

Figure 10. Mean number of granivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

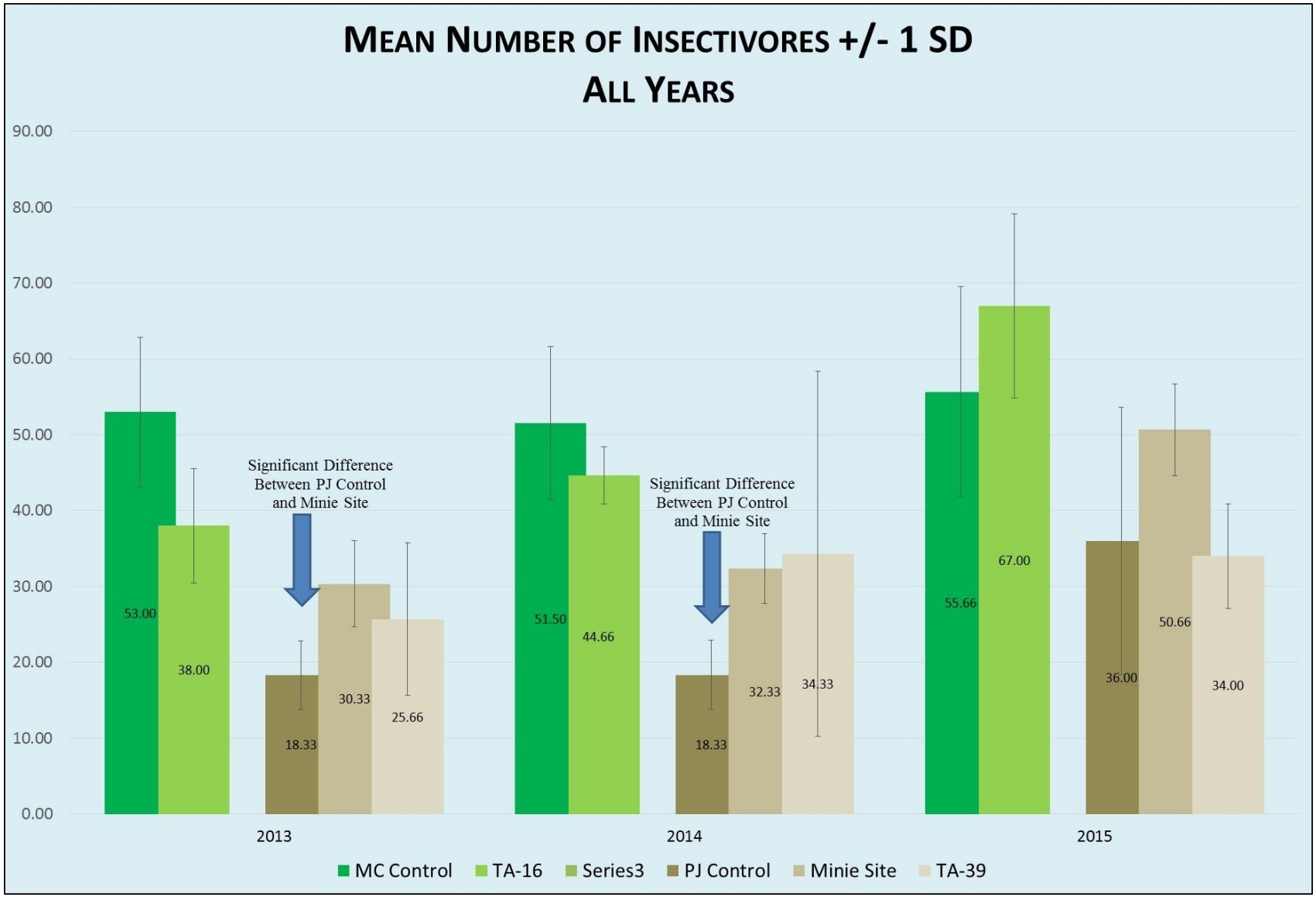

Figure 11. Mean number of insectivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

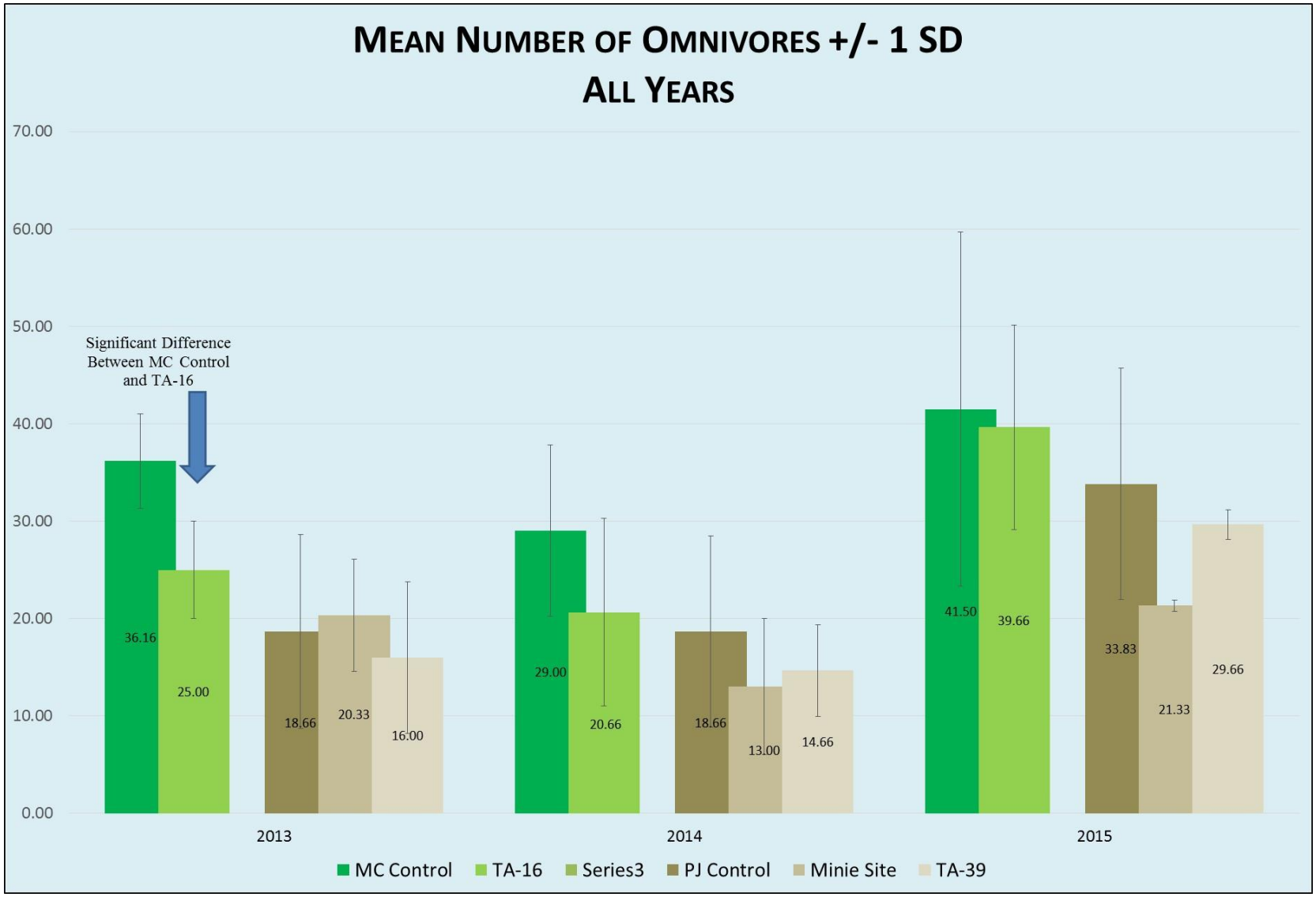

Figure 12. Mean number of omnivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

Table 4. Comparing the mean number of birds between years among feeding guilds for each study site.

	TA-16			TA-39			Minie Site		
Feeding Guild	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**
Granivore	Z = 1.7979 (p = 0.07)	Z = 1.1237 (p = 0.26)	Z = -1.7712 (p = 0.07)	Z = 0.0000 (p = 1.0)	Z = 0.2214 (p = 1.0)	Z = -0.8729 (p = 0.38)	Z = -0.4637 (p = 0.64)	Z = 0.0000 (p = 1.0)	Z = 0.0000 (p = 1.0)
Insectivore	Z = -0.8729 (p = 0.38)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)	Z = 0.0000 (p = 1.0)	Z = -0.8856 (p = 0.37)	Z = -0.4428 (p = 0.65)	Z = -0.4637 (p = 0.64)	Z = -1.7457 (p = 0.08)	Z = -1.7712 (p = 0.07)
Omnivore	Z = 0.4364 (p = 0.66)	Z = -1.3093 (p = 0.19)	Z = -1.3093 (p = 0.19)	Z = 0.2214 (p = 1.0)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)	Z = 0.8856 (p = 0.37)	Z = -0.4495 (p = 0.65)	Z = -1.7712 (p = 0.07)

Table 5. Comparing the mean number of birds between years among feeding guilds for each control site.

	MC Control			PJ Control		
Feeding Guild	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**
Granivore	**Z = 2.3550 (p = 0.01)**	Z = 0.8901 (p == 0.37)	Z = -0.8077 (p = 0.41)	Z = 0.8854 (p = 0.37)	Z = -0.1607 (p = 0.87)	Z = -1.3659 (p = 0.17)
Insectivore	Z = 0.2410 (p = 0.80)	Z = -0.5624 (p = 0.57)	Z = -1.4812 (p = 0.63)	Z = 0.1633 (p = 0.87)	**Z = -2.6608 (p < 0.01)**	**Z = -2.5711 (p = 0.01)**
Omnivore	Z = 1.4462 (p = 0.14)	Z = 0.0000 (p = 1.0)	Z = -1.2010 (p = 0.22)	Z = -1.1610 (p = 0.87)	**Z = -2.0051 (p = 0.04)**	**Z = -2.0890 (p = 0.03)**

Note: statistically significant results are shaded.

Table 6. Comparing the mean number of birds between study sites and their control by feeding guilds for each year.

	2013			2014			2015		
Site Comparisons	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**
MC Control and TA-16	Z = -1.1921 (p = 0.23)	Z = -1.6783 (p = 0.09)	**Z = -2.2039 (p = 0.02)**	Z = -1.8226 (p = 0.06)	Z = -0.9113 (p = 0.36)	Z = -0.9037 (p = 0.36)	Z = -0.5208 (p = 0.60)	Z = 0.7778 (p = 0.43)	Z = 0.1291 (p = 0.89)
PJ Control and Minie Site	Z = -1.1717 (p = 0.24)	**Z = 1.9696 (p = 0.04)**	Z = 0.3956 (p = 0.69)	Z = -0.2593 (p = 0.79)	**Z = 2.2132 (p = 0.02)**	Z = -0.7811 (p = 0.43)	Z = -1.0371 (p = 0.29)	Z = 1.4201 (p = 0.15)	Z = -1.4260 (p = 0.15)
PJ Control and TA-39	Z = -1.1668 (p = 0.24)	Z = 0.9191 (p = 0.35)	Z = -0.3939 (p = 0.69)	Z = -0.5186 (p = 0.60)	Z = 1.0415 (p = 0.29)	Z = -0.6482 (p = 0.51)	Z = -1.1619 (p = 0.24)	Z = 0.0000 (p = 1.0)	Z = -0.5186 (p = 0.60)

Note: statistically significant results are shaded.

At TA-16, 11 nests were found and 10 of the nests fledged young successfully. This was an occupancy rate of 73% with a 90% success rate.

The occupancy and success rates at Minie site and TA-16 were greater than the results in the overall network. The nestboxes at TA-39 have a placement problem that will be addressed in 2016. More years of data are needed to begin to look at the results in a more robust manner.

The nestbox data suggest that LANL operations at these sites are not negatively affecting nest success at two of the study sites, and more work is needed for TA-39.

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 55 species detected at the three study sites, all are protected under the MBTA. Additionally, three of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those three species are the Peregrine Falcon, Juniper Titmouse, and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three study sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the MBTA and associated memorandums of understanding, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three study sites from 2013–2015.

Species	2013	2014	2015	2013	2014	2015	2013	2014	2015
	TA-36			TA-39			TA-16		
	Pinyon-Juniper Woodland			Pinyon-Juniper Woodland			Mixed Conifer Forest		
Acorn Woodpecker							5		3
American Kestrel				1					
American Robin	1	1	2	1	1		7		9
Ash-throated Flycatcher	11	5	14	19	11	29	3	5	6
Audubon's Warbler		2					6	5	1
Bewick's Wren	4	8	9	3	10	15			
Black-chinned Hummingbird		1	1	3	2		1		1
Black-headed Grosbeak	1	3			2	4			1
Black-throated Gray Warbler			1	5	6	4			
Blue-gray Gnatcatcher	3	14	16	2		7		6	2
Broad-tailed Hummingbird	2	1	3	3	1	2	5	11	11
Brown Creeper							1		
Brown-headed Cowbird	1					2	4	1	
Bushtit		2		2	14				
Canada Goose						16			
Canyon Towhee	2		5	1	1	2	1		
Canyon Wren						2			2
Cassin's Kingbird	6	13	13	7	6	2			
Chipping Sparrow	3	16	17	6	6	5	1	5	3
Clark's Nutcracker								4	
Common Nighthawk	6		5	5	1	3			1

Species	2013	2014	2015	2013	2014	2015	2013	2014	2015
	TA-36			TA-39			TA-16		
	Pinyon-Juniper Woodland			Pinyon-Juniper Woodland			Mixed Conifer Forest		
Common Raven	2	5	1	1		2	5	6	2
Cooper's Hawk							1		
Cordilleran Flycatcher							5	10	6
Dark-eyed Junco							6	2	4
Downy Woodpecker								1	
Dusky Flycatcher						1			
Eurasian Collared-Dove	3								
Evening Grosbeak	3		4			8	5		29
Grace's Warbler							6	4	4
Gray Flycatcher	12	6	5	10	10	11			
Great-horned Owl		3		1					
Green-tailed Towhee	3	1		1					
Hairy Woodpecker			2			5	1	1	
Hammond's Flycatcher							8	9	12
Hepatic Tanager						1			
Hermit Thrush								4	6
House Finch	16	17	26	21	4	23	16	2	5
House Wren							1	1	
Juniper Titmouse	12		7	11	13	18			
Lesser Goldfinch	2	6	7	4	12	9	3		8
Mountain Bluebird		2	20		4				4
Mountain Chickadee	5	2	1				5	8	9
Mourning Dove	17	17	13	13	22	10	4		1
Northern Mockingbird					1				
Peregrine Falcon						1			

Species	2013	2014	2015	2013	2014	2015	2013	2014	2015
	TA-36			TA-39			TA-16		
	Pinyon-Juniper Woodland			Pinyon-Juniper Woodland			Mixed Conifer Forest		
Pine Siskin	10	2		6		3	12	4	5
Plumbeous Vireo	10	10	7	1		1	11	16	15
Pygmy Nuthatch						2	11	13	26
Red Crossbill					2			2	9
Red-shafted Flicker	3	1	3	3	2	4	3	4	11
Red-tailed Hawk						1			
Rock Wren	3	3	4	7	10	4	1	2	2
Say's Phoebe	2	1	2	2	1		1		1
Scaled Quail			1						
Spotted Towhee	17	8	19	12	6	33	11	18	16
Steller's Jay							3	2	5
Townsend's Solitaire	1								
Turkey Vulture							1		
Violet-green Swallow		5	7	6	4	1		2	19
Virginia's Warbler						1	17	11	21
Warbling Vireo							2	9	7
Western Bluebird	15	11	18	5	19	12	20	20	49
Western Scrub-Jay	5	1	3	8	10	4	1		
Western Tanager		2	3		2	1	2	3	7
Western Wood-Pewee	10	8	18		4	2	15	10	16
White-breasted Nuthatch	1	4	9			2	9	8	7
White-throated Swift					1				
White-winged Dove	1	5	9	7	5	6			1
Grand Total	**193**	**186**	**275**	**177**	**193**	**259**	**220**	**209**	**347**

Appendix 2. The full datatset for the control sites for point count surveys (2011–2015) including the Shannon's diversity index.

Breeding bird survey results from 2011 to 2015 for all control sites. Replicate control sites were not added until 2012.

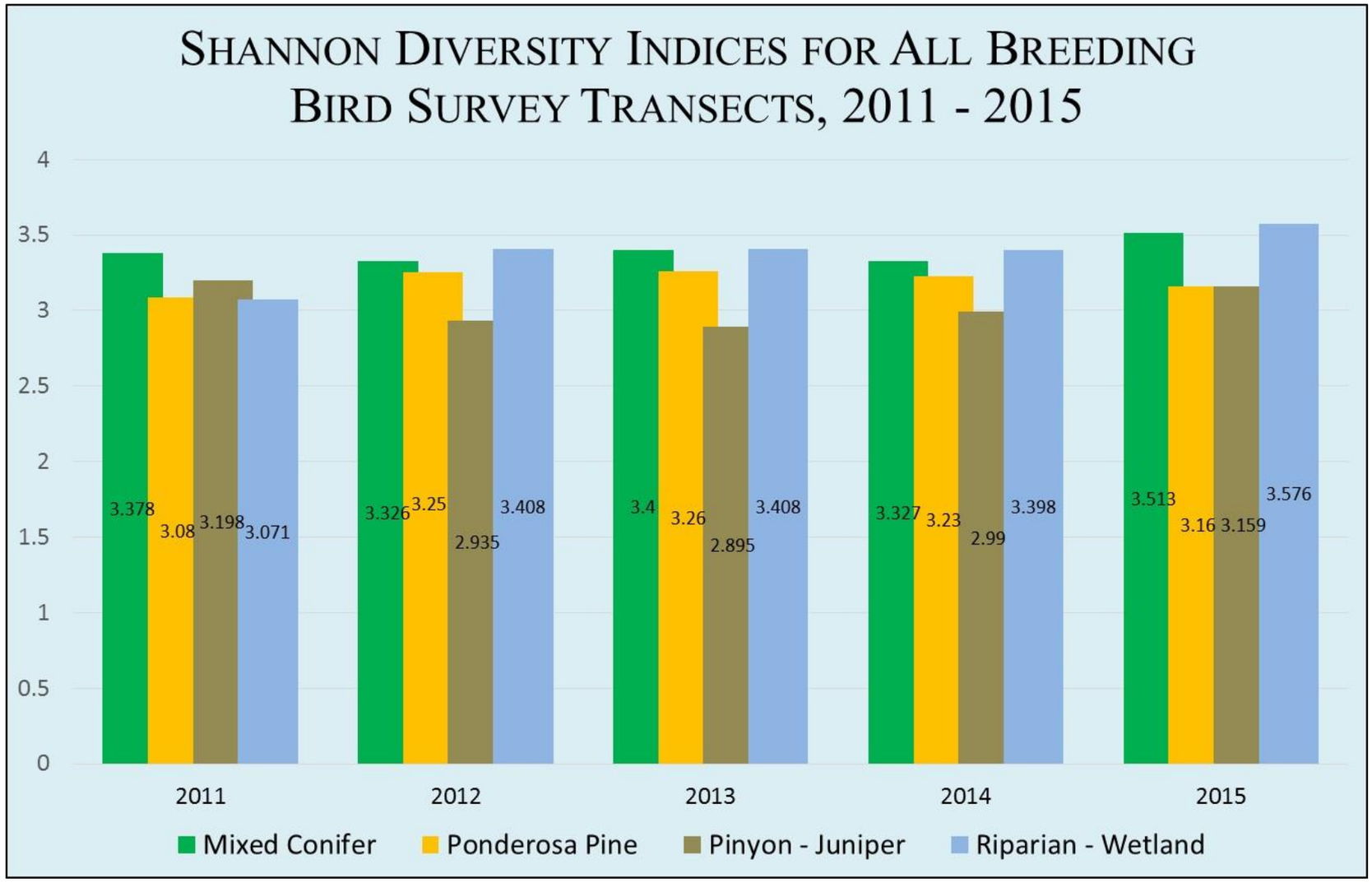
	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
Species	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Acorn Woodpecker	10				11	2		5	7	3		7	9			2	13	1		2
American Crow	3		1																	
American Kestrel		1						1										1	1	
American Robin	18	3	6	22	20	10	15	29	21	4	5	23	11	7	3	22	29	13	3	34
Ash-throated Flycatcher	5	7	29	9	18	8	52	8	13	1	33	10	17	6	30	10	10	1	50	4
Audubon's Warbler	1	5			7	26	1	2		6			4	21	1		6	47		2
Bewick's Wren	1		2				12	4			19	1			18	1	1		35	4
Black-chinned Hummingbird	1	1	2	3	1		1		3	5	4	9	4		2	10	2	3	5	3
Black-headed Grosbeak	7	2		4	1		1		9	2	6		4	1			9	2	5	3
Black-throated Gray Warbler															1				5	
Blue Grosbeak				4				1								1				1
Blue-gray Gnatcatcher			4	2			6	2	2		6	5			6	3		1	12	1
Broad-tailed Hummingbird	16	13	9	1	14	15	2	11	25	27	5	26	25	22	6	8	37	38	2	19
Brown Creeper					3	1							3			1	6			
Brown-headed Cowbird	5	1	9	4	10	5	3	7	12	7	2	9	3	2		4	5	3		24
Bullock's Oriole				1								2				2			2	1

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Bushtit	1	3	1	20			2		10			2			6	2			18	11
Canada Goose								6												16
Canyon Towhee	2		4	2	1		4	3	2		9				8	4		1	10	4
Canyon Wren	8				12				12				6		2	2	23		4	4
Cassin's Finch								1		2										
Cassin's Kingbird		3	4			5				13	3			3	8	8		2	24	6
Cedar Waxwing																	5			
Chipping Sparrow	4	11	14	3	7	17	8	6	1	20	1	3	1	15	5	7	18	52	30	15
Clark's Nutcracker						1														
Common Nighthawk			1								11	1			5			5	6	1
Common Raven	16	8	7	1	28	15	4	6	24	13	4	6	20	23	4	17	29	21	12	24
Cooper's Hawk						1				1			1	1			1			
Cordilleran Flycatcher	3				9				7	1		3	9	4		3	6	2		
Dark-eyed Junco	6	8	1		3	13		2	2	7		5		1		1	4	13	1	2
Downy Woodpecker	3			2																
Dusky Flycatcher	1																2	4		1
Eurasian Collared-Dove						2		3		3		3		3		1		2		3
European Starling								18												
Evening Grosbeak	47	81	10	43	4	3		6	8	28	4	21		10		2	2	26	49	7
Flammulated Owl						2	1	1												
Grace's Warbler						3		1	12	11		1	9	8		2	5	10		

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Gray Flycatcher		1	17			1	6	1			14				7				8	1
Great-tailed Grackle			19																	
Green-tailed Towhee	2		7	1		3	7	1			5	4		2						
Hairy Woodpecker	3	3	1	2	5	2	4	6	2				5	3	3	1	2	2	2	2
Hammond's Flycatcher	3	2			21	6			19	9			15	2			16	4		1
Hepatic Tanager				1					1											
Hermit Thrush		1			5	2		1		3			3	5			9	7		
House Finch	3	21	25	13	30	38	43	33	12	39	89	34	2	37	47	28	2	35	59	25
House Wren		2		1	1	3		11	1			20	2			12	3	3		10
Indigo Bunting								1												
Juniper Titmouse			13	8			21	5			20	1			12		1		16	
Lazuli Bunting								2												
Lesser Goldfinch	16	5	13	28	19	22	11	31	35	14	19	28	7	9	14	16	21	17	42	25
Lincoln's Sparrow					1											1				1
MacGillivray's Warbler	2	4		1	1							2	2						1	1
Marsh Wren																				1
Mountain Bluebird															3				1	
Mountain Chickadee	11	3		2	20	7		1	31	10		6	21	4		6	11	5		7
Mourning Dove	3	4	16	6	28	7	38	30	35	4	25	10	15	3	36	16	27	4	30	12
Northern Mockingbird			1				1				1	2			1					
Northern Saw-whet Owl	1																			

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Orange-crowned Warbler									1									3		3
Pine Siskin	13	7		5	1	5			12	27	8	5	15	28		11	40	47	6	6
Pinyon Jay							1								41					
Plumbeous Vireo	9	21	2	3	31	27	1	6	38	23		9	17	22	1	8	18	25	3	10
Pygmy Nuthatch	4	10			57	70		9	47	33		15	59	54		26	26	105		21
Red Crossbill		7				15	2			5				8			3	21		
Red-breasted Nuthatch	2	1				2														
Red-shafted Flicker	2	12	1	4	7	10	4	4	12	1	2	9	9	3	1	9	9	15	3	14
Red-tailed Hawk					1			7	2		2	5	4			2	1		1	3
Red-winged Blackbird								13				29				49				57
Rock Wren		2		1		3	5	3	1		6	3	8	1	8	9	4		5	9
Ruby-crowned Kinglet	4	2		1													4			
Rufous Hummingbird								2												
Say's Phoebe		1	3	1		1		7	2		1	3		2	1	4	3			
Song Sparrow	1				1			17	1			16				11				15
Sora																				6
Spotted Towhee	20	4	13	33	39	23	42	27	44	20	29	31	36	16	23	27	50	29	46	33
Steller's Jay	1	3			7	3		1	9	6		3	7	6		1	6	10		2
Summer Tanager			1																	
Townsend's Solitaire		1	1					1						2			2	1		1
Turkey Vulture					25	1	1		4	12		1	17	3	2		8		4	1

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Unknown Hummingbird					11	6	1	8	2		2									
Violet-green Swallow	23	10	6	6	54	51	7	47	38	28	8	52	52	21		38	43	43	3	52
Virginia Rail								1				7								10
Virginia's Warbler	18	11		16	26	13	5	13	38	30	1	15	15	19	1	8	20	22	1	7
Warbling Vireo	16				15				18			2	28	5		5	28	3	1	2
Western Bluebird	6	26	11	2	3	35	17	8	1	44	3	2	11	43	9	11	5	91	26	11
Western Scrub-Jay	1	1	14	5		1	28	11	1		16	8			11	2			20	7
Western Tanager	7		1	1	2	3	1		15	9	2	1	4	3	1	2	10	3		5
Western Wood-Pewee	8	19	8	19	49	49	11	49	38	36	3	18	33	38	2	31	50	41	4	53
White-breasted Nuthatch	4	9		1	25	16		4	15	3		8	17	5		5	11	19	4	10
White-crowned Sparrow	1															1				
White-throated Swift					36	6			7	4			28	5			32		2	8
White-winged Dove			3	1			1	1			2	1		1	5	2	4		8	15
Williamson's Sapsucker		2						2												
Willow Flycatcher				1																
Wilson's Warbler	1																4			2
Yellow Warbler				1					1							1				1
Yellow-breasted Chat				1																1
Wilson's Warbler	1																4			2
Yellow Warbler				1					1							1				1
Yellow-breasted Chat				1																1



Shannon's diversity indices during the breeding season from 2011 to 2015 for all control sites. Replicate control sites were not added until 2012.

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 8 – Hathcock *et al.* 2017

Environmental Report:

Hathcock, C.D., B.E. Thompson, and J. T. Berryhill. January 2017. *2016 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory*. LA-UR-17-20359.

Minor Revision April 2017

2016 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts are compared among years and with avifauna monitoring conducted at other areas across LANL. The objectives of this study are to determine whether LANL firing site operations impact bird abundance or diversity. LANS biologists completed the fourth year of this effort in 2016. The overall results from 2016 continue to indicate that operations are not *negatively* affecting bird populations. Data suggest that community structure may be changing at some sites and this trend will continue to be monitored.

Three avian point count surveys were completed at each of the study sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground (hereafter referred to as Minie site, TA-39, and TA-16) between May and July 2016. A total of 730 birds representing 54 species were recorded at the study sites. Three avian point count surveys were also completed at each of the control sites between May and July 2016.

The data were analyzed to determine abundance using an estimate of birds detected per hour, and to calculate the species diversity. The number of birds detected in three different feeding guilds were compared to examine functional community differences among areas.

Results from 2016 monitoring indicate a slight decrease from 2015 in bird abundances in pinyon-juniper (PJ) habitat and a small increase in bird abundances in mixed conifer (MC) habitat across LANL. The decrease is likely indicative of effects from below-average precipitation in the winter of 2015 into the spring and early summer of 2016. Precipitation drives habitat suitability, which can potentially drive animal populations using the resources. The link between moisture and habitat quality for a migratory bird indicates that the availability of high-quality habitats is dynamic due to variation in precipitation among seasons and years (Smith et al. 2010). Mixed conifer habitat is wetter than PJ, which may account for the small increase in bird abundance in the MC habitat. This increase in bird abundance was significantly higher ($p = 0.03$) in the MC control habitat compared with TA-16. There were no significant differences in bird abundance for the other two sites when comparing their respective controls.

The species diversity indices at Minie site were significantly less ($p = 0.01$) than its PJ control, with fourteen fewer species present. The TA-16 bird diversity was also significantly less ($p < 0.01$) than its MC control, with seven fewer species present. The fluctuations in bird abundances are not alarming and the differences between the study sites and control sites are not biologically significant. The 2016 results at the three study sites are still higher than the first two years of the study. The significant drop in species diversity at Minie site may be indicative of a change in community structure. Due to increased fuels reduction, including more tree removals, the habitat availability is changing. The site is becoming more grassland-like than PJ. There are currently no control sites for grasslands at LANL and this may be needed in the future.

In addition to avian point counts, nestboxes were monitored around all three study sites. These data are compared with the overall avian nestbox monitoring network. This network was established in 1997 to investigate the occupancy rates and reproductive success of cavity-nesting bird populations at LANL. The total number of boxes in the network in 2016 was 416, with another 42 placed around the three study sites. In 2016 there was an overall occupancy rate of 47% with a 65% success rate for the avian nestbox network at LANL. The percent occupancy and nest success at both Minie site and TA-16 were similar to the overall rate, suggesting that the firing site operations are not negatively affecting nest success. Further study is needed at TA-39 to ascertain if the 2016 re-deployment of some nestboxes within the more open habitat east of point 6 continues to lead to increased occupancy. An additional three boxes are needed at TA-39 to maintain even numbers at all three sites.

Introduction

As part of the Resource Conservation and Recovery Act permitting process at LANL for two open detonation sites (TA-36 Minie site and TA-39 point 6), and one open burn site, (TA-16 burn ground), an avian monitoring program was started at these locations in 2013 (Hathcock and Fair 2013). The goal is to compare avian abundance, diversity, and productivity at these sites with other locations at LANL of the same habitat type. Comparisons are made with control sites that have been surveyed since 2011 (Hathcock et al. 2011).

LANS biologists used standard point count methodology to record avian abundance and diversity along transects at the three study sites and associated control sites during the summer of 2016. Summer surveys provide information about what birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. They also can be correlated to changes in the natural environment at LANL.

In addition to avian point counts, nestboxes are monitored around all three study sites to investigate any potential impacts to occupancy rates and productivity of cavity-nesting birds. These data are compared with the overall LANL avian nestbox monitoring network established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys are conducted along single transects in the forested, undeveloped land surrounding the study sites (Figures 1–3). The habitat types around the sites are PJ for the sites at TA-36 and TA-39 and MC at TA-16. These habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study sites were compared with control sites at LANL of the same habitat type. The control sites (Figure 4) are monitored annually in ongoing surveys that have been conducted at LANL since

2011 as described in Hathcock et al. (2011). Each habitat type control contains two replicate transects that are monitored in the same way as the study sites with the same number of points and during the same time periods. In each survey month, all study site and control site transects are randomized and surveyed following the random order.

The PJ study sites at Minie site and TA-39 are similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at TA-16 is similar in elevation and overstory vegetation to the MC control sites, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon in TA-43, TA-2, and TA-21. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present at the control sites.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along the transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an “unlimited-distance circular plot”; however, the distance to each bird out to 100 m should be noted. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, note any birds encountered that have not otherwise been counted from a previous point or future point. The surveyor’s main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Do not conduct surveys during rain events or winds greater than 15 mph.
- Record all birds encountered on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- Use the “NOTES” section to indicate any potentially important aspects of the survey that may affect the data. Examples include excess noise from nearby equipment and vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

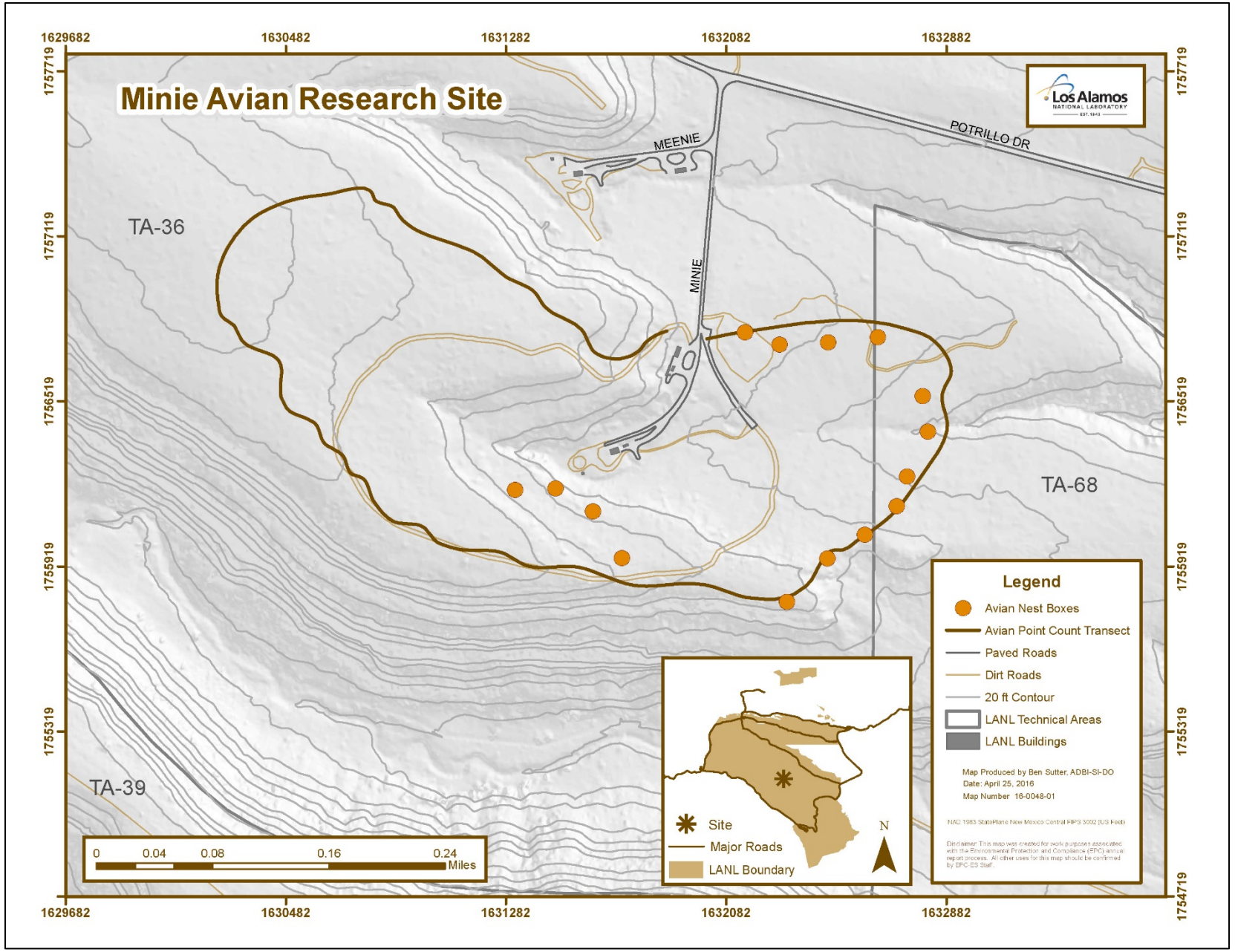

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site.

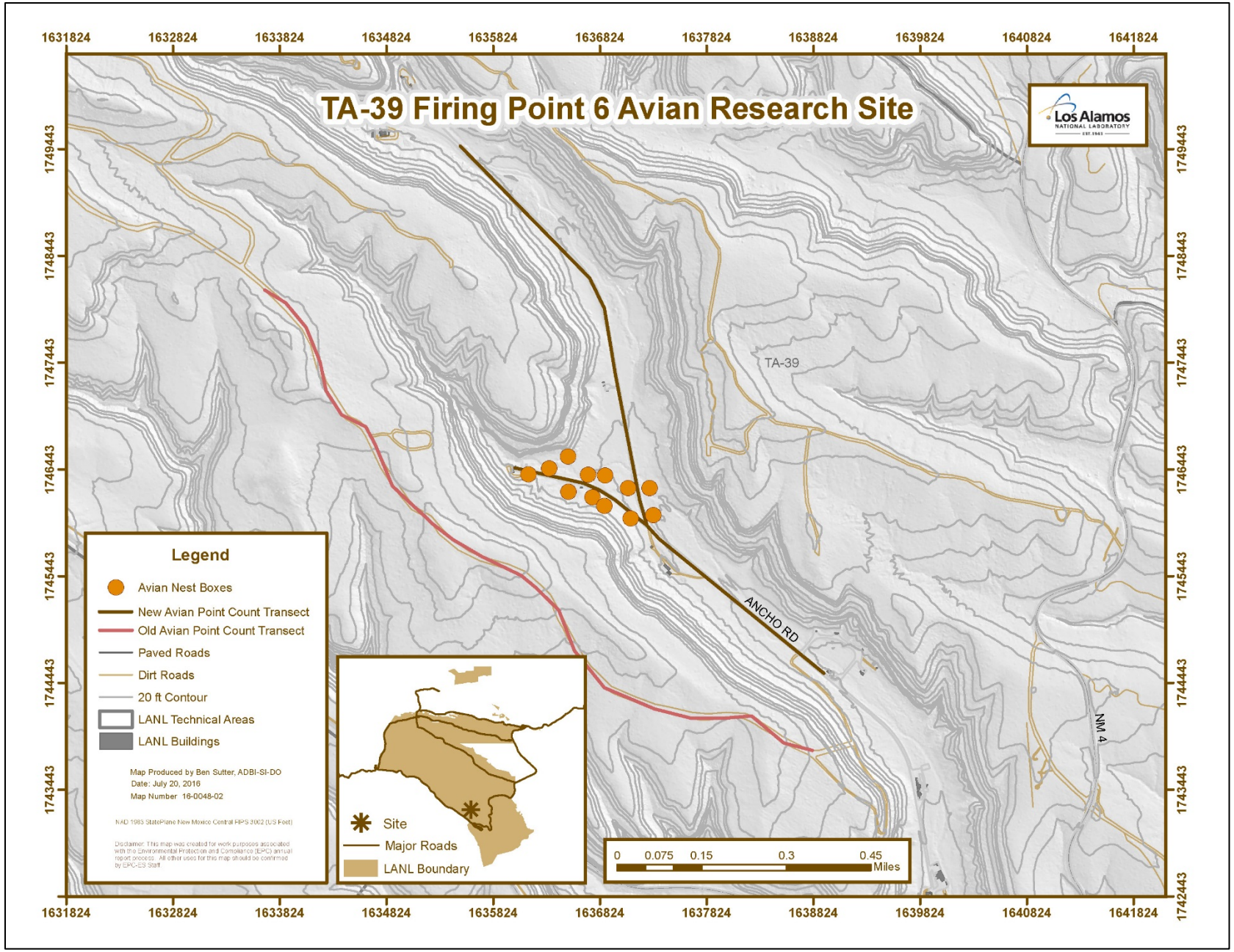

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6.

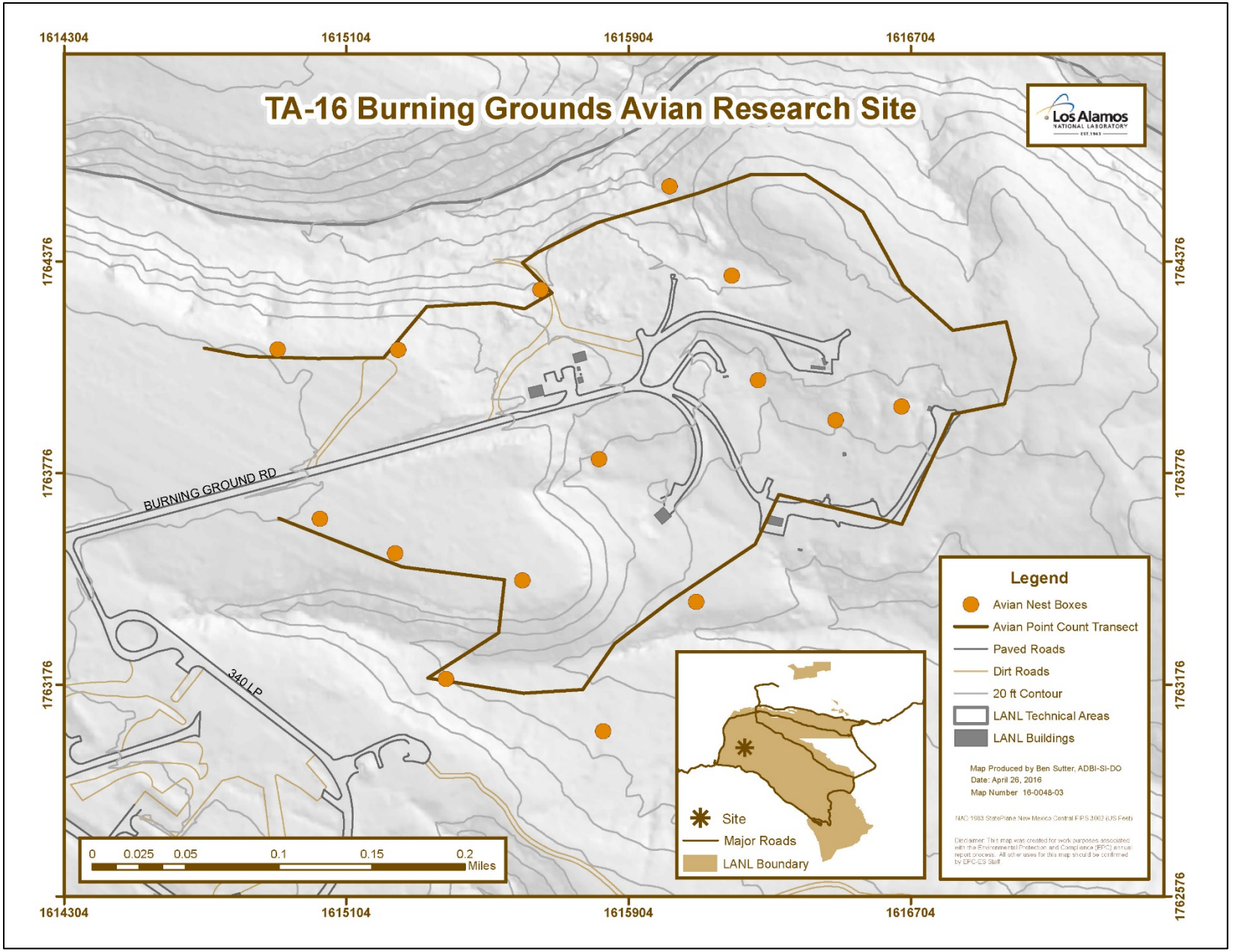

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground.

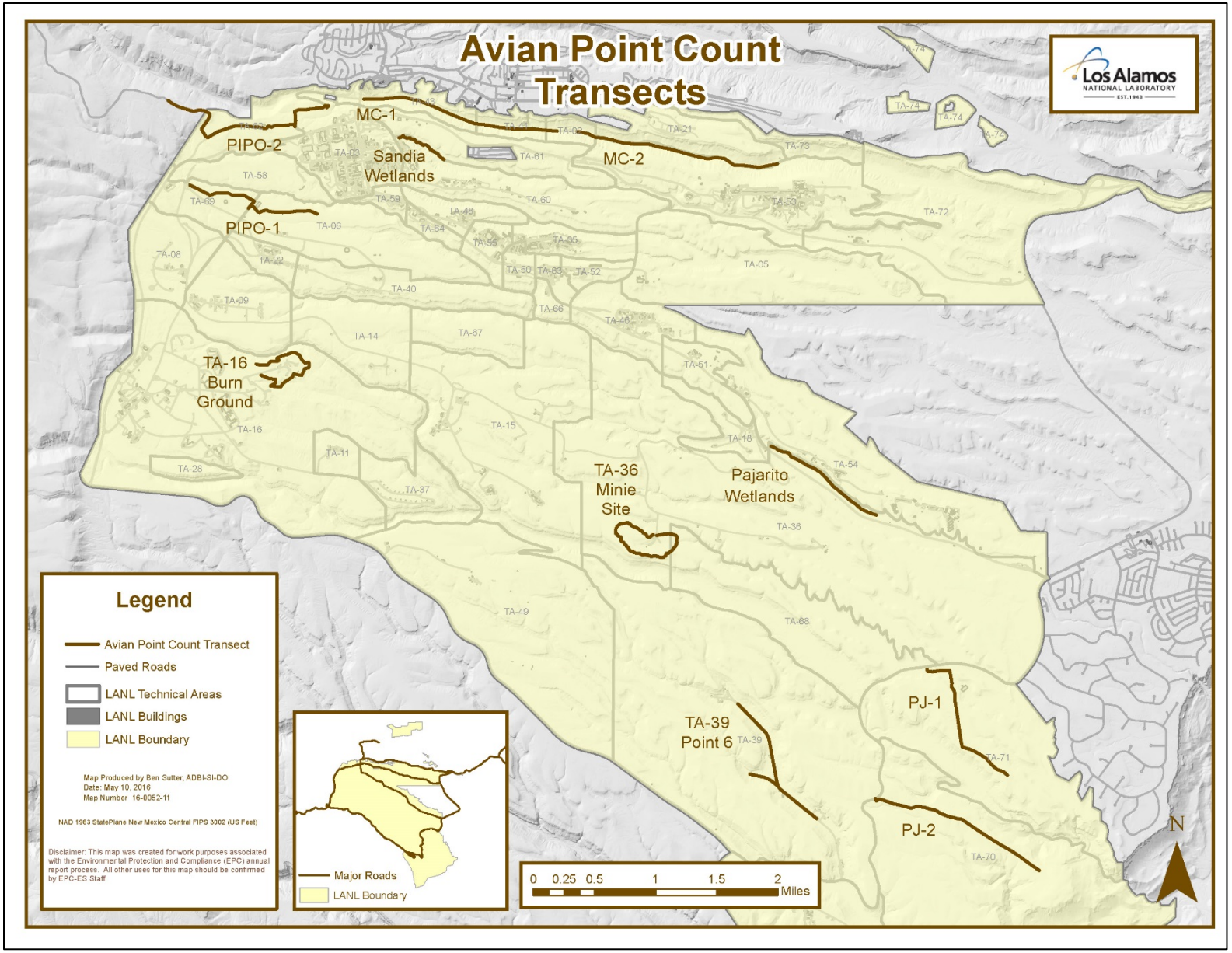

Figure 4. All avian point count transects around LANL.

MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland.

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie site and TA-39 (Figures 1 and 2) and in 2015 nestboxes were added to TA-16 (Figure 3). Data from the three study sites are compared with the overall avian nestbox network at LANL that was established in 1997.

Nestboxes are monitored every 1 to 2 weeks for active nests. When an active nest is found, it is monitored more closely to determine whether the nest fails or successfully fledges young.

Statistical Methods

The data were summarized to look at trends in avian abundance and diversity for the three study sites and the control sites. To compare relative abundances between years and sites, the birds per hour (BPH) was calculated for each site by taking the total number of birds detected per survey and dividing by the total number of minutes surveyed. The result is multiplied by 60 to get the BPH. The BPH of the study sites and control sites were compared using the Mann-Whitney U non-parametric two-sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine avian diversity for the study and control sites. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1 (p_i (\ln (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

To compare indices, a Shannon *t* test was used. As described in Magurran (1988), the variance of *H* is determined, which then allows the determination of the *t* value and degrees of freedom. Probability values of 0.05 or less indicated a significant difference in *H* between the two samples. The diversity indices and Shannon's *t* test were computed using PAST version 3.08 statistical software (Hammer et al. 2001).

Birds were categorized into feeding guilds based on the work of De Graaf et al. (1985). For food type, they did not necessarily include all foods taken by each species, only the major food items (20% of diet during a given period).

- Carnivore: vertebrates
- Crustaceovore: crustaceans
- Frugivore: fruits
- Granivore: nuts
- Herbivore: plants (leaves, stems, roots)

- Insectivore: insects
- Moltuscovore: mollusks
- Omnivore: a variety of foods including both animal and plant foods (the less common food group makes up 10% of diet)
- Piscivore: fish
- Vermivore: sandworms, earthworms, etc.

The guilds were customized to account for some bird species being split since the publication. Other changes were made to make it more suited to this study. All woodpeckers were changed from frugivores to omnivores; vermivores (American Robins in this study) were changed to omnivores; hummingbirds were changed from omnivores to nectarivores; Cassin's and House finches were changed from frugivores to granivores. Nectarivores and carnivores were dropped from the analysis due to low samples sizes, leaving granivores, insectivores, and omnivores for this report. The mean number of birds and standard deviation were calculated for each feeding guild. The means of the study sites and control sites were compared using the Mann-Whitney U non-parametric two-sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant. All significant values in tables are bolded and shaded gray.

Occupancy rate and nest success rate of the nestboxes at the three study sites and in the overall network were calculated. For any single site or overall, the number of active nestboxes divided by the total number of nestboxes is the occupancy rate. Similarly, the number of nestboxes that successfully fledged young divided by the number of active nestboxes is the nest success rate.

Results and Discussion

Three surveys were completed at each of the three study sites and the associated control sites between May and July 2016. A total of 730 birds representing 54 species were recorded at the three study sites. A full account of the 2013–2016 data is detailed in Appendix 1.

The mean BPH abundance values with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figure 5. The BPH was compared between study sites and their control site for each year using the Mann-Whitney U non-parametric two sample test (Table 1). These results indicate that in 2016 the relative abundance of the bird communities at Minie Site and TA-39 was similar to its respective control site. The MC control site was significantly ($p = 0.03$) higher than TA-16.

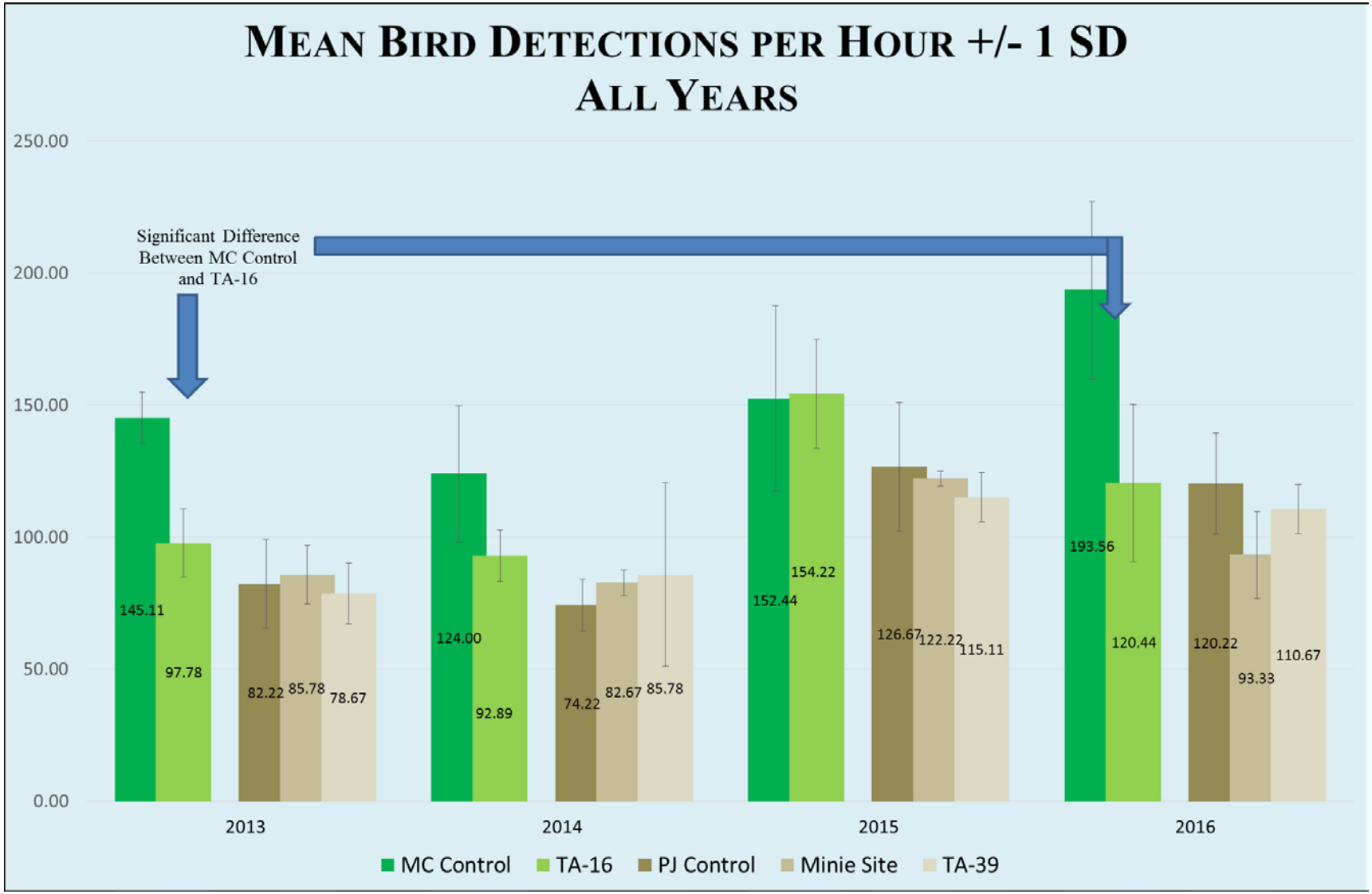

Figure 5. Birds per hour for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

Table 1. Comparisons of BPH between study sites and control sites among years.

Years	MC Control to TA-16	PJ Control to TA-39	PJ Control to Minie Site
2013	**Z = -2.203 (p = 0.03)**	Z = -0.1313 (p = 0.89)	Z = 0.3889 (p = 0.69)
2014	Z = -1.6853 (p = 0.09)	Z = -0.3889 (p = 0.69)	Z = 1.1818 (p = 0.23)
2015	Z = 0.1291 (p = 0.89)	Z = -0.1296 (p = 0.89)	Z = 0.3939 (p = 0.69)
2016	**Z = -2.194 (p = 0.03)**	Z = -0.6482 (p = 0.52)	Z = -1.1668 (p = 0.24)

Note: statistically significant results are shaded.

Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in BPH in 2015 were attributed to the increased precipitation. Links between moisture and habitat quality for a migratory bird have been documented (Smith et al. 2010) and may be a causal factor. The winter of 2015 and into early 2016 was drier. The fluctuations in bird abundances are not alarming and the differences between the study sites and control sites are not *biologically* significant. The 2016 results at the three study sites are still higher than the first two years of the study. The data suggest that LANL operations are not negatively affecting the bird abundances at the three study sites.

The species diversity was determined using the Shannon's diversity index for each of the three study sites as well as the comparable habitat type control sites. The Shannon's diversity values for each site by year are represented in Figure 6. The bird diversity was compared between study sites and their control site for each year using the *t* test (Table 2).

Table 2. Shannon values for the study sites and control sites.

Years	MC Control and TA-16	PJ Control and Minie Site	PJ Control and TA-39
2013	t = 1.4194, df = 376, p = 0.15	**t = 2.9717, df = 510, p < 0.01**	**t = 2.3053, df 466, p = 0.02**
2014	t = 1.9235, df 412, p = 0.06	t = 1.8716, df = 455, p = 0.06	t = 1.0396, df = 477, p = 0.29
2015	**t = 4.4626, df = 653, p < 0.01**	t = 0.52699, df = 663, p = 0.59	t = -0.2166, df = 482, p = 0.82
2016	**t = -2.6496, df 501, p < 0.01**	**t = 2.5304, df = 489, p = 0.01**	t = -1.587, df = 515, p = 0.11

Note: statistically significant results are shaded.

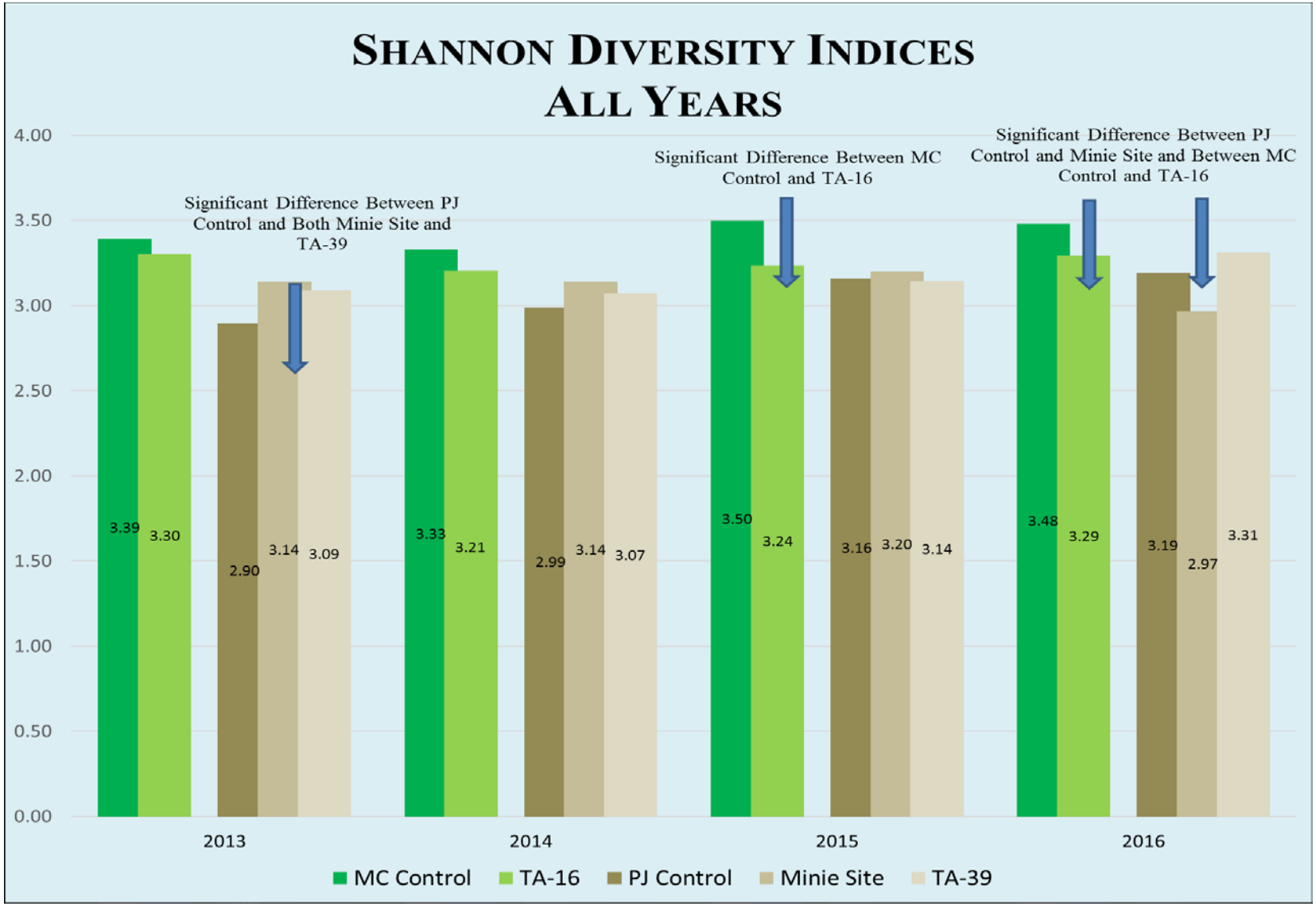

Figure 6. Shannon's diversity indices for the study and control sites.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat.

The 2013 results indicated that the bird diversities in the PJ control sites were significantly less than Minie site ($p < 0.01$) and TA-39 ($p = 0.02$) trending toward similarity in following years. The results also indicate that in 2015 the bird diversity at TA-16 was significantly lower ($p < 0.01$) than the MC control. Hathcock and Fair (2013) discussed this issue and attributed it to the circumstance that the MC control sites were located in a canyon bottom closer to the townsite compared with TA-16 located on a mesa top.

In 2016, the species diversity indices at Minie site were significantly less ($p = 0.01$) than its PJ control, with 14 fewer species present. The TA-16 bird diversity was also significantly less ($p < 0.01$) than its MC control, with seven fewer species present. The significant drop in species diversity at Minie site may be indicative of a change in community structure. Due to increased fuels reduction, including more tree removals, the habitat availability is changing. The site is becoming more grassland-like than PJ. There are currently no control sites for grasslands at LANL but additional control sites may be needed in the future. The 2016 data also show that species diversity was again significantly less at TA-16 than the MC control sites. This trend will continue to be monitored and new research may be warranted to investigate changes in habitat structure and quality.

A new analysis was started in 2015 for this study. Bird species were categorized into feeding guilds based on the work of De Graaf et al. (1985). Only granivores, insectivores, and omnivores are presented in this report. The mean number of birds for these three feeding guilds with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figures 7–9. Insectivores have consistently been the largest feeding guild, followed by the omnivores and the granivores.

The mean number of birds in 2016 were compared between years and among feeding guilds by study site using the Mann-Whitney U non-parametric two-sample test (Table 3). These results indicate that omnivores increased in the MC control and were significantly higher ($p = 0.03$) than at TA-16. Additionally, the overall number of granivores increased in the PJ control and were significantly higher ($p = 0.03$) than at Mine site. The control sites were analyzed similarly and trends very generally indicate that the mean numbers dropped slightly from 2013 to 2014, increased dramatically in 2015 and then decreased slightly in 2016. This fits well with the precipitation discussion earlier with the BPH differences.

Feeding guilds are also useful to monitor for habitat changes. From Figure 7 it is apparent that granivores are more prevalent in PJ habitats compared with MC. The opposite is seen in Figure 8 as insectivores are much higher in MC habitat than PJ. The omnivores are more evenly distributed among both habitats (Figure 9), which is indicative of their generalist nature, although the MC habitat does still have higher numbers of these birds.

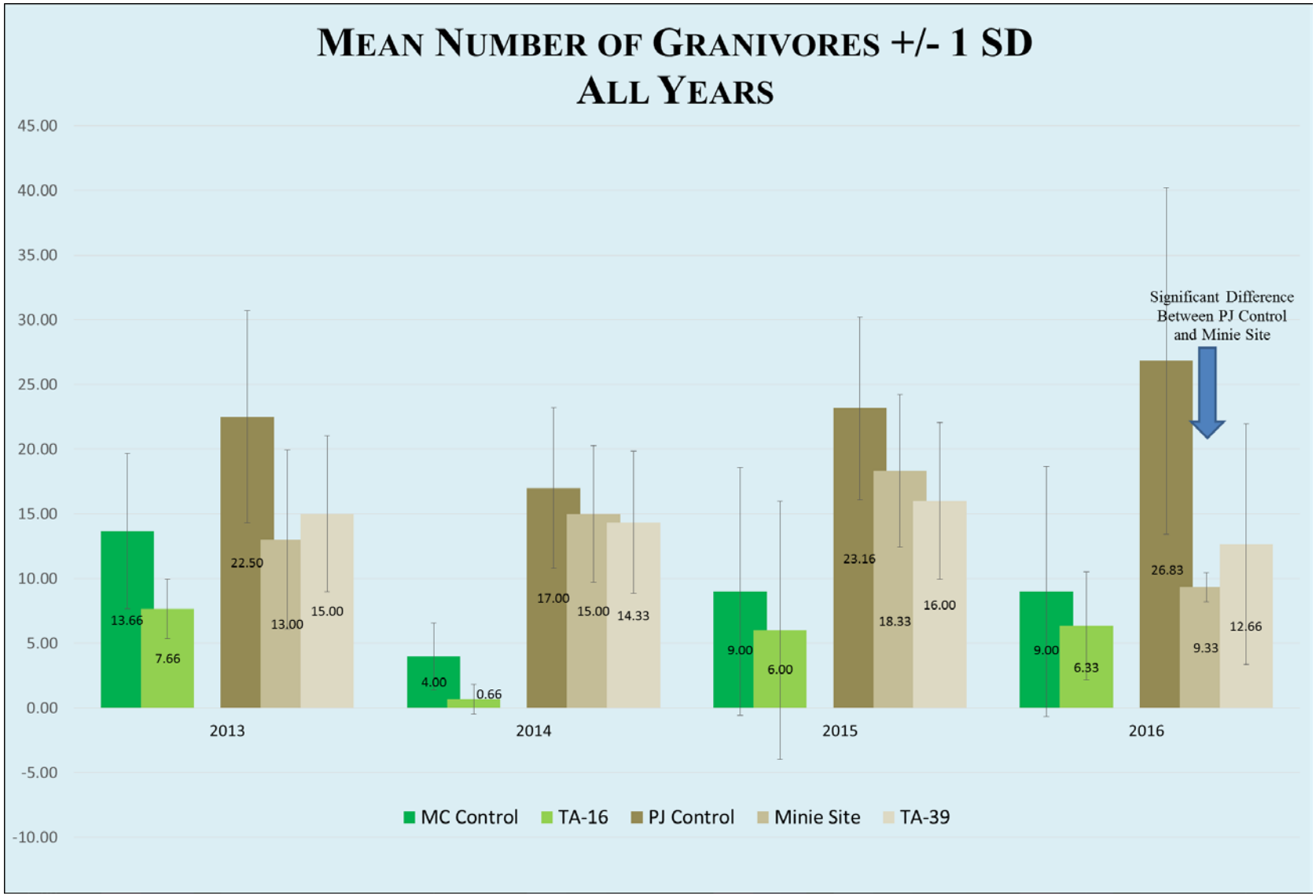

Figure 7. Mean number of granivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

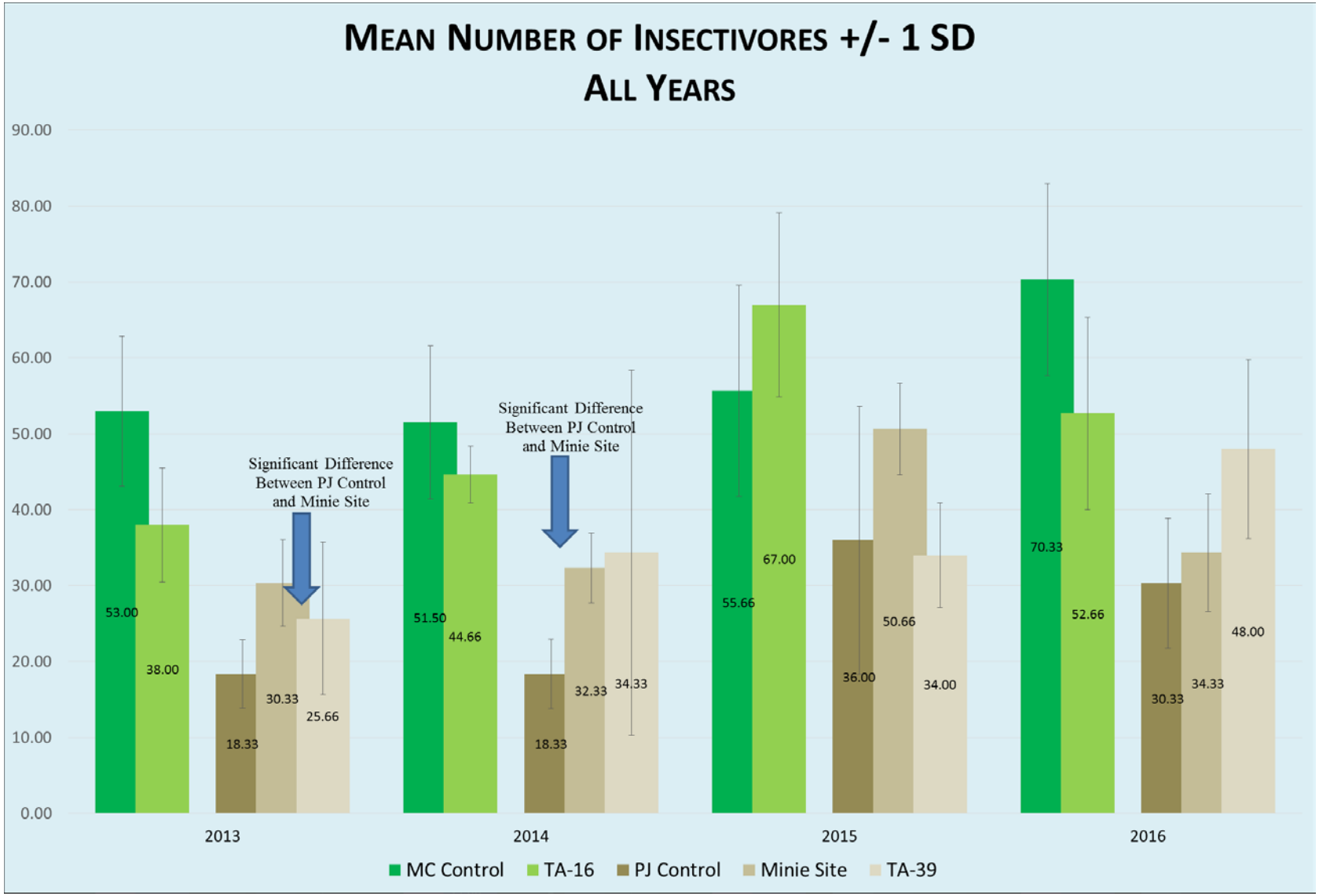

Figure 8. Mean number of insectivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

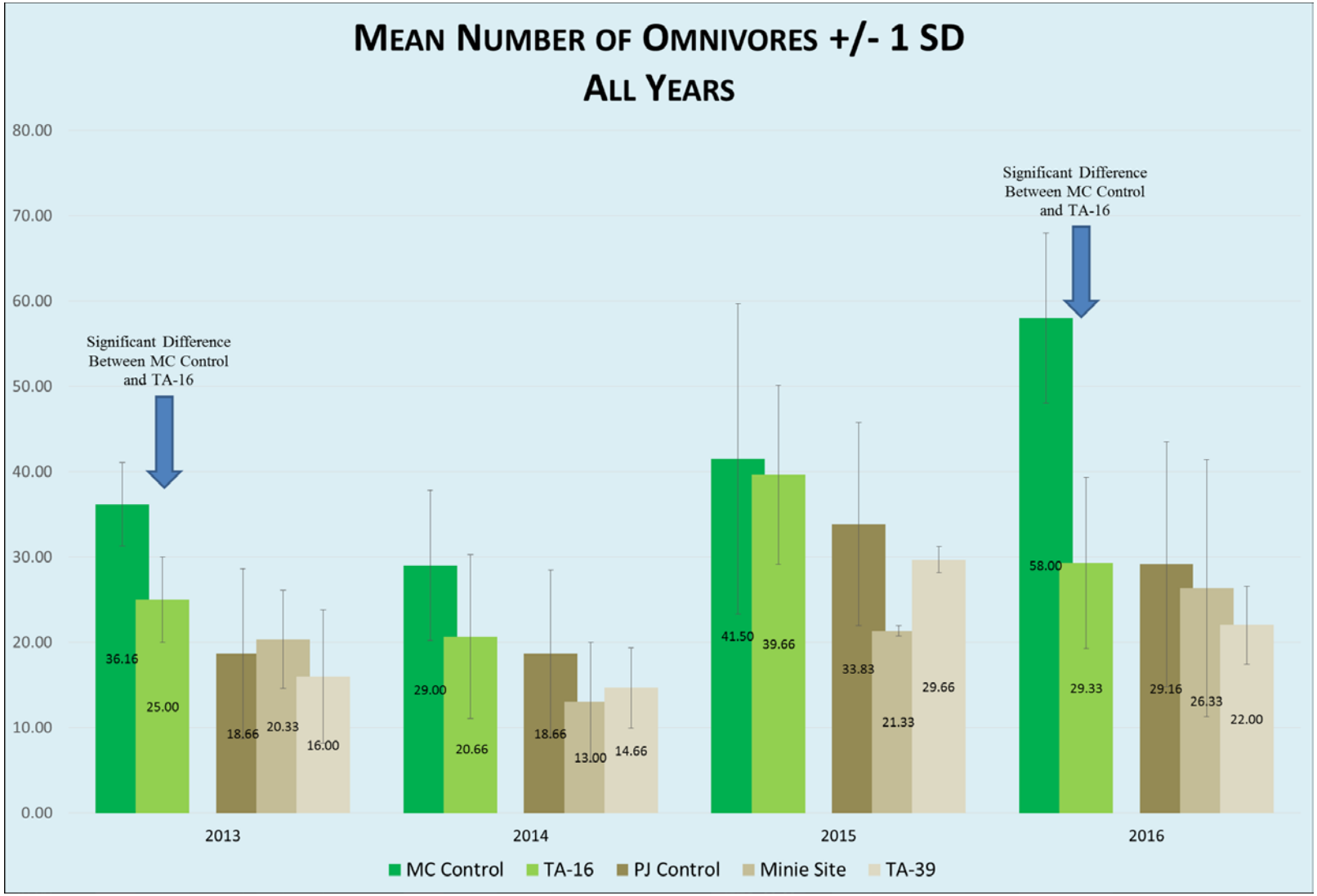

Figure 9. Mean number of omnivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

Table 3. Comparing the mean number of birds between study sites and their control by feeding guilds for each year.

	2013			2014		
Site Comparisons	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**
MC Control and TA-16	Z = -1.1921 (p = 0.23)	Z = -1.6783 (p = 0.09)	**Z = -2.2039 (p = 0.03)**	Z = -1.8226 (p = 0.07)	Z = -0.9113 (p = 0.36)	Z = -0.9037 (p = 0.36)
PJ Control and Minie Site	Z = -1.1717 (p = 0.24)	**Z = 1.9696 (p = 0.05)**	Z = 0.3956 (p = 0.69)	Z = -0.2593 (p = 0.79)	**Z = 2.2132 (p = 0.03)**	Z = -0.7811 (p = 0.43)
PJ Control and TA-39	Z = -1.1668 (p = 0.24)	Z = 0.9191 (p = 0.35)	Z = -0.3939 (p = 0.69)	Z = -0.5186 (p = 0.60)	Z = 1.0415 (p = 0.29)	Z = -0.6482 (p = 0.51)

Note: statistically significant results are shaded.

(Continued)

	2015			2016		
Site Comparisons	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**
MC Control and TA-16	Z = -0.5208 (p = 0.60)	Z = 0.7778 (p = 0.43)	Z = 0.1291 (p = 0.89)	Z = 0.0000 (p = 1.00)	Z = -1.6783 (p = 0.09)	**Z = -2.1947 (p = 0.03)**
PJ Control and Minie Site	Z = -1.0371 (p = 0.29)	Z = 1.4201 (p = 0.15)	Z = -1.4260 (p = 0.15)	**Z = -2.2039 (p = 0.03)**	Z = 0.3873 (p = 0.69)	Z = -0.2593 (p = 0.79)
PJ Control and TA-39	Z = -1.1619 (p = 0.24)	Z = 0.0000 (p = 1.0)	Z = -0.5186 (p = 0.60)	Z = -1.2964 (p = 0.19)	Z = 1.6783 (p = 0.09)	Z = -0.2593 (p = 0.79)

Note: statistically significant results are shaded.

During the 2016 nesting season, fifteen nestboxes each at Minie site and TA-16 and twelve nestboxes at TA-39 were actively monitored. The overall avian nestbox network without the three study sites contained 416 nestboxes in 2016. Of those, 188 contained active nests and 130 of those nests fledged young successfully. This was an overall occupancy rate of 45% with a 69% success rate.

At Minie site, thirteen nests were found and three of the nests fledged young successfully. Only eleven nestboxes were occupied, but two of those nestboxes had a second clutch. This was an occupancy rate of 73% with a 23% success rate.

At TA-39, seven nests were found. This was an occupancy rate of 58% with a 57% success rate. These nestboxes at TA-39 were relocated in 2016, and their occupancy increased seven-fold. The

firing site at TA-39 is in a small narrow canyon and the nestboxes were moved a little further out to a more open area to increase nesting attractiveness. The number of nestboxes in 2016 will also increase to 15 to be consistent.

At TA-16, eleven nests were found and seven of the nests fledged young successfully. This was an occupancy rate of 73% with a 63% success rate.

The occupancy rates at Minie site and TA-16 were greater than the results in the overall network. Yet, the nest success rates of these sites dropped well below the average of the rest of the network. This was largely due to an increase in predation. The redeployment of nestboxes within TA-39 also led to higher occupancy and nest success over previous years' placement. However, more years of data are needed to begin to look at the results in a more robust manner.

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 54 species detected at the three study sites, all are protected under the Migratory Bird Treaty Act. Additionally, two of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three study sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three study sites from 2013–2016.

Species	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
	TA-36				TA-39				TA-16			
	Pinyon-Juniper Woodland				Pinyon-Juniper Woodland				Mixed Conifer Forest			
Acorn Woodpecker									5		3	2
American Kestrel				1	1			2				
American Robin	1	1	2		1	1		2	7		9	4
Ash-throated Flycatcher	11	5	14	13	19	11	29	12	3	5	6	2
Audubon's Warbler		2						2	6	5	1	6
Bewick's Wren	4	8	9	9	3	10	15	9				
Black-chinned Hummingbird		1	1		3	2			1		1	
Black-headed Grosbeak	1	3				2	4	1			1	2
Black-throated Gray Warbler			1		5	6	4					
Blue-gray Gnatcatcher	3	14	16	8	2		7	5		6	2	1
Broad-tailed Hummingbird	2	1	3		3	1	2		5	11	11	5
Brown Creeper									1			
Brown-headed Cowbird	1						2		4	1		
Bushtit		2		2	2	14						
Canada Goose							16					
Canyon Towhee	2		5	3	1	1	2	10	1			1
Canyon Wren							2	3			2	
Cassin's Kingbird	6	13	13	5	7	6	2	21				1
Chipping Sparrow	3	16	17	29	6	6	5	8	1	5	3	10
Clark's Nutcracker										4		1
Common Nighthawk	6		5	2	5	1	3	2			1	2
Common Raven	2	5	1		1		2	1	5	6	2	2
Cooper's Hawk									1			1

	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Species	TA-36				TA-39				TA-16			
	Pinyon-Juniper Woodland				Pinyon-Juniper Woodland				Mixed Conifer Forest			
Cordilleran Flycatcher									5	10	6	3
Dark-eyed Junco									6	2	4	
Downy Woodpecker				1				1		1		1
Dusky Flycatcher				1			1					
Eurasian Collared-Dove	3											
Evening Grosbeak	3		4				8		5		29	
Grace's Warbler									6	4	4	8
Gray Flycatcher	12	6	5	7	10	10	11	10				
Great Horned Owl		3			1							
Green-tailed Towhee	3	1			1							
Hairy Woodpecker			2	1			5	3	1	1		1
Hammond's Flycatcher									8	9	12	5
Hepatic Tanager							1	2				1
Hermit Thrush										4	6	1
House Finch	16	17	26	17	21	4	23	9	16	2	5	5
House Wren									1	1		2
Juniper Titmouse	12		7	6	11	13	18	6				
Lesser Goldfinch	2	6	7	4	4	12	9	10	3		8	9
MacGillivray's Warbler												1
Mountain Bluebird		2	20	10		4					4	4
Mountain Chickadee	5	2	1	2				1	5	8	9	6
Mourning Dove	17	17	13	5	13	22	10	3	4		1	3
Northern Flicker								3				
Northern Mockingbird						1						
Peregrine Falcon							1					

	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Species	TA-36				TA-39				TA-16			
	Pinyon-Juniper Woodland				Pinyon-Juniper Woodland				Mixed Conifer Forest			
Pine Siskin	10	2		5	6		3	3	12	4	5	
Plumbeous Vireo	10	10	7	3	1		1	6	11	16	15	14
Pygmy Nuthatch				2			2	4	11	13	26	29
Red Crossbill						2				2	9	13
Red-shafted Flicker	3	1	3	2	3	2	4	5	3	4	11	11
Red-tailed Hawk							1	1				
Rock Wren	3	3	4		7	10	4	12	1	2	2	6
Say's Phoebe	2	1	2		2	1		5	1		1	3
Scaled Quail			1									
Spotted Towhee	17	8	19	27	12	6	33	16	11	18	16	14
Steller's Jay									3	2	5	6
Townsend's Solitaire	1											
Turkey Vulture									1			
Violet-green Swallow		5	7	1	6	4	1	9		2	19	2
Virginia's Warbler							1	2	17	11	21	13
Warbling Vireo									2	9	7	6
Western Bluebird	15	11	18	17	5	19	12	21	20	20	49	37
Western Scrub-Jay	5	1	3	4	8	10	4	8	1			
Western Tanager		2	3			2	1	1	2	3	7	2
Western Wood-Pewee	10	8	18	11		4	2	10	15	10	16	14
White-breasted Nuthatch	1	4	9	10			2	4	9	8	7	9
White-throated Swift						1						
White-winged Dove	1	5	9	2	7	5	6	16			1	2
Grand Total	**193**	**186**	**275**	**210**	**177**	**193**	**259**	**249**	**220**	**209**	**347**	**271**

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 9 – Hathcock *et al.* 2018

Environmental Report:

Hathcock, C.D., A.W. Bartlow, and B.E. Thompson. March 2018. *2017 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory*. LA-UR-18-22897.

March 2018

2017 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

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EST. 1943

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts were compared among years to monitor trends. The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Additionally, nesting success of secondary-cavity nesting birds was examined using nestboxes. LANS biologists completed the fifth year of this effort in 2017. The overall results from 2017 continue to indicate that operations are not negatively affecting bird populations; however, we are seeing some species turnover through time and that will continue to be monitored.

Three bird point count surveys were completed at each of the treatment sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2017. A total of 785 birds representing 59 species were recorded at the treatment sites. Three bird point count surveys were also completed at each of the control sites between May and July 2017. Occupancy and nest success data from nestboxes at treatment sites were compared with the overall avian nestbox monitoring network.

Species richness and diversity at the treatment sites were not statistically different than their associated controls. Avian abundance showed more variability but treatment and controls were trending together year to year. Species composition seems to indicate some species turnover in the habitat types but very little difference between treatment and control sites.

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Introduction

An annual avian monitoring program was started in 2013 as part of the Resource Conservation and Recovery Act permitting process at Los Alamos National Laboratory (LANL) for two open detonation sites, Technical Area (TA) 36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017). The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Comparisons were made with control sites of similar habitat that have been surveyed since 2011 (Hathcock et al. 2011).

Los Alamos National Security, LLC (LANS) biologists used standard point count methodology to record avian abundance and diversity along transects at the three treatment sites and associated control sites during the summer of 2017. Summer surveys provide information about what birds were breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental change at LANL.

In addition to avian point counts, nestboxes were monitored around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success data were compared with the overall avian nestbox monitoring network, which was established in 1997.

Changes to the analysis methodologies were implemented this year. TA-16 is now being compared with a different set of controls, switching from a mixed conifer control to a ponderosa control. This change is retroactive for this report and all previous years were reanalyzed. The larger analysis of feeding guilds was dropped because of low sample sizes and difficulty in assigning guilds, they are still mentioned in a more general sense. Also, more robust statistics are used to analyze the datasets. In this report, the year 2017 is first analyzed separately, and then all years are analyzed to examine trends over time.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon-juniper woodland (PJ) for Minie and TA-39 and a ponderosa pine forest (PIPO) at TA-16. These habitat descriptions were based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) were monitored

annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock et al. (2011). Each habitat type control contained two replicate transects that were monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects were randomized and surveyed according to the random order.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was more natural.

Transects were approximately 2.0 to 2.5 km in length and allowed for nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site and surveys must be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an “unlimited-distance circular plot”; however, the distance to each bird out to 100 m should be noted. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, note any species encountered that have not otherwise been counted from a previous point or future point. The surveyor’s main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Record all birds encountered on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- Use the “NOTES” section to indicate any potentially important aspects of the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Other wildlife or evidence of wildlife that could be used for other projects should be recorded.

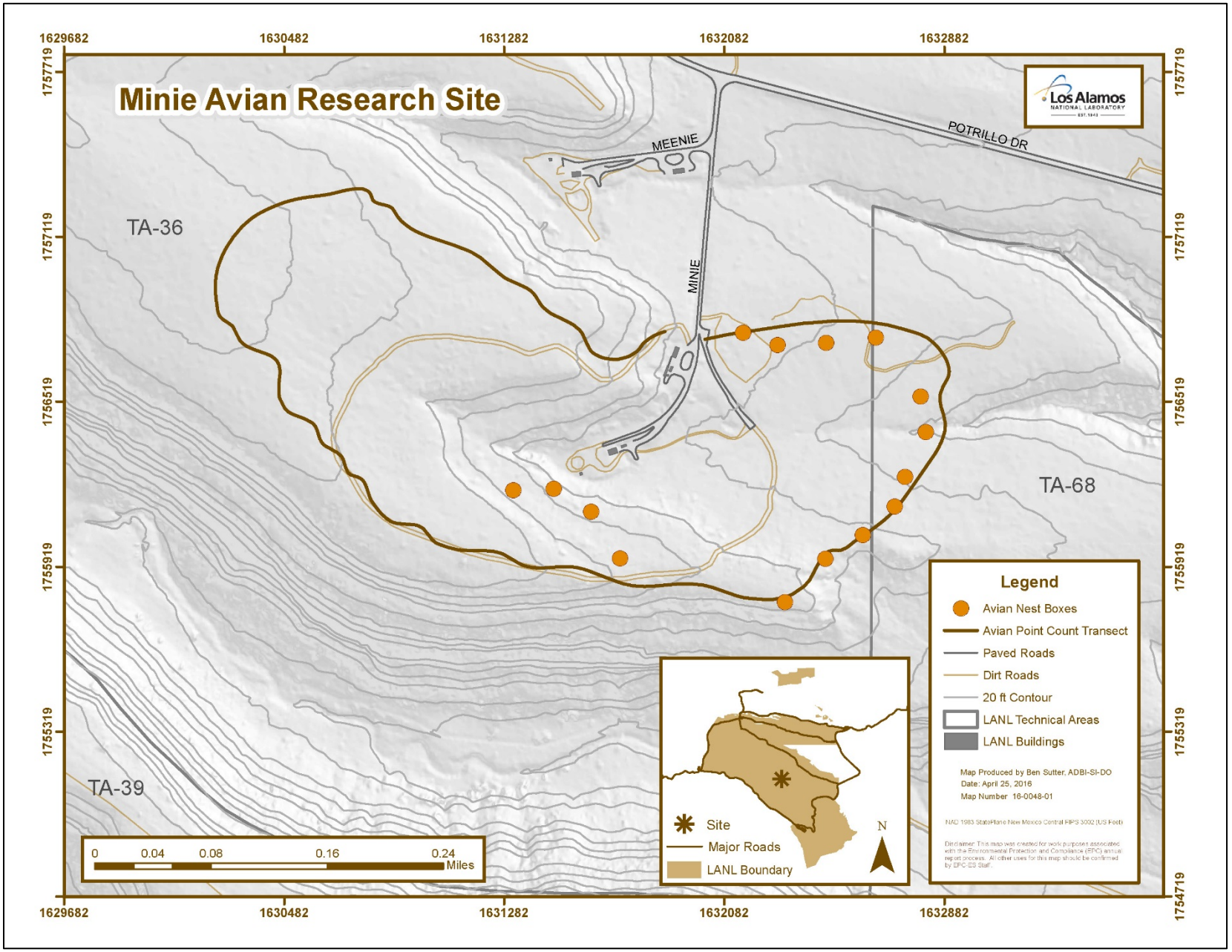


Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site

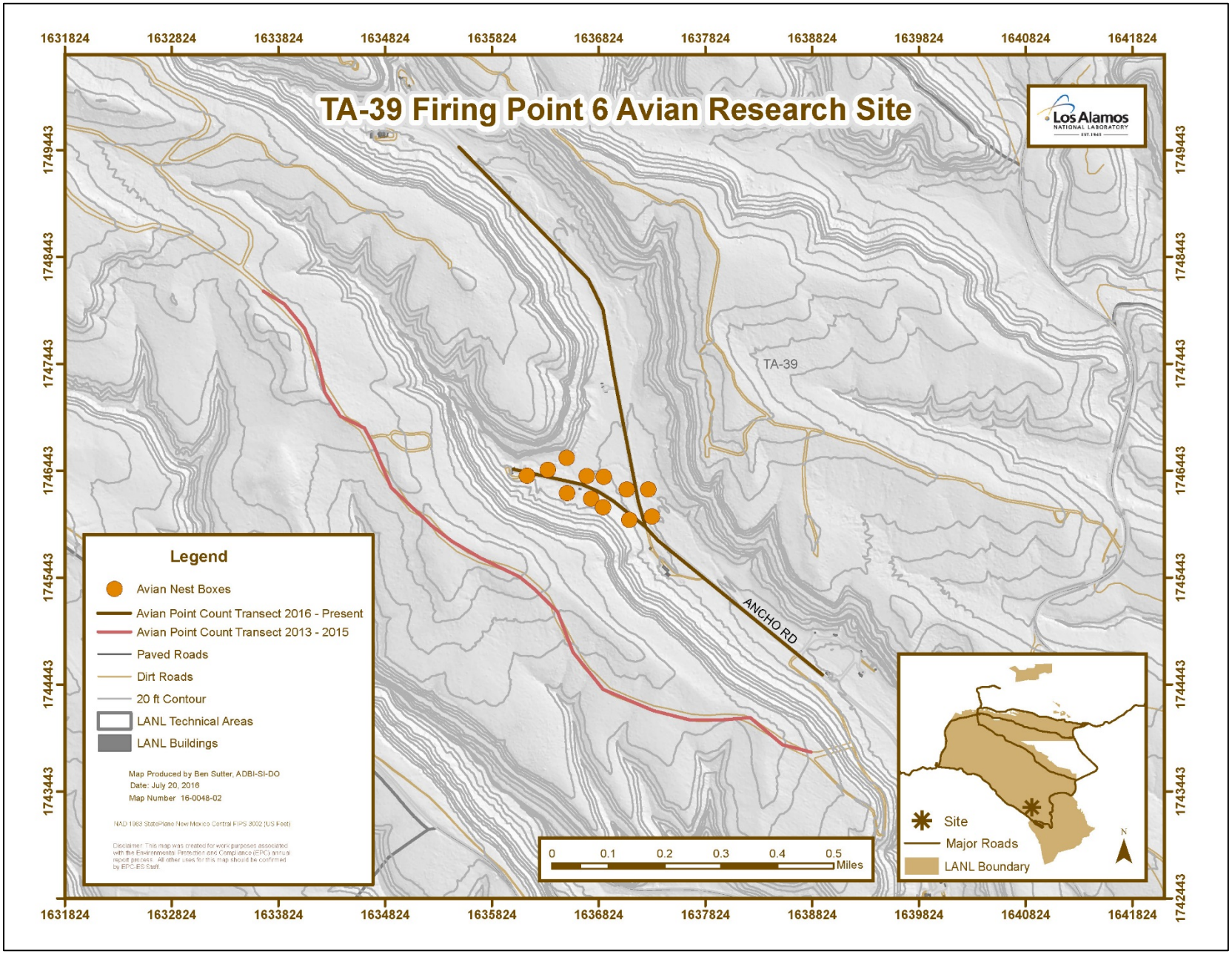


Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6

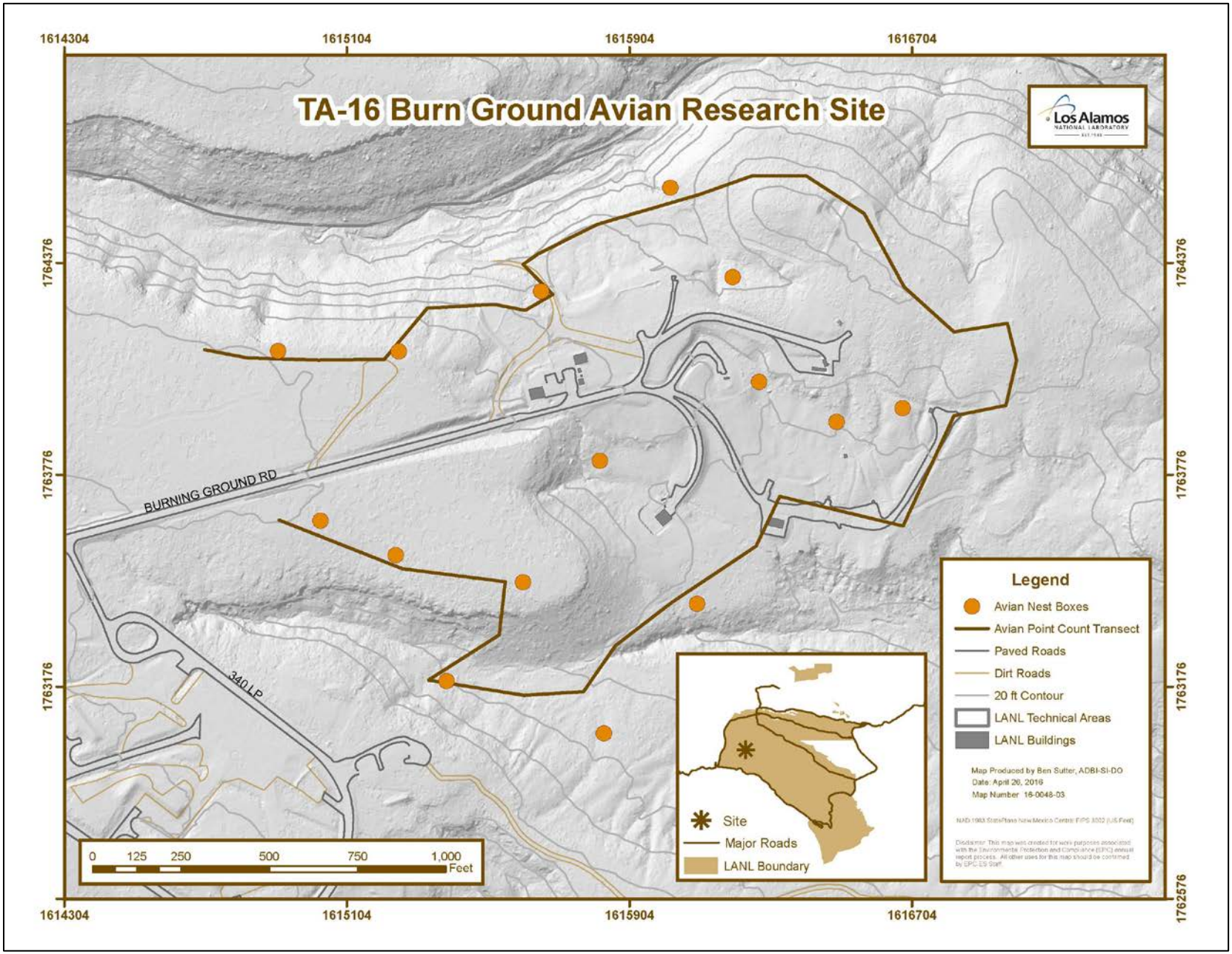


Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground

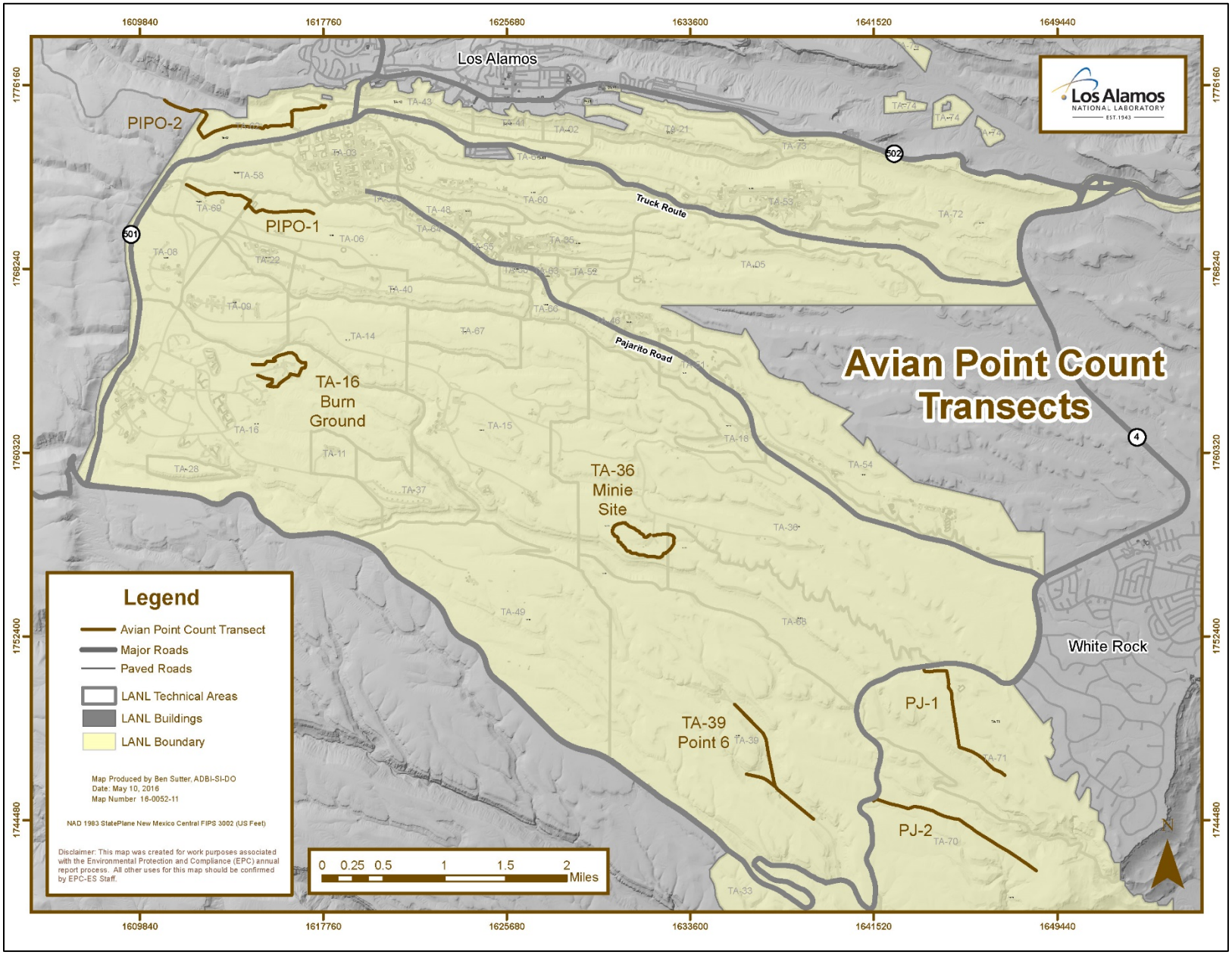


Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie and TA-39 (Figures 1 and 2). In 2015, nestboxes were added to TA-16 (Figure 3). Nestboxes were monitored every 1 to 2 weeks for active nests. When an active nest was found, it was monitored more frequently to determine whether the nest failed or successfully fledged young. Nestlings were also banded and the sex determined after the age of 10 days.

Statistical Methods for Point Counts

The data were summarized to compare species richness, diversity, abundance, and composition between sites and among years using the statistical software R (version 3.4.1; R Core Team 2017). Species richness and diversity were computed using the R-package 'iNEXT' (Hsieh et al. 2016; Chao et al. 2014) and plotted with bootstrap confidence intervals around the mean for rarefied/extrapolated samples, facilitating the comparisons of richness and diversity. The estimated asymptote along with a confidence interval was also provided. The Simpson's diversity index was calculated using the following formula: $D = 1 - (\sum n(n-1) / N(N-1))$, where n = the total number of organisms of a particular species and N = the total number of organisms of all species. The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0 represents no diversity. Species diversity was also computed using the statistical software PAST (Hammer et al. 2001) and a t-test was used to test for differences between treatment and control sites each year. Comparisons of Simpson diversity in two samples is described by Hutcheson (1970) and is an alternative to the permutation test. To examine species abundance, we used the number of individual birds among sites and across years and looked for trends. To examine species composition, non-metric multidimensional scaling (NMDS) was used to determine dissimilarity among sites. To compare species composition between treatments and years, an analysis of similarity (ANOSIM) was conducted using 1000 permutations. These analyses were completed using the community ecology package 'vegan' (Oksanen et al. 2017) in R.

Statistical Methods for Nestboxes

Occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network were calculated. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. Annually, data from the three treatment sites were compared with the overall avian nestbox network at LANL that was established in 1997.

Results and Discussion

Year 2017

Three surveys were completed at each of the three treatment sites and the associated control sites between May and July 2017. A total of 785 birds representing 59 species were recorded at the three treatment sites. A full account of the 2013–2017 data is detailed in Appendix 1.

Species richness is the number of different species represented in an ecological community and is simply a count of species. In this case, each treatment site and control are individual communities. Species diversity is a measure that takes into account the species richness and the overall abundance to compare evenness across a community. Here we used the Simpson's diversity index which measures the probability that two individuals randomly selected from a sample will belong to different species. The abundance is the total number recorded of a given species. Table 1 details the species richness, diversity, and abundance for 2017 for each site and its associated controls.

Table 1. The species richness, diversity, and abundance recorded at each site in 2017

2017	*Minie Site*	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	35	34	37	39	41	46	44
Diversity	0.9429	0.9486	0.9211	0.9462	0.9429	0.931	0.9462
Abundance	222	261	240	300	302	447	449

Species rarefaction and extrapolation from 2017 show no differences between treatment and control sites for species richness. There were overlapping 95% confidence intervals for species richness (Figures 5A–7A) for all three treatments and their controls. Simpson's diversity (Figures 5B–7B) was not as clear with 95% confidence intervals being further apart. To further analyze species diversity, we compared treatments to control sites using t-tests and confirmed that there was not a significant difference (Minie/Control t-test: $t = 0.1504$, $p = 0.88$; TA-39/Control t-test: $t = 1.2234$, $p = 0.22$; TA-16/Control t-test: $t = -0.6903$, $p = 0.49$) when comparing treatment to combined control sites. The two control transects for PJ were not as similar in diversity as expected ($t = -2.5322$, $p = 0.01$). For the PJ habitat type, control 1 is a walking transect and control 2 is a driving transect and the act of driving between points may be causing more species to be seen.

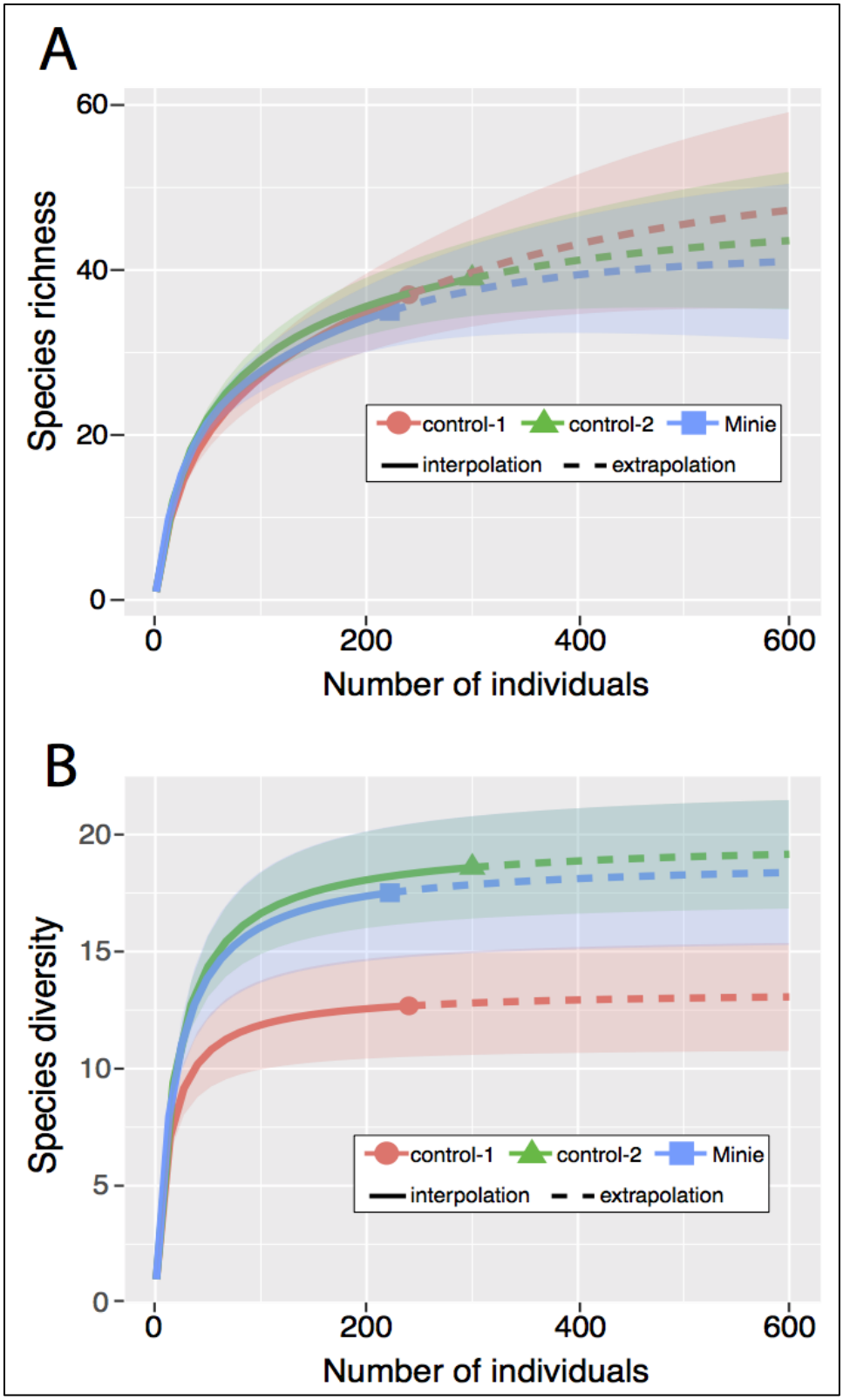


Figure 5. **Species rarefaction and extrapolation for species richness and diversity comparing Minie with the PJ controls**

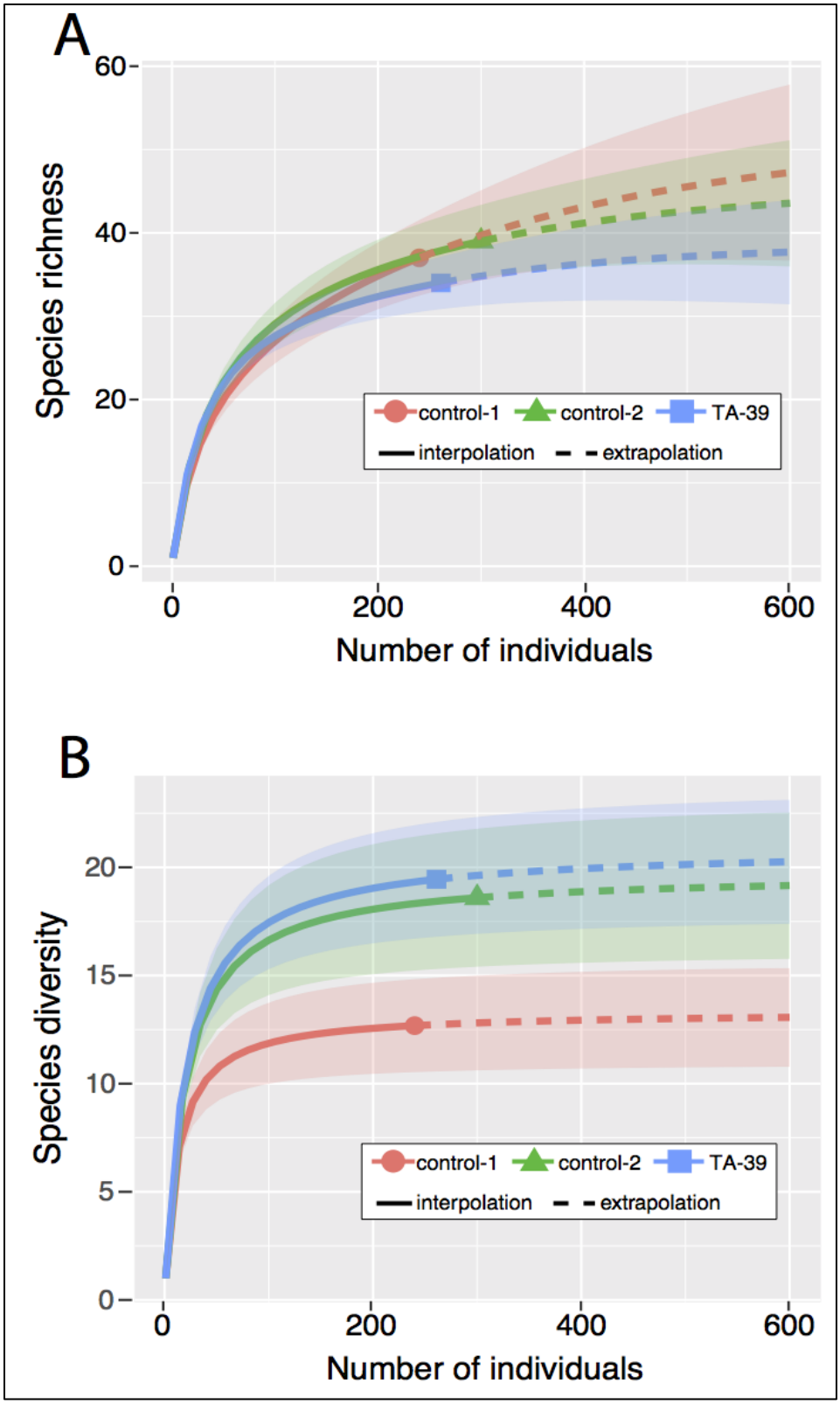


Figure 6. **Species rarefaction and extrapolation for species richness and diversity comparing TA-39 with the PJ controls**

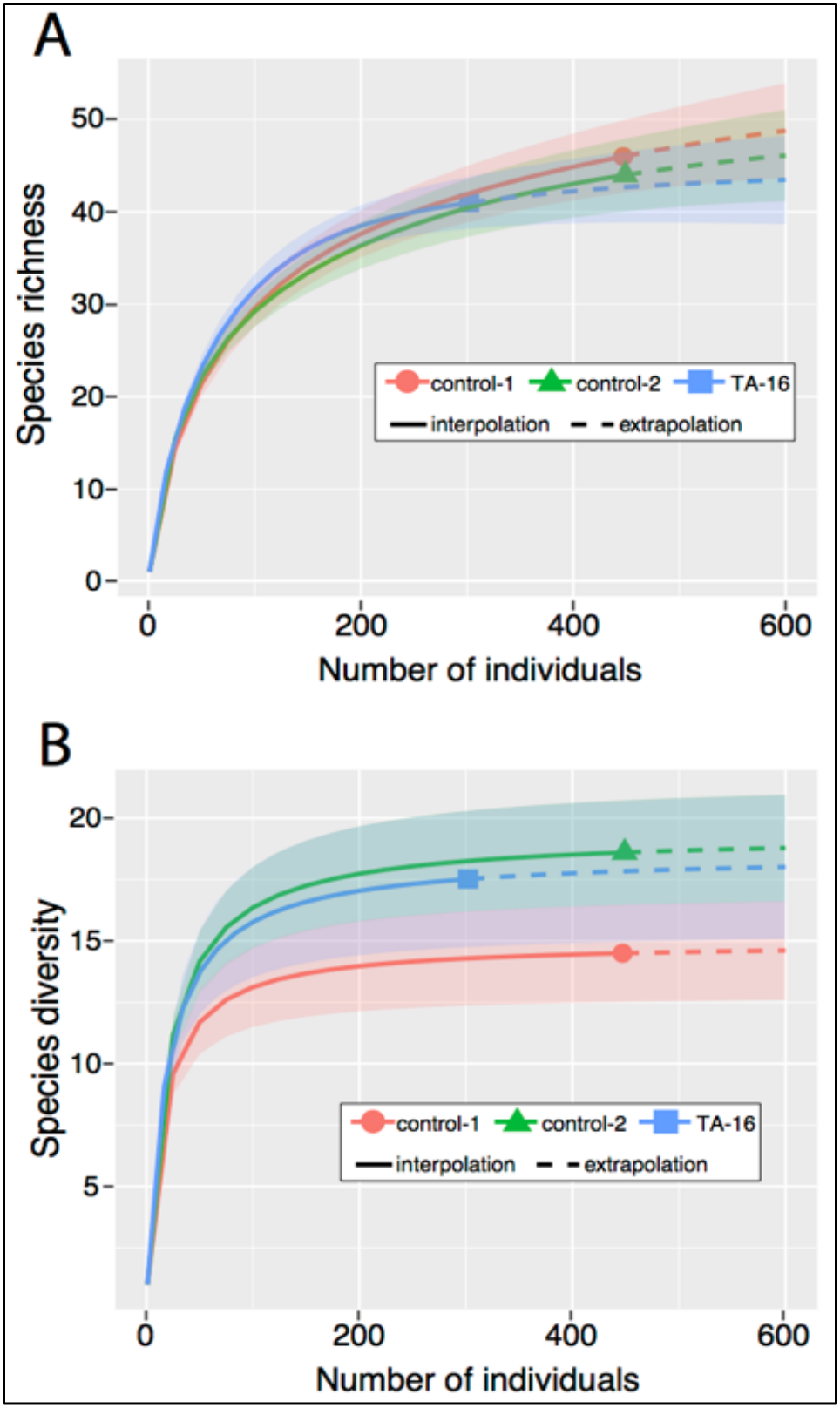


Figure 7. Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls

Multivariate analysis with ordination was used to explore the data further to look for patterns that may be explained by a multitude of other environmental factors not assessed directly. We used NMDS with three dimensions (Gardener 2014) in which a measure of 'stress' (mismatch between the rank order of distances in the data, and the rank order of distances in the ordination) was calculated. The samples were moved slightly in a direction that decreases the stress until stress appeared to reach a minimum. The final configuration of points is represented in Figure 8. Here, the species surrounding each site means that these species were important in separating the sites. The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated habitat types. This graphically shows how the data for the PJ control sites were not as similar as the PIPO control sites in terms of species composition, which were on either side of the y-axis. This also shows what species were driving the patterns. The transect in TA-39 was in a canyon bottom whereas the PJ control transects were on mesa tops. The species driving the location of TA-39 was the White-winged Dove (WWDO), which is not as prevalent at both of the PJ control transects. Additionally, the Pinyon Jay (PIJA) and the Black-throated Gray Warbler (BTYW) were found mostly in PJ sites, while the Acorn Woodpecker (ACWO) and Hammond's Flycatcher (HAFL) were mainly found in ponderosa habitats. Based on their known habitat preferences, these data were consistent. The treatment sites were not significantly different from control sites (ANOSIM: R = 0.0, P = 0.4).

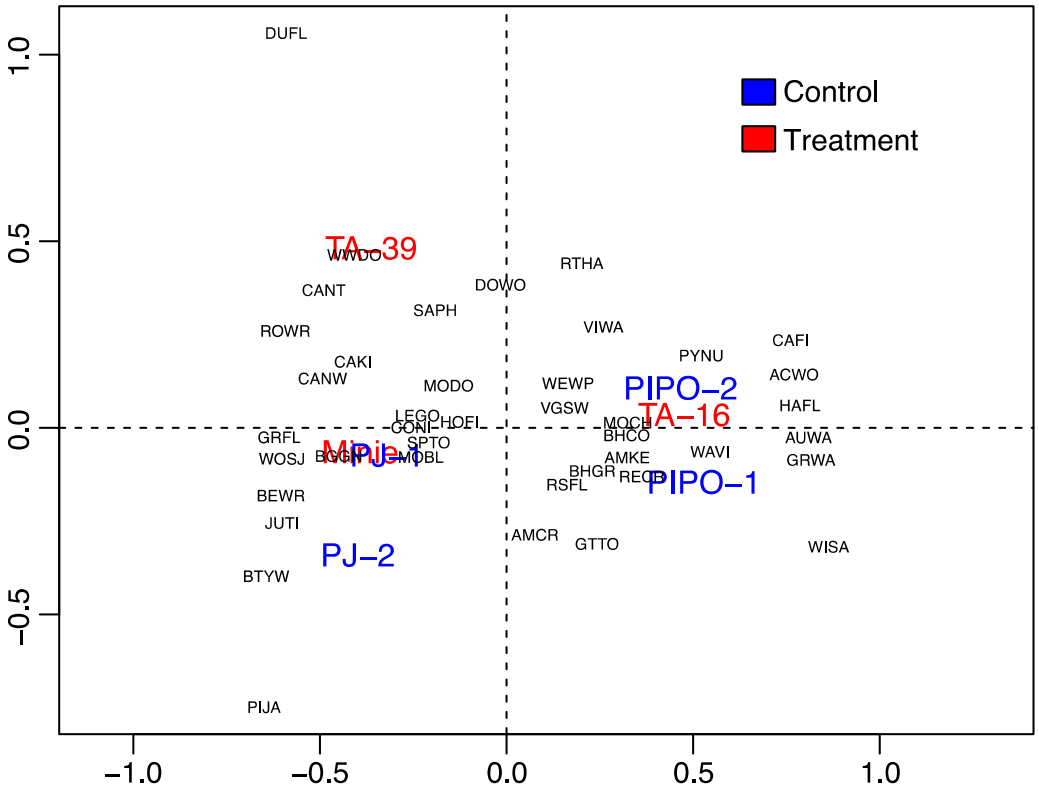


Figure 8. Non-metric multidimensional scaling of bird species and sites in 2017

Trends Over Time

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for a migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The fluctuations in bird abundances are not alarming, and the differences between the treatment sites and control sites are not biologically significant.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*
Minie	33	33	34	30	35
TA-39	31	31	39	38	34
PJ Control 1	29	30	33	36	37
PJ Control 2	30	29	37	33	39
TA-16	33	33	40	44	41
PIPO Control 1	34	34	30	41	41
PIPO Control 2	33	36	43	43	44

Tables 3–5 compare the species diversity over time between the treatment site and the combined control. The two control sites were combined to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of the study. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Figures 9 and 10 graphically represent the data fluctuations over time. Even though we see significant differences, the bird diversity at all sites is greater than 0.90, which compared with other systems, is very high.

Figures 11 and 12 graphically represent bird abundances over time. The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower, but the percent abundance is similar year to year when compared with the control sites.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls*

	2013	*2014*	*2015*	*2016*	*2017*
Minie	0.9464	0.9463	0.9502	0.9315	0.9429
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419
t-test	t = 3.9572 df = 501.3 p = <0.01	t = 2.5469 df = 510.42 p = 0.01	t = 1.5902 df = 644.91 p = 0.11	t = 0.4385 df = 499.33 p = 0.66	t = 0.1504 df = 448.66 p = 0.88

* Darker shading indicates a significant difference.

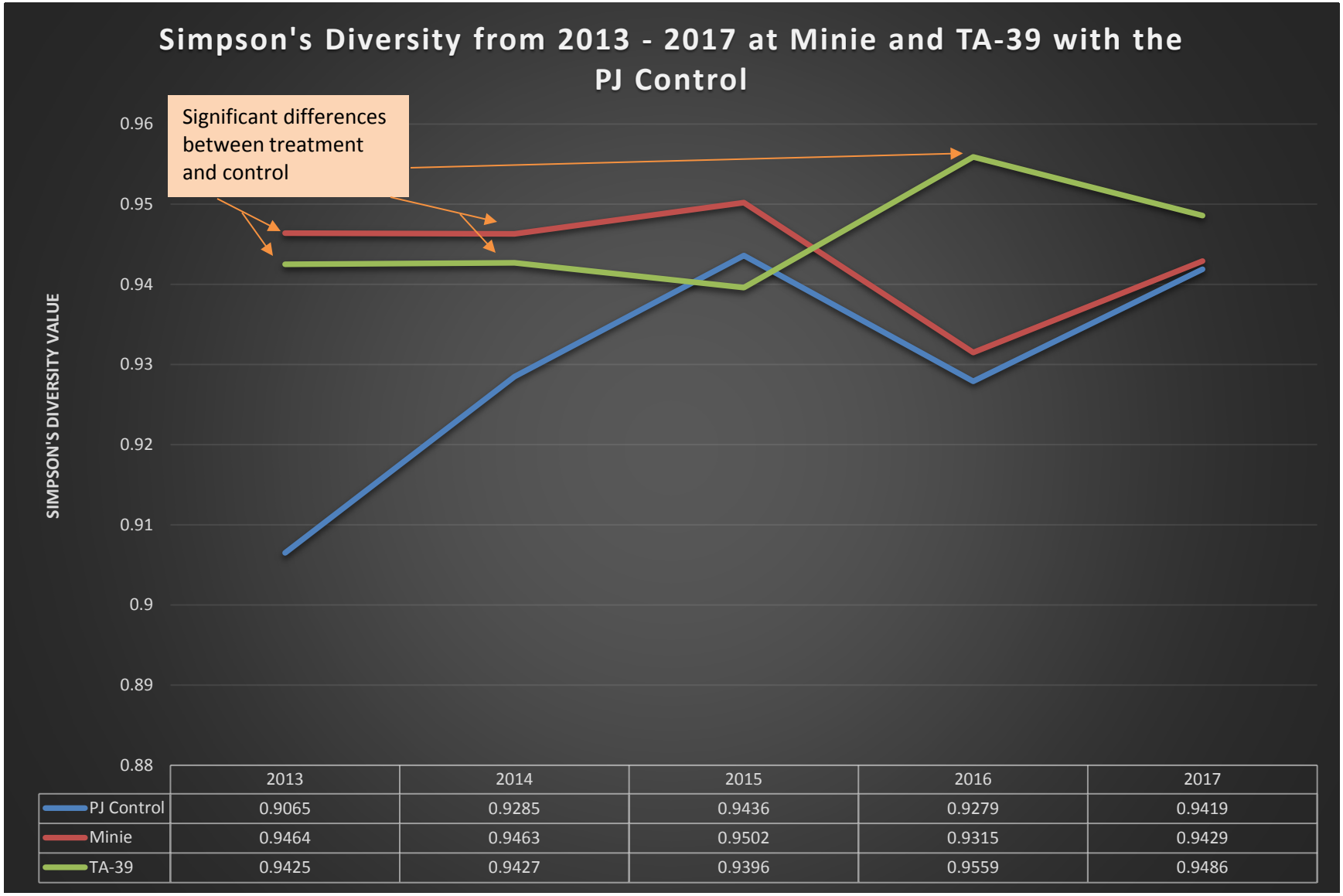
Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls*

	2013	*2014*	*2015*	*2016*	*2017*
TA-39	0.9425	0.9427	0.9396	0.9559	0.9486
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419
t-test	t = 3.3636 df = 538 p <0.01	t = 1.9703 df = 509.25 p = 0.05	t = -0.6751 df = 401.58 p = 0.50	t = 4.5611 df = 783.86 p <0.01	t = 1.2234 df = 705.5 p = 0.22

* Darker shading indicates a significant difference.

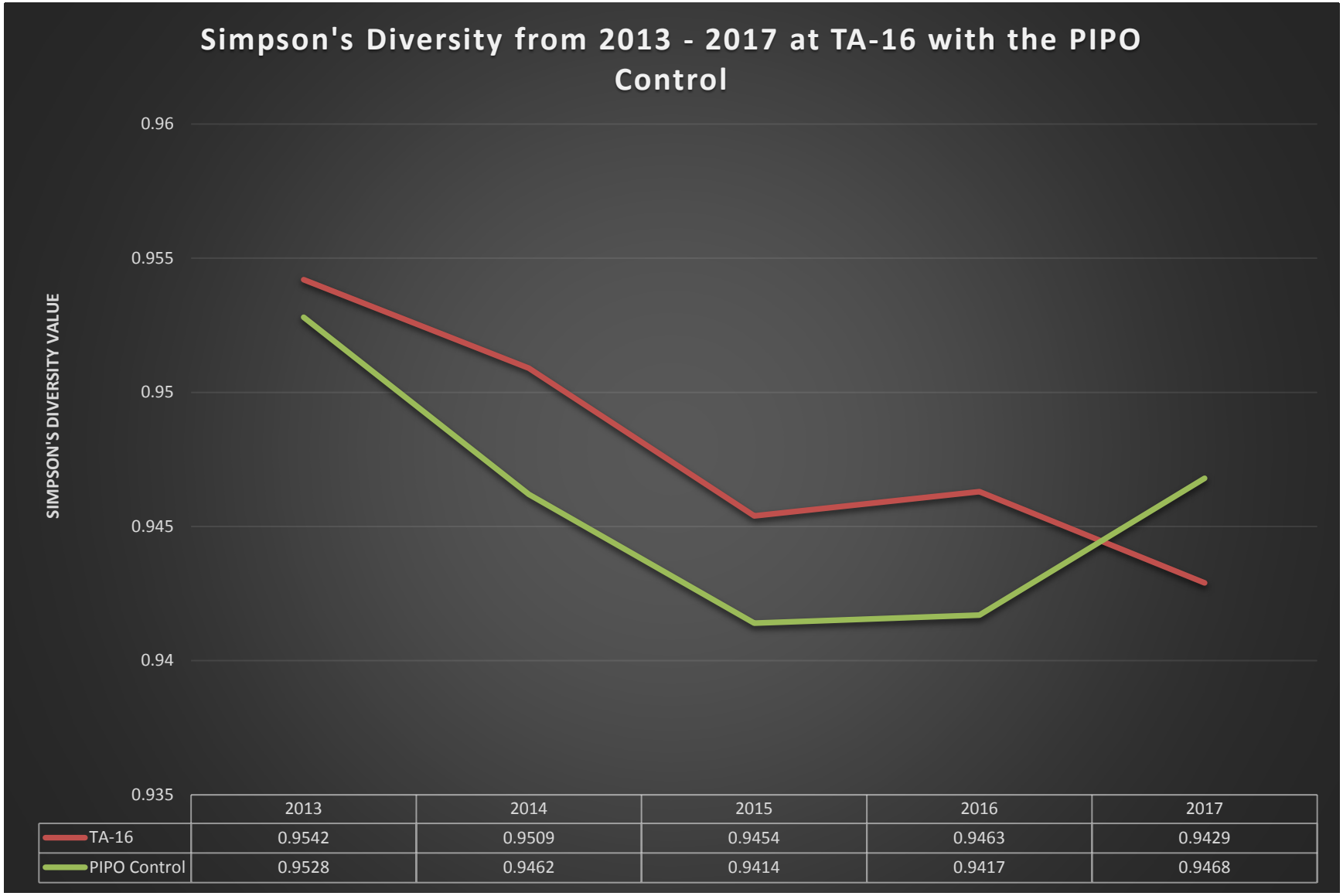
Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*
TA-16	0.9542	0.9509	0.9454	0.9463	0.9429
PIPO Control	0.9528	0.9462	0.9414	0.9417	0.9468
t-test	t = 0.3323 df = 378.91 p = 0.73	t = 0.9236 df = 472.24 p = 0.35	t = 0.748 df = 633.26 p = 0.45	t = 0.7438 df = 475.6 p = 0.45	t = -0.6903 df = 444.95 p = 0.49



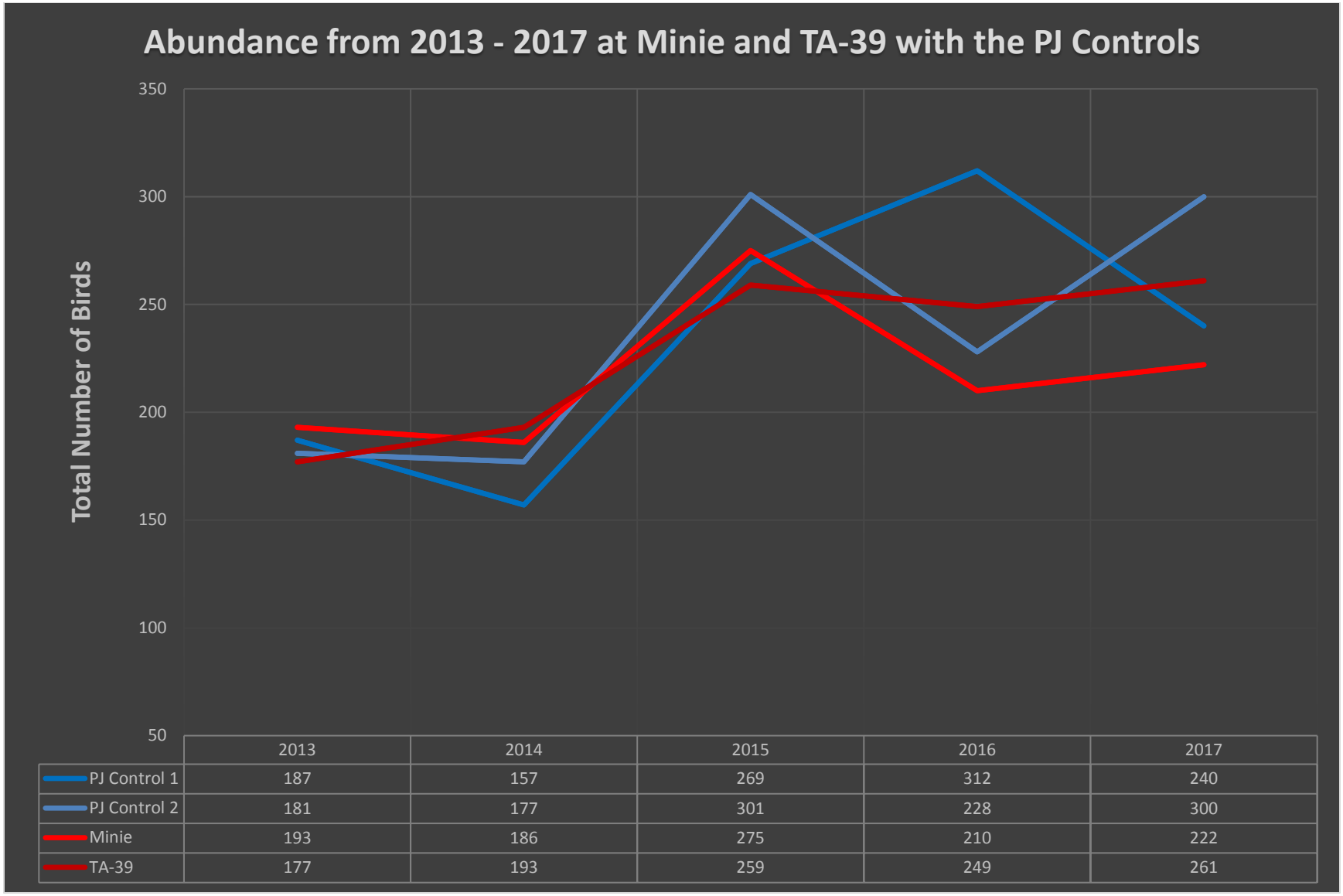
	2013	2014	2015	2016	2017
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419
Minie	0.9464	0.9463	0.9502	0.9315	0.9429
TA-39	0.9425	0.9427	0.9396	0.9559	0.9486

Figure 9. Changes in species diversity over time comparing Minie and TA-39 with the PJ controls



	2013	2014	2015	2016	2017
TA-16	0.9542	0.9509	0.9454	0.9463	0.9429
PIPO Control	0.9528	0.9462	0.9414	0.9417	0.9468

Figure 10. Changes in species diversity over time comparing TA-16 with the PIPO controls



	2013	2014	2015	2016	2017
PJ Control 1	187	157	269	312	240
PJ Control 2	181	177	301	228	300
Minie	193	186	275	210	222
TA-39	177	193	259	249	261

Figure 11. Changes in abundance over time comparing Minie and TA-39 with the PJ controls

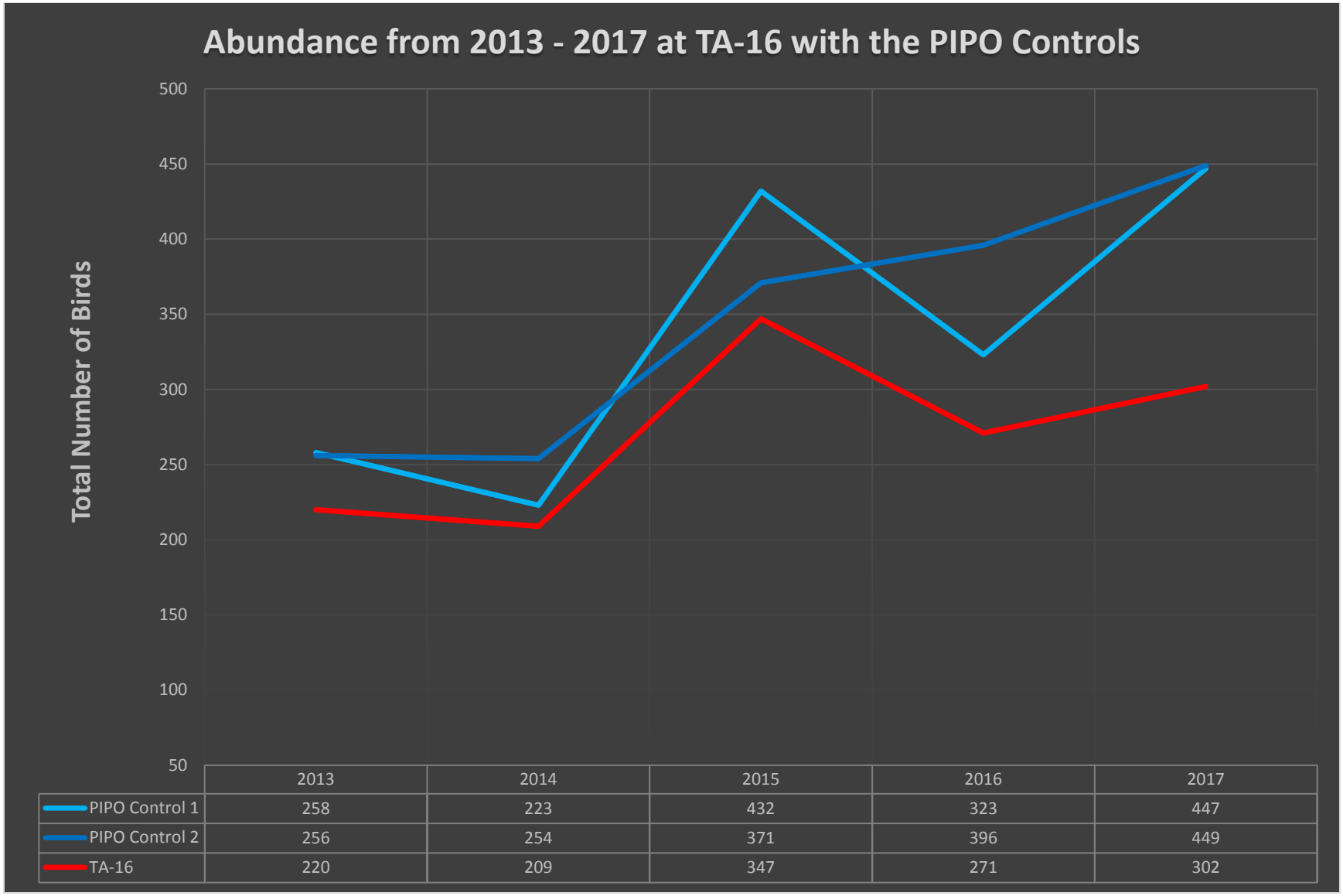


Figure 12. Changes in abundance over time comparing TA-16 with the PIPO controls

Species composition was analyzed over time according to whether sites were controls or treatments for PJ sites and ponderosa sites separately (Figures 13 and 14). Figure 13 shows the species composition for PJ sites for each year. The difference in species composition was significant between treatment sites and control sites for PJ habitats (ANOSIM: R = 0.35, P = 0.05; Figure 13). The species closest to each site were the species most important in separating those sites from the rest.

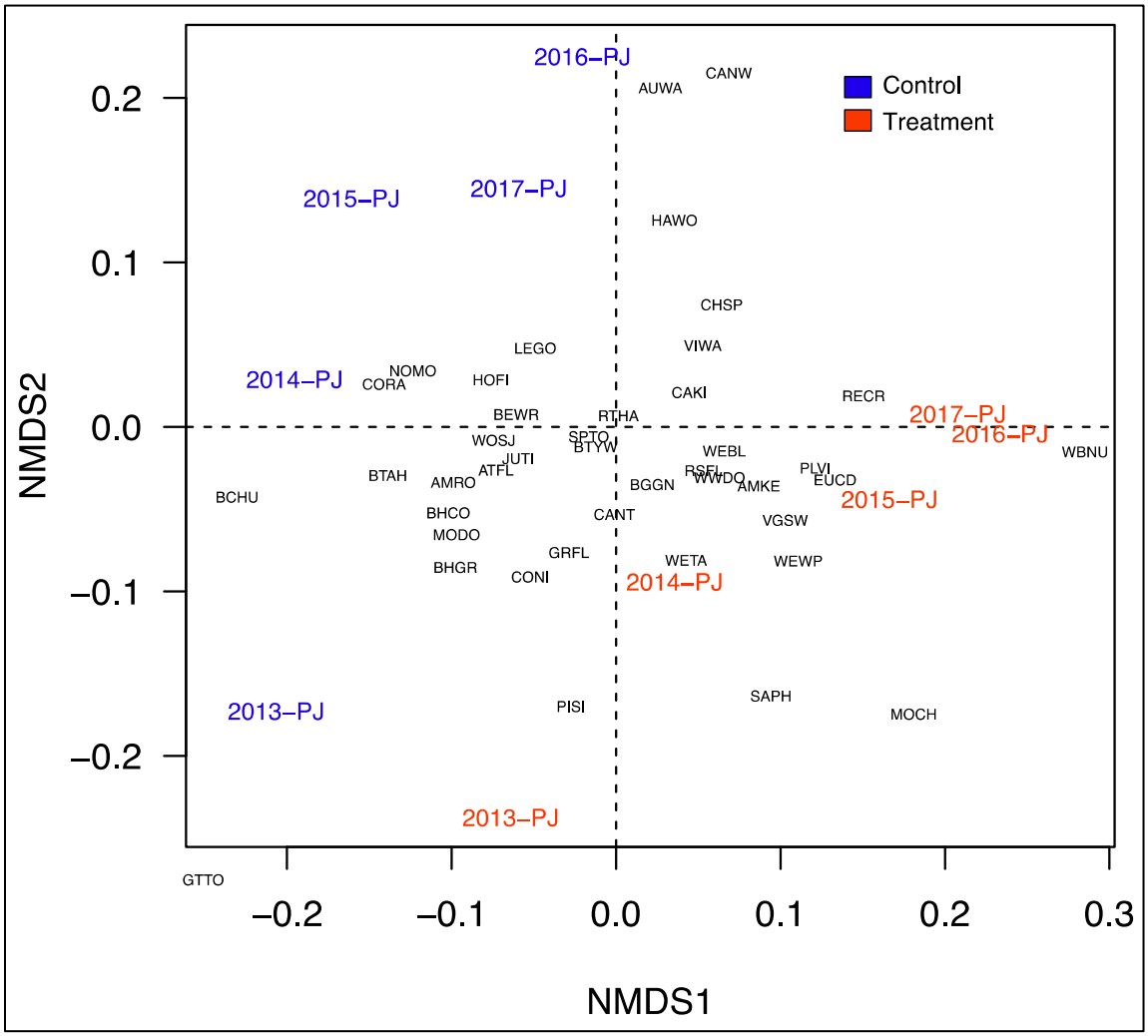


Figure 13. Non-metric multidimensional scaling of bird species from 2013 to 2017 by treatment for PJ sites

Species composition over time for ponderosa sites is shown in Figure 14. The difference in species composition was significant between treatment sites and control sites for ponderosa habitats (ANOSIM: R = 0.85, P = 0.007; Figure 14). Collectively, Figures 13 and 14 suggest that the control sites have different species composition than treatment sites over the course of the study.

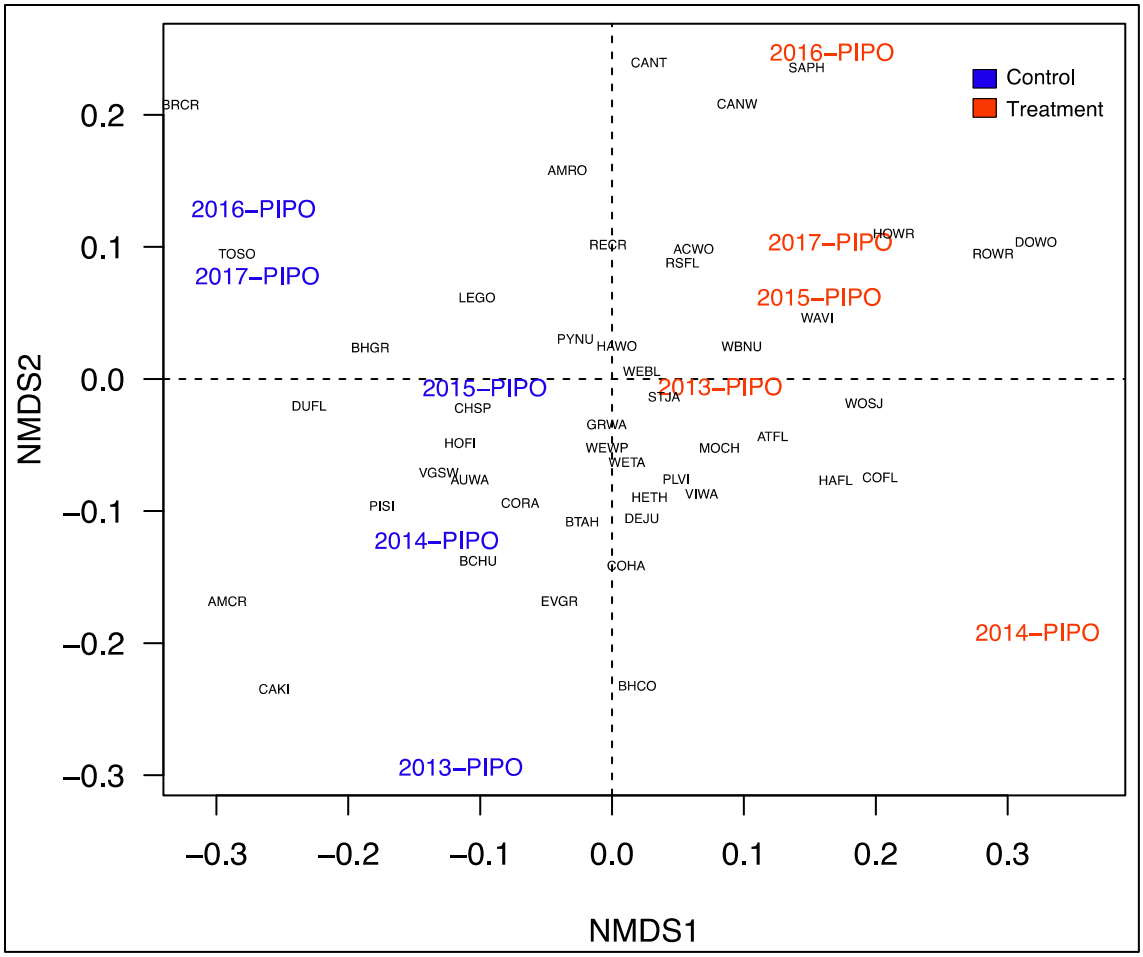


Figure 14. Non-metric multidimensional scaling of bird species from 2013 to 2017 by treatment for ponderosa sites

Figures 13 and 14 also show patterns over the five years. To examine these patterns further, we compared early years (2013 and 2014) and later years (2016 and 2017), excluding 2015. We tested for differences in similarity between the two time points for each of the habitat types, disregarding treatment for these tests. Species composition significantly differed between time points for PJ habitats (ANOSIM: R = 0.73, P = 0.029). This significance indicates that species composition has changed over the last five years. Species composition was similar between both time points for ponderosa sites (ANOSIM: R = 0.0, P = 0.44).

Rather than plot these results, we determined the top ten most abundant species for each habitat type for the early and late years (Tables 6 and 7). In PJ habitat, two of the top ten from early years, Mourning Dove and Gray Flycatcher, are absent in the late years. They were replaced by the Chipping Sparrow and Cassin's Kingbird. Additionally, bird abundances went up in later years. Although species turnover is happening, the top ten for both early and late years are equally represented by granivores and insectivores and the replacements were of the same feeding guild. In ponderosa habitat, only one of the top ten from early years, the Virginia's

Warbler, is absent in late years. It was replaced by the Chipping Sparrow. Again, the granivores and insectivores are well represented in the top ten list for early and late years.

Table 6. The top ten bird species in abundance in PJ habitat for early (2013 and 2014) and late (2016 and 2017) years

PJ Habitat Early		PJ Habitat Late	
Species	Number seen	**Species**	Number seen
House Finch	194	House Finch	247
Mourning Dove	130	Spotted Towhee	175
Ash-throated Flycatcher	109	Chipping Sparrow	143
Spotted Towhee	95	Ash-throated Flycatcher	107
Juniper Titmouse	68	Lesser Goldfinch	102
Western Bluebird	62	Juniper Titmouse	93
Bewick's Wren	62	Western Bluebird	93
Gray Flycatcher	59	Bewick's Wren	89
Lesser Goldfinch	57	Cassin's Kingbird	78
Woodhouse's Scrub-Jay	51	Woodhouse's Scrub-Jay	76

Table 7. The top ten bird species in abundance in ponderosa habitat for early (2013 and 2014) and late (2016 and 2017) years

Ponderosa Habitat Early		Ponderosa Habitat Late	
Species	Number seen	**Species**	Number seen
Western Bluebird	127	Pygmy Nuthatch	269
Pygmy Nuthatch	111	Western Bluebird	234
Western Wood-Pewee	99	House Finch	157
House Finch	94	Pine Siskin	145
Virginia's Warbler	77	Western Wood-Pewee	132
Plumbeous Vireo	72	Chipping Sparrow	128
Pine Siskin	71	Spotted Towhee	115
Spotted Towhee	65	Violet-green Swallow	91
Broad-tailed Hummingbird	65	Plumbeous Vireo	86
Violet-green Swallow	51	Broad-tailed Hummingbird	77

Species in a community align themselves in ways similar to those described by MacArthur and Wilson (1967) in *The Theory of Island Biogeography*. It hypothesized how distance and area could combine to regulate the balance between immigration and extinction in an island population. Immigration is the appearance of a new species in a community, while extinction is the disappearance of a species from a community. This relationship is known as species turnover. This concept of species turnover is what is driving the changes in composition over time. More study is needed to better understand these patterns and to determine the mechanism for species

turnover in these areas. For example, are the changes in species composition normal fluctuations that occur every few years or are we actually seeing permanent loss and gain of species? This and similar questions can be answered by continuing to monitor these sites and to analyze bird community data in other areas on the Pajarito Plateau.

Nestboxes

During the 2017 nesting season, 15 nestboxes at each of the treatment sites were actively monitored. The overall avian nestbox network without the three treatment sites contained 475 nestboxes in 2017. Of those, 226 contained active nests and 129 of those nests fledged young successfully. This was an overall occupancy rate of 48% with a 57% success rate.

At Minie, seven nests were found and two of the nests fledged young successfully. This was an occupancy rate of 46% with a 29% success rate.

At TA-39, three nests were found and none were successful. This was an occupancy rate of 20% with a 0% success rate. These are lower than the overall avian nestbox network; however, when compared with nestboxes within the greater Ancho Canyon area, the numbers are similar.

At TA-16, 17 nests were found and 13 of the nests fledged young successfully. Some of the nestboxes had double clutches, which is why the number of nests is higher than the number of nestboxes. This was an occupancy rate of 100% with a 76% success rate.

The occupancy rates at Minie and TA-16 were similar and greater than the results in the overall network. Yet, the nest success rates at Minie dropped well below the average of the rest of the network. This was largely due to an increase in predation of nests in this area.

In 2017, nonviable eggs and tissue samples from nestlings that died before fledging were submitted to an analytical lab for chemical analysis. Gaukler (2017) explained that eggs collected from all locations contained significantly higher concentrations of copper when compared with background concentrations from samples on nearby public lands. Macronutrients magnesium, potassium, and sodium were also higher compared with background eggs. Eggs collected from TA-16 also contained significantly higher concentrations of barium, mercury, and selenium. Nestlings collected from Minie, TA-39, and TA-16 contained detectable concentrations of some dioxin and furan congeners and also exceeded regional statistical reference levels (RSRLs). Polychlorinated biphenyls were detected in nestlings, although all concentrations were below RSRLs. Lastly, 2,3,7,8-tetrachlorodibenzodioxin toxic equivalents were calculated. Although there were significant differences, most chemical concentrations were below RSRLs, lowest observable adverse effect levels, and biota dose screening levels and were therefore not of ecological concern. As these data were preliminary, more samples are needed to make a robust assessment, including additional background samples.

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 59 species detected at the three treatment sites, all are protected under the Migratory Bird Treaty Act. Additionally, two of the species detected at the three treatment sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three treatment sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three treatment sites, contribute to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2017

Species	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
	TA-36 Minie Site					TA-39 Point 6					TA-16 Burn Grounds				
	Pinyon-Juniper Woodland					Pinyon-Juniper Woodland					Ponderosa Pine Forest				
Acorn Woodpecker											5		3	2	3
American Crow															1
American Kestrel				1		1			2						
American Robin	1	1	2		2	1	1		2		7		9	4	4
Ash-throated Flycatcher	11	5	14	13	13	19	11	29	12	8	3	5	6	2	3
Audubon's Warbler		2							2		6	5	1	6	
Bewick's Wren	4	8	9	9	14	3	10	15	9	2					
Black-chinned Hummingbird		1	1			3	2				1		1		1
Black-headed Grosbeak	1	3					2	4	1				1	2	
Black-throated Gray Warbler			1		2	5	6	4							
Blue-gray Gnatcatcher	3	14	16	8	10	2		7	5	4		6	2	1	3
Broad-tailed Hummingbird	2	1	3		1	3	1	2		3	5	11	11	5	7
Brown Creeper											1				
Brown-headed Cowbird	1							2			4	1			4
Bushtit		2		2		2	14			1					
Canada Goose								16							
Canyon Towhee	2		5	3	6	1	1	2	10	13	1			1	
Canyon Wren					1			2	3	8			2		
Cassin's Kingbird	6	13	13	5	2	7	6	2	21	21				1	
Chipping Sparrow	3	16	17	29	6	6	6	5	8	15	1	5	3	10	5
Clark's Nutcracker												4		1	

Species	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
	TA-36 Minie Site					TA-39 Point 6					TA-16 Burn Grounds				
	Pinyon-Juniper Woodland					Pinyon-Juniper Woodland					Ponderosa Pine Forest				
Common Nighthawk	6		5	2	4	5	1	3	2	7			1	2	2
Common Raven	2	5	1		1	1		2	1		5	6	2	2	5
Cooper's Hawk					1						1			1	
Cordilleran Flycatcher											5	10	6	3	3
Dark-eyed Junco											6	2	4		5
Downy Woodpecker				1					1	2		1		1	1
Dusky Flycatcher				1				1		1					
Eurasian Collared-Dove	3									4					
Evening Grosbeak	3		4					8			5		29		
Grace's Warbler											6	4	4	8	5
Gray Flycatcher	12	6	5	7	3	10	10	11	10	5					
Great Horned Owl		3				1									
Green-tailed Towhee	3	1				1									
Hairy Woodpecker			2	1				5	3		1	1		1	1
Hammond's Flycatcher											8	9	12	5	7
Hepatic Tanager								1	2	1				1	
Hermit Thrush												4	6	1	2
House Finch	16	17	26	17	12	21	4	23	9	30	16	2	5	5	12
House Wren											1	1		2	2
Juniper Titmouse	12		7	6	9	11	13	18	6	1					
Lesser Goldfinch	2	6	7	4	9	4	12	9	10	14	3		8	9	4
MacGillivray's Warbler														1	3
Mountain Bluebird		2	20	10	11		4						4	4	4
Mountain Chickadee	5	2	1	2					1	1	5	8	9	6	8
Mourning Dove	17	17	13	5	8	13	22	10	3	15	4		1	3	17

Species	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
	TA-36 Minie Site					TA-39 Point 6					TA-16 Burn Grounds				
	Pinyon-Juniper Woodland					Pinyon-Juniper Woodland					Ponderosa Pine Forest				
Northern Mockingbird					2		1								
Peregrine Falcon								1							
Pine Siskin	10	2		5	1	6		3	3		12	4	5		4
Plumbeous Vireo	10	10	7	3	9	1		1	6	6	11	16	15	14	11
Pygmy Nuthatch				2				2	4	12	11	13	26	29	41
Red Crossbill					1		2					2	9	13	9
Red-shafted Flicker	3	1	3	2	5	3	2	4	8		3	4	11	11	5
Red-tailed Hawk								1	1	1					
Rock Wren	3	3	4		2	7	10	4	12	14	1	2	2	6	
Say's Phoebe	2	1	2		2	2	1		5	2	1		1	3	3
Scaled Quail			1												
Spotted Towhee	17	8	19	27	32	12	6	33	16	12	11	18	16	14	21
Steller's Jay											3	2	5	6	3
Townsend's Solitaire	1														1
Turkey Vulture					1						1				
Violet-green Swallow		5	7	1	3	6	4	1	9	6		2	19	2	2
Virginia's Warbler					1			1	2	4	17	11	21	13	7
Warbling Vireo											2	9	7	6	5
Western Bluebird	15	11	18	17	16	5	19	12	21	13	20	20	49	37	32
Western Tanager		2	3		1		2	1	1	2	2	3	7	2	4
Western Wood-Pewee	10	8	18	11	10		4	2	10	8	15	10	16	14	22
White-breasted Nuthatch	1	4	9	10	13			2	4	4	9	8	7	9	20
White-throated Swift							1								
White-winged Dove	1	5	9	2		7	5	6	16	15			1	2	
Woodhouse's Scrub-Jay	5	1	3	4	8	8	10	4	8	6	1				

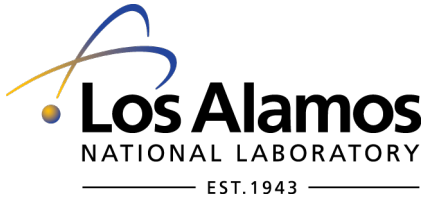
Revised Supplement 4-1
Alt Tech Evaluation
Attachment 10 – Hathcock *et al.* 2019

Environmental Report:

Hathcock, C.D., *et al.* May 2019. *2018 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory*. LA-UR-19-24156.

May 2019

2018 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory



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Executive Summary

Los Alamos National Laboratory biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts were compared among years to monitor trends. The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Additionally, nesting success of secondary-cavity nesting birds was examined using nestboxes. LANL biologists completed the sixth year of this effort in 2018. The overall results from 2018 continue to indicate that operations are not negatively affecting bird populations; however, we are seeing some species turnover through time and that will continue to be monitored.

Three bird point count surveys were completed at each of the treatment sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2018. A total of 842 birds representing 58 species were recorded at the three treatment sites. Three bird point count surveys were also completed at each of the control sites between May and July 2018. Occupancy and nest success data from nestboxes at treatment sites were compared with the overall avian nestbox monitoring network.

Species richness at the treatment sites was not statistically different from their associated controls; however, species diversity was. In all three cases, the diversity was higher at the treatment sites than at the control sites. Avian abundance showed more variability but treatment and controls were trending together year to year. Species composition seems to indicate some species turnover in the habitat types but very little difference between treatment and control sites.

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Introduction

An annual avian monitoring program was started in 2013 as part of the Resource Conservation and Recovery Act permitting process at Los Alamos National Laboratory (LANL) for two open detonation sites, Technical Area (TA) 36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014 & 2015; Hathcock et al. 2017 & 2018). The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Comparisons were made with control sites of similar habitat that have been surveyed since 2011 (Hathcock et al. 2011).

Biologists at LANL used standard point count methodology to record avian abundance and diversity along transects at the three treatment sites and associated control sites during the summer of 2018. Summer surveys provide information about what birds were breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental change at LANL.

In addition to avian point counts, nestboxes were monitored around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success data were compared with the overall avian nestbox monitoring network, which was established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon-juniper woodland (PJ) for Minie and TA-39 and a ponderosa pine forest (PIPO) at TA-16. These habitat descriptions were based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) were monitored annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock et al. (2011). Each habitat type control contained two replicate transects that were monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects were randomized and surveyed according to the random order.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar

in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was more natural.

Transects were approximately 2.0 to 2.5 km in length and allowed for nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site and surveys must be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an "unlimited-distance circular plot"; however, the distance to each bird out to 100 m should be noted. Ensure individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, note any species encountered that have not otherwise been counted from a previous point or future point. The surveyor's main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Record all birds encountered on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- Use the "NOTES" section to indicate any potentially important aspects of the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Other wildlife or evidence of wildlife that could be used for other projects should be recorded.

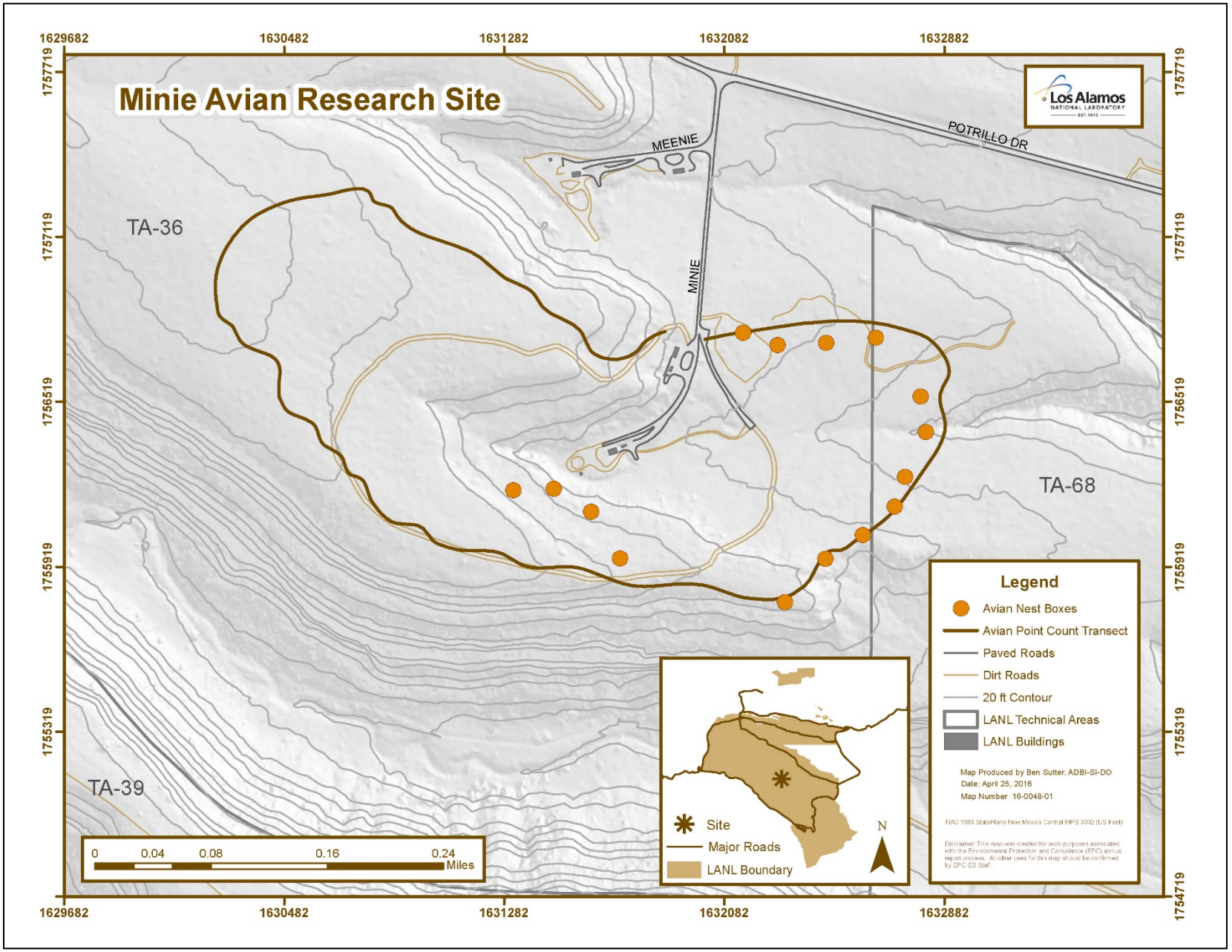

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site

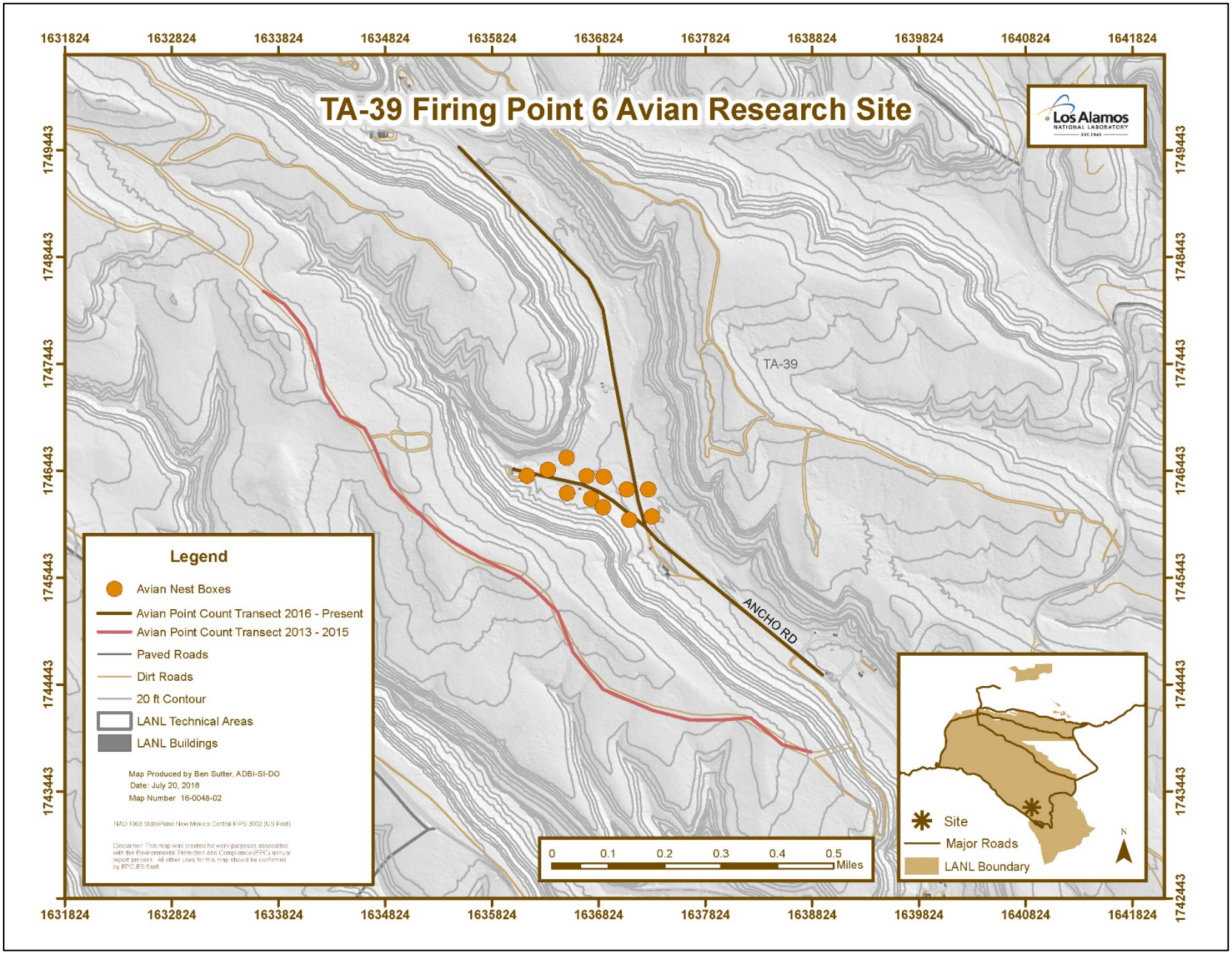

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6

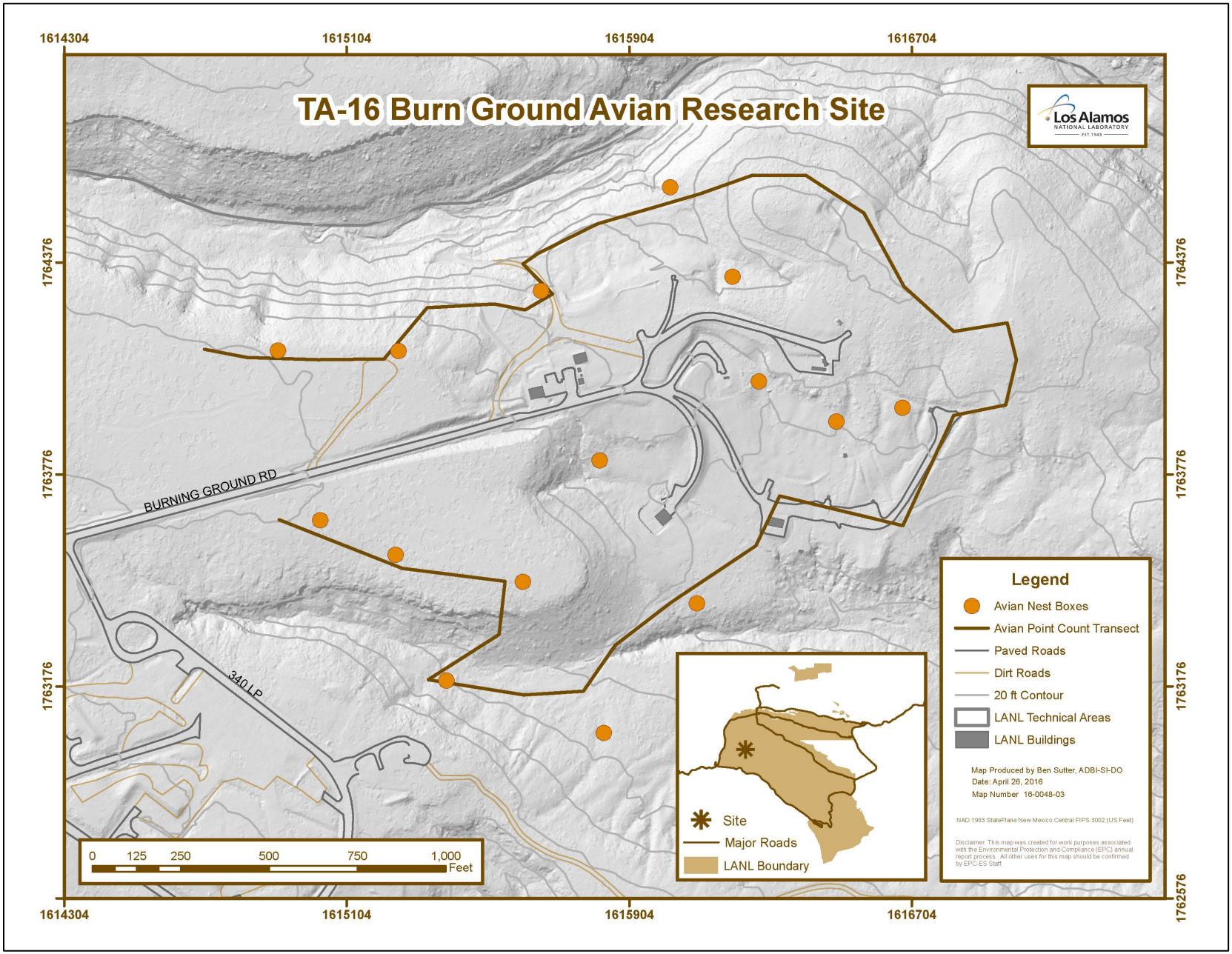

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground

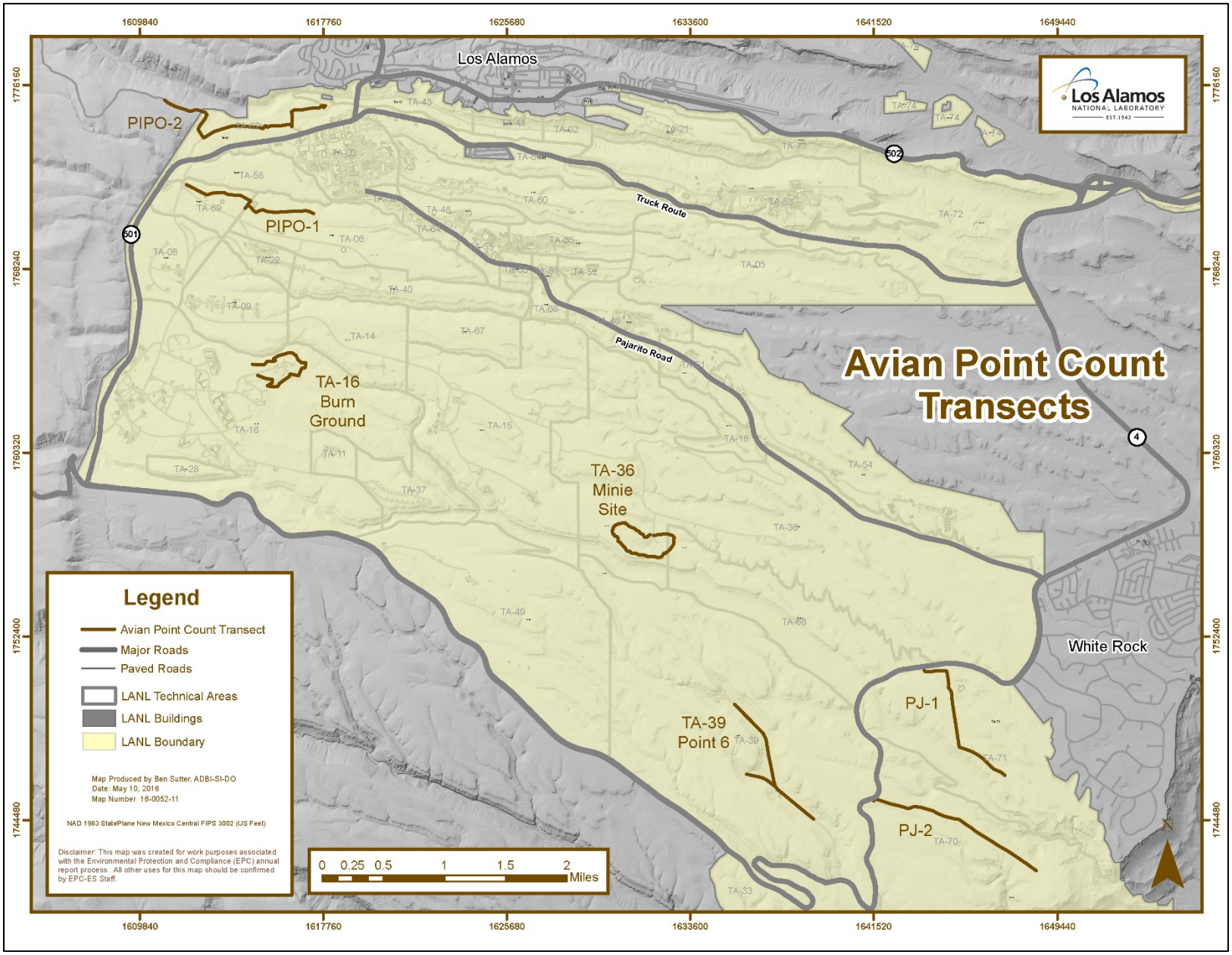

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie and TA-39 (Figures 1 and 2). In 2015, nestboxes were added to TA-16 (Figure 3). Nestboxes were monitored every 1 to 2 weeks for active nests. When an active nest was found, it was monitored more frequently to determine whether the nest failed or successfully fledged young. Nestlings were also banded and the sex determined after the age of 10 days.

Statistical Methods for Point Counts

The data were summarized to compare species richness, diversity, abundance, and composition between sites and among years using the statistical software R (version 3.4.1; R Core Team 2017). Species richness and diversity were computed using the R-package 'iNEXT' (Hsieh et al. 2016; Chao et al. 2014) and plotted with bootstrap confidence intervals around the mean for rarefied/extrapolated samples, facilitating the comparisons of richness and diversity. The estimated asymptote along with a confidence interval were also provided. The Simpson's diversity index was calculated using the following formula: $D = 1 - (\sum n(n-1) / N(N-1))$, where n = the total number of organisms of a particular species and N = the total number of organisms of all species. The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0 represents no diversity. Species diversity was also computed using the statistical software PAST (Hammer et al. 2001) and a t-test was used to test for differences between treatment and control sites each year. Comparisons of Simpson diversity in two samples are described by Hutcheson (1970) and is an alternative to the permutation test. To examine species composition, non-metric multidimensional scaling (NMDS) was used to determine dissimilarity among sites. To compare species composition between treatments and years, an analysis of similarity (ANOSIM) was conducted using 1000 permutations. These analyses were completed using the community ecology R-package 'vegan' (Oksanen et al. 2017).

Statistical Methods for Nestboxes

Occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network were calculated. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. Annually, data from the three treatment sites were compared with the overall avian nestbox network at LANL that was established in 1997.

In 2019 a nest survival model (Dinsmore et al. 2002) in Program MARK was generated to estimate nest survival (S) for Western Bluebirds during a 22-year period (1997-2018). The nesting period spanned 21 April to 16 August (118 days) across all years of the study. Data for each nest were subdivided into the incubation and nestling periods and formatted as groups for analyses in Program MARK (Dinsmore and Dinsmore 2007). There was also an interest in survival estimates for the three treatment sites. Because there were not enough data to fit models

specific to each site, a simple constant survival model was used, by nest stage. These estimates are presented for planning purposes only and are not meant to be directly comparable to estimates generated from the entire dataset (Unpublished data 2019).

Results and Discussion

Year 2018

Three surveys were completed at each of the three treatment sites and the associated control sites between May and July 2018. A total of 842 birds representing 58 species were recorded at the three treatment sites. A full account of the 2013–2018 data is detailed in Appendix 1.

Species richness is the number of different species represented in an ecological community and is simply a count of species. In this case, each treatment site and control are individual communities. Species diversity is a measure that takes into account the species richness and the overall abundance to compare evenness across a community. Here we used the Simpson's diversity index, which measures the probability that two individuals randomly selected from a sample will belong to different species. The abundance is the total number recorded of a given species. Table 1 details the species richness, diversity, and abundance for 2018 for each treatment site.

Table 1. The species richness, diversity, and abundance recorded at each site in 2018

2018	*Minie Site*	*TA-39*	*TA-16*
Richness	35	39	43
Diversity	0.9494	0.9405	0.9541
Abundance	242	315	285

To further analyze species richness and diversity, species rarefaction and extrapolation plots were developed with the control sites being combined. Species rarefaction and extrapolation from 2018 show no differences between treatment and control sites for species richness. There were overlapping 95% confidence intervals for species richness (Figures 5A–6A) for all three treatments and their controls. Simpson's diversity (Figures 5B–6B) was significantly different since the 95% confidence intervals did not overlap. In these cases, the treatment sites were higher in diversity than the controls.

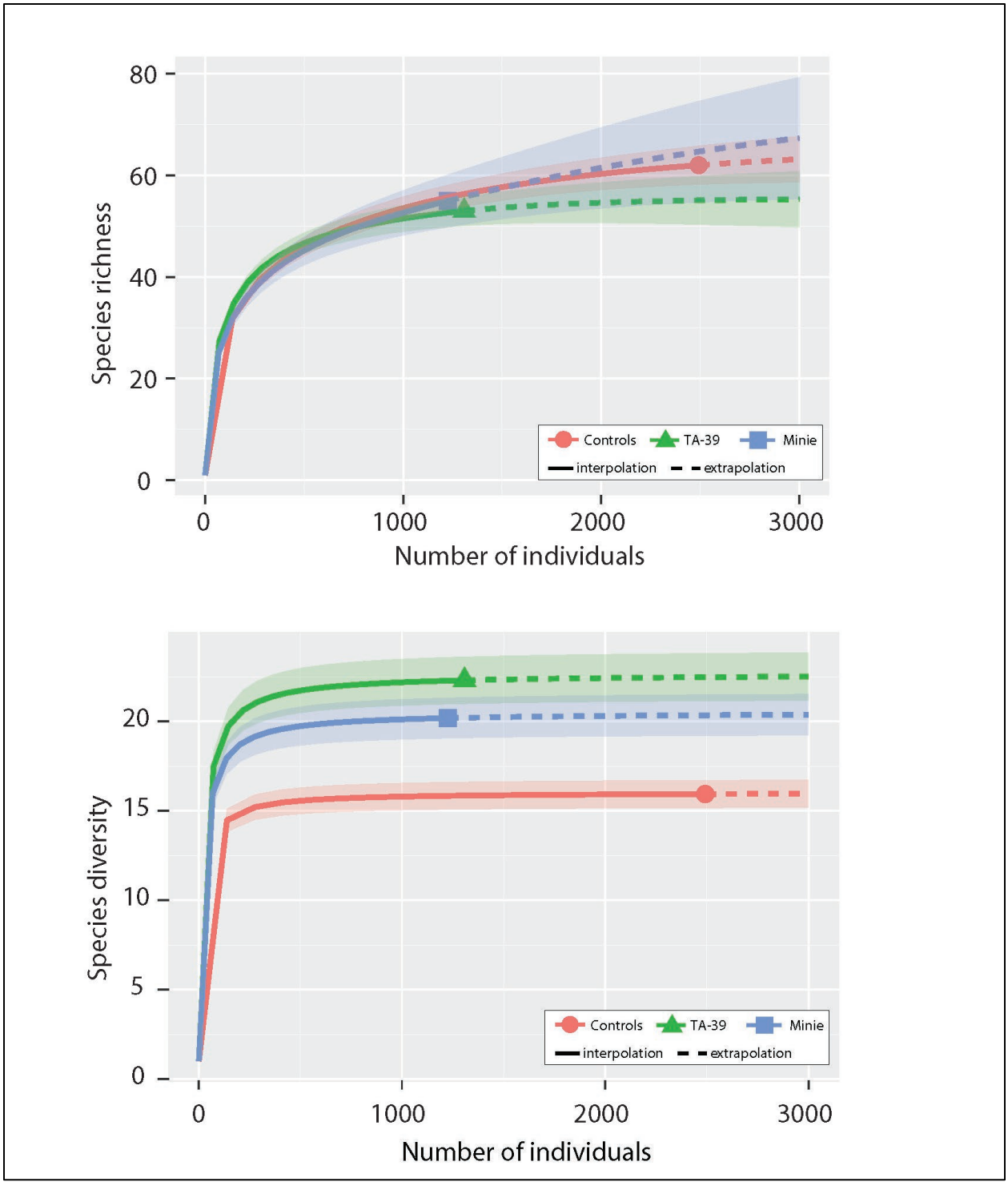

Figure 5. Species rarefaction and extrapolation for species richness and diversity comparing Minie and TA-39 with the PJ controls

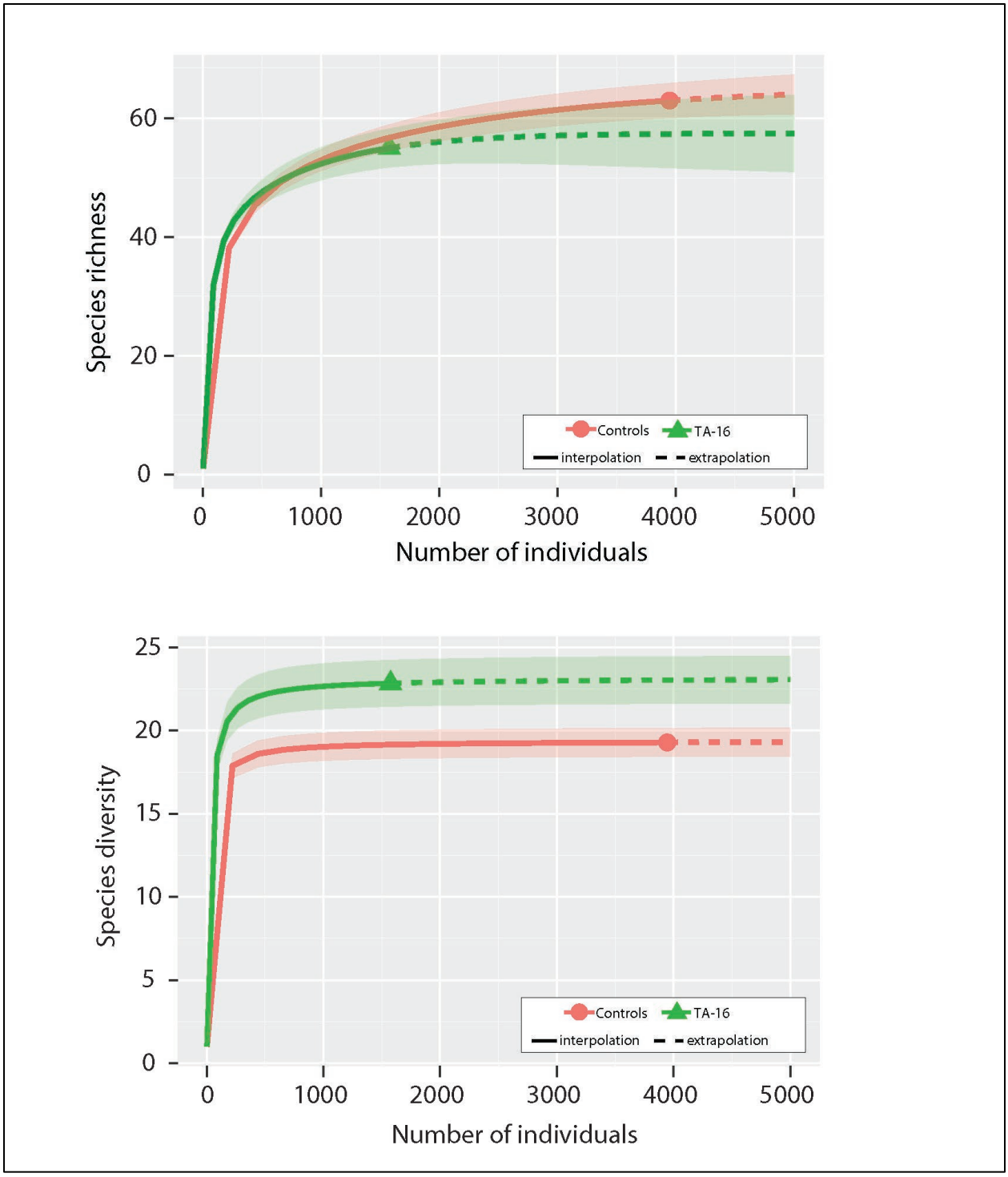

Figure 6. Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls

Multivariate analysis with ordination was used to explore the data further to look for patterns that may be explained by a multitude of other environmental factors not assessed directly. We used non-metric multidimensional scaling (NMDS) (Gardener 2014). NMDS is a method used to

collapse data from multiple dimensions–such as several communities in different sites–into just a few dimensions. A measure of 'stress' (mismatch between the rank order of distances in the actual data, and the rank order of distances in the ordination) is calculated according to the number of dimensions (k). Lower stress values (typically < 0.1) mean greater conformity of the ordinated distances to the actual multivariate distances. Using this method, the samples are moved slightly in a direction that decreases the stress until stress reaches a minimum. More dimensions can be added when high stress is produced from too few dimensions. The final configuration of points for 2018 is represented in Figure 7 where the treatments and controls are plotted (k = 3, stress = 0.002). The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated habitat types. Here, the PJ sites are grouped on the left and PIPO sites on the right. In the plot it is clear that the PJ-2 control transect is slightly different that the other control and the two treatments. The species that seem to be driving the PJ-2 control are the Black-throated Gray Warbler, American Kestrel, Black-chinned Hummingbird, and Juniper Titmouse. There must be some subtle habitat differences between the two controls for PJ. The PIPO controls and treatment site are more closely aligned with one another. In 2018, even with some variation, the treatments were not statistically different than the controls overall (ANOSIM: R = -0.15, P = 0.67) and the two habitat types were different as one would expect (ANOSIM: R = 0.96, P = 0.037).

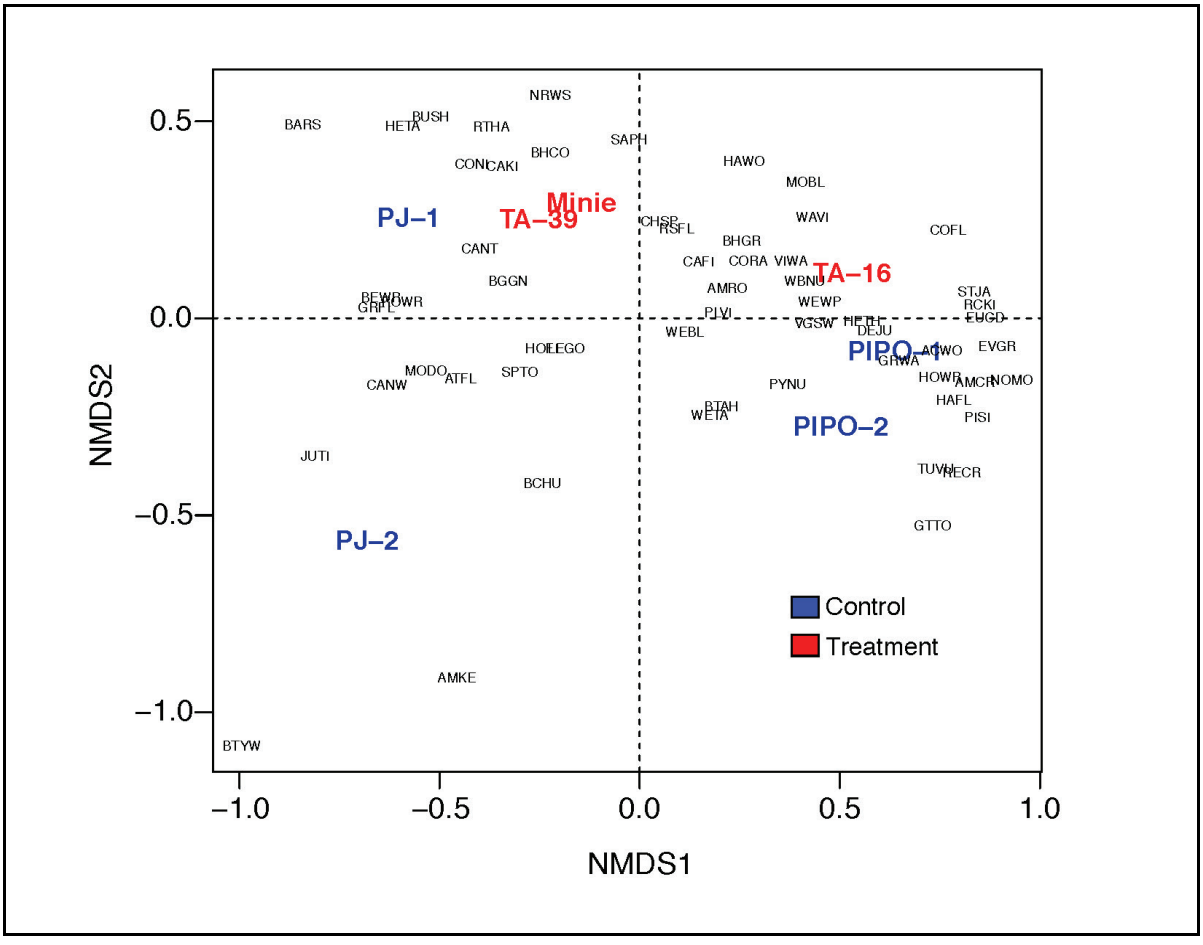

Figure 7. Non-metric multidimensional scaling of bird species and sites in 2018

Trends Over Time

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for a migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The fluctuations in bird abundances are not alarming, and the differences between the treatment sites and control sites are not biologically significant. The winter moisture for the winter of 2018-2019 was at or slightly above normal (personal communication B. Parmenter) so it will be interesting to see what the effects will be to bird numbers in 2019.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
Minie	33	33	34	30	35	35
TA-39	31	31	39	38	34	39
PJ Control 1	29	30	33	36	37	30
PJ Control 2	30	29	37	33	39	23
TA-16	33	33	40	44	41	43
PIPO Control 1	34	34	30	41	41	37
PIPO Control 2	33	36	43	43	44	40

Tables 3–5 compare the species diversity over time between the treatment site and the combined control. The two control sites were combined to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of the study. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is greater than 0.90, which compared with ecological systems in general, is very high.

The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower, but the percent abundance is similar year to year when compared with the control sites. Darker shading indicates a significant difference.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
Minie	0.9464	0.9463	0.9502	0.9315	0.9429	0.9494
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419	0.9255
t-test	t = 3.9572 df = 501.3 p = <0.01	t = 2.5469 df = 510.42 p = 0.01	t = 1.5902 df = 644.91 p = 0.11	t = 0.4385 df = 499.33 p = 0.66	t = 0.1504 df = 448.66 p = 0.88	t = 3.577 df = 644.09 p < 0.01

Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
TA-39	0.9425	0.9427	0.9396	0.9559	0.9486	0.9405
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419	0.9255
t-test	t = 3.3636 df = 538 p <0.01	t = 1.9703 df = 509.25 p = 0.05	t = -0.6751 df = 401.58 p = 0.50	t = 4.5611 df = 783.86 p <0.01	t = 1.2234 df = 705.5 p = 0.22	t = 2.085 df = 717.79 p = 0.03

Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
TA-16	0.9542	0.9509	0.9454	0.9463	0.9429	0.9541
PIPO Control	0.9528	0.9462	0.9414	0.9417	0.9468	0.9431
t-test	t = 0.3323 df = 378.91 p = 0.73	t = 0.9236 df = 472.24 p = 0.35	t = 0.748 df = 633.26 p = 0.45	t = 0.7438 df = 475.6 p = 0.45	t = -0.6903 df = 444.95 p = 0.49	t = 2.52 df = 570.39 p = 0.01

Species composition was analyzed over time according to whether sites were controls or treatments for PJ sites and ponderosa sites separately (Figures 8 and 9 respectively). Figure 8 shows the species composition for PJ sites for each year (k = 4, stress = 0.09). Four dimensions were used to decrease the stress and get a better representation of the data. As expected, the difference in species composition was significant between treatment sites and control sites for PJ habitats (ANOSIM: R = 0.64, P = 0.001). In the figure, the species closest to each site were the species most important in separating those sites from the rest. An early versus late analysis was done where the years 2013 – 2015 were compared to 2016 – 2018. The differences in species composition was not significantly different (ANOSIM: R = 0.108, P = 0.11).

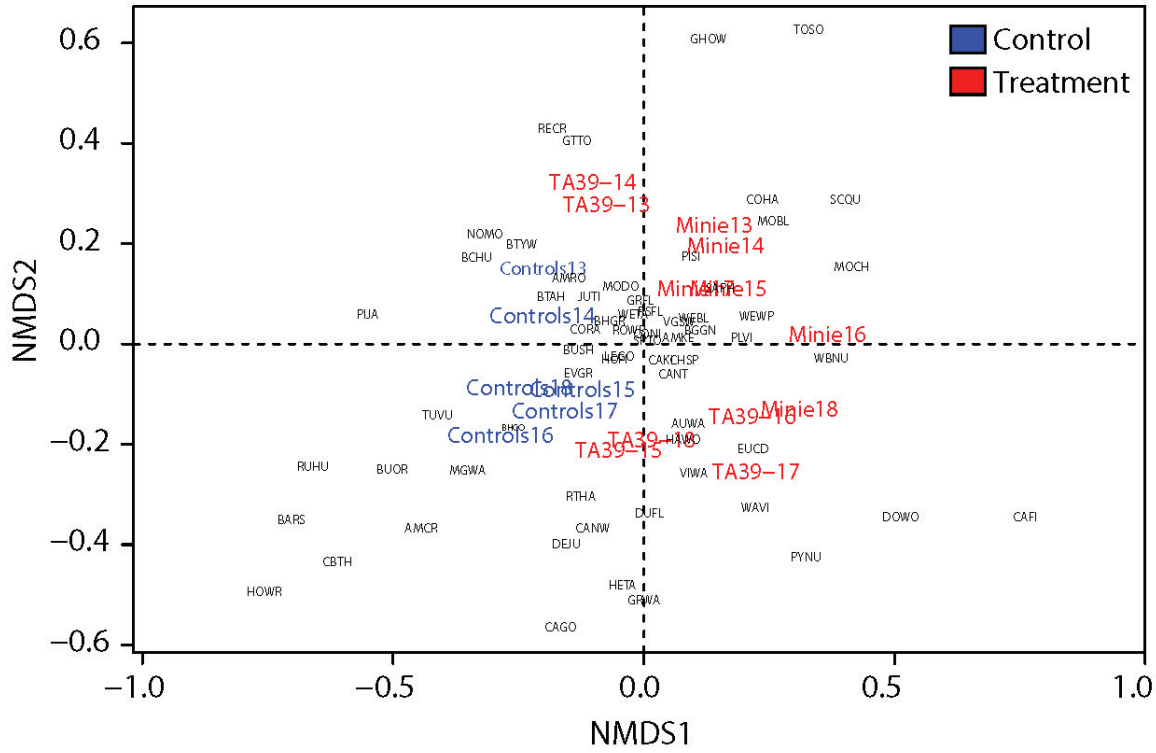

Figure 8. Non-metric multidimensional scaling of bird species from 2013 to 2018 by treatment for PJ sites

Species composition over time for ponderosa sites are shown in Figure 9 (k = 3, stress = 0.06). As expected, the difference in species composition was significant between treatment sites and control sites for ponderosa habitats (ANOSIM: R = 0.88, P = 0.003). The species closest to each site were the species most important in separating those sites from the rest. An early versus late analysis was done where the years 2013 – 2015 were compared to 2016 – 2018. The differences in species composition was not significantly different (ANOSIM: R = -0.026, P = 0.46).

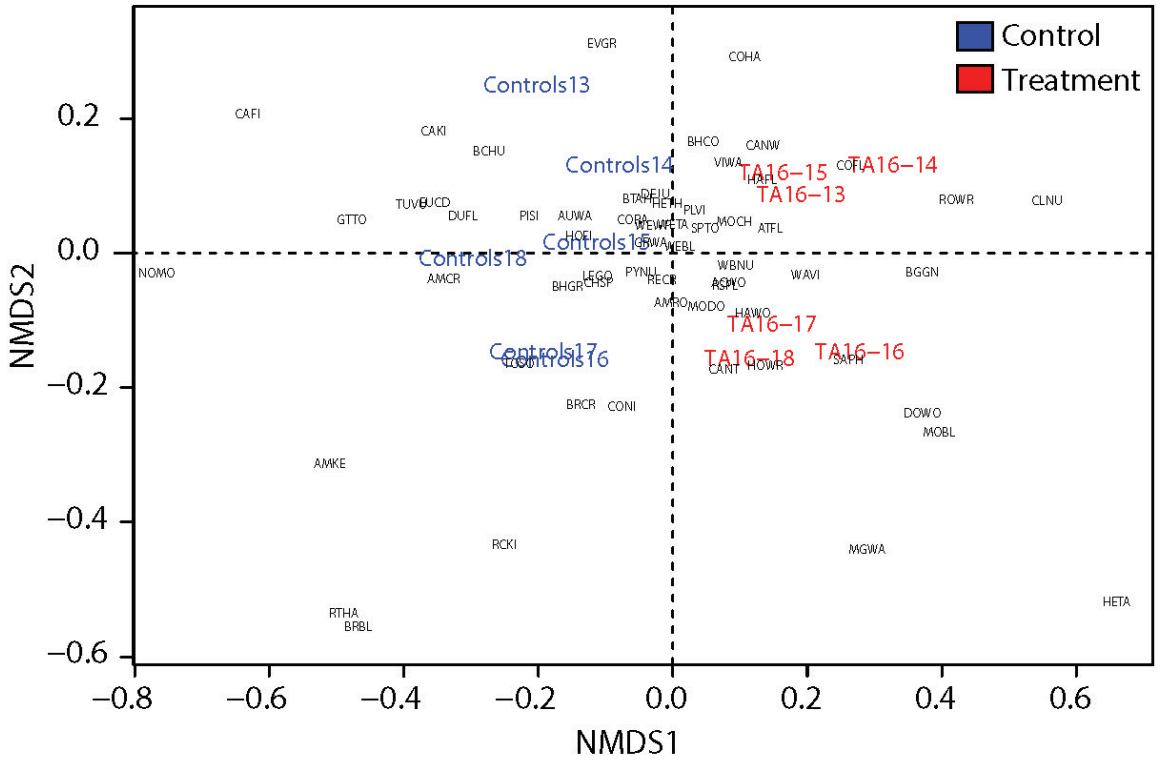

Figure 9. Non-metric multidimensional scaling of bird species from 2013 to 2018 by treatment for ponderosa sites

Collectively, Figures 8 and 9 suggest that the control sites have slightly different species composition than treatment sites over the course of the study.

Species in a community align themselves in ways similar to those described by MacArthur and Wilson (1967) in *The Theory of Island Biogeography*, which hypothesized how distance and area could combine to regulate the balance between immigration and extinction in an island population. Immigration is the appearance of a new species in a community, while extinction is the disappearance of a species from a community. This relationship is known as species turnover. The concept of species turnover is what drives the changes in composition over time.

More study is needed to better understand these patterns and to determine the mechanism for species turnover in these areas. The subtle changes in composition over time may be normal fluctuations, but if the gap widens then it may be indicative of a larger process at work. This and similar questions can be answered by continuing to monitor these sites and to analyze bird community data in other areas on the Pajarito Plateau.

Nestboxes

During the 2018 season, the overall avian nestbox network was managed at lower levels than previously. The treatment sites were maintained at previous years' effort, but site-specific constraints from increased fire restrictions in 2018 limited the overall network management.

During the 2018 nesting season, 15 nestboxes each at Minie, Burn Grounds, and TA-39 were actively monitored. The overall avian nestbox network, without the three treatment sites, only contained 177 nestboxes in 2018. Of those, 94 contained active nests and 46 of those nests fledged young successfully. This was an overall occupancy rate of 53% with a 49% success rate.

Tables 6 and 7 compare the occupancy and success rates for each treatment site and the overall nestbox network since 2015.

Table 6. Comparison of occupancy for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*
Overall Network	40%	45%	48%	53%
Minie	66%	73%	46%	20%
TA-39	8%	58%	20%	33%
TA-16	-	73%	100%	53%

Table 7. Comparison of success for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*
Overall Network	66%	69%	57%	49%
Minie	64%	23%	29%	33%
TA-39	100%	57%	0%	40%
TA-16	-	63%	76%	63%

In 2018 there were three successful nests that fledged young at Minie, five at TA-39, and eight at TA-16. The occupancy rate at Minie is lower and stands out in comparison to previous years.

Precipitation was low, possibly contributing to reduced nesting attempts and lower box occupancy rates. Success rates at the three treatment sites were not very different in comparison to the overall network and did not display decrease over time.

In 2018, nonviable eggs collected from nestboxes at Minie, TA-16, and TA-39 were submitted to an analytical lab for chemical analyses. Eggs collected from two of the firing sites (Minie and TA-39) contained higher concentrations of copper when compared with background concentrations from samples on nearby public lands. The source of elevated copper found in two western bluebird egg samples collected near the firing sites could be from some high-explosives testing; copper has historically been detected above soil screening levels at Technical Area 39 (Juarez and Vigil-holterman 2011). Yet, copper soil levels at Minie, near the firing site were below the regional statistical reference level (RSRL) in 2018. However, it has been suggested that birds are relatively resistant to copper toxicity when compared with other taxa (Eisler 1998). Although magnesium, potassium, and sodium concentrations were higher compared with background egg concentrations, these elements are macronutrients which are required by living organisms in large quantities. Eggs collected from TA-16 contained higher concentrations of antimony, mercury, and selenium and exceeded regional RSRLs, but were all below the known lowest observable adverse effects levels (LOAELs). Eggs collected from TA-39 contained higher concentrations of mercury and selenium compared to the RSRLs, but were below the LOAEL. Most chemical concentrations that were detected at all of the sites were below RSRLs and all were below the LOAELs. These data suggest that egg element concentrations observed here are not of ecological concern. As these data are preliminary, more samples are needed to make a robust assessment, including additional background samples.

Nest survival estimates for the three treatment sites for the incubation and nestling periods of the Western Bluebird are in figures 10 and 11. Nest survival is comprised of two phases for this analysis, the incubation phase and the nestling phase. Due to low sample sizes for this type of analysis, confidence intervals are large and these results should be considered only for possible pattern analyses. During incubation, survival at Burn Grounds and TA-39 Point 6 did not differ from all other sites while survival at Minie Site was lower than that at all other sites pooled (Figure 10). During the nestling period survival at the three sites did not differ from that at all other sites pooled together (Figure 11).

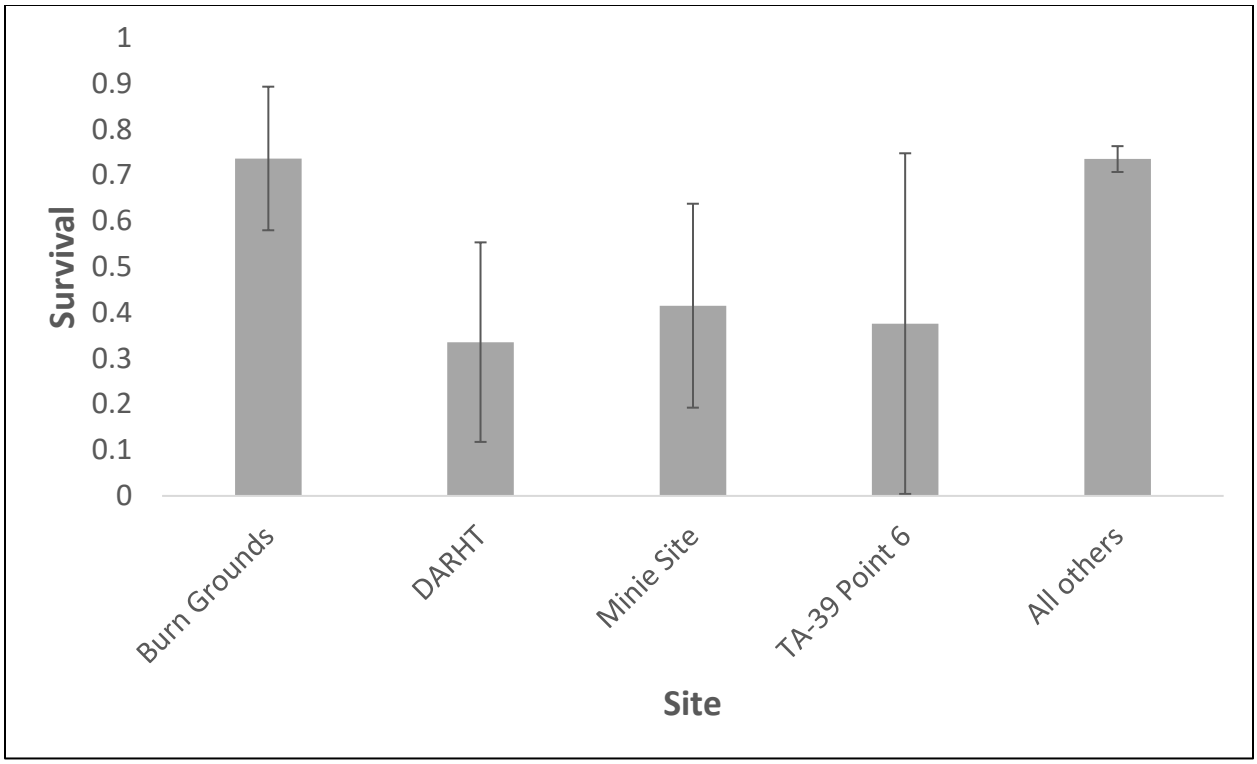

Figure 10. Estimated probability of surviving the 14-day incubation period for Western Bluebird nests at selected sites. Estimates (±95% CI) were generated using a constant survival model with no covariates.

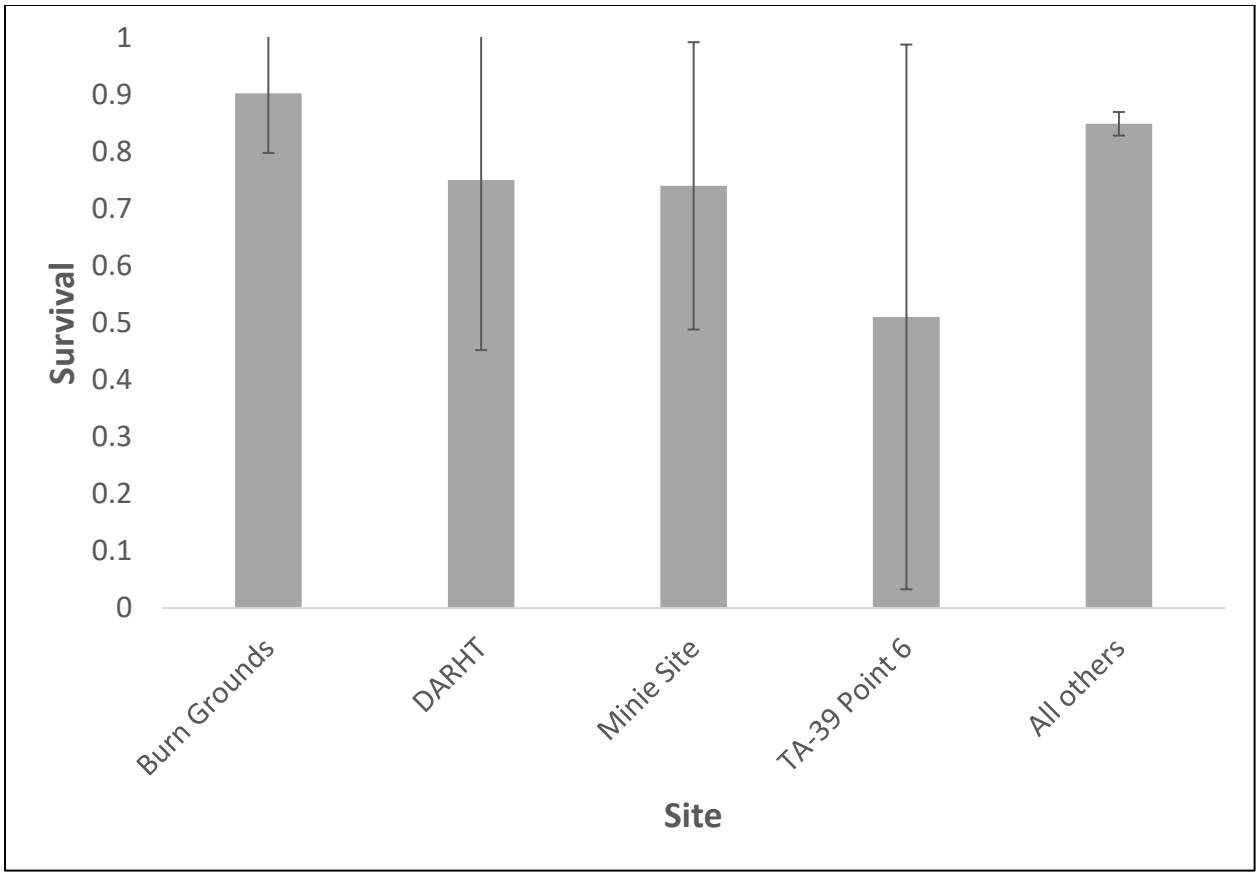

Figure 11. Estimated probability of surviving the 18-day nestling period for Western Bluebird nests at selected sites. Estimates (±95% CI) were generated using a constant survival model with no covariates.

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 59 species detected at the three treatment sites, all are protected under the Migratory Bird Treaty Act. Additionally, two of the species detected at the three treatment sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three treatment sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three treatment sites, contribute to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and allow LANL to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2018

Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Acorn Woodpecker													5		3	2	3	5
American Crow																	1	1
American Kestrel				1			1			2								
American Robin	1	1	2		2		1	1		2		4	7		9	4	4	6
Ash-throated Flycatcher	11	5	14	13	13	10	19	11	29	12	8	8	3	5	6	2	3	8
Audubon's Warbler		2				5				2			6	5	1	6		1
Bewick's Wren	4	8	9	9	14	14	3	10	15	9	2	8						
Black-chinned Hummingbird		1	1				3	2				1	1		1		1	
Black-headed Grosbeak	1	3				1		2	4	1		3			1	2		2
Black-throated Gray Warbler			1		2		5	6	4									
Blue-gray Gnatcatcher	3	14	16	8	10	9	2		7	5	4	2		6	2	1	3	6
Broad-tailed Hummingbird	2	1	3		1		3	1	2		3	1	5	11	11	5	7	10
Brown Creeper													1					
Brown-headed Cowbird	1								2			3	4	1			4	2
Bushtit		2		2		11	2	14			1	12						
Canada Goose									16									
Canyon Towhee	2		5	3	6	2	1	1	2	10	13	19	1			1		1
Canyon Wren					1				2	3	8	6			2			
Cassin's Finch						4												
Cassin's Kingbird	6	13	13	5	2	5	7	6	2	21	21	32				1		

	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
Chipping Sparrow	3	16	17	29	6	22	6	6	5	8	15	25	1	5	3	10	5	21
Clark's Nutcracker														4		1		
Common Nighthawk	6		5	2	4	4	5	1	3	2	7	5			1	2	2	
Common Raven	2	5	1		1	2	1		2	1		1	5	6	2	2	5	5
Cooper's Hawk					1								1			1		
Cordilleran Flycatcher													5	10	6	3	3	1
Dark-eyed Junco												1	6	2	4		5	2
Downy Woodpecker				1						1	2			1		1	1	1
Dusky Flycatcher				1					1		1							
Eurasian Collared-Dove	3										4							1
Evening Grosbeak	3		4						8				5		29			1
Grace's Warbler												2	6	4	4	8	5	8
Gray Flycatcher	12	6	5	7	3	6	10	10	11	10	5	8						
Great Horned Owl		3					1											
Green-tailed Towhee	3	1					1											
Hairy Woodpecker			2	1		1			5	3			1	1		1	1	2
Hammond's Flycatcher													8	9	12	5	7	5
Hepatic Tanager									1	2	1	2				1		
Hermit Thrush						1								4	6	1	2	2
House Finch	16	17	26	17	12	18	21	4	23	9	30	44	16	2	5	5	12	7
House Wren													1	1		2	2	6
Juniper Titmouse	12		7	6	9	3	11	13	18	6	1							
Lesser Goldfinch	2	6	7	4	9	12	4	12	9	10	14	19	3		8	9	4	8
MacGillivray's Warbler																1	3	

	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
Mountain Bluebird		2	20	10	11	1		4							4	4	4	7
Mountain Chickadee	5	2	1	2						1	1		5	8	9	6	8	9
Mourning Dove	17	17	13	5	8	8	13	22	10	3	15	11	4		1	3	17	3
Northern Mockingbird					2			1										
Peregrine Falcon									1									
Pine Siskin	10	2		5	1		6		3	3			12	4	5		4	2
Plumbeous Vireo	10	10	7	3	9	9	1		1	6	6	5	11	16	15	14	11	18
Pygmy Nuthatch				2		2			2	4	12	9	11	13	26	29	41	20
Red Crossbill					1			2						2	9	13	9	
Red-shafted Flicker	3	1	3	2	5	2	3	2	4	8		3	3	4	11	11	5	5
Red-tailed Hawk									1	1	1	1						
Rock Wren	3	3	4		2	10	7	10	4	12	14	14	1	2	2	6		
Ruby-crowned Kinglet																		2
Say's Phoebe	2	1	2		2	5	2	1		5	2	4	1		1	3	3	4
Scaled Quail			1															
Spotted Towhee	17	8	19	27	32	24	12	6	33	16	12	16	11	18	16	14	21	22
Steller's Jay													3	2	5	6	3	4
Townsend's Solitaire	1																1	
Turkey Vulture					1								1					1
Violet-green Swallow		5	7	1	3	2	6	4	1	9	6	6		2	19	2	2	4
Virginia's Warbler					1	3			1	2	4		17	11	21	13	7	5
Warbling Vireo						2							2	9	7	6	5	4
Western Bluebird	15	11	18	17	16	19	5	19	12	21	13	6	20	20	49	37	32	27
Western Tanager		2	3		1			2	1	1	2	2	2	3	7	2	4	6

	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
Western Wood-Pewee	10	8	18	11	10	7		4	2	10	8	11	15	10	16	14	22	20
White-breasted Nuthatch	1	4	9	10	13	5			2	4	4	2	9	8	7	9	20	10
White-throated Swift								1										
White-winged Dove	1	5	9	2		3	7	5	6	16	15	15			1	2		
Woodhouse's Scrub-Jay	5	1	3	4	8	7	8	10	4	8	6	4	1					
Northern Rough-winged Swallow						3												

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 11 – Sanchez *et al.* 2020

Environmental Report:

Sanchez, A.A., C.D. Hathcock, and B.E. Thompson, January 2020. *2019 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at the Los Alamos National Laboratory*. LA-UR-20-20436-Rev.01.

January 2020

2019 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

Prepared by: Charles D. Hathcock, Audrey, A. Sanchez, and Brent E. Thompson

Environmental Protection and Compliance Division

Environmental Stewardship Group

Los Alamos National Laboratory

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Executive Summary

Los Alamos National Laboratory biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts were compared among years to monitor trends. The objectives of this study were to 1) determine whether LANL operations impact bird species richness, diversity, or abundance 2) evaluate trends in species abundance by feeding guild, and 3) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. LANL biologists completed the seventh year of this effort in 2019.

Three bird point count surveys were completed at each of the treatment sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2019. A total of 853 birds representing 53 species were recorded at the three treatment sites and compared to their associated controls. Occupancy and nest success data from nestboxes at treatment sites were compared with the overall avian nestbox monitoring network.

In 2019 the species richness and diversity at the treatment sites were not statistically different from their associated controls. Rarefaction and extrapolation plots for all years through 2018 suggest that over time the species diversity was statistically different between treatments and controls, although the diversity was higher at the treatment sites than the control sites. Avian abundance showed more variability but treatment and controls were trending together year to year. The mean number of granivores, insectivores, and omnivores varies from year to year, but there is not a significant trend at any of the treatment sites. The dominant feeding guild at the treatment sites continues to be insectivores.

The overall results from 2019 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations. This long-term monitoring will continue to monitor for any changes over time.

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Introduction

As part of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) started an annual avian monitoring program in 2013. The permit was for two open detonation sites, Technical Area (TA)-36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018). This program supported a study with the objectives to (1) determine whether LANL operations impact bird species richness, diversity, or abundance (2) evaluate species abundance by feeding guilds over time and (3) examine nest success of secondary-cavity nesting birds using nestboxes. Comparisons were made with control sites of similar habitat that have been surveyed since 2011 (Hathcock et al. 2011).

Biologists at LANL used standard point count methodology to record avian richness, diversity, and abundance along transects at the three treatment sites and associated control sites during the summer of 2019. Summer surveys provide information about what birds are breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental changes at LANL.

In addition to avian point counts, nestboxes were monitored around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success data were compared with the overall avian nestbox monitoring network, which was established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon (*Pinus edulis*) –juniper (*Juniperus monosperma*) woodland (PJ) for Minie (Figure 1) and TA-39 (Figure 2) and a ponderosa pine (*Pinus ponderosa*) forest (PIPO) at TA-16 (Figure 3). These habitat descriptions were based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) were monitored annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock et al. (2011). Each habitat type control contained two replicate transects that were monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects were randomized and surveyed according to the random order.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was in an undeveloped area.

Transects were approximately 2.0 to 2.5 km in length with nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor looks and listens for 5 minutes, recording all birds encountered at each point on a data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point. The observation distance is considered as an “unlimited-distance circular plot”; however, the distance to each bird out to 100 m should be recorded. A range finder should be used if available. Avoid re-counting individuals between points.
- While walking between points, any obvious species not recorded at the previous point that also wouldn’t be counted at the next point should be recorded. The surveyor should not spend excess time looking for birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Use the “NOTES” section to indicate any additional information about the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Other wildlife or unusual sightings that could be used for other projects should be recorded.

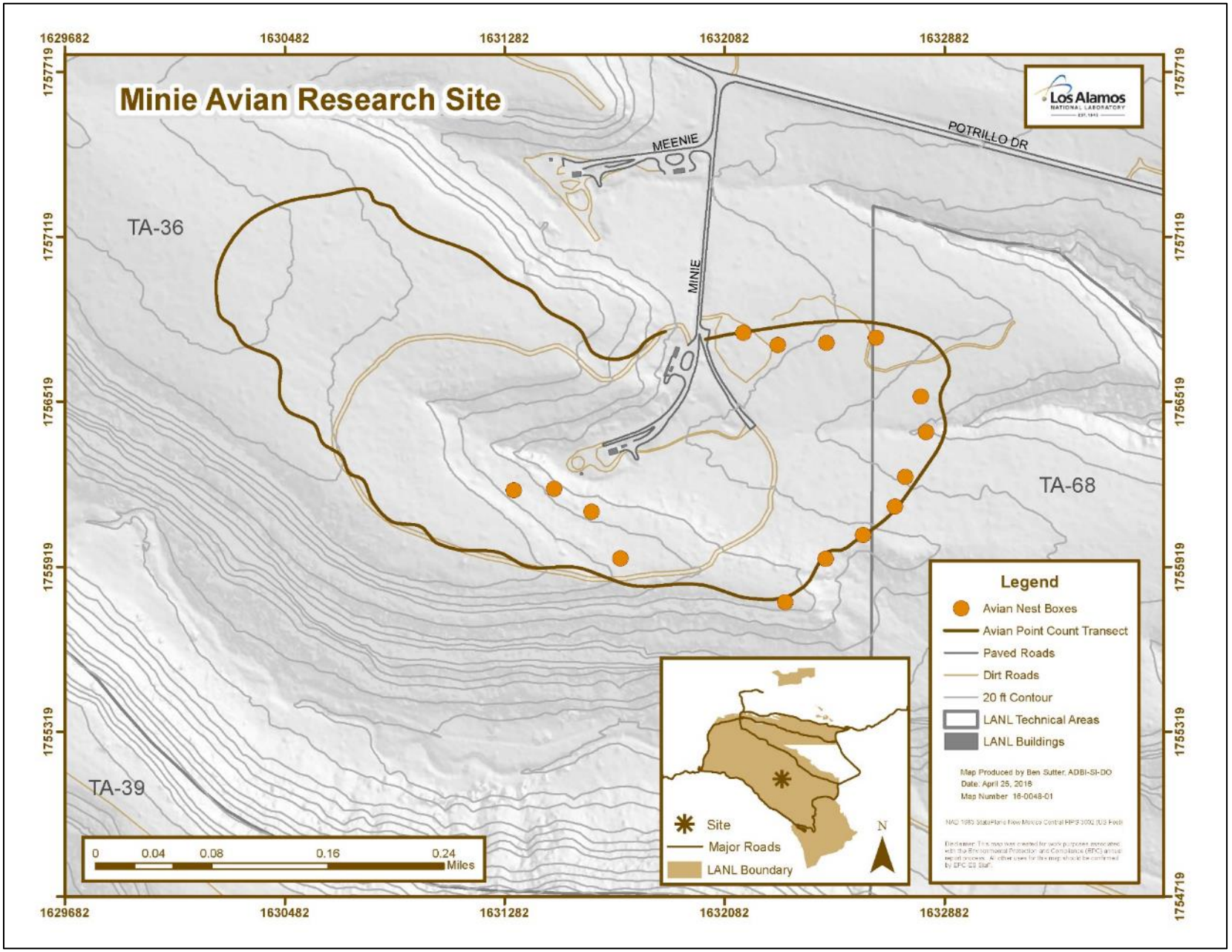

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site

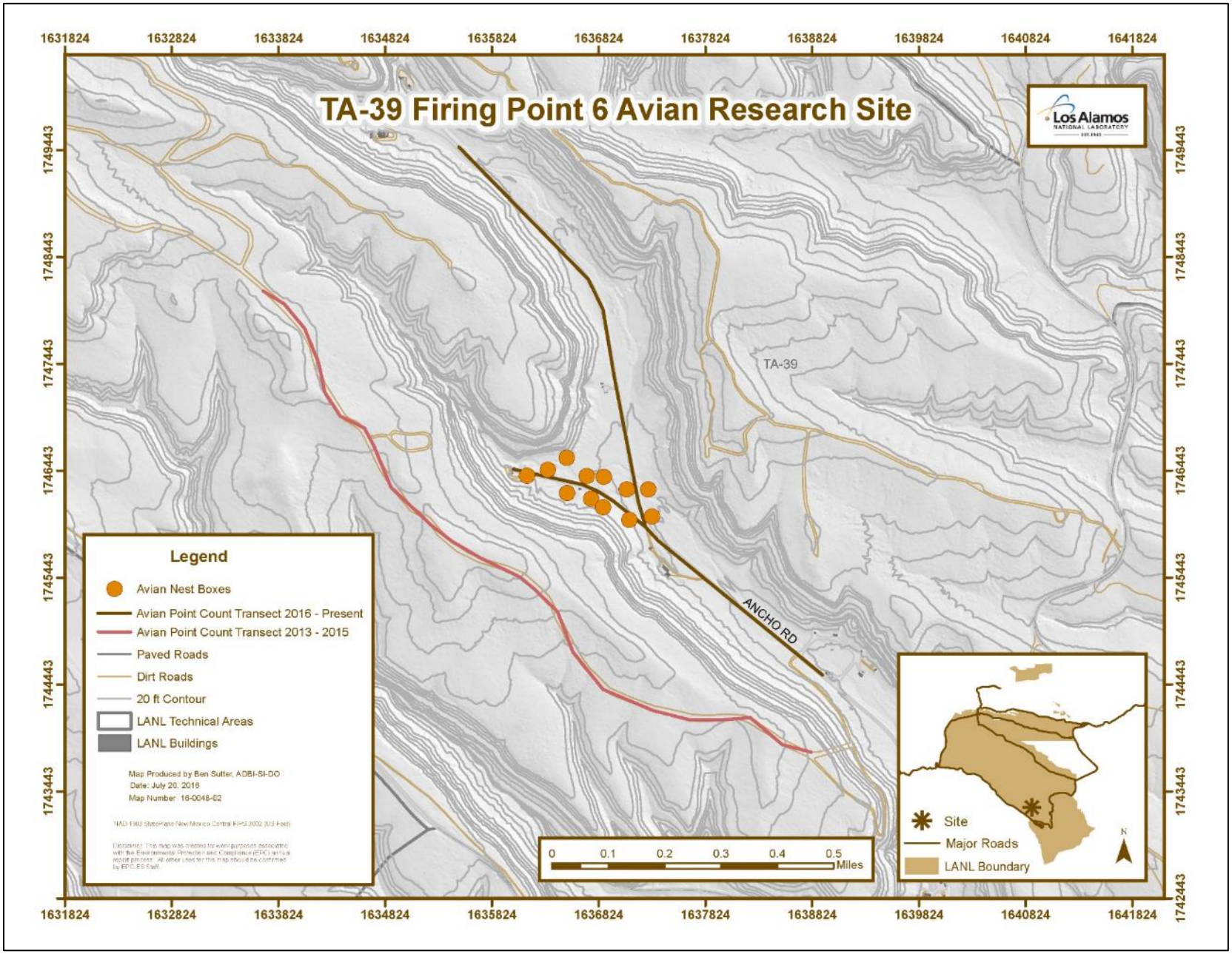

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6

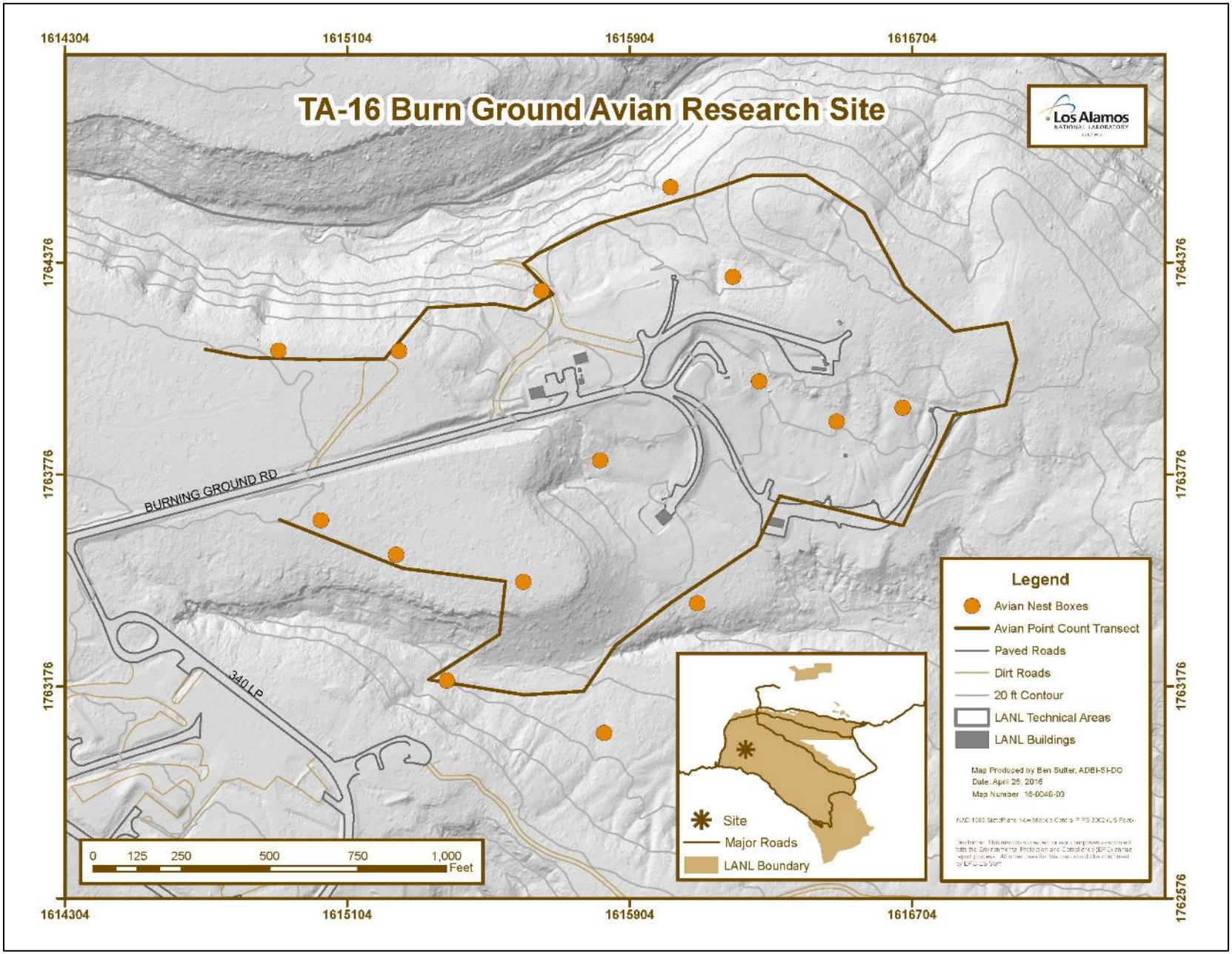

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground

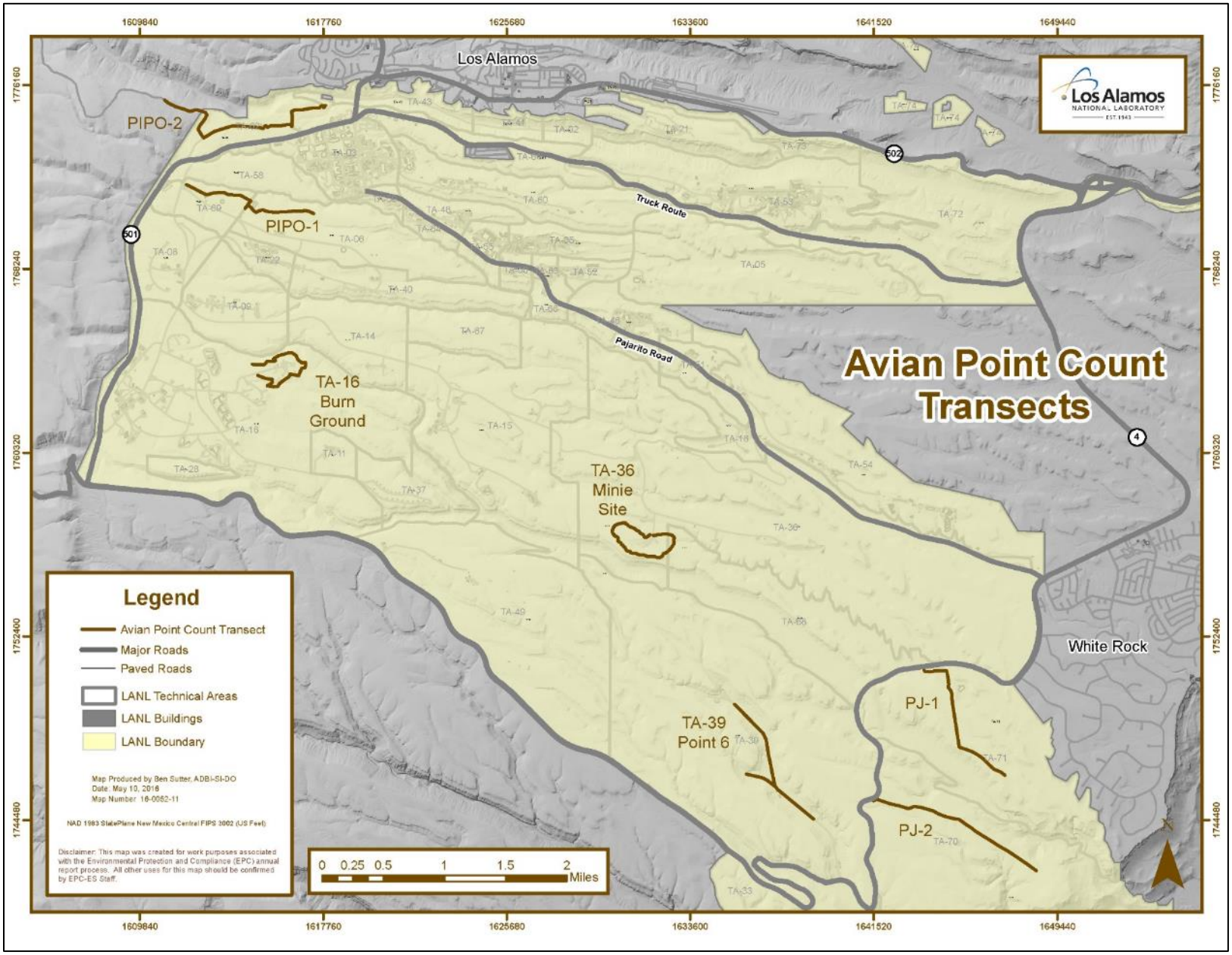

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Statistical Methods for Point Counts

These data were summarized to compare species richness, diversity, and abundance between treatment and control sites and over time. Species richness and abundance were calculated in Microsoft Excel©, and species diversity was computed using the statistical software PAST (Hammer et al. 2001). The Shannon's diversity index (Shannon and Weaver 1949) was used to compare diversity between habitats (Clarke et al. 2014). Shannon's diversity ranges for most ecological systems are between 1.5 and 3.5, and are rarely greater than 4.5, where high values indicate high diversity. A t-test was used to test for differences between treatment and control site diversity each year.

In addition, these data were summarized to compare species of three feeding guilds at each transect over time. The three feeding guilds included granivores, insectivores, and omnivores. Since there are three surveys completed at each transect per year, these data at each transect were averaged and compared over time.

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie and TA-39 (Figures 1 and 2). In 2015, nestboxes were added to TA-16 (Figure 3). Nestboxes were monitored every one to two weeks for active nests. When an active nest was found, it was monitored more frequently to determine whether the nest failed or successfully fledged young. Nestlings were also banded and the sex was determined after the age of 10 days.

Statistical Methods for Nestboxes

Occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network were calculated. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. Annually, data from the three treatment sites were compared with the overall avian nestbox network at LANL which was established in 1997.

Results and Discussion

Point Count Surveys-Year 2019

Three surveys were completed at each of the three treatment sites and the associated control sites between May and July 2019. A total of 853 birds representing 53 species were recorded at the three treatment sites. A full account of the 2013–2019 data is detailed in Appendix 1.

Species richness is the number of different species represented in an ecological community and is simply a count of species. In this case, each treatment site and control are individual communities. Species diversity is a measure that takes into account the species richness and the

overall abundance to compare evenness across a community. Here we used the Shannon's diversity index, which measures the probability that two individuals randomly selected from a sample will belong to different species. The abundance is the total number recorded of a given species. Tables 1 and 2 detail the species richness, diversity, and abundance for 2019 for each treatment and control site.

Table 1. The species richness, diversity, and abundance recorded at all treatment and control sites in 2019

	Minie	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	34	38	30	33	39	41	41
Diversity	3.063	3.083	2.755	2.901	3.291	3.127	3.292
Abundance	245	298	226	187	310	364	394

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The moisture for the winter of 2018–2019 was at or slightly above normal, but the species richness at all sites was similar to the previous year.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Minie	33	33	34	30	35	35	34
TA-39	31	31	39	38	34	39	38
PJ Control 1	29	30	33	36	37	30	30
PJ Control 2	30	29	37	33	39	23	33
TA-16	33	33	40	44	41	43	39

PIPO Control 1	34	34	30	41	41	37	41
PIPO Control 2	33	36	43	43	44	40	41

Tables 3–5 compare the species diversity over time between the treatment site and the combined control. The two control sites were combined to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of this study. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is around 3, which compared with ecological systems in general is very high.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Minie	3.141	3.141	3.161	2.968	3.134	3.220	3.060
PJ Control	2.895	2.990	3.159	3.075	3.241	2.940	2.970
t-test	**t = -3.2012**	t = -1.8716	t = -0.5269	t = 1.291	t =1.4637	**t =-3.907**	t =-1.2465
	df = 508	df = 455	df = 663	df = 460	df = 498	**df = 588**	df = 626
	p = 0.001	p = 0.06	p = 0.60	p = 0.20	p = 0.14	**p < 0.01**	p = 0.21

Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
TA-39	3.090	3.073	3.143	3.318	3.178	3.130	3.080
PJ Control	2.895	2.990	3.159	3.075	3.241	2.940	2.970
t-test	**t = -2.527**	t = -1.0396	t = 0.2166	**t = -3.7477**	t = 0.95934	**t = -2.7474**	t = -1.4205
	df = 464	df = 477	df = 483	**df =664**	df = 675	**df = 699**	df = 670
	p = 0.012	p = 0.30	p = 0.83	**p <0.01**	p = 0.34	**p = 0.006**	p = 0.16

Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
TA-16	3.304	3.207	3.236	3.293	3.238	3.360	3.290
PIPO Control	3.261	3.225	3.161	3.216	3.296	3.170	3.320
t-test	t = -0.66864	t = 0.26454	t = -1.2603	t = -1.1396	t = 0.88237	**t = -2.9553**	t = 0.51719
	df = 404	df = 495	df = 689	df = 511	df = 539	**df = 578**	df =648
	p = 0.50	p = 0.79	p = 0.21	p = 0.25	p = 0.38	**p = 0.003**	p = 0.61

To further analyze richness and Simpson's diversity (Simpson 1949) over time, species rarefaction and extrapolation plots (Hsieh et al. 2016, Chao et al. 2014) were developed in 2018 that included all years of data with the control sites combined. Species rarefaction and extrapolation show no differences between treatment and control sites for species richness. There were overlapping 95% confidence intervals for species richness (Figures 5A–6A) for all three treatments and their controls. Simpson's diversity is normally a measure between 0 and 1, but when analyzed using Hill numbers (Hsieh et al. 2016) it effectively reports the number of dominant species. The rarefaction and extrapolation plots for species diversity (Figures 5B–6B) were significantly different since the 95% confidence intervals did not overlap. In these cases, the treatment sites were higher in diversity than the controls with a higher number of dominant species. Tables 3-5 show there were no significant differences of diversity between treatment and control sites in 2019. Since the extrapolation curves are not expected to change much between years, these will be reanalyzed every five years.

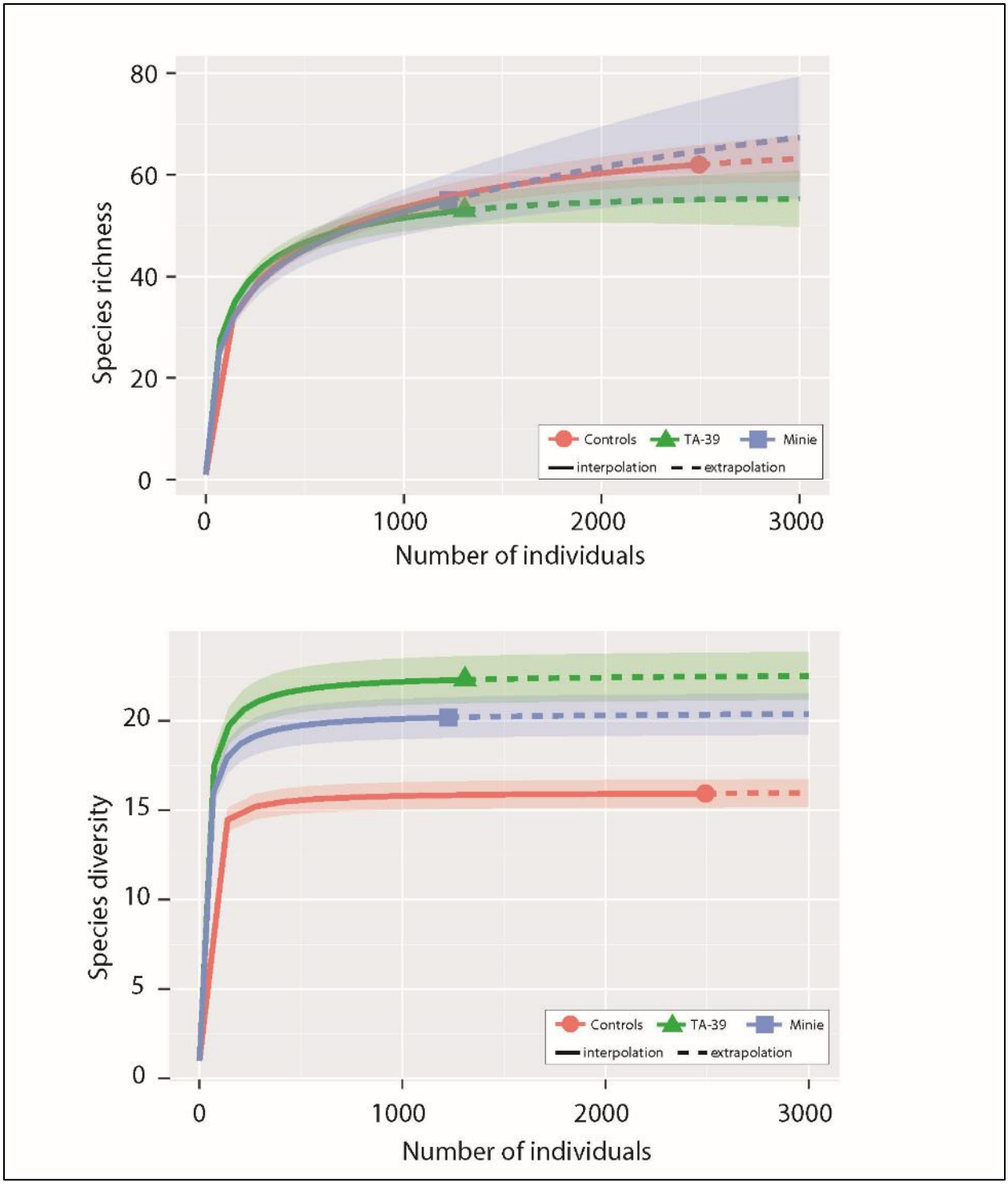

Figure 5. 2013 – 2018 Species rarefaction and extrapolation for species richness and diversity comparing Minie and TA-39 with the PJ controls

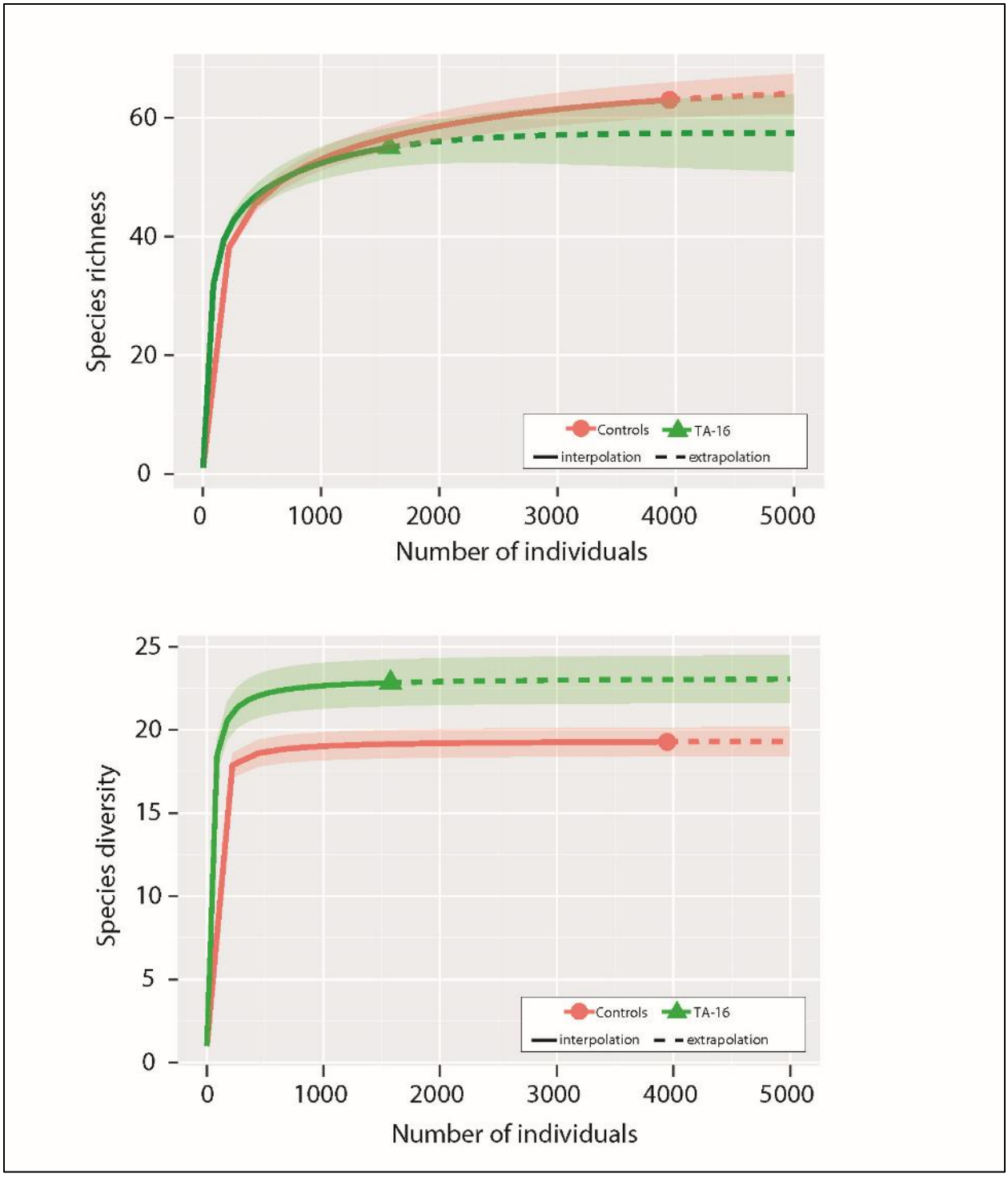

Figure 6. 2013 – 2018 Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls

The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower, but the percent abundance is similar year to year when compared with the control sites. Table 6 compares the abundance between the treatment and control sites over time. Similar to the species richness trends, there was an increase in abundance in 2015. The fluctuations in bird abundances were not alarming, and the differences between the treatment sites and control sites were not biologically significant. The moisture for the winter of 2018–2019 was at or slightly above normal, but the species abundance at all sites were similar to previous years.

Table 6. Changes in species abundance over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Minie	193	186	275	210	222	242	245
TA-39	177	193	259	249	261	315	298
PJ Control 1	187	157	269	312	240	235	226
PJ Control 2	181	177	301	228	300	168	187
TA-16	220	209	347	271	302	285	310
PIPO Control 1	258	223	432	323	447	374	364
PIPO Control 2	256	254	371	396	449	366	394

Figures 7-9 summarize the feeding guild trends over time at the treatment sites and the combined control sites. Overall, there are fewer granivores at all transect locations. Most of the species documented are insectivores and omnivores. Tracking bird abundance by feeding guild is important, because recent studies have shown changes in food sources, specifically for insectivores, have cascading effects on bird populations (Hallmann et al. 2017). Although there are periods of significant differences between years, they tend to follow the fluctuations in abundance and species richness.

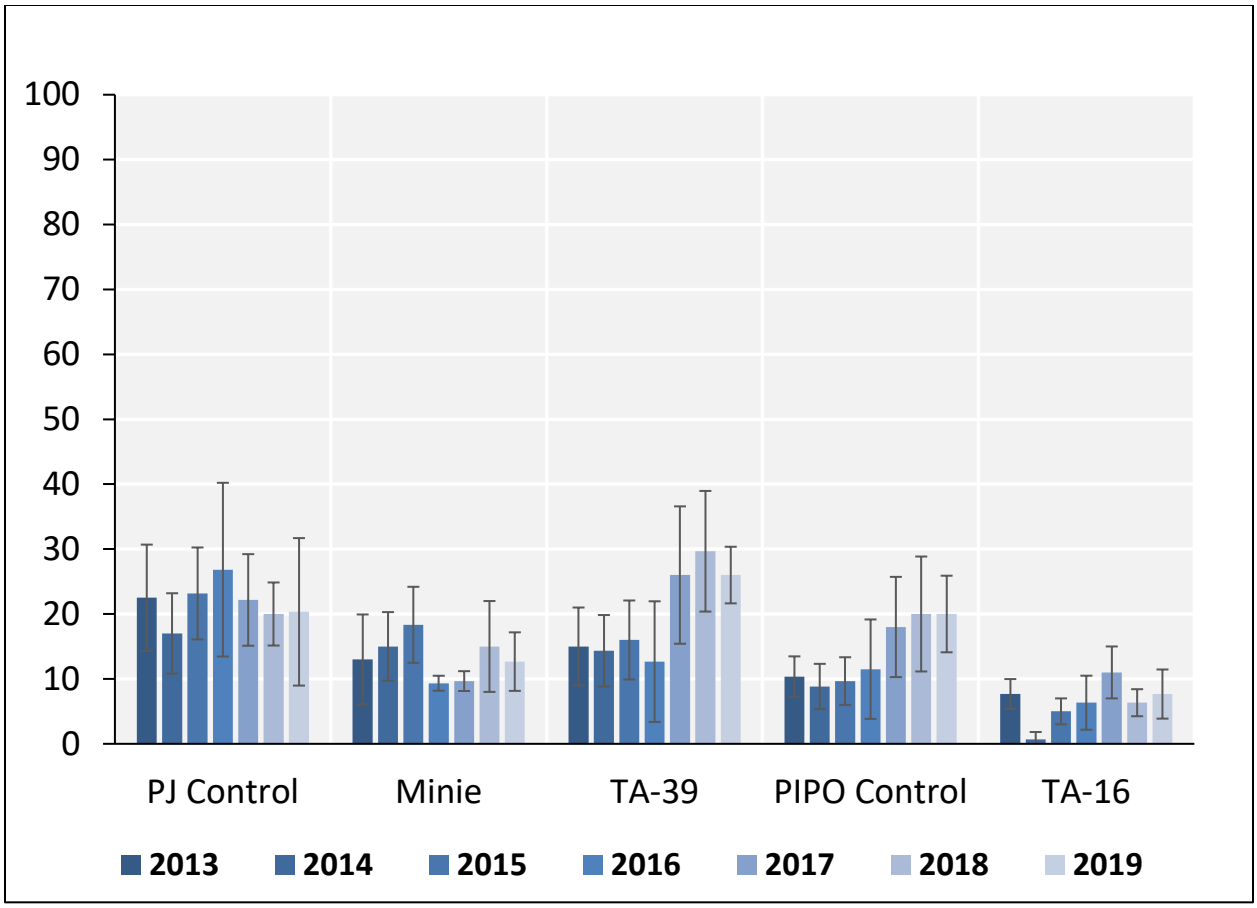

Figure 7. Average number of granivores +/- 1 standard deviation during breeding bird surveys at treatment sites and combined control sites over time.

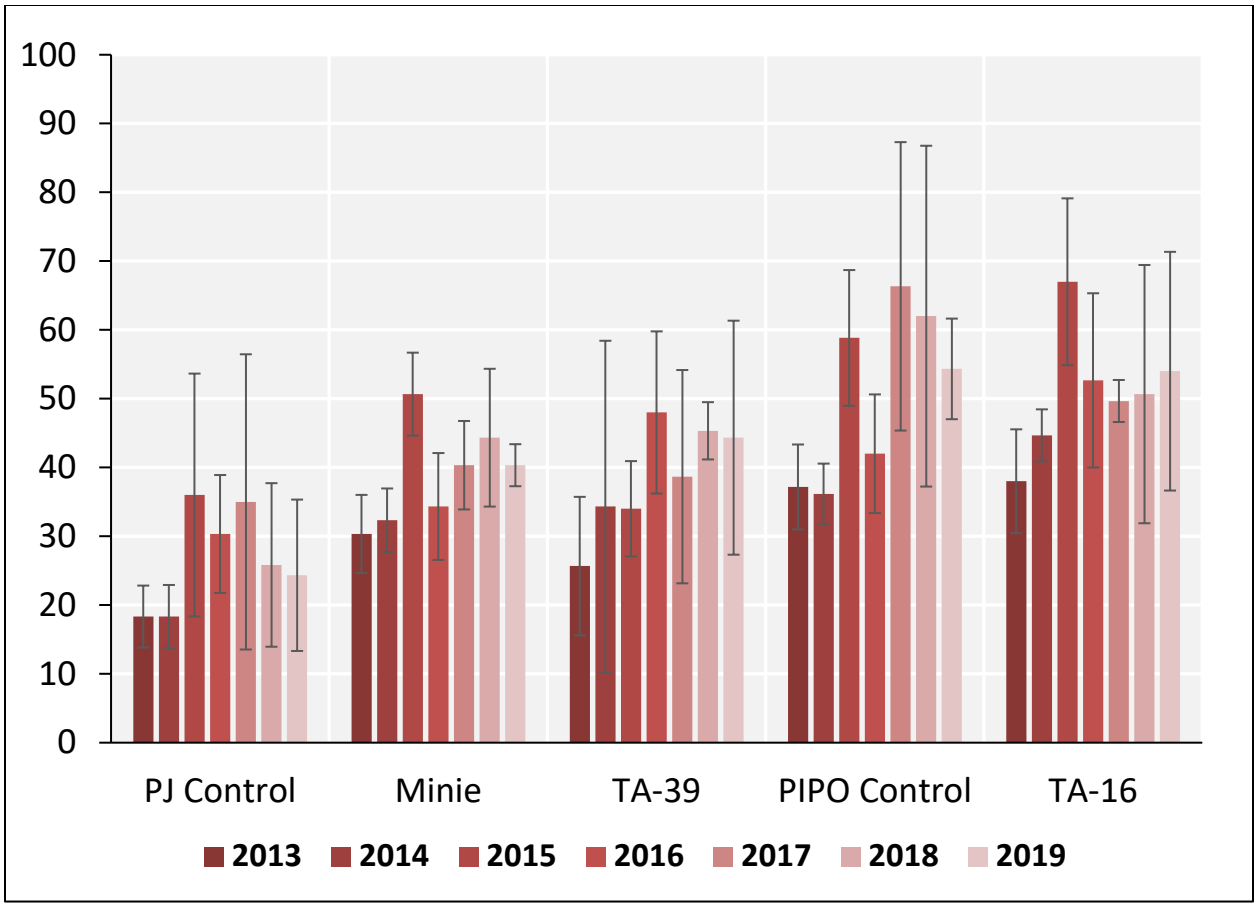

Figure 8. Average number of insectivores +/- 1 standard deviation during breeding bird surveys at treatment sites and combined control sites over time.

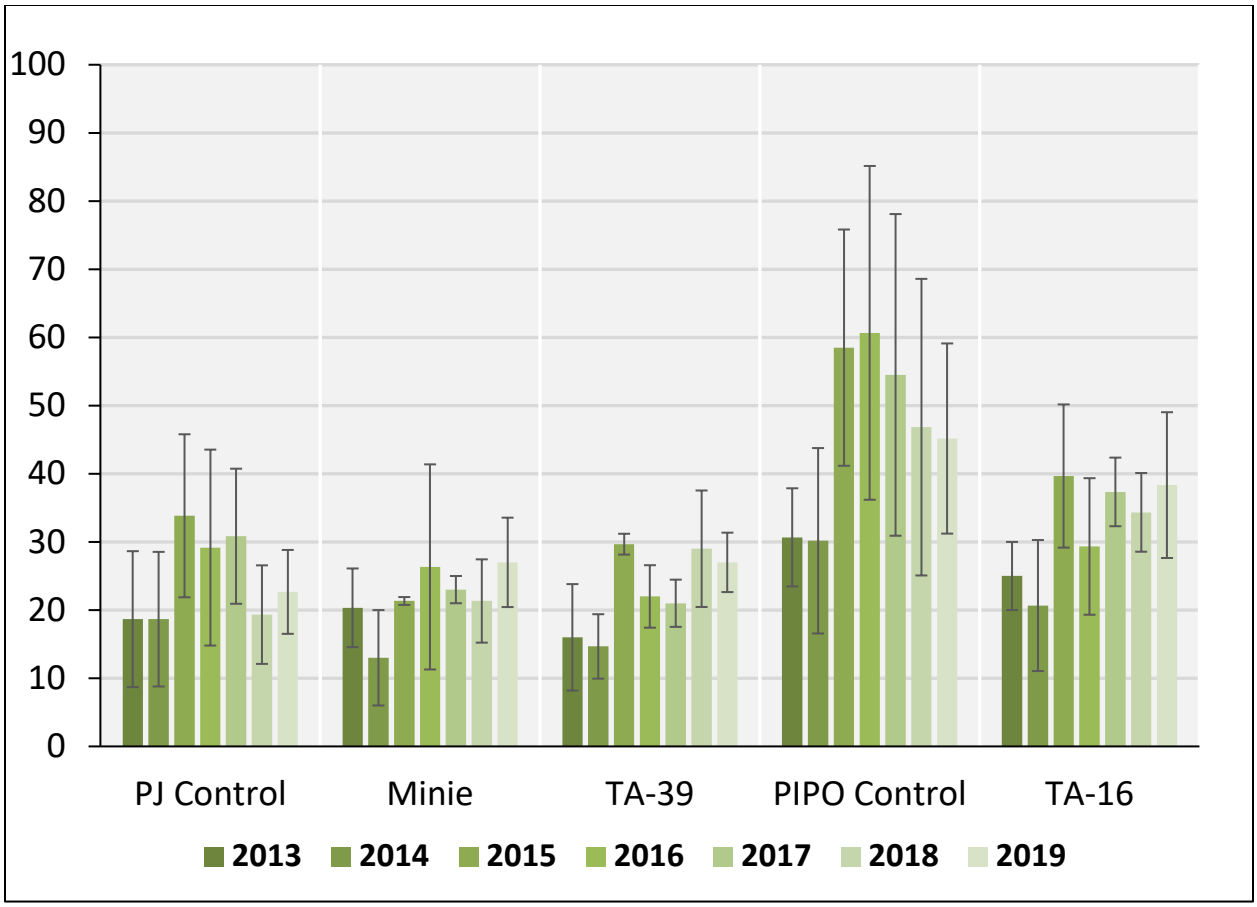

Figure 9. Average number of omnivores +/- 1 standard deviation during breeding bird surveys at treatment sites and combined control sites over time.

The number of granivores at TA-16 in comparison with the PIPO controls is lower overall. TA-16 is located on a mesa top surrounded by canyons with rocky cliff faces. Perhaps there is less understory vegetation on the cliff faces surrounding TA-16, resulting in less food for granivores. More study on habitat components between TA-16 and the PIPO control is needed to determine potential causes of the granivore variation.

Nestboxes

During the 2018 season, the overall avian nestbox network was managed at lower levels. Treatment sites were maintained at previous years' effort, but site-specific constraints from increased fire restrictions in 2018 limited the overall network management. In 2019, there were no restrictions and the nestbox network was managed throughout the breeding season with no limitations.

During the 2019 nesting season, 15 nestboxes at each treatment site were actively monitored. The overall avian nestbox network, without the three treatment sites, contained 378 nestboxes in

2019. Of those, 167 contained active nests and 85 of those nests fledged young successfully. This was an overall occupancy rate of 44% with a 51% success rate.

Tables 7 and 8 compare the occupancy and success rates for each treatment site and the overall nestbox network since 2015.

Table 7. Comparison of occupancy for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*	*2019*
Overall Network	40%	45%	48%	53%	44%
Minie	66%	73%	46%	20%	60%
TA-39	8%	58%	20%	33%	13%
TA-16	-	73%	100%	53%	87%

Table 8. Comparison of success for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*	*2019*
Overall Network	66%	69%	57%	49%	51%
Minie	64%	23%	29%	33%	44%
TA-39	100%	57%	0%	40%	0%
TA-16	-	63%	76%	63%	54%

In 2019, there were four successful nests that fledged young at Minie, zero at TA-39, and seven at TA-16. Both occupancy and success rates at TA-39 were low in comparison to the other treatment sites and the overall network. TA-39 is the lowest elevation treatment site and occupancy has been decreasing over time at this site and surrounding areas of the avian nestbox network. Wysner et al. (2019) found that Western Bluebirds, one of the target species of the network, have increased their nesting elevation over time in the study area. Western Bluebirds have the highest occupancy rates throughout the nestbox network, and the shift in nesting elevation could be driving the lower occupancy rates at TA-39. Occupancy and success rates at

the other two treatment sites seem to be fluctuating naturally in comparison to the overall network and have not displayed a decreasing trend over time.

In 2019, nonviable eggs collected from nestboxes at the treatment sites and the rest of the nestbox network were submitted to an analytical lab for chemical analyses. These data will be reported in a separate report.

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 53 species detected at the three treatment sites, all are protected under the Migratory Bird Treaty Act. In addition, sensitive species from the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008), the New Mexico Avian Conservation Partners Species Conservation Level One List (NMACP 2019), and the Birder's Conservation Handbook (Wells 2007) have been documented at the treatment sites. Those species are the Juniper Titmouse, Grace's Warbler, Virginia's Warbler, and the Woodhouse's Scrub Jay. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901).

Continuing the research reported herein will provide a long-term dataset for the ecological health of avifauna at the three treatment sites at LANL. In addition, this research contributes to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and it allows LANL to contribute to national goals in avian conservation monitoring and research.

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Thanks to the following individuals for technical and field support work in 2019: Jesse Berryhill, Jenna Stanek, Luciana Vigil-Holterman, Elisa Abeyta, Maricela Salazar, Jadzia Rodriguez, Makenzie Quintana, and former staff and interns that helped in previous years.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2019

Species	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
Acorn Woodpecker															5		3	2	3	5	3
American Crow																			1	1	
American Kestrel				1				1			2										
American Robin	1	1	2		2			1	1		2		4	2	7		9	4	4	6	12
Ash-throated Flycatcher	11	5	14	13	13	10	17	19	11	29	12	8	8	6	3	5	6	2	3	8	4
Audubon's Warbler		2				5					2				6	5	1	6		1	11
Bewick's Wren	4	8	9	9	14	14	5	3	10	15	9	2	8	1							
Black-chinned Hummingbird		1	1				1	3	2				1	2	1		1		1		1
Black-headed Grosbeak	1	3				1	1		2	4	1		3	2			1	2		2	
Black-throated Gray Warbler			1		2			5	6	4											
Blue-gray Gnatcatcher	3	14	16	8	10	9	8	2		7	5	4	2	13		6	2	1	3	6	4
Broad-tailed Hummingbird	2	1	3		1		3	3	1	2		3	1	2	5	11	11	5	7	10	8
Brown Creeper															1						
Brown-headed Cowbird	1									2			3	2	4	1			4	2	8
Bushtit		2		2		11		2	14			1	12								
Canada Goose										16				2							
Canyon Towhee	2		5	3	6	2	3	1	1	2	10	13	19	6	1			1		1	
Canyon Wren					1					2	3	8	6	2			2				
Cassin's Finch						4															
Cassin's Kingbird	6	13	13	5	2	5	6	7	6	2	21	21	32	37				1			
Chipping Sparrow	3	16	17	29	6	22	10	6	6	5	8	15	25	27	1	5	3	10	5	21	8

Species	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
Clark's Nutcracker																4		1			
Common Nighthawk	6		5	2	4	4	1	5	1	3	2	7	5	7			1	2	2		
Common Raven	2	5	1		1	2	3	1		2	1		1	2	5	6	2	2	5	5	7
Cooper's Hawk					1										1			1			1
Cordilleran Flycatcher															5	10	6	3	3	1	2
Dark-eyed Junco													1	1	6	2	4		5	2	
Downy Woodpecker				1							1	2		1		1		1	1	1	
Dusky Flycatcher				1						1		1									
Eurasian Collared-Dove	3											4								1	
Evening Grosbeak	3		4							8					5		29			1	
Grace's Warbler							1						2	4	6	4	4	8	5	8	22
Gray Flycatcher	12	6	5	7	3	6	3	10	10	11	10	5	8	3							
Great Horned Owl		3						1													
Green-tailed Towhee	3	1						1													
Hairy Woodpecker			2	1		1				5	3			1	1	1		1	1	2	1
Hammond's Flycatcher															8	9	12	5	7	5	10
Hepatic Tanager										1	2	1	2					1			
Hermit Thrush						1										4	6	1	2	2	5
House Finch	16	17	26	17	12	18	17	21	4	23	9	30	44	50	16	2	5	5	12	7	12
House Wren														1	1	1		2	2	6	8
Juniper Titmouse	12		7	6	9	3	26	11	13	18	6	1									
Lesser Goldfinch	2	6	7	4	9	12	8	4	12	9	10	14	19	15	3		8	9	4	8	5
MacGillivray's Warbler																		1	3		
Mountain Bluebird		2	20	10	11	1	9		4								4	4	4	7	4
Mountain Chickadee	5	2	1	2							1	1		1	5	8	9	6	8	9	1

Species	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
Mourning Dove	17	17	13	5	8	8	11	13	22	10	3	15	11	8	4		1	3	17	3	5
Northern Mockingbird					2		1		1												
Northern Rough-winged Swallow						3															
Peregrine Falcon										1											
Pine Siskin	10	2		5	1			6		3	3				12	4	5		4	2	
Plumbeous Vireo	10	10	7	3	9	9	15	1		1	6	6	5	5	11	16	15	14	11	18	16
Pygmy Nuthatch				2		2	3			2	4	12	9	11	11	13	26	29	41	20	16
Red Crossbill					1				2							2	9	13	9		6
Red-shafted Flicker	3	1	3	2	5	2	1	3	2	4	8		3	2	3	4	11	11	5	5	2
Red-tailed Hawk							1			1	1	1	1								
Rock Wren	3	3	4		2	10	11	7	10	4	12	14	14	12	1	2	2	6			4
Ruby-crowned Kinglet																				2	
Say's Phoebe	2	1	2		2	5	1	2	1		5	2	4		1		1	3	3	4	1
Scaled Quail			1																		
Spotted Towhee	17	8	19	27	32	24	19	12	6	33	16	12	16	15	11	18	16	14	21	22	34
Steller's Jay							1								3	2	5	6	3	4	4
Townsend's Solitaire	1																		1		
Turkey Vulture					1										1					1	
Vesper Sparrow																					1
Violet-green Swallow		5	7	1	3	2	1	6	4	1	9	6	6	9		2	19	2	2	4	2
Virginia's Warbler					1	3	1			1	2	4		5	17	11	21	13	7	5	5
Warbling Vireo						2									2	9	7	6	5	4	6
Western Bluebird	15	11	18	17	16	19	21	5	19	12	21	13	6	7	20	20	49	37	32	27	20
Western Tanager		2	3		1				2	1	1	2	2	6	2	3	7	2	4	6	16
Western Wood-Pewee	10	8	18	11	10	7	18		4	2	10	8	11	12	15	10	16	14	22	20	24

Species	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
White-breasted Nuthatch	1	4	9	10	13	5	2			2	4	4	2	6	9	8	7	9	20	10	10
White-throated Swift									1												
White-winged Dove	1	5	9	2		3	2	7	5	6	16	15	15	5			1	2			1
Woodhouse's Scrub-Jay	5	1	3	4	8	7	14	8	10	4	8	6	4	5	1						

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 12 – Rodriguez & Abeyta 2021

Environmental Report:

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March 2021

2020 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY

Prepared by: **Jadzia Rodriguez and Elisa Abeyta, Environmental Protection and Compliance Division, Environmental Stewardship Group, Los Alamos National Laboratory**

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EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL) biologists in the Environmental Protection and Compliance Division initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. In this annual report we compare monitoring results from these efforts among years to monitor trends. The objectives of this study are to 1) determine whether LANL operations impact bird species richness, diversity, or abundance and 2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. LANL biologists completed the eighth year of this effort in 2020.

Between May and July 2020, we completed three avian point count surveys at each of the treatment sites which are the Technical Area (TA)-36 Minie site, the TA-39 point 6, and the TA-16 burn ground. We recorded a total of 1,005 birds representing 63 species at the three treatment sites and compared these results to data from their associated control sites. We also compared occupancy and nest success data from nestboxes at treatment sites with the overall avian nestbox monitoring network.

In 2020, species richness and avian abundance showed variability, but treatment and controls were trending together year to year. The species diversity at the TA-36 Minie site and TA-16 burn ground were statistically different from their associated controls. To examine this further, we prepared rarefaction and extrapolation plots for all years and over time. The species diversity at all three treatment sites has been diverging from the controls over the last few years. We determined that the diversity was higher at the treatment sites than the controls which is not alarming. Nestbox results suggest natural fluctuations year to year.

The overall results from 2020 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations. This long-term project will continue to monitor for any changes over time.

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INTRODUCTION

As part of the Resource Conservation and Recovery Act permit process, Los Alamos National Laboratory (LANL) started an annual avian monitoring program in 2013. The permit was for two open detonation sites, Technical Area (TA)-36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018; Sanchez et al. 2020). The objectives of this long-term monitoring program are to (1) determine whether LANL operations impact bird species richness, diversity, or abundance and (2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. This involves making comparisons with control sites of similar habitat that LANL biologists have surveyed since 2011 (Hathcock et al. 2011).

LANL biologists used standard point count methodology to record avian richness, diversity, and abundance along transects at the three treatment sites and their associated control sites during the summer of 2020. Summer surveys provide information about what birds are breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental changes at LANL.

In addition to avian point counts, LANL biologists monitored nestboxes around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success were compared to the overall avian nestbox monitoring network, which was established in 1997.

METHODS

Field Methods for Point Count Surveys

LANL biologists conducted the point count surveys along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon (*Pinus edulis*) – juniper (*Juniperus monosperma*) woodland (PJ) for Minie (Figure 1) and TA-39 (Figure 2) and a ponderosa pine (*Pinus ponderosa*) forest (PIPO) at TA-16 (Figure 3). The habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) are monitored annually. The control sites were originally established in 2011 (Hathcock et al. 2011). Each habitat type control contained two replicate transects that LANL biologists monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects are monitored randomly.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in

the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was in an undeveloped area.

Transects were approximately 2.0 to 2.5 km in length with nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site conducted between 0.5 hours before sunrise and four hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor looks and listens for five minutes, recording all birds encountered at each point on a data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point. The observation distance is considered as an "unlimited-distance circular plot"; however, surveyors should be recording the distance to each bird out to 100 m. A range finder should be used if available. Avoid re-counting individuals between points.
- While walking between points, surveyors should be recording any obvious species not recorded at the previous point that also wouldn't be counted at the next point. The surveyor should not spend excess time looking for birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Use the "NOTES" section to indicate any additional information about the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Surveyors should be recording other wildlife or unusual sightings that could be used for other projects.

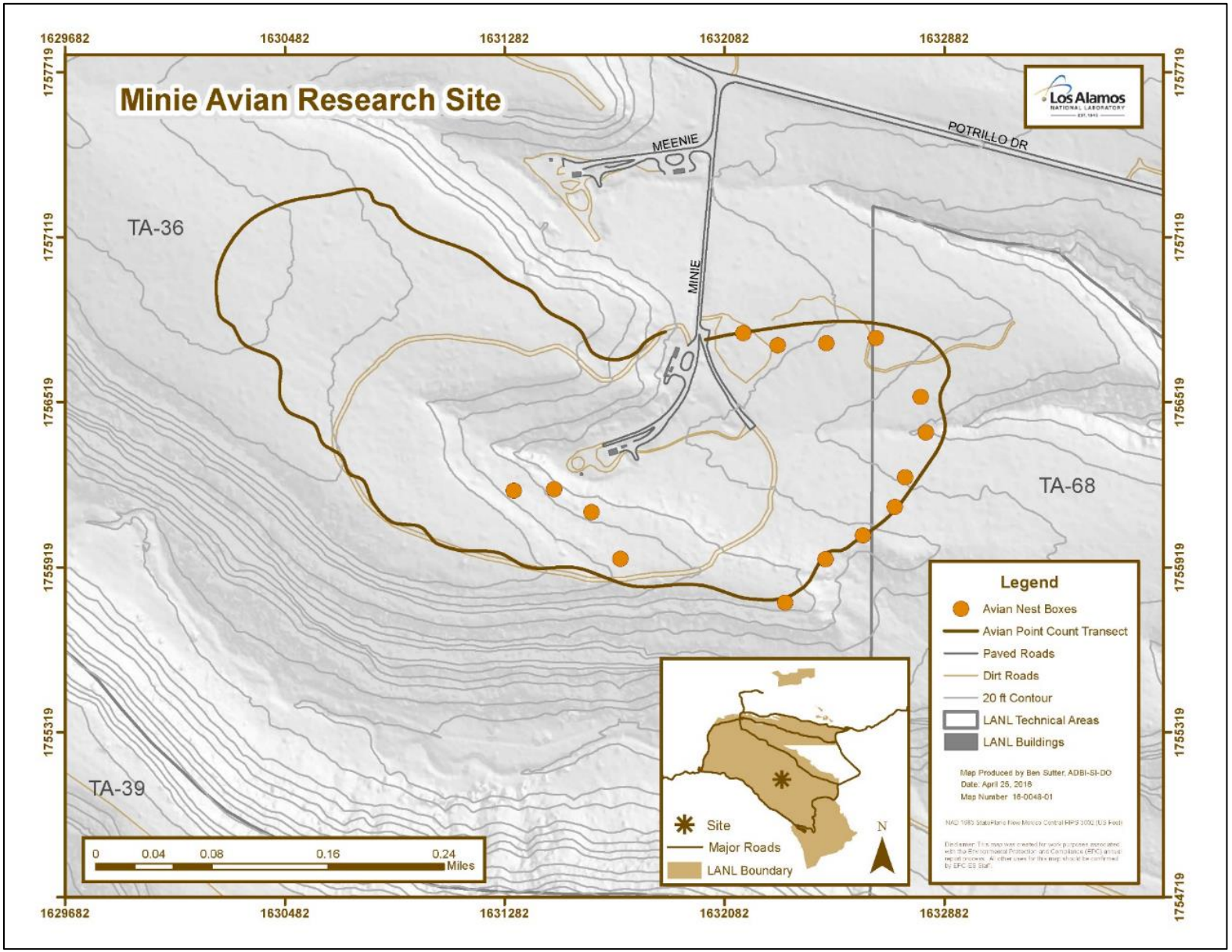

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie Site

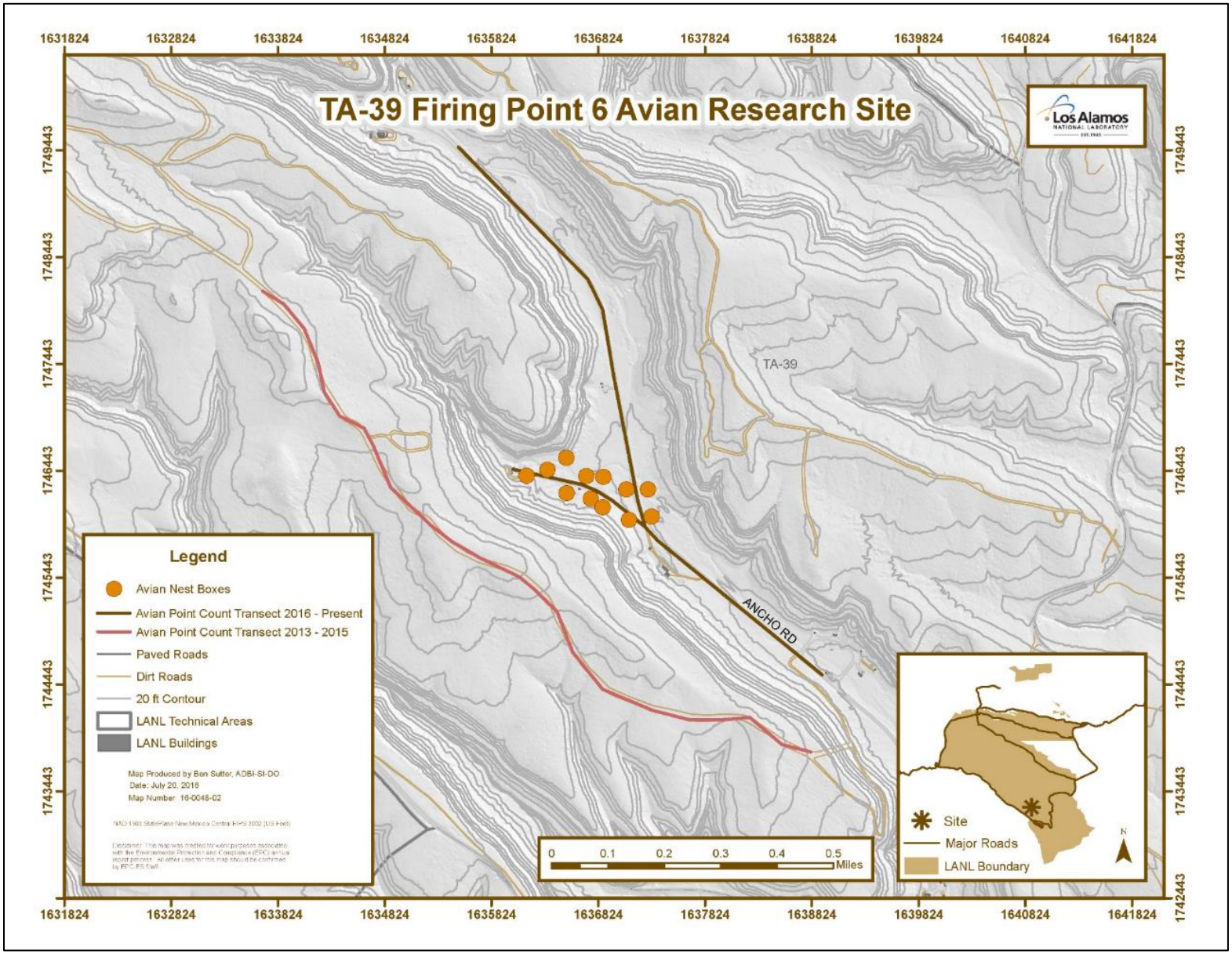

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 Point 6

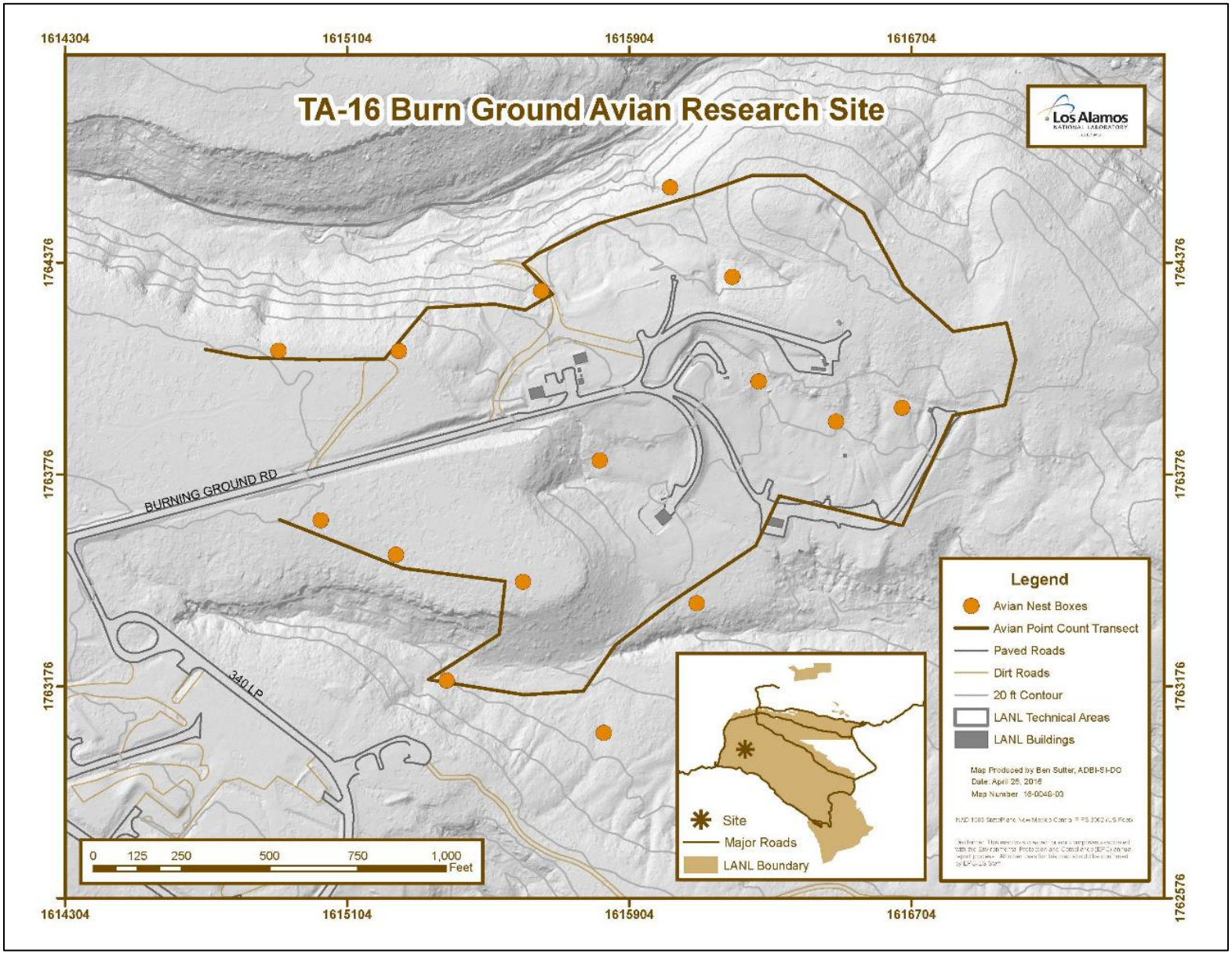

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 Burn Ground

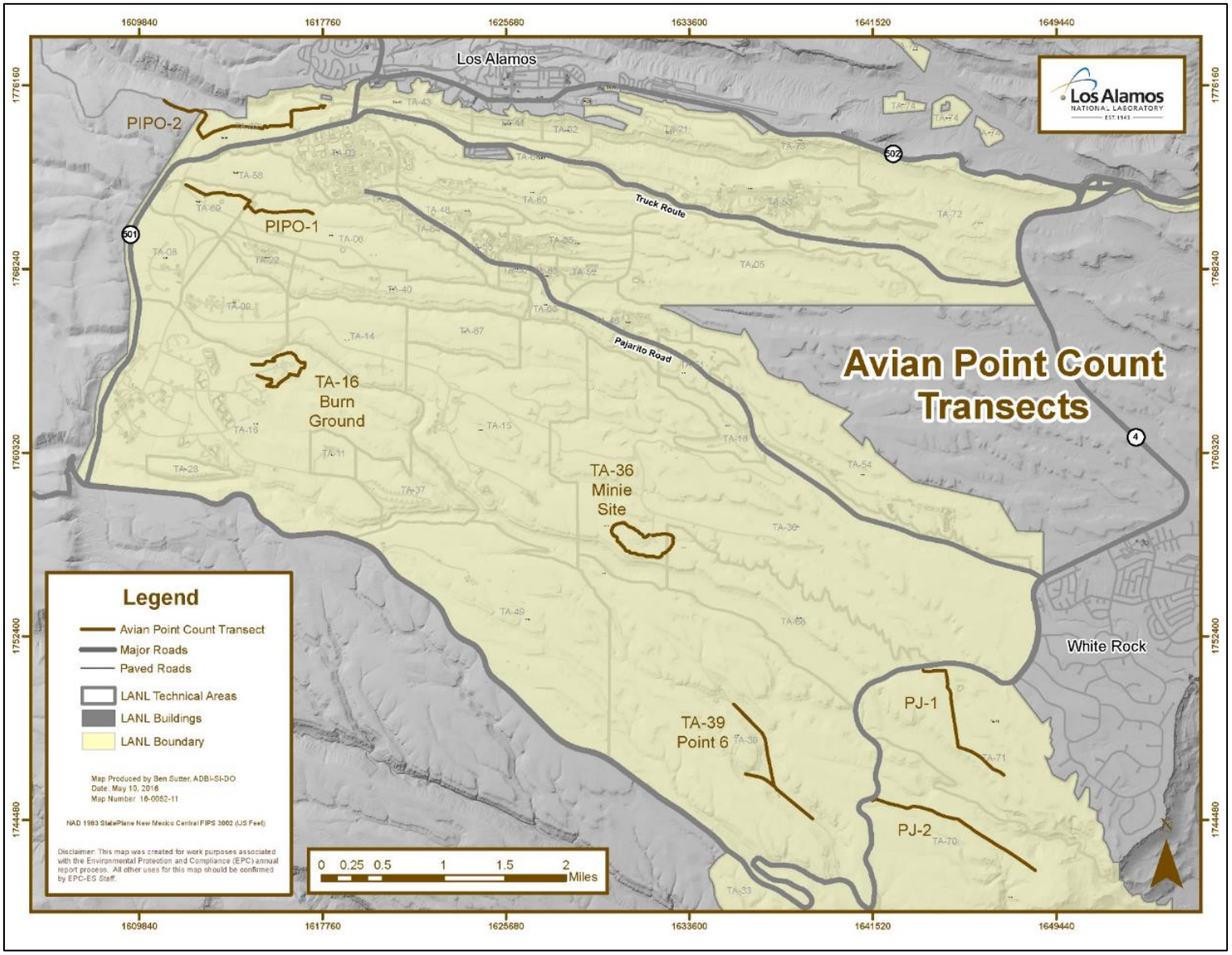

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Statistical Methods for Point Counts

We summarized these data to compare species richness, diversity, and abundance between treatment and control sites and over time. We considered each treatment site and control to be individual communities. Species richness is the number of different species represented in an ecological community and is simply a count of species (Boulinier et al. 1998). Species diversity is a measure that takes into account the species richness and the overall abundance to compare evenness across a community (Tramer 1969). Shannon's diversity index measures the probability that two individuals randomly selected from a sample will belong to different species (Shannon and Weaver 1949). The abundance is the total number recorded of a given species (Gotelli and Colwell 2011).

We calculated species richness and abundance using the statistical software R (version 3.6.1; R Core Team 2019) and computed species diversity using the statistical software PAST (Hammer et al. 2001). We used the Shannon's diversity index to compare diversity between habitats (Clarke et al. 2014). Shannon's diversity ranges for most ecological systems are between 1.5 and 3.5, and are rarely greater than 4.5, where high values indicate high diversity. We used a diversity t-test in the PAST software to test for differences between treatment and combined control site diversity each year.

We also used the R-package 'iNEXT' to compute species rarefaction and extrapolation plots (Hsieh et al. 2016, Chao et al. 2014) that analyzed species richness and Simpson's diversity over time (Simpson 1949), which included all years of data with the control sites combined. We used the Simpson's diversity index for the interpolation and extrapolation plots of species diversity. The Simpson's diversity index differs from Shannon's diversity index because it is influenced by the dominant species in a community based on abundance (Fontana et al. 2011). Simpson's diversity is normally a measure between zero and one, with zero representing no diversity and one representing infinite diversity. This index resists drastic changes to diversity by placing more importance on species evenness. We analyzed species diversity using Hill numbers (Hsieh et al. 2016) in order to effectively report the number of dominant species in the plots.

We examined species composition at TA-39 using non-metric multidimensional scaling (NMDS) to determine dissimilarity among the years when surveys were conducted. This was done to try to explain how changing the transect location from the canyon rim to the canyon bottom affected the data over time at TA-39. We conducted an analysis of similarity (ANOSIM) using 1000 permutations to compare the species composition at TA-39 between survey years. We used the community ecology R-package 'vegan' (Dixon 2003) to complete the NMDS and ANOSIM analyses. NMDS is an ordination technique that condenses highly-dimensional multivariate datasets into a smaller number of dimensions (Dexter et al. 2018). An NMDS plot is usually reduced to two or three dimensions to observe patterns in community data between species composition and other environmental variables. The number of dimensions is used to calculate a measure of 'stress', which is the discrepancy between the rank order of distances in the actual

data and the rank order of distances in the ordination. A high stress value (>0.2) indicates that the data is misleading while a low stress value (<0.1) indicates that the ordination is a good representation of the rank order of distances in the multivariate dataset (Dexter et al. 2018). Stress is reduced in an ordination by maintaining the rank order of distances while rearranging the sample points in slightly different positions (Dexter et al. 2018, De Fraga et al. 2014). A lower stress value can be attained by adding more dimensions, but too many dimensions could lead to misinterpretation of the data. We selected an NMDS plot with a low stress value and the minimum number of dimensions to minimize the distortion to the actual dataset. The R-package 'vegan' generated a Shepard diagram to display the stress in the NMDS plot. A Shepard diagram is a type of scatter plot with a fitted regression line that compares the distance between sample points in the actual data and in the ordination (Khan et al. 2020, Clarke 1993).

Field Methods for Nestbox Monitoring

In 2011, LANL biologists added nestboxes to Minie and TA-39 (Figures 1 and 2). In 2015, biologists added nestboxes to TA-16 (Figure 3). We monitored nestboxes every one to two weeks for active nests. When an active nest was found, we monitored it more frequently to determine whether the nest failed or successfully fledged young. We also banded nestlings and determined the sex after the age of 10 days. We compared the data from the nestboxes at the treatment sites to the data from the overall nestbox network at LANL. This year, due to the coronavirus pandemic (SARS-CoV-2) (Zhou et al. 2020) and its impact on personnel working together, we only managed a subset of the overall nestbox network.

Statistical Methods for Nestboxes

We calculated occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. We compared the 2020 data from the three treatment sites with the overall avian nestbox network at LANL which was established in 1997 (Fair and Myers 2002).

RESULTS AND DISCUSSION

Point Count Surveys-Year 2020

LANL biologists completed three surveys at each of the three treatment sites and the associated control sites between May and July 2020. A total of 1,005 birds representing 63 species were recorded at the three treatment sites. A full account of the 2013 – 2020 data is detailed in Appendix 1.

Table 1 details the species richness, diversity, and abundance for 2020 for each treatment and control site.

Table 1. The species richness, diversity, and abundance recorded at all treatment and control sites in 2020

	Minie	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	33	40	37	32	46	33	40
Diversity	3.134	3.076	2.874	2.862	3.367	2.900	3.176
Abundance	203	413	292	269	389	373	429

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The moisture for the winter of 2018 – 2019 was at or slightly above normal, but the species richness at all sites was similar to the previous year. Temperatures were above average during the summer of 2020 while the winter moisture of 2019 – 2020 was below average (Weather Machine 2020). Species richness at all sites varied during 2020, which may have been influenced by the above average total precipitation Los Alamos received in the middle of March. We predict that the species richness in 2021 will be lower at several sites due to an unusually early and cold storm system that occurred in September 2020. The cold front contributed to a mass mortality event of migratory songbirds across New Mexico (NMDGF 2020), which may influence the data collected for next year's surveys.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Minie	33	33	34	30	35	35	34	33
TA-39	31	31	39	38	34	36	38	40
PJ Control 1	29	30	33	36	37	30	30	37
PJ Control 2	30	29	37	33	39	23	33	32

TA-16	39	33	40	44	41	43	39	46
PIPO Control 1	34	34	30	40	46	40	41	33
PIPO Control 2	33	36	43	43	44	39	40	40

Tables 3 – 5 compare the species diversity over time between the treatment site and the combined controls. We combined the two control sites to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of this study which are indicated in bold font with a darker shading. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is around 3, which compared with ecological systems in general is very high.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Minie	3.141	3.141	3.191	2.968	3.134	3.215	3.063	3.134
PJ Control	2.877	2.990	3.159	3.067	3.241	2.938	2.967	2.975
t-test	**t = -3.2012 df = 508 p = 0.001**	t = -1.8716 df = 455 p = 0.062	t = -0.52699 df = 663 p = 0.60	t = 1.291 df = 460 p = 0.20	t =1.4637 df = 498 p = 0.14	**t =-3.907 df = 588 p < 0.01**	t =-1.2465 df = 626 p = 0.21	**t = -2.139 df = 502 p = 0.033**

Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
TA-39	3.090	3.073	3.140	3.318	3.178	3.131	3.083	3.076
PJ Control	2.877	2.990	3.159	3.067	3.241	2.938	2.967	2.975

t-test	**t = -2.527 df = 464 p = 0.012**	t = -1.0396 df = 477 p = 0.30	t = 0.26785 df = 484 p = 0.79	**t = -3.7477 df =664 p <0.01**	t = 0.95934 df = 675 p = 0.34	**t = -2.7474 df = 699 p = 0.006**	t = -1.4205 df = 670 p = 0.16	t = -1.4646 df = 942 p = 0.14

Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
TA-16	3.304	3.207	3.236	3.293	3.238	3.357	3.291	3.367
PIPO Control	3.261	3.225	3.161	3.213	3.296	3.171	3.316	3.184
t-test	t = -0.66864 df = 404 p = 0.50	t = 0.26454 df = 494 p = 0.79	t = -1.2603 df = 689 p = 0.21	t = -1.1396 df = 511 p = 0.25	t = 0.88237 df = 539 p = 0.38	**t = -2.9553 df = 578 p = 0.003**	t = 0.44118 df =640 p = 0.66	**t = -3.3172 df = 824 p = 0.001**

We analyzed species richness and Simpson's diversity data between 2013 – 2020 using extrapolation curves (Figures 5A – 6B). Species rarefaction and extrapolation show a significant difference between treatment and control sites for species richness (Figure 5A). Figure 5A displays 95% confidence intervals where the TA-39 treatment site and the PJ Controls do not overlap. However, the species rarefaction and extrapolation for the PJ treatment and control sites between 2013 – 2018 did not show any significant differences for species richness (Hathcock et al. 2018). The Minie and TA-16 treatment sites and their associated controls had overlapping 95% confidence intervals for species richness (Figures 5A and 6A). The cause of the difference in species richness may be attributed to a change of transect locations at the TA-39 treatment site in 2016 (Figure 2). The original transect was located on the mesa above the treatment site and was more of a pinyon-juniper woodland while the replacement transect sited in 2016 was along the canyon bottom around the treatment site and contained more ponderosa pine trees. Slight differences in habitat structure have been shown to impact species composition (Seymour and Dean 2010). We looked at these data using an NMDS plot. Figure 7 represents the final configuration of survey years as points in the NMDS plot for TA-39 (dimensions = 2, stress = 0.0225). The Shepard diagram (Figure 8) shows minimal scatter around the regression line between the observed dissimilarity and ordination distance, which indicates that the NMDS plot

has low stress (non-metric fit $R^2 = 0.999$, linear fit $R^2 = 0.997$). NMDS ordinations use the rank order of distances to show the dissimilarity between samples (Faith et al. 1987), which means samples in close proximity to one another are similar while samples that are distant from each other are not alike. Figure 7 shows how the species composition at TA-39 was more similar between years that are clustered together on the NMDS plot (Debinski et al. 2006). We separated the years when surveys occurred into early year (2013 – 2015) and later year (2016 – 2020) categories to reflect the change in habitat corresponding to the selection of a new transect location. The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated categories of survey years. The NMDS plot grouped early years on the left and later years on the right (Figure 7). Our NMDS plot only displayed 16 species to improve clarity (Figure 7). These 16 species represent the top ten most commonly observed species for early years and later years (Table 6). Species that appeared in the list for both categories of survey years are in bold. The species that seem to be driving the difference between early and later years are the Juniper Titmouse, Cassin's Kingbird, and the Western Wood-Pewee. Even though the polygons for the early and later years are not closely aligned with one another and do not overlap, the categories of survey years were not statistically different from each other (ANOSIM: $R = 0.05917$, $P = 0.08$).

The rarefaction and extrapolation plots for species diversity (Figures 5B and 6B) were significantly different since the 95% confidence intervals did not overlap. In these cases, the treatment sites were higher in diversity than the controls with a higher number of dominant species. These results are similar to the 2013 – 2018 species rarefaction and extrapolation results presented in a previous report (Hathcock et al. 2018). Tables 3 – 5 show there were significant differences of diversity between the Minie and TA-16 treatment sites and their associated control sites in 2020. Since the extrapolation curves are not expected to change much between years, these will be reanalyzed every five years after this report.

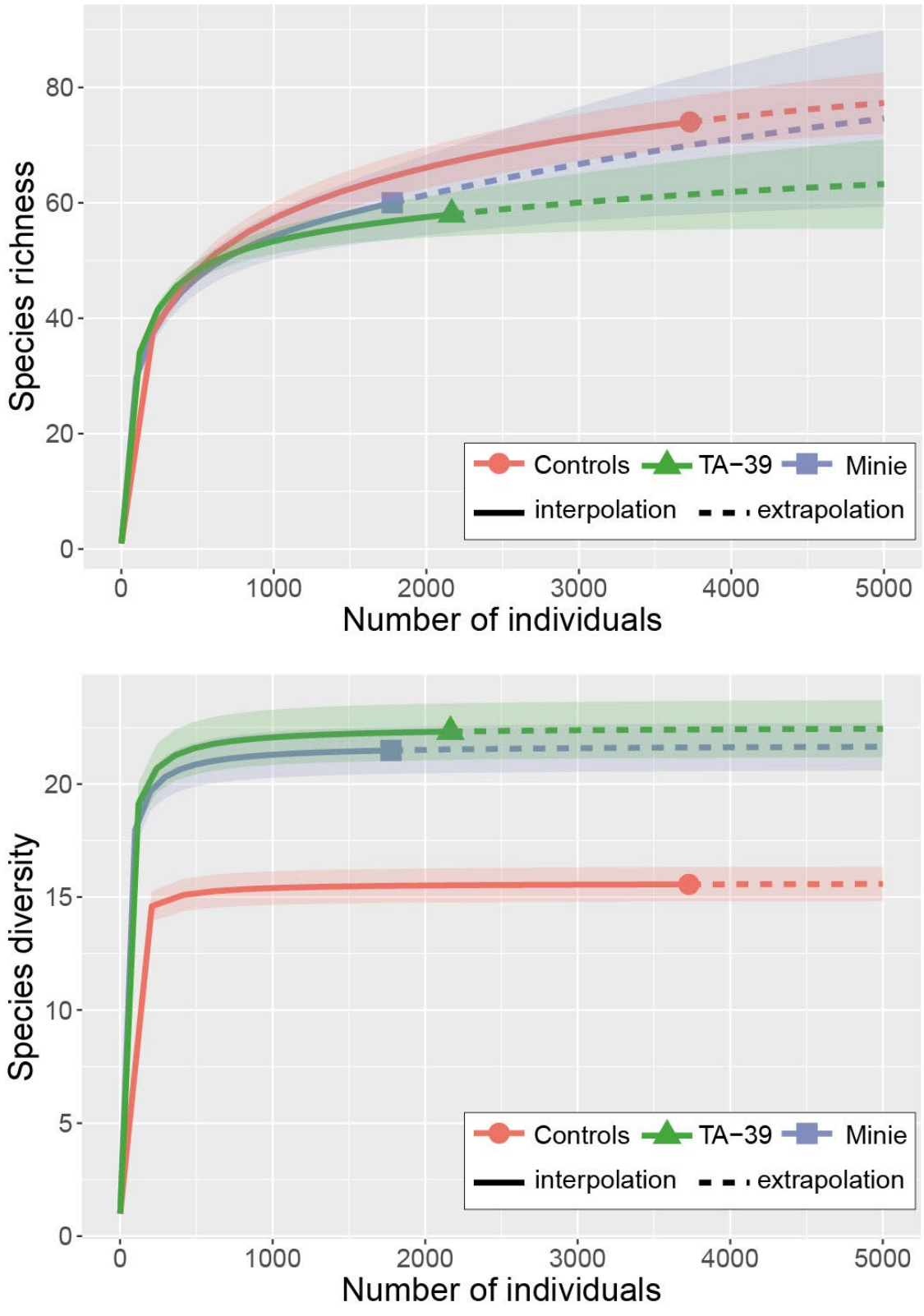

Figure 5. 2013 – 2020 Species rarefaction and extrapolation for species richness and diversity comparing Minie and TA-39 with the PJ controls. Top is "A" and bottom is "B".

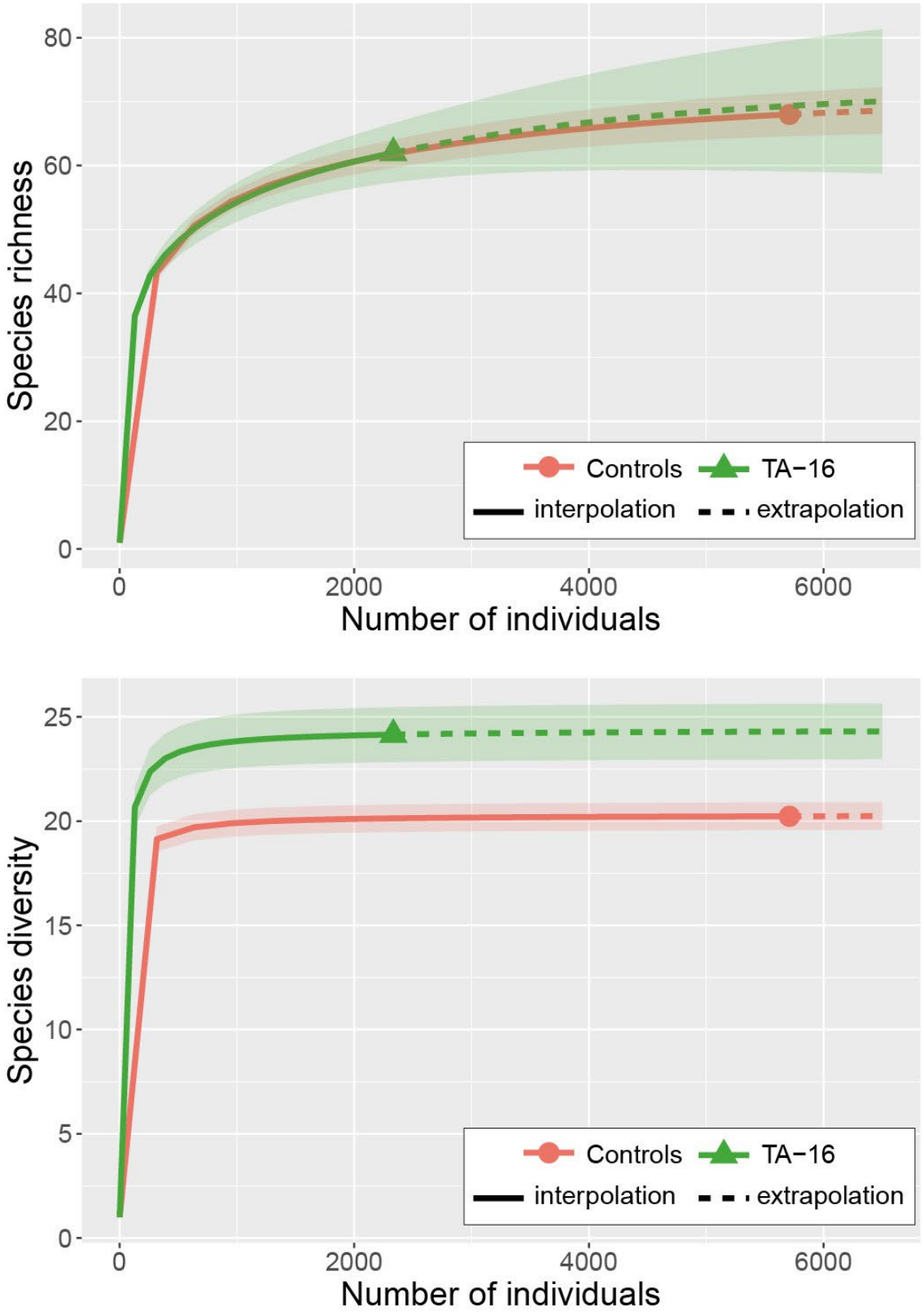

Figure 6. 2013 – 2020 Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls. Top is "A" and bottom is "B".

Table 6. Top 10 most common species of birds observed at TA-39 during Early Years (2013 – 2015) and Later Years (2016 – 2020)

Early Years		*Later Years*	
Species	*Abundance*	*Species*	*Abundance*
Ash-throated Flycatcher	60	**House Finch**	186
Spotted Towhee	51	Cassin's Kingbird	160
House Finch	48	Chipping Sparrow	99
Mourning Dove	45	**Lesser Goldfinch**	85
Juniper Titmouse	42	**Spotted Towhee**	79
Western Bluebird	36	Violet-green Swallow	77
Gray Flycatcher	31	Rock Wren	72
Bewick's Wren	28	**Western Bluebird**	64
Lesser Goldfinch	25	Western Wood-Pewee	59
Woodhouse's Scrub-Jay	22	White-winged Dove	53

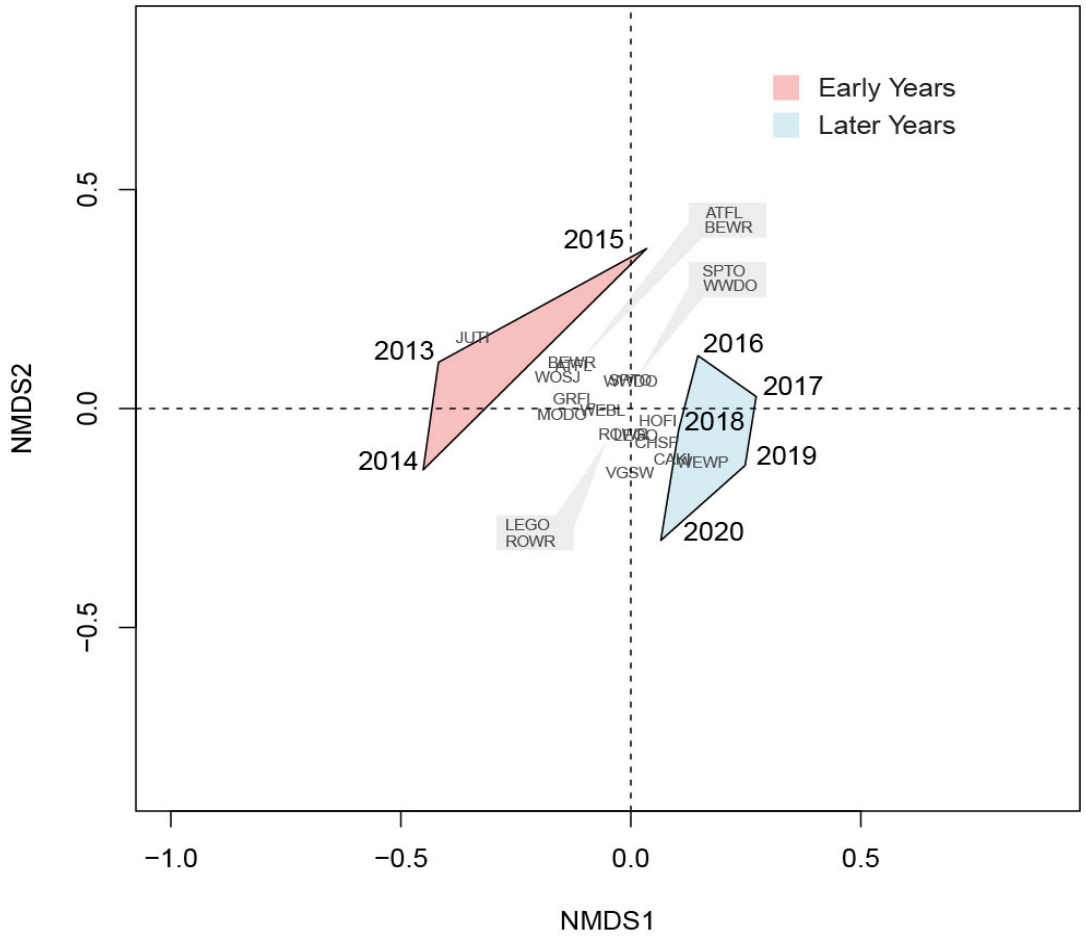

Figure 7. Non-metric multidimensional scaling (NMDS) of bird species and years at the TA-39 treatment site

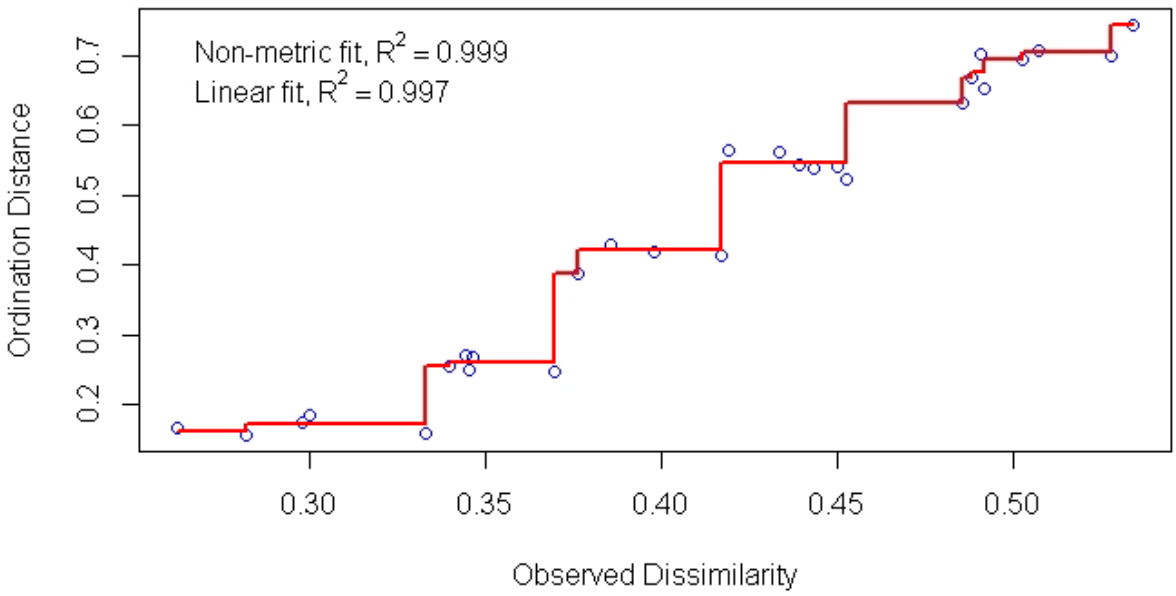

Figure 8. Shepard diagram of NMDS ordination for the TA-39 treatment site

The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower when compared with the PIPO 1 and PIPO 2 control sites. Table 7 compares the abundance between the treatment and control sites over time. Similar to the species richness trends, there was an increase in abundance in 2015. The fluctuations in bird abundances were not alarming, and the differences between the treatment sites and control sites were not biologically significant. The moisture for the winter of 2018 – 2019 was at or slightly above normal, but the species abundance at all sites were similar to previous years. The abundance increased in 2020, except at Minie, despite below average moisture for the winter of 2019 – 2020.

Table 7. Changes in species abundance over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Minie	193	186	275	210	222	242	245	203
TA-39	177	193	260	249	261	315	298	413
PJ Control 1	187	157	269	312	240	235	226	292
PJ Control 2	181	177	301	228	300	168	187	269
TA-16	220	209	347	271	302	285	310	389

PIPO Control 1	258	223	432	323	447	374	364	373
PIPO Control 2	256	254	371	396	449	366	394	429

Nestboxes

During the 2020 nesting season, LANL biologists actively monitored 15 nestboxes at each treatment site. We monitored 157 nestboxes throughout the overall avian nestbox network, without the three treatment sites. Of those, 117 contained active nests and 69 of those nests fledged young successfully. This was an overall occupancy rate of 58% with a 59% success rate.

Tables 7 and 8 compare the occupancy and nest success rates for each treatment site and the overall nestbox network since 2015.

Table 8. Comparison of occupancy for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
Overall Network	40%	45%	48%	53%	44%	58%
Minie	66%	73%	46%	20%	60%	47%
TA-39	8%	58%	20%	33%	13%	27%
TA-16	-	73%	100%	53%	87%	87%

Table 9. Comparison of nest success for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
Overall Network	66%	69%	57%	49%	51%	59%
Minie	64%	23%	29%	33%	44%	86%
TA-39	100%	57%	0%	40%	0%	75%
TA-16	-	63%	76%	63%	54%	54%

In 2020, there were six successful nests that fledged young at Minie, three at TA-39, and seven at TA-16. Occupancy at TA-39 was low in comparison to the other treatment sites and the overall network. The nest success rate at TA-39 seemed to fluctuate in 2020 since the occupied nestboxes had a higher success rate compared to previous years. TA-39 is the lowest elevation treatment site and occupancy has been decreasing over time at this site and surrounding areas of the avian nestbox network. Wysner et al. (2019) found that Western Bluebirds, one of the target species of the network, have increased their nesting elevation over time in the study area. Western Bluebirds have the highest occupancy rates throughout the nestbox network, and the shift in nesting elevation could be driving the lower occupancy rates at TA-39. Occupancy and success rates at the other two treatment sites seem to be fluctuating naturally in comparison to the overall network and have not displayed a decreasing trend over time.

In 2020, LANL biologists submitted nonviable eggs collected from nestboxes at the treatment sites and the rest of the nestbox network to an analytical lab for chemical analyses. These data will be presented in a separate report.

MANAGEMENT RECOMMENDATIONS

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 63 species detected at the three treatment sites, the Migratory Bird Treaty Act protects all but one species. The Eurasian Collared-Dove is not native and therefore not protected under the Migratory Bird Treaty Act. In addition, LANL biologists have documented sensitive species from the Sensitive Species Best Management Practices Source Document (Berryhill et al. 2020) and the Birds of Management Concern and Focal Species list (USFWS 2011) at the treatment sites. Those species are the Juniper Titmouse, Grace's Warbler, Virginia's Warbler, Black-throated Gray Warbler, and the Mourning Dove. Sensitive species documented at the control sites are the Cassin's Finch and the Gray Vireo. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901).

Continuing the research reported herein will provide a long-term dataset for the ecological health of avifauna at the three treatment sites at LANL. In addition, this research contributes to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and it allows LANL to contribute to national goals in avian conservation monitoring and research.

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APPENDIX 1. ALL BIRDS RECORDED AT THE THREE TREATMENT SITES FROM 2013–2020

Species	TA-36 Minie Site – Pinyon-Juniper Woodland								TA-39 Point 6 – Pinyon-Juniper Woodland								TA-16 Burn Grounds – Ponderosa Pine Forest							
	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
Acorn Woodpecker																	5		3	2	3	5	3	5
American Crow																					1	1		1
American Kestrel				1				1	1			2												
American Robin	1	1	2		2				1	1		2		4	2		7		9	4	4	6	12	6
Ash-throated Flycatcher	11	5	14	13	13	10	17	12	19	11	30	12	8	8	6	11	3	5	6	2	3	8	4	6
Audubon's Warbler		2				5						2				5	6	5	1	6		1	11	14
Bewick's Wren	4	8	9	9	14	14	5	10	3	10	15	9	2	8	1	2								
Black-chinned Hummingbird		1	1				1	2	3	2				1	2	3	1		1		1		1	12
Black-headed Grosbeak	1	3				1	1	2		2	4	1		3	2	1			1	2		2		1
Black-throated Gray Warbler			1		2			2	5	6	4													
Blue-gray Gnatcatcher	3	14	16	8	10	9	8	11	2		7	5	4	2	13	5		6	2	1	3	6	4	9
Broad-tailed Hummingbird	2	1	3		1		3	2	3	1	2		3	1	2	9	5	11	11	5	7	10	8	
Brown Creeper																	1							
Brown-headed Cowbird	1										2			3	2	10	4	1			4	2	8	4
Bushtit		2		2		11			2	14			1	12		2								
Canada Goose											16				2									
Canyon Towhee	2		5	3	6	2	3	5	1	1	2	10	13	19	6	3	1			1		1		
Canyon Wren					1						2	3	8	6	2	4			2					
Cassin's Finch						4																		
Cassin's Kingbird	6	13	13	5	2	5	6	5	7	6	2	21	21	32	37	49				1				2
Chipping Sparrow	3	16	17	29	6	22	10	10	6	6	5	8	15	25	27	24	1	5	3	10	5	21	8	32
Clark's Nutcracker																		4		1				
Common Nighthawk	6		5	2	4	4	1	5	5	1	3	2	7	5	7	3			1	2	2			1
Common Raven	2	5	1		1	2	3		1		2	1		1	2	5	5	6	2	2	5	5	7	4
Cooper's Hawk					1												1			1			1	
Cordilleran Flycatcher																	5	10	6	3	3	1	2	4
Dark-eyed Junco														1	1		6	2	4		5	2		2
Downy Woodpecker				1								1	2		1	2		1		1	1	1		
Dusky Flycatcher				1							1		1											2
Eurasian Collared-Dove	3												4			2						1		
Evening Grosbeak	3		4								8						5		29			1		
Grace's Warbler							1							2	4	1	6	4	4	8	5	8	22	12

Species	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
	TA-36 Minie Site								TA-39 Point 6								TA-16 Burn Grounds							
	Pinyon-Juniper Woodland								Pinyon-Juniper Woodland								Ponderosa Pine Forest							
Gray Flycatcher	12	6	5	7	3	6	3	2	10	10	11	10	5	8	3	14								
Great Horned Owl		3							1															
Green-tailed Towhee	3	1							1															1
Hairy Woodpecker			2	1		1		1			5	3			1	1	1	1		1	1	2	1	1
Hammond's Flycatcher																	8	9	12	5	7	5	10	5
Hepatic Tanager											1	2	1	2						1				
Hermit Thrush						1												4	6	1	2	2	5	5
House Finch	16	17	26	17	12	18	17	11	21	4	23	9	30	44	50	53	16	2	5	5	12	7	12	18
House Wren															1		1	1		2	2	6	8	2
Juniper Titmouse	12		7	6	9	3	26	8	11	13	18	6	1			3								
Lesser Goldfinch	2	6	7	4	9	12	8	4	4	12	9	10	14	19	15	27	3		8	9	4	8	5	6
MacGillivray's Warbler																				1	3			1
Mountain Bluebird		2	20	10	11	1	9	3		4						2			4	4	4	7	4	5
Mountain Chickadee	5	2	1	2								1	1		1		5	8	9	6	8	9	1	4
Mourning Dove	17	17	13	5	8	8	11	9	13	22	10	3	15	11	8	10	4		1	3	17	3	5	17
Northern Mockingbird					2		1	4		1														
Northern Rough-winged Swallow						3																		
Orange-crowned Warbler																								1
Peregrine Falcon											1													
Pine Siskin	10	2		5	1			1	6		3	3					12	4	5		4	2		6
Plumbeous Vireo	10	10	7	3	9	9	15	3	1		1	6	6	5	5	12	11	16	15	14	11	18	16	24
Pygmy Nuthatch				2		2	3				2	4	12	9	11	10	11	13	26	29	41	20	16	23
Red Crossbill					1					2						1		2	9	13	9		6	26
Red-shafted Flicker	3	1	3	2	5	2	1		3	2	4	8		3	2	2	3	4	11	11	5	5	2	7
Red-tailed Hawk							1	2			1	1	1	1										
Rock Wren	3	3	4		2	10	11	10	7	10	4	12	14	14	12	20	1	2	2	6			4	1
Ruby-crowned Kinglet																						2		
Savannah Sparrow																								1
Say's Phoebe	2	1	2		2	5	1	1	2	1		5	2	4		6	1		1	3	3	4	1	1
Scaled Quail			1																					
Spotted Towhee	17	8	19	27	32	24	19	20	12	6	33	16	12	16	15	20	11	18	16	14	21	22	34	24
Steller's Jay							1										3	2	5	6	3	4	4	2
Townsend's Solitaire	1																				1			
Turkey Vulture					1			2								1	1					1		
Vesper Sparrow																							1	
Violet-green Swallow		5	7	1	3	2	1	6	6	4	1	9	6	6	9	47		2	19	2	2	4	2	7

Species	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
	TA-36 Minie Site								TA-39 Point 6								TA-16 Burn Grounds							
	Pinyon-Juniper Woodland								Pinyon-Juniper Woodland								Ponderosa Pine Forest							
Virginia's Warbler					1	3	1				1	2	4		5		17	11	21	13	7	5	5	8
Warbling Vireo						2											2	9	7	6	5	4	6	3
Western Bluebird	15	11	18	17	16	19	21	23	5	19	12	21	13	6	7	17	20	20	49	37	32	27	20	27
Western Tanager		2	3		1					2	1	1	2	2	6	1	2	3	7	2	4	6	16	10
Western Wood-Pewee	10	8	18	11	10	7	18	14		4	2	10	8	11	12	18	15	10	16	14	22	20	24	28
White-breasted Nuthatch	1	4	9	10	13	5	2	1			2	4	4	2	6	3	9	8	7	9	20	10	10	8
White-throated Swift										1						2								
White-winged Dove	1	5	9	2		3	2	1	7	5	6	16	15	15	5	2			1	2			1	
Woodhouse's Scrub-Jay	5	1	3	4	8	7	14	10	8	10	4	8	6	4	5		1							

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 13 – Gadek & Velardi 2021

Environmental Report:

Gadek, C.R. and M. S. Velardi, October 2021. *2021 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory*. LA-UR-21-30407.

October 2021

2021 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

Los Alamos NATIONAL LABORATORY

Prepared by: **Chauncey Gadek and Milu Velardi, Environmental Protection and Compliance Division, Environmental Stewardship Group, Los Alamos National Laboratory**

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Executive Summary

Los Alamos National Laboratory (LANL) biologists in the Environmental Protection and Compliance Division initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. In this annual report we compare monitoring results from these efforts among years to assess trends in local migratory bird communities. The objectives of this study are to 1) determine whether LANL operations impact bird abundance, species richness, or diversity, and 2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. LANL biologists completed the ninth year of this effort in 2021.

Between May and July 2021, we completed three avian point count surveys at each of the treatment sites which are the Technical Area (TA)-36 Minie site, the TA-39 point 6, and the TA-16 burn ground. We recorded a total of 778 birds representing 58 species at the three treatment sites and compared these results to data from their associated control sites. We also compared occupancy and nest success data from nestboxes at treatment sites with the overall avian nestbox monitoring network.

In 2021, abundance and species richness at treatment and control sites continued to trend similarly from year to year with minor random deviations. Though richness remained stable across all sites, three new bird species were observed at the treatment sites: Blue Grosbeak, White-crowned Sparrow, and Willow Flycatcher indicative of a healthy avian community. The species diversity at the TA-36 Minie site and TA-39 were statistically higher than their associated controls. The species diversity at all three treatment sites has been consistently lower at control relative to treatment sites, likely due to subtle habitat differences. The slightly elevated diversity at treatment sites in 2021 is not unexpected and shows no clear pattern of diverging with diversity at treatment sites. Overall diversity remains high across all sites relative to similar habitats.

Nestbox occupancy and success continue to fluctuate annually, though all three treatment sites experienced decreases in nest success between 2020 and 2021, likely driven by extremely low precipitation levels during winter of 2020.

The overall results from 2021 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations. This long-term project will continue to monitor for any changes over time.

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Introduction

As part of the Resource Conservation and Recovery Act permit process, Los Alamos National Laboratory (LANL) started an annual avian monitoring program in 2013. The permit was for two open detonation sites, Technical Area (TA)-36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018, 2019; Sanchez et al. 2020; Rodriguez and Abeyta 2021). The objectives of this long-term monitoring program are to (1) determine whether LANL operations impact bird abundance, species richness, or diversity, and (2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. This involves comparing community and nestbox metrics at treatment sites with control sites of similar habitat that LANL biologists have surveyed since 2011 (Hathcock et al. 2011).

LANL biologists used standard point count methodology to record avian abundance, richness, and diversity along transects at the three treatment sites and their associated control sites during the summer of 2021. Summer surveys provide information about which bird species are breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental changes at LANL.

In addition to avian point counts, LANL biologists monitored nestboxes around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success were compared to the overall avian nestbox monitoring network, which was established in 1997 (Fair and Myers 2002).

Methods

Field Methods for Point Count Surveys

LANL biologists conducted the point count surveys along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon (*Pinus edulis*) – juniper (*Juniperus monosperma*) woodland (PJ) for Minie (Figure 1) and TA-39 (Figure 2) and a ponderosa pine (*Pinus ponderosa*) forest (PIPO) at TA-16 (Figure 3). The habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) are monitored annually. The control sites were originally established in 2011 (Hathcock et al. 2011). Each habitat type control contained two replicate transects that LANL biologists monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects are monitored randomly.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was in an undeveloped area.

Transects were approximately 2.0 to 2.5 km in length with nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 11 through July 9. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site conducted between 0.5 hours before sunrise and four hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor looks and listens for five minutes, recording all birds encountered at each point on a data sheet. For each observation, the minimum data collected is point number, time, species, number of individuals, and distance from the point. The observation distance is considered as an “unlimited-distance circular plot”; however, surveyors record the distance to each bird out to an estimated 100 m. A range finder should be used if available. Surveyors avoid re-counting individuals between points.
- While walking between points, surveyors record any obvious species not recorded at the previous point that also wouldn’t be counted at the next point. Surveyors do not spend excess time looking for birds between points.
- Surveys are not conducted during rain events or winds greater than 24 kph.
- Surveyors use the “NOTES” section to indicate any additional information about the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Surveyors record other wildlife or unusual sightings that could be used for other projects.

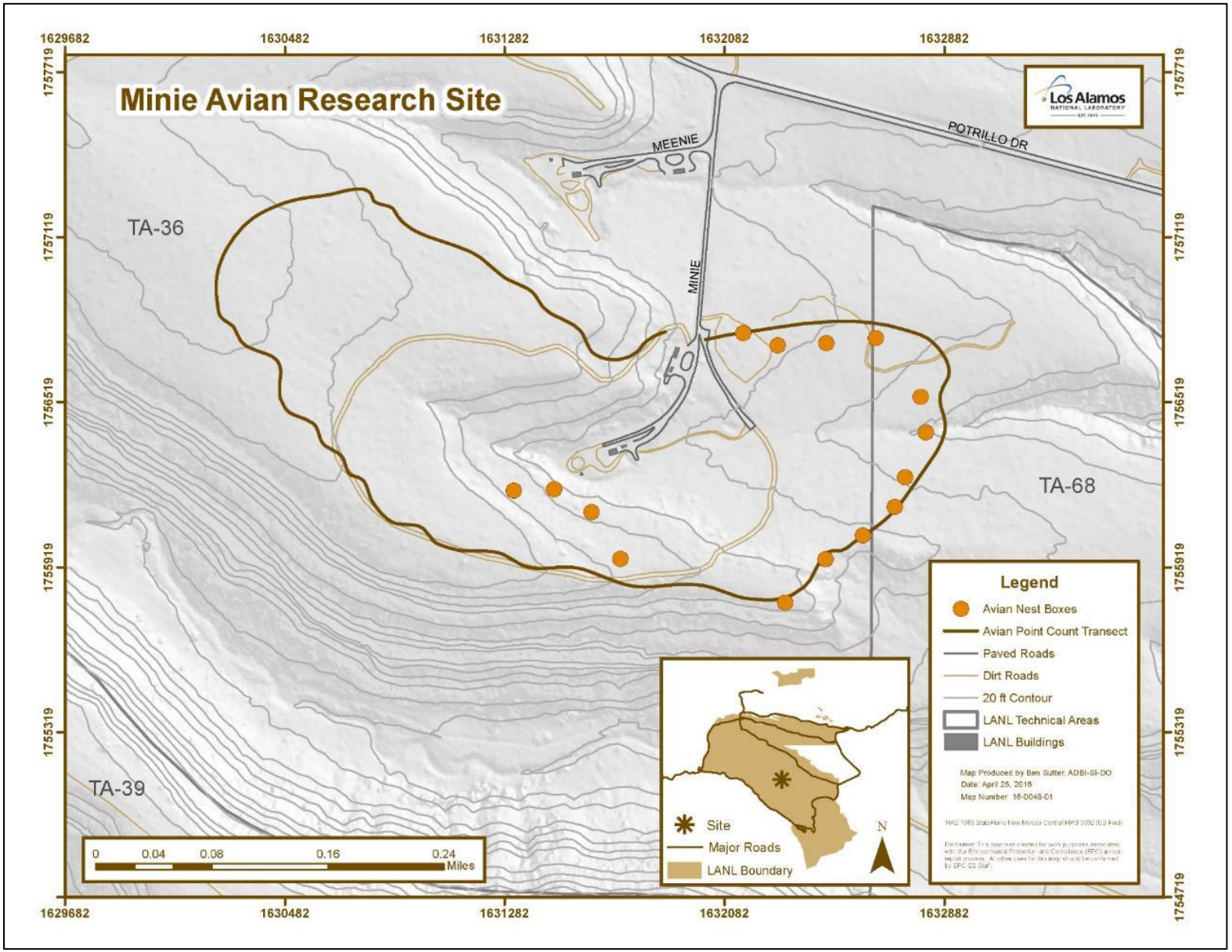

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie Site

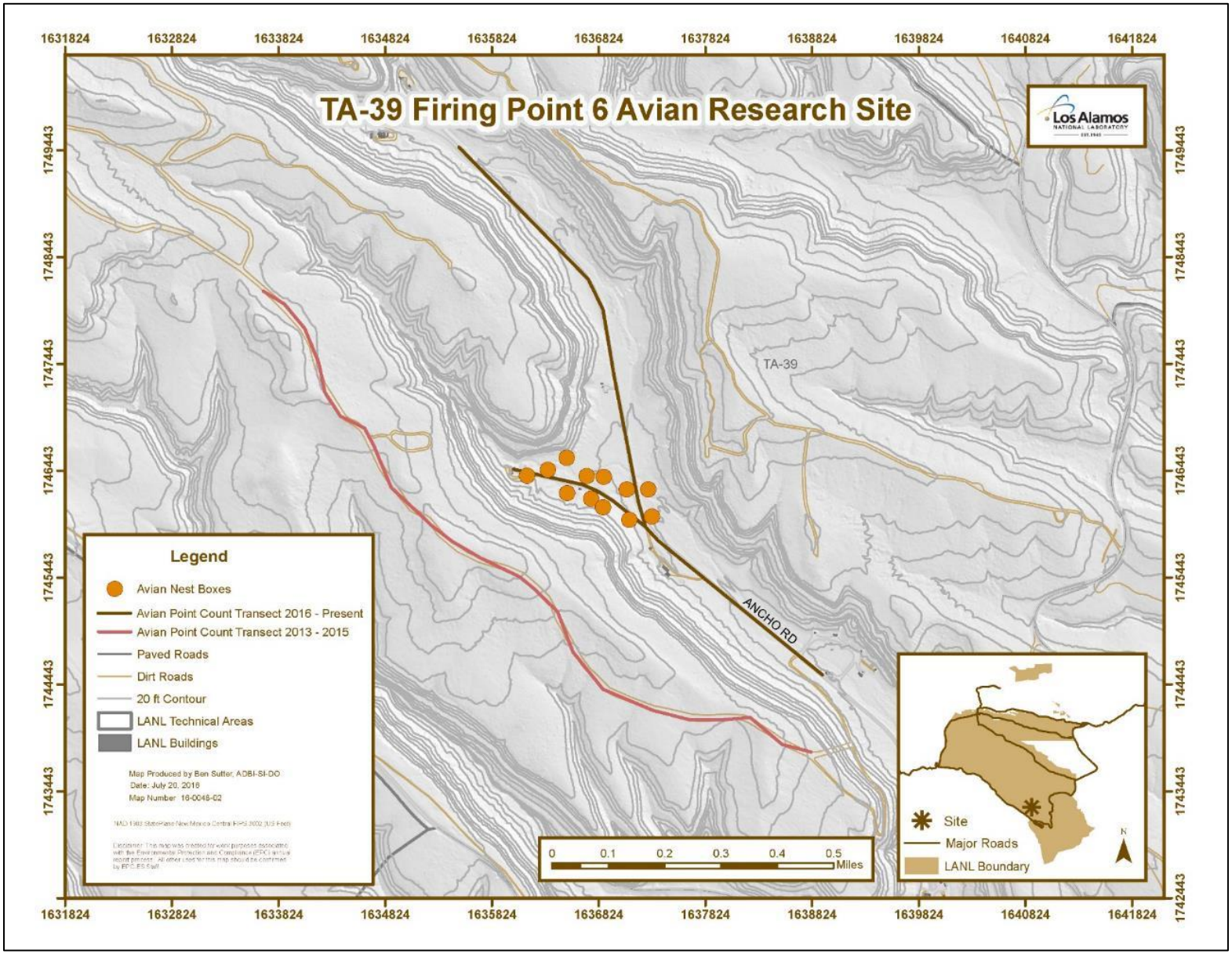

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 Point 6

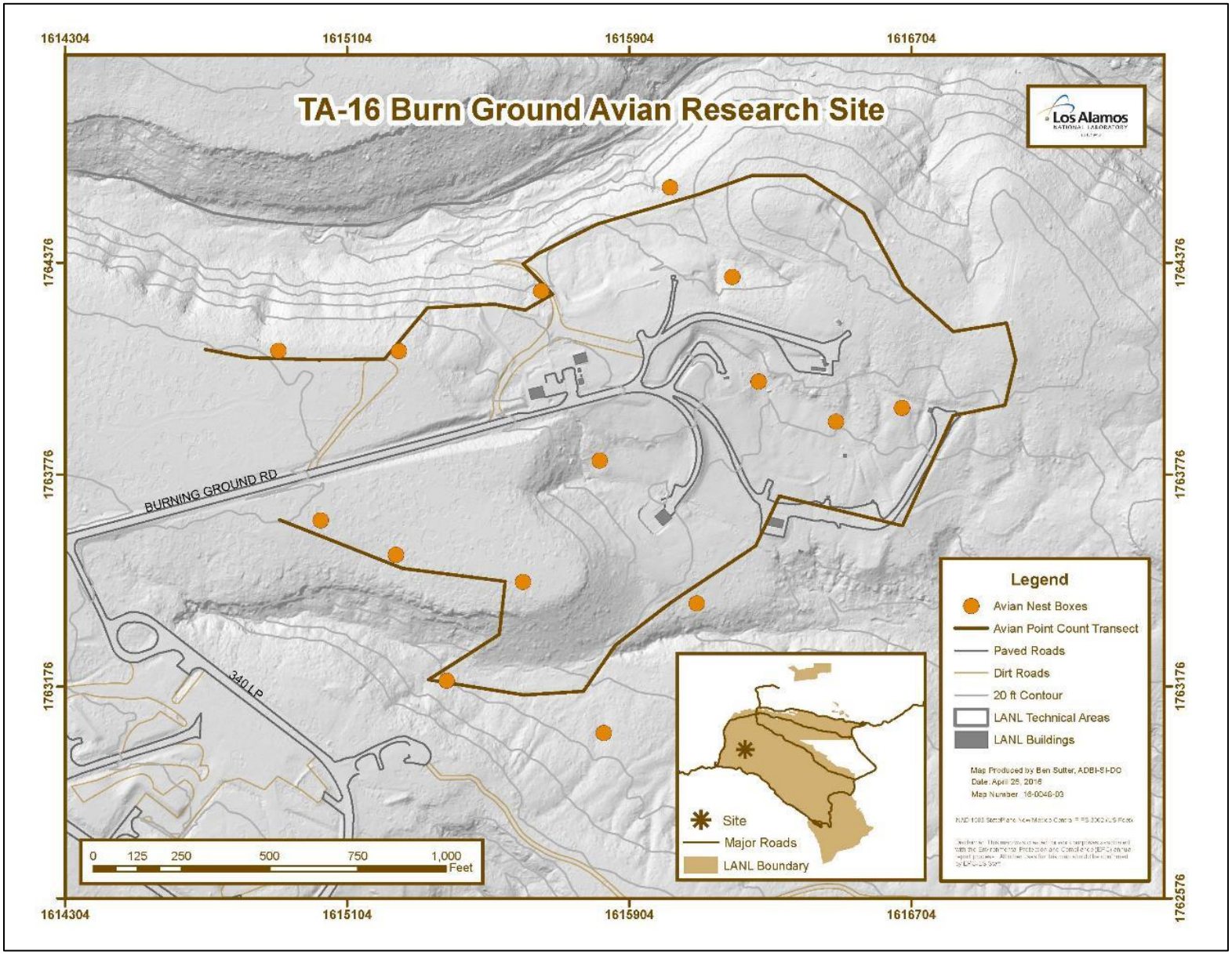

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 Burn Ground

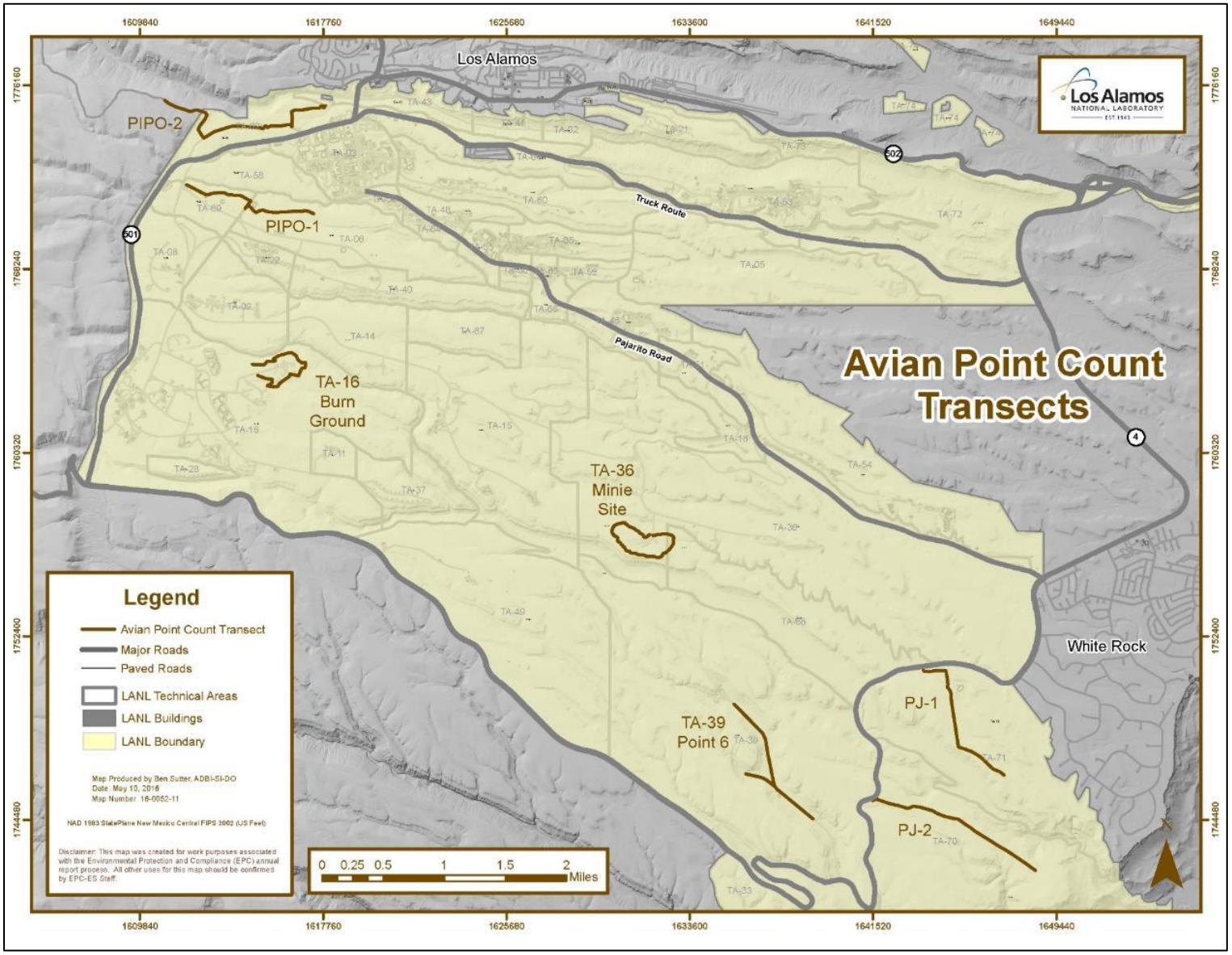

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Statistical Methods for Point Counts

We summarized these data to compare abundance, species richness, and diversity between treatment and control sites and over time. We considered each treatment site and control to be individual communities. Abundance is the total number of individuals recorded of a given species (Gotelli and Colwell 2011). Species richness is the number of different species represented in an ecological community and is simply a count of species (Boulinier et al. 1998). Species diversity is a measure that takes into account species richness and the overall abundance to compare evenness across a community (Tramer 1969). As a species diversity metric, we used Shannon's diversity index which measures the probability that two individuals randomly selected from a sample will belong to different species (Shannon and Weaver 1949).

We calculated species richness, diversity, and abundance using the statistical software R (version 4.1.0; R Core Team 2021) and the package *vegan* (Dixon 2003). We used the Shannon's diversity index to compare diversity between habitats (Clarke et al. 2014). Shannon's diversity ranges for most ecological systems are between 1.5 and 3.5, and are rarely greater than 4.5, where high values indicate high diversity. We used a Hutcheson's T-test in the R package *ecolTest* (Salinas and Ramirez-Delgado 2021) to test for differences between treatment and combined control site diversity each year.

In September of 2020, biologists and concerned citizens documented a large avian mortality event across New Mexico (NMDGF 2020). While researchers have yet to determine the causal factors of the die-off, an anomalous early cold front and record breaking wildfires along the Pacific coast coincided with the event. In 2021, LANL biologists predicted to see a decrease in species richness due to the mass mortality event in 2020. To test for a signal of the avian mortality event, we looked for differences in richness and abundance between 2020 and 2021 using a repeated measures ANOVA framework with transect as a repeated measurement in the R package *lme4* (Bates et al. 2015). Because bird species recovered from the 2020 mortality event tended to be insectivores (D'Ammassa 2020), we also binned all species in two major summer feeding guilds (insectivores and omnivores) in the ANOVAs.

Field Methods for Nestbox Monitoring

In 2011, LANL biologists added nestboxes to Minie and TA-39 (Figures 1 and 2). In 2015, biologists added nestboxes to TA-16 (Figure 3). We monitored nestboxes every one to two weeks for active nests. When an active nest was found, we monitored it more frequently to determine whether the nest failed or successfully fledged young. We also banded nestlings and determined the sex after the age of 10 days. We compared the data from the nestboxes at the treatment sites to the data from the overall nestbox network at LANL.

Statistical Methods for Nestboxes

We calculated occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network. For any single site or overall, the occupancy rate was the number of

active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. We compared the 2021 data from the three treatment sites with the overall avian nestbox network at LANL which was established in 1997 (Fair and Myers 2002).

Results and Discussion

Point Count Surveys-Year 2021

LANL biologists completed three surveys at each of the three treatment sites and the associated control sites between May and July 2021. Table 1 summarizes the species richness, diversity, and abundance for 2021 for each treatment and control site. A total of 778 birds representing 58 species were recorded at the three treatment sites. A full account of the 2013 – 2021 data is detailed in Appendix 1.

Table 1. The species richness, diversity, and abundance recorded at all treatment and control sites in 2021

	Minie	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	33	38	33	25	37	36	44
Diversity	3.00	3.03	2.82	2.54	3.20	3.01	3.22
Abundance	209	286	225	159	283	349	448

Abundance

Overall bird abundance has trended similarly for both treatment and control sites (Figure 5 & Table 2). Overall abundance has tended to increase since 2013 with minor fluctuations. The fluctuations in bird abundances were not alarming, and abundances at treatment sites and control sites have continued to trend together (Figure 5). Bird abundances seems to partially track winter precipitation levels with 2015-2017 representing the wettest winters in our dataset (NOAA 2021). Abundance values marginally decreased in 2021, with the exception of Minie and PIPO-2 sites, potentially driven by extreme drought conditions during winter 2020 and spring 2021 (NOAA 2021).

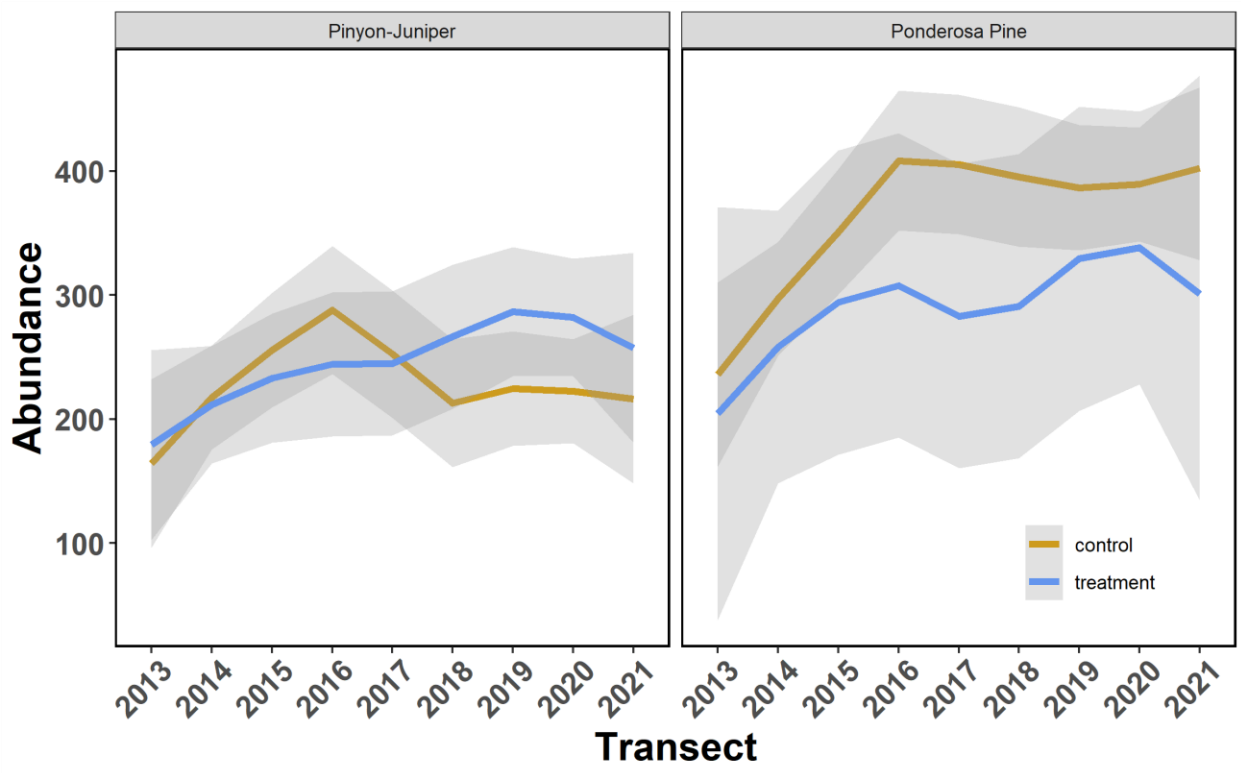

Figure 5. Abundance values by year averaged across treatment (blue line) and control sites (orange line). Shaded gray areas represent local smoothed 95% CI.

Table 2. Changes in species abundance over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Minie	193	186	275	210	222	242	245	203	209
TA-39	177	193	260	249	261	315	298	413	286
PJ Control 1	187	157	269	312	240	235	226	292	225
PJ Control 2	181	177	301	228	300	168	187	269	159
TA-16	220	209	347	271	302	285	310	389	283
PIPO Control 1	258	223	432	323	447	374	364	373	349
PIPO Control 2	256	254	371	396	449	366	394	429	448

Species Richness

Figure 6 & Table 3 illustrate changes in species richness over time at the treatment and individual control sites. Overall the mean richness at treatment sites has remained stable with small annual fluctuations since monitoring began (Figure 6 & Table 3). Species richness at both treatment and control sites have largely trended together with average richness at treatment sites slightly increasing in 2015- 2017, similar to abundance values, suggesting richness may also be influenced by winter precipitation.

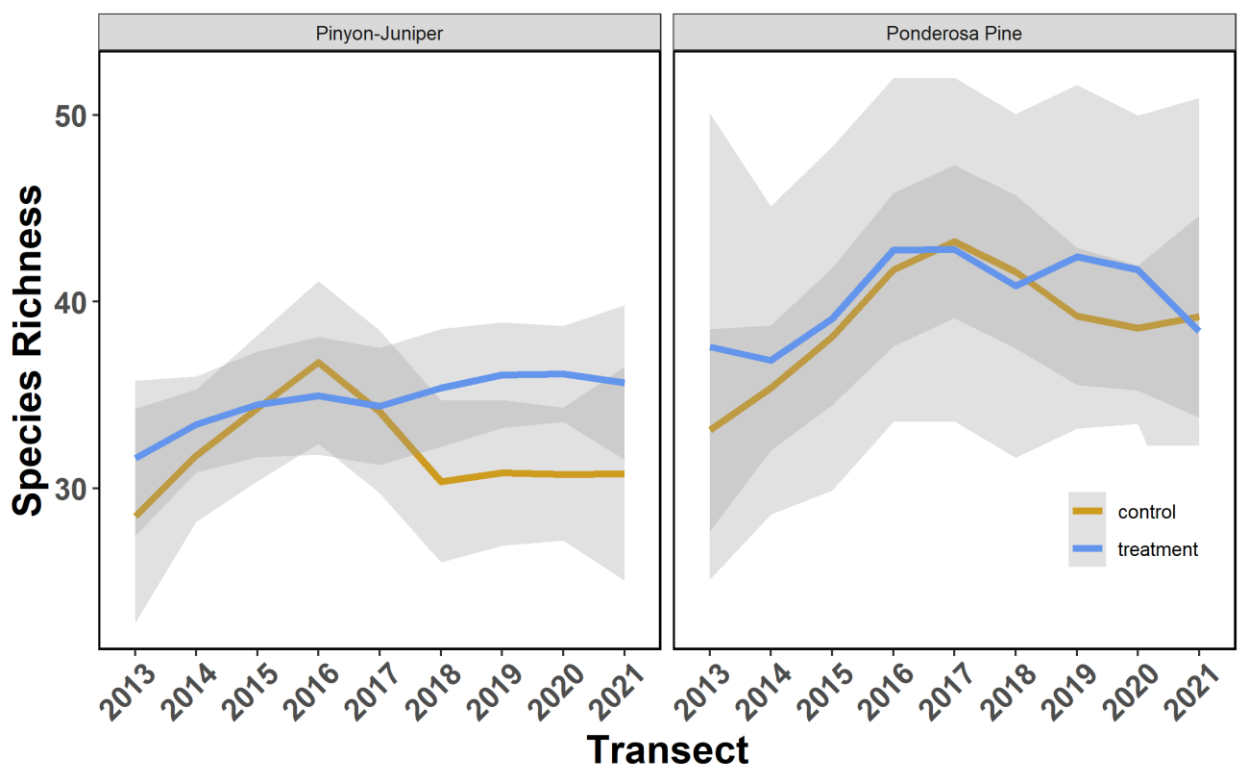

Figure 6. Species richness values by year averaged across treatment (blue line) and control sites (orange line). Shaded gray areas represent local smoothed 95% CI.

Table 3. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Minie	33	33	34	30	35	35	34	33	33
TA-39	31	31	39	38	34	36	38	40	38
PJ Control 1	29	30	33	36	37	30	30	37	33
PJ Control 2	30	29	37	33	39	23	33	32	25
TA-16	39	33	40	44	41	43	39	46	37

PIPO Control 1	34	34	30	40	46	40	41	33	36
PIPO Control 2	33	36	43	43	44	39	40	40	44

Diversity

Figure 7 and Tables 4 – 6 compare the species diversity over time between the treatment site and the combined controls. We combined the two control sites to analyze diversity because we were interested in the relative abundances among species. Significant differences in diversity between sites by year are indicated in bold font with a darker shading. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is around 3, which—compared with ecological systems in general—is very high.

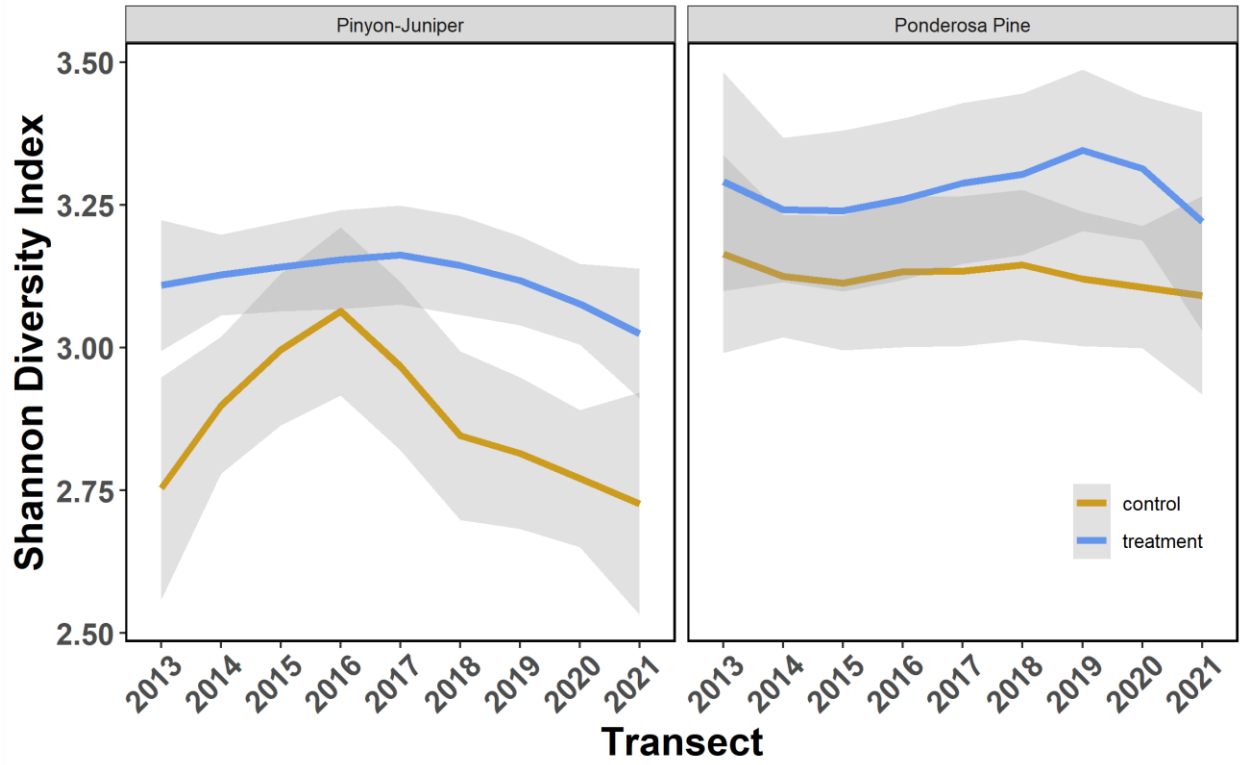

Figure 7. Shannon diversity index values by year averaged across treatment (blue line) and control sites (orange line). Shaded gray areas represent local smoothed 95% CI.

Table 4. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Minie	3.14	3.14	3.19	2.97	3.13	3.21	3.06	3.13	3.00
PJ Control	2.88	2.99	3.16	3.07	3.24	2.94	2.97	2.98	2.80
Hutcheson's t-test	**t = 3.34 df = 523 p < 0.001**	t = 1.97 df = 468 p = 0.05	t = 0.55 df = 683 p = 0.58	t = -1.34 df = 473 p = 0.18	t = -1.53 df = 515 p = 0.13	**t = 4.07 df = 599 p < 0.0001**	t = 1.29 df = 634 p = 0.20	**t = 2.23 df = 528 p = 0.03**	**t = 2.41 df = 532 p = 0.02**

Table 5. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
TA-39	3.09	3.07	3.13	3.32	3.18	3.13	3.08	3.07	3.03
PJ Control	2.88	2.99	3.16	3.07	3.24	2.94	2.97	2.97	2.80
Hutcheson's t-test	**t = 2.64 df = 481 p < 0.01**	t = 1.08 df = 488 p = 0.28	t = -0.28 df = 492 p = 0.78	**t = 3.91 df = 690 p < 0.00001**	t = -1.00 df = 693 p = 0.32	**t = 2.83 df = 702 p < 0.01**	t = 1.46 df = 673 p = 0.15	t = 1.49 df = 945 p = 0.14	**t = 2.73 df = 644 p < 0.01**

Table 6. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
TA-16	3.30	3.21	3.23	3.29	3.24	3.36	3.29	3.36	3.20
PIPO-Control	3.26	3.22	3.16	3.21	3.20	3.17	3.31	3.18	3.22
Hutcheson's t-test	t = 0.71 df = 419 p = 0.48	t = -0.28 df = 517 p = 0.78	t = 1.30 df = 702 p = 0.20	t = 1.18 df = 524 p = 0.24	t = -0.91 df = 549 p = 0.36	**t = 3.07 df = 598 p < 0.005**	t = -0.46 df = 659 p = 0.65	**t = 3.42 df = 842 p < 0.001**	t = -0.24 df = 583 p = 0.81

Detecting 2020 Mass Mortality Event

Though upwards of 100,000 birds are thought to have died in the mass mortality event last September (NMDGF 2020), repeated measures ANOVAs between years and foraging guilds, controlled for transect, showed no significant difference in abundance or richness between 2020 and 2021 (Figure 8). It is likely that most of the birds involved in the die-off, were migrants flying through New Mexico and therefore did not contribute to local breeding populations.

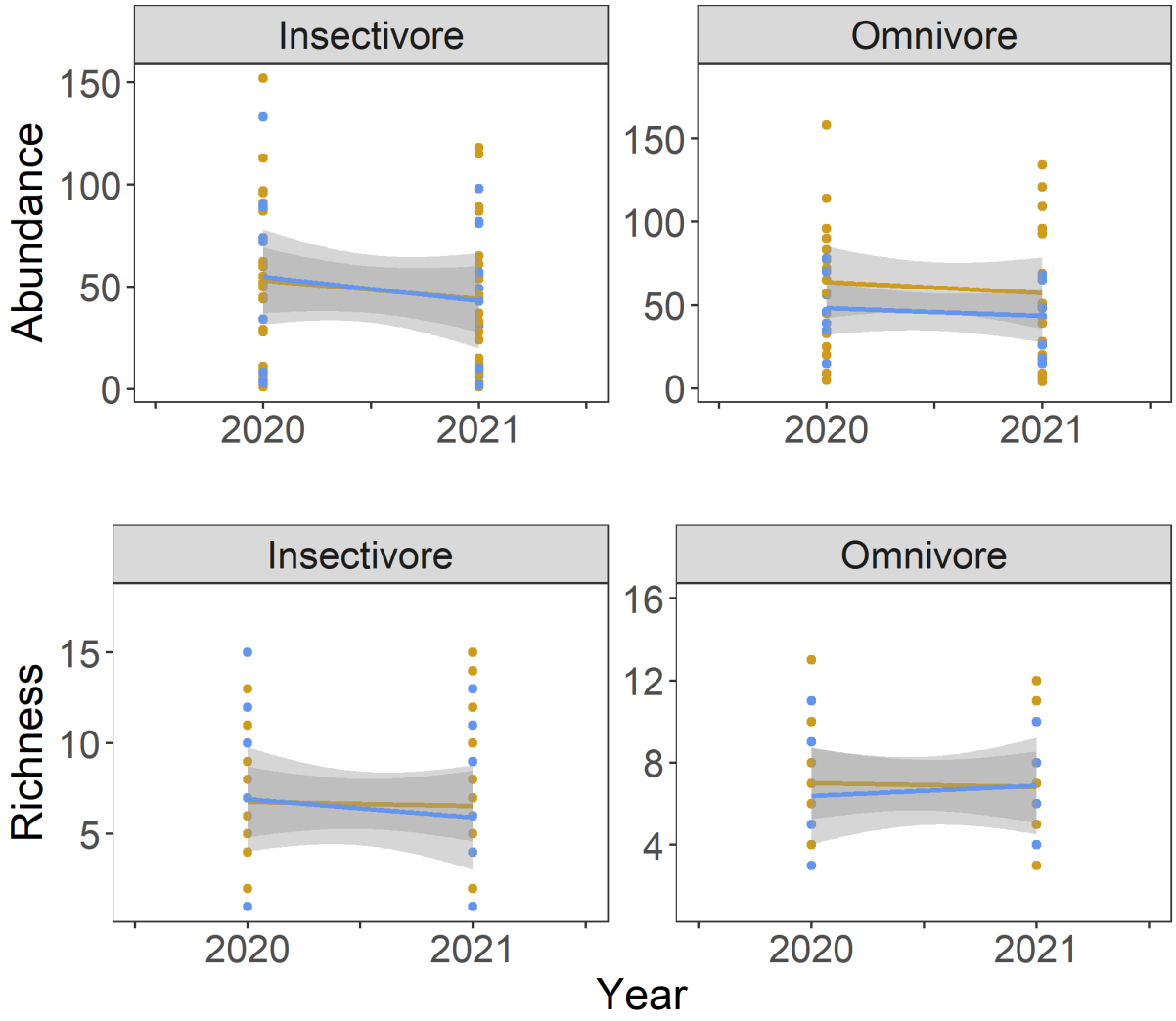

Figure 8. Richness compared between 2020 and 2021 for two major summer foraging guilds between control sites (orange) and treatment sites (blue).

Nestboxes

During the 2021 nesting season, LANL biologists actively monitored 15 nestboxes at each treatment site and a total of 365 nestboxes throughout the overall avian nestbox network. Of those, 110 contained active nests and 49 of those nests fledged young successfully for an overall

occupancy rate of 30% and a 45% success rate. Both the occupancy and success rates for 2021 were the lowest recorded since the start of the nestbox monitoring at firing sites in 2015 (Tables 7 & 8). Figure 9 and Tables 7 and 8 compare the occupancy and nest success rates for each treatment site and the overall nestbox network since 2015.

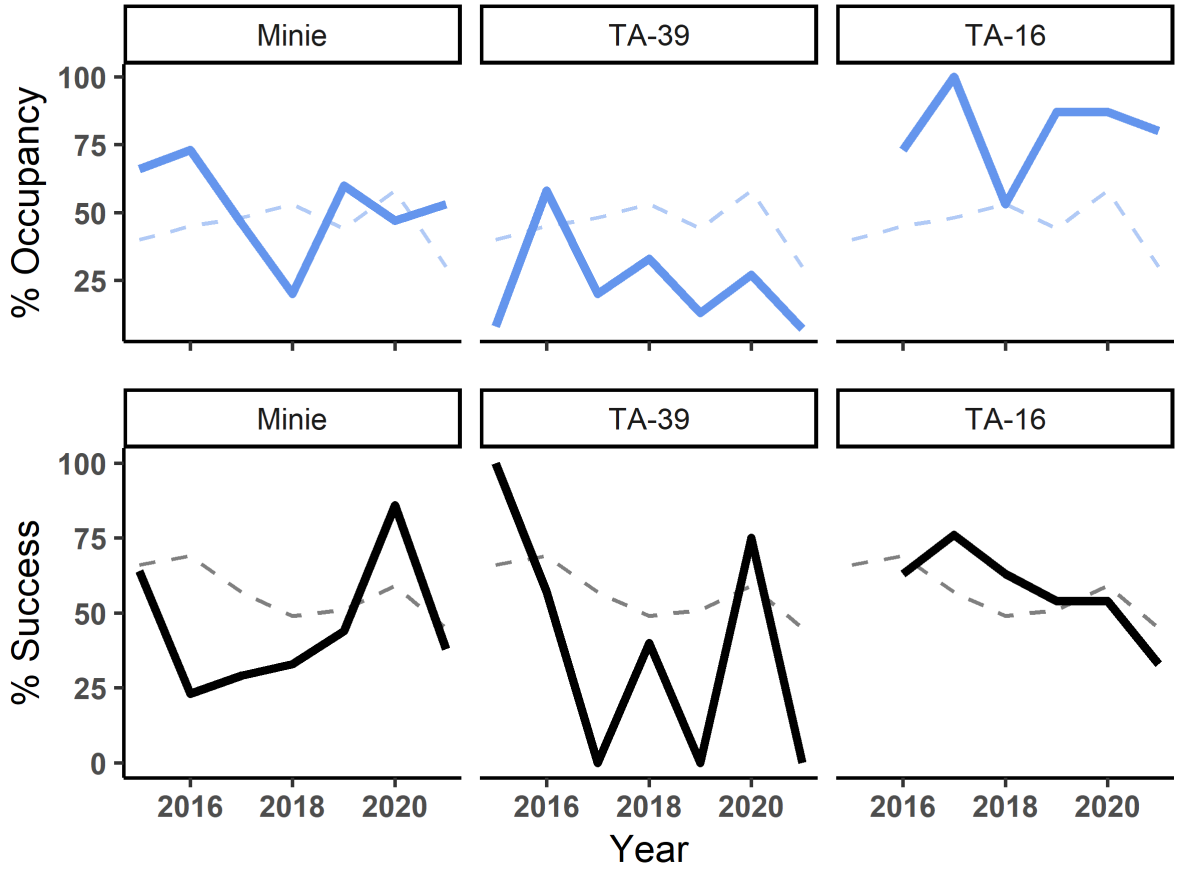

Figure 9. Nestbox occupancy (blue line; top) and success (black line; bottom) plotted by year for the three treatment sites. Dashed lines are global yearly mean for occupancy and success combined across all sites.

Table 7. Comparison of occupancy for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Overall Network	40%	45%	48%	53%	44%	58%	30%
Minie	66%	73%	46%	20%	60%	47%	53%
TA-39	8%	58%	20%	33%	13%	27%	7%

TA-16	-	73%	100%	53%	87%	87%	80%

Table 8. Comparison of nest success for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Overall Network	66%	69%	57%	49%	51%	59%	45%
Minie	64%	23%	29%	33%	44%	86%	38%
TA-39	100%	57%	0%	40%	0%	75%	0%
TA-16	-	63%	76%	63%	54%	54%	33%

In 2021, there were three successful nests that fledged young at Minie, four at TA-16, and zero at TA-39. Occupancy at TA-39 was also low relative to the other treatment sites and the overall network. The nest success rate at TA-39 has been highly variable since monitoring began in 2015 ranging between 0% and 75%. TA-39 is the lowest elevation treatment site and occupancy has been decreasing over time at this site and surrounding areas of the avian nestbox network (Figure 9 & Table 7). Wysner et al. (2019) found that Western Bluebirds, one of the target species of the network, have increased their nesting elevation over time in the study area. Western Bluebirds have the highest occupancy rates throughout the nestbox network, and shifts in nesting elevation could be driving the lower occupancy rates at TA-39. Occupancy and success rates at the Minie treatment site have fluctuated annually and have not displayed a decreasing trend over time, though the success rate dropped substantially between 2020 and 2021 (Figure 9 & Table 8). While occupancy has been relatively high and naturally fluctuating at TA-16, the success rate has been decreasing since 2017 with the largest decrease in success occurring in 2021.

Decreases in occupancy and nest success were pervasive across both control and treatment sites between 2020 and 2021 with 79% of all nestbox sites showing a decrease in occupancy and 86% showing a decrease in nesting success (Figure 10 & Table 9). These decreases are likely driven by extreme low precipitation values winter 2020 and spring 2021 (NOAA 2021). Decreases in precipitation have been linked to declines in body mass which may indirectly impact reproductive success (Smith et al. 2010).

In 2021, LANL biologists submitted nonviable eggs collected from nestboxes at the treatment sites and the rest of the nestbox network to an analytical lab for chemical analyses. These data will be presented in a separate report.

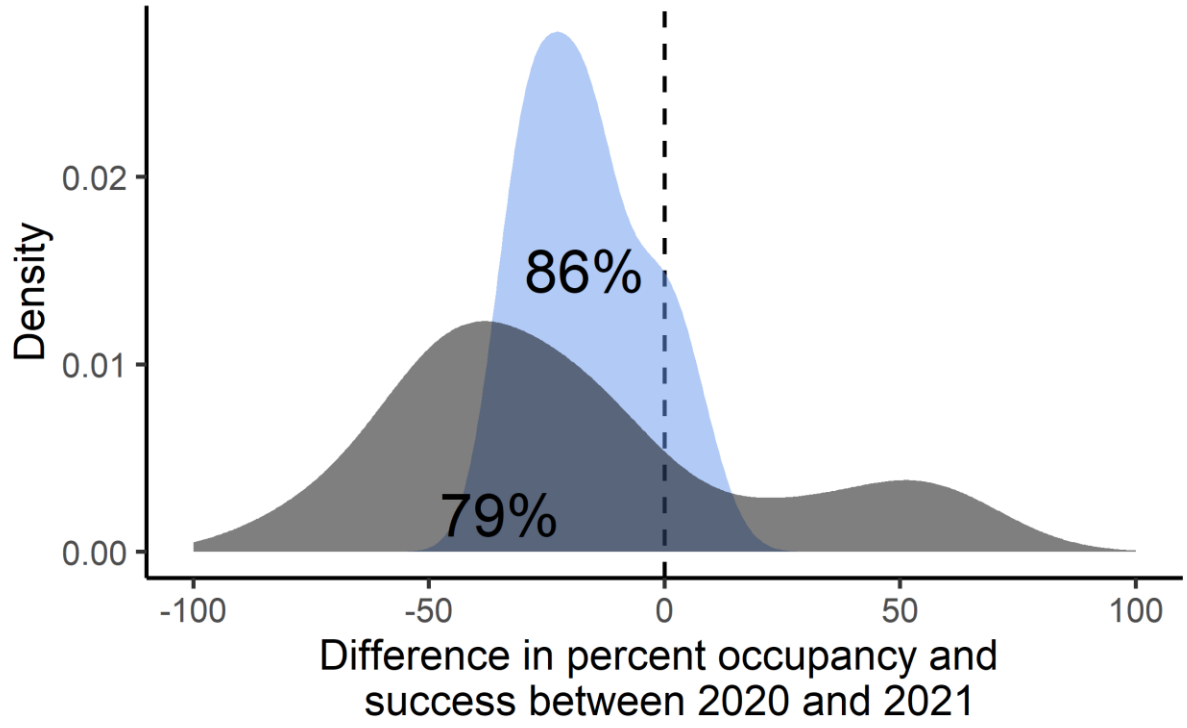

Figure 10. Distribution of between-year comparisons of percent occupancy (grey) and success (blue) between 2020 and 2021. Shaded area to left of dashed line illustrates number of sites that had a reduction in percent occupancy or success in 2021 compared to 2020. Percentages indicate number of comparisons falling below zero.

Table 9. Results from best fit repeated measures ANOVA for comparison between 2020 and 2021 abundance and richness binned by foraging guild and using transect as repeated measure.

Insectivore			
Abundance ~ Year + Site Cat	**df**	**t**	**P value**
Year	20	-1.320	0.20
Site Category (Treatment/Control)	12	0.823	0.43
Richness ~ Year + Site Cat	**df**	**t**	**P value**
Year	21	-0.728	0.48

Site Category (Treatment/Control)	13	0.780	0.45
Omnivore			
Abundance ~ Year + Site Cat	**df**	**t**	**P value**
Year	12	-1.532	0.15
Site Category (Treatment/Control)	12	0.036	0.97
Richness ~ Year + Site Cat	**df**	**t**	**P value**
Year	12	-0.628	0.54
Site Category (Treatment/Control)	12	0.674	0.51

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Over the 9 year study period LANL biologists have documented sensitive species from the Sensitive Species Best Management Practices Source Document (Berryhill et al. 2020) and the Birds of Management Concern and Focal Species list (USFWS 2021) at the treatment sites. Those species are the Cassin's Finch, Juniper Titmouse, Grace's Warbler, Virginia's Warbler, Black-throated Gray Warbler, Evening Grosbeak, Peregrine Falcon, and the Mourning Dove. The Gray Vireo is the only sensitive species documented in only control sites. Of the 79 species detected at the three treatment sites, the Migratory Bird Treaty Act protects all but one species. The Eurasian Collared-Dove is not native and therefore not protected under the Migratory Bird Treaty Act.

Continuing to document migratory bird occurrences and nest success across treatment and control sites, provides a long-term dataset to assess the ecological health of avifauna at the three treatment sites at LANL. In addition, this research contributes to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and it allows LANL to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2021

Species	TA-36 Minie Site									TA-39 Point 6									TA-16 Burn Grounds								
	Pinyon-Juniper Woodland									Pinyon-Juniper Woodland									Ponderosa Pine Forest								
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
Acorn Woodpecker																			5		3	2	3	5	3	5	1
American Crow																							1	1		1	1
American Kestrel				1				1	1	1			2					2									
American Robin	1	1	2		2					1	1		2		4	2			7		9	4	4	6	12	6	14
Ash-throated Flycatcher	11	5	14	13	13	10	17	12	12	19	11	30	12	8	8	6	11	4	3	5	6	2	3	8	4	6	6
Audubon's Warbler		2				5							2				5		6	5	1	6		1	11	14	9
Bewick's Wren	4	8	9	9	14	14	5	10	4	3	10	15	9	2	8	1	2										
Black-chinned Hummingbird		1	1				1	2	1	3	2				1	2	3		1		1		1		1	12	1
Black-headed Grosbeak	1	3				1	1	2	1		2	4	1		3	2	1	1			1	2		2		1	1
Black-throated Gray Warbler			1		2			2		5	6	4															
Blue-gray Gnatcatcher	3	14	16	8	10	9	8	11	8	2		7	5	4	2	13	5	2		6	2	1	3	6	4	9	3
Blue Grosbeak																		1									
Broad-tailed Hummingbird	2	1	3		1		3	2		3	1	2		3	1	2	9	3	5	11	11	5	7	10	8		
Brown Creeper																			1								
Brown-headed Cowbird	1								1			2			3	2	10	3	4	1			4	2	8	4	4
Bushtit		2		2		11				2	14			1	12		2									
Canada Goose												16				2											
Canyon Towhee	2		5	3	6	2	3	5	3	1	1	2	10	13	19	6	3	9	1			1		1			
Canyon Wren					1							2	3	8	6	2	4				2						
Cassin's Finch						4																					1
Cassin's Kingbird	6	13	13	5	2	5	6	5	4	7	6	2	21	21	32	37	49	14				1				2	
Chipping Sparrow	3	16	17	29	6	22	10	10	10	6	6	5	8	15	25	27	24	16	1	5	3	10	5	21	8	32	6
Clark's Nutcracker																				4		1					
Common Nighthawk	6		5	2	4	4	1	5		5	1	3	2	7	5	7	3	1			1	2	2			1	
Common Raven	2	5	1		1	2	3			1		2	1		1	2	5		5	6	2	2	5	5	7	4	2
Cooper's Hawk					1														1			1			1		
Cordilleran Flycatcher																			5	10	6	3	3	1	2	4	
Dark-eyed Junco															1	1			6	2	4		5	2		2	3
Downy Woodpecker				1									1	2		1	2	1		1		1	1	1			
Dusky Flycatcher				1								1		1												2	1
Eurasian Collared-Dove	3													4			2							1			
Evening Grosbeak	3		4						1			8							5		29			1			
Grace's Warbler							1								2	4	1	6	6	4	4	8	5	8	22	12	17
Gray Flycatcher	12	6	5	7	3	6	3	2	4	10	10	11	10	5	8	3	14	5									

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
	TA-36 Minie Site									TA-39 Point 6									TA-16 Burn Grounds								
	Pinyon-Juniper Woodland									Pinyon-Juniper Woodland									Ponderosa Pine Forest								
Great Horned Owl		3								1																	
Green-tailed Towhee	3	1								1																1	
Hairy Woodpecker			2	1		1		1	1			5	3			1	1	4	1	1		1	1	2	1	1	
Hammond's Flycatcher																			8	9	12	5	7	5	10	5	7
Hepatic Tanager									2			1	2	1	2			1				1					
Hermit Thrush						1														4	6	1	2	2	5	5	2
House Finch	16	17	26	17	12	18	17	11	11	21	4	23	9	30	44	50	53	22	16	2	5	5	12	7	12	18	11
House Wren																1			1	1		2	2	6	8	2	1
Juniper Titmouse	12		7	6	9	3	26	8	20	11	13	18	6	1			3	2									
Lesser Goldfinch	2	6	7	4	9	12	8	4	4	4	12	9	10	14	19	15	27	8	3		8	9	4	8	5	6	2
MacGillivray's Warbler																						1	3			1	
Mountain Bluebird		2	20	10	11	1	9	3	2		4						2	1			4	4	4	7	4	5	
Mountain Chickadee	5	2	1	2									1	1		1			5	8	9	6	8	9	1	4	6
Mourning Dove	17	17	13	5	8	8	11	9	7	13	22	10	3	15	11	8	10	9	4		1	3	17	3	5	17	5
Northern Mockingbird					2		1	4			1							2									
Northern Rough-winged Swallow						3																					
Orange-crowned Warbler																										1	
Peregrine Falcon									1			1						1									
Pine Siskin	10	2		5	1			1		6		3	3						12	4	5		4	2		6	
Plumbeous Vireo	10	10	7	3	9	9	15	3	3	1		1	6	6	5	5	12	4	11	16	15	14	11	18	16	24	17
Pygmy Nuthatch				2		2	3		1			2	4	12	9	11	10	1	11	13	26	29	41	20	16	23	5
Red Crossbill					1						2						1			2	9	13	9		6	26	1
Red-shafted Flicker	3	1	3	2	5	2	1		1	3	2	4	8		3	2	2		3	4	11	11	5	5	2	7	5
Red-tailed Hawk							1	2	1			1	1	1	1												
Rock Wren	3	3	4		2	10	11	10	4	7	10	4	12	14	14	12	20	15	1	2	2	6			4	1	
Ruby-crowned Kinglet																								2			1
Savannah Sparrow																										1	
Say's Phoebe	2	1	2		2	5	1	1	2	2	1		5	2	4		6	5	1		1	3	3	4	1	1	4
Scaled Quail			1																								
Spotted Towhee	17	8	19	27	32	24	19	20	17	12	6	33	16	12	16	15	20	14	11	18	16	14	21	22	34	24	16
Steller's Jay							1												3	2	5	6	3	4	4	2	1
Townsend's Solitaire	1																						1				
Turkey Vulture					1			2									1		1					1			
Vesper Sparrow																									1		
Violet-green Swallow		5	7	1	3	2	1	6		6	4	1	9	6	6	9	47	5		2	19	2	2	4	2	7	6
Virginia's Warbler					1	3	1					1	2	4		5		2	17	11	21	13	7	5	5	8	3

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
	TA-36 Minie Site									TA-39 Point 6									TA-16 Burn Grounds								
	Pinyon-Juniper Woodland									Pinyon-Juniper Woodland									Ponderosa Pine Forest								
Warbling Vireo						2													2	9	7	6	5	4	6	3	7
Western Bluebird	15	11	18	17	16	19	21	23	8	5	19	12	21	13	6	7	17	3	20	20	49	37	32	27	20	27	8
Western Tanager		2	3		1						2	1	1	2	2	6	1	2	2	3	7	2	4	6	16	10	7
Western Wood-Pewee	10	8	18	11	10	7	18	14	10		4	2	10	8	11	12	18	12	15	10	16	14	22	20	24	28	25
White-breasted Nuthatch	1	4	9	10	13	5	2	1	2			2	4	4	2	6	3	2	9	8	7	9	20	10	10	8	10
White-crowned Sparrow																		1									
White-throated Swift											1						2										
White-winged Dove	1	5	9	2		3	2	1	1	7	5	6	16	15	15	5	2	5			1	2			1		
Willow Flycatcher																		1									
Woodhouse's Scrub-Jay	5	1	3	4	8	7	14	10	10	8	10	4	8	6	4	5		2	1								

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Attachment 14 – Gaulker & Stanek 2019

Environmental Report:

Gaukler, S.M. and J. Stanek, June 2019. *Inorganic Element Concentrations in Passerine Eggs Collected at Technical Areas 36, 39, and 16 at Los Alamos National Laboratory*. LA-UR-19-25647.

June 2019

Inorganic Element Concentrations in Passerine Eggs Collected at Technical Areas 36, 39, and 16 at Los Alamos National Laboratory

Los Alamos
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EST. 1943

Prepared by: Shannon Gaukler and Jenna Stanek
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Prepared for: U.S. Department of Energy, National Nuclear Security Administration,
Los Alamos Field Office

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ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LOAELs	lowest observable adverse effect levels
mg/kg	milligrams per kilogram
RSRLs	regional statistical reference levels
TA	Technical Area
TAL	total analyte list

SUMMARY

In 2018, nonviable avian eggs were opportunistically collected at Los Alamos National Laboratory near open detonation sites at Technical Area (TA) 36 and TA-39 and near the TA-16 burning grounds and were evaluated for inorganic elements (mostly metals). A total of eight western bluebird *Sialia mexicana*) and ash-throated flycatcher (*Myiarchus cinerascens*) egg samples were collected among the three locations of interest. Due to the small sample size, statistical comparisons could not be made. However, concentrations of inorganic elements observed in this study were compared with the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval; regional statistical reference level [RSRL]). Several inorganic elements were not detected in avian eggs and the majority of inorganic elements detected were below the RSRL. The few elements that exceeded the RSRL were below the lowest observable adverse effect level (LOAEL), when available. These data suggest that inorganic element concentrations in eggs observed here are not of ecological concern. As these data are preliminary, more data are needed to make a robust assessment, including additional background samples.

INTRODUCTION

Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of nonviable eggs and/or nestlings that die of natural causes is noninvasive and is nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Sources of inorganic elements include both anthropogenic and natural sources and birds can be exposed through a number of routes including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals) and dioxins and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

OBJECTIVES

The objective of this study is to document chemical concentrations in eggs and nestlings collected near TAs 36, 39, and 16 and to compare concentrations of inorganic elements observed in this study with the upper-level bounds of background concentrations.

METHODS

Sample Collection

Eggs were collected from nest boxes when they were determined to be nonviable due to documented timing of known incubation periods for the species. In 2018, two nonviable egg samples were collected from TA-36, two egg samples from TA-39, and four samples from TA-16. All egg samples were either western bluebirds (*Sialia mexicana*) or ash-throated flycatchers (*Myiarchus cinerascens*) and were collected in June and July of 2018. No nestling samples were obtained in 2018 because the nest boxes located in the areas of interest did not have nestlings that died of natural causes that could be collected opportunistically.

Chemical Analyses

Due to limited sample mass, nonviable eggs were analyzed for TAL only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. The two samples collected near TA-36 and submitted for analyses consisted of one individual western bluebird egg and one composite of six western bluebird eggs. The two samples collected near TA-39 and submitted for analyses consisted of one individual ash-throated flycatcher egg and one composite of three western bluebird eggs. The four samples collected near TA-16 and submitted for analyses consisted of two individual western bluebird eggs, one composite of four western bluebird eggs, and one composite of two ash-throated flycatcher eggs.

Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All metal results were reported on an mg/kg (milligram per kilogram) dry weight basis.

Analyses of Chemical Levels

The 2018 results could not be statistically compared with background data due to small sample sizes; more data are needed to enable a robust evaluation of open detonation sites and background locations. However, results from 2018 were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from nonviable eggs of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2016 and 2018 (n=8). Results were also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

PRELIMINARY RESULTS AND DISCUSSION

Many of the inorganic elements assessed in this study were not detected in passerine egg samples. Elements that are not (or very little is) maternally transferred into eggs or do not accumulate in eggs include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001).

Minie Firing Site (TA-36)

The two western bluebird egg samples collected from TA-36 did not have detectable levels of several elements including aluminum, antimony, arsenic, beryllium, cadmium, lead, nickel, silver, or vanadium. Detectable concentrations of barium, calcium, chromium, cobalt, iron, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were all below the RSRL and the LOAEL (when available). One egg sample contained copper concentrations of 4.1 mg/kg that was higher than the RSRL of 3.6 mg/kg (Table 1).

The elevated copper in western bluebird egg samples observed in 2018 at TA-36 and TA-39 (see below) are similar with previous observations (Gaukler, 2017) and could be from some high-explosives testing. Copper has historically been detected above soil screening levels at Technical Area 39 (Juarez and Vigil-holterman 2011). Contrarily, copper soil levels at Technical Area 36, near the firing site were below the RSRL in 2018. No reliable screening levels exists for egg tissues, although it has been suggested that birds are relatively resistant to copper toxicity when compared with other taxa (Eisler 1998).

TA-39

Two egg samples collected from nest boxes at TA-39 did not contain detectable concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of barium, cobalt, and zinc were all below the RSRL. One western bluebird egg sample contained higher concentrations of calcium, copper, iron, magnesium, manganese, mercury, potassium, selenium, and sodium compared with RSRLs (Table 2). Although calcium, magnesium, potassium, and sodium were higher in eggs collected at Technical Area 39 compared with the RSRL, these elements are macronutrients, which are required by living organisms in large quantities. Copper, iron, manganese and selenium are essential micronutrients to living organisms in small concentrations, but can become toxic at high enough levels. No reliable screening levels are available for copper, iron, and manganese; however, both mercury and selenium egg concentrations were below the LOAELs for these elements (Heinz et al 1996; Thompson et al 1996)

TA-16 Burn Grounds

Western bluebird and ash-throated flycatcher eggs collected from nest boxes at TA-16 did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, lead, nickel, thallium or vanadium. One sample out of the four collected contained higher concentrations of antimony (0.21 mg/kg) compared with the RSRL (0.11 mg/kg). Two samples out of four collected contained higher concentrations of mercury (0.23 and 0.25 mg/kg) compared with RSRLs (0.18 mg/kg; Table 3). However, both of the samples were below the LOAEL for mercury (1.67 mg/kg, converted from wet to dry weight), suggesting that adverse health effects are not expected at the observed concentrations (Thompson et al 1996). No reliable screening levels are available for antimony; therefore, it is unknown at what concentrations adverse effects could be expected.

CONCLUSIONS

The overall results indicate that the levels of inorganic elements in the eggs of western bluebirds and ash-throated flycatcher are not likely to cause adverse effects in breeding bird populations. Most constituents were not detected in the nonviable egg samples collected near firing sites at TA-36 and TA-39 and the burning grounds at TA-16. Most constituents that were detected were below RSRLs and all were below the LOAELs (when available). These data suggest that egg elements concentrations observed here are not of ecological concern. As these data are preliminary, more data from nonviable eggs and nestlings are needed to make a robust assessment, including additional

background samples. Evaluating avian nestling samples for high explosives is also of interest for future work as those data become available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near the Minie Firing Site (TA-36) compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

Element	Western bluebird (n=1) SFB-18-160523	Western bluebird (n=6) SFB-18-160524	RSRL
Barium	19	12	35
Calcium	3100	3200	4983
Chromium	ND	0.22	1.3
Cobalt	ND	0.03	0.6
Copper	2.8	**4.1**	3.6
Iron	160	130	250
Magnesium	390	350	447
Manganese	1.6	2.9	4.5
Mercury	0.04	0.08	0.18
Potassium	7500	7500	12040
Selenium	1.9	2.1	3.2
Sodium	7300	7600	10299
Thallium	ND	0.0019	0.0192
Zinc	46	51	78

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near TA-39 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

Element	Western bluebird (n=3) SFB-18-160525	Ash-throated flycatcher (n=1) SFB-18-160526	RSRL
Barium	11	7.9	35
Calcium	**8900**	2400	4983
Cobalt	0.15	0.06	0.6
Copper	**9.2**	2.4	3.6
Iron	**350**	86	250
Magnesium	**1100**	330	447
Manganese	**6.5**	0.78	4.5
Mercury	**0.62**	0.15	0.18
Potassium	**27000**	7600	12040
Selenium	**8.3**	2.6	3.2
Sodium	**24000**	9200	10299
Zinc	150	33	78

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

Table 3. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near TA-16 burning grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

Element	Western bluebird (n=1) SFB-18-160510	Ash-throated flycatcher (n=2) SFB-18-160520	Western bluebird (n=1) SFB-18-160521	Western bluebird (n=4) SFB-18-160522	RSRL
Antimony	**0.21**	ND	ND	ND	0.11
Barium	15	6.8	12	9.8	35
Calcium	600	3700	2900	2900	4983
Chromium	ND	ND	ND	0.28	1.3
Cobalt	ND	0.07	ND	0.04	0.6
Copper	3.2	3.1	2.2	2.5	3.6
Iron	38	150	87	190	250
Magnesium	420	320	290	320	447
Manganese	1.3	2.3	1.8	3.1	4.5
Mercury	**0.23**	**0.25**	0.16	0.13	0.18
Potassium	11000	8200	8400	8200	12040
Selenium	1.3	3.2	2.9	2.7	3.2
Silver	ND	0.026	ND	ND	0.04
Sodium	8700	7600	9100	6700	10299
Zinc	8.7	50	30	54	78

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

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Attachment 15 – Gaulker & Stanek 2020

Environmental Report:

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March 2020

2019 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and a Nestling Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory

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Prepared for: U.S. Department of Energy, National Nuclear Security Administration, Los Alamos Field Office

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in single or composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n = 23). 14

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in a mountain bluebird composite egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n = 23). No values were above the RSRL. 15

Table 3. Inorganic element concentrations (mg/kg dry weight) detected in a western bluebird composite egg sample collected near TA-39 Point 6 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n=23). No values were above their respective RSRL. 16

ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LOAEL	slowest observable adverse effect levels
mg/kg	milligrams per kilogram
pg/g	picograms per gram
PCBs	polychlorinated biphenyls
RSRLs	regional statistical reference levels
TA	Technical Area
TCDD	tetrachlorodibenzodioxin-2,3,7,8
TEF	toxic equivalent factors
TEQ	toxic equivalents
WHO	World Health Organization

1.0 SUMMARY

In 2019, non-viable avian eggs and one nestling were opportunistically collected at Los Alamos National Laboratory (LANL) near open detonation sites located at Technical Area (TA) 16 burn grounds, TA-36 Minie, and TA-39 Point 6. These samples were evaluated for inorganic elements (mostly metals), polychlorinated biphenyls (PCBs), dioxins, and furans. A total of 26 western bluebird (*Sialia mexicana*) and five mountain bluebird (*Sialia currucoides*) egg samples and one non-viable ash-throated flycatcher (*Myiarchus cinerascens*) nestling were collected among the three locations of interest. Concentrations of inorganic elements observed in this study were compared with the regional statistical reference level (RSRL) which is the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Several inorganic elements were not detected in avian eggs and the majority of inorganic elements detected were below the RSRL. The few elements that exceeded the RSRL were below the lowest observable adverse effect level (LOAEL), when available. One nestling collected from TA-16 contained detectable concentrations of some dioxin and furan congeners. Octachlorodibenzodioxin-1,2,3,4,6,7,8,9 concentration exceeded the RSRL, but did not exceed the calculated tetrachlorodibenzodioxin-2,3,7,8 (TCDD) toxic equivalent LOAEL. PCBs were also detected in the nestling sample and were above the RSRL but below the LOAEL. These data suggest that inorganic and organic element concentrations in eggs and nestlings are not of ecological concern. More data are needed to make a robust assessment and to evaluate trends over time.

2.0 INTRODUCTION

In support of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) began annual avian monitoring in 2013 around TA-16 burn grounds and at two firing sites, TA-36 Minie and TA-39 Point 6. Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of non-viable eggs and/or nestlings that die of natural causes is noninvasive and is nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Several congeners of PCBs, dioxins, and furans elicit similar toxic effects (i.e., immunotoxicity, carcinogenicity, and endocrine disruption) as those caused by tetrachlorodibenzodioxin-2,3,7,8 (TCDD), the most potent in this class of chemicals (Van den Berg et al. 2006). These congeners, like TCDD, have a high binding affinity to the aryl hydrocarbon receptor (Van den Berg et al. 2006). The World Health Organization (WHO) developed toxic equivalency factors (TEFs) for TCDD-like compounds that can be used to determine the relative potency, or toxic equivalents (TEQs), of dioxin-like compounds for different classes of animals (i.e., fish, birds,

and mammals), as well as to facilitate risk assessment for TCDD-like exposure (Van den Berg et al. 2006).

Sources of inorganic elements include both anthropogenic and natural sources; birds can be exposed through a number of routes, including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals), dioxins, and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

3.0 OBJECTIVES

The objective of this study is to document chemical concentrations in eggs and nestlings collected near TA-16 burn grounds, TA-36 Minie, and TA-39 Point 6 and to compare concentrations of inorganic elements, polychlorinated biphenyls (PCBs), dioxins, and furans observed in this study with the upper-level bounds of background concentrations.

4.0 METHODS

4.1. Sample Collection

Eggs and nestlings were collected from nest boxes when they were determined to be non-viable, based on documented timing of known incubation periods for the species. In 2019, warm temperatures in the early spring and then a period of very cold temperatures led to higher than usual numbers of non-viable eggs. We collected a total of 31 non-viable eggs at LANL near the TA-16 burn grounds (Figure 1) and near open detonation sites TA-36 Minie (Figure 2) and TA-39 Point 6 (Figure 3). At TA-16, 22 non-viable western bluebird (*Sialia mexicana*) samples and one non-viable ash-throated flycatcher (*Myiarchus cinerascens*) nestling sample were collected and submitted as six composite samples and one individual sample, respectively. At TA-36, five non-viable mountain bluebird (*Sialia currucoides*) eggs were collected and submitted as one composite sample. At TA-39, four non-viable western bluebird eggs were collected and submitted as one composite sample. All samples were collected May through July of 2019. Concentrations of chemicals in eggs and nestlings have been monitored annually at these locations since 2014.

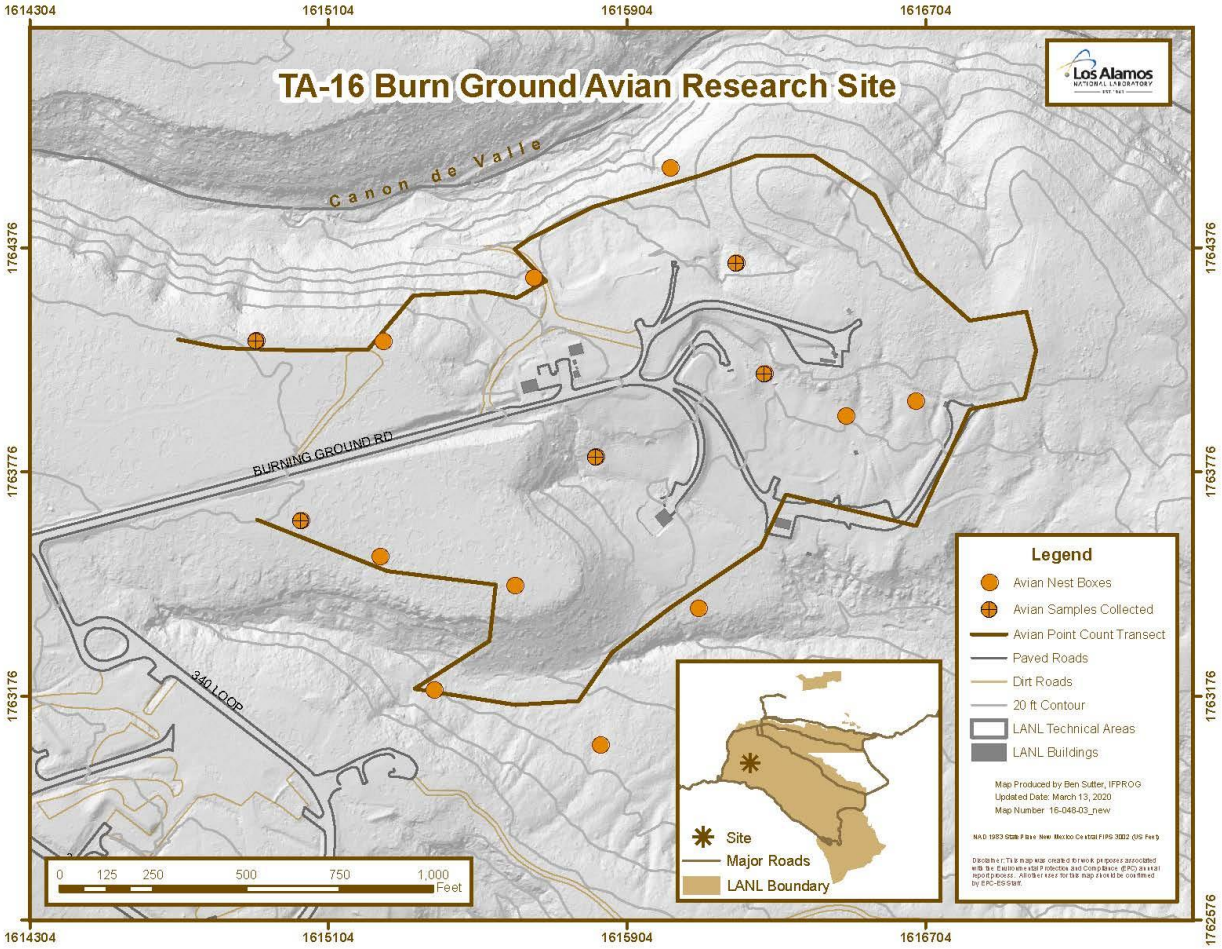

Figure 1. Avian nest box locations around TA-16 burn grounds.

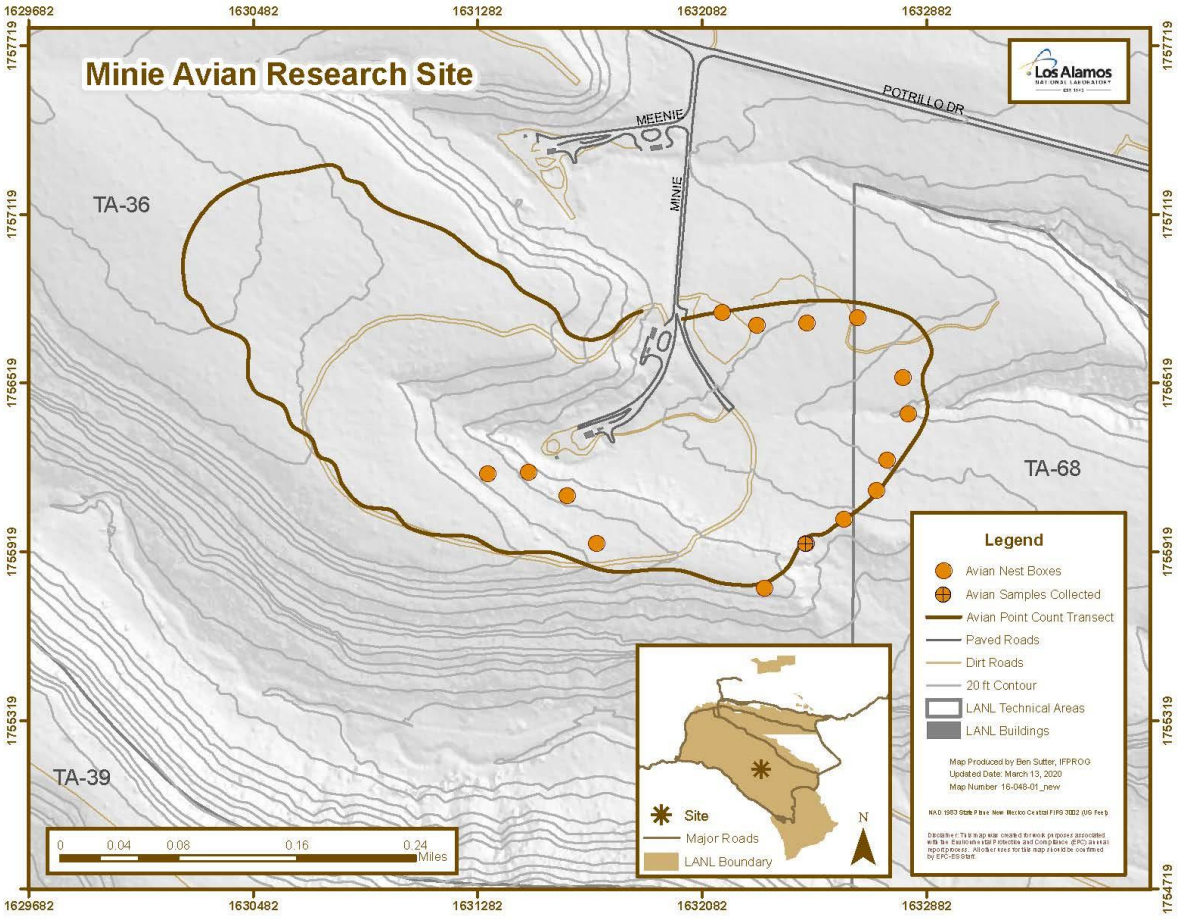

Figure 2. Avian nest box locations around TA-36 Minie.

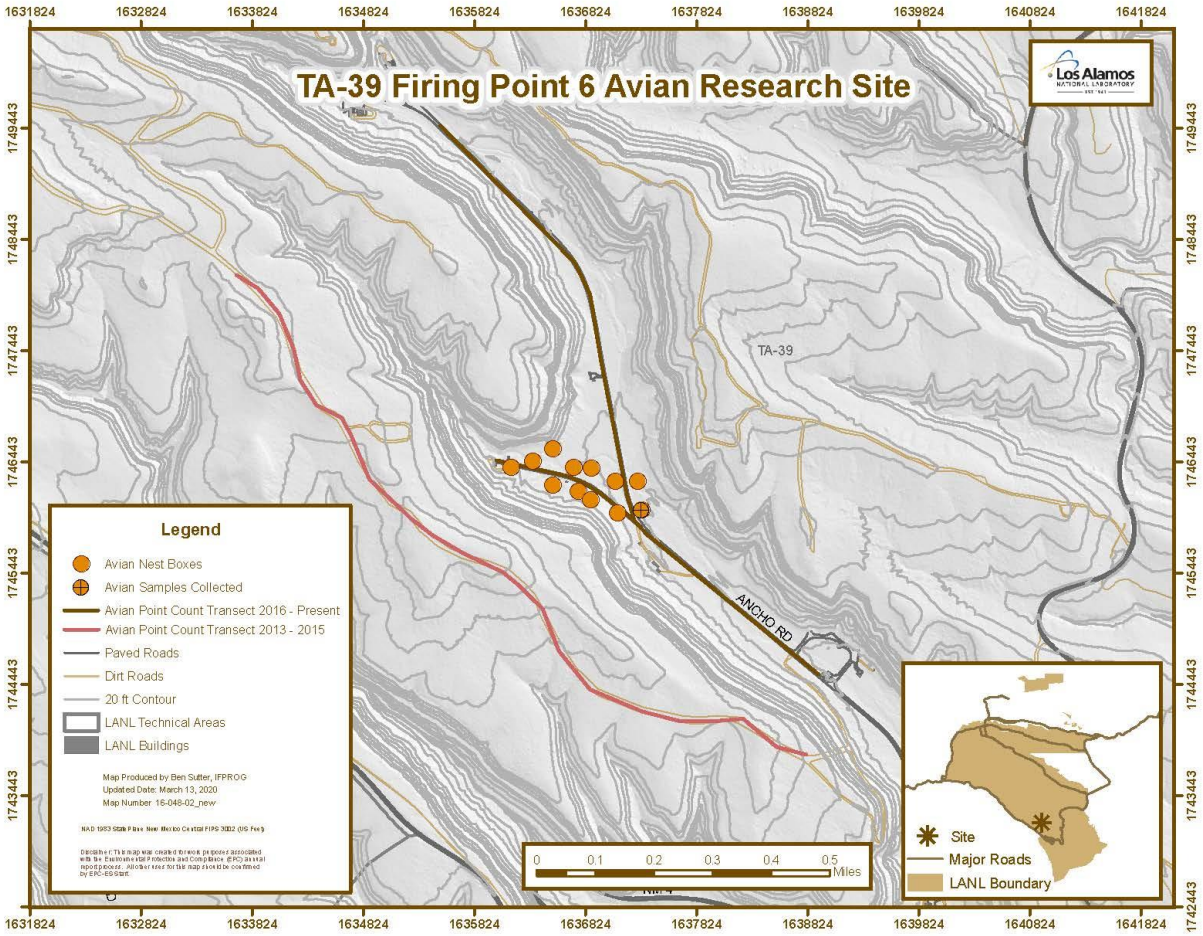

Figure 3. Avian nest box locations around TA-39 Point 6.

4.2. Chemical Analyses

Due to limited sample mass, non-viable eggs were analyzed for total analyte list (mostly inorganic metals) only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured in egg samples by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All inorganic element results were reported on an mg/kg (milligram per kilogram) dry weight basis.

The non-viable nestling sample collected near TA-16 was analyzed for PCB congeners by EPA Method 1668A and dioxin/furan congeners by EPA SW-846 Method 8290 at Cape Fear Analytical LLC, Wilmington, North Carolina. All organic chemical results are reported on a wet weight basis.

4.3. Statistical Methods

The 2019 results were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from non-viable eggs of western bluebirds and ash-throated flycatchers collected from Bandelier National Monument from 2016 through 2019 (n = 23). Non-viable egg results are also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

In the nestling, TCDD-like TEQs were calculated for all aryl hydrocarbon–binding PCB, dioxin, and furan congeners; these include:

- non-*ortho*-substituted PCB congeners 77, 81, 126, and 169
- mono-*ortho*-substituted PCB congeners 105, 114, 118, 123, 156, 157, 167, and 189
- tetrachlorodibenzodioxin-2,3,7,8
- pentachlorodibenzodioxin-1,2,3,7,8
- hexachlorodibenzodioxin-1,2,3,4,7,8
- hexachlorodibenzodioxin1,2,3,6,7,8
- hexachlorodibenzodioxin-1,2,3,7,8,9
- heptachlorodibenzodioxin-1,2,3,4,6,7,8
- octachlorodibenzodioxin-1,2,3,4,6,7,8,9
- tetrachlorodibenzofuran-2,3,7,8
- pentachlorodibenzofuran-1,2,3,7,8
- pentachlorodibenzofuran-2,3,4,7,8
- hexachlorodibenzofuran-1,2,3,4,7,8
- hexachlorodibenzofuran-1,2,3,6,7,8
- hexachlorodibenzofuran-1,2,3,7,8,9
- hexachlorodibenzofuran-2,3,4,6,7,8
- heptachlorodibenzofuran-1,2,3,4,6,7,8
- heptachlorodibenzofuran-1,2,3,4,7,8,9
- octachlorodibenzofuran-1,2,3,4,6,7,8,9

Each congener was multiplied by its respective avian-specific WHO TEF (Van den Berg et al. 2006), and added together for a total TEQ for the nestling sample. PCB congeners 156 and 157 co-eluted, and therefore were treated as one; the WHO TEFs were the same for both PCB congeners.

Nestling sample results of PCBs, dioxin, furans, and TEQs were compared with RSRLs and LOAELs, when available. The nestling RSRL was calculated from non-viable nestlings of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2018 and 2019 (n = 4 samples).

5.0 RESULTS AND DISCUSSION

Similar with previous years, many of the inorganic elements assessed in this study were not detected in passerine egg samples. Several elements are not (or very little is) maternally transferred into eggs or do not accumulate in eggs and include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001), which may explain why these elements were mostly not detected.

Similarly, most dioxins and furans were not detected in the nestling sample collected from TA-16 burn grounds. Most constituents that were detected in eggs and the nestling were below RSRLs, and all constituents were below the LOAELs, when available.

5.1. TA-16 Burn Grounds

Western bluebird eggs collected from nest boxes at TA-16 burn grounds did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, nickel, or vanadium. Of the elements containing detectable concentrations in eggs, only antimony, barium, and selenium were detected at concentrations above the RSRLs (Table 1). One sample out of the six collected contained slightly higher concentrations of antimony (0.27 mg/kg) compared with the RSRL (0.26 mg/kg). No reliable screening levels were available for antimony. One sample out of six collected contained higher concentrations of selenium (3.5 mg/kg) when compared with the RSRL (3.3 mg/kg dry weight). Selenium is an essential micronutrient and needed by living organisms. Additionally, the selenium concentration was far below the LOAEL of 10 mg/kg dry weight (Heinz et al. 1989).

Two samples out of six collected contained higher concentrations of barium (68 and 210 mg/kg) when compared with RSRL (31 mg/kg; Table 1). Legacy barium in the canyon sediment is known to occur in the area (Reid 2003) and has been detected in water samples near Cañon de Valle, which may suggest that birds may be exposed by direct drinking of water, and then the constituent is maternally transferred to their eggs. No reliable screening levels were available for barium; therefore, it is unknown at what concentrations adverse effects could be expected. However, of the non-viable egg samples collected at TA-16 burn grounds since 2016 ($n = 17$), only five of them contained barium concentrations above their respective RSRLs. Additionally, percentages of eggs hatched in nest boxes at TA-16 burn grounds ($n= 48$) compared with nest boxes at the background location ($n = 120$) were not statistically different (Mann-Whitney U test; $p > 0.05$). The hatching success in nest boxes at TA-16 burn grounds ($n = 48$) was 74.5% and was consistent with those reported previously for the area (Fair and Myers 2002). Barium did not have a negative impact on eggshell thickness when TA-16 burn grounds ($n = 40$) data was compared with background locations ($n = 54$; mixed-effects regression model; $p > 0.05$). These results suggest that adverse effects at the population level are unlikely to occur.

PCBs were detected in the nestling sample at 0.0126 mg/kg and were above the RSRL of 0.0045 mg/kg but well below the LOAEL in avian eggs of 3.0 mg/kg (Hoffman et al. 1996). Thus, even though the PCB concentrations were higher than the RSRL, these levels are not expected to negatively impact the bird population.

Most dioxins and furans were not detected in the nestling sample collected from TA-16 burn grounds. The nestling contained detectable concentrations of octachlorodibenzodioxin-1,2,3,4,6,7,8,9 of 7.65 mg/kg, which exceeds the RSRL of 2.42 mg/kg. Lowest observable adverse effect levels were not available for each dioxin and furan congener. However, the most potent dioxin congener, TCDD, is found to induce toxic effects in eastern bluebirds (*Sialia sialis*) when egg concentrations are between 0.001 and 0.01 mg/kg (Thiel et al. 1988). The TCDD toxic equivalency factor of octachlorodibenzodioxin-1,2,3,4,6,7,8,9 for avian species is 0.0001 (Van den Berg et al. 2006). Multiplying the detectable concentration of 7.65 mg/kg by the toxic equivalency factor yields a value of 0.000765 mg/kg, which was much less than the TCDD

LOAEL observed in eastern bluebird eggs. Total toxic equivalents (dioxin-like PCB, dioxin, and furan congeners) were 13.63 pg/g and were well below the RSRL of 23.51 pg/g.

5.2. TA-36 Minie

The one mountain bluebird egg sample, collected from TA-36 Minie, did not have detectable levels of several elements, including aluminum, antimony, arsenic, beryllium, cadmium, nickel, silver, or vanadium. Detectable concentrations of barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were all below the RSRL (Table 2). Mercury and selenium concentrations were well below LOAELs (Heinz et al. 1989, Thompson 1996); no other LOAELs were available.

5.3. TA-39 Point 6

One egg sample collected from a nest box at TA-39 Point 6 did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, chromium, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of antimony, barium, calcium, cobalt, copper, iron, magnesium, manganese, mercury, potassium, selenium, sodium, and zinc were all below the RSRLs (Table 3). Mercury and selenium concentrations were well below LOAELs (Heinz et al. 1989, Thompson 1996); no other LOAELs were available.

6.0 CONCLUSIONS

The overall results indicate that the levels of constituents detected in the eggs and nestlings are not likely to cause adverse effects in breeding bird populations. Several constituents were not detected in the non-viable egg and nestling samples collected near TA-16 burn grounds, TA-36 Minie, and TA-39. Most constituents that were detected were below RSRLs and all were below the LOAELs, when available. These results suggest that the detectable concentrations observed here were not of ecological concern. More data from non-viable eggs and nestlings are needed to make a robust assessment and to examine trends over time. Evaluating avian nestling samples for high explosives are also of interest for future work as those data becomes available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in single or composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n = 23).

Element	Western bluebird (n = 2) SFB-19-184785	Western bluebird (n = 5) SFB-19-184786	Western bluebird (n=1) SFB-19-184787	Western bluebird (n=4) SFB-19-184788	Western bluebird (n=4) SFB-19-184789	Western bluebird (n=4) SFB-19-184790	RSRL
Antimony	0.110	0.057	0.069	**0.270**	0.076	0.081	0.264
Barium	24	**68**	**210**	17	11	34	31
Calcium	2,700	2,500	3,800	3,800	2,900	2,600	5,637
Chromium	ND	0.20	ND	ND	ND	0.22	1.74
Cobalt	ND	0.089	0.077	0.046	0.041	0.063	0.354
Copper	3.10	2.30	2.80	3.90	3.30	2.80	4.85
Iron	180	170	100	130	120	150	274
Lead	ND	0.028	ND	ND	0.030	0.029	0.405
Magnesium	380	320	340	380	370	320	436
Manganese	2.80	2.70	2.00	1.20	2.40	3.40	4.47
Mercury	0.032	0.061	0.042	0.110	0.064	0.038	0.143
Potassium	7,400	6,700	6,800	8,200	7,000	6,200	11,035
Selenium	2.7	**3.5**	2.7	2.9	2.9	2.7	3.3
Silver	ND	ND	ND	ND	0.005	ND	0.040
Sodium	7,200	9,100	7,700	8,900	8,600	6,800	10,561
Thallium	ND	0.0076	0.0120	ND	0.0052	0.0090	0.0222
Zinc	65.0	65.0	43.0	62.0	51.0	52.0	95.8

ND = non-detect
Bold values indicate a detectable concentration that are higher than the RSRL.

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in a mountain bluebird composite egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n = 23). No values were above the RSRL.

Element	Mountain bluebird (n = 5) SFB-19-184791	RSRL
Barium	15	31
Calcium	3,100	5,637
Chromium	0.20	1.74
Cobalt	0.049	0.354
Copper	2.90	4.85
Iron	140	274
Lead	0.042	0.405
Magnesium	330	436
Manganese	3.40	4.47
Mercury	0.011	0.143
Potassium	7,200	11,035
Selenium	2.0	3.3
Sodium	9,000	10,561
Thallium	0.0082	0.0222
Zinc	54.0	95.8

Table 3. Inorganic element concentrations (mg/kg dry weight) detected in a western bluebird composite egg sample collected near TA-39 Point 6 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n=23). No values were above their respective RSRL.

Element	Western bluebird (n = 4) SFB-19-184792	RSRL
Antimony	0.130	0.264
Barium	10	31
Calcium	3,100	5,637
Cobalt	0.043	0.354
Copper	2.70	4.85
Iron	110	274
Magnesium	360	436
Manganese	2.20	4.47
Mercury	0.059	0.143
Potassium	6,900	11,035
Selenium	2.3	3.3
Sodium	7,200	10,561
Zinc	55.0	95.8

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 16 – Gaulker & Stanek 2021

Environmental Report:

Gaukler, S.M. and J. Stanek, March 2021. *2020 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and a Nestling Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory*. LA-UR-21-22303.

22 February 2022

2020 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and Nestlings Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory: Revision 1

A note from the authors regarding the revision: In report number LA-UR-21-22303, inorganic element results were reported on a wet weight basis when after further review, we have concluded that the results are consistent with dry weight values. This change does not affect the observations, the comparisons, or conclusions of the study.

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ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LOAEL	slowest observable adverse effect levels
mg/kg	milligrams per kilogram
pg/g	picograms per gram
PCBs	polychlorinated biphenyls
RSRLs	regional statistical reference levels
TA	Technical Area
TCDD	tetrachlorodibenzodioxin-2,3,7,8
TEF	toxic equivalent factors
TEQ	toxic equivalents
RCRA	Resource Conservation and Recovery Act
WHO	World Health Organization

1.0 SUMMARY

In 2020, non-viable avian eggs and two nestling were opportunistically collected at Los Alamos National Laboratory (LANL) near open detonation sites located at Technical Area (TA) 16 burn grounds, TA-36 Minie, and TA-39 Point 6. These samples were evaluated for inorganic elements (mostly metals), dioxins, and furans. A total of six eggs and two deceased western bluebird (*Sialia mexicana*) nestling samples were collected among the three locations of interest. Concentrations of inorganic elements observed in this study were compared with the regional statistical reference level (RSRL) which is the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Several inorganic elements were not detected in avian eggs and all inorganic elements detected were below the RSRL and the lowest observable adverse effect level (LOAEL), when available. One nestling collected from TA-39 contained detectable concentrations of two dioxin congeners. Heptachlorodibenzodioxin-1,2,3,4,6,7,8 and octachlorodibenzodioxin-1,2,3,4,6,7,8,9 concentration exceeded the RSRL, but did not exceed the calculated tetrachlorodibenzodioxin-2,3,7,8 (TCDD) toxic equivalent LOAEL. These data suggest that inorganic and organic element concentrations in eggs and nestlings are not of ecological concern. More data are needed to make a robust assessment and to evaluate trends over time.

2.0 INTRODUCTION

In support of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) began annual avian monitoring in 2013 around TA-16 burn grounds and at two firing sites, TA-36 Minie and TA-39 Point 6. Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of non-viable eggs and/or nestlings that die of natural causes is non-invasive and is non-destructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Several congeners of polychlorinated biphenyls (PCBs), dioxins, and furans elicit similar toxic effects (i.e., immunotoxicity, carcinogenicity, and endocrine disruption) as those caused by tetrachlorodibenzodioxin-2,3,7,8 (TCDD), the most potent in this class of chemicals (Van den Berg et al. 2006). These congeners, like TCDD, have a high binding affinity to the aryl hydrocarbon receptor (Van den Berg et al. 2006). The World Health Organization (WHO) developed toxic equivalency factors (TEFs) for TCDD-like compounds that can be used to determine the relative potency, or toxic equivalents (TEQs), of dioxin-like compounds for different classes of animals (i.e., fish, birds, and mammals), as well as to facilitate risk assessment for TCDD-like exposure (Van den Berg et al. 1998).

Sources of inorganic elements include both anthropogenic and natural sources; birds can be exposed through a number of routes, including diet, ingestion of soil, drinking water, and

inhalation. Inorganic elements (mostly metals), dioxins, and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

3.0 OBJECTIVES

The objective of this ongoing study is to document chemical concentrations in eggs and nestlings collected near TA-16 burn grounds, TA-36 Minie, and TA-39 Point 6 and to compare concentrations of inorganic elements, PCBs, dioxins, and furans observed in this study with the upper-level bounds of background concentrations.

4.0 METHODS

4.1. Sample Collection

Eggs and nestlings were collected from nest boxes when they were determined to be non-viable, based on documented timing of known incubation periods for the species. We collected a total of six non-viable eggs and two deceased nestlings at LANL near the TA-16 burn grounds (Figure 1) and near open detonation sites TA-36 Minie (Figure 2) and TA-39 Point 6 (Figure 3). At TA-16, five non-viable western bluebird (*Sialia mexicana*) eggs and one deceased nestling samples were collected and submitted as one composite sample and four individual samples. At TA-36, one non-viable western bluebird egg was collected and submitted and at TA-39, one deceased western bluebird nestling was collected and submitted. All samples were collected May through July of 2020. Concentrations of chemicals in eggs and nestlings have been monitored annually at these locations since 2014.

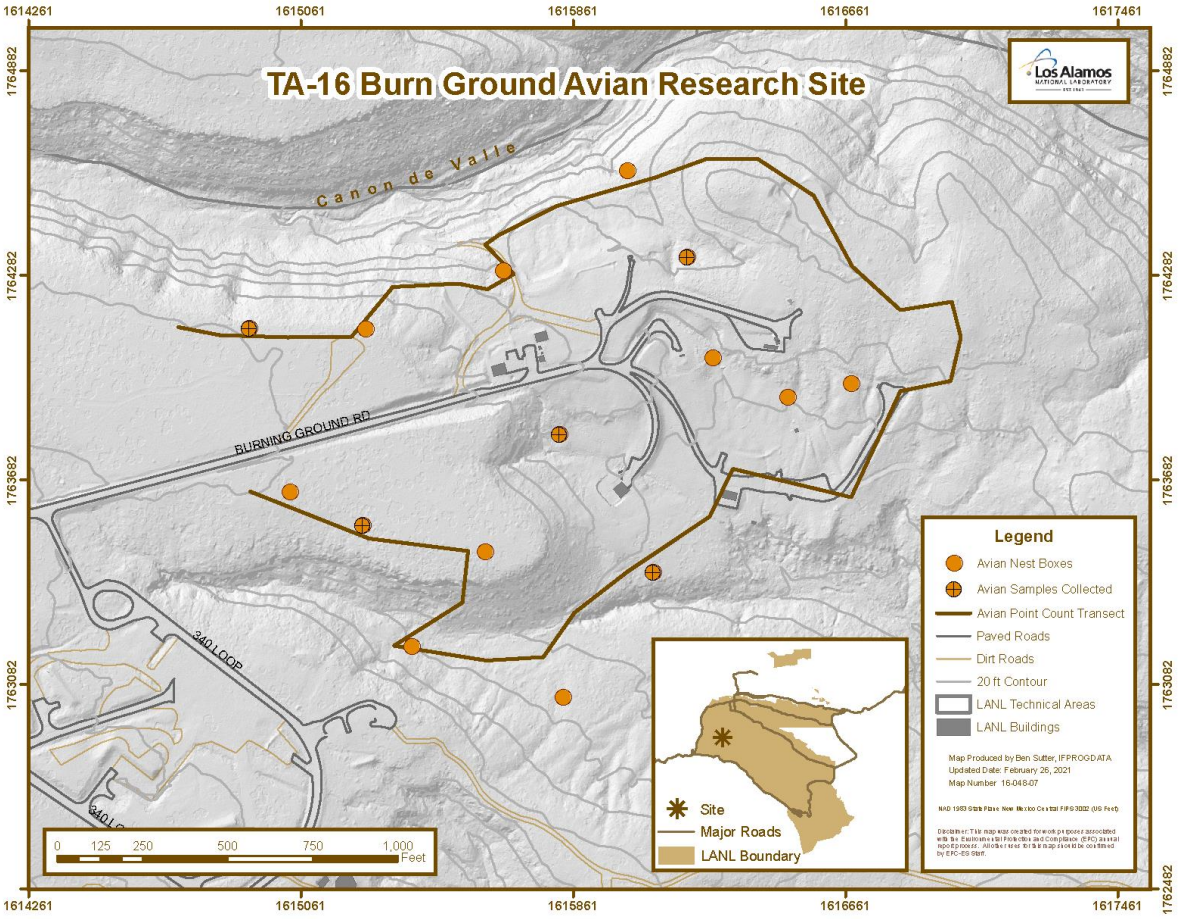

Figure 1. Avian nest box locations around TA-16 burn grounds.

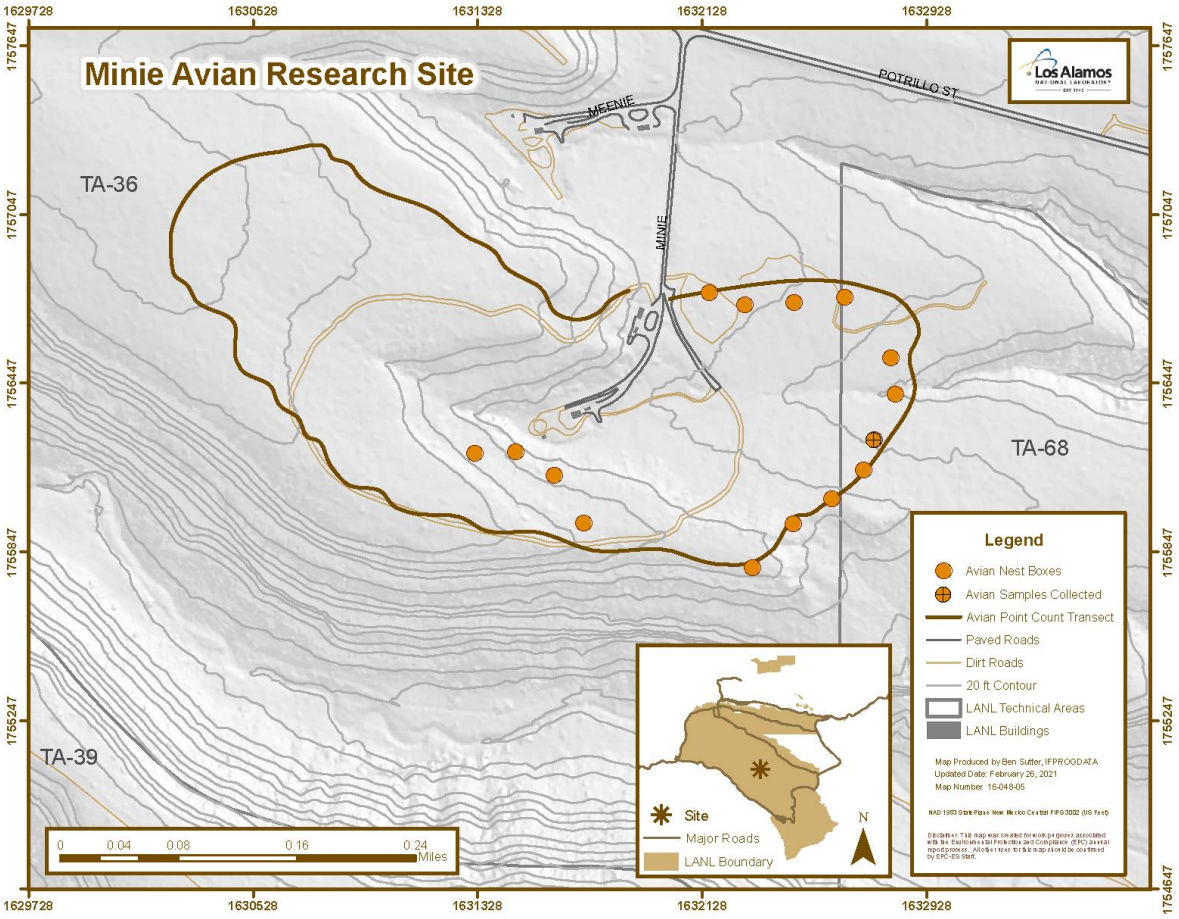

Figure 2. Avian nest box locations around TA-36 Minie.

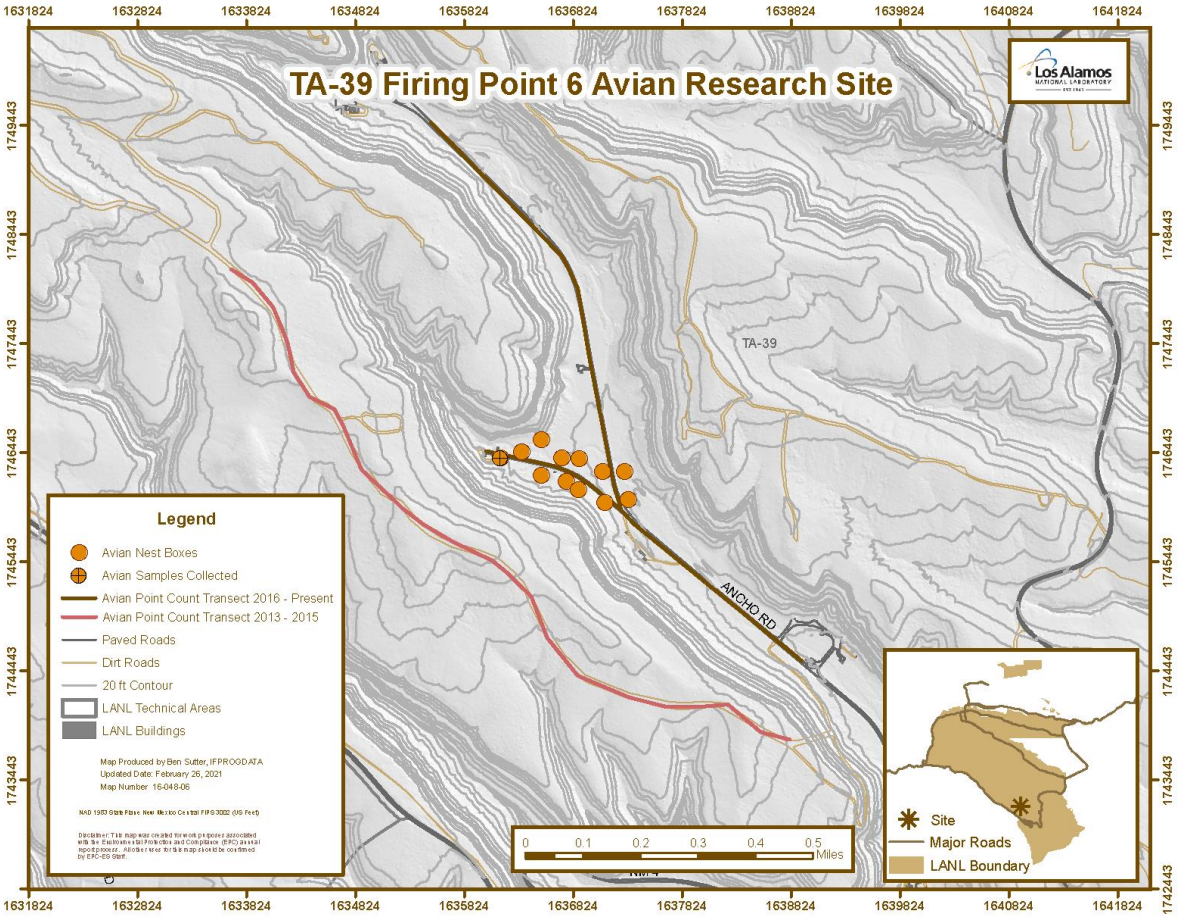

Figure 3. Avian nest box locations around TA-39 Point 6.

4.2. Chemical Analyses

Due to limited sample mass, non-viable eggs and one nestling sample were analyzed for total analyte list (mostly inorganic metals) only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured in egg samples by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All inorganic element results were reported on an mg/kg (milligram per kilogram) dry weight basis.

The non-viable nestling sample collected near TA-39 was analyzed for dioxin and furan congeners by EPA SW-846 Method 8290 at Cape Fear Analytical LLC, Wilmington, North Carolina. All organic chemical results are reported on a wet weight basis.

4.3. Statistical Methods

The 2020 results were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from non-viable eggs of western bluebirds and ash-throated flycatchers (*Myiarchus cinerascens*) collected from Bandelier National Monument in 2020 (n = 7 samples). Non-viable egg results are also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

Nestling sample results of dioxin and furans, were compared with RSRLs and LOAELs, when available. The nestling RSRL was calculated from non-viable nestlings of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2018 and 2019 (n = 5 samples). Nestling sample results of TAL were compared directly with one sample collected from background locations.

5.0 RESULTS AND DISCUSSION

Similar with previous years, many of the inorganic elements assessed in this study were not detected in passerine egg samples. Several elements are not (or very little is) maternally transferred into eggs or do not accumulate in eggs and include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001), which may explain why these elements were mostly not detected.

Similarly, most dioxins and furans were not detected in the nestling sample collected from TA-39 burn grounds. Overall, most constituents that were detected in egg and the nestling samples were below RSRLs, and all constituents were below the LOAELs, when available.

5.1. TA-16 Burn Grounds

Western bluebird eggs collected from nest boxes at TA-16 burn grounds did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, chromium, cobalt, nickel, silver, or vanadium. Of the elements containing detectable concentrations in eggs, all concentrations were below the RSRLs (Table 1). Mercury and selenium concentrations were well below LOAELs (Ohlendorf and Heinz, 2011, Shore et al. 2011); no other LOAELs were available.

Many inorganic elements were not detected in the non-viable nestling sample from TA-16 burn grounds. Detections patterns and concentrations of inorganic elements between the nestling from TA-16 and the nestling sample from a background location are similar.

5.2. TA-36 Minie

The one western bluebird egg sample collected from TA-36 Minie, did not have detectable levels of several elements, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of antimony, barium, calcium, copper, iron, magnesium, manganese, mercury, potassium, selenium, sodium, and

zinc were all below the RSRL (Table 2). Mercury and selenium concentrations were well below LOAELs (Ohlendorf and Heinz, 2011, Shore et al. 2011); no other LOAELs were available.

5.3. TA-39 Point 6

Most dioxins and furans were not detected in the nestling sample collected from TA-39. The sample contained detectable concentrations of 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at 4.51 pg/g (picograms per gram) and 1,2,3,4,6,7,8-heptachlorodibenzodioxin at 1.83 pg/g, which exceeds the RSRL of 2.36 pg/g and 1.43 pg/g, respectively. Lowest observable adverse effect levels are not available for each dioxin and furan congener. However, TCDD, the most potent dioxin congener, induces toxic effects in avian eggs at concentrations between 1,000 to 10,000 pg/g wet weight (Harris and Elliott 2011). Toxic equivalent factors can be used to calculate the toxic equivalent values of dioxin-like compounds. The toxic equivalent factor for 1,2,3,4,6,7,8,9-octachlorodibenzodioxin and 1,2,3,4,6,7,8-heptachlorodibenzodioxin for avian species is 0.0001 and 0.001, respectively (Van den Berg et al. 1998). Multiplying the detectable concentration by the toxic equivalent factors yield values that are orders of magnitude less than the lowest observable adverse effect level for TCDD observed in avian eggs (Harris and Elliott 2011).

6.0 CONCLUSIONS

The overall results indicate that the levels of constituents detected in the eggs and nestlings are not likely to cause adverse effects in breeding bird populations. Several constituents were not detected in the non-viable egg and nestling samples collected near TA-16 burn grounds, TA-36 Minie, and TA-39. Most constituents that were detected were below RSRLs and all were below the LOAELs, when available. These results suggest that the detectable concentrations observed here were not of ecological concern. More data from non-viable eggs and nestlings are needed to make a robust assessment and to examine trends over time. Evaluating avian nestling samples for high explosives are also of interest for future work as those data become available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in single or composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2020 (n = 7). No values were above the RSRL.

Element	Western bluebird (n = 1) SFB-20-206077	Western bluebird (n = 1) SFB-20-206078	Western bluebird (n=1) SFB-20-206079	Western bluebird (n=2) SFB-20-206080	RSRL
Antimony	0.140	0.140	0.130	0.087	0.228
Barium	95	55	8	85	124
Calcium	1,900	3,300	3,600	2,500	18,838
Copper	3.70	3.00	2.20	2.60	4.65
Iron	150	150	280	150	292
Lead	0.39	ND	ND	ND	0.43
Magnesium	300	270	360	380	620
Manganese	1.80	1.50	1.70	2.00	3.88
Mercury	0.072	0.057	0.060	0.180	0.192
Potassium	9,700	9,100	7,900	7,800	11,225
Selenium	2.6	2.6	3.2	2.6	4.0
Sodium	9,400	10,000	8,300	8,300	11,221
Thallium	ND	ND	ND	0.0076	0.0263
Zinc	44.0	39.0	42.0	51.0	61.9

ND = non-detect

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in a western bluebird egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2020 (n = 7). No values were above the RSRL.

Element	Western bluebird (n = 1) SFB-20-206081	RSRL
Antimony	0.19	0.228
Barium	17	124
Calcium	17,000	18,838
Copper	4.10	4.65
Iron	150	292
Magnesium	530	620
Manganese	2.80	3.88
Mercury	0.021	0.192
Potassium	10,000	11,225
Selenium	2.0	4.0
Sodium	9,700	11,221
Zinc	55.0	61.9

Revised Supplement 4-1
2024 Alt Tech Evaluation
Attachment 17 – Gaulker & Stanek 2022

Environmental Report:

Gaukler, S.M. and J. Stanek, March 2022. *2021 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and a Nestling Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory*. LA-UR-22-21423.

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11 February 2022

2021 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and Nestlings Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory

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ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LOAEL	lowest observable adverse effect levels
mg/kg	milligrams per kilogram
PCBs	polychlorinated biphenyls
RSRLs	regional statistical reference levels
TA	Technical Area
TCDD	tetrachlorodibenzodioxin-2,3,7,8
TEF	toxic equivalent factors
TEQ	toxic equivalents
RCRA	Resource Conservation and Recovery Act
WHO	World Health Organization

1.0 SUMMARY

In 2021, non-viable avian eggs and one nestling were opportunistically collected at Los Alamos National Laboratory (LANL) near open detonation sites located at Technical Area (TA) 16 burn grounds and TA-36 Minie. Similar to previous years, nestboxes were monitored at TA-39 Point 6, however, no avian samples were available for opportunistic collection. Samples were evaluated for inorganic elements (mostly metals), dioxins, and furans. One ash-throated flycatcher (*Myiarchus cinerascens*) egg sample was collected from TA-16 burn grounds. One ash-throated flycatcher and one mountain bluebird (*Sialia currucoides)* egg sample and one deceased western bluebird (*Sialia mexicana*) nestling sample were collected from TA-36 Minie. Concentrations of inorganic elements observed in this study were compared with the regional statistical reference level (RSRL) which is the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Several inorganic elements were not detected in avian eggs. Most inorganic elements detected were below the RSRL and all were the lowest observable adverse effect level (LOAEL), when available. The nestling collected from TA-36 did not contain detectable concentrations of dioxin or furan congeners. These data suggest that inorganic and organic element concentrations in eggs and nestlings are not of ecological concern. More data are needed to make a robust assessment and to evaluate trends over time.

2.0 INTRODUCTION

In support of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) began annual avian monitoring in 2013 around TA-16 burn grounds and at two firing sites, TA-36 Minie and TA-39 Point 6. Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of non-viable eggs and/or nestlings that die of natural causes is non-invasive and is non-destructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Several congeners of polychlorinated biphenyls (PCBs), dioxins, and furans elicit similar toxic effects (i.e., immunotoxicity, carcinogenicity, and endocrine disruption) as those caused by tetrachlorodibenzodioxin-2,3,7,8 (TCDD), the most potent in this class of chemicals (Van den Berg et al. 2006). These congeners, like TCDD, have a high binding affinity to the aryl hydrocarbon receptor (Van den Berg et al. 2006). The World Health Organization (WHO) developed toxic equivalency factors (TEFs) for TCDD-like compounds that can be used to determine the relative potency, or toxic equivalents (TEQs), of dioxin-like compounds for different classes of animals (i.e., fish, birds, and mammals), as well as to facilitate risk assessment for TCDD-like exposure (Van den Berg et al. 1998).

Sources of inorganic elements include both anthropogenic and natural sources; birds can be exposed through a number of routes, including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals), dioxins, and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

3.0 OBJECTIVES

The objective of this ongoing study is to document chemical concentrations in eggs and nestlings collected near TA-16 burn grounds, TA-36 Minie, and TA-39 Point 6 and to compare concentrations of inorganic elements, PCBs, dioxins, and furans observed in this study with the upper-level bounds of background concentrations.

4.0 METHODS

4.1. Sample Collection

Eggs and nestlings were collected from nest boxes when they were determined to be non-viable, based on documented timing of known incubation periods for the species. We collected a total of four non-viable eggs and one deceased nestling at LANL near the TA-16 burn grounds (Figure 1) and near open detonation site TA-36 Minie (Figure 2). At TA-16 burn grounds, two non-viable ash-throated flycatcher (*Myiarchus cinerascens*) egg samples were collected and submitted as one composite sample. At TA-36 Minie, one non-viable mountain bluebird egg (*Sialia currucoides)*, one non-viable ash-throated flycatcher egg, and one deceased western bluebird (*Sialia mexicana*) nestling were collected and submitted as individual samples. All samples were collected May through July of 2021. Concentrations of chemicals in eggs and nestlings have been monitored annually at these locations since 2014.

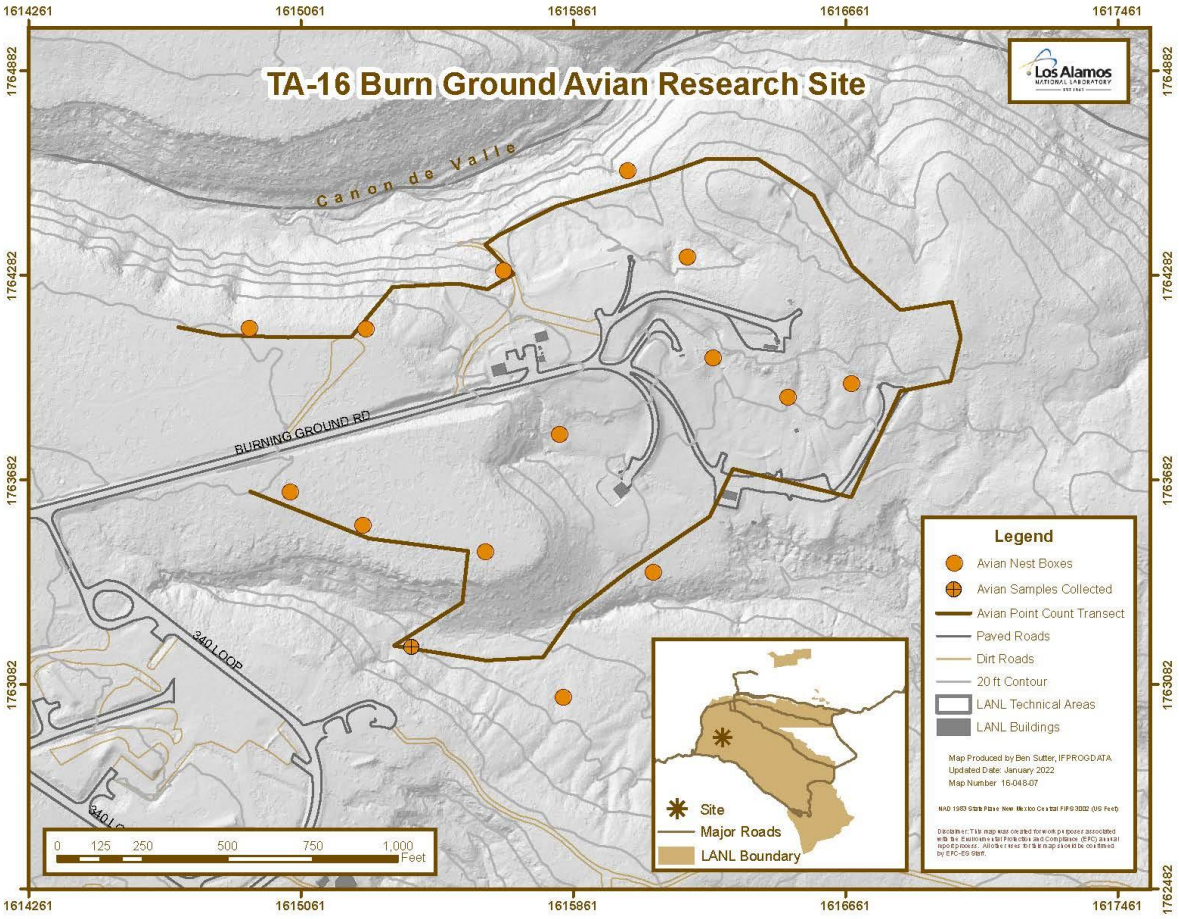

Figure 1. Avian nest box locations around TA-16 burn grounds.

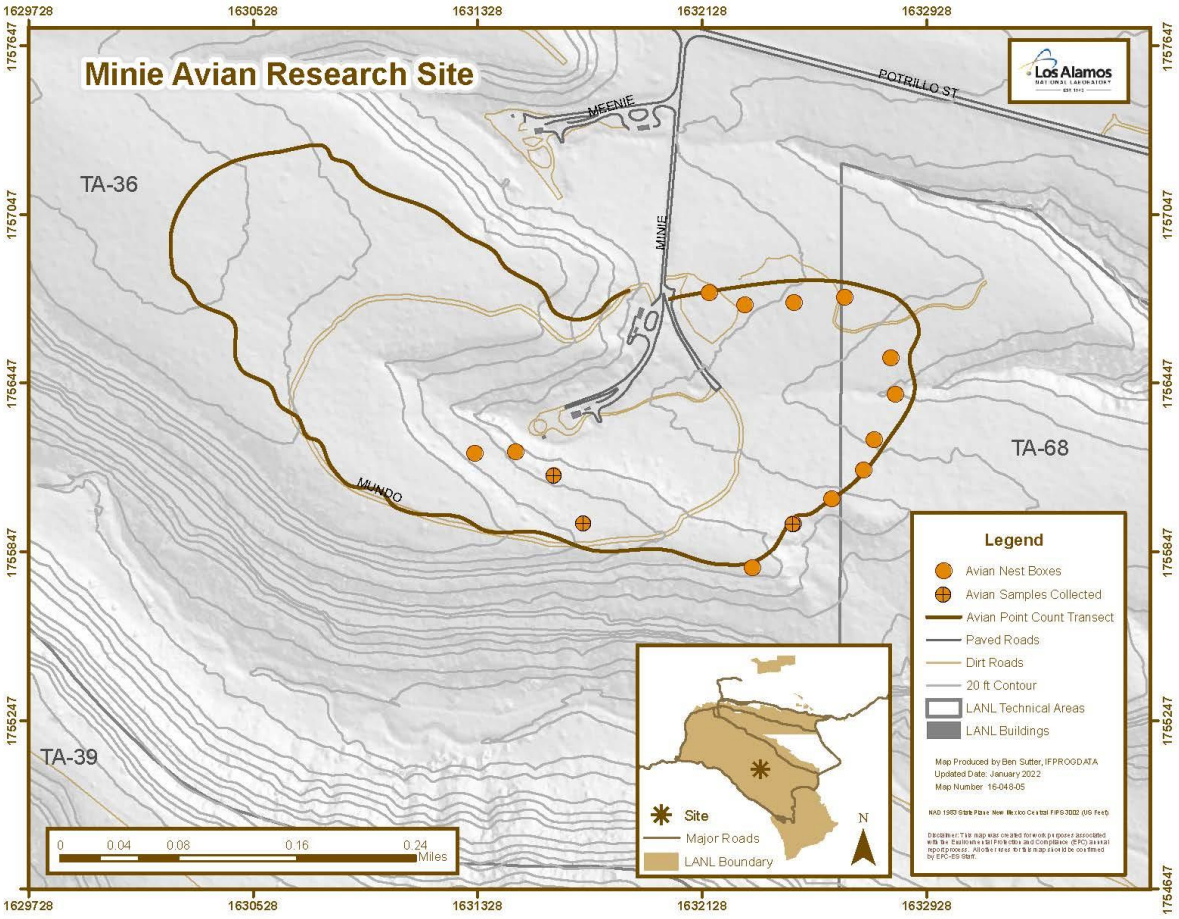

Figure 2. Avian nest box locations around TA-36 Minie.

4.2. Chemical Analyses

Due to limited sample mass, non-viable eggs were analyzed for total analyte list (mostly inorganic metals) only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured in egg samples by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All inorganic element results were reported on an mg/kg (milligram per kilogram) wet weight basis.

The non-viable nestling sample collected near TA-36 Minie was analyzed for dioxin and furan congeners by EPA SW-846 Method 8290 at Cape Fear Analytical LLC, Wilmington, North Carolina. All organic chemical results are reported on a wet weight basis.

4.3. Statistical Methods

The 2021 results were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from non-viable eggs of western bluebirds and ash-throated flycatchers collected from Bandelier National Monument from 2021 (n = 10 samples). Non-viable egg results are also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

Detectable concentrations of dioxin and furans congeners are compared with RSRLs and LOAELs, when available. The nestling RSRL was calculated from non-viable nestlings of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2018 through 2020 (n = 8 samples).

5.0 RESULTS AND DISCUSSION

Similar with previous years, many of the inorganic elements assessed in this study were not detected in passerine egg samples. Several elements are not (or very little is) maternally transferred into eggs or do not accumulate in eggs and include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001), which may explain why these elements were mostly not detected. Similarly, no dioxins and furans were detected in the nestling sample collected from TA-36 Minie.

5.1. TA-16 Burn Grounds

The composite ash-throated flycatcher egg sample collected from nest boxes at TA-16 burn grounds did not contain detectable concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, silver, thallium or vanadium. Mercury was detected at a concentration of 0.031 mg/kg and slightly exceeded the RSRL of 0.011 (Table 1), but was far below the LOAEL of 1.9 mg/kg (Shore et al. 2011). The remaining detectable elements were below the RSRLs (Table 1). Selenium concentrations were also below the LOAEL of 2.6 mg/kg (Ohlendorf and Heinz, 2011,); no other LOAELs were available.

5.2. TA-36 Minie

The one mountain bluebird and one ash-throated flycatcher egg sample collected from TA-36 Minie, did not have detectable levels of several elements, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, thallium, or vanadium. The mountain bluebird egg sample contained antimony concentrations of 0.024, which slightly exceeded the RSRL of 0.019 mg/kg (Table 2). The ash-throated flycatcher egg sample contained mercury concentrations of 0.019 mg/kg which slightly exceeded the RSRL of 0.011 (Table 2), but was far below the LOAEL of 1.9 mg/kg (Shore et al. 2011). The remaining detectable elements were below the RSRLs (Table 2). Selenium concentrations were also below the LOAEL of 2.6 mg/kg (Ohlendorf and Heinz, 2011,); no other LOAELs were available. No dioxin and furan congeners were detected in the western bluebird nestling sample collected from TA-36 Minie.

6.0 CONCLUSIONS

The overall results indicate that the levels of constituents detected in the eggs and nestlings are not likely to cause adverse effects in breeding bird populations. Several constituents were not detected in the non-viable egg and nestling samples collected near TA-16 burn grounds and TA-36 Minie. The majority of constituents that were detected were below RSRLs and all were below the LOAELs, when available. These results suggest that the detectable concentrations observed here are not of ecological concern. More data from non-viable eggs and nestlings are needed to make a robust assessment and to examine trends over time. Evaluating avian nestling samples for high explosives are also of interest for future work as those data become available.

7.0 REFERENCES

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Table 1. Detectable inorganic element concentrations (mg/kg wet weight) detected in a composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data in 2021 (n = 10).

Element	Ash-throated Flycatcher (n = 2) SFB-21-233901	RSRL
Barium	0.47	3.9
Calcium	550	6,588
Copper	0.53	1.71
Iron	23	70
Magnesium	62	130
Mercury	0.031	0.011
Potassium	1,900	3,227
Selenium	0.85	1.0
Sodium	2,400	3,506
Zinc	11	23.1

Table 2. Inorganic element concentrations (mg/kg wet weight) detected in a single egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data in 2021 (n = 10).

Element	Mountain bluebird (n = 1) SFB-21-233902	Ash-throated flycatcher (n = 1) SFB-21-233903	RSRL
Antimony	0.024	ND	0.019
Barium	1.9	ND	3.9
Calcium	690	640	6,588
Copper	0.45	0.54	1.71
Iron	17	23	70
Magnesium	81	72	130
Manganese	ND	0.36	1.04
Mercury	0.003	0.019	0.011
Potassium	2,000	1,400	3,227
Selenium	0.42	0.64	1.0
Sodium	2,300	1,900	3,506
Zinc	7.4	9.5	23.1

ND = Not detected

Supplement 4-2

Open Detonation Unit Groundwater Monitoring and Surface Drainage Information

Table 4.2-1. Pertinent Groundwater Data At or Above Regulatory Standards for Monitoring the TA-36-8 OD Unit, 2000 - 2019

Location	Analyte	# of Analyses	# of Detects	% Detects	Detects versus Nondetects	Minimum Report Result	Maximum Report Result	Action Limit	Units	Action Limit Type	# of Exceedances	First Sample Date	Last Sample Date	Date(s) of Exceedances
Alluvial														
WCO-1r	Iron	4	4	100.0	4/0	113	1560	1000	µg/L	NM GW STD	1	9/20/2010	8/16/2019	3/15/2019
Regional														
R-19 S3	Gross alpha	15	1	6.7	1/14	16.5	16.5	15	pCi/L	EPA MCL	1	9/26/2000	4/14/2015	4/14/2015
R-19 S3	Iron	45	6	13.3	6/39	32.3	1100	1000	µg/L	NM GW STD	1	9/26/2000	4/14/2015	9/26/2000
R-19 S3	Radium-226	7	3	42.9	3/4	0.462	10.4	5	pCi/L	NM GW STD	1	4/9/2001	9/14/2009	4/9/2001, 7/10/2001, 6/14/2004
R-20 S1	Nitrate-Nitrite as Nitrogen	30	16	53.3	16/14	0.0587	748	10	mg/L	EPA MCL	1	3/11/2004	10/23/2019	8/3/2010
R-20 S1	Radium-226	8	4	50.0	4/4	0.578	32.1	5	pCi/L	NM GW STD	3	3/15/2004	10/23/2019	3/15/2004, 5/11/2004, 9/20/2004
R-20 S2	Dioxane[1,4-]	35	1	2.9	1/34	61.4	61.4	4.59	µg/L	NMED A1 TAP SCRN LVL	1	7/19/2005	10/17/2019	9/18/2008
R-20 S2	Manganese	48	48	100.0	48/0	38.5	388	200	µg/L	NM GW STD	10	3/10/2004	10/17/2019	3/10/2004 (2), 5/5/2004 (2), 9/3/2004, 9/7/2004, 11/8/2004(2), 7/19/2005 (2)
R-20 S2	Perchlorate	32	21	65.6	21/11	0.0923	32.5	13.8	µg/L	NMED A1 TAP SCRN LVL	1	3/10/2004	10/17/2019	11/8/2004
R-20 S2	Radium-226	9	5	55.6	5/4	0.559	62.2	5	pCi/L	NM GW STD	3	3/10/2004	10/17/2019	3/10/2004, 5/5/2004, 11/8/2004
R-23	Acetone	54	8	14.8	8/46	1.35	21100	14100	µg/L	NMED A1 TAP SCRN LVL	2	9/24/2002	10/23/2019	9/24/2002 (2)
R-23	Benzo(a)anthracene	39	1	2.6	1/38	0.255	0.255	0.12	µg/L	NMED A1 TAP SCRN LVL	1	9/24/2002	10/23/2019	7/22/2011
R-23	Bis(2-ethylhexyl)phthalate	38	5	13.2	5/33	0.769	7.6	6	µg/L	EPA MCL	1	9/24/2002	10/23/2019	12/17/2003
R-23	Manganese	62	33	53.2	33/29	2.5	604	200	µg/L	NM GW STD	2	12/17/2003	10/23/2019	12/17/2003, 9/3/2009
R-23	Radium-226	14	5	35.7	5/9	0.524	13.9	5	pCi/L	NM GW STD	3	9/24/2002	10/23/2019	10/17/2002, 12/17/2003, 3/23/2004
R-27	Indeno(1,2,3-cd)pyrene	17	1	5.9	1/16	0.4	0.4	0.343	µg/L	NMED A1 TAP SCRN LVL	1	7/1/2006	2/8/2019	9/14/2010
R-31 S3	Iron	7	7	100.0	7/0	250	5190	1000	µg/L	NM GW STD	6	12/16/2000	5/21/2007	8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2)
R-31 S3	Manganese	7	7	100.0	7/0	257	3500	200	µg/L	NM GW STD	7	12/16/2000	5/21/2007	8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2), 12/16/2000
R-32 S1	Bis(2-ethylhexyl)phthalate	34	5	14.7	5/29	2.37	6	6	µg/L	EPA MCL	1	3/1/2004	10/15/2019	6/9/2008
R-32 S1	Radium-226	11	1	9.1	1/10	21.4	21.4	5	pCi/L	NM GW STD	1	3/1/2004	10/15/2019	3/1/2004
R-39	Bis(2-ethylhexyl)phthalate	21	4	19.0	4/17	7.04	9.8	6	µg/L	EPA MCL	4	2/19/2009	10/23/2019	10/26/2016, 10/25/2017, 10/24/2018, 10/23/2019
R-49 S1	Dibenz(a,h)anthracene	20	1	5.0	1/19	0.0515	0.0515	0.0343	µg/L	NMED A1 TAP SCRN LVL	1	6/23/2009	10/29/2019	10/22/2015
R-54 S1	Bis(2-ethylhexyl)phthalate	8	1	12.5	1/7	11.2	11.2	6	µg/L	EPA MCL	1	2/15/2010	11/2/2011	2/15/2010
R-54 S1	Iron	16	16	100.0	16/0	101	4600	1000	µg/L	NM GW STD	9	2/15/2010	11/2/2011	2/15/2010, 7/27/2010 (2), 10/13/2010 (2), 7/12/2011 (2), 1/14/2011 (2)
R-54 S1	Manganese	16	16	100.0	16/0	42.1	306	200	µg/L	NM GW STD	8	2/15/2010	11/2/2011	7/27/2010 (2), 10/13/2010 (2), 7/12/2011 (2), 1/14/2011 (2)

EPA TAP SCRN LVL = U.S. Environmental Protection Agency screening level for tap water.
NMED A1 TAP SCRN LVL = New Mexico Environment Department screening level for tap water.
NM GW STD = New Mexico groundwater standard.
(2) = number of samples

Table 4.2-2. Pertinent Groundwater Data At or Above Regulatory Standards for Monitoring the TA-39-6 OD Unit, 2000-2019

Location	Analyte	# of analyses	# of Detects	% Detects	Detects versus Nondetects	Minimum Report Result	Maximum Report Result	Action Limit	Units	Action Limit Type	# of Exceedances	First Sample Date	Last Sample Date	Date(s) of Exceedances
Regional														
R-31 S3	Iron	7	7	100.0	7/0	250	5190	1000	µg/L	NM GW STD	7	12/16/2000	5/21/2007	12/16/2000, 8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2)
R-31 S3	Manganese	7	7	100.0	7/0	257	3500	200	µg/L	NM GW STD	7	12/16/2000	5/21/2007	12/16/2000, 8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2)
Spring 8A	Dichlorobenzidine[3,3'-]	11	1	9.1	1/10	9.6	9.6	1.25	µg/L	NMED A1 TAP SCRN LVL	1	9/26/2000	10/12/2017	10/7/2003

EPA TAP SCRN LVL = U.S. Environmental Protection Agency screening level for tap water.
NMED A1 TAP SCRN LVL = New Mexico Environment Department screening level for tap water.
NM GW STD = New Mexico groundwater standard.
(2) = number of samples

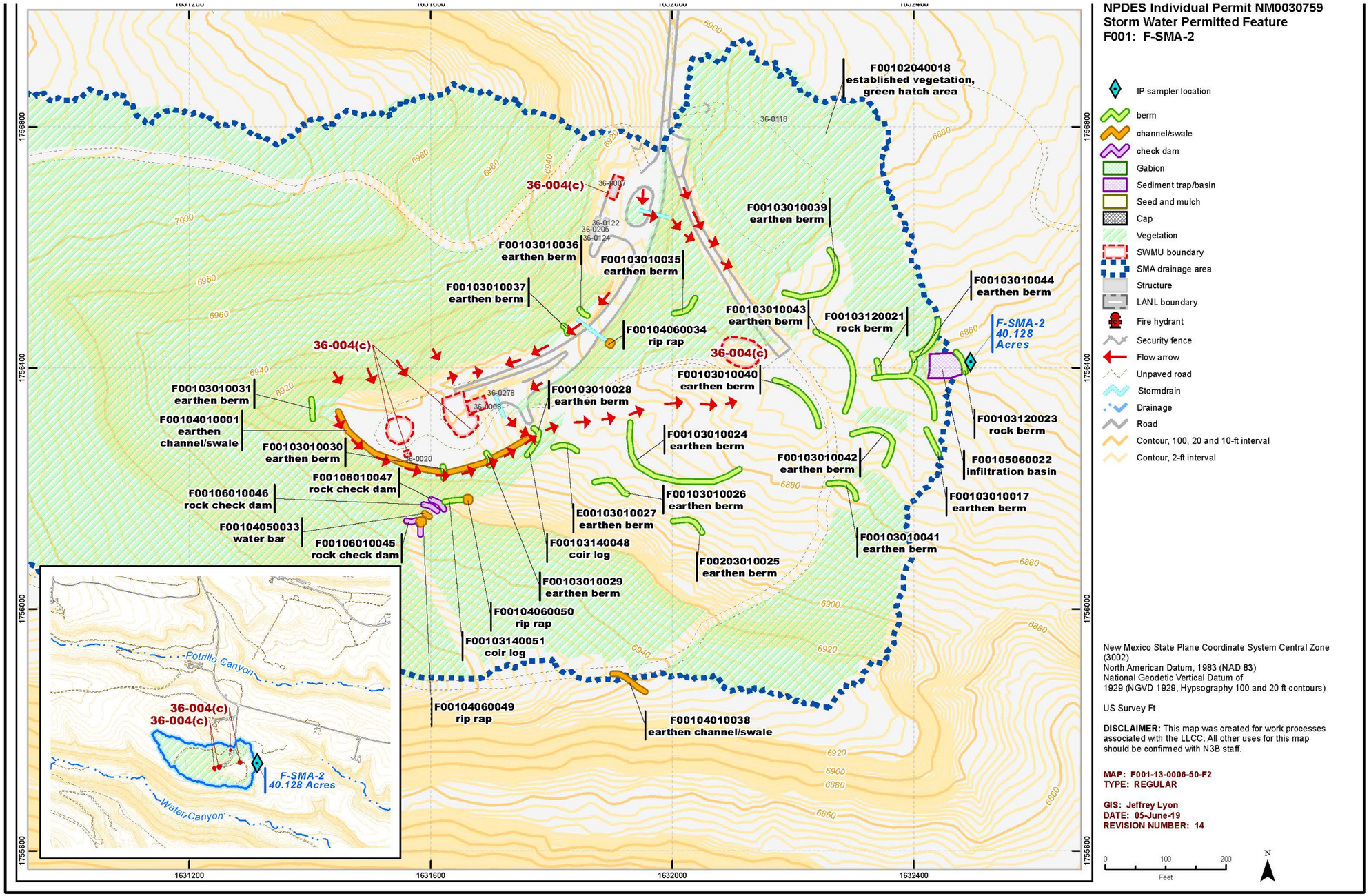

Figure 4.2-1. Drainage Control Features Near the TA-36-8 OD Unit.

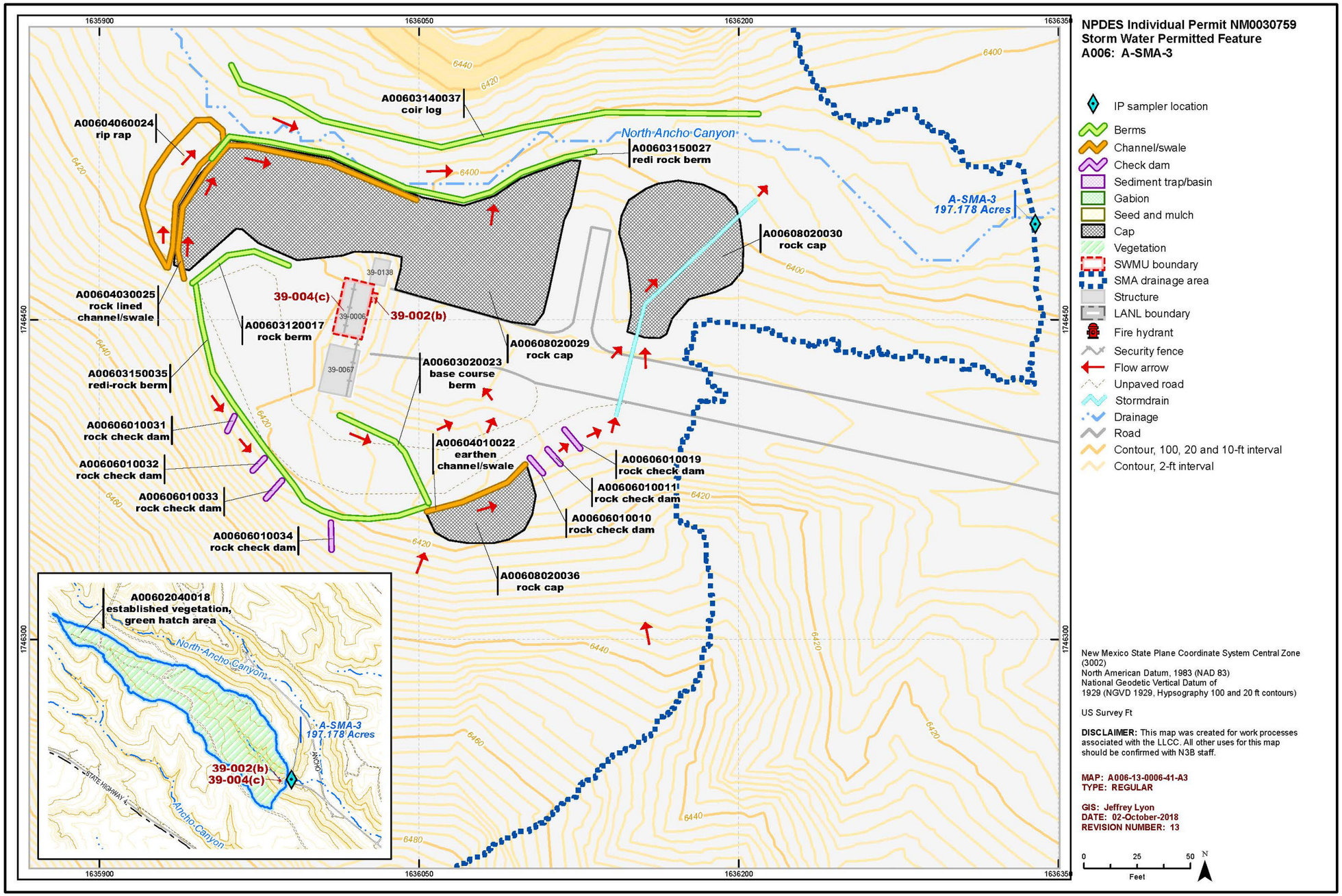

Figure 4.2-2. Drainage Control Features Near the TA-39-6 OD Unit.

Water Table Contours and Sampling Locations Downgradient of Unit at TA-36

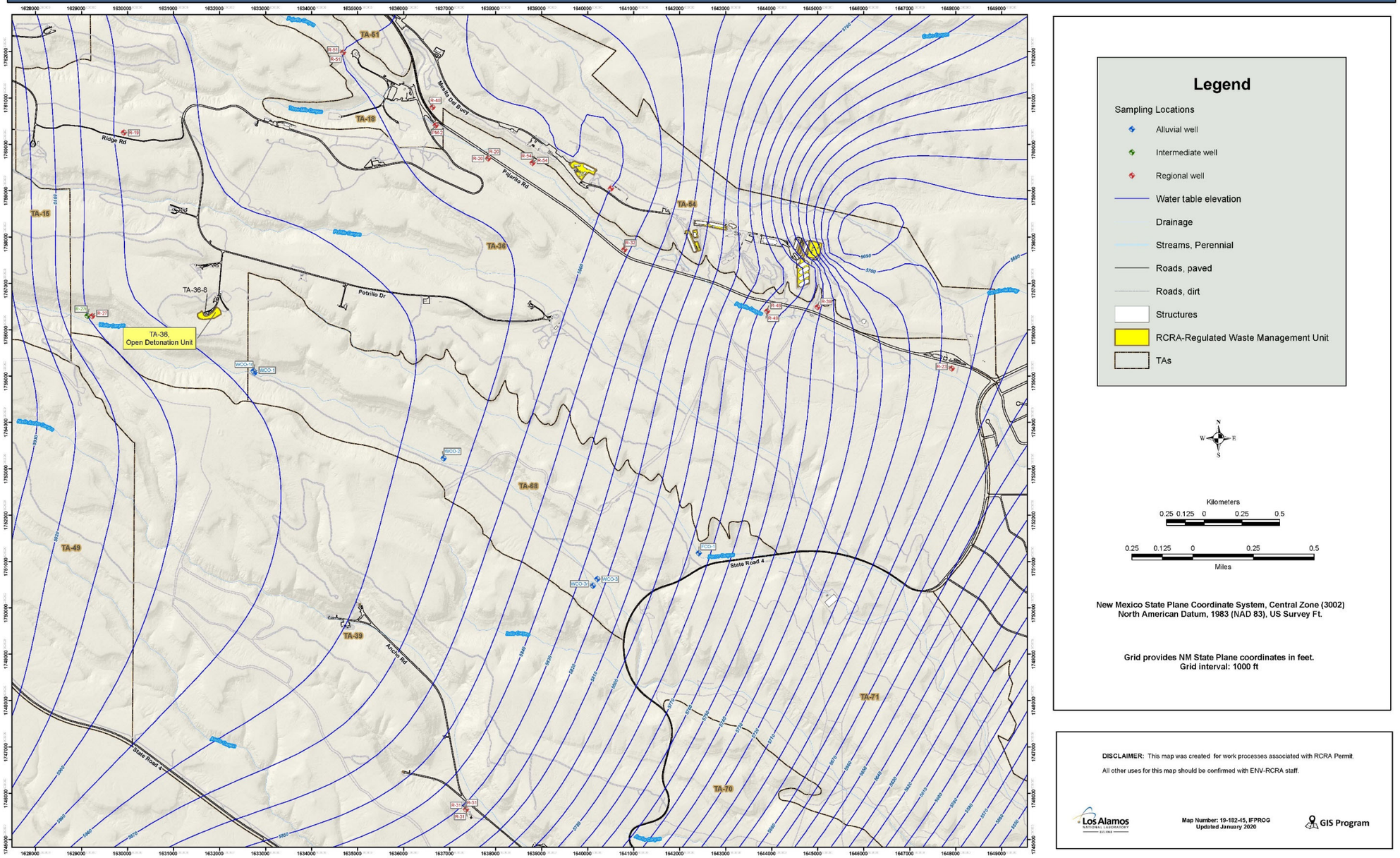

Figure 4.2-3. Water Table Contours and Sampling Locations Downgradient of Unit at Technical Area 36

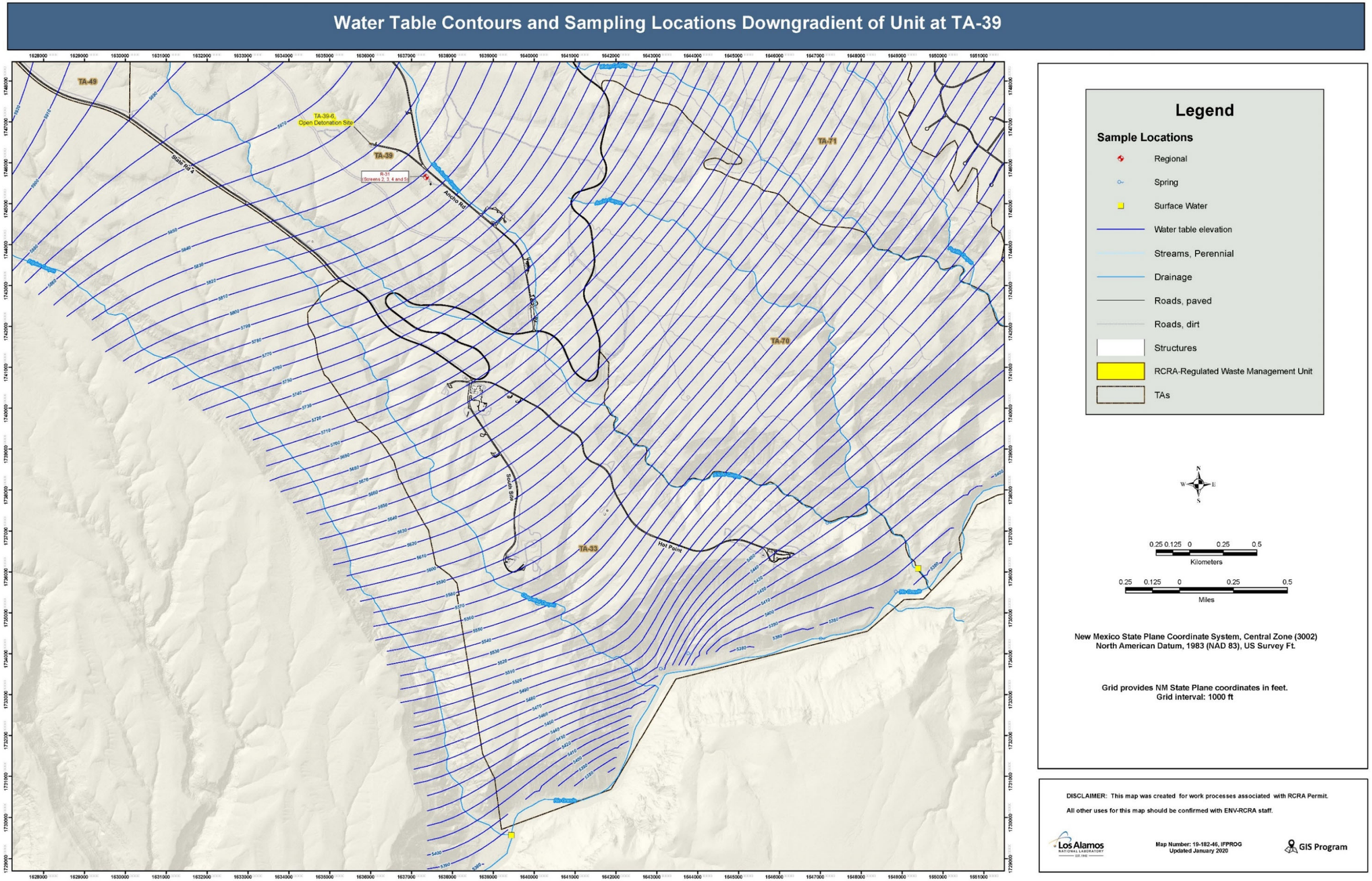

Figure 4.2-4. Water Table Contours and Sampling Locations Downgradient of Unit at Technical Area 39

Supplement 4-3

Hybrid Air Modeling Analysis and Ecological and Health Risk Assessment for Open Burning and Open Detonation Operations at Los Alamos National Laboratory

March 2024

Hybrid Air Modeling Analysis and Ecological and Health Risk Assessment for Open Burning and Open Detonation Operations at Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY

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1 Facility Description

This report describes the air modeling analysis associated with a risk evaluation for open burn (OB) and open detonation (OD) operations at Los Alamos National Laboratory (LANL). The OB operations are conducted at Technical Area (TA) 16, and the OD operations are conducted at TA-36 and TA-39. The purpose of the air modeling is to develop reasonable estimates of air quality impacts from OB and OD operations at these units for a subsequent ecological and health risk assessment.

LANL is located in Los Alamos County in north-central New Mexico. It is approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. It is located on 40 square miles of land that comprises multiple canyons and mesa tops with elevations that range from 5400 feet along the southwestern boundary to 8000 feet on the western boundary along the Jemez Mountains. The facilities and the associated residential and commercial areas of Los Alamos County are situated on the Pajarito Plateau. The facility is owned and co-operated by the U.S. Department of Energy (DOE)/National Nuclear Security Administration and Triad National Security, LLC.

2 Purpose of Hybrid Air Quality Dispersion Modeling

The purpose of the air dispersion modeling is to demonstrate that the OB and OD emissions comply with the national ambient air quality standards (NAAQS) and the New Mexico ambient air quality standards (NMAAQS). Dispersion modeling is also necessary to demonstrate that ambient concentrations and soil concentrations from the effects of deposition of toxic air pollutants and other pollutants of concern (POC) do not result in ecological or human health risks. The modeling proposed will follow the procedures in the current dispersion modeling guidelines published by the New Mexico Environment Department (NMED) Air Quality Bureau (AQB) on July 21, 2022 (NMEDa 2022), and the general guidelines provided by the U.S. Environmental Protection Agency (EPA) based on hybrid modeling performed at the Holston Army Ammunition Plant in EPA Region 4 (email dated August 17, 2022, from Sasha Gerhard, EPA Office of Resource Conservation & Recovery, Attachment 1). The air dispersion modeling protocol for OB and OD for the ATK Launch Systems, Inc., in Promontory, Utah, will also be referenced (ATK Addendum 2013).

3 Methodology for Hybrid Air Dispersion Modeling

The EPA currently recommends a hybrid approach to modeling dispersion from open burning and open detonation processes. Using two separate regulatory models—OBODM (Open Burn/Open Detonation Dispersion Model) and AERMOD (AMS/EPA Regulatory Model)—in the analysis allows facilities to draw on the strengths of both models while reducing the weaknesses of each model on the modeling results. For example, OBODM more closely models the source characteristics of open burning and open detonation operations compared with the volume source algorithm in AERMOD, whereas AERMOD features more-refined algorithms for handling meteorological data and predicting air concentrations and deposition fluxes. OBODM is an older method, but it performs well when applied to OB or OD. The EPA has not maintained the software to operate on current computer systems, but it is still available on the EPA SCRAM (Support Center for Regulatory Atmospheric Modeling) website. AERMOD has replaced OBODM as the standard model to use for open burn and open detonation hazardous waste management units (HWMUs; Attachment 1). LANL maintains a copy of OBODM on a stand-alone computer with a Microsoft XP operating system that allows the software to be used.

OBODM was used in 2013 to conduct the initial modeling that supports the risk assessment for the LANL Resource Conservation and Recovery Act (RCRA) Subpart X permit application. OBODM is intended for

use in evaluating the potential air quality impacts of the open burning and open detonation of obsolete munitions and solid propellants at U.S. Department of Defense and DOE installations (Bjorklund, et al., 1998a). The OB and OD treatment of waste propellants and propellant-contaminated material can be classified as instantaneous events for OD treatment and as quasi-continuous events for OB treatment; however, propellants are not treated by OB or OD at LANL.

OBODM predicts the downwind transport of pollutants using cloud rise and dispersion model algorithms from existing dispersion models. A complete description of the plume rise and dispersion algorithms used in OBODM is found in Volume II of the user's manual (Bjorklund, et al., 1998b). OBODM allows for a simplistic representation of local meteorology and includes a screening-level complex terrain algorithm. All OBODM source and receptor locations are defined relative to a rectangular or a polar coordinate system in which north (0 degrees) is the positive Y-axis and east (90 degrees) is the positive X-axis. All vertical (z) coordinates are heights above ground level except when the OBODM complex terrain screening mode is used, in which case the z coordinates are terrain heights above mean sea level. Overall, the designation of receptors for OBODM is based on the original modeling completed in 2013 for LANL OB and OD events. Concentrations for this limited number of receptors will be used for determining ambient concentrations for the updated risk assessment; however, they will be compared with AERMOD results for an expanded receptor grid to ensure that the most conservative ground level concentration (GLC) values are applied.

OBODM has two distinct parts. The first part simulates the OB and OD events and generates initial parameters of the emission cloud (emission rate, cloud height, cloud diameter). OB and OD result in combustion of the energetics and the rapid rise of the hot combustion products—due to buoyancy—until a final height is reached. At this point, the emission cloud has no upward momentum and begins to disperse downwind. This process can be estimated using the air dispersion model OBODM to predict the final cloud height of the OB or OD plumes.

OBODM calculates peak air concentrations, time-weighted air concentrations, and dosage (time-integrated concentration) for OB and OD releases. It can also consider the effects on concentration and dosage of the gravitational settling and deposition of particulates; however, OBODM has several limitations that constrain the modeling in this application. For example, a receptor grid for OBODM is limited with a maximum of 100 X coordinates and 100 Y coordinates that can be specified in either rectangular or polar coordinates. Also, a maximum of 100 discrete or unique points may be specified. Additionally, OBODM cannot predict deposition in complex terrain and uses older algorithms for downwind dispersion of emitted pollutants.

To overcome these limitations, the hybrid modeling approach will use results of the OBODM modeling as source input parameters for the AERMOD model, which is the EPA's preferred dispersion model for short-range transport (up to 50 kilometers). The OBODM final plume rise results will be evaluated to determine the most conservative parameters for input in AERMOD as a volume source to predict downwind dispersion and deposition.

The GLC results of the open burn/open detonation dispersion (OBOD) modeling (based on a limited receptor grid and public receptors) will be compared with the results from AERMOD to ensure that the most conservative estimates of ambient concentrations are applied to subsequent analyses.

4 OB and OD Operations Information, Source Parameters, and Methodology

4.1 Open Burning

4.1.1 *Description of Open Burning Unit*

The TA-16-388 Flash Pad is located at the TA-16 Burn Ground in the southwestern quadrant of LANL. The TA-16 Burn Ground is bounded on the northern side by Cañon de Valle and on the southern side by Water Canyon. The unit is used for the open burning treatment of detonable quantities of explosive waste and explosives-contaminated wastes. The location of the open burning unit at LANL that is addressed in this protocol is shown in Figure 4-1.

The unit consists of a 22-foot (ft) by 22 ft concrete pad that has 3 ft high concrete walls along the back and two sides. Each of the three walls has a 5 ft long, forced-air propane burner mounted on it. The propane burners provide the heat and fuel for waste treatment operations at the TA-16-388 Flash Pad. A picture of the unit is included as Figure 4-2. Treatment operations are most often conducted using the two side burners to treat waste placed in a steel tray. A retractable steel structure covers the concrete pad, burners, and trays when the unit is not in use. The location coordinates of the open burn unit in UTM[1] Zone 13, NAD 83[2] coordinates are as follows:

Unit	X-Coordinate	Y-Coordinate
TA-16-388 Flash Pad	379670.0m	3967821.0m

The unit is used only for treatment of explosive waste and explosives-contaminated waste. All treatment events use at least two propane burners, and an average treatment operation lasts up to 1 hour.

[1] Universal Transverse Mercator
[2] North American Datum of 1983

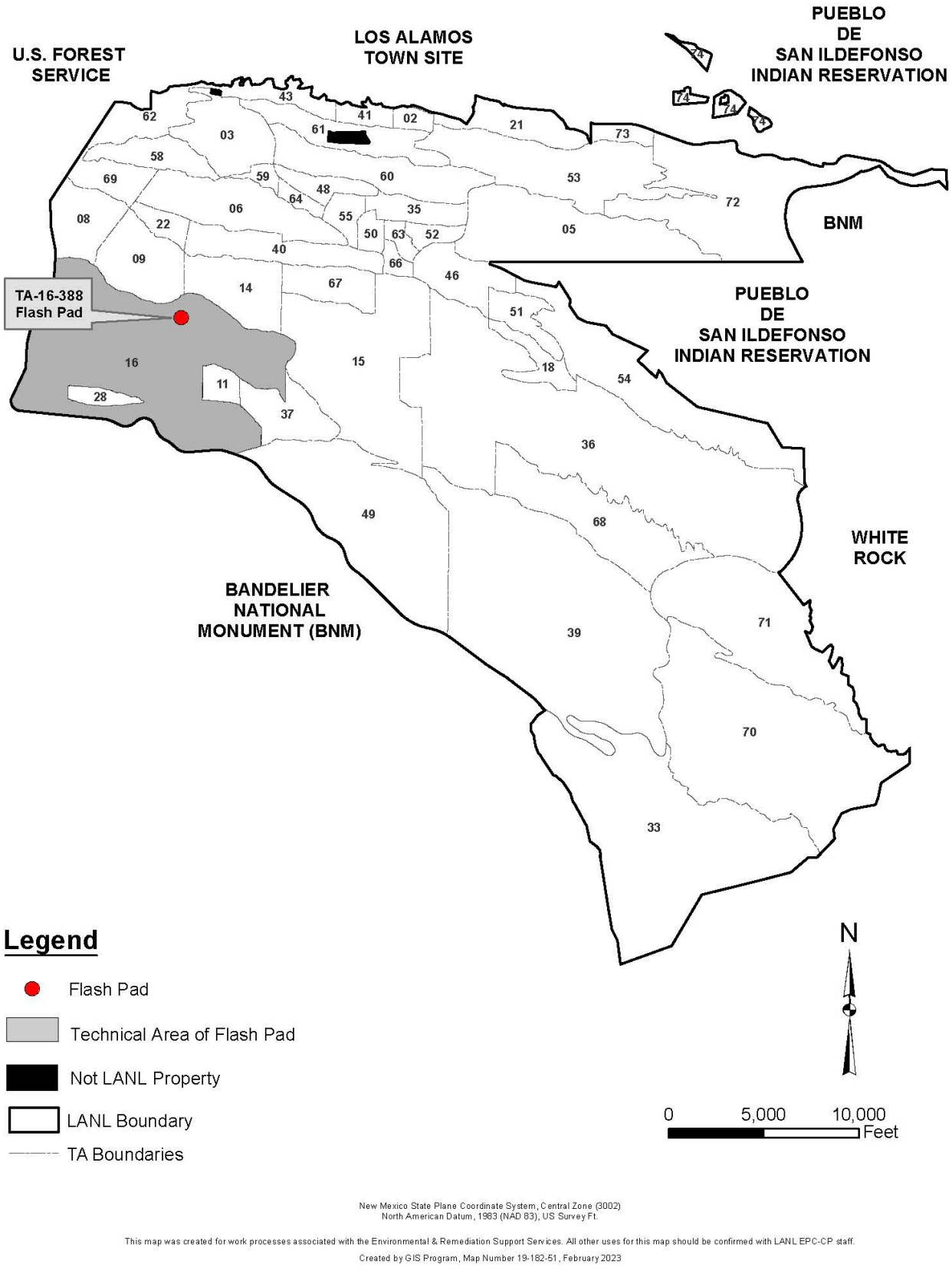

Figure 4-1. Location map of open burning unit at Los Alamos National Laboratory.

Figure 4-2. Photograph of Technical Area 16-388 Flash Pad.

4.1.2 *Source Characterization: Typical Open Burning Treatment Operations for the OBOD Modeling*

The maximum amount of explosive waste that can be treated at the TA-16-388 Flash Pad is 200 pounds (lb) at any one time. Although the explosive waste burn could include other noncombustible material, the 200 lb burn amount is assumed to be 100% combustible material. Other noncombustible material waste could be included, such as equipment or metal waste, but assuming the burn amount is all combustible material provides a conservative estimate. Additionally, the maximum annual amount of explosive waste that can be treated is 6000 lb. This approach allows for the calculation of annual air impacts for a potential maximum volume of waste per year and the calculation of the cumulative effects associated with that potential maximum.

The number of treatment operations and the amount of time it takes to complete treatment operations at the TA-16-388 Flash Pad were overestimated as part of this air impacts analysis. Modeling of air impacts will assume that the unit conducted treatment operations for a full hour and could have operated continuously from 8 a.m. to 5 p.m. over an entire year to ensure that the maximum hourly annual air concentration was captured. However, most treatment events are conducted in approximately 1 hour and in the morning when the wind is generally the lowest of the day; only one burn is conducted per day. The average number of actual treatment events per year is approximately 58 burns per year. If the unit

operated continuously from 8 a.m. to 5 p.m. every weekday, 58 burns that took 1 hour each would calculate to just over one week's worth of open burning.

The waste streams treated at the TA-16-388 Flash Pad are different from the waste streams on which the emissions factors used in this analysis are based; the actual waste streams treated are less hazardous to human health and the environment. No attempt was made to eliminate non-characteristic emissions from the analysis, which increases the conservative nature of the analysis. Waste stream emissions factors that have been chosen for this analysis estimate a higher air impact than would be released from day-to-day operations at the TA-16-388 Flash Pad.

4.1.3 *Source Parameter Input Values*

The input values used in the model runs are summarized in Table 4-1. The fuel heat content for waste burned is representative of the range of wastes treated; however, the heat content of propane used to assist each burn is much higher than waste heat content. The calculated propane heat content assumes that 1 gallon of propane is burned each minute during the 1-hour burn, with a weight of 4.24 lb/gallon (60 gallons/hr). This assumption yields 254.4 lb propane per burn. A representative propane heat content is 6030 kcal/liter or 11,893 cal/g (EPA 2008). The fuel quantities are maximum hourly and annual values. The fuel burn rates were calculated from the hourly fuel quantity divided by the fuel burn time. A release height of 0.5 meters was specified.

Table 4-1. Model Input Values

Parameter	Input Value
Fuel Heat Content, cal/g	12,893 (1000 waste; 11,893 propane)
Hourly Fuel Quantity, lb	454.4 (200 waste; 254.4 propane)
Annual Fuel Quantity, lb	13,632 (6000 waste; 7632 propane)
Fuel Burn Time, sec	2498
Fuel Burn Rate, lb/sec	0.18
Fuel Burn Rate, g/sec	82.5
Contaminant Emission Rate, g/sec	1

4.1.4 *OBODM Steps for Open Burning*

OBODM runs were conducted to determine the maximum GLC for various averaging periods. The methodology comprises the following steps:

1. A source strength model input file is prepared for determining short-term GLCs using the maximum quantity of hourly waste treated and propane used. The input file contains the maximum quantity for each hour from 8 a.m. to 5 p.m. for each day of the year.
2. Using a 1-year continuous, hourly, onsite, meteorological dataset, OBODM was run using the hourly source strength file for the short-term 1-, 3-, 8-, and 24-hour averaging periods.
3. The hourly model results were used to create a source strength input file for estimating annual or chronic GLCs. In a descending order, hourly fuel quantity from Table 4-1 is assigned to the hours of the year with the highest predicted GLC from the hourly model runs until the sum of the hourly values equals the maximum annual waste and propane use.
4. OBODM was run using the annual source strength file and the same 1-year onsite meteorological dataset for the annual averaging period.

5. In each model run, the contaminant emission rate was set at 1 gram per second (1 g/sec); thus, the maximum GLC predicted is for a contaminant emission rate of 1 g/sec.
6. For OBODM/AERMOD hybrid modeling, the OB results were analyzed to determine minimum and maximum plume rise at a given distance downwind of the open burn based on the days generating the highest 1-, 3-, 8-, and 24-h GLC recorded for the year. These results were used as input to AERMOD to determine the worst-case ambient impacts. Overall, it has been documented that a conservative impact assessment will result from the minimum plume rise (ATK Addendum 2013).

Each run was conducted using the appropriate source strength file as described above and the 1-year hourly meteorological dataset from the LANL TA-6 station. Table 4-2 summarizes the two scenarios modeled, and Table 4-3 describes the receptors.

Table 4-2. Open Burning Model Scenarios

Averaging Period	Waste Quantity (lb)
1, 3, 8, and 24 hours[1]	454.4 (200 waste; 254.4 propane)
Annual	13,632 (6000 waste; 7632 propane)

[1] The 1-, 3-, 8-, and 24-hour averaging periods are used to ensure that worst-case plume rise will be used as input to AERMOD.

4.1.5 *Meteorological Data*

LANL maintains a network of onsite meteorological stations that is adequate to predict maximum downwind concentrations from open burning operations when using a full year of meteorological data. The centrally located TA-6 station is the official meteorological station for LANL, and data from it are reported to the National Weather Service. The station consists of a 92-meter-high tower instrumented for wind and temperature at four levels. A 1-year continuous hourly record from this station was used in the model input. The dataset for 2021 was processed for both OBODM and AERMOD and was submitted to NMED for review and approval. The TA-16 Burn Ground site elevation is 7500 ft, and the elevation of the TA-6 Meteorological Station is 7424 ft. The TA-6 station is also the closest LANL meteorological station to the burn ground—about 1.5 miles away. The use of an official meteorological station consistently lessens uncertainty and increases the ability to compare current, previous, and future modeling.

4.1.6 *Receptors for OBODM*

Receptors are locations (onsite or offsite) where an individual may be exposed to contaminants due to a stationary source of contamination to the air. Receptors with terrain elevations are established to ensure the maximum downwind concentrations are captured in the model runs. For OBODM, a Cartesian receptor grid is set up with the burn ground being the center point of a 2000- by 2000-meter grid with 100-meter spacing between receptors. Public receptors include nearby roadways, recreation areas, schools, hospitals, and tribal land. A list of public receptors is shown in Table 4-3.

Table 4-3. Open Burning Public Receptors

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation (meters)
Bandelier Entrance at SR 4	384789.7	3962060.7	2031.2
Bandelier Visitor Center	385202.9	3960086.4	1845.1
San Ildefonso West of SR 4	388891.3	3967279.6	2006.7
White Rock Overlook Park	393146.0	3965274.7	1911.6

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation (meters)
Piñon Elementary School, White Rock	390207.5	3964769.6	1981.0
Elk Ridge Trailer Park	382432.8	3970723.1	2228.0
Los Alamos Medical Center	381001.8	3971679.6	2226.7
West Jemez Road	377585.0	3969284.5	2386.7
Ponderosa Campground	377386.1	3966238.8	2311.2
LANL SE Boundary	388723.0	3958724.3	1643.8
SR 4 SE	387161.9	3961999.5	1993.5
SR 4 SE	387131.3	3963223.8	1952.0
SR 4 SE	388019.0	3963805.4	1985.6
Pajarito Rd[2]	388416.9	3965488.9	2003.9
Pajarito Rd[2]	386702.8	3966284.8	2035.8
Pajarito Rd[2]	385417.2	3967692.8	2130.0
Pajarito Rd[2]	383764.3	3968549.8	2180.4
Pajarito Rd[2]	382142.0	3969498.7	2220.6
West Jemez Rd	377367.0	3967907.1	2364.6
West Jemez Rd	378132.2	3970600.7	2406.3
SR 4 SW	383427.6	3962917.7	2105.2
SR 4 SW	382264.4	3964080.9	2156.9
SR 4 SW	380948.2	3965427.7	2208.7
SR 4 SW	379142.3	3966223.5	2260.6

[1]All UTM coordinates are based on NAD 83.
[2]Public receptors used in OBODM and in past OBOD modeling reports but not used in AERMOD modeling because they are located on a private, restricted road. Key: SR = State Road; SE = Southeast; SW = Southwest

Figure 4-3 shows the LANL property boundary, roadways, and the location of the onsite and offsite receptors used in the analysis. LANL property is shaded darker than the surrounding land in the figure. The sites and associated receptor grid are indicated in the black grid squares. Public receptors are indicated in yellow.

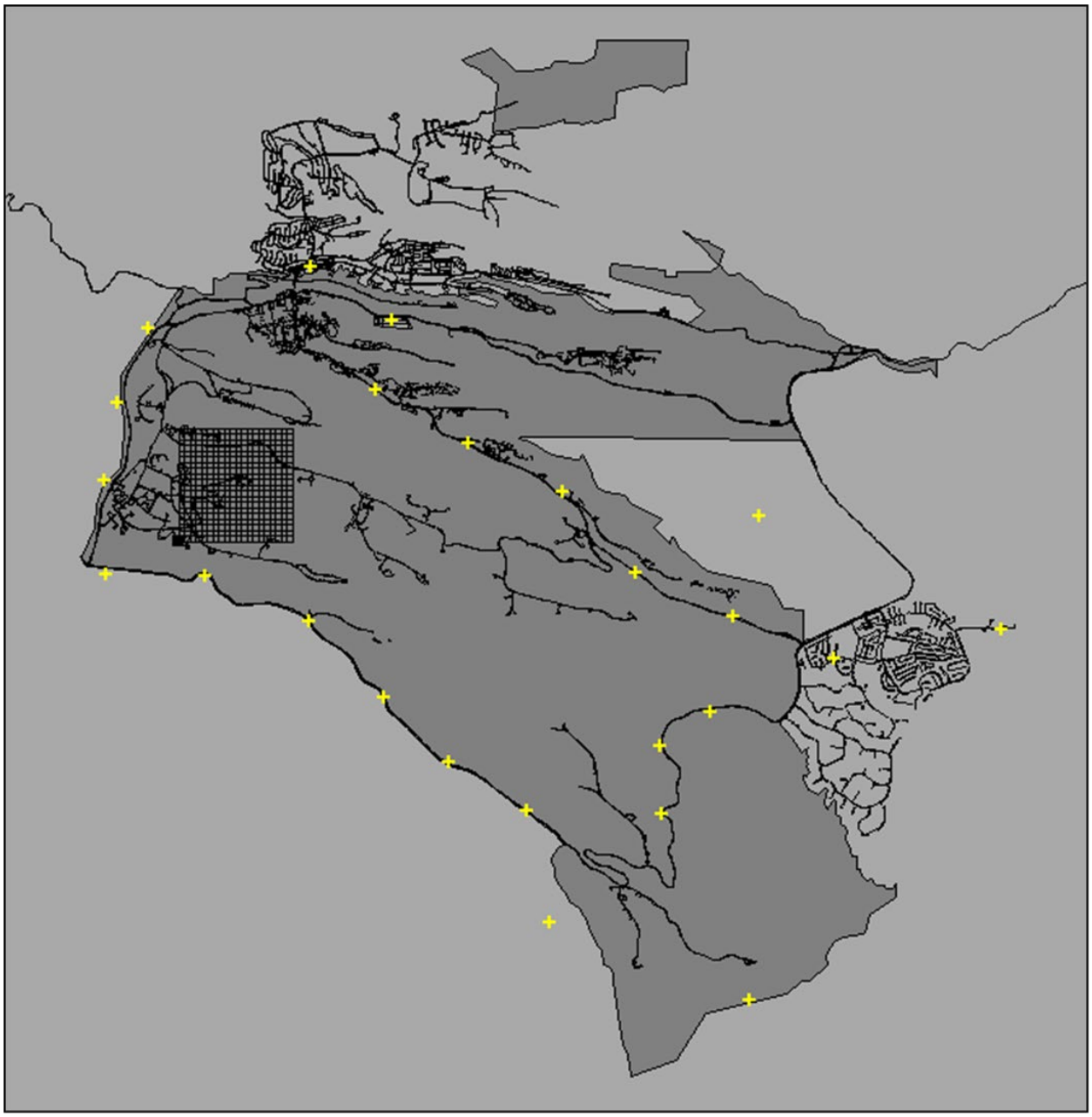

Figure 4-3. Location map of public receptors and receptor grid (Black grid squares are receptors at the site location; yellow plus signs are public receptors.)

4.2 Open Detonation

4.2.1 *Description of the Open Detonation Units and Operations*

OD operations are conducted at TA-36 and TA-39, as shown in Figure 4-4. TA-36 is located in the east-central portion of LANL and is spread over several mesa tops between a branch of Pajarito Canyon to the north and Water Canyon to the south. Mesa-top elevations at TA-36 range from approximately 6380 to 7120 feet above mean sea level. TA-36 contains an OD unit, several firing sites, and supporting offices where research is conducted with various types of explosives. The OD unit at TA-36 is located in

the southern portion of TA-36 near Building TA-36-8 and is shown in Figure 4-5. A picture of the detonation site is shown in Figure 4-6. The TA-36-8 OD unit consists of an irregularly shaped, sand- and grass-covered area that measures approximately 500 feet east to west and 300 feet north to south. The western portion is relatively flat; the eastern portion is concave to minimize fragment dispersion. The TA-36-8 OD unit may be used to treat solid and liquid hazardous explosive waste.

The TA-36-8 OD unit has a maximum treatment capacity of 2000 lb of explosive waste per detonation. Due to preparation time and monitoring requirements at this unit, only one detonation is performed per hour. The unit is used primarily for nontreatment-related experimental test detonations and occasionally for treatment of hazardous explosive waste. Following waste placement at the unit, detonation operations are conducted from Building TA-36-8, the control building.

TA-39 is located in the southern portion of LANL and includes much of the mesa between Water Canyon to the north and Ancho Canyon to the south. Mesa-top elevations at TA-39 range from approximately 6500 to 7000 feet above mean sea level. The area was established in 1959 for testing of explosive materials and has been used continuously for that purpose. The OD unit at TA-39 is located in a canyon bottom and consists of a relatively flat, sand-covered area that measures approximately 40 ft by 40 ft. Steep canyon walls rise to heights of 100 ft or more in the immediate vicinity of the OD unit, roughly forming a semicircle around the unit. The canyon walls serve to attenuate the force of the detonations. The OD unit at TA-39 is associated with Building TA-39-6, as shown in Figure 4-7. A picture of the detonation site is provided in Figure 4-8. Building TA-39-6 is a reinforced concrete structure that extends partially beneath the detonation area. The TA-39-6 OD unit may be used to treat solid and liquid hazardous explosive waste.

Table 4-4. Location map of open detonation units at Los Alamos National Laboratory

Unit	X-Coordinate	Y-Coordinate
TA-36-8	384428.8m	3965530m
TA-39-6	385714m	3962501m

The TA-39-6 OD unit has a maximum waste treatment capacity of 1000 lb of explosive waste per detonation per hour. The unit is used primarily for nontreatment-related experimental test detonations and occasionally for treatment of hazardous explosive waste. Following waste placement at the unit,

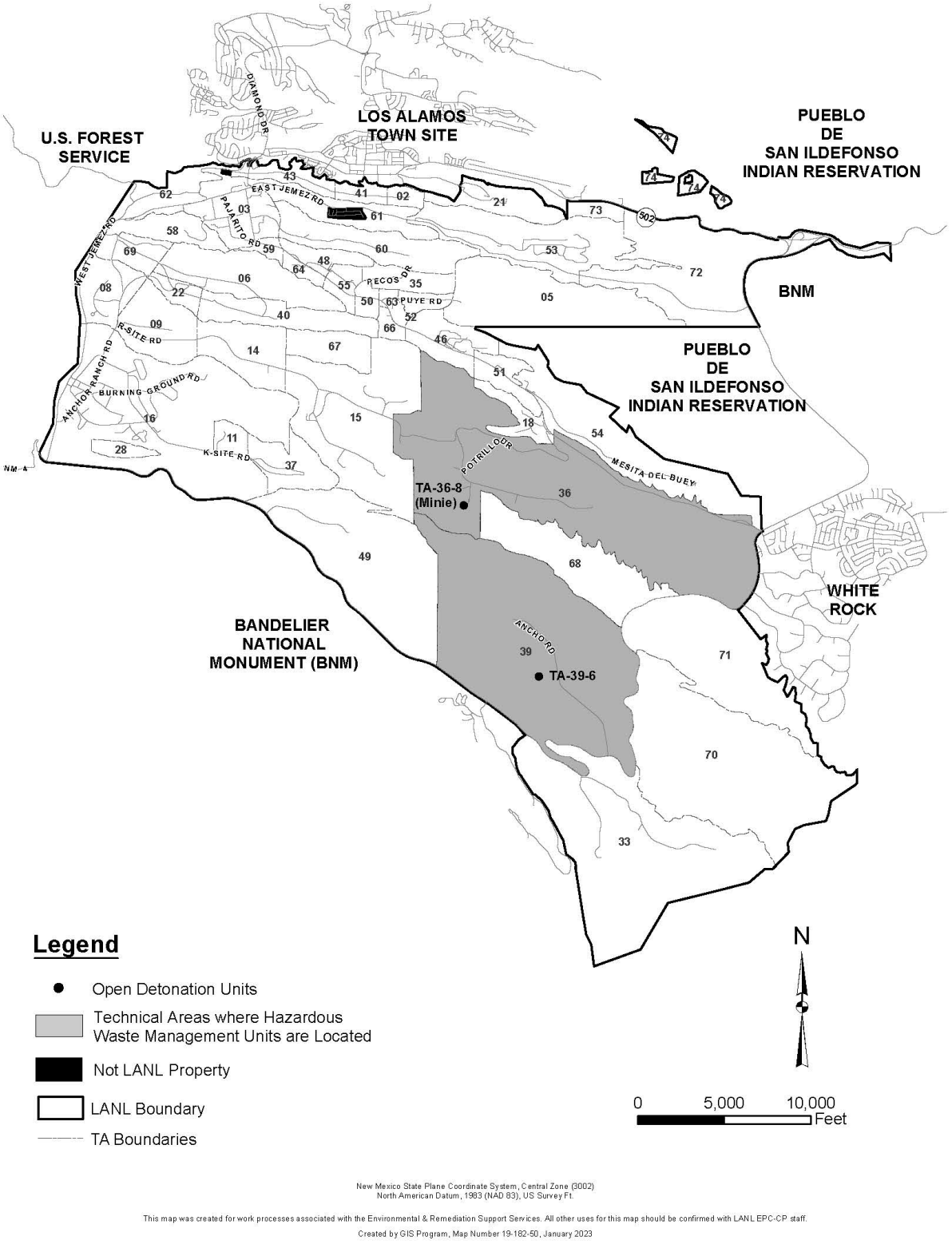

Figure 4-4. Location map of open detonation units at Los Alamos National Laboratory.

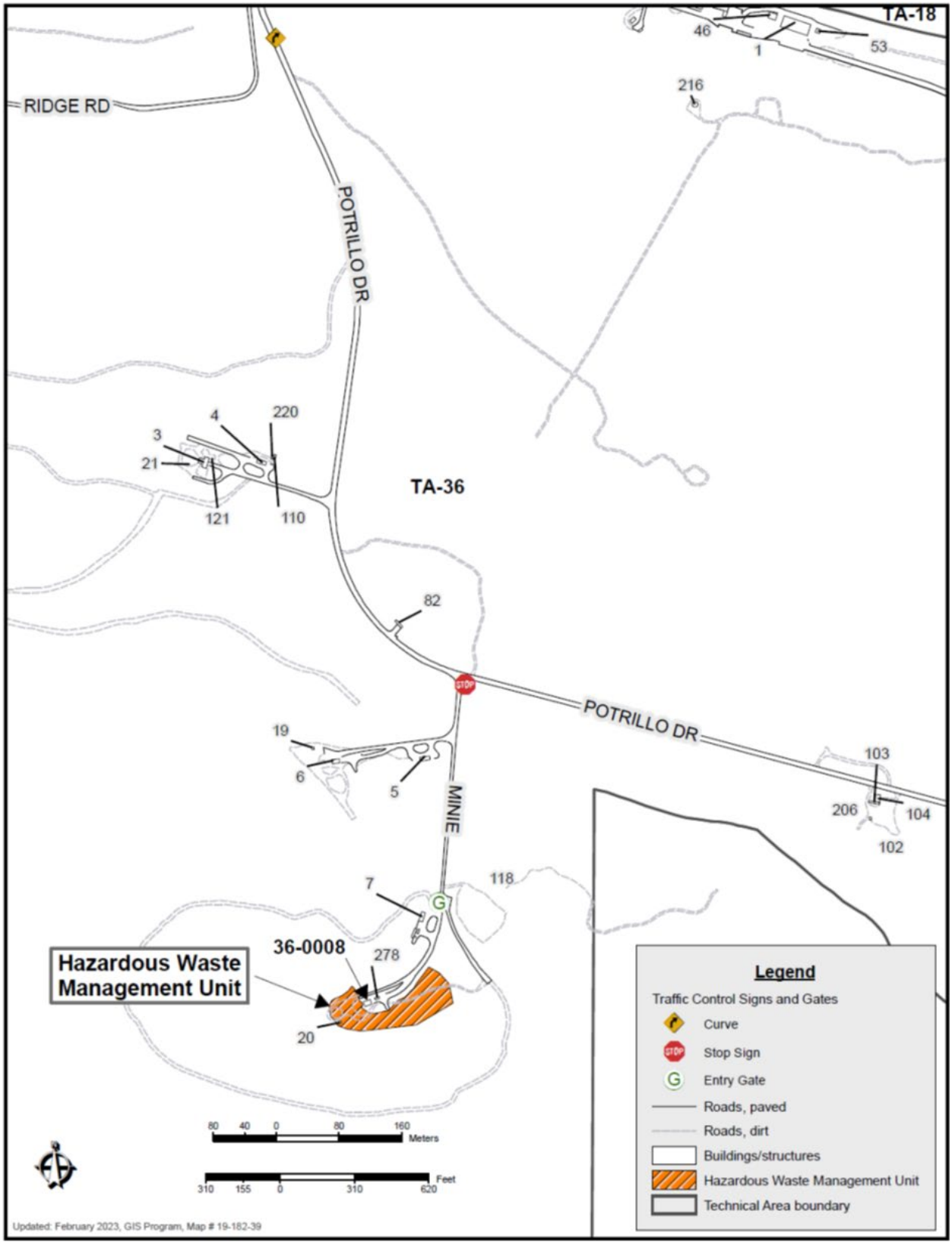

Figure 4-5. Map showing open detonation unit at Technical Area 36 Building 8.

Figure 4-6. Photograph of Technical Area 36-8 detonation pad.

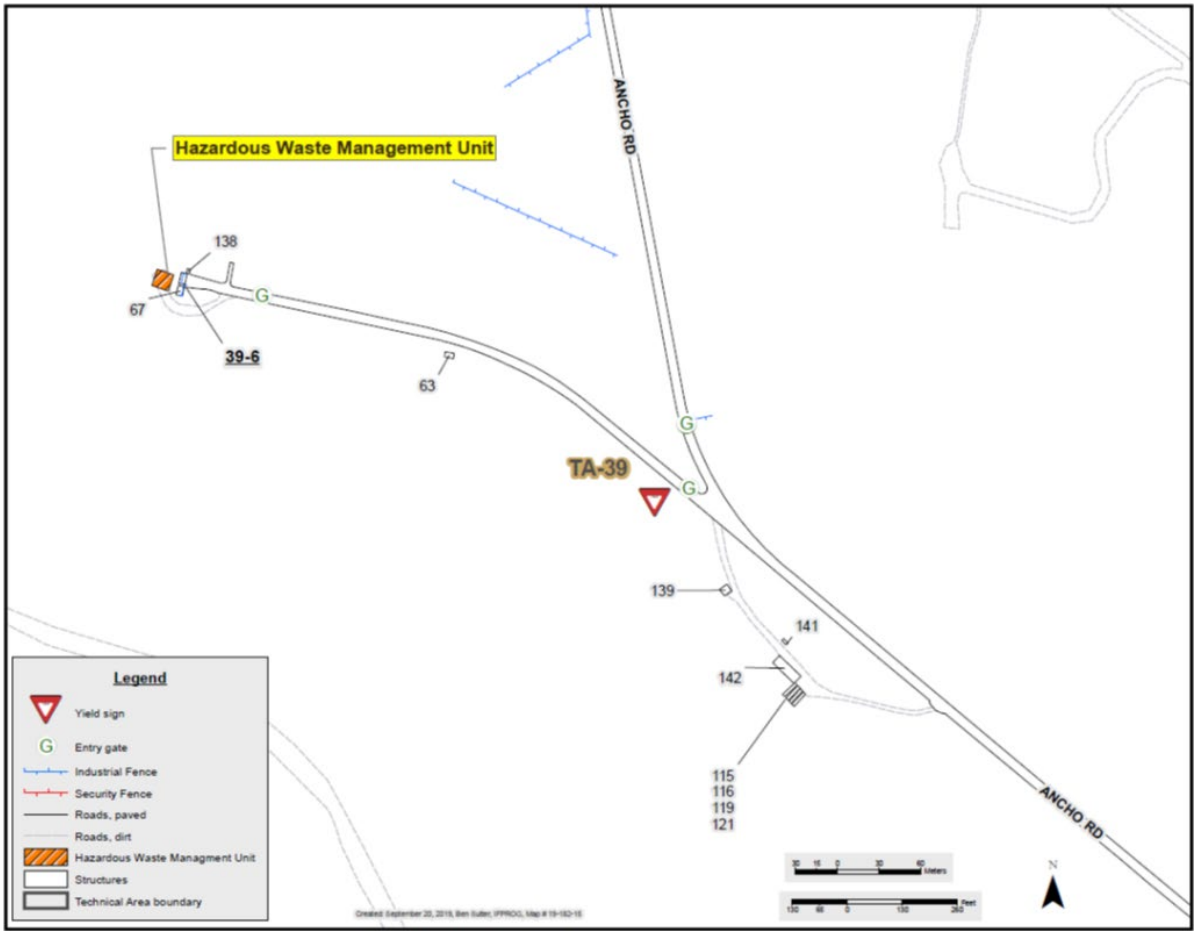

Figure 4-7. Map showing open detonation unit at Technical Area 39 Building 6.

Figure 4-8. Photograph of Technical Area 39-6 detonation pad.

4.2.2 *Source Characterization: Typical Open Detonation Treatment Operations*

OD operations are necessary for hazardous waste treatment to remove the characteristic of reactivity. Treatment by OD renders hazardous waste nonreactive and any infrequent residue amenable to handling and dispositioning. Nontreatment-related experimental test detonations (i.e., shots) are also currently performed at these locations.

Solid and liquid hazardous explosive waste may be treated (i.e., open detonated) at the unit. Waste streams treated through OD include

- excess explosives that vary from large pieces of explosives, small amounts of standard explosives, and developmental explosives;
- detonators, initiators, and mild detonating fuses that may be in metal or plastic casings and may contain lead-based primaries or be enclosed in a lead sheath;
- shaped charges and test assemblies with metal or plastic liners, sheaths, or holders;
- projectiles and munitions that may be larger than 50 caliber or smaller caliber ammunition that is damaged;
- pressing molds that are contaminated with explosives;
- explosives-contaminated waste generated in laboratories, make-up rooms, and at the firing site; and
- black powder or gun powder.

The previous list separates the two basic categories of explosives that may be managed at the OD treatment units. The first category consists of explosives-contaminated waste; the second category consists of explosive waste. Most of the waste treated at the OD units is explosive waste.

Explosives-contaminated waste includes make-up room (also called preparation room) wastes, laboratory wastes, contaminated molds, firing site debris, and decommissioning and demolition waste. Make-up room waste and laboratory waste consist of explosives-contaminated waste, such as paper towels, swabs, and similar materials that contain no tangible pieces of explosives but are used in the preparation of shots in the make-up building or as part of research and development processes. Firing site debris—wood scraps, cardboard, burlap, Plexiglas/Lexan, plastic, glass, Styrofoam, electrical cables, and metallic foils used for pin switches or metals such as target plates—is not generally explosives contaminated; however, firing site debris potentially contaminated with explosives can be generated occasionally. If the debris is explosives-contaminated and not rendered safe immediately, it is stored in the satellite accumulation area within the make-up building and treated as soon as possible.

Decommissioning and demolition waste can be generated when buildings are upgraded or removed from service. These wastes may be metal or glass piping that is not amenable to steam cleaning or open burning. Firing site debris could also include corrective action wastes or wastes generated as a result of investigation or remediation in the future. Other explosives-contaminated waste includes molds and other materials—used in the manufacturing of high-explosives parts—that may become contaminated and cannot be steam cleaned.

Explosive waste includes identifiable excess explosives that are safe to handle. It includes explosives assemblies and explosives, identifiable booster charge scrap, and any other process or cleanup wastes that are believed to be potentially reactive. Waste containers for explosives-contaminated waste and explosive waste generally consist of plastic bags or paper-lined cardboard boxes. These wastes make up most of the waste treated through OD at LANL. Up to 90 percent of the wastes treated within a year are excess explosives. Munitions, detonators, projectiles, and initiators make up an estimated annual quantity of approximately 2 percent of waste treated through OD.

4.2.3 *Source Parameter Input Values*

OD operations at TA-36 and TA-39 occur from 8 a.m. to 5 p.m. local time in the summer and from 9 a.m. to 4 p.m. in the winter. At TA-36-8, up to 2000 lb of high-explosives waste is treated in each open-air surface detonation, with a maximum of 15,000 lb of waste per year. Due to preparation and radiation-monitoring requirements, only one shot per hour is conducted for TA-36-8. At TA-39-6, up to 1000 lb of high-explosives waste is treated per open-air surface detonation per hour, with a maximum of 15,000 lb of waste per year.

Typically, only one detonation occurs daily; however, to ensure that the maximum hourly concentration is captured, all hours of the year from 8 a.m. to 5 p.m. were modeled using OBODM. The modeling is done by using as input a source strength file with the maximum hourly high-explosives waste quantity for each site of 2000 lb for TA-36 and 1000 lb for TA-39 for each hour. All other hours are specified as 0 lb of waste.

To ensure that the maximum annual air concentration is captured by the analysis, annual source strength files for each site were created based on the results of the hourly model run. Using an annual file with 8760 hours per year, hourly waste quantities are placed within the file for the hour of the year, which corresponds to the hours that show the highest concentrations in the hourly model runs. This process is done in a descending manner, starting with the hour that shows the highest concentration and moving down the hourly results until the annual waste quantities of 15,000 lb/year are reached.

The source parameter input values used in the OBODM model runs are summarized in Table 4-5. The fuel heat content specified is representative of the range of wastes treated. The fuel quantities are maximum hourly and annual values. Selection of the instantaneous emission type in model setup results in the model calculated fuel burn time of 2.5 seconds. The fuel burn rates are calculated from the hourly

fuel quantity divided by the fuel burn time. The model option for OBODM to calculate plume rise and present the results for each hour will be selected.

Table 4-5. Model Input Values

Parameter	TA-36-8	TA-39-6
Fuel Heat Content, cal/g	1000	1000
Hourly Fuel Quantity, lb	2000	1000
Annual Fuel Quantity, lb	15,000	15,000
Fuel Burn Time, sec	2.5	2.5
Fuel Burn Rate, lb/s	800	100
Fuel Burn Rate, g/sec	36,287.4	45,359
Contaminant Emission Rate, g/sec	1	1

4.2.4 *Methodology Steps for Open Detonation Modeling*

OBODM runs are conducted to determine the maximum GLC. The methodology comprises the following steps:

1. For each detonation site, a source strength model input file is prepared for short-term GLCs using the maximum hourly waste quantity for each site. The input file contains the maximum waste quantity for each hour from 8 a.m. to 5 p.m. for each day of the year.
2. Using a 1-year, continuous, hourly, onsite meteorological dataset, OBODM is run for each site using the hourly source strength file for the short-term 1-, 3-, 8-, and 24-hour averaging periods.
3. The hourly model results are used to create a source strength input file for estimating annual or chronic GLCs. In a descending order, the hourly fuel quantity is assigned to the hours of the year with the highest predicted GLC from the hourly model runs until the sum of the hourly values equaled the maximum annual waste quantity.
4. OBODM is run for each site using the annual source strength file and the same 1-year, onsite meteorological dataset for the annual averaging period.
5. In each model run, the contaminant emission rate is set at 1 g/sec; thus, the maximum GLC predicted was for a contaminant emission rate of 1 g/sec. The maximum GLC over the 1-g/sec emission rate, referenced as the X/Q value, has units of $\mu g/m^3$ per 1 g/sec.
6. Emission factors, together with maximum waste quantities, are used to calculate the emission rate in g/sec for each specific pollutant or contaminant projected to occur from a detonation.
7. For the hybrid modeling, the OD results for plume rise will be analyzed to determine minimum and maximum plume rise at a given distance downwind of the open detonation based on the days that generate the highest 1-, 3-, 8-, and 24-h GLC recorded for the year. Overall, it has been documented that a conservative impact assessment will result from the minimum plume rise (ATK Addendum 2013). The plume parameters will be used as inputs to AERMOD to determine the ambient impacts. OBODM ambient impacts will be compared to the AERMOD results to determine the worst-case ambient impacts for the health and ecological risk assessments and the air quality standards.

Each run will be conducted using the appropriate source strength file as previously described: the 1-year, hourly, meteorological dataset from the LANL TA-6 station. Table 4-6 summarizes the four scenarios modeled.

Table 4-6. Four Modeling Scenarios

OD Site	Averaging Period	Waste Quantity
TA-36-8	1, 3, 8, and 24 hours	2000 lb
TA-36-8	Annual[1]	15,000 lb
TA-39-6	1, 3, 8, and 24 hours	1000 lb
TA-39-6	Annual	15,000 lb

[1] The annual source strength file for this site used 8 hours with 2000 lb per hour rather than a single hour with 1000 lb of waste, to produce a 15,000-lb total; therefore, the maximum concentration is conservative.

4.2.5 *Meteorological Data*

See Section 4.1.5 for discussion of meteorological data for OBOD modeling.

4.2.6 *Receptors for OD Modeling*

Receptors with terrain elevations are established to ensure that the maximum downwind concentrations are captured in the model runs. A Cartesian receptor grid is set up for each detonation site, with the site being the center point of a 1000- by 1000-meter grid with 100-meter spacing between receptors. Public receptors include nearby roadways, recreation areas, schools, hospitals, and tribal land. A list of public receptors is shown in

Table 4-7.

Figure 4-9 shows the LANL property boundary, roadways, and the receptors used in the analysis. In the figure, LANL property is shaded darker than the surrounding land. The two sites and associated receptor grids are indicated in the black grid squares, with TA-36 north of the TA-39 site. Public receptors are indicated in yellow.

Table 4-7. Public Receptors

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation[2] (feet)
Bandelier Entrance at SR 4	384789.7	3962060.7	2031.2
Bandelier Visitor Center	385202.9	3960086.4	1845.1
Midpoint 2 OD Sites[2]	385071.3	3964015.1	2058.1
TA-36-8 Proximity[2]	384473.6	3965417.7	2117.9
San Ildefonso West of SR 4	388891.3	3967279.6	2006.7
White Rock Overlook Park	393146.0	3965274.7	1911.6
Piñon Elementary School, White Rock	390207.5	3964769.6	1981.0
Elk Ridge Trailer Park	382432.8	3970723.1	2228.0
Los Alamos Medical Center	381001.8	3971679.6	2226.7
West Jemez Road	377585.0	3969284.5	2386.7
Ponderosa Campground	377386.1	3966238.8	2311.2
TA-39 Entrance[2]	386855.8	3961142.4	1916.8
LANL SE Boundary	388723.0	3958724.3	1643.8
SR 4 SE	387161.9	3961999.5	1993.5
SR 4 SE	387131.3	3963223.8	1952.0

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation[2] (feet)
SR 4 SE	388019.0	3963805.4	1985.6
Pajarito Rd[2]	388416.9	3965488.9	2003.9
Pajarito Rd[2]	386702.8	3966284.8	2035.8
Pajarito Rd[2]	385417.2	3967692.8	2130.0
Pajarito Rd[2]	383764.3	3968549.8	2180.4
Pajarito Rd[2]	382142.0	3969498.7	2220.6
West Jemez Rd	377367.0	3967907.1	2364.6
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SR 4 SW	383427.6	3962917.7	2105.2
SR 4 SW	382264.4	3964080.9	2156.9
SR 4 SW	380948.2	3965427.7	2208.7
SR 4 SW	379142.3	3966223.5	2260.6

[1]All UTM coordinates are based on NAD 83.
[2]Public receptors used in OBODM and in past OBOD modeling reports but not used in AERMOD modeling because they are located on a private, restricted road.
Key: SR = State Road; SE = Southeast; SW = Southwest

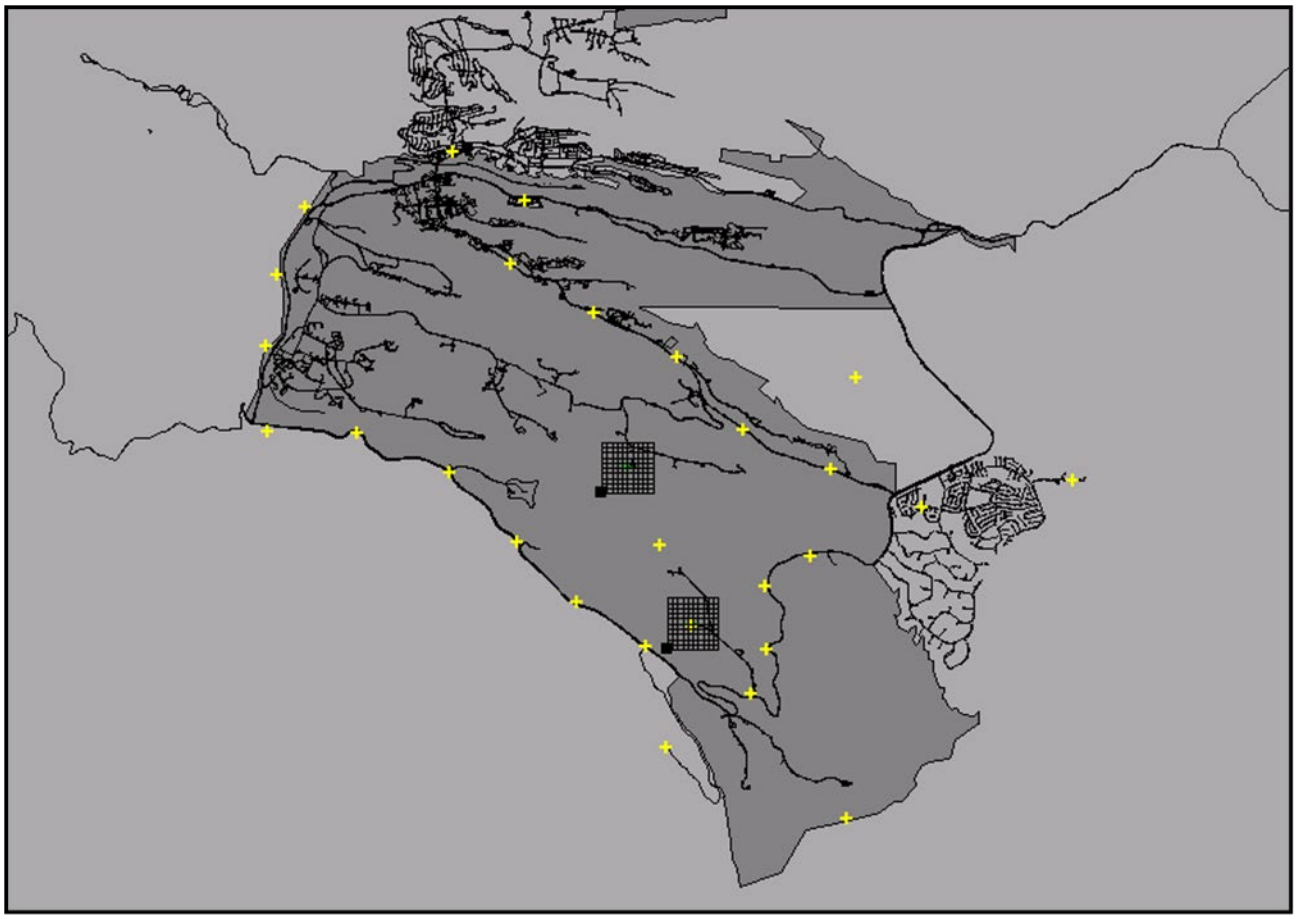

Figure 4-9. Location map of public receptors and receptor grids for OBODM OD modeling.

4.3 AERMOD

4.3.1 *Dispersion Model Input Options*

The dispersion modeling analysis used AERMOD, an EPA-preferred and NMED-recommended Gaussian plume model for use within 50 kilometers of emission sources. AERMOD is appropriate for determining compliance with the ambient air quality standards in the complex topography around LANL. LANL will use the current version of BEEST, a commercial graphical interface of AERMOD. The analysis will use all EPA default regulatory options specified in AERMOD.

4.3.2 *Source Characterization*

Methodology for Processing Plume Rise Results for Input in AERMOD

The plume rise determinations are based on Volume 1 and Volume 2 of the OBODM User's Guide. The AERMOD GLC results were used for the analysis of the NAAQS, NMAAQS, toxic air pollutants (TAP), hazardous air pollutants (HAP), and other POCs in the report for the RCRA Subpart X application.

For the purposes of this modeling approach, OBODM is applied to OB or OD events to determine the most conservative values for the plume rise at a given distance downwind. Open burning and open detonation results in combustion of the energetics and the rapid rise of the hot combustion products, due to buoyancy, until a final height is reached. At this point, the emission cloud has no upward momentum and begins to disperse downwind. This process can be estimated using OBODM to predict the final cloud height of the OB or OD plume. This height is then specified as the release height in the volume source algorithm in AERMOD.

The initial diameter of the cloud at final plume height for the open burn and open detonation events were determined using Equation 2-71 from Volume 2, Section 2.6.3, of the OBODM User's Guide for calculating the radius:

$$r(x) = [\gamma c][\Delta hc(x)] + rR$$

where:
$r(x)$ = radius of the cloud at final plume height
x = the distance at which final plume height is achieved
γc = 0.6 (OBODM default value)
$\Delta hc(x)$ = final plume height
rR = radius of a circle with same area as burn/detonation pans

Assuming that the vapor cloud is a sphere, the sigmas for the AERMOD volume source can be calculated from the results obtained from Equation 2-71. Thus, according to the AERMOD User's Guide, the initial vertical and horizontal sigmas for a volume source, such as the vapor cloud, can be calculated by dividing the calculated cloud diameter by 4.3.

Based on OB and OD modeling, the most conservative plume rise results will be applied to the AERMOD source parameters as a volume source. A unitized emission rate of 1.0 gram/second is used in each model run to preclude modeling each potentially emitted constituent separately. Unitized emissions rates will be adjusted for each POC's specific emission factor to calculate the ambient concentration and deposition rate for the risk assessment. Concentration and deposition are directly proportional to air modeling results based on the unit emission rate employed in the AERMOD modeling analysis.

Emission Factors for OB

This section describes the sources of emission factors and the emission factors applied to each waste stream treated by open burning. Waste streams treated by open burning are described in Section 4.1.2 of this document. An emission factor is a documented representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Based on the waste streams described, emission factors were chosen for pollutants that had air quality standards. Emission factors are not shown for pre-treatment and post-treatment emissions (such as fugitive dust) because no equipment operates off-road, earth-moving operations are not part of the open burning/open detonation activities, and ash generation is routinely negligible from open burning operations. Additionally, emission factors for the detonation of explosives—of which more recent research has been conducted and is available—were not considered for use because detonation has processes, such as fragment formation, that do not occur during open burning.

Materials burned at the TA-16-388 Flash Pad may vary in composition from mostly to all explosives and explosives pieces to small quantities of explosives on contaminated combustible solids or noncombustible solids. Most of the emissions products (more than 99 percent) associated with open burning are carbon, nitrogen, and oxygen. In fact, emission products from most energetic material treated by open burning can be adequately represented by the analytes carbon dioxide, carbon monoxide, nitrogen oxide, and nitrogen dioxide—with only trace quantities of total saturated hydrocarbons, acetylene, ethylene, propene, benzene, toluene, and particulates (EPA 1998).

To characterize the potential impact to the site from air dispersion and depositions, the minimal fractions of contaminants that may be produced during open burning treatment activities have been estimated using calculations and emission factors from documented sources. The maximum amount of burnable material that can be treated at the TA-16-388 Flash Pad is 200 lb per burn and 6000 lb per year. To reasonably but conservatively represent waste treatment activities at the TA-16-388 Flash Pad, a combined waste stream was developed that encompasses the most conservative emission factors from surrogates that represent the waste streams treated by open burning. This methodology sufficiently covers the worst-case scenario for emissions from the unit.

Surrogate waste streams described in the following sections and chosen to represent each waste stream detailed in Section 4.1.2 were chosen from one of the limited documented sources. The waste-stream-specific emission factors were combined to create a single surrogate waste stream that encompasses all waste streams that may be treated at the TA-16-388 Flash Pad. This waste stream is represented by the combined emission factors shown in Table 4-8. Emission factors for the propane that is used as fuel for open burning waste treatment are shown separately but are included with the waste stream surrogate as part of the air impact assessment.

Table 4-8. OB Emission Factors by Surrogate Waste Streams and Combined Waste Stream[1]

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
1,2,4-Trimethylbenzene			3.87E−07	4.25E−07	2.43E−04	2.43E−04	Diesel and Dunnage
1,2,4-Trimethylbenzene & sec-Butylbenzene		3.43E−07	4.53E−07	1.10E−06	5.09E−04	5.09E−04	Diesel and Dunnage
1,3,5-Trimethylbenzene		4.29E−08	9.07E−08	2.99E−07	5.57E−04	5.57E−04	Diesel and Dunnage
1,3-Butadiene			9.07E−08	4.98E−07	1.34E−06	1.34E−06	Diesel and Dunnage
1-Butene		2.29E−07	2.72E−07	5.97E−07	4.69E−06	4.69E−06	Diesel and Dunnage
1-Hexene		1.07E−07			2.19E−06	2.19E−06	Diesel and Dunnage
1-Pentene		3.55E−08	9.07E−08	9.95E−08	1.72E−06	1.72E−06	Diesel and Dunnage
2,2,4-Trimethylpentane		1.29E−07			6.97E−06	6.97E−06	Diesel and Dunnage
2,2-Dimethylbutane		4.29E−08				4.29E−08	M31A1E1
2,3,4-Trimethylpentane					1.38E−06	1.38E−06	Diesel and Dunnage
2,3-Dimethylbutane		3.55E-08			2.06E-06	2.06E-06	Diesel and Dunnage
2,3-Dimethylhexane					5.40E-06	5.40E-06	Diesel and Dunnage
2,3-Dimethylpentane					3.33E−06	3.33E−06	Diesel and Dunnage
2,4,4-Trimethyl-1-pentene		8.58E−08	9.07E−08	1.99E−07		1.99E−07	PBXN-110
2,4-Dimethylhexane				1.99E−07	6.42E−06	6.42E−06	Diesel and Dunnage
2,4-Dimethylpentane					2.16E−06	2.16E−06	Diesel and Dunnage
2,5-Dimethylhexane					1.11E−05	1.11E−05	Diesel and Dunnage
2-Methyl-1-butene			9.07E−08	1.99E−07	1.05E−06	1.05E−06	Diesel and Dunnage
2-Methyl-2-butene			9.07E−08			9.07E−08	M-43
2-Methylheptane		3.44E−08	9.07E−08		4.42E−05	4.42E−05	Diesel and Dunnage
2-Methylhexane		4.29E−08	1.81E−07		1.38E−05	1.38E−05	Diesel and Dunnage
2-Methylnaphthalene					2.18E−05	2.18E−05	Diesel and Dunnage
2-Methylpentane		6.89E−08			9.47E−06	9.47E06	Diesel and Dunnage
3-Ethylhexane, 3-Methylheptane		1.07E-07	9.07E-08		5.90E-05	5.90E−05	Diesel and Dunnage
3-Methyl-1-butene			9.07E−08	1.99E−07		1.99E−07	PBXN-110
3-Methylhexane					1.55E−05	1.55E−05	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
3-Methylpentane		3.77E−08			5.08E−06	5.08E−06	Diesel and Dunnage
Acenaphthylene					6.71E−06	6.71E−06	Diesel and Dunnage
Acetophenone					1.74E−07	1.74E−07	Diesel and Dunnage
Acetylene		1.02E−06	5.89E−06	3.09E−06	9.52E−05	9.52E−05	Diesel and Dunnage
Aluminum					7.13E−07	7.13E−07	Diesel and Dunnage
Anthracene					1.02E−07	1.02E−07	Diesel and Dunnage
Aromative (e.g., Styrene)		5.43E−05	2.81E−06	7.07E−06	2.29E−03	2.29E−03	Diesel and Dunnage
Barium		4.20E−07			1.61E−07	4.20E−07	M31A1E1
Benzene		9.98E−07	1.76E−06	4.88E−06	7.84E−05	7.84E−05	Diesel and Dunnage
Benzo(a)anthracene					9.81E−07	9.81E−07	Diesel and Dunnage
Benzo(a)pyrene					7.42E−07	7.42E−07	Diesel and Dunnage
Benzo(b)fluoranthene					7.84E−07	7.84E−07	Diesel and Dunnage
Benzo(ghi)perylene					3.45E−07	3.45E−07	Diesel and Dunnage
Benzo(k)fluoranthene					7.46E−07	7.46E−07	Diesel and Dunnage
Benzyl alcohol		1.91E−09			3.96E−05	3.96E−05	Diesel and Dunnage
Biphenyl					6.45E−06	6.45E−06	Diesel and Dunnage
Butylbenzyl phthalate (85-68-7)					1.22E−07	1.22E−07	Diesel and Dunnage
Carbon Tetrachloride		6.89E−08				6.89E−08	Diesel and Dunnage
Chromium		3.97E−07				3.97E−07	M31A1E1
Chrysene					9.33E−07	9.33E−07	Diesel and Dunnage
cis-2-Butene		1.29E−07	9.07E−08	1.99E−07		1.99E−07	PBXN-110
cis-2-Pentene			9.07E−08			9.07E−08	M-43
CO	2.80E−02	1.66E−04	1.40E−03	2.32E−02	2.98E−02	2.98E−02	Diesel and Dunnage
CO2		6.45E−01	7.73E−01	1.04E+00	1.63E+00	1.63E+00	Diesel and Dunnage
Copper		6.31E−06				6.31E−06	M31A1E1
Cyclohexane		3.55E−08	9.07E−08		2.67E−05	2.67E−05	Diesel and Dunnage
Cyclopentane		4.29E−08	9.07E−08	9.95E−08	1.53E−06	1.53E−06	Diesel and Dunnage
Dibenz (a, h) anthracene					2.00E−07	2.00E−07	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
Diethyl phthalate		6.58E−08			7.00E−08	7.00E−08	Diesel and Dunnage
Dimethyl phthalate					1.88E−07	1.88E−07	Diesel and Dunnage
Di-n-butyl phthalate		3.30E−07			1.46E−07	3.30E−07	M31A1E1
Di-n-octyl phthalate					9.19E−07	9.19E−07	Diesel and Dunnage
Ethane		6.38E−08	1.81E−07	9.95E−07	1.15E−05	1.15E−05	Diesel and Dunnage
Ethyl chloride		6.89E−08				6.89E−08	M31A1E1
Ethylbenzene		4.44E−07	3.42E−07	7.96E−07	5.49E−05	5.49E−05	Diesel and Dunnage
Ethylene		9.78E−07	4.81E−06	6.67E−06	7.43E−05	7.43E−05	Diesel and Dunnage
Fluoranthene					7.85E−07	7.85E−07	Diesel and Dunnage
HCL			9.97E−04	1.79E−04		9.97E−04	M-43
i-Butane		7.11E−08			1.24E−06	1.24E−06	Diesel and Dunnage
i-Butene		1.51E−07	5.44E−07	1.29E−06	2.26E−06	2.26E−06	Diesel and Dunnage
Indeno(1,2,3-cd) pyrene					2.83E−07	2.83E−07	Diesel and Dunnage
i-Pentane			9.07E−08		1.08E−05	1.08E−05	Diesel and Dunnage
i-Propylbenzene					1.03E−04	1.03E−04	Diesel and Dunnage
m- & p-Xylene		1.33E−06	6.83E−07	7.96E−07	4.52E−04	4.52E−04	Diesel and Dunnage
Methane					8.72E−05	8.72E−05	Diesel and Dunnage
Methyl chloroform		3.44E−08				3.44E−08	M31A1E1
Methylchloride		2.84E−07		1.81E−07		2.84E−07	M31A1E1
Methylcyclohexane		3.30E−07			1.56E−04	1.56E−04	Diesel and Dunnage
Methylcyclopentane					9.93E−06	9.93E−06	Diesel and Dunnage
Methylenechloride		7.46E−07				7.46E−07	M31A1E1
m-Ethyltoluene		8.58E−08		1.99E−07	1.28E−04	1.28E−04	Diesel and Dunnage
Naphthalene					8.38E−05	8.38E−05	Diesel and Dunnage
n-Butane		3.44E−07	9.07E−08	9.95E−08	4.60E−06	4.60E−06	Diesel and Dunnage
n-Decane		3.55E−08	8.16E−07	1.29E−06	1.97E−03	1.97E−03	Diesel and Dunnage
n-Heptane			9.07E−08		5.90E−05	5.90E−05	Diesel and Dunnage
n-Hexane			9.07E−08		1.60E−05	1.60E−05	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
Nitrogen dioxide (peroxide)		9.67E−05	4.69E−04	2.82E−04	5.07E−05	4.69E−04	M-43
Nitrogen Oxide		1.18E−03	6.28E−03	2.62E−03	7.99E−04	6.28E−03	M-43
Nitrogen Oxides	7.50E−02					7.50E−02	TNT
n-Nonane		4.29E−08		1.99E−07	1.03E−03	1.03E−03	Diesel and Dunnage
n-Octane		3.55E−08	9.07E−08		2.48E−04	2.48E−04	Diesel and Dunnage
Non-methane Organic Compound		1.03E−07	4.99E−05	1.07E−04	7.84E−03	7.84E−03	Diesel and Dunnage
n-Pentane					9.05E−06	9.05E−06	Diesel and Dunnage
n-Propylbenzene		1.72E−07		9.95E−08	8.16E−05	8.16E−05	Diesel and Dunnage
OCDD					1.03E−11	1.03E−11	Diesel and Dunnage
o-Ethyltoluene		3.90E−07		2.99E−07		3.90E−07	M31A1E1
o-Xylene		3.44E−07	9.07E−08	3.75E−07	1.25E−04	1.25E−04	Diesel and Dunnage
Particulates	9.00E−02					9.00E−02	TNT
Perylene					1.72E−07	1.72E−07	Diesel and Dunnage
p-Ethyltoluene		7.11E−08	1.81E−07	4.25E−07	1.53E−04	1.53E−04	Diesel and Dunnage
Phenanthrene					7.17E−06	7.17E−06	Diesel and Dunnage
Phenol					1.56E−05	1.56E−05	Diesel and Dunnage
PM10		9.10E−01	1.18E−03	4.87E−01	5.44E−03	9.10E−01	M31A1E1
Propane		3.08E−07		2.99E−07	2.22E−06	2.22E−06	Diesel and Dunnage
Propene			1.09E−06	2.99E−06	1.30E−05	1.30E−05	Diesel and Dunnage
Pyrene					7.06E−07	7.06E−07	Diesel and Dunnage
Styrene		2.57E−07			4.99E−05	4.99E−05	Diesel and Dunnage
Sulfur Dioxide		1.22E−03	1.18E−04	3.47E−04	1.88E−04	1.22E−03	M31A1E1
Toluene		2.84E−07	5.44E−07		1.22E−04	1.22E−04	Diesel and Dunnage
Total Alkanes (Paraffins)		2.33E−06	5.44E−07		3.50E−03	3.50E−03	Diesel and Dunnage
Total Alkenes (Olefins)		2.57E−06	1.33E−05	1.59E−05	1.93E−04	1.93E−04	Diesel and Dunnage
Total Non-methane Hydrocarbons/NMHC		9.88E−05	4.13E−05	5.11E−05	1.20E−02	1.20E−02	Diesel and Dunnage
Total Unidentified Hydrocarbons		1.92E−05	2.47E−05	4.41E−05	6.04E−03	6.04E−03	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
trans-2-Butene		5.19E−08	1.81E−07	3.98E−07	2.91E−06	2.91E−06	Diesel and Dunnage
trans-2-Pentene					1.08E−06	1.08E−06	Diesel and Dunnage
Vinyl Chloride				2.23E−07		2.23E−07	PBXN-110
Vinylidene Chloride		2.15E−07				2.15E−07	M31A1E1
Volatile Organic Compounds	5.50E−04					5.50E−04	TNT
Zinc		4.14E−07			6.26E−05	6.26E−05	Diesel and Dunnage

[1] Emission factors are displayed in units of grams of pollutant per grams of waste treated.
[2] The highest emission factor of all surrogate waste streams was included within the combined emission factor to provide the most conservative set of emission factors possible.

Emission Factors for Excess Explosives, Explosives Machining Waste, and Explosives-Contaminated Noncombustible Debris

Approximately 99 percent of the waste treated at the TA-16-388 Flash Pad is a combination of explosives machining waste, excess explosives waste, and explosives-contaminated noncombustible debris. The excess explosives waste stream consists of

- pure explosives that could be held within plastic bags, cardboard, or paper in some cases;
- the explosives-machining waste stream consists of pure explosives shavings or cuttings, water, and sometimes cloth filters; and
- the explosives-contaminated noncombustible debris consists primarily of metal piping, equipment, concrete, or soil generated during decommissioning and environmental restoration activities.

Because the non-combustible materials themselves do not burn, the only emissions result from the burning of the explosives.

The specific types of explosives treated by open burning vary depending primarily on research and development and stockpile stewardship activities. The primary types of explosives treated are 1,3,5-triamino-2,4,6-trinitrobenzene (TATB), cyclotetramethylenetetranitramine (HMX), trinitrotoluene (TNT), and cyclonite (RDX). Emission factors are not available for all the explosives treated.

TNT is the least oxygenated; therefore, it is an explosive that burns less completely ("dirtier") than others treated at the TA-16-388 Flash Pad. Emission factors for burning TNT are available in Chapter 6, Section 3, Table 6.3-1 of the EPA's Compilation of Air Pollutant Emission Factors (EPA 1983). There are no toxic air pollutant emission factors for TNT in AP-42; therefore, the emission factors available from the *Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide* (Bjorklund, et al., 1998a.) for burning types of explosives like those burned at the TA-16-388 Flash Pad were reviewed. The types of materials in the OBODM User's Guide that are most like those treated at LANL are:

- M-43, which contains RDX;
- PBXN-110, which contains HMX; and
- M31A1E1, a mixture of explosives.

Although these waste stream surrogates contain some of the explosives treated by open burning at LANL, several contaminants are within the surrogates that would not be present in LANL explosives. No attempt has been made to eliminate from this analysis emissions that could be considered non-characteristic waste treated at LANL. Emission factors from each of the waste stream surrogates are used as published for this assessment to provide a conservative emissions estimate. The highest pollutant-specific emission factor for any of the three waste stream surrogates was chosen for inclusion in this air impact assessment. Columns 2 through 5 of Table 4-8 summarize the emission factors used to represent this waste stream in grams (g) of pollutant per g of waste (g/g) and identify the waste surrogate of origin.

Emission Factors for Combustible Solids

Emission factors from the diesel and dunnage surrogate waste in the OBODM User's Guide (Bjorklund, et al., 1998a) were used for this waste category. The diesel and dunnage waste consisted of scrap wood, dead branches from trees and shrubs, Styrofoam packing material, other combustibles, and diesel fuel. These emission factors, shown in Column 6 of Table 4-8, should be much higher than those produced from the typical treatment of explosives-contaminated combustible waste stream at LANL. In contrast with the diesel and dunnage surrogate waste, the explosives-contaminated combustible debris waste stream

at LANL is characterized by dry waste, no vegetation, no diesel, a high heating value from the explosives in the waste, and clean supplemental fuel (propane burners).

While reviewing available surrogate waste streams from the OBODM User's Guide, it was initially determined that the aluminized ammonium perchlorate (AP) propellant manufacturing waste category might be a better fit as a surrogate for the LANL explosives-contaminated, combustible-debris waste stream. The manufacturing surrogate waste was conceptually designed to simulate the mix of AP-contaminated plastic gloves, cotton rags, Kimwipes, wood towel rods, and similar materials that result from the clean-up of the vessels used to manufacture AP-based propellants (EPA 1998). As a general description, this surrogate gets far closer to the waste stream treated at LANL than the diesel and dunnage waste surrogate; however, there are two major reasons this surrogate was not ultimately selected to represent this LANL waste stream. The first reason is that LANL does not treat AP through open burning, so these emission factors are not accurately representative of the wastes treated at LANL. The second and more important reason for not choosing this waste surrogate is that the trial-run execution for the development of emission factors for the AP-manufacturing surrogate waste was flawed and therefore was not used to represent any waste stream that is treated by open burning at LANL.

Specifically, it was determined that the surrogate waste used for the trials was not representative of a true manufacturing waste because of the way the propellant was placed in contact with the combustible materials. One-inch cubes were placed randomly on top and in contact with the combustible materials rather than dispersed over the materials as a powder—the way in which the waste stream would be generated. Because of this cube-dispersion method, all of the trials resulted in holes in the stainless steel pan. The unique mix of emission products, the melted plastic, and the rate of conversion of N to NO_x observed for the surrogate AP-manufacturing waste demonstrated that this burn was very different from all other burns that involved energetic materials (EPA 1998).

An additional consideration during the development of an emission factor list for this waste stream is the potential for dioxin and furan formation. Dioxins and furans are formed from burning almost any kind of material, including forest fires, residential wood combustion, and residential oil heating (EPA 1997). The factors that affect dioxin formation include temperature, time and turbulence, oxygen, carbon, chlorine, bromine, catalysts, and humidity. Precursors to the formation of dioxins/furans within the lower range of temperatures (200–400° Celsius [C]) rely heavily on the presence of the products of incomplete combustion, including chlorine compounds, halogens, soot or fly ash, and metals (Zhang, et al., 2017). For the reasons described as follows, these compounds generally are not present in the waste treated by open burning, and the temperature at which treatment events occur is sustained well above this lower temperature range.

The temperature of the propane burners is more than 760° C. The temperature of the burn area stays consistently above 982° C. The types of explosives burned at the TA-16-388 Flash Pad most often range in burn temperature from approximately 1070° C to 2030° C and often make up a large percentage of the waste being treated. Temperatures that exceed 400° C are documented to provide destruction at a faster pace than formation (Zhang, et al., 2017). At higher temperatures (650–900 °C), there is a very close dependence of the formation of chlorinated and nonchlorinated aromatic compounds on a longer residence time in a combustion and afterburning chamber with the presence of the necessary parameters (Wielgosiński 2011).

This result is not the case for treatment events at the TA 16 388 Flash Pad. The formation of dioxins/furans requires incomplete combustion. The nature of propane burning ensures complete combustion of materials by providing an environment for the three Ts of combustion: temperature, time, and turbulence.

The documented temperature of treatment events is more than sufficient to ensure that the reactive characteristic (explosives content) within the waste is eliminated, and the creation of dioxin/furan compounds is avoided by ensuring that the combustion process is complete. The temperature of the burn is high enough that there is no smoldering, char, or soot formation within the process that would be necessary for dioxin formation and very little ash is generated by the treatment process overall. The TA 16 388 Flash Pad internal operating procedures require that, for all burn events, the waste must continue to be treated until the operator visually determines that the waste is fully treated. The system design and operations of the treatment process ensure that sufficient oxygen is available for complete combustion. The multidirectional propane burners ensure that high combustion turbulence is maintained throughout the treatment event. There is minimal residence time for gases and soot/carbon if present to be trapped with metal catalysts to form dioxins/furans. Additionally, the air turbulence of the operation of two propane burners in an open-air environment further decreases the residence time of gas and other material.

Materials are present in the waste that may contribute to the formation of dioxins/furans. Chlorine and halogens are generally not present in the waste treated by open burning. However, paper and small plastic bags (which make up less than 1 percent of waste material treated by open burning at LANL) are materials that may potentially produce chlorine compounds when burned. Metals are present within the waste streams treated by open burning; however, the intent of the waste treatment is to burn off explosives contamination on the metal, not to completely vaporize the metal. Carbon is present fundamentally as a part of an explosive waste stream; however, it is actively burned rather than allowed to smolder and generate char or soot. Lastly, though most of the waste treated by controlled open burning at the TA 16 388 Flash Pad is wetted waste, the water is evaporated off the waste explosive as the waste is burned and the moisture does not contribute to the formation of dioxins/furans.

The documented waste treatment at the open burn unit ensures that all waste is treated so that waste byproducts are not created and that the formation of dioxin/furans does not occur.

Emission Factors for Open Burning of Liquids

The explosives-contaminated solvent waste stream historically consisted of oils and solvents contaminated with explosives. Due to changes in processes and improved waste characterization, this waste stream has decreased considerably in recent history. No oils and most solvents will not be treated by open burning in the future. The only solvent that may be treated at the TA-16-388 Flash Pad is dimethyl sulfoxide (DMSO), which contains 25 percent or greater dissolved explosives.

No emission factors were identified for burning explosives-contaminated liquids. Also, DMSO is not a petroleum product; therefore, emission factors from burning of fuel oil used in past analyses are not applicable. This waste stream is treated infrequently, so no emission factors specific to DMSO have been incorporated into the assessment. The trace solvents discussed previously for the surrogate waste streams serve as solvent representation.

Emission Factors for Open Burning of Propane

Propane is burned to improve combustion efficiency of explosives and explosives-contaminated waste streams. A typical burn uses two burners at a time for approximately 60 minutes per burn. The two burners combined consume approximately 1 gallon of propane per minute, for a total of 60 gallons (254.4 lb) per burn. Emissions from burning the propane are additive to the emissions from burning the waste. The emission factors were obtained from Chapter 1.5, Table 1.5-1 of AP-42 (EPA 2008). The commercial boiler emission factors were used because the heat input capacities for commercial boilers are generally between 0.3 and 10 million British Thermal Units per hour. No toxic air pollutant emission factors were located. Propane is a very clean-burning fuel, and products of incomplete combustion should be minimal. Emission factors are shown in Table 4-9.

Table 4-9. Emission Factors for Propane

Contaminant	Emission Factor (lb/1000 gal)	Emission Factor (lb/lb)
Nitrogen Oxides	13	3.07E−03
Carbon Monoxide	7.5	1.77E−03
PM10	0.7	1.65E−04
PM2.5	0.7	1.65E−04
Sulfur Dioxide	9	2.12E−03
Nonmethane Hydrocarbons	1	2.36E−04

Emission Factors for OD

Waste streams treated through OD are described in Section 4.1.2 of this document. After review of the operating record, it was determined that wastes treated during calendar year 2006 were varied and represented a dataset that encompassed all waste streams and waste stream components expected to be treated at the units throughout the current and future waste treatment uses. For the treatment units, all emission factors (except PM2.5 and PM10) were chosen based on the components within the waste streams treated in 2006 using the draft Chapter 16 for AP-42 (AP-42 2009; Attachment 12). The emission factors provided in AP-42 draft Chapter 16 are a summary of the data publicly available through 1995, except PM emission factors are based on the study by Aurell, et al., 2014. Based on the draft Chapter 16, Section 16.2.1, the emission factors were obtained from a series of emission characterization studies conducted on an open test range and in a 32,900 ft^3, 50 ft diameter hemispherical detonation chamber. These studies were conducted at Dugway Proving Grounds, Utah (DPG), between 1989 and 1995.

As stated in draft Chapter 16, Section 16.1.1, in 1988, the U.S. Army conducted a highly successful study using a detonation chamber at Sandia National Laboratories (SNL) in Albuquerque, New Mexico. Based on the test results, the DoD concluded that the plumes released when energetic materials are destroyed by OB and OD processes do not contain sufficient quantities of toxic or hazardous pollutants to pose a danger to human health or the environment. The study also concluded that the emission factors for the predominant emission products produced in the emissions tests were statistically equivalent to those produced in the DPG open-range tests, i.e., the emission products did not change substantially even when the quantity of energetic material detonated increased by a factor of 32,000.

In this document, the primary reference for emission factors is Table 16.2-14, Summary Statistics for the Detonation Data Sets (AP-42 2009). In this table, many of the units of measure for the emission products are expressed in such forms as lb/lb NEW (net explosive weight), where NEW is the total weight of all explosive substances (i.e., high explosives weight, propellant weight, and pyrotechnic weight). Other listed emission factors are provided as lb/lb N (nitrogen), lb/lb C (carbon), or lb/lb S (sulfur), etc. These emission factors allow a more reasonable and less conservative estimate of emissions if applied. For most of the modeling assessments to determine the environmental impacts, the amounts of NEW, nitrogen, carbon, or sulfur were not assessed in the LANL waste materials; however, the lb metal/lb waste was assessed for this application based on the waste assessments for the materials treated at the OD sites. The fractions for barium, copper, and lead were calculated separately for each metal based on the information in the 2006 waste profile as presented in Attachment 4. The adjusted total amount of metals was assessed for computing the fraction of metal emissions for the remaining metal constituents. Otherwise, all other calculations were based on the total mass of explosive waste used in the detonation. Applying lb/lb explosive waste for the unit of measure in lieu of the specific emission factors where lb/lb NEW, lb/lb N or lb/lb C, etc. increases the conservativeness of the estimate of environmental impact for the risk assessment because the total mass of combined waste is greater than any one of the

constituents, such as NEW, carbon, or nitrogen, etc. LANL applied the mean emission factor values listed in Table 16.2-14. These emission factors are presented in Table 4-10.

Table 4-10. Emission Factors for OD Operations based on the Draft AP-42 Ch. 16, Table 16.2-14

Emission Products	CAS RN	Emission Factor[1] for OD	UOM as Listed in Draft AP-42 Ch. 16	UOM as Applied for Modeling
Carbon Monoxide	630-08-0	7.1E-02	lb/lb C	lb/lb waste[2]
Carbon Dioxide	124-38-9	3.5E+00	lb/lb C	lb/lb waste[2]
Nitrogen Oxides	N/A	5.3E-02	lb/lb N	lb/lb waste[2]
Sulfur Dioxide	7446-09-5	4.8E-04	lb/lb NEW	lb/lb waste[2]
Energetics	N/A	4.5E-07	lb/lb Energetic	lb/lb waste[2]
SVOCs in Energetics	N/A	1.00E-08	lb/lb SVOC	lb/lb waste[2]
SVOCs Not in Energetics	N/A	2.8E-07	lb/lb NEW	lb/lb waste[2]
Benzene	71-43-2	2.0E-04	lb/lb C	lb/lb waste[2]
TNMHC	N/A	7.7E-03	lb/lb C	lb/lb waste[2]
Acetylene	74-86-2	7.7E-04	lb/lb C	lb/lb waste[2]
Ethylene	74-85-1	7.1E-04	lb/lb C	lb/lb waste[2]
Methylene Chloride	75-09-2	6.2E-04	lb/lb C	lb/lb waste[2]
Propylene	115-07-1	1.3E-04	lb/lb C	lb/lb waste[2]
Toluene	108-88-3	6.7E-05	lb/lb C	lb/lb waste[2]
Naphthalene (as SVOC)	91-20-3	2.8E-07	lb/lb NEW	lb/lb waste[2]
Metals in Energetics as Particle (or Elemental)	N/A	9.8E-02	lb/lb metal	lb metal/lb waste[2,3]
Metals in Alloys	N/A	3.1E-02	lb/lb metal	lb metal/lb waste[2,3]
Metals in Energetics As Compound	N/A	2.6E-01	lb/lb metal	lb metal/lb waste[2,3]

[1] The mean emission factor as listed in AP-42 Ch. 16 draft is used in the calculation of the ground-level concentration.
[2] Application of the emission factor to the weight of waste processed in lieu of the initial draft Ch. 16 value is a conservative estimate of emissions.
[3] Based on the data for 2006 RCRA Waste Explosive Descriptions, EPA Waste Codes, and Explosives Detonated at TA-36 and TA-39 OD units. These data provided a lb/lb waste calculation that was adjusted for the amount of metal per lb of waste using a factor of 0.077 lb metal/lb waste for all metals except barium, copper and lead. See Attachment 4 for further details.
Key: SVOC = semi-volatile organic compound

Research on OD emissions at the Naval Air Warfare Center Weapons Division at China Lake, California, addressed the fate of metals from munitions during OD treatment operations (NAVAIR 2004). This research showed that metal components of waste (e.g., casings, projectiles, platings, paints, coatings) do not melt or vaporize during OD but rather fragment. During OD, explosives quickly transform from solid to high-temperature and high-pressure gases, which cause the metal components to fracture. The metal fragments are in contact with the hot gases but not long enough to cause the metal to melt or vaporize. The metal fragments are accelerated outside of the detonation zone by the initial blast and are not exposed to the afterburning (fireball) phase of the detonation. Most metal components end up as fragments, with a minor proportion becoming particulates. In this regard, the emission calculations for metals are an overestimate of particulate by allowing the assumption that the fragment portion is modeled as particulate.

Research conducted by the Navy at China Lake, California, addressed the formation of dioxins during OD treatment operations (NAVAIR 2005). This research pointed out significant differences between OD of wastes and incineration of wastes. During incineration, dioxins are formed through recombination of combustion gases (e.g., oxygen, chlorine). Very specific conditions are needed to form dioxins, including a temperature range of 250–450°C (482–842°F) and a residence time of seconds to minutes. These

conditions are common in incinerators but are not present during OD operations. OD occurs in microseconds, and the afterburning phase is complete in seconds. Temperatures during OD operations can range from about 2500–5600°C, and the temperatures associated with afterburning are on the order of 700°C to 1700°C (NAVAIR 2004). These higher temperatures cause the dioxin precursor molecules to fall apart. Also, OD operations occur at very high pressures—on the order of hundreds of kilo bars—whereas incinerators operate at ambient pressure.

As described in the draft AP-42 Chapter 16 (AP-42 2009), the intramolecular rearrangement for detonations is so fast that only a small percentage of the atoms in one molecule have time to react with atoms in adjacent energetic molecules that are decomposing at the exact same time. Because the detonation of explosives does not require air, it can occur in a vacuum, in an inert atmosphere, or even under water. The initial detonation products are free carbon (soot), carbon monoxide, hydrogen, methane, ethane, formaldehyde, nitrogen, carbon dioxide, water vapor, small hydrocarbons, and small CxHy fragments. The initial stage of the detonation process is over in less than 10 microseconds and is followed by a 2- to 10-second duration fireball (afterburn). In this second stage of the process, combustible detonation reaction products (e.g., carbon monoxide, methane, ethane, formaldehyde, hydrogen, and the CxHy fragments) are spontaneously oxidized (combusted) to CO_2 and H_2O. Fireball temperatures are on the order of 926.7–1704.4°C. As the plume expands, it entrains additional air, which allows further combustion reactions to take place until the plume temperature falls to approximately 815°C, where these reactions stop. This effect prevents dioxins from forming during OD operations; therefore, dioxins/furans are not considered emissions during OD operations at TA-36 or TA-39 and are not included in the modeling exercise.

For volatile organic compound (VOC) emissions, Section 2.1.4.3 of the background document for the draft Chapter 16 (Background Document AP-42 2009; Attachment C) states that the SNL and DPG test results demonstrated conclusively that the VOCs emitted were almost exclusively the first members of the alkane, alkene, and alkyne classes of hydrocarbons and the first members of the aromatic hydrocarbon class, of which benzene is the most toxic. A key point was that for every energetic material detonated in the SNL study and on the test range at DPG, benzene represented a substantial percentage of the total mass of the aromatic hydrocarbons found but was only 2.0 percent of the total mass for all the non-methane hydrocarbons (TNMHCs).

The emission products and related emission factors used in the modeling exercise for OD operations at TA-36 and TA-39 are shown in Table 4-10. These emission factors are based primarily on Table 16.2-14, Summary Statistics for the Detonation Data Sets from the draft AP-42 Chapter 16. A list of explosives detonated at the units was developed from the operating record for the RCRA waste explosives detonated. The chemicals were placed into categories, with a single emission factor for each category. Categories can generally be described to be components of the waste stream itself (e.g., energetics, metals, and fuel) or constituents produced as part of the treatment process (i.e., emission products). A list of emission products and emission factors was derived from a list of explosives and explosives-contaminated waste detonated at the OD units.

For this application submittal, the draft Chapter 16 for AP-42 represents the most current publicly available information as prepared for the U.S. Army Defense Ammunition Center, McAlester, Oklahoma, under Contract Number DACA87-02-D0028; however, subsequent work and OD plume studies have been conducted since 2010 as part of a program under the direction of Dr. Keith Clift, and program studies have been conducted by Dr. Brian Gullett. Dr. Clift was the Demilitarization Capabilities Division Chief for the Demilitarization Directorate at the Joint Munitions Command (JMC). Dr. Clift's program has continued OB/OD emissions testing with Dr. Gullet's team for a two-fold purpose: to continue to fill data gaps for OB/OD emissions factors (i.e., covered OD data gaps, etc.) and to increase both the quantity and representativeness of the data by collecting open-air/live-fire data from actual production OB/OD demilitarization operations. Some of the testing is being done because of the improved sampling methods

and/or analytical methods available, including the use of drones, which allows for much-improved latitude to sample emissions within the dynamic OB/OD plume. Interim data processing is currently being performed. The program is an ongoing effort to enhance and improve the data quality of existing OB/OD emission factors.

Dr. Gullett is the Senior Professional Research Engineer for the Air and Energy Management Division at the National Risk Management Research Laboratory at the Office of Research and Development for the EPA in the Research Triangle Park in North Carolina. Dr. Gullett is the lead researcher for the JMC demilitarization program for OB/OD studies. Since 2010, Dr. Gullett's team has compiled a database on OB/OD emission factors for the military's JMC. This database references data that have gone through the EPA's quality assurance review process and are published in public journals or DoD reports. The published journals and DoD reports currently available for public review have little or no additional information on (uncovered) open-range detonations such as those being conducted at LANL. Additional studies, including those for uncovered open-range detonations, were planned for 2020, but were not conducted until August and November 2021. Based on a communication with Dr. Gullett (email dated March 1, 2023), the EPA is preparing an updated emission factor database that should be available by mid-2024.

In Table 4-11, emission factors are shown with the emitted contaminants and are indicated in units emitted per unit of explosive material detonated. Emission products and related constituents were obtained from a third party based on waste treated at LANL (CCS 2011). The emission factors are applied as listed in Table 4-11. The emission factors are listed for the constituents that are identified as criteria pollutants or TAPs and those with known human health risk or ecological screening values.

Table 4-11. Emission Products and Emission Factors for Explosive Waste Detonated at OD Sites

Contaminant	Note	Emission Factor (lb/lb waste)
Carbon Monoxide	1	7.1E-02
PM10	2	2.9E-01
PM2.5	2	4.2E-01
Nitrogen Oxides	(as NO_2 only)	5.3E-02
Sulfur Dioxide	1	4.8E-04
Benzene	1	2.0E-04
TNMHC	1	7.7E-03
Acetylene	1	7.7E-04
Ethylene	1	7.1E-04
Propylene	1	1.3E-04
Toluene	1	6.7E-05
Naphthalene	3	2.8E-07
Methylene Chloride	1	6.2E-04
Aluminum Oxide	5	7.7E-02
Barium	5	4.2E-02
Cobalt Acetoacetonate	5	5.9E-04
Copper	5	5.9E-04
Lead	5	4.4E-03
Trioctyl phosphate	4	2.6E-01
Aluminum	5	9.8E-02

Contaminant	Note	Emission Factor (lb/lb waste)
Titanium	5	9.8E-02
Ammonium perchlorate	3	2.8E-07
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX)	3	2.8E-07
Nitrocellulose	3	2.8E-07
Nitroguanidine	3	2.8E-07
Nitromethane	3	2.8E-07
Pentaerythritol tetranitrate (PETN)	3	2.8E-07
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	3	2.8E-07
Tetryl	3	2.8E-07
2,4,6-trinitrotoluene (TNT)	3	2.8E-07
Acrylonitrile	6	1.00E−08
Bis(2-ethylhexyl) adipate	6	1.00E−08
tris-2-chloroethyl phosphate	6	1.00E−08
Dibutylphthalate	6	1.00E−08
Dinitrotoluene (2,4-)	6	1.00E−08
Dioctyladipate	6	1.00E−08
Dioctylphthalate	6	1.00E−08
Diphenylamine	6	1.00E−08

Notes:
[1] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42
[2] Emission factors for $PM_{2.5}$ and PM_{10} are based on the paper "Aerostat-based sampling of emissions from open burning and open detonation of military ordnance," J. Aurell, et al. *Journal of Hazardous Materials*, Oct. 2014.
[3] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42 for SVOCs Not in Energetics
[4] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42 for Metals in Energetics as Compounds
[5] Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is less than 7.7% for metals, except Lead, Barium, and Copper. See Attachment 4 for the calculation. The metal fractions of metal waste for Lead, Barium and Copper are calculated separately in Att. 4.
[6] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42 for SVOCs in Energetics. Because no data are listed for this emission product, the value for below detection limits was assigned as explained in Section 2.1.4.4, Page 22, of the Ch. 16 Background Document.

4.3.3 *Receptor Grid Description*

The LANL site and outermost property boundary are extensive in size. In addition, some public roadways and houses are located within the outermost boundary. Receptor grid specifications consider these factors. In addition to the receptors listed for the OB and OD modeling using OBODM, the following receptor grids were used in the analysis:

- a fence line grid with 100-meter spacing along the outermost property boundary;
- a fine grid with 100-meter spacing that extends 1 km from the property boundary;
- a medium grid with 500-meter spacing that extends 5 km from the property boundary;
- a coarse grid with 1000-meter spacing that extends 10 km from the property boundary; and
- additional fine grids at the Elk Ridge trailer park on East Jemez Road (the truck route) and along public roadways that cross LANL (SR 4 from White Rock to TA-33, Main Hill Road up to and through Los Alamos, and West Jemez Road at TA-3 up to the intersection with SR 4).

Public entry is prohibited on Pajarito Road to provide additional security for key LANL operations along that corridor. No receptors were placed on Pajarito Road for AERMOD modeling.

Public receptors contained within the established grids total a large figure greater than 22,500 grid dimensions and are conservative because of the extensive property boundary, and public receptor grids extending beyond the required modeling distances. Evaluating impacts for receptors located in a grid at each OB/OD site also increases the grid size. The receptor grids established for this analysis ensure that the maximum impacts were captured for both public receptors and receptors located in grids surrounding the OB and OD sites.

LANL is located in a complex terrain. Ground elevations were obtained from https://apps.nationalmap.gov/downloader/#/. A national elevation dataset GeoTiff file for the modeling domain was downloaded. The dataset has a resolution of 1/3 arc-second (approximately 10 meters) and uses the NAD 83 UTM coordinate system.

4.3.4 *Meteorological Data*

The 2021 LANL TA-6 meteorological tower data was used in the dispersion modeling. The TA-6 tower is LANL's official weather station and is representative of the meteorological conditions at the facility. The TA-6 station consists of a 92-meter tower instrumented for wind and temperature at four levels and near-surface instrumentation for measuring temperature, moisture, pressure, precipitation, and surface energy balance terms. Surface data from all four levels of the tower for calendar year 2021 were used. For preparation of the dataset, Trinity Consultants used AERSURFACE to produce detailed land use inputs, including surface roughness that varies depending on the wind direction (and corresponding upwind land use) at each hour. Trinity also switched the NWS surface station for cloud cover data from Albuquerque to the Los Alamos Airport (KLAM) because of the good-quality cloud cover data for 2021, where the base elevation is 2263 meters. The 2021 1-year dataset containing the profile and surface files were submitted to NMED for review and approval.

4.3.5 *Ambient Air Quality Standards*

National and New Mexico Ambient Air Quality Standards

Ambient air quality standards are the maximum allowable concentrations designed to protect the most sensitive individuals from harm from airborne pollutants. Table 4-12 is from the "New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines" and lists the national and New Mexico ambient air quality standards and applicable significance levels. Air toxics as listed in 20.2.72 New Mexico Administrative Code are pollutants, and the emissions will be assessed. Modeling will be completed where required by the guidance.

Table 4-12. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Period	Significance Level ($\mu g/m^3$)	Class I Significance Level ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	NMAAQS ($\mu g/m^3$ unless noted)	PSD Increment Class I ($\mu g/m^3$)	PSD Increment Class II ($\mu g/m^3$)
CO	8-hour	500		10,303.6	9960.1		
	1-hour	2000		40,069.6	14,997.5		
H_2S	1-hour	1.0			13.9		
	1/2-hour	5.0			139.3		

Pollutant	Averaging Period	Significance Level (µg/m^3)	Class I Significance Level (µg/m^3)	NAAQS (µg/m^3)	NMAAQS (µg/m^3 unless noted)	PSD Increment Class I (µg/m^3)	PSD Increment Class II (µg/m^3)
	1/2-hour	5.0			41.8		
Pb	Quarterly	0.03		0.15			
NO_2	annual	1.0	0.1	99.66	94.02	2.5	25
	24-hour	5.0			188.03		
	1-hour	7.52		188.03			
O_3	8-hour	1.96		137.3			
PM2.5	annual	0.2	0.05	12		1	4
	24-hour	1.2	0.27	35		2	9
PM_{10}	annual	1.0	0.2			4	17
	24-hour	5.0	0.3	150		8	30
SO_2	annual	1.0	0.1		52.4	2	20
	24-hour	5.0	0.2		261.9	5	91
	3-hour	25.0	1.0	1309.3		25	512
	1-hour	7.8		196.4			
Reduced S	1/2-hour				3 ppb		
	1/2-hour				10 ppb		

Source: NMED 2022

Air dispersion modeling for this project does not include an assessment for Prevention of Significant Deterioration (PSD) increment consumption. LANL is located in Air Quality Control Region 157, where minor source baseline has not been triggered and PSD increment-consuming emission sources do not exist. Facility emissions that result in ambient impacts below significance levels are not considered to contribute to exceedance of air quality standards and were not analyzed further for cumulative impact.

4.3.6 *Cumulative Impact Analysis*

Cumulative impact analyses will be conducted for pollutants and averaging period for which a significance level is exceeded. A neighboring source emission inventory was obtained for each OB and OD site from the NMED AQB Modeling Group in May 2023 for a modeling analysis to determine the impact of nearby sources. For insignificant impacts, cumulative impact determination using the addition of background concentration or surrounding source analysis will not be conducted.

For CO, NO_2, and SO_2, the dispersion modeling guidelines allow two methods to determine cumulative impact. The measured background concentration from an ambient air quality monitor is added to the modeled facility's maximum impact. Alternatively, the dispersion modeler has the option to model all nearby sources instead of adding a background concentration if the facility is more than 10 km from the center of Albuquerque and El Paso. For this project, LANL is choosing to add background concentration from approved ambient monitors (see Table 4-13) to obtain conservative maximum cumulative impact. LANL is situated in a rural area with few offsite nearby emission sources and most nearby sources are other LANL operations. Adding background concentrations from ambient monitors located in areas with more population and higher industrial activity, such as Santa Fe, Bloomfield, and Albuquerque (see Table 4-13) will result in a conservatively high prediction of the maximum ambient impact.

For particulate emissions, in accordance with the AQB dispersion modeling guidelines, all permitted nearby emission sources within 10 km will be modeled, a secondary formation concentration will be calculated (for PM2.5), and a background concentration from appropriate ambient monitor will be combined to obtain the cumulative impact.

The dispersion modeling included analysis of groups of selected emission sources—called *source categories*—to determine their ambient contribution. At a minimum, the groups analyzed will include (1) the OB-OD emission sources alone, and (2) the nearby emission sources to determine the cumulative impact where applicable.

Cumulative impact analysis will include two methods:

- For gaseous pollutants such as CO, NO_2 and SO_2, facility-only impact will be added to the background concentrations for the selected averaging period from appropriate ambient monitors (Table 4-13) approved by the NMED AQB. Most of the monitors listed are from highly populated (Albuquerque) or highly industrialized (Bloomfield) areas and will result in higher backgrounds when compared with the LANL airshed and surrounding area.
- For particulate matter, facility and nearby sources will be modeled separately since facility emissions are based on unitized emission rates, and the background concentrations from appropriate ambient monitors will be added as specified in the modeling guidelines. For PM2.5, the concentration for secondary formation will be added to the cumulative impact.

Table 4-13. Methods Proposed for Cumulative Impact Analysis

Pollutant	Averaging Time	Cumulative Impact Method	Background Ambient Concentration µg/m^3	Ambient Monitor	NAAQS or NMAAQS µg/m^3
CO	8-hour	Maximum screening high 8- hour concentration plus background concentration	1265	Albuquerque del Norte High School	9960.1
CO	1-hour	Maximum screening high 1-hour concentration plus background concentration	2148	Albuquerque del Norte High School	14,997.5
NO_2	Annual	Maximum screening concentration plus background concentration	17.2	Albuquerque del Norte High School	94.02
NO_2	24-hour	Compliance with the NO_2 1-hour standard satisfies this requirement but modeling was completed for the 24-hour standard.	–	–	188.03
NO_2	1-hour	Maximum screening concentration plus 1-hour 98th%ile background concentration	81.2	Albuquerque del Norte High School	188.03
PM2.5	Annual	Maximum screening concentration plus annual background concentration	3.7	Santa Fe	12
PM2.5	24-hour	Maximum concentration plus nearby sources, plus secondary formation, plus 98th %ile background concentration	9.2	Santa Fe	35

Pollutant	Averaging Time	Cumulative Impact Method	Background Ambient Concentration µg/m^3	Ambient Monitor	NAAQS or NMAAQS µg/m^3
PM10	24-hour	Facility plus surrounding sources, plus nearby sources, plus 2nd high background concentration	19.0	Santa Fe	150
SO_2	Annual	Maximum screening concentration plus annual 99th%ile background concentration	1.3	Albuquerque del Norte High School	52.4
SO_2	24-hour	Per NMED AQB guidelines, SO_2 1-hour NAAQS is the surrogate that demonstrates compliance, but modeling was completed for the 24-hour standard.	–	Not applicable	261.9
SO_2	3-hour	Per NMED AQB guidelines, SO_2 1-hour NAAQS is the surrogate that demonstrates compliance, but modeling was completed for the 3-hour standard.	–	Not applicable	1309.3
SO_2	1-hour	Maximum screening concentration plus 1-hour 99th%ile background concentration	10.1	Albuquerque del Norte High School	196.4

4.3.7 *Summary of OBODM and AERMOD Unitized Emission Rate Modeling*

The following tables and figures focus on the results of using OBODM results for both maximum concentrations for the 1-hour, 3-hour, 8-hour, and 24-hour averaging periods and the associated analysis of the plume rise parameters. Overall, the worst-case plume rise (minimum plume rise as noted in ATK Addendum 2013) parameters are directly associated with the conditions that created the maximum concentration for the one-hour averaging period. The plume rise parameters associated with the maximum one-hour concentration for each of the three sites is presented in Table 4-14.

Results for the hybrid OBODM/AERMOD air dispersion modeling project demonstrated that the AERMOD modeling produced considerably higher results than the maximum OBODM results (see Figure 4-10). Table 4-16 through Table 4-18 demonstrate these findings. The AERMOD results of the listed averaging times and locations are presented in Figure 4-11 through Figure 4-13 for each site.

For the maximum 1-hour concentration for ODTA-39-6, operations were modeled based on the period of 8 a.m. to 5 p.m. The hours of operation for the AERMOD modeling were restricted to the period of 10 a.m. to 3 p.m. for 1000-pound-per-hour detonations because of the potential impact of PM2.5 at the public receptors. See Section 5.0 for further details and the analysis of PM2.5 cumulative impact.

In summary, the details provided in Table 4-16 through Table 4-18 demonstrate that the AERMOD results using the hybrid modeling methods are considerably higher than the OBODM results for all averaging times evaluated above; therefore, the hybrid modeling method provides much more conservative results than OBODM modeling alone.

Table 4-14. Date and time for maximum OBODM 1-hour concentration and calculation of volume source release height, and initial horizontal and vertical dimensions.

							AERMOD Release Hgt. or max.plume Rise	Release Hgt. (Center of Vol. above ground)	Radius (m) of cloud at	Diameter (m) of cloud at	Initial Horizontal	Initial Vertical	1-hr Max
				Minimum Plume Rise and Distance									
OB-OD Sites	MONTH	DAY	HOUR	Rise - m	Max Hgt.- m	Distance - m	meters	meters	final plume Ht.	final plume Ht.	Dim. (SYINIT)	Dim. (SZINIT)	ug/m3
ODTA-36-8	1	21	0900	145.9	159.2	107.6	159.2	79.60	96.48	192.96	44.87	37.02	0.252
ODTA-39-6	1	8	0800	123.6	134.2	250.6	134.2	67.10	81.48	162.96	37.90	31.21	4.157
OBTA-16-388	12	11	0900	89.8	90.3	94.8	90.3	45.2	55.14	110.28	25.65	21.00	17.15

Table 4-15. List of OBODM and AERMOD Modeling File Names

OB / OD site	Model Run	File Names
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr 1-3-8-24hr AllReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr 1-3-8-24hr PublicReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr Annual AllReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr Annual PublicReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr Monthly PublicReceptors CO2_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr 1-3-8-24hr AllRec 1000-lb 10am-3pmOps_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr 1-3-8-24hr PublicRec 1000-lb 10am-3pmOps_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr Annual AllRec 1000-lb 10am-3pm M-F_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr Annual+Monthly PublicRec 1000-lb 10am-3pmOps_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr AllRecs_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr Public rec_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr Annual AllReceptors_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr Annual Public rec_2021_CO2
TA-39-6	OBODM	39H1TST.INP and 39H1TST.OUT
TA-16-388	OBODM	388H1Y23.INP and 388H1Y23.OUT
TA-36-8	OBODM	36H1Y23.INP and 36H1Y23.OUT

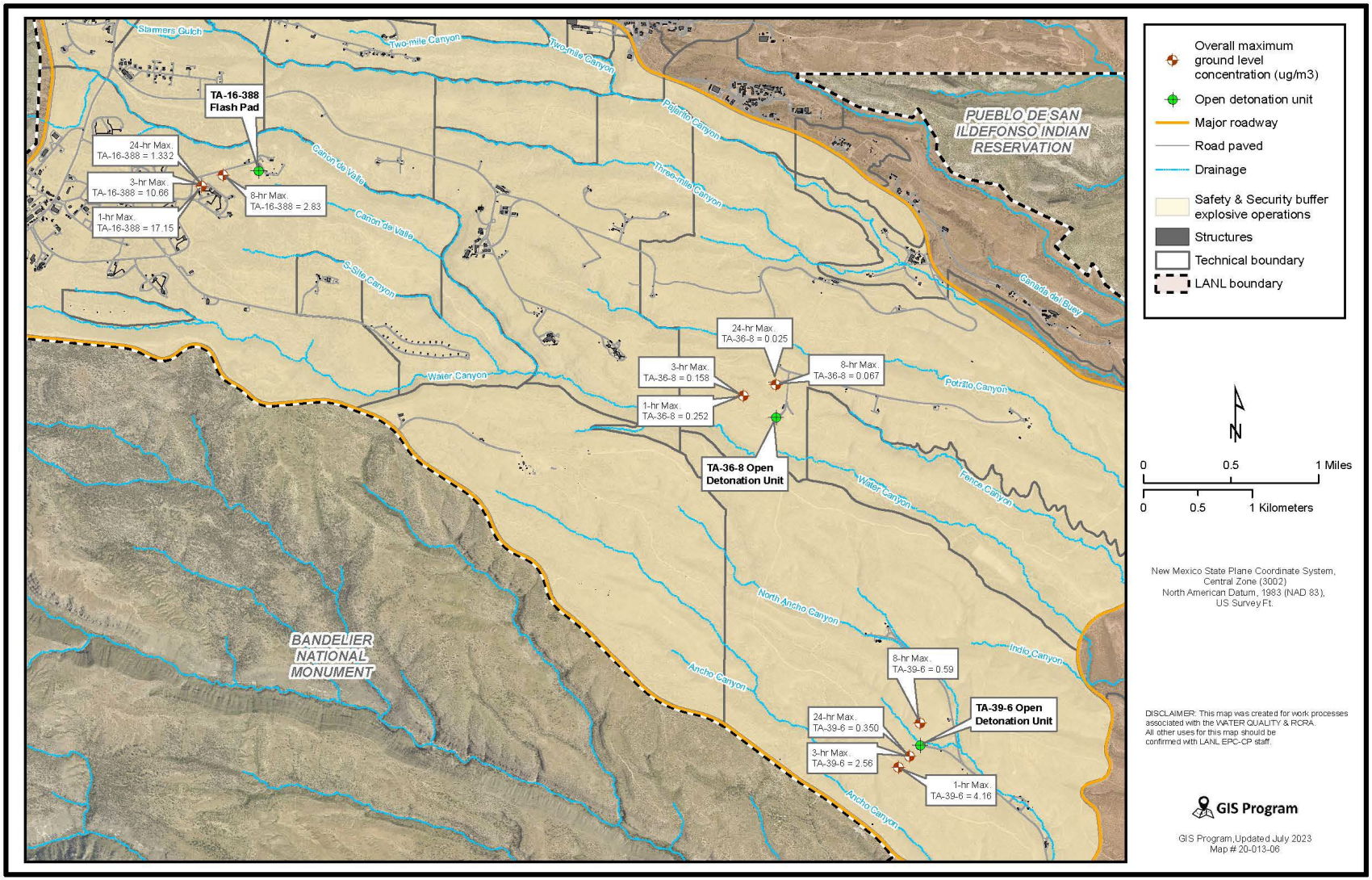

Figure 4-10. Maximum OBODM concentrations for a unitized emission rate and location of results.

Table 4-16. Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors, plus ratio of AERMOD results to OBODM results for All Receptors at ODTA-36-8.

											All Receptors
				AERMOD							AERMOD/
OD TA-36-8	OBODM			Concentration		AERMOD			AERMOD		OBODM
	All Receptors			for Same OBODM	AERMOD	All Receptors		AERMOD	Public Receptors Only		Conc. Ratio
Model	8am-5pm	X-Coordinate	Y-coordinate	Receptor	All Receptors	X-Coordinate	Y-coordinate	Public Receptors	X-Coordinate	Y-coordinate	Increase or
Averaging (t)	ug/m3	meters	meters	ug/m3	ug/m3	meters	meters	ug/m3	meters	meters	(-) Decrease
1-hr Max. (C)	0.252	384130.0	3965730.0	21.47	51.92	384230.0	3965530.0	6.18	383102.6	3963208.6	205.70
3-hr Max. (C)	0.158	384130.0	3965730.0	10.74	21.06	384330.0	3965530.0	2.07	383102.6	3963208.6	133.41
8-hr Max. (C)	0.067	384430.0	3965830.0	6.70	13.11	384330.0	3965630.0	1.44	382217.7	3964283.6	196.34
24-hr Max. (C)	0.025	384430.0	3965830.0	2.33	4.37	384330.0	3965630.0	0.48	382217.7	3964283.6	176.02
Annual Max. (C)	Not Available (NA) (1)				1.07	384430.0	3965630.0	0.029	382217.7	3964283.6	NA (1)
Notes											
(1) Desktop with Windows XP failed before annual concentrations were modeled using OBODM. However, the key plume rise parameters for calculating the volume source release parameters is based on the hourly results.											

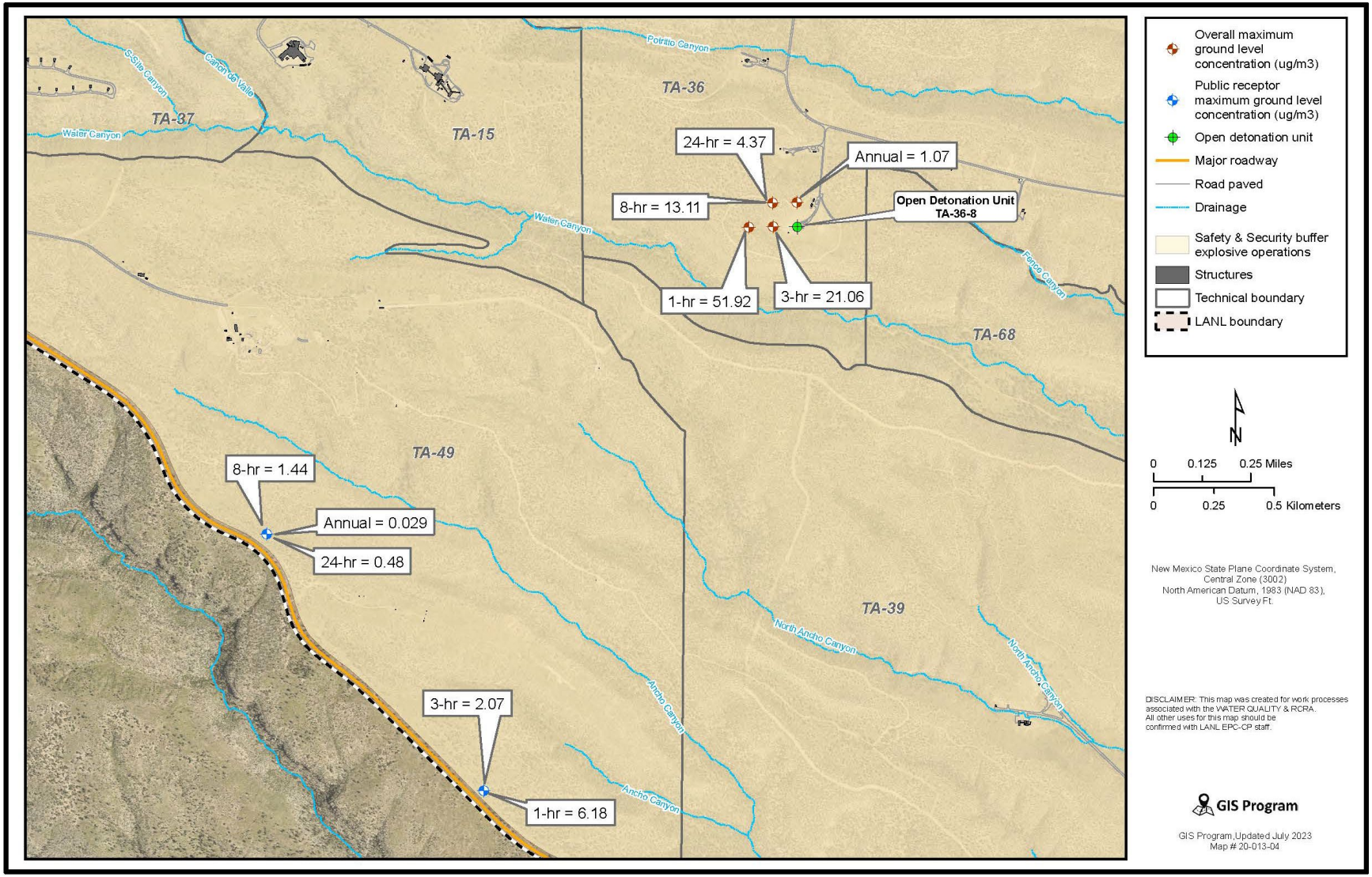

Figure 4-11. ODTA-36-8 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors.

Table 4-17. ODTA-39-6 Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

											All Receptors
				AERMOD		AERMOD		AERMOD			AERMOD/
OD TA-39-6	OBODM			Concentration	AERMOD	All Receptors		AERMOD	Public Receptors Only		OBODM
	All Receptors			for Same OBODM	10a-3pm	10a-3pm		10a-3pm	10a-3pm		Conc. Ratio
Model	8am-5pm	X-Coordinate	Y-coordinate	Receptor	All Receptors	X-Coordinate	Y-coordinate	Public Receptors	X-Coordinate	Y-coordinate	Increase or
Averaging (t)	ug/m3	meters	meters	ug/m3	ug/m3	meters	meters	ug/m3	meters	meters	(-) Decrease
1-hr Max. (C)	4.16	385514.0	3962301.0	19.38	38.34	385614.0	3962306.0	10.38	384957.8	3962054.5	9.22
3-hr Max. (C)	2.56	385614	3962401	21.71	21.71	385614.0	3962401.0	5.51	384943.4	3962068.0	8.48
8-hr Max. (C)	0.59	385714	3962701	3.66	11.90	385714.0	3962601.0	2.61	384943.4	3962068.0	20.07
24-hr Max. (C)	0.350	385614	3962401	3.49	3.97	385714.0	3962601.0	0.87	384943.4	3962068.0	11.33
Annual Max. (C)	Not Available (NA) (1)				0.79	385714.0	3962601.0	0.043	384957.8	3962054.5	NA (1)
Notes											
(1) Desktop with Windows XP failed before annual concentrations were modeled using OBODM. However, the key plume rise parameters for calculating the volume source release parameters is based on the hourly results.											

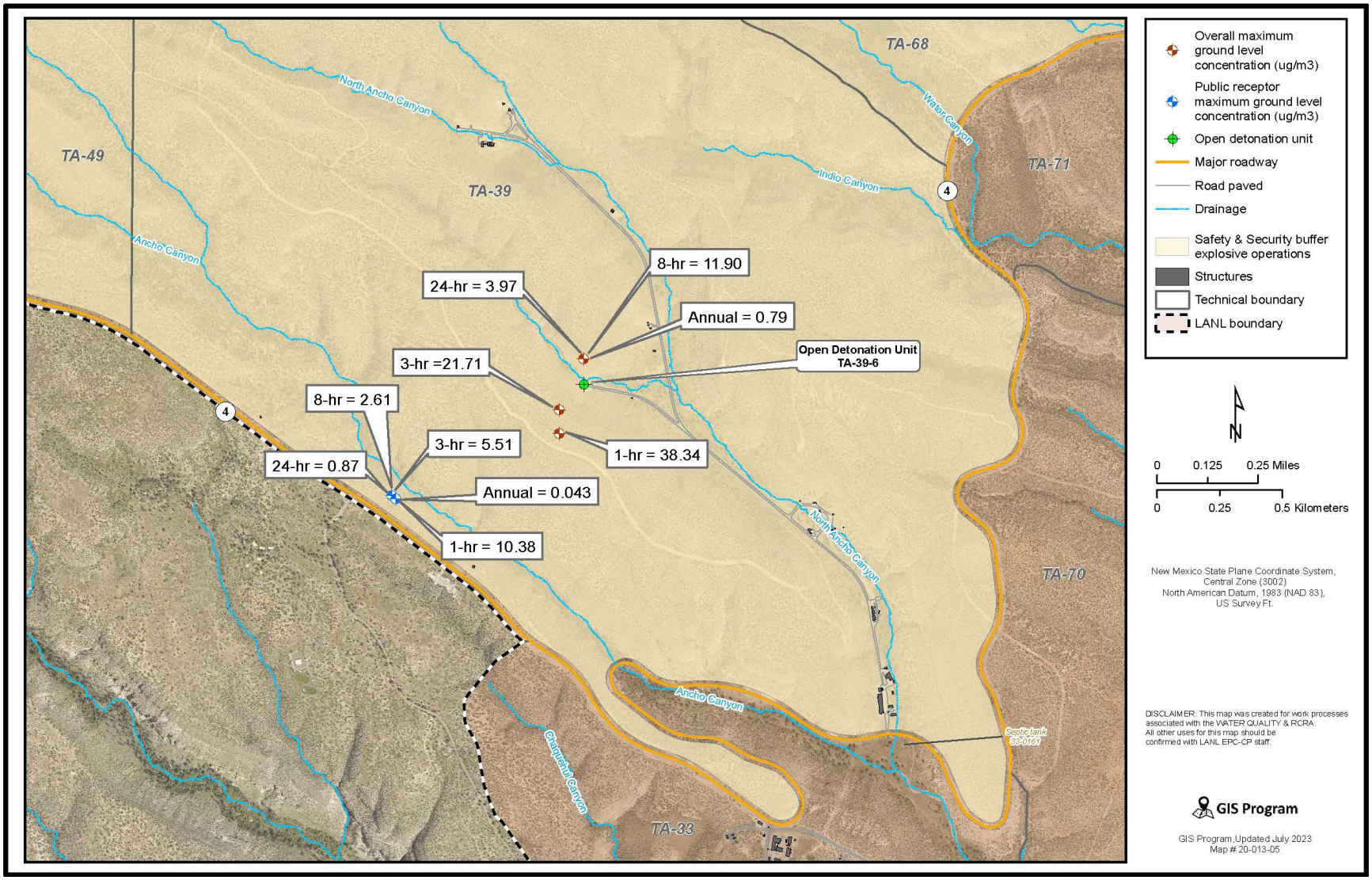

Figure 4-12. ODTA-39-6 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

Table 4-18. OBTA-16-388 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

											All Receptors
				AERMOD							AERMOD/
OB TA-16-388	OBODM			Concentration		AERMOD			AERMOD		OBODM
	All Receptors			for Same OBODM	AERMOD	All Receptors		AERMOD	Public Receptors Only		Conc. Ratio
Model	8am-5pm	X-Coordinate	Y-coordinate	Receptor	All Receptors	X-Coordinate	Y-coordinate	Public Receptors	X-Coordinate	Y-coordinate	Increase or
Averaging (t)	ug/m3	meters	meters	ug/m3	ug/m3	meters	meters	ug/m3	meters	meters	(-) Decrease
1-hr Max. (C)	17.15	379170.0	3967721.0		132.55	379570.0	3967821.0	16.05	377650.0	3962796.0	7.73
3-hr Max. (C)	10.66	379170.0	3967721.0		51.42	379570.0	3967821.0	5.47	379282.3	3966223.5	4.82
8-hr Max. (C)	2.83	379370.0	3967821.0		34.97	379570.0	3967821.0	2.06	377233.6	3966970.0	12.36
24-hr Max. (C)	1.332	379170.0	3967721.0		12.60	379570.0	3967821.0	0.76	379282.3	3966223.5	9.45
Annual Max. (C)	Not Available (NA) (1)				2.56	379570.0	3967821.0	0.054	379048.3	3966298.6	NA (1)
Notes											
(1) Desktop with Windows XP failed before annual concentrations were modeled using OBODM. However, the key plume rise parameters for calculating the volume source release parameters is based on the hourly results.											

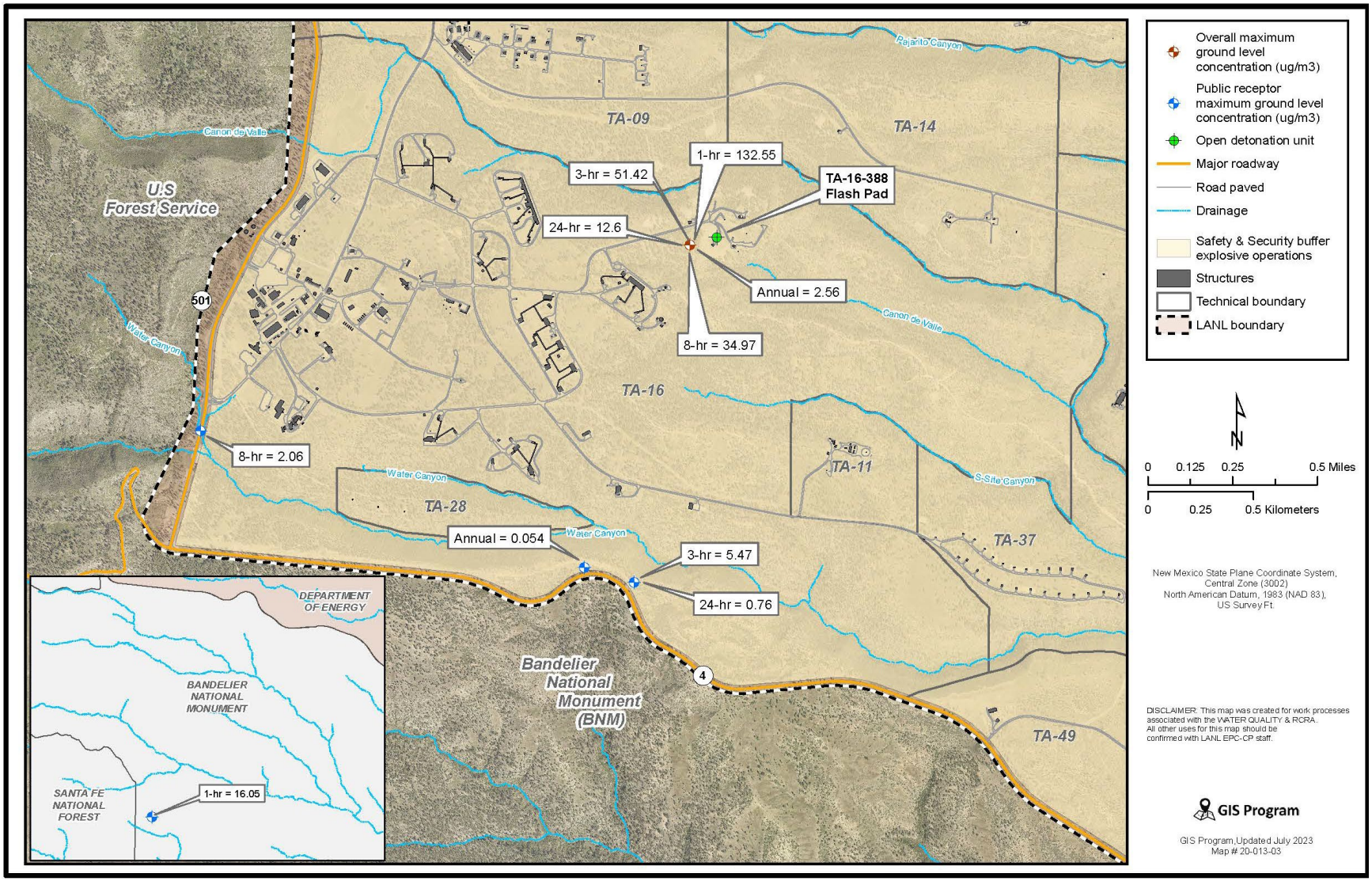

Figure 4-13. OBTA-16-388 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

5 Results for Assessment of the Criteria Pollutant Air Quality Standards and Acute Health, Chronic Health, and Soil Deposition and LANL ESL Screening Levels

The AERMOD analysis of TA-16-388, TA-36-8, and TA-39-6 had similar results for the assessment of NAAQS and NMAAQS criteria pollutants. Based on the hybrid air modeling dispersion methods described herein, none of the evaluations resulted in exceedances of the criteria listed in Tables 5-1 to 5-6c. For criteria pollutants, only a few Significant Impact Levels (SIL) were exceeded, but for each exceedance of a SIL, the subsequent cumulative impact analyses were less than the respective NAAQS or NMAAQS.

AERMOD predicted that the CO, SO2, Lead, annual PM2.5, and annual NO2 emissions result in insignificant impacts to the ambient air and did not require further analysis. The emissions of regulated pollutants 1-hour NO_2, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ resulted in significant impacts (exceedance of a SIL) for ambient air, and each pollutant required a cumulative impact determination. AERMOD analysis used an extensive receptor grid extending beyond 10 kilometers from the LANL property boundary, together with property boundary receptors, as well as receptors at public locations within the LANL boundary. The cumulative impacts for gaseous pollutants 1-hour NO_2, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ were determined by adding the NMED-recommended ambient monitor background to the ambient impact of each pollutant for each OB/OD site. The cumulative ambient impact for particulate emissions was determined by modeling all nearby permitted sources and combining this result with the maximum AERMOD OB and OD modeling results where a unitized emission rate was used. These were combined with the recommended ambient monitor background to the model predicted ambient impact. $PM_{2.5}$ also included an estimate of secondary emissions calculated based on NMED modeling guidance (NMEDa 2022).

Again, the dispersion model results predict that the OB and OD emissions of Pb, CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$ comply with the air quality standards and do not cause or contribute to exceedance of the NAAQS or NMAAQS. Additionally, this study demonstrates that the cumulative impacts, when surrounding source emissions, background pollutant concentrations, and secondary formation for $PM_{2.5}$ are included, do not cause or contribute to exceedance of NAAQS and NMAAQS.

Excel spreadsheets were used to calculate constituent-specific air and soil concentrations and for comparison to appropriate screening levels. For each OD site the following calculations and comparisons were made:

- Maximum 1-, 3-, 8-, 24-hour, quarterly (Pb) concentrations, and annual average concentrations were calculated and compared to the NAAQS and NMAAQS for public receptors;
- Maximum 1-hour concentrations were calculated and compared to the lesser of the AIEC acute values and CA-OEHHA acute Reference Exposure Level (REL) (CA OEHHA 2023) where values exist;
- Annual average air concentrations were calculated and compared to the lesser of the CA-OEHHA Non-Cancer REL Chronic (µg/m3) (CA OEHHA 2023) and EPA Resident Air Non-carcinogenic SL for THI = 0.1 (µg/m3) (EPA 2023);
- Soil concentrations from deposition were calculated and compared to NMED Human Health Cancer and Non-Cancer Residential Soil SSLs (NMED 2022b and NMED 2022c). Where both Cancer and Non-Cancer values existed, both values were compared to the maximum concentration based on AERMOD results. Where NMED data was not available, EPA RSL screening levels for Residential Soil were applied (EPA 2023). EPA Carcinogenic SL values are based on a target risk of $TR=1E^{-06}$ and Non-Carcinogenic SL Child values are based on a Target Hazard Index (THI) of 0.1 (mg/kg). The LANL-derived ESLs are also included for review and comparison and in some cases was the only value available for soil concentration analysis.

- Concentrations for emission products were calculated whether there was a screening level or not. A comparison of the calculated values from model results with the EPA and NMED ambient air quality standards are summarized in Tables 5-1, 5-2, and 5-3. In cases where there is a NAAQS and NMAAQS for the same pollutant and same averaging period, the more stringent standard was evaluated. Background concentrations for all forms of particulate matter have been added to model results as specified by NMED and the total value is shown in the tables for comparison to standards (NMEDa, 2022).

The Ambient Air Quality Standard (AAQS) included within Tables 5-1, 5-2, and 5-3 includes both an EPA NAAQS and a New Mexico NMAAQS where applicable. All calculations used in providing results, as well as all NAAQS and NMAAQS, are shown in the following tables.

This AAQS analysis was conducted using the highest maximum model result that occurred at any public receptor. Receptors on LANL property were not used as is the protocol under NMED modeling guidelines when demonstrating compliance with ambient air quality standards for permit purposes (NMEDa, 2022). In this respect, NMED follows EPA direction regarding the definition of *ambient air*, which defines where the air quality standards are applicable.

As demonstrated in the tables, no AAQS were exceeded. All results are conservatively predicted and presented in Tables 5-1, 5-2, and 5-3. Tables 5-4a, 5-4b, 5-4c, 5-5a, 5-5b, 5-5c, 5-6a, 5-6b, and 5-6c compare the calculated values from model results with the acute and chronic air health screening levels and the soil deposition screening and LANL ESL levels. Gravitational deposition would be significant only for relatively large particles deposited close to the detonation sites. Wet deposition should be insignificant for detonations which occur infrequently and never during precipitation events. Thus, non-gravitational dry deposition should be the major contributor to soil concentrations of contaminants. This type of deposition was conservatively estimated using the calculation provided by the California EPA for air toxics analyses found in the document *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (CA OEHHA, 2015).

There are several levels of conservatism present in the deposition estimates using this approach. First, the annual contaminant air concentration used in the calculation is based on running AERMOD using the unitized emissions rate of 1 gram/second to calculate an annual concentration to be used for each pollutant assessment, and the pollutant emission factor is applied to the maximum annual waste to be treated to calculate the maximum annual concentration. Second, the single maximum annual air concentration is used, which is a non-depleted value (e.g., there is no removal of contaminant mass from the detonation cloud as a function of downwind distance). In the calculation, it is assumed there is no degradation of organic compounds in the soil over time, which again results in an over prediction of soil concentrations during the 10-year estimate. The deposition rate or Dep-rate used was the CAL EPA recommended value for an uncontrolled source, which is 0.05 meters/second.

Using this procedure, soil concentrations were calculated using the maximum annual air concentrations for each contaminant. The calculation is shown below:

$C_s = Dep \times X / (K_s \times SD \times BD \times T_t)$

Dep = Deposition on the affected soil area per day ($\mu g/m^2/d$)

Dep = GLC × Dep-rate × 86,400

GLC = chemical specific annual ground level concentration from the AERMOD result and emission factor ($\mu g/m^3$)

Dep-rate = 0.05 m/sec (default value for uncontrolled source)

86,400 = Seconds per day conversion factor

$X = [\{e^{-K_s \times T_f} - e^{-K_s \times T_o}\} \div K_s] + T_t$

e = 2.718

K_s = Soil elimination constant = 6.93×10^{-9} (no degradation of contaminant in soil assumed)

T_f = End of evaluation period (d) = 3650

T_o = Beginning of evaluation period (d) = 0

T_t = Total days of exposure period $T_f - T_o$ (d) = 3650 (10-year period)

SD = Soil mixing depth (m) = 0.01 for soil ingestion or dermal pathway (analysis is on Laboratory property)

BD = Soil bulk density (kg/m^3) = 1,333

Table 5-1. Air Quality Standards Results for TA-36-8

Basis								
2000	**lb/hr detonation**							
1	detonations/hr							
0.0044	Lead compounds fraction - lb Pb/lb waste (1)(1a)							
15000	lb/yr detonation							
1	g/sec contaminant emission rate							
AERMOD Results (X/Q)								
-	**ODTA36-8 1-21-2021 0900hr 1-3-8-24hr PublicReceptors CO2_2021_CO2**							
-	**ODTA36-8 1-21-2021 0900hr Annual PublicReceptors CO2_2021_CO2**							
6.1820	1-hour maximum value, µg/m³ per g/sec contaminant							
3.8079	4th highest 1-hour maximum value, µg/m³ per g/sec contaminant for SO2							
2.9686	8th highest 1-hour value, µg/m³ per g/sec contaminant for NO2							
2.0659	3-hour maximum value, µg/m³ per g/sec contaminant							
1.4412	8-hour maximum value, µg/m³ per g/sec contaminant							
0.4807	24-hour maximum value, µg/m³ per g/sec contaminant							
0.2995	2nd highest 24-hour maximum value, µg/m³ per g/sec contaminant for PM10 only							
0.1802	8th highest 24-hour value, µg/m³ per g/sec contaminant for PM2.5 only							
0.0552	Monthly maximum value, µg/m³ per g/sec contaminant							
0.0289	Annual maximum value, µg/m³ per g/sec contaminant							

					Secondary PM2.5			
						NO2 tpy	**SO2 tpy**	
					Annual Emissions	0.3975	0.0036	
					MERP 24-hr	42498	9753	
						PM2.5 24-hr	**1.1667E-05**	**µg/m3**
					MERP Annual	130260	53898	
						PM2.5 Annual	**6.24E-07**	**µg/m3**

Pollutant	Averaging Time	Emission Factor lb/lb waste	Emission Rate g/sec	Maximum Concentration µg/m³	Significance Level (SIL) µg/m³	NAAQS µg/m³	NMAAQS µg/m³	Air Quality Standard Exceeded or SIL?
Nitrogen Dioxide (3)		0.053						
	1-hour		13.36	39.65	7.52			Yes
	Background			81.20				
	1-hour Total			120.85		188.03	none	No
	24-hour (4)				none	none	188.0	No
	Annual		0.011	0.0003	1.0	99.66	none	No
Carbon Monoxide		0.071						
	1-hour		17.89	110.61	2000	40,069.6	14,997.5	No
	8-hour		17.89	25.79	500	10,303.6	9,960.1	No
Sulfur Dioxide		0.00048						
	1-hour		0.121	0.46	7.8	196.4	none	No
	3-hour		0.121	0.25	25.0	1309.30	none	No
	24-hour		0.121	0.06	5.0	none	261.9	No
	Annual		0.000104	0.000003	1.0	none	52.4	No

PM10 (5)(6)(7)		0.29						
	24-hour		73.08	21.88	5.0			Yes
	Background			19.00				
	Nearby Sources			3.206				
	24-hour Total			40.88		150.0	none	No
PM2.5 (5)(6)(8)		0.42						
	24-hour		105.84	19.07	1.2			Yes
	Background			9.20				
	Secondary Formation			0.000012				
	Nearby Sources			2.006				
	24-hour Total			30.28		35.0	none	No
PM2.5 (5)	Annual	0.42	0.09	0.0026	0.2	12.0	none	No
Lead (1a)	Quarterly(9)	0.0044	1.109	0.0612	0.03			Yes
						0.15	none	No

Notes:

1. Based on all waste being treated by OD at TA-36-8, the explosive waste with overall metal contamination is less than 7.7%. See Attachment 4 for the calculation.

1a. The metal fraction of total waste for lead is calculated separately in Attachment 4.

2. Both federal and state AAQS values are listed in the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines dated July 2022.
3. NO_2 1-hour: If one year of onsite meteorological data are used, the 98th-percentile value associated with the 1-year period of meteorological data modeled is the design value.
4. Demonstration of compliance with 1-hour standard is automatically a demonstration of compliance with the 24-hour NMAAQS. Otherwise, the 24-hour NO_2 standard is compared with the highest 24-hour average calculated by the model.
5. Emission factor for $PM_{2.5}$ and PM_{10} is based on the paper, "Aerostat-based sampling of emissions from OB and OD of military ordnance," J. Aurell, et.al., *Journal of Hazardous Materials*, Oct. 2014.
6. Particulate matter background concentrations added as specified from NMED Air Dispersion Modeling Guidelines, July 2022.
7. PM10 24-h background – July 2022 - North Central - Santa Fe - 19.0 $\mu g/m^3$ max. for 24-hour 2nd high background.
8. PM2.5 24-h background – July 2022 - North Central - Santa Fe - 98 percentile - 9.2 $\mu g/m^3$.
9. For modeling quarterly lead (Pb) averages, use the monthly averaging period as a conservative approach. Model the entire facility without surrounding sources and compare the high month concentration to the standard. No background concentration is added.

Table 5-2. Air Quality Standards Results for TA-39-6

Basis	**TA39-6 OD Volume Source 1-3-8-24 1000 lb Public Receptors 10am-3pm**					**Secondary PM2.5**			
1000	lb/hr detonation						**NO2 tpy**	**SO2 tpy**	
1	detonations/hr					**Annual Emissions**	0.3975	0.0036	
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)					**MERP 24-hr**	42498	9753	
15000	lb/yr detonation						**PM2.5 24-hr**	**1.1667E-05**	**µg/m3**
1	g/sec contaminant emission rate					**MERP Annual**	130260	538989	
AERMOD Results (X/Q)							**PM2.5 Annual**	**6.12E-07**	**µg/m3**
	ODTA39-6 1-8-2021 0800hr 1-3-8-24hr PublicRec 1000-lb 10am-3pmOps_2021_CO2								
	ODTA39-6 1-8-2021 0800hr Annual+Monthly PublicRec 1000-lb 10am-3pmOps_2021_CO2								
10.376	1-hour maximum value, µg/m³ per g/sec contaminant								
7.156	4th highest 1-hour maximum value, µg/m3 per g/sec contaminant for SO2								
5.851	8th highest 1-hour value, µg/m3 per g/sec contaminant for NO2								
5.514	3-hour maximum value, µg/m³ per g/sec contaminant								
2.606	8-hour maximum value, µg/m³ per g/sec contaminant								
0.869	24-hour maximum value, µg/m³ per g/sec contaminant								
0.627	2nd highest 24-hour maximum value, µg/m³ per g/sec contaminant for PM10 only								
0.416	8th highest 24-hour value, µg/m³ per g/sec contaminant for PM2.5 only								
0.1085	Monthly maximum value, µg/m³ per g/sec contaminant								
0.0432	Annual maximum value, µg/m³ per g/sec contaminant								

Pollutant	Averaging Time	Emission Factor lb/lb waste	Emission Rate g/sec	Maximum Concentration µg/m³	Significance Level µg/m³	NAAQS µg/m³	NMAAQS µg/m³	Air Quality Standard Exceeded?
Nitrogen Dioxide (3)		0.053						
	1-hour		6.68	39.07	7.52			Yes
	Background			81.20				
	1-hour Total			120.27		188.03	none	No
	24-hr. (4)					none	188.0	No
	Annual		0.011	0.0005	1.0	99.66	94.02	No
Carbon Monoxide		0.071						
	1-hour		8.95	92.82	2000	40,069.6	14,997.5	No
	8-hour		8.95	23.31	500	10,303.6	9,960.1	No
Sulfur Dioxide		0.00048						
	1-hour		0.060	0.43	7.8	196.4	none	No
	3-hour		0.060	0.33	25.0	1,309.30	none	No
	24-hour		0.060	0.05	5.0	NA	261.9	No
	Annual		0.000104	0.000004	1.0	NA	52.4	No
PM10 (5)(6)(7)		0.29						
	24-hour		36.54	22.92	5.0			Yes
	Background			19.00				
	Nearby Sources			3.206				
	24-hour Total			41.92		150.0	none	No

PM2.5 (5)(6)(8)		0.42						
	24-hour		52.92	22.00	1.2			Yes
	Background			9.20				
	Secondary Formation			0.000012				
	Nearby Sources			2.006				
	24-hour Total			.21		35.0	none	No
PM2.5 (5)	Annual	0.42	0.09	0.0039	0.2	12.0	none	No
Lead	Quarterly(9)	0.0044	0.554	0.0601	0.03			Yes
						0.15	none	No

Notes:

1. Based on all waste being treated by OD at TA-36-8, the explosive waste with overall metal contamination is less than 7.7%. See Attachment 4 for the calculation.

1a. The metal fraction of total waste for Lead is calculated separately in Attachment 4.

2. Both federal and state AAQS values are listed in the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines dated July 2022.
3. NO2 1-hour: If one year of on-site meteorological data are used, the 98th-percentile value associated with the 1-year period of meteorological data modeled is the design value.
4. Demonstration of compliance with 1-hour standard is automatically a demonstration of compliance with the 24-hour NMAAQS. Otherwise, the 24-hour NO2 standard is compared with the highest 24-hour average calculated by the model.
5. Emission factor for PM2.5 and PM10 is based on the paper "Aerostat-based sampling of emissions from OB and OD of military ordnance," J. Aurell, et.al., *Journal of Hazardous Materials*, Oct. 2014.
6. Particulate matter background concentrations added as specified from NMED Air Dispersion Modeling Guidelines, July 2022.
7. PM10 24-h background – July 2022 - North Central - Santa Fe - 19.0 $\mu g/m^3$ max. for 24-hour 2nd high background
8. PM2.5 24-h background – July 2022 - North Central - Santa Fe - 98 percentile - 9.2 $\mu g/m^3$
9. For modeling quarterly Lead (Pb) averages, use the monthly averaging period as a conservative approach. Model the entire facility without surrounding sources and compare the high month concentration to the standard. No background concentration is added.

Table 5-3. Air Quality Standards Results for TA-16-388

Basis

			Secondary PM2.5	
			NO2 tpy	SO2 tpy
200	lb waste/hr	**Annual Emissions**	0.0128	0.0006
6000	lb waste/yr	**MERP 24-hr**	42498	9753
254.4	lb propane/hr		**PM2.5 24-hr**	**4.409E-07** **µg/m³**
7632.0	lb propane/yr			

1 g/sec contaminant emission rate

Model Results (X/Q) **OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr Public rec_2021_CO2 and OBTA16-388-2023 12-11-2021 0900hr Annual Public rec_2021_CO2**

16.047 1-hour maximum value, µg/m³ per g/sec contaminant
7.576 8th highest overall 1-hour maximum value, µg/m³ per g/sec contaminant (as applied to 1-hour NO_2 NAAQS)
5.469 3-hour maximum value, µg/m³ per g/sec contaminant
2.063 8-hour maximum value, µg/m³ per g/sec contaminant
0.761 24-hour maximum value, µg/m³ per g/sec contaminant
0.655 2nd high 24-hour maximum value, µg/m³ per g/sec contaminant (as applied to 24-hr PM_{10})
0.520 8th highest overall 24-hour maximum value, µg/m³ per g/sec contaminant (as applied to 24-hour $PM_{2.5}$ NAAQS)
0.054 Annual maximum value, µg/m³ per g/sec contaminant

Pollutant	Averaging Time	OB Waste Emission Factor lb/lb waste	OB Waste Emission Rate g/sec	OB Waste Maximum Concentration µg/m³	Propane Emission Factor, lb/lb propane	Propane Emission Rate, g/sec	Propane Maximum Concentration µg/m³	Maximum Concentration Total µg/m³	Significance Level µg/m³	NAAQS(1) µg/m³	NMAAQS(1) µg/m³	Air Quality Standard Exceeded or SIL?
Nitrogen Dioxide		0.075			0.0031							
	1-hour (2)		1.890	14.32		0.10	0.7445	15.1	7.52			Yes
	Background							81.2				
	1-hour Total							96.3		188.03	none	No
	24-hour (3)		1.890	1.44		0.10	0.0748	1.5	None	none	188.03	No
	Annual		0.006	0.00035		0.00	0.000018	0.00037	1.0	99.66	94.02	No
Carbon Monoxide		0.030			0.00177							
	1-hour		0.751	12.05		0.06	0.91	13.0	2000	40069.6	14997.5	No
	8-hour		0.751	1.55		0.06	0.12	1.7	500	10303.6	9960.1	No
Sulfur Dioxide		0.0012			0.00212							
	1-hour		0.031	0.493		0.07	1.09	1.6	7.8	196.40	none	No
	3-hour		0.031	0.168		0.07	0.37	0.54	25.0	1309.30	none	No
	24-hour		0.031	0.023		0.07	0.05	0.08	5.0	none	261.90	No
	Annual		0.00011	0.0000057		0.00	0.00	0.0000183	1.0	none	52.40	No
PM10 (4)(5)(6)		0.910			0.00017							
	24-hour		22.932	15.03		0.0053	0.00347	15.035	5.0			Yes
	Background			19.00								
	Nearby Sources			3.206								
	24-hour Total			37.24			0.00347	37.241		150	none	No

PM2.5 (4)(7)(8)		0.910			0.00017							
	24-hour		22.932	11.92		0.0053	0.0028	11.923	1.2			Yes
	Background			9.20								
	Secondary Formation			0.00000044								
	Nearby Sources			2.006								
	24-hour Total			23.13			0.0028	23.13		35	none	No
PM2.5 (7)	Annual	0.910	0.079	0.00426	0.00017	0.000018	0.00000098	0.00426	0.2	12.0	none	No

Notes:

1. Both federal and state AAQS values are listed in the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines dated July 2022.
2. NO_2 1-hour: If one year of on-site meteorological data are used, the 98th-percentile value associated with the 1-year period of meteorological data modeled is the design value.
3. Demonstration of compliance with 1-hour standard is automatically a demonstration of compliance with the 24-hour NMAAQS; otherwise, the 24-hour NO_2 standard is compared with the highest 24-hour average calculated by the model.
4. Particulate matter background concentrations added as specified from NMED Air Dispersion Modeling Guidelines, July 2022.
5. Calculated maximum concentration for the 24-hour PM_{10} NAAQS is based on 2nd high from AERMOD model runs. This is more conservative than the high-2nd-high as specified by NMED Air Dispersion Modeling Guideline, July 2022.
6. PM_{10} 24-h background – July 2022 - North Central - Santa Fe - 19.0 µg/m^3 max. for 24-hour 2nd high background
7. Emission factor for PM_{10} used also for $PM_{2.5}$ which overpredicts $PM_{2.5}$ concentrations.
8. Calculated maximum concentrations for 24-hour $PM_{2.5}$ NAAQS is based on the 8th high overall value from the AERMOD model runs using one year of met data. This is more conservative than the high 8th high as specified by NMED Air Dispersion Modeling Guideline, July 2022.
9. $PM_{2.5}$ 24-h background – July 2022 - North Central - Santa Fe – 98th percentile - 9.2 µg/m^3

Table 5-4a. Acute Health Screening Level Results for TA-36-8

	2000	lb/hr detonation
	0.077	Metal Waste fraction for metals emissions (see Explosives List explanation) - lb metal/lb waste (1a)
	0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a)
	0.0044	Lead compounds fraction - lb Pb/lb waste (1a)
	0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)
	1	g/sec contaminant emission rate
AERMOD Model Result (X/Q)		**ODTA36-8 1-21-2021 0900hr 1-3-8-24hr AllReceptors CO2_2021_CO2**
	51.920	1-hour maximum value, µg/m³ per g/sec contaminant
	28.130	1-hour 8th high value for NO2 only, µg/m³ per g/sec contaminant (5)

Contaminant	Emission Factor lb/lb waste	Emission Rate g/sec	1-Hour Concentration µg/m³	Air Inhalation Emission Concentration (AIEC) - acute (µg/m³)	CA-OEHHA Non-Cancer Reference Exposure Level (REL) - Acute (µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	1.79E+01	9.29E+02	NA	2.30E+04	No
Nitrogen Oxides (as NO_2 only)(1)	5.30E-02	1.34E+01	3.76E+02	NA	4.70E+02	No
Sulfur Dioxide (1)	4.80E-04	1.21E-01	6.28E+00	NA	6.60E+02	No
Benzene (1)	2.00E-04	5.04E-02	2.62E+00	1.30E+03	2.70E+01	No
TNMHC (1)	7.70E-03	1.94E+00	1.01E+02	NA	NA	NA
Acetylene (1)	7.70E-04	1.94E-01	1.01E+01	NA	NA	NA
Ethylene (1)	7.10E-04	1.79E-01	9.29E+00	NA	NA	NA
Propylene (1)	1.30E-04	3.28E-02	1.70E+00	NA	NA	NA
Toluene (1)	6.70E-05	1.69E-02	8.77E-01	3.70E+04	5.00E+03	No
Naphthalene (2)	2.80E-07	7.06E-05	3.66E-03	7.50E+04	NA	No
Methylene Chloride (1)	6.20E-04	1.56E-01	8.11E+00	1.40E+04	1.40E+04	No
Aluminum Oxide (1a)	7.70E-02	1.94E+01	1.01E+03	NA	NA	NA
Barium(1a)	4.20E-02	1.06E+01	5.50E+02	1.50E+03	NA	No
Copper (1a)	5.90E-04	1.49E-01	7.72E+00	NA	1.00E+02	No
Lead (1a)	4.40E-03	1.11E+00	5.76E+01	1.50E+02	NA	No
Trioctyl phosphate (3)	2.60E-01	6.55E+01	3.40E+03	NA	NA	NA
Aluminum (1a)	7.70E-02	1.94E+01	1.01E+03	NA	NA	NA
Titanium (1a)	7.70E-02	1.94E+01	1.01E+03	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Nitrocellulose (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Nitroguanidine (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Nitromethane (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Tetryl (Trinitrophenylmethylnitramine)(2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	7.06E-05	3.66E-03	1.50E+03	NA	No
Acrylonitrile (4)	1.00E-08	2.52E-06	1.31E-04	2.18E+04	NA	No
Bis(2-ethylhexyl)adipate (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA
tris-2-chloroethyl phosphate (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	2.52E-06	1.31E-04	1.50E+04	NA	No
Dinitrotoluene (2,4-) (4)	1.00E-08	2.52E-06	1.31E-04	6.00E+02	NA	No

Dioctyladipate (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA
Dioctylphthalate (4)	1.00E-08	2.52E-06	1.31E-04	1.00E+04	NA	No
Diphenylamine (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is less than 7.7%. See Attachment 4 for the calculation. The metal fractions of total waste for lead, barium and copper are calculated separately in Attachment 4.

2 Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics.

3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.

4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Anti-oxidants in Attachment 4. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.

5. 8th highest concentration for NO_2, same the NAAQS/NMAAQS design value or 98th percentile concentration.

6. NA - Chemical Not Available in database

7. Screening concentrations from acute (1 hr) inhalation exposures concentrations (AIEC) from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2016). https://archive.epa.gov/epawaste/hazard/tsd/td/web/mdb/05hhrapchemdat.mdb

8. REL 1-hour acute screening concentrations are from the CA OEHHA, October 2023, Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf

9. An exceedance is based on the maximum 1-hr concentration being greater than or equal to the NMED or EPA standards.

Table 5-4b. Chronic Health Screening Level Results for TA-36-8

Basis

15,000	lb/yr detonation
1	g/sec contaminant emission rate
0.077	lb metal / lb waste (1a)
0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a)
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)
0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)

AERMOD Results (X/Q) **ODTA36-8 1-21-2021 0900hr Annual AllReceptors CO2_2021_CO2**

1.0672 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Emission Factor (1) (lb/lb waste)	Emission Rate (g/sec)	Maximum Annual Concentration µg/m³	CA-OEHHA Non-Cancer Reference Exposure Level (REL) Chronic (6) (µg/m³)	EPA Resident Air Non-carcinogenic (RSL) for THI = 0.1 (7) (µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	1.53E-02	1.63E-02	NA	NA	NA
Nitrogen Oxides (as NO_2 only) (1)	5.30E-02	1.14E-02	1.22E-02	NA	NA	NA
Sulfur Dioxide (1)	4.80E-04	1.04E-04	1.11E-04	NA	NA	NA
Benzene (1)	2.00E-04	4.32E-05	4.60E-05	3.00E+00	3.1E+00	No
TNMHC (1)	7.70E-03	1.66E-03	1.77E-03	NA	NA	NA
Acetylene (1)	7.70E-04	1.66E-04	1.77E-04	NA	NA	NA
Ethylene (1)	7.10E-04	1.53E-04	1.63E-04	NA	NA	NA
Propylene (1)	1.30E-04	2.80E-05	2.99E-05	3.00E+03	3.1E+02	No
Toluene (1)	6.70E-05	1.45E-05	1.54E-05	4.20E+02	5.2E+02	No
Naphthalene (2)	2.80E-07	6.04E-08	6.45E-08	9.00E+00	3.1E-01	No
Methylene Chloride (1)	6.20E-04	1.34E-04	1.43E-04	4.00E+02	6.3E+01	No
Aluminum Oxide (1a)	7.70E-02	1.66E-02	1.77E-02	NA	5.20E-01	No
Barium (1a)	4.20E-02	9.06E-03	9.67E-03	NA	5.20E-02	No
Copper (1a)	5.90E-04	1.27E-04	1.36E-04	NA	NA	NA
Lead (1a)	4.40E-03	9.49E-04	1.01E-03	NA	1.5E-01	No
Trioctyl phosphate (3)	2.60E-01	5.61E-02	5.99E-02	NA	NA	NA
Aluminum (1a)	7.70E-02	1.66E-02	1.77E-02	NA	5.20E-01	No
Titanium (1a)	7.70E-02	1.66E-02	1.77E-02	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Nitrocellulose (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Nitroguanidine (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Nitromethane (2)	2.80E-07	6.04E-08	6.45E-08	NA	5.20E-01	No
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Tetryl (Trinitrophenylmethylnitramine)(2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Acrylonitrile (4)	1.00E-08	2.16E-09	2.30E-09	5.00E+00	2.10E-01	No
Bis or Di(2-ethylhexyl)adipate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
tris-2-chloroethyl phosphate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA

Dinitrotoluene (2,4-) (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Dioctyladipate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Dioctylphthalate/Di-n-octyl phthalate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Diphenylamine (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is 7.7% (not including Ba, Pb, or Cu). See Attachment 4 for the calculation. The metal fractions of total waste for lead, barium and copper are calculated separately in Attachment 4.

2. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics
3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.
4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Antioxidants in Attachment 2. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.
5. NA - Chemical Not Available in database
6. Chronic REL annual screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
7. U.S. EPA air non-carcinogenic screening levels are from the Regional Screening Levels (RSLs) – Generic Tables. November 2023. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
8. An exceedance is based on the maximum concentration being greater than or equal to the NMED or EPA standards.

Table 5-4c. Residential Soil Screening Level and LANL ESL Screening Level Results for TA-36-8

Basis

15,000 lb/yr detonation

1 g/sec contaminant emission rate

AERMOD Result (X/Q) **ODTA36-8 1-21-2021 0900hr Annual AllReceptors CO2_2021_CO2**

1.0672 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Maximum Annual Concentration µg/m³	10-Year Soil Concentration mg/kg	NMED Cancer - Residential Soil TR=1E-05 (mg/kg)	NMED Non-Cancer Residential Soil Screening Level (mg/kg)	Carcinogenic Target Risk - EPA SL - Resident Soil based on TR=1E-06 (mg/kg)	Noncancer Child HI EPA RSLs - Resident Soil based on THI = 0.1 (mg/kg)	Screening Level Exceeded?	Minimum LANL ESL mg/kg	Receptor	ESL Exceeded?
Carbon Monoxide	1.63E-02	9.67E+00	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxides (as NO_2 only)	1.22E-02	7.22E+00	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur Dioxide	1.11E-04	6.54E-02	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	4.60E-05	2.72E-02	1.78E+01	1.14E+02	1.20E+00	8.20E+00	No	2.40E+02	Deer mouse	No
TNMHC	1.77E-03	1.05E+00	NA	NA	NA	NA	NA	NA	NA	NA
Acetylene	1.77E-04	1.05E-01	NA	NA	NA	NA	NA	NA	NA	NA
Ethylene	1.63E-04	9.67E-02	NA	NA	NA	NA	NA	NA	NA	NA
Propylene	2.99E-05	1.77E-02	NA	NA	NA	2.20E+02	No	NA	NA	NA
Toluene	1.54E-05	9.12E-03	NA	5.23E+03	NA	4.90E+02	No	2.30E+01	Montane shrew	No
Naphthalene	6.45E-08	3.81E-05	2.26E+01	1.62E+02	2.00E+00	1.30E+01	No	1.00E+00	Plant	No
Methylene Chloride	1.43E-04	8.44E-02	7.66E+02	4.09E+02	5.70E+01	3.50E+01	No	2.60E+00	Deer mouse	No
Aluminum Oxide	1.77E-02	1.05E+01	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Barium	9.67E-03	5.72E+00	NA	1.56E+04	NA	1.50E+03	No	1.10E+02	Plant	No
Copper	1.36E-04	8.03E-02	NA	3.13E+03	NA	3.10E+02	No	1.40E+01	American robin	No
Lead	1.01E-03	5.99E-01	NA	NA	NA	4.00E+02	No	1.10E+01	American robin	No
Trioctyl phosphate	5.99E-02	3.54E+01	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	1.77E-02	1.05E+01	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Titanium	1.77E-02	1.05E+01	NA	NA	NA	NA	NA	7.70E+01	Montane shrew	No
Ammonium perchlorate	6.45E-08	3.81E-05	NA	NA	NA	5.50E+00	No	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX)	6.45E-08	3.81E-05	NA	3.85E+03	NA	3.90E+02	No	1.60E+01	Earthworm	No
Nitrocellulose	6.45E-08	3.81E-05	NA	NA	NA	1.90E+07	No	NA	NA	NA
Nitroguanidine	6.45E-08	3.81E-05	NA	NA	NA	6.30E+02	No	NA	NA	NA
Nitromethane	6.45E-08	3.81E-05	NA	NA	5.40E+00	8.80E+00	No	NA	NA	NA
Pentaerythritol tetranitrate (PETN)	6.45E-08	3.81E-05	NA	NA	1.30E+02	5.70E+01	No	1.00E+02	Deer mouse	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	6.45E-08	3.81E-05	8.31E+01	3.01E+02	8.30E+00	3.00E+01	No	2.30E+00	American robin	No
Tetryl (Trinitrophenylmethylnitramine)	6.45E-08	3.81E-05	NA	1.56E+02	NA	1.60E+01	No	1.50E+00	Deer mouse	No

2,4,6-trinitrotoluene (TNT)	6.45E-08	3.81E-05	2.11E+02	3.60E+01	2.10E+01	3.60E+00	No	7.50E+00	American robin	No
Acrylonitrile	2.30E-09	1.36E-06	4.93E+00	3.99E+01	2.50E-01	1.30E+00	No	NA	NA	NA
Bis(2-ethylhexyl)adipate	2.30E-09	1.36E-06	NA	NA	4.50E+02	3.80E+03	No	NA	NA	NA
tris-2-chloroethyl phosphate	2.30E-09	1.36E-06	NA	NA	2.70E+01	4.40E+01	No	NA	NA	NA
Di-n-butyl phthalate (Dibutyl phthalate)	2.30E-09	1.36E-06	NA	6.16E+03	NA	6.30E+02	No	1.10E-02	American robin	No
2,4-Dinitrotoluene (2,4-DNT)	2.30E-09	1.36E-06	1.71E+01	1.23E+02	1.70E+00	1.30E+01	No	6.00E+00	Plant	No
Dioctyladipate	2.30E-09	1.36E-06	NA	NA	NA	NA	NA	NA	NA	NA
Dioctyl Phthalate, (Bis(2-ethylhexyl)phthalate), (di(2-ethylhexyl)phthalate), DEHP)	2.30E-09	1.36E-06	3.80E+02	1.23E+03	3.90E+01	1.30E+02	No	9.10E-01	Montane shrew	No
Diphenylamine	2.30E-09	1.36E-06	NA	NA	NA	6.30E+02	No	1.00E+01	Robin insectivore	No

Notes:
1. The calculation methodology is described in Section 5.

Table 5-5a. Acute Health Screening Level Results for TA-39-6

Basis						
1000	lb/hr detonation					
1	detonation/hr					
0.077	Metal Waste fraction for metals emissions (see Explosives List explanation) - lb metal/lb waste (1a)					
0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a)					
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)					
0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)					
1	g/sec contaminant emission rate					
AERMOD Results (X/Q)	**TA39-6 OD Volume Source 1-3-8-24 1000 lb All Receptors 10am-3pm M-F**					
38.34	1-hour maximum value, µg/m³ per g/sec contaminant for 1 detonation/hr					
28.37	1-hour 8th high value for NO2 only, µg/m³ per g/sec contaminant for 1 detonation/hr (5)					
Contaminant	Mean Emission Factor (1) lb/lb waste	Emission Rate g/sec	Maximum 1-Hour Concentration µg/m³	Air Inhalation Emission Concentration (AIEC) - acute µg/m³)	CA-OEHHA Non-Cancer Reference Exposure Level (REL) – Acute (µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	8.95E+00	3.43E+02	NA	2.30E+04	No
Nitrogen Oxides (as NO_2 only)(1)	5.30E-02	6.68E+00	1.89E+02	NA	4.70E+02	No
Sulfur Dioxide (1)	4.80E-04	6.05E-02	2.32E+00	NA	6.60E+02	No
Benzene (1)	2.00E-04	2.52E-02	9.66E-01	1.30E+03	2.70E+01	No
TNMHC (1)	7.70E-03	9.70E-01	3.72E+01	NA	NA	NA
Acetylene (1)	7.70E-04	9.70E-02	3.72E+00	NA	NA	NA
Ethylene (1)	7.10E-04	8.95E-02	3.43E+00	NA	NA	NA
Propylene (1)	1.30E-04	1.64E-02	6.28E-01	NA	NA	NA
Toluene (1)	6.70E-05	8.44E-03	3.24E-01	3.70E+04	5.00E+03	No
Naphthalene (2)	2.80E-07	3.53E-05	1.35E-03	7.50E+04	NA	No
Methylene Chloride (1)	6.20E-04	7.81E-02	2.99E+00	1.40E+04	1.40E+04	No
Aluminum Oxide (1a)	7.70E-02	9.70E+00	3.72E+02	NA	NA	NA
Barium(1a)	4.20E-02	5.29E+00	2.03E+02	1.50E+03	NA	No
Copper (1a)	5.90E-04	7.43E-02	2.85E+00	NA	1.00E+02	No
Lead (1a)	4.40E-03	5.54E-01	2.13E+01	1.50E+02	NA	No
Trioctyl phosphate (3)	2.60E-01	3.28E+01	1.26E+03	NA	NA	NA
Aluminum (1a)	7.70E-02	9.70E+00	3.72E+02	NA	NA	NA
Titanium (1a)	7.70E-02	9.70E+00	3.72E+02	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Nitrocellulose (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Nitroguanidine (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Nitromethane (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Tetryl (Trinitrophenylmethylnitramine)(2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	3.53E-05	1.35E-03	1.50E+03	NA	No
Acrylonitrile (4)	1.00E-08	1.26E-06	4.83E-05	2.18E+04	NA	No
Bis(2-ethylhexyl)adipate (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA

tris-2-chloroethyl phosphate (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	1.26E-06	4.83E-05	1.50E+04	NA	No
Dinitrotoluene (2,4-) (4)	1.00E-08	1.26E-06	4.83E-05	6.00E+02	NA	No
Dioctyladipate (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA
Dioctylphthalate (4)	1.00E-08	1.26E-06	4.83E-05	1.00E+04	NA	No
Diphenylamine (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is less than 7.7%. See Attachment 4 for the calculation. The metal fractions of total waste for Lead, Barium and Copper are calculated separately in Attachment 4.

2 Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics.

3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.

4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Anti-oxidants in Attachment 4. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.

5. 8th highest concentration for NO2, same the NAAQS/NMAAQS design value or 98th percentile concentration

6. NA - Chemical Not Available in database

7. Screening concentrations from acute (1 hr) inhalation exposures concentrations (AIEC) from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2016). https://archive.epa.gov/epawaste/hazard/tsd/td/web/mdb/05hhrapchemdat.mdb

8. REL 1-hour acute screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf

9. An exceedance is based on the maximum 1-hr concentration being greater than or equal to the NMED or EPA standards.

Table 5-5b. Chronic Health Screening Level Results for TA-39-6

Basis

15,000	lb/yr detonation
1	g/sec contaminant emission rate
0.077	lb metal / lb waste (1a)
0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)
0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)
Model Result (X/Q)	**TA39-6 OD Volume Source Annual 1000 lb All Receptors 10am-3pm M-F**
0.790	Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Emission Factor (1) (lb/lb waste)	Emission Rate g/sec)	Maximum Annual Concentration µg/m³	CA-OEHHA Non-Cancer Reference Exposure Level (REL) Chronic (6) µg/m³)	EPA Resident Air Non-carcinogenic (RSL) for THI = 0.1 (7) µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	1.53E-02	1.21E-02	NA	NA	NA
Nitrogen Oxides (as NO_2 only) (1)	5.30E-02	1.14E-02	9.04E-03	NA	NA	NA
Sulfur Dioxide (1)	4.80E-04	1.04E-04	8.19E-05	NA	NA	NA
Benzene (1)	2.00E-04	4.32E-05	3.41E-05	3.00E+00	3.1E+00	No
TNMHC (1)	7.70E-03	1.66E-03	1.31E-03	NA	NA	NA
Acetylene (1)	7.70E-04	1.66E-04	1.31E-04	NA	NA	NA
Ethylene (1)	7.10E-04	1.53E-04	1.21E-04	NA	NA	NA
Propylene (1)	1.30E-04	2.80E-05	2.22E-05	3.00E+03	3.1E+02	No
Toluene (1)	6.70E-05	1.45E-05	1.14E-05	4.20E+02	5.2E+02	No
Naphthalene (2)	2.80E-07	6.04E-08	4.77E-08	9.00E+00	3.1E-01	No
Methylene Chloride (1)	6.20E-04	1.34E-04	1.06E-04	4.00E+02	6.3E+01	No
Aluminum Oxide (1a)	7.70E-02	1.66E-02	1.31E-02	NA	5.20E-01	No
Barium (1a)	4.20E-02	9.06E-03	7.16E-03	NA	5.20E-02	No
Copper (1a)	5.90E-04	1.27E-04	1.01E-04	NA	NA	NA
Lead (1a)	4.40E-03	9.49E-04	7.50E-04	NA	1.5E-01	No
Trioctyl phosphate (3)	2.60E-01	5.61E-02	4.43E-02	NA	NA	NA
Aluminum (1a)	7.70E-02	1.66E-02	1.31E-02	NA	5.20E-01	No
Titanium (1a)	7.70E-02	1.66E-02	1.31E-02	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Nitrocellulose (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Nitroguanidine (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Nitromethane (2)	2.80E-07	6.04E-08	4.77E-08	NA	5.20E-01	No
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Tetryl (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Acrylonitrile (4)	1.00E-08	2.16E-09	1.71E-09	5.00E+00	2.10E-01	No
Bis(2-ethylhexyl)adipate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
tris-2-chloroethyl phosphate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA

Dinitrotoluene (2,4-) (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Dioctyladipate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Dioctylphthalate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Diphenylamine (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is 7.7% (not including Ba, Pb, or Cu). See Attachment 4 for the calculation. The metal fractions of total waste for Lead, Barium and Copper are calculated separately in Attachment 4.

2. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics.
3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.
4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Antioxidants in Attachment 2. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.
5. NA - Chemical Not Available in database
6. Chronic REL annual screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
7. U.S. EPA air non-carcinogenic screening levels are from the Regional Screening Levels (RSLs) – Generic Tables. November 2023. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
8. An exceedance is based on the maximum concentration being greater than or equal to the NMED or EPA standards.

Table 5-5c. Residential Soil Screening Level and LANL ESL Screening Level Results for TA-39-6

Basis

15,000 lb/yr detonation

1 g/sec contaminant emission rate

AERMOD Result (X/Q) **TA39-6 OD Volume Source Annual 1000 lb All Receptors 10am-3pm M-F**

0.7904 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Maximum Annual Concentration µg/m³	10-Year Soil Concentration mg/kg	NMED Non-Cancer Residential Soil Screening Level (mg/kg)	NMED Cancer - Residential Soil TR = 1E-05 mg/kg)	Carcinogenic Target Risk - EPA SL - Resident Soil based on TR = 1E-06 (mg/kg)	Non-Cancer Child HI EPA RSLs - Resident Soil based on THI = 0.1 (mg/kg)	Screening Level Exceeded?	Minimum (No Effect) LANL ESL mg/kg	Receptor	ESL Exceeded?
Carbon Monoxide	1.21E-02	7.16E+00	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxides (as NO_2 only)	9.04E-03	5.35E+00	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur Dioxide	8.19E-05	4.84E-02	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	3.41E-05	2.02E-02	1.78E+01	1.14E+02	1.20E+00	8.20E+00	No	2.40E+02	Deer mouse	No
TNMHC	1.31E-03	7.77E-01	NA	NA	NA	NA	NA	NA	NA	NA
Acetylene	1.31E-04	7.77E-02	NA	NA	NA	NA	NA	NA	NA	NA
Ethylene	1.21E-04	7.16E-02	NA	NA	NA	NA	NA	NA	NA	NA
Propylene	2.22E-05	1.31E-02	NA	NA	NA	2.20E+02	No	NA	NA	NA
Toluene	1.14E-05	6.76E-03	NA	5.23E+03	NA	4.90E+02	No	2.30E+01	Montane shrew	No
Naphthalene	4.77E-08	2.82E-05	2.26E+01	1.62E+02	2.00E+00	1.30E+01	No	1.00E+00	Plant	No
Methylene Chloride	1.06E-04	6.25E-02	7.66E+02	4.09E+02	5.70E+01	3.50E+01	No	2.60E+00	Deer mouse	No
Aluminum Oxide	1.31E-02	7.77E+00	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Barium	7.16E-03	4.24E+00	NA	1.56E+04	NA	1.50E+03	No	1.10E+02	Plant	No
Copper	1.01E-04	5.95E-02	NA	3.13E+03	NA	3.10E+02	No	1.40E+01	American robin	No
Lead	7.50E-04	4.44E-01	NA	NA	NA	4.00E+02	No	1.10E+01	American robin	No
Trioctyl phosphate	4.43E-02	2.62E+01	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	1.31E-02	7.77E+00	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Titanium	1.31E-02	7.77E+00	NA	NA	NA	NA	NA	7.70E+01	Montane shrew	No
Ammonium perchlorate	4.77E-08	2.82E-05	NA	NA	NA	5.50E+00	No	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX)	4.77E-08	2.82E-05	NA	3.85E+03	NA	3.90E+02	No	1.60E+01	Earthworm	No
Nitrocellulose	4.77E-08	2.82E-05	NA	NA	NA	1.90E+07	No	NA	NA	NA
Nitroguanidine	4.77E-08	2.82E-05	NA	NA	NA	6.30E+02	No	NA	NA	NA
Nitromethane	4.77E-08	2.82E-05	NA	NA	5.40E+00	8.80E+00	No	NA	NA	NA
Pentaerythritol tetranitrate (PETN)	4.77E-08	2.82E-05	NA	NA	1.30E+02	5.70E+01	No	1.00E+02	Deer mouse	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	4.77E-08	2.82E-05	8.31E+01	3.01E+02	8.30E+00	3.00E+01	No	2.30E+00	American robin	No
Tetryl (Trinitrophenylmethylnitramine)	4.77E-08	2.82E-05	NA	1.56E+02	NA	1.60E+01	No	1.50E+00	Deer mouse	No

2,4,6-trinitrotoluene (TNT)	4.77E-08	2.82E-05	2.11E+02	3.60E+01	2.10E+01	3.60E+00	No	7.50E+00	American robin	No
Acrylonitrile	1.71E-09	1.01E-06	4.93E+00	3.99E+01	2.50E-01	1.30E+00	No	NA	NA	NA
Bis(2-ethylhexyl)adipate	1.71E-09	1.01E-06	NA	NA	4.50E+02	3.80E+03	No	NA	NA	NA
tris-2-chloroethyl phosphate	1.71E-09	1.01E-06	NA	NA	2.70E+01	4.40E+01	No	NA	NA	NA
Di-n-butyl phthalate (Dibutyl phthalate)	1.71E-09	1.01E-06	NA	6.16E+03	NA	6.30E+02	No	1.10E-02	American robin	No
2,4-Dinitrotoluene (2,4-DNT)	1.71E-09	1.01E-06	1.71E+01	1.23E+02	1.70E+00	1.30E+01	No	6.00E+00	Plant	No
Dioctyladipate	1.71E-09	1.01E-06	NA	NA	NA	NA	NA	NA	NA	NA
Dioctyl Phthalate, (Bis(2-ethylhexyl)phthalate), (di(2-ethylhexyl)phthalate), DEHP)	1.71E-09	1.01E-06	3.80E+02	1.23E+03	3.90E+01	1.30E+02	No	9.10E-01	Montane shrew	No
Diphenylamine	1.71E-09	1.01E-06	NA	NA	NA	6.30E+02	No	1.00E+01	Robin insectivore	No

Notes:
1. The calculation methodology is described in Section 5.

Table 5-6a. Acute Health Screening Level Results for TA-16-388

Basis

200 lb/hr waste burn
254.4 lb propane/hr
1 g/sec contaminant emission rate

Model Result (X/Q) - AERMOD **OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr AllRecs_2021_CO2**

132.55 1-hour maximum value, µg/m³ per g/sec contaminant
79.90 1-hour 8th high value for NO2 only, µg/m³ per g/sec contaminant (6)

Contaminant	CAS No.	Emission Factor (lb/lb of waste)	Emission Rate (g/sec)	Maximum 1-hour Concentration (2) (µg/m³)	Air Inhalation Emission Concentration (AIEC) – Acute (µg/m³)	CA-OEHHA Non-Cancer Reference Exposure Level (REL) – Acute (µg/m³)	Screening Level Exceeded(7)?
1,2,4-Trimethylbenzene	95-63-6	2.43E-04	6.12E-03	8.12E-01	NA	2.40E+03	No
sec-Butylbenzene	135-98-8	5.09E-04	1.28E-02	1.70E+00	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	5.57E-04	1.40E-02	1.86E+00	1.25E+05	2.40E+03	No
1,3-Butadiene	106-99-0	1.34E-06	3.38E-05	4.48E-03	NA	6.60E+02	No
1-Butene	106-98-9	4.69E-06	1.18E-04	1.57E-02	NA	NA	NA
1-Hexene	592-41-6	2.19E-06	5.52E-05	7.32E-03	NA	NA	NA
1-Pentene	109-67-1	1.72E-06	4.33E-05	5.75E-03	NA	NA	NA
2,2,4-Trimethylpentane	540-84-1	6.97E-06	1.76E-04	2.33E-02	NA	NA	NA
2,2-Dimethylbutane	75-83-2	4.29E-08	1.08E-06	1.43E-04	NA	NA	NA
2,3,4-Trimethylpentane	565-75-3	1.38E-06	3.48E-05	4.61E-03	NA	NA	NA
2,3-Dimethylbutane	79-29-8	2.06E-06	5.19E-05	6.88E-03	NA	NA	NA
2,3-Dimethylhexane	584-94-1	5.40E-06	1.36E-04	1.80E-02	NA	NA	NA
2,3-Dimethylpentane	565-59-3	3.33E-06	8.39E-05	1.11E-02	NA	NA	NA
2,4,4-Trimethyl-1-pentene	107-39-1	1.99E-07	5.01E-06	6.65E-04	NA	NA	NA
2,4-Dimethylhexane	589-43-5	6.42E-06	1.62E-04	2.14E-02	NA	NA	NA
2,4-Dimethylpentane	108-08-7	2.16E-06	5.44E-05	7.21E-03	NA	NA	NA
2,5-Dimethylhexane	592-13-2	1.11E-05	2.80E-04	3.71E-02	NA	NA	NA
2-Methyl-1-butene	563-46-2	1.05E-06	2.65E-05	3.51E-03	NA	NA	NA
2-Methyl-2-butene	513-35-9	9.07E-08	2.29E-06	3.03E-04	NA	NA	NA
2-Methylheptane	592-27-8	4.42E-05	1.11E-03	1.48E-01	NA	NA	NA
2-Methylhexane	591-76-4	1.38E-05	3.48E-04	4.61E-02	NA	NA	NA
2-Methylnaphthalene	91-57-6	2.18E-05	5.49E-04	7.28E-02	NA	NA	NA
2-Methylpentane	107-83-5	9.47E-06	2.39E-04	3.16E-02	NA	NA	NA
3-Ethylhexane, 3-Methylheptane	589-81-1	5.90E-05	1.49E-03	1.97E-01	NA	NA	NA
3-Methyl-1-butene	563-45-1	1.99E-07	5.01E-06	6.65E-04	NA	NA	NA
3-Methylhexane	589-34-4	1.55E-05	3.91E-04	5.18E-02	NA	NA	NA
3-Methylpentane	96-14-0	5.08E-06	1.28E-04	1.70E-02	NA	NA	NA
Acenaphthylene	208-96-8	6.71E-06	1.69E-04	2.24E-02	NA	NA	NA
Acetophenone	98-86-2	1.74E-07	4.38E-06	5.81E-04	3.00E+04	NA	No
Acetylene	74-86-2	9.52E-05	2.40E-03	3.18E-01	NA	NA	NA
Aluminum	7429-90-5	7.13E-07	1.80E-05	2.38E-03	NA	NA	NA
Anthracene	120-12-7	1.02E-07	2.57E-06	3.41E-04	6.00E+03	NA	No

Aromative (e.g. Styrene)		2.29E-03	5.77E-02	7.65E+00	NA	NA	NA
Barium	7440-39-3	4.20E-07	1.06E-05	1.40E-03	1.50E+03	NA	No
Benzene	71-43-2	7.84E-05	1.98E-03	2.62E-01	1.30E+03	2.70E+01	No
Benzo(a)anthracene	56-55-3	9.81E-07	2.47E-05	3.28E-03	3.00E+02	NA	No
Benzo(a)pyrene	50-32-8	7.42E-07	1.87E-05	2.48E-03	6.00E+02	NA	No
Benzo(b)fluoranthene	205-99-2	7.84E-07	1.98E-05	2.62E-03	6.00E+02	NA	No
Benzo(ghi)perylene	191-24-2	3.45E-07	8.69E-06	1.15E-03	NA	NA	NA
Benzo(k)fluoranthene	207-08-9	7.46E-07	1.88E-05	2.49E-03	6.00E+02	NA	No
Benzyl alcohol	100-51-6	3.96E-05	9.98E-04	1.32E-01	6.00E+04	NA	No
Biphenyl	92-52-4	6.45E-06	1.63E-04	2.15E-02	NA	NA	NA
Butyl benzyl phthalate	85-68-7	1.22E-07	3.07E-06	4.08E-04	1.50E+04	NA	No
Carbon Tetrachloride	56-23-5	6.89E-08	1.74E-06	2.30E-04	1.90E+03	1.90E+03	No
Chromium	7440-47-3	3.97E-07	1.00E-05	1.33E-03	1.50E+03	NA	No
Chrysene	218-01-9	9.33E-07	2.35E-05	3.12E-03	6.00E+02	NA	No
cis-2-Butene	590-18-1	1.99E-07	5.01E-06	6.65E-04	NA	NA	NA
cis-2-Pentene	627-20-3	9.07E-08	2.29E-06	3.03E-04	NA	NA	NA
Carbon Monoxide (2)	630-08-0	2.98E-02	7.51E-01	1.00E+02	NA	2.30E+04	No
Carbon Dioxide	124-38-9	1.63E+00	4.11E+01	5.44E+03	NA	NA	NA
Copper	7440-50-8	6.31E-06	1.59E-04	2.11E-02	NA	1.00E+02	No
Cyclohexane	110-82-7	2.67E-05	6.73E-04	8.92E-02	NA	NA	NA
Cyclopentane	287-92-3	1.53E-06	3.86E-05	5.11E-03	NA	NA	NA
Dibenz(a,h)anthracene / Dibenzo(a,h)anthracene	53-70-3	2.00E-07	5.04E-06	6.68E-04	3.00E+04	NA	No
Diethyl phthalate	84-66-2	7.00E-08	1.76E-06	2.34E-04	1.50E+04	NA	No
Dimethyl phthalate	113-11-3	1.88E-07	4.74E-06	6.28E-04	1.50E+04	NA	No
Di-n-butyl phthalate / Dibutyl Phthalate	84-74-2	3.30E-07	8.32E-06	1.10E-03	1.50E+04	NA	No
Di-n-octyl phthalate	117-84-0	9.19E-07	2.32E-05	3.07E-03	5.00E+04	NA	No
Ethane	74-84-0	1.15E-05	2.90E-04	3.84E-02	NA	NA	NA
Ethyl chloride / Chloroethane	75-00-3	6.89E-08	1.74E-06	2.30E-04	2.50E+06	NA	No
Ethylbenzene	100-41-4	5.49E-05	1.38E-03	1.83E-01	5.00E+05	NA	No
Ethylene	74-85-1	7.43E-05	1.87E-03	2.48E-01	NA	NA	NA
Fluoranthene	206-44-0	7.85E-07	1.98E-05	2.62E-03	1.50E+01	NA	No
HCL - Hydrochloric Acid	7647-01-0	9.97E-04	2.51E-02	3.33E+00	2.10E+03	2.10E+03	No
i-Butane	75-28-5	1.24E-06	3.12E-05	4.14E-03	NA	NA	NA
i-Butene	115-11-7	2.26E-06	5.70E-05	7.55E-03	NA	NA	NA
Indeno(1,2,3-cd)pyrene	193-39-5	2.83E-07	7.13E-06	9.45E-04	5.00E+02	NA	No
i-Pentane	78-78-4	1.08E-05	2.72E-04	3.61E-02	NA	NA	NA
i-Propylbenzene / Cumene	98-82-8	1.03E-04	2.60E-03	3.44E-01	2.46E+05	NA	No
m- & p-Xylene	108-38-3 & 106-42-3	4.52E-04	1.14E-02	1.51E+00	2.20E+04	2.20E+04	No
Methane	74-82-8	8.72E-05	2.20E-03	2.91E-01	NA	NA	NA
Methyl chloroform / Trichloroethane, 1,1,1-	71-55-6	3.44E-08	8.67E-07	1.15E-04	6.80E+04	6.80E+04	No
Methyl chloride	74-87-3	2.84E-07	7.16E-06	9.49E-04	2.00E+05	NA	No
Methylcyclohexane	108-87-2	1.56E-04	3.93E-03	5.21E-01	NA	NA	NA
Methylcyclopentane	96-37-7	9.93E-06	2.50E-04	3.32E-02	NA	NA	NA
Methylene chloride / dichloromethane	75-09-2	7.46E-07	1.88E-05	2.49E-03	1.40E+04	1.40E+04	No
m-Ethyltoluene	620-14-4	1.28E-04	3.23E-03	4.28E-01	NA	NA	NA

Naphthalene	91-20-3	8.38E-05	2.11E-03	2.80E-01	7.50E+04	NA	No
n-Butane	106-97-8	4.60E-06	1.16E-04	1.54E-02	NA	NA	NA
n-Decane	124-18-5	1.97E-03	4.96E-02	6.58E+00	NA	NA	NA
n-Heptane	142-82-5	5.90E-05	1.49E-03	1.97E-01	NA	NA	NA
n-Hexane	110-54-3	1.60E-05	4.03E-04	5.34E-02	NA	NA	NA
Nitrogen dioxide / Nitrogen peroxide	10102-44-0	4.69E-04	1.18E-02	9.44E-01	NA	4.70E+02	No
Nitrogen Oxide	10024-97-2	6.28E-03	1.58E-01	2.10E+01	NA	NA	NA
Nitrogen Oxides (2)		7.50E-02	1.89E+00	2.52E+02	NA	NA	NA
n-Nonane	111-84-2	1.03E-03	2.60E-02	3.44E+00	NA	NA	NA
n-Octane	111-65-9	2.48E-04	6.25E-03	8.28E-01	NA	NA	NA
Non-methane Organic Compound /NMHC (2)		7.84E-03	1.98E-01	2.63E+01	NA	NA	NA
n-Pentane	109-66-0	9.05E-06	2.28E-04	3.02E-02	NA	NA	NA
n-Propylbenzene	103-65-1	8.16E-05	2.06E-03	2.73E-01	NA	NA	NA
OCDD *Screening Limits are for TetraCDD, 2,3,7,8-	TCDD CAS no. 1746-01-6	1.03E-11	2.60E-10	3.44E-08	1.50E+00	NA	No
o-Ethyltoluene	611-14-3	3.90E-07	9.83E-06	1.30E-03	NA	NA	NA
o-Xylene	95-47-6	1.25E-04	3.15E-03	4.18E-01	2.20E+04	2.20E+04	No
Perylene	198-55-0	1.72E-07	4.33E-06	5.75E-04	NA	NA	NA
p-Ethyltoluene	622-96-8	1.53E-04	3.86E-03	5.11E-01	NA	NA	NA
Phenanthrene	85-01-8	7.17E-06	1.81E-04	2.39E-02	1.00E+03	NA	No
Phenol	108-95-2	1.56E-05	3.93E-04	5.21E-02	5.80E+03	5.80E+03	No
PM10 (2)(3)		9.10E-01	2.29E+01	3.04E+03	NA	NA	NA
Propane	74-98-6	2.22E-06	5.59E-05	7.42E-03	NA	NA	NA
Propene	115-07-1	1.30E-05	3.28E-04	4.34E-02	NA	NA	NA
Pyrene	129-00-0	7.06E-07	1.78E-05	2.36E-03	1.50E+04	NA	No
Styrene	100-42-5	4.99E-05	1.26E-03	1.67E-01	2.10E+04	2.10E+04	No
Sulfur Dioxide (2)	7446-09-5	1.22E-03	3.07E-02	4.79E+00	NA	6.60E+02	No
Toluene	108-88-3	1.22E-04	3.07E-03	4.08E-01	3.70E+04	5.00E+03	No
Total Alkanes (Paraffins)	NA	3.50E-03	8.82E-02	1.17E+01	NA	NA	NA
Total Alkenes (Olefins) (e.g. Ethylene)	NA	1.93E-04	4.86E-03	6.45E-01	NA	NA	NA
Total Non-methane Hydrocarbons - TNMHC (2)	NA	1.20E-02	3.02E-01	4.02E+01	NA	NA	NA
Total Unidentified Hydrocarbons	NA	6.04E-03	1.52E-01	2.02E+01	NA	NA	NA
trans-2-Butene	624-64-6	2.91E-06	7.33E-05	9.72E-03	NA	NA	NA
trans-2-Pentene	646-04-8	1.08E-06	2.72E-05	3.61E-03	NA	NA	NA
Vinyl Chloride	75-01-4	2.23E-07	5.62E-06	7.45E-04	1.80E+05	1.80E+05	No
Vinylidene Chloride / Dichloroethylene, 1,1-	75-35-4	2.15E-07	5.42E-06	7.18E-04	7.50E+04	NA	No
Volatile Organic Compounds		5.50E-04	1.39E-02	1.84E+00	NA	NA	NA
Zinc	7440-66-6	6.26E-05	1.58E-03	2.09E-01	3.00E+04	NA	No

Notes:

1. NA = Chemical not available in database.
2. Impacts from propane combustion have been added to waste impact concentrations for nitrogen oxides, carbon monoxide, PM10, sulfur dioxide and NMHC.
3. PM10 emissions factor and emissions are the same for PM2.5
4. Screening concentrations from acute (1 h) inhalation exposures concentrations (AIEC) from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2016). https://archive.epa.gov/epawaste/hazard/tsd/td/web/mdb/05hhrapchemdat.mdb
5. REL 1-hour acute screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values. https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
6. 8th highest concentration for NO2, same as the NAAQS/NMAAQS design value or 98th percentile concentration

Table 5-6b. Chronic Health Screening Level Results for TA-16-388

Basis

6,000 lb waste/yr

1 g/sec contaminant emission rate

Model Result (X/Q) **OBTA16-388-2023 12-11-2021 0900hr Annual AllReceptors_2021_CO2**

2.556 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	CAS No.	Emission Factor lb/lb waste	Emission Rate g/sec	Maximum Annual Concentration µg/m³	CA-OEHHA Non-Cancer Chronic Reference Exposure Level (REL)(5) (µg/m³)	EPA Resident Air Non-Carcinogenic (RSL)(6) for THI = 0.1 (µg/m³)	Screening Level Exceeded(6)?
1,2,4-Trimethylbenzene	95-63-6	2.43E-04	2.10E-05	5.36E-05	4.00E+00	6.30E+00	No
sec-Butylbenzene	135-98-8	5.09E-04	4.39E-05	1.12E-04	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	5.57E-04	4.81E-05	1.23E-04	4.00E+00	6.30E+00	No
1,3-Butadiene	106-99-0	1.34E-06	1.16E-07	2.96E-07	2.00E+00	2.10E-01	No
1-Butene	106-98-9	4.69E-06	4.05E-07	1.03E-06	NA	NA	NA
1-Hexene	592-41-6	2.19E-06	1.89E-07	4.83E-07	NA	NA	NA
1-Pentene	109-67-1	1.72E-06	1.48E-07	3.79E-07	NA	NA	NA
2,2,4-Trimethylpentane	540-84-1	6.97E-06	6.02E-07	1.54E-06	NA	NA	NA
2,2-Dimethylbutane	75-83-2	4.29E-08	3.70E-09	9.46E-09	NA	NA	NA
2,3,4-Trimethylpentane	565-75-3	1.38E-06	1.19E-07	3.04E-07	NA	NA	NA
2,3-Dimethylbutane	79-29-8	2.06E-06	1.78E-07	4.54E-07	NA	NA	NA
2,3-Dimethylhexane	584-94-1	5.40E-06	4.66E-07	1.19E-06	NA	NA	NA
2,3-Dimethylpentane	565-59-3	3.33E-06	2.87E-07	7.35E-07	NA	NA	NA
2,4,4-Trimethyl-1-pentene	107-39-1	1.99E-07	1.72E-08	4.39E-08	NA	NA	NA
2,4-Dimethylhexane	589-43-5	6.42E-06	5.54E-07	1.42E-06	NA	NA	NA
2,4-Dimethylpentane	108-08-7	2.16E-06	1.86E-07	4.77E-07	NA	NA	NA
2,5-Dimethylhexane	592-13-2	1.11E-05	9.58E-07	2.45E-06	NA	NA	NA
2-Methyl-1-butene	563-46-2	1.05E-06	9.06E-08	2.32E-07	NA	NA	NA
2-Methyl-2-butene	513-35-9	9.07E-08	7.83E-09	2.00E-08	NA	NA	NA
2-Methylheptane	592-27-8	4.42E-05	3.81E-06	9.75E-06	NA	NA	NA
2-Methylhexane	591-76-4	1.38E-05	1.19E-06	3.04E-06	NA	NA	NA
2-Methylnaphthalene	91-57-6	2.18E-05	1.88E-06	4.81E-06	NA	NA	NA
2-Methylpentane	107-83-5	9.47E-06	8.17E-07	2.09E-06	NA	NA	NA
3-Ethylhexane, 3-Methylheptane	589-81-1	5.90E-05	5.09E-06	1.30E-05	NA	NA	NA
3-Methyl-1-butene	563-45-1	1.99E-07	1.72E-08	4.39E-08	NA	NA	NA
3-Methylhexane	589-34-4	1.55E-05	1.34E-06	3.42E-06	NA	NA	NA
3-Methylpentane	96-14-0	5.08E-06	4.38E-07	1.12E-06	NA	NA	NA
Acenaphthylene	208-96-8	6.71E-06	5.79E-07	1.48E-06	NA	NA	NA
Acetophenone	98-86-2	1.74E-07	1.50E-08	3.84E-08	NA	NA	NA
Acetylene	74-86-2	9.52E-05	8.22E-06	2.10E-05	NA	NA	NA
Aluminum	7429-90-5	7.13E-07	6.15E-08	1.57E-07	NA	5.20E-01	No
Anthracene	120-12-7	1.02E-07	8.80E-09	2.25E-08	NA	NA	NA
Aromative (e.g. Styrene)		2.29E-03	1.98E-04	5.05E-04	NA	NA	NA
Barium	7440-39-3	4.20E-07	3.62E-08	9.27E-08	NA	5.20E-02	No

Benzene	71-43-2	7.84E-05	6.77E-06	1.73E-05	3.00E+00	3.10E+00	No
Benzo(a)anthracene	56-55-3	9.81E-07	8.47E-08	2.16E-07	NA	NA	NA
Benzo(a)pyrene	50-32-8	7.42E-07	6.40E-08	1.64E-07	NA	2.10E-04	No
Benzo(b)fluoranthene	205-99-2	7.84E-07	6.77E-08	1.73E-07	NA	NA	NA
Benzo(ghi)perylene	191-24-2	3.45E-07	2.98E-08	7.61E-08	NA	NA	NA
Benzo(k)fluoranthene	207-08-9	7.46E-07	6.44E-08	1.65E-07	NA	NA	NA
Benzyl alcohol	100-51-6	3.96E-05	3.42E-06	8.74E-06	NA	NA	NA
Biphenyl, 1,1'-	92-52-4	6.45E-06	5.57E-07	1.42E-06	NA	4.20E-02	No
Butyl benzyl phthalate	85-68-7	1.22E-07	1.05E-08	2.69E-08	NA	NA	NA
Carbon Tetrachloride	56-23-5	6.89E-08	5.95E-09	1.52E-08	4.00E+01	1.00E+01	No
Chromium	7440-47-3	3.97E-07	3.43E-08	8.76E-08	NA	NA	NA
Chrysene	218-01-9	9.33E-07	8.05E-08	2.06E-07	NA	NA	NA
cis-2-Butene	590-18-1	1.99E-07	1.72E-08	4.39E-08	NA	NA	NA
cis-2-Pentene	627-20-3	9.07E-08	7.83E-09	2.00E-08	NA	NA	NA
CO (2)	630-08-0	2.98E-02	2.57E-03	6.58E-03	NA	NA	NA
CO2	124-38-9	1.63E+00	1.41E-01	3.60E-01	NA	NA	NA
Copper	7440-50-8	6.31E-06	5.45E-07	1.39E-06	NA	NA	NA
Cyclohexane	110-82-7	2.67E-05	2.30E-06	5.89E-06	NA	6.30E+02	No
Cyclopentane	287-92-3	1.53E-06	1.32E-07	3.38E-07	NA	NA	NA
Dibenz(a,h)anthracene	53-70-3	2.00E-07	1.73E-08	4.41E-08	NA	NA	NA
Diethyl phthalate	84-66-2	7.00E-08	6.04E-09	1.54E-08	NA	NA	NA
Dimethyl phthalate	113-11-3	1.88E-07	1.62E-08	4.15E-08	NA	NA	NA
Di-n-butyl phthalate / Dibutyl Phthalate	84-74-2	3.30E-07	2.85E-08	7.28E-08	NA	NA	NA
Di-n-octyl phthalate	117-84-0	9.19E-07	7.93E-08	2.03E-07	NA	NA	NA
Ethane	74-84-0	1.15E-05	9.92E-07	2.54E-06	NA	NA	NA
Ethyl chloride	75-00-3	6.89E-08	5.95E-09	1.52E-08	3.00E+04	4.20E+02	No
Ethylbenzene	100-41-4	5.49E-05	4.74E-06	1.21E-05	2.00E+03	1.00E+02	No
Ethylene	74-85-1	7.43E-05	6.41E-06	1.64E-05	NA	NA	NA
Fluoranthene	206-44-0	7.85E-07	6.77E-08	1.73E-07	NA	NA	NA
HCL / Hydrogen Chloride	7647-01-0	9.97E-04	8.60E-05	2.20E-04	9.00E+00	2.10E+00	No
i-Butane	75-28-5	1.24E-06	1.07E-07	2.74E-07	NA	NA	NA
i-Butene	115-11-7	2.26E-06	1.95E-07	4.99E-07	NA	NA	NA
Indeno(1,2,3-cd)pyrene	193-39-5	2.83E-07	2.44E-08	6.24E-08	NA	NA	NA
i-Pentane	78-78-4	1.08E-05	9.32E-07	2.38E-06	NA	NA	NA
i-Propylbenzene / Cumene	98-82-8	1.03E-04	8.89E-06	2.27E-05	NA	4.20E+01	No
m- & p-Xylene	108-38-3 & 106-42-3	4.52E-04	3.90E-05	9.97E-05	7.00E+02	1.00E+01	No
Methane	74-82-8	8.72E-05	7.53E-06	1.92E-05	NA	NA	NA
Methyl chloroform / Trichloroethane, 1,1,1-	71-55-6	3.44E-08	2.97E-09	7.59E-09	1.00E+03	5.20E+02	No
Methylchloride / Chloromethane	74-87-3	2.84E-07	2.45E-08	6.27E-08	NA	9.40E+00	No
Methylcyclohexane	108-87-2	1.56E-04	1.35E-05	3.44E-05	NA	9.90E+00	No
Methylcyclopentane	96-37-7	9.93E-06	8.57E-07	2.19E-06	NA	NA	NA
Methylene chloride	75-09-2	7.46E-07	6.44E-08	1.65E-07	4.00E+02	6.30E+01	No

m-Ethyltoluene	620-14-4	1.28E-04	1.10E-05	2.82E-05	NA	NA	NA
Naphthalene	91-20-3	8.38E-05	7.23E-06	1.85E-05	9.00E+00	3.10E-01	No
n-Butane	106-97-8	4.60E-06	3.97E-07	1.01E-06	NA	NA	NA
n-Decane	124-18-5	1.97E-03	1.70E-04	4.35E-04	NA	NA	NA
n-Heptane	142-82-5	5.90E-05	5.09E-06	1.30E-05	NA	4.20E+01	No
n-Hexane	110-54-3	1.60E-05	1.38E-06	3.53E-06	7.00E+03	7.30E+01	No
Nitrogen dioxide (peroxide)	10102-44-0	4.69E-04	4.05E-05	1.03E-04	NA	NA	NA
Nitrogen Oxide	10024-97-2	6.28E-03	5.42E-04	1.39E-03	NA	NA	NA
Nitrogen Oxides (2)		7.50E-02	6.47E-03	1.65E-02	NA	NA	NA
n-Nonane	111-84-2	1.03E-03	8.89E-05	2.27E-04	NA	2.10E+00	No
n-Octane	111-65-9	2.48E-04	2.14E-05	5.47E-05	NA	NA	NA
Non-methane Organic Compound/NMHC (2)		7.84E-03	6.77E-04	1.73E-03	NA	NA	NA
n-Pentane	109-66-0	9.05E-06	7.81E-07	2.00E-06	NA	1.00E+02	No
n-Propylbenzene	103-65-1	8.16E-05	7.04E-06	1.80E-05	NA	1.00E+02	No
OCDD *Screening Limits are for TCDD,2,3,7,8-	TCDD CAS no. 1746-01-6	1.03E-11	8.89E-13	2.27E-12	4.00E-05	4.20E-06	No
o-Ethyltoluene	611-14-3	3.90E-07	3.37E-08	8.60E-08	NA	NA	NA
o-Xylene	95-47-6	1.25E-04	1.08E-05	2.76E-05	7.00E+02	1.00E+01	No
Perylene	198-55-0	1.72E-07	1.48E-08	3.79E-08	NA	2.10E-04	No
p-Ethyltoluene	622-96-8	1.53E-04	1.32E-05	3.38E-05	NA	NA	NA
Phenanthrene	85-01-8	7.17E-06	6.19E-07	1.58E-06	NA	NA	NA
Phenol	108-95-2	1.56E-05	1.35E-06	3.44E-06	2.00E+02	2.10E+01	No
PM10 (2)(3)		9.10E-01	7.85E-02	2.01E-01	NA	NA	NA
Propane	74-98-6	2.22E-06	1.92E-07	4.90E-07	NA	NA	NA
Propene / Propylene	115-07-1	1.30E-05	1.12E-06	2.87E-06	3.00E+03	3.10E+02	No
Pyrene	129-00-0	7.06E-07	6.09E-08	1.56E-07	NA	NA	NA
Styrene	100-42-5	4.99E-05	4.31E-06	1.10E-05	9.00E+02	1.00E+02	No
Sulfur Dioxide (2)	7446-09-5	1.22E-03	1.05E-04	2.71E-04	NA	NA	NA
Toluene	108-88-3	1.22E-04	1.05E-05	2.69E-05	4.20E+02	5.20E+02	No
Total Alkanes (Paraffins)	NA	3.50E-03	3.02E-04	7.72E-04	NA	NA	NA
Total Alkenes (Olefins) (e.g., Ethylene)	NA	1.93E-04	1.67E-05	4.26E-05	NA	NA	NA
Total Non-methane Hydrocarbons / TNMHC(2)	NA	1.20E-02	1.04E-03	2.65E-03	NA	NA	NA
Total Unidentified Hydrocarbons	NA	6.04E-03	5.21E-04	1.33E-03	NA	NA	NA
trans-2-Butene	624-64-6	2.91E-06	2.51E-07	6.42E-07	NA	NA	NA
trans-2-Pentene	646-04-8	1.08E-06	9.32E-08	2.38E-07	NA	NA	NA
Vinyl Chloride	75-01-4	2.23E-07	1.92E-08	4.92E-08	NA	1.00E+01	No
Vinylidene Chloride / Dichloroethylene (1,1)	75-35-4	2.15E-07	1.86E-08	4.74E-08	7.00E+01	2.10E+01	No
Volatile Organic Compounds	NA	5.50E-04	4.75E-05	1.21E-04	NA	NA	NA
Zinc	7440-66-6	6.26E-05	5.40E-06	1.38E-05	NA	NA	NA

Notes:

1. NA = Chemical not available in database.
2. Impacts from propane combustion have been added to waste impact concentrations for nitrogen oxides, carbon monoxide, PM10, sulfur dioxide and NMHC.
3. PM10 emissions factor and emissions are the same for PM2.5.
4. Chronic REL annual screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values. https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
5. U.S. EPA air non-carcinogenic screening levels are from the Regional Screening Levels (RSLs) – Generic Tables. November 2023. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

Table 5-6c. Residential Soil Screening Level and LANL ESL Screening Level Results for TA-16-388

Basis

6,000 lb waste/yr

1 g/sec contaminant emission rate

Model Result (X/Q)

2.556 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	CAS Nos.	Maximum Annual Concentration µg/m³	10 Year Soil Concentration mg/kg	NMED Cancer - Residential Soil TR=1E-05 (mg/kg)	NMED Non-Cancer Residential Soil Screening Level (mg/kg)	Carcinogenic Target Risk - EPA SL - Resident Soil based on TR = 1E-06 (mg/kg)	Noncancer Child HI EPA RSLs - Resident Soil based on THI = 0.1 (mg/kg)	NMED or EPA Screening Levels Exceeded?	Minimum LANL ESL mg/kg	Receptor	LANL ESL Screening Levels Exceeded ?
1,2,4-Trimethylbenzene	95-63-6	5.36E-05	3.17E-02	NA	NA	NA	3.00E+01	No	NA	NA	NA
sec-Butylbenzene	135-98-8	1.12E-04	6.64E-02	NA	NA	NA	7.80E+02	No	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	1.23E-04	7.27E-02	NA	NA	NA	2.70E+01	No	NA	NA	NA
1,3-Butadiene	106-99-0	2.96E-07	1.75E-04	9.48E-01	2.30E+00	7.60E-02	1.80E-01	No	NA	NA	NA
1-Butene	106-98-9	1.03E-06	6.12E-04	NA	NA	NA	NA	NA	NA	NA	NA
1-Hexene	592-41-6	4.83E-07	2.86E-04	NA	NA	NA	NA	NA	NA	NA	NA
1-Pentene	109-67-1	3.79E-07	2.24E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,2,4-Trimethylpentane	540-84-1	1.54E-06	9.09E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dimethylbutane	75-83-2	9.46E-09	5.60E-06	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4-Trimethylpentane	565-75-3	3.04E-07	1.80E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,3-Dimethylbutane	79-29-8	4.54E-07	2.69E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,3-Dimethylhexane	584-94-1	1.19E-06	7.05E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,3-Dimethylpentane	565-59-3	7.35E-07	4.35E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,4,4-Trimethyl-1-pentene	107-39-1	4.39E-08	2.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylhexane	589-43-5	1.42E-06	8.38E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylpentane	108-08-7	4.77E-07	2.82E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,5-Dimethylhexane	592-13-2	2.45E-06	1.45E-03	NA	NA	NA	NA	NA	NA	NA	NA
2-Methyl-1-butene	563-46-2	2.32E-07	1.37E-04	NA	NA	NA	NA	NA	NA	NA	NA
2-Methyl-2-butene	513-35-9	2.00E-08	1.18E-05	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylheptane	592-27-8	9.75E-06	5.77E-03	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylhexane	591-76-4	3.04E-06	1.80E-03	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	91-57-6	4.81E-06	2.84E-03	NA	2.32E+02	NA	2.40E+01	No	1.60E+01	Montane Shrew	No
2-Methylpentane	107-83-5	2.09E-06	1.24E-03	NA	NA	NA	NA	NA	NA	NA	NA
3-Ethylhexane, 3-Methylheptane	589-81-1	1.30E-05	7.70E-03	NA	NA	NA	NA	NA	NA	NA	NA
3-Methyl-1-butene	563-45-1	4.39E-08	2.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylhexane	589-34-4	3.42E-06	2.02E-03	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylpentane	96-14-0	1.12E-06	6.63E-04	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	208-96-8	1.48E-06	8.76E-04	NA	NA	NA	NA	NA	1.20E+02	Montane Shrew	No
Acetophenone	98-86-2	3.84E-08	2.27E-05	NA	7.82E+03	NA	7.80E+02	No	NA	NA	NA

Acetylene	74-86-2	2.10E-05	1.24E-02	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	7429-90-5	1.57E-07	9.30E-05	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Anthracene	120-12-7	2.25E-08	1.33E-05	NA	1.74E+04	NA	1.80E+03	No	6.80E+00	Generic Plant	No
Aromative (e.g. Styrene)		5.05E-04	2.99E-01	NA	NA	NA	NA	NA	NA	NA	NA
Barium	7440-39-3	9.27E-08	5.48E-05	NA	1.56E+04	NA	1.50E+03	No	1.10E+02	Generic Plant	No
Benzene	71-43-2	1.73E-05	1.02E-02	1.78E+01	1.14E+02	1.20E+00	8.20E+00	No	2.40E+01	Deer Mouse	No
Benzo(a)anthracene	56-55-3	2.16E-07	1.28E-04	1.53E+00	NA	1.10E+00	NA	No	7.30E-01	American Robin	No
Benzo(a)pyrene	50-32-8	1.64E-07	9.68E-05	1.12E+00	1.74E+01	1.10E-01	1.80E+00	No	6.20E+01	Montane Shrew	No
Benzo(b)fluoranthene	205-99-2	1.73E-07	1.02E-04	1.53E+00	NA	1.10E+00	NA	No	1.80E+01	Generic Plant	No
Benzo(ghi)perylene	191-24-2	7.61E-08	4.50E-05	NA	NA	NA	NA	NA	2.50E+01	Montane Shrew	No
Benzo(k)fluoranthene	207-08-9	1.65E-07	9.73E-05	1.53E+01	NA	1.10E+01	NA	No	7.10E+01	Montane Shrew	No
Benzyl alcohol	100-51-6	8.74E-06	5.17E-03	NA	NA	NA	6.30E+02	No	1.20E+02	Deer Mouse	No
Biphenyl, 1,1'-	92-52-4	1.42E-06	8.42E-04	8.48E+02	3.91E+04	8.70E+01	4.70E+00	No	NA	NA	NA
Butylbenzyl phthalate	85-68-7	2.69E-08	1.59E-05	NA	NA	2.90E+02	1.30E+03	No	9.00E+01	Montane Shrew	No
Carbon Tetrachloride	56-23-5	1.52E-08	8.99E-06	1.07E+01	1.44E+02	6.50E-01	1.00E+01	No	NA	NA	NA
Chromium (total)	7440-47-3	8.76E-08	5.18E-05	9.66E+01	4.52E+04	NA	NA	No	2.30E+01	American Robin	No
Chrysene	218-01-9	2.06E-07	1.22E-04	1.53E+02	NA	1.10E+02	NA	No	3.10E+00	Montane Shrew	No
cis-2-Butene	590-18-1	4.39E-08	2.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
cis-2-Pentene	627-20-3	2.00E-08	1.18E-05	NA	NA	NA	NA	NA	NA	NA	NA
CO	630-08-0	6.58E-03	3.89E+00	NA	NA	NA	NA	NA	NA	NA	NA
CO2	124-38-9	3.60E-01	2.13E+02	NA	NA	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	1.39E-06	8.23E-04	NA	3.13E+03	NA	3.10E+02	No	1.40E+01	American Robin	NA
Cyclohexane	110-82-7	5.89E-06	3.48E-03	NA	3.91E+02	NA	6.50E+02	No	NA	NA	NA
Cyclopentane	287-92-3	3.38E-07	2.00E-04	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	53-70-3	4.41E-08	2.61E-05	1.53E-01	NA	1.10E-01	NA	No	1.40E+01	Montane Shrew	No
Diethyl phthalate	84-66-2	1.54E-08	9.13E-06	NA	4.93E+04	NA	5.10E+03	No	1.00E+02	Generic Plant	No
Dimethyl phthalate	113-11-3	4.15E-08	2.45E-05	NA	NA	NA	NA	NA	1.00E+01	Earthworm	No
Di-n-butyl phthalate / Dibutyl Phthalate	84-74-2	7.28E-08	4.31E-05	NA	6.16E+03	NA	6.30E+02	No	1.10E-02	American Robin	No
Di-n-octyl phthalate	117-84-0	2.03E-07	1.20E-04	NA	NA	NA	6.30E+01	No	9.10E-01	Montane Shrew	No

Ethane	74-84-0	2.54E-06	1.50E-03	NA	NA	NA	NA	NA	NA	NA	NA
Ethyl chloride / Chloroethane	75-00-3	1.52E-08	8.99E-06	NA	1.90E+04	NA	5.40E+02	No	NA	NA	NA
Ethylbenzene	100-41-4	1.21E-05	7.16E-03	7.51E+01	3.93E+03	5.80E+00	2.40E+02	No	NA	NA	NA
Ethylene	74-85-1	1.64E-05	9.70E-03	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	206-44-0	1.73E-07	1.02E-04	NA	2.32E+03	NA	2.40E+02	No	1.00E+01	Earthworm	No
HCL / Hydrogen Chloride	7647-01-0	2.20E-04	1.30E-01	NA	NA	NA	2.80E+06	No	NA	NA	NA
i-Butane	75-28-5	2.74E-07	1.62E-04	NA	NA	NA	NA	NA	NA	NA	NA
i-Butene	115-11-7	4.99E-07	2.95E-04	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	193-39-5	6.24E-08	3.69E-05	1.53E+00	NA	1.10E+00	NA	No	7.10E+01	Montane Shrew	No
i-Pentane	78-78-4	2.38E-06	1.41E-03	NA	NA	NA	NA	NA	NA	NA	NA
i-Propylbenzene / Cumene	98-82-8	2.27E-05	1.34E-02	NA	2.36E+03	NA	1.90E+02	No	NA	NA	NA
m- & p-Xylene	108-38-3 & 106-42-3	9.97E-05	5.90E-02	NA	7.64E+02	NA	5.50E+01	No	1.40E+00	Montane Shrew	No
Methane	74-82-8	1.92E-05	1.14E-02	NA	NA	NA	NA	NA	NA	NA	NA
Methyl chloroform/1,1,1-Trichloroethane (TCA)	71-55-6	7.59E-09	4.49E-06	NA	1.44E+04	NA	8.10E+02	No	2.60E+02	Montane Shrew	No
Methyl chloride/Chloromethane	74-87-3	6.27E-08	3.71E-05	4.11E+01	2.68E+02	NA	1.10E+01	No	NA	NA	NA
Methyl cyclohexane	108-87-2	3.44E-05	2.04E-02	NA	5.50E+03	NA	9.80E+00	No	NA	NA	NA
Methyl cyclopentane	96-37-7	2.19E-06	1.30E-03	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride/Dicloromethane	75-09-2	1.65E-07	9.73E-05	7.66E+02	4.09E+02	5.70E+01	3.50E+01	No	2.60E+00	Deer Mouse	No
m-Ethyltoluene	620-14-4	2.82E-05	1.67E-02	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	91-20-3	1.85E-05	1.09E-02	2.26E+01	1.62E+02	2.00E+00	1.30E+01	No	1.00E+00	Generic Plant	No
n-Butane	106-97-8	1.01E-06	6.00E-04	NA	NA	NA	NA	NA	NA	NA	NA
n-Decane	124-18-5	4.35E-04	2.57E-01	NA	NA	NA	NA	NA	NA	NA	NA
n-Heptane	142-82-5	1.30E-05	7.70E-03	NA	NA	NA	2.20E+00	No	NA	NA	NA
n-Hexane	110-54-3	3.53E-06	2.09E-03	NA	6.15E+02	NA	6.10E+01	No	NA	NA	NA
Nitrogen dioxide (peroxide)	10102-44-0	1.03E-04	6.12E-02	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxide	10024-97-2	1.39E-03	8.19E-01	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxides		1.65E-02	9.79E+00	NA	NA	NA	NA	NA	NA	NA	NA
n-Nonane	111-84-2	2.27E-04	1.34E-01	NA	NA	NA	1.10E+00	No	NA	NA	NA
n-Octane	111-65-9	5.47E-05	3.24E-02	NA	NA	NA	NA	NA	NA	NA	NA
Non-methane Organic Compound		1.73E-03	1.02E+00	NA	NA	NA	NA	NA	NA	NA	NA
n-Pentane	109-66-0	2.00E-06	1.18E-03	NA	NA	NA	8.10E+01	No	NA	NA	NA
n-Propylbenzene	103-65-1	1.80E-05	1.06E-02	NA	NA	NA	3.80E+02	No	NA	NA	NA
OCDD *Screening Limits are for TCDD, 2,3,7,8	TCDD CAS no. 1746-01-6	2.27E-12	1.34E-09	4.90E-05	5.06E-05	4.80E-06	5.10E-06	No	2.90E-07	Montane Shrew	No
o-Ethyltoluene	611-14-3	8.60E-08	5.09E-05	NA	NA	NA	NA	NA	NA	NA	NA

o-Xylene	95-47-6	2.76E-05	1.63E-02	NA	8.05E+02	NA	6.40E+01	No	1.40E+00	Montane Shrew	No
Perylene	198-55-0	3.79E-08	2.24E-05	NA	NA	NA	5.40E-01	No	NA	NA	NA
p-Ethyltoluene	622-96-8	3.38E-05	2.00E-02	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	85-01-8	1.58E-06	9.36E-04	NA	1.85E+03	NA	NA	No	5.50E+00	Earthworm	No
Phenol	108-95-2	3.44E-06	2.04E-03	NA	1.85E+04	NA	1.90E+03	No	7.90E-01	Generic Plant	No
PM10		2.01E-01	1.19E+02	NA	NA	NA	NA	NA	NA	NA	NA
Propane	74-98-6	4.90E-07	2.90E-04	NA	NA	NA	NA	NA	NA	NA	NA
Propene / Propylene	115-07-1	2.87E-06	1.70E-03	NA	NA	NA	2.20E+02	No	NA	NA	NA
Pyrene	129-00-0	1.56E-07	9.21E-05	NA	1.74E+03	NA	1.80E+02	No	1.00E+01	Earthworm	No
Styrene / Ethenylbenzene	100-42-5	1.10E-05	6.51E-03	NA	7.26E+03	NA	6.00E+02	No	1.20E+00	Earthworm	No
Sulfur Dioxide	7446-09-5	2.71E-04	1.60E-01	NA	NA	NA	NA	NA	NA	NA	NA
Toluene / Methylbenzene	108-88-3	2.69E-05	1.59E-02	NA	5.23E+03	NA	4.90E+02	No	2.30E+01	Montane Shrew	No
Total Alkanes (Paraffins)	NA	7.72E-04	4.57E-01	NA	NA	NA	NA	NA	NA	NA	NA
Total Alkenes (Olefins) (e.g. Ethylene)	NA	4.26E-05	2.52E-02	NA	NA	NA	NA	NA	NA	NA	NA
Total Non-methane Hydrocarbons / NMHC	NA	2.65E-03	1.57E+00	NA	NA	NA	NA	NA	NA	NA	NA
Total Unidentified Hydrocarbons	NA	1.33E-03	7.88E-01	NA	NA	NA	NA	NA	NA	NA	NA
trans-2-Butene	624-64-6	6.42E-07	3.80E-04	NA	NA	NA	NA	NA	NA	NA	NA
trans-2-Pentene	646-04-8	2.38E-07	1.41E-04	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl Chloride/Chlorothene	75-01-4	4.92E-08	2.91E-05	7.42E-01	1.13E+02	5.90E-02	7.00E+00	No	1.20E-01	Montane Shrew	No
Vinylidene Chloride / Dichloroethylene, 1,1-	75-35-4	4.74E-08	2.81E-05	NA	4.40E+02	NA	2.30E+01	No	1.10E+01	Montane Shrew	No
Volatile Organic Compounds	NA	1.21E-04	7.18E-02	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	1.38E-05	8.17E-03	NA	2.35E+04	NA	2.30E+03	No	4.70E+01	American Robin	No

Notes:
1. The calculation methodology is described in Section 5.

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7 Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
AERMOD	AMS/EPA Regulatory Model
AP	ammonium perchlorate
AQB	Air Quality Bureau
ARM2	Ambient Ratio Method Tier 2 option (EPA)
C	carbon
°C	degrees Celsius
DMSO	dimethyl sulfoxide
DoD	(U.S.) Department of Defense
DOE	(U.S.) Department of Energy
DPG	Dugway Proving Grounds, Utah
EPA	(U.S.) Environmental Protection Agency
ft	foot
°F	degrees Fahrenheit
g	gram
h	hour
GLC	ground level concentration
HMX	cyclotetramethylenetetranitramine
JMC	Joint Munitions Command
LANL	Los Alamos National Laboratory
lb	pounds
N	nitrogen
NAAQS	national ambient air quality standards
NAD 83	North American Datum of 1983
NEW	net explosive weight
NMAAQS	New Mexico ambient air quality standards
NMED	New Mexico Environment Department
OB	open burn
OBOD	open burn/open detonation
OBODM	Open Burn/Open Detonation Dispersion Model
OD	open detonation
POC	pollutant of concern
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
RDX	cyclonite
ROI	radius of impact
S	sulfur
SNL	Sandia National Laboratories
SR	state road
SVOC	semi-volatile organic compound

Acronym/ Abbreviation	Definition
TA	technical area
TAP	toxic air pollutant
TNMHCs	non-methane hydrocarbons
TNT	trinitrotoluene
U.S.	United States
UTM	Universal Transverse Mercator
VOC	volatile organic compound

Attachment 1 E-mail dated August 17, 2022

From: Gerhard, Sasha <Gerhard.Sasha@epa.gov>
Sent: Wednesday, August 17, 2022 7:03 PM
To: Littleton, Brian <Littleton.Brian@epa.gov>
Subject: FW: air modeling for open burning / open detonation

Hi Brian,

I searched back through my emails to find where R4 had provided their approach to modeling emissions from Holston Army Ammunition Plant's OB units. Hope this helps and again, if you have questions, I can provide the R4 contacts.

"OBODM is an older method but it does dispersions well if applying to open burn pans. However, this method is dated and has not been maintained to operate on current computer systems. AERMOD has replaced OBODM as the standard model to use for Open Burn and Open Detonation hazardous waste management units (HWMUs). EPA R4 recommends the following air modeling approach for OB and OD."

GENERAL MODELING APPROACH

EPA currently recommends a hybrid approach to modeling dispersion from open burning and open detonation processes. Using two separate regulatory models, the OBODM and the AERMOD Modeling System, in the analysis which allows facilities to draw on the strengths of both models while reducing the impacts of their weaknesses on the modeling results. For example, OBODM more closely models the source characteristics of an open burning operation compared to the elevated volume source algorithm in AERMOD, while AERMOD features more refined algorithms for handling meteorological data and predicting air concentrations and deposition fluxes. AERMOD also includes options that support the implementation of the 2005 HHRAP when modeling units such as the Burn Pan Unit at HSAAP.

Open burning results in combustion of the energetics and the rapid rise of the hot combustion products, due to buoyancy, until a final height is reached. At this point, the emission cloud has no upward momentum and begins to disperse downwind. This process can be estimated using OBODM to predict the final cloud height of the open burn plume. This height is then specified as the release height in the elevated volume source algorithm in AERMOD.
Note, the below information is provided as general guidance in the development of an air modeling methodology for the Burn Pan Unit at HSAAP. HSAAP should consult the 2005 HHRAP, Volume 1 and Volume 2 of the OBODM Users Guide, and the AERMOD Users Guide (along with other EPA air modeling related documents, to develop an effective air modeling protocol for the Burn Pan Unit. The final methodology should be documented and submitted in an air modeling protocol for review and approval by EPA before any air dispersion and deposition modeling is conducted.

OBODM Modeling

OBODM should be performed in the vapor phase (for CO_2) to determine the final plume height(s) to be used in the dispersion and deposition modeling analysis.
The OBODM modeling analysis should address all air modeling scenarios and waste stream types/combinations that represent typical open burns at HSAAP. In order to obtain the plume

height(s) for use in the AERMOD modeling, HSAAP should model every hour of meteorological data during which open burning can occur.
During rapid rise of the vapor cloud from the Burn Pan Unit, atmospheric air is entrained and the size of the cloud increases. If observational data on the initial size of the OB cloud at final plume height are not available for the Burn Pan Unit, equation 2-71 from Section 2.6.3 of Volume 2 of the OBODM Users Guide can be used.

Equation 2-71:

$r(x)= [\gamma_c][\Delta h_c(x)] + r_R$

where:

r(x) = radius of the cloud at final plume
height x = the distance at which final
plume height is achieved
γ_c = 0.6 (OBODM default value)
$\Delta h_c(x)$ = final plume height
r_R = radius of a circle with same area as burn pans

Assuming that the vapor cloud is a sphere, the sigmas for the AERMOD volume source can be calculated from the results obtained from equation 2-71. Thus, the initial vertical and horizontal sigmas for an elevated volume source, such as the vapor cloud, can be calculated by dividing the calculated cloud diameter by 4.3.

Meteorological Data

Sources of meteorological data should be evaluated based on distance, elevation, and surface roughness to determine the most representative meteorological data for use in the air modeling analysis. Tennessee may also have AERMOD-ready meteorological data available for HSAAP. Note that the model-ready meteorological data files for OBODM and AERMOD must be based on the same raw meteorological data set but have different formatting requirements, dictating the use of the appropriate meteorological data preprocessor (e.g., AERMET, PCRAMMET) in file preparation. Surface characteristics, including surface roughness values should be calculated using AERSURFACE, the surface characteristics preprocessor included in the AERMOD modeling system.

Five years of meteorological data should be used unless the data are collected at HSAAP, in which case only one year of meteorological data is required.

Operating Conditions

The Burn Pan Unit at HSAAP does not operate continuously. Section 2.2.4.1, Selection of Air COPCs, of Attachment 11-1 states that open burning operations area assumed to occur 5 days per week, 50 weeks per year, with each open burning event lasting one hour. According to Section E-2-4(c)(4), Burn Pan Unit Source Parameters, of Appendix III, open burning events were modeled daily, 5 days per week (Monday through Friday), between 12:00 pm and 4:00 pm with the first event beginning at 12 and the last event commencing at 3:00 pm. Each open burning event is limited to 5,000 lb of NEW. Thus, HSAAP modeled the open burning of 20,000 lb of NEW per day. However, HSAAP can treat no more than 5,000 lb of NEW per day. This resulted in HSAAP modeling 4 times the allowable NEW in the analysis of annual impacts from open burning. AERMOD includes options that allow for input of actual or simulations of actual operating schedules so that annual impacts predicted by the model do not require additional manipulation. More details are available from Section 3.3.12 Specifying an hourly emission rate file

(HOUREMIS), of the User's Guide for the AMS/EPA Regulatory Model (AERMOD), EPA-454/B-19-027, dated August 2019 (AERMOD Users Guide).

Unit Emission Rate

A unitized emission rate of 1.0 gram/second should be used in each model run to preclude modeling each potentially emitted constituent separately. Unitized emissions rates will be adjusted to COPC specific air parameters (air concentrations and deposition rates) using COPC specific emissions rates in the risk model. Concentration and deposition are directly proportional to air modeling results based on the unit emission rate employed in the AERMOD modeling analysis.

Receptor Grid and Terrain

The receptor grids and discrete receptor locations used in the Brown and Root Air Pathway Assessment should be reevaluated in concert with the recommendations for receptor locations in Section 3.6.3, Receptor Pathway, of the 2005 HHRAP and the AERMOD Modeling System. Based on that analysis, the modeled receptor locations can be specified for inclusion in the AERMOD modeling runs. Specification of model-ready receptor lists will likely involve application of AERMAP, a terrain data preprocessor that is part of the AERMOD Modeling System.

There are terrain features in the vicinity of the Burn Pan Unit; therefore, terrain options available in AERMOD should be used in the dispersion and deposition modeling. Again, AERMAP should be used to convert digital terrain data into model-ready files.

Particle Size Distribution

To estimate particle and particle-bound phase deposition rates, AERMOD needs an initial particle size distribution, broken out by particle diameter. HSAAP should provide the site-specific particle size data or surrogate data to be used with AERMOD. Constituents released from open burning as particulates are modeled using mass fractions allocated to each particle size while emitted organics released in the vapor and particle-bound phases and use a surface-area weighting scheme. Additional details on specifying the particle size distribution can be found in Sections 3.2.2 and 3.2.3 of the 2005 HHRAP and Section 3.3.4, Specifying Source Parameters for Particle Deposition, of the AERMOD Users Guide.

Partitioning of Emissions

Emissions from the Burn Pan Unit will partition into the vapor phase, particle phase, and particle bound phase. Due to the limitations of the AERMOD model, estimates of vapor phase, particle-phase, and particle bound phase impacts cannot be provided in a single AERMOD model run. Each of these phases should be modeled separately. Section 3.2, Partitioning Emissions, and Subsections 3.2.1 through 3.2.3 of the 2005 HHRAP provides additional information.

Sasha Gerhard
USEPA, Office of Resource Conservation & Recovery
Program Implementation & Information Division, 5303T
202-566-0346

Attachment 2 AP-42 Chapter 16 Draft

AP-42 CHAPTER 16

EMISSION FACTORS FOR DEMILITARIZATION PROCESSES: OPEN BURNING AND OPEN AIR DETONATION

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May 12, 2009

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16.0 INTRODUCTION

When subjected to heat, impact, friction, or shock, energetic compounds undergo a very rapid, self-propagating, intramolecular oxidation-reduction reaction (combustion) that results in the formation of highly stable simple gases and the release of heat (energy). This chapter of AP-42 applies to the emissions resulting from the disposal of energetic compounds and materials containing these compounds by open burning in burn pans and by surface detonation. All of the explosive and propellant (energetic) materials covered by this chapter of AP-42 are solids at normal environmental temperatures and pressures and have melting points between 120 and 400^0F and vapor pressures less than 8E-05 kilopascals (7.9E-07 atmospheres).

The materials commonly disposed of by detonation are: reclaimed high explosives that cannot be reused, cased munitions, explosively-loaded ordnance components (e.g., primers and fuzes) and detonable rocket motor propellants. The materials commonly destroyed by open burning are: propellants, reclaimed high explosives that cannot be detonated and combustible materials contaminated with energetic residues from ammunition and ordnance manufacturing processes (Explosive Contaminated Waste, ECW).

16.1 AN OVERVIEW OF DETONATION AND OPEN BURN PROCESSES

The initial step in both open burning and detonation processes is an adiabatic, oxidation-reduction process, which involves oxidant (e.g., $-ONO_2$, $-NO_2$, $-NHNO_2$) and reductant (e.g., C_xH_y) radicals within the energetic molecule. Once this reaction is initiated, it will proceed to completion without any additional energy being required.

The major differences between the open burning and the detonation processes are the speed with which this adiabatic, oxidation-reduction reaction proceeds through the energetic material and the pressures and temperatures involved. In open burning the oxidation-reduction reaction occurs on the surface of the energetic material at close to atmospheric pressure and takes seconds to a few minutes to go to completion. The rate determining factors in open burning are the rate of heat transfer into the material and the rate of decomposition of the energetic material itself. There is no shock wave. In contrast, in detonation processes, the oxidation-reduction reaction proceeds through the material at a velocity (detonation velocity) between 7,000 and 35,000 ft/s and the reaction is completed within a few microseconds. Detonations produce pressures as high as 350,000 atmospheres (35,300,000 kPa) and temperatures as high as $6{,}300^0$F.

In detonations, this intramolecular rearrangement is so fast that only a small percentage of the atoms in one molecule have time to react with atoms in adjacent energetic molecules that are decomposing at the exact same time. Because the detonation of explosives does not require air, it can occur in a vacuum, in an inert atmosphere, or even under water. The initial detonation products are free carbon (soot), carbon monoxide, hydrogen, methane, ethane, formaldehyde, nitrogen, carbon dioxide, water vapor, small hydrocarbons and small C_xH_y fragments. The initial stage of the detonation process is over in less than 10 microseconds and is followed by a 2 to 10 second duration fireball (afterburn). In this second stage of the process, combustible detonation reaction products (e.g., carbon monoxide, methane, ethane, formaldehyde, hydrogen and the C_xH_y fragments) are spontaneously oxidized (combusted) to CO_2 and H_2O. Fireball temperatures are on the order of 1,700 to 3,100°F. As the plume expands it entrains additional air which allows further combustion reactions to take place until the plume temperature falls to approximately $1{,}500^0$F where these reactions stop (freeze out temperature). The air-entrainment and afterburning occur almost simultaneously and are highly coupled. As the gases rise and air is entrained, soil is pulled into the plume. This entrained soil, along with the dirt released from the crater, forms the visible plume associated with detonations. (The gaseous products produced by the detonation and the afterburning are not visible to the eye.) Plume formation takes seconds to hundreds of seconds to complete, and the subsequent dispersion of the plume in the atmosphere can take hours.

When easy-to-detonate materials are detonated, the detonation can often be initiated using an electric blasting cap (EBC) and plastic explosives such as C4 or A-3 or blocks of TNT. These latter materials are frequently referred as the detonation initiating charge and demolition charge. However, when difficult-to detonate materials are to be destroyed by detonation, its common practice to place an easy-to-detonate material (donor material or donor charge) in close contact with the difficult-to-detonate material and to use the detonation of this donor material to detonate the difficult-to-detonate material (sympathetic detonation). The manner in which the donor charges are placed, the methods used to prime or initiate the donor charges, and the amount of confinement (tamp), can strongly influence the effectiveness in the ability of the detonation to completely destroy all of the energetics, particularly in stacks of mixed ordnance. For example, common practice is to simultaneously initiate the detonation of the donor charges from both ends and also top center of the stack to minimize the possibility of munitions being expelled from the stack instead of being destroyed.

Open burning is generally conducted using steel pans sitting on concrete pads to avoid contact with the soil surface. The pans have sufficient depth and size to contain treatment residues and are kept covered when not in use. In open burning the materials are placed in a steel burn pan to a depth of four inches or less, and the burn is initiated with an electric match or a black powder train. Open burns of propellant materials, which usually involve between 1,000 and 5,000 lb of propellant generally go to completion in less than a minute, whereas the burns of the other materials generally take at least three minutes to go to completion. The ash is recovered, and unless chemical analysis recommends otherwise, is disposed of as a hazardous waste.

16.1.1 Emissions from Open Burning and Detonation Processes

Between 1961 and 1981, Ornellas conducted a series of detonation experiments in bomb calorimeters, and evaluated how the following factors affected the efficiency and effectiveness of the detonation process: explosive density, purity, and particle size; the degree of confinement; and the type of initiating charge.[1] These experiments involved detonating one-ounce cylindrical pellets of 43 energetic materials in a 5.3 L bomb calorimeter and determining the chemical composition of the detonation plume.

His experiments established that the major emission products (EPs) from an unconfined detonation are N_2, CO_2, and H_2O and the minor emission products were CO, H_2, CH_4, NO, NO_2, HCN, HCl, HF and small organic molecules that are gases at ambient temperatures and pressures (VOCs). Generally, at least 97% of the nitrogen in the energetic was released as nitrogen and the rest was released as NO and NO_2. He also showed that the chemical composition of the initial detonation products was not greatly affected by the degree of confinement. For example, the initial emission products formed by detonating an energetic in a pure carbon dioxide atmosphere will be essentially the same as those formed when the energetic is detonated in a vacuum, regardless of the degree the energetic is oxygen-balanced.

The first comprehensive Department of Defense (DOD) study to characterize the air emissions from real world open burning and detonation operations was conducted at Dugway Proving Ground (DPG), UT from 1984 through 1986. In this study, helicopters equipped with standard air pollutant sampling systems attempted to identify and quantify the pollutants in the plumes produced when 2,000 to 11,000 lb of bulk high explosives and propellants were open burned and detonated on a DPG test range. The results were inconclusive.[2]

In 1988, the United States Army conducted a highly successful follow-on study.[3-5] The first stage of this follow-on study involved detonating 0.5 lb quantities of TNT and open burning 5 lb quantities of a double-base and a composite propellant in a 32,900 ft^3 hemispherical chamber (BangBox) at Sandia National Laboratories (SNL) in Albuquerque, NM. A suite of state-of-the art sampling systems was then used to characterize the identities and quantities of the emission products present in the plumes. The results from these burns and detonations were used to select the plume sampling equipment subsequently used to measure chemicals of environmental concern in the plumes produced when large quantities of energetic materials were detonated and burned on an open test range at DPG. The sampling equipment selected was installed in a twin-engine turboprop aircraft and the aircraft was used to sample the plumes released when 2,000 lb of high explosives [contained in either wood boxes or steel barrels] were detonated and when 5,000 to 7,000 lb of propellants were open burned in steel pans at DPG.

Based on the test results, DOD concluded that the plumes released when energetic materials are destroyed by open burning and detonation processes do not contain sufficient quantities of toxic or hazardous pollutants to pose a danger to human health or the environment. It also concluded that the

emission factors for the predominant EPs produced in the BangBox (BB) emissions tests were statistically equivalent to those produced in the DPG open range tests and also those produced in Ornellas' calorimeter experiments. That is, the EPs did not change substantially even when the quantity of energetic material detonated increased by a factor of 32,000.

In 1992, the U.S. EPA concurred with DOD's conclusions and agreed to accept BangBox-produced emission factors as representative of those that would be derived through ground level, open-air detonation and burn tests.[4] The U. S. Army then installed a BangBox at DPG and conducted a series of studies that characterized the air emissions produced when bulk and cased high explosives were detonated and bulk propellants were burned . These studies were then followed by larger scale detonation and burn experiments in a larger chamber at the Nevada Test Site that involved detonating 155MM projectiles and burning Hawk and NIKE rocket motors.[6-10] All of these studies employed plume sampling and analysis systems that were similar to those used in the earlier DPG open range studies, but also added the following target analytes: 140 additional VOCs, 100 additional semi-volatile organic compounds (SVOCs) and d polycyclic organic matter (POMs), HCl, Cl_2, metals, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDDs) and SO_2.

These follow-on studies filled in some of the major data gaps left by the open range studies and reconfirmed the conclusions of Ornellas and the open range studies that the predominant emission products for open burning and detonation processes are: particulate, CO_2, N_2, soot, CO, NO_x, metals and the first members of the saturated, unsaturated and aromatic hydrocarbon series. Further, polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran compounds (PCDDs/PCDFs) were not detected in the plumes.

Further, in the few instances when SVOCs/POMs were detected, the concentrations were indistinguishable from those found in ambient air and it is very likely that these compounds were present in the ambient air, when the detonation was initiated. The failure to find PCDDs/PCDFs, SVOCs and POMs might seem surprising, because these compounds are detected in the combustion gases of hazardous waste incinerators and the second stage of open burn and detonation processes involves combustion reactions. The reasons they are not present are: (1) by the time the second stage begins, the energetic material has already decomposed into very small, mostly thermodynamically stable molecules, and (2) the short duration and high temperatures associated with the second stage prevent the reactions from occurring that would convert a meaningful number of these small molecules into polycyclic molecules. In contrast, the temperature associated with the combustion of hazardous wastes are on the order of 900 to $1,600^0$F, and the original waste material is held in this temperature range for more than a minute, conditions that promote the formation of polycyclic organic molecules.[11 - 15]

16.1.2 Emission Controls

There are no emissions controls on either detonations or open burning operations per se. However, some of the engineering controls used to reduce the intensity of the propagation of the blast (sound) and pressure waves and the release of shrapnel from detonations do affect the relative ratios of the emission products released into the environment. This is especially true when the formation of a full fireball is inhibited. For example, compared to an unconfined detonation of the same material, detonating an energetic material under a light soil cover, which provides some confinement, increases the quantity of soot, CO, and unsaturated hydrocarbon emission products released into the plume, but decreases the quantity of CO_2 and the height to which the plume rises.

References for Section 16.1

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5a. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Field Test Series A, B and C, Volume II, Part A, Quality Assurance and Quality Control*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

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16.2 EMISSIONS FROM DETONATIONS
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16.2.1 Sources of the Emission Factors for Open Air Detonation

This section of Chapter 16 contains a compilation of the emission factors obtained from series of emissions characterization studies conducted on an open test range (OTR) and in a 32,900 ft^3, 50-ft diameter hemispherical detonation chamber (BangBox). These studies were conducted at Dugway Proving Grounds, UT (DPG) between 1989 and 1995.[1-3]

In the open range study, an instrumented airplane was used to collect samples from the plumes produced when 2000 lb of bulk high explosives (HE) were open detonated on and slightly above the ground on a test range at Dugway Proving Grounds. The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between three and seven seconds. For safety reasons and to allow all chemical reactions to go to completion, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted aluminum probe that outside the aircraft's boundary layer at a position forward and above the copilot's windshield. Each detonation trial consisted of three to five detonation events spaced 10 to 25 minutes apart.

In the BangBox study, air sampling equipment located inside the BangBox and in a building attached to it was used to collect samples from the plumes produced when 0.3 to 0.5 lb of bulk HE and munitions were detonated.

Table 16.2-1 identifies the test materials whose emissions were selected for inclusion in this section of Chapter 16 of AP-42, the energetic substances in these items and the number of detonation trials conducted on each test material. The chemical composition of these test materials, the detonation setup (configuration) used for each test material and the sampling systems used to characterize the emissions from these test materials are described in detail in Section 2.0 of the background document[4] This background document also describes the procedures used in selecting and grading the emission factors included in this section of Chapter 16 of AP-42.

16.2.2 Explanation of the Units of Measure Used

The emissions data are presented in two formats: (1) the traditional reporting unit (lb of emission product (EP) per lb net explosive weight (NEW) detonated; and (2) an alternate reporting unit (lb EP/ lb of a specific chemical substance in the material detonated. This alternate reporting unit is used when there was a known relationship between an emission product and a substance in the test material. This alternative unit is designated as the Environmental Fate Factor (EFF) and the traditional unit is designated as EF. The EF and EFF reporting units used for each EP and EP category are presented in Table 16.2-2. This alternate reporting unit was developed because there is no direct relationship between the mass of the EP and the NEW detonated. But there is such a relationship between the composition of the energetic material and the mass of the metal and some of the carbon and nitrogen containing EPs. Knowing these relationships can be very important when trying to use emissions data derived from chamber-based experiments to assess the true risk posed to human health and the environment by a specific detonation.

Table 16.2-1 TEST ITEMS FOR THE DETONATION EMISSION FACTORS

Study	Test Material	NSN	Major Energetiic Composition	Number of Detonation Trials
Open Test Range (OTR)	Surface Detonation, Reclaimed RDX	None	RDX	6
	Surface Detonation, Reclaimed Exoplosive D	None	Ammonium Picrate	6
	Surface Detonation, Reclaimed Composition B	None	RDX, TNT	6
	Surface Detonation, Reclaimed TNT	None	TNT	11
	Above Ground Detonation, Reclaimed TNT	None	TNT	3
BangBox (BB)	20mm HEI Cartridge, M56A4	1305-01-118-9928	RDX, NC, NG, Al, 2-Nitrodiphenylamine	3
	40mm HEI Catridge, M384	1310-00-039-1254	RDX, NC, NG	3
	Impulse Cartridge, M187	1377-00-516-9924	NC, NG	3
	Impulse Cartridge, BBU 36B	1377-01-037-8650	NC, NG	3
	Impulse Cartridge, MK107	1377-00-779-2601	NC, NG	3
	M206 Aircraft Flare	1370-01-048-2138	NC, Mg	3
	M43A2 Red Star Flare	1370-00-618-5790	$KClO_4$, MG	3
	M158 Red Star Flare	1370-00-490-7363	Black Powder, Mg	3
	FMU-139 Tail Bomb Fuze	1325-01-214-7311	Tetryl	3
	FMU-54A/B Tail Bomb Fuze	1325-01-613-0484	Tetryl	3
	M18A1 Claymore Mine	1345-00-710-6964	RDX	3
	Surrogate Composition B	None	RDX, TNT	3
	Surrogate HBX	None	RDX, TNT, Al	3
	TNT	None	TNT	3
	Surrogate Amatol	None	TNT, Ammonium Nitrate	3
	Surrogate Tritonal	None	TNT, Al	3
	Detonation Train	None	RDX, PETN	3

Table 16.2-2 EF AND EFF UNITS USED

EP/EP Category	Units
Carbon dioxide, carbon monoxide and volatile organic compounds (VOCs)(a)	lb EP/total lb carbon detonated
Nitrogen oxides	lb EP/lb total nitrogen detonated
Energetic compounds	lb EP/total lb related energetic
PM-10	lb EP/total lb NEW detonated
Semi-volatile organic compounds (SVOCs) and polycyclic organic matter (POMs) in the energetic material detonated (b)	lb EP/total lb related SVOC/POM detonated
SVOCs/POMs not in the energetic material	lb EP/total lb NEW detonated
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs)	lb EP/total lb NEW detonated
Metals(d)	lb EP/total lb related metal detonated
Sulfur dioxide	lb EP/total lb NEW detonated(c)

(a) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa.

(b) The terms SVOC (semi-volatile organic compounds) and POMs (polycyclic organic matter) apply to more than 100 organic compounds. They are defined in the Federal Clean Air Act as compounds with more than one benzene ring that also have boiling points greater than or equal to 100^0C. The terms are sometimes used interchangeably.

(c) EFF values could not be calculated because sulfur content of the test materials is uncertain.

(d) Most alloys contain a least one metal of environmental concern. S discussed in reference 1 of the Background Document there is an extensive body of theoretical and experimental data showing that these metals are not released from the alloy during the detonation.

16.2.3 Definitions of the Letter Codes Used in the Tables

When it was either not possible or not appropriate to enter a numerical EF or EFF value, the letter codes presented in Table 16.2-3 were used.

Table 16.2-3. EXPLANATION OF THE LETTER CODES USED

Letter Code	Explanation
NS (No Sample)	Not a target analyte.
NA (Not Applicable)	There is no information available to indicate that the test material contained a substance that could produce this EP.
ND (No Data)	Sample collected but either no result reported or data generator invalidated sampling result.
	Not possible to adjust the reported value for the contribution from test chamber surfaces and/or background air.
	Not possible to adjust the reported value for an erroneous background correction adjustment.
	Not possible to convert the traditional EF to the alternate EFF because critical composition data is not available for the test material.
BDL (Below Detection Limit)	Possible emission product, but either never detected or, if detected, never detected above the background level.

16.2.4 Tabulation of the Open Air Detonation Emissions Factors

16.2.4.1 Open Test Range (OTR) Emissions Factors

The TNT emission factors are presented in Table 16.2-4 and the RDX, Comp B, and Explosive D emission factors are presented in Table 16.2-5. The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

16.2.4.2 BangBox (BB) Emissions Factors

Table 16.2-6 contains the results for the Detonation Initiation Train and the Claymore mine, Tables 16.2-7 thru 16.2-9 present the results for the bulk HE, and Tables 16.2-10 thru 16.2-13 present the results for the cased materials (canon rounds, bomb fuzes, impulse cartridges and flares). The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

Table 16.2-4 EMISSION FACTORS FOR THE DETONATION OF TNT

EP Category	CASRN	EP	Units	Reclaimed TNT (Surface)		Reclaimed TNT (Suspended)	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	7.2E+00	D	1.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	B	BDL	B
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	B	BDL	B
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	7.5E-08	B	BDL	B
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	8.5E-09	B	BDL	B
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	B	BDL	B
	122-39-4	Diphenylamine	lb/lb NEW	BDL	B	BDL	B
	581-89-5	2-Nitronaphthalene	lb/lb NEW	4.0E-08	B	BDL	B
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	B	BDL	B
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B
	56-55-3	Benz(a)anthracene	lb/lb NEW	5.0E-08	B	3.2E-07	B
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	B	BDL	B
	132-64-9	Dibenzofuran	lb/lb NEW	9.0E-08	B	1.9E-07	B
	91-20-3	Naphthalene	lb/lb NEW	1.3E-06	B	1.8E-06	B
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	B	BDL	B
	85-01-8	Phenanthrene	lb/lb NEW	BDL	B	BDL	B
	108-95-2	Phenol	lb/lb NEW	1.0E-06	B	1.0E-06	B
	129-00-0	Pyrene	lb/lb NEW	1.1E-07	B	1.9E-08	B
	110-86-1	Pyridine	lb/lb NEW	BDL	B	BDL	B
Energetics	118-96-7	TNT	lb/lb TNT	1.4E-07(b)	B	9.3E-08(c)	B
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	A	3.8E+00	A
	630-08-0	Carbon monoxide	lb/lb C	1.5E-01	A	1.9E-02	A
	NA	Nitrogen oxides	lb/lb N	1.8E-02	A	2.6E-02	A
VOCs(d)	71-43-2	Benzene	lb/lb C	2.6E-04	B	1.7E-04	B
	74-82-8	Methane	lb/lb C	4.1E-03	B	4.0E-03	B
	NA	TNMHC	lb/lb C	4.9E-03	B	1.3E-02	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.4 of the background document for more information.[4]

(b) EFF is the average of the maximum EFF obtained for TNT across all detonation plumes in Phases A and C of the OTR study. See Section 2.1.4.5 of the background document for more information.[4]

(c) EFF is the largest EFF obtained for TNT across all of the plumes sampled. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.5 of the background document for more information.[4]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. The Army analyzed the plumes for 40 VOCs, but the test report contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 2.1.4.3 of the background document.[4]

Table 16.2-5 EMISSION FACTORS FOR THE DETONATION OF RDX, COMP B AND EXPLOSIVE D

EP Category	CASRN	EP	Units	Reclaimed Comp B		Reclaimed Explosive D		Reclaimed RDX	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	9.0E+00	D	1.1E+01	D	9.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	5.9E-08	B	1.8E-08	B	5.0E-08	B
	522-43-0	1-Nitropryene	lb/lb NEW	5.6E-08	B	1.1E-08	B	5.0E-08	B
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	B	BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	4.5E-07	B	5.9E-07	B	2.1E-07	B
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	2.4E-08	B	8.0E-08	B	4.1E-08	B
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	7.2E-08	B	5.8E-08	B	3.4E-08	B
	122-39-4	Diphenylamine	lb/lb NEW	6.6E-08	B	1.9E-08	B	3.1E-07	B
	581-89-5	2-Nitronaphthalene	lb/lb NEW	8.6E-08	B	4.3E-08	B	4.9E-08	B
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	B	BDL	B	BDL	B
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	B	1.9E-08	B	9.3E-08	B
	50-32-8	Benz(a)pyrene	lb/lb NEW	1.4E-08	B	3.8E-08	B	1.4E-07	B
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	B	1.1E-07	B	2.0E-06	B
	91-20-3	Naphthalene	lb/lb NEW	4.2E-07	B	6.3E-07	B	2.0E-07	B
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	3.6E-08	B	5.8E-08	B	BDL	B
	85-01-8	Phenanthrene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	108-95-2	Phenol	lb/lb NEW	BDL	B	BDL	B	BDL	B
	129-00-0	Pyrene	lb/lb NEW	2.1E-07	B	1.8E-07	B	2.2E-07	B
	110-86-1	Pyridine	lb/lb NEW	BDL	B	BDL	B	BDL	B
Energetics	121-82-4	RDX	lb/lb RDX	8.3E-10(b)	B	NA	NA	2.0E-06(c)	B
	118-96-7	TNT	lb/lb TNT	ND	NA	NA	NA	NA	NA
	88-89-1	Picric acid	lb/lb PA	NA	NA	5.0E-10(b)	A	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	A	3.4E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide	lb/lb C	1.2E-01	A	1.8E-01	A	2.0E-01	A
	NA	Nitrogen oxides	lb/lb N	6.4E-03	A	9.6E-03	A	1.7E-03	A
VOCs(d)	71-43-2	Benzene	lb/lb C	2.4E-05	B	3.8E-04	B	4.4E-04	B
	74-82-8	Methane	lb/lb C	2.3E-03	B	2.6E-02	B	1.3E-03	B
	NA	TNMHC	lb/lb C	4.7E-03	B	6.8E-03	B	8.4E-03	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.4 of the background document for more information.[4]

(b) EFF derived by substituting 1/2MDL for a BDL value. See Section 2.1.4.5 of the background document for more information.[5]

(c) EFF is the largest EFF obtained for RDX across all of the plumes sampled. Even if the RDX was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.5 of the background document for more information.[5]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. The Army analyzed the plumes for 40 VOCs, but the test report contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 2.1.4.3 of the background document.[4]

Table 16.2-6 EFs & EFFs FOR THE CLAYMORE MINE AND THE DETONATION INITIATION TRAIN

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	2.3E-01	D	3.6E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	NA	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	479-45-8	TETRYL	lb/lb Tetryl	NA	NA	NS	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	4.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	ND	NA
	630-08-0	Carbon monoxide	lb/lb C	2.2E-02	C	6.1E-02	C
	NA	Nitrogen Oxides	lb/lb N	NS	NA	3.8E-02	B
Metals(b)	7429-90-5	Al (In alloy)	lb/lb Al	6.3E-02	D	ND	NA
	7440-47-3	Cr (In Alloy)	lb/lb Cr	ND	NA	NA	NA
	7440-50-8	Cu (In Alloy)	lb/lb Cu	2.2E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	4.0E-01	D
	7439-92-1	Pb (In Alloy)	lb/lb Pb	ND	NA	NA	NA

Table 16.2-6 EFs & EFFs FOR THE CLAYMORE MINE
AND THE DETONATION INITIATION TRAIN (Continued)

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-86-2	Acetylene	lb/lb C	7.3E-04	B	6.9E-04	D
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	B
	71-43-2	Benzene	lb/lb C	6.0E-04	B	1.3E-04	C
	74-85-1	Ethylene	lb/lb C	1.8E-04	B	2.1E-03	B
	75-09-2	Methylene chloride	lb/lb C	8.1E-05	C	1.5E-04	D
	74-98-6	Propane	lb/lb C	2.7E-06	C	2.5E-05	B
	115-07-1	Propylene	lb/lb C	1.8E-05	C	3.9E-04	C
	108-88-3	Toluene	lb/lb C	1.9E-04	C	2.2E-05	B
	NA	TNMHC	lb/lb C	4.7E-03	C	2.3E-02	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-7 EFs & EFFS FOR THE DETONATION OF COMP B AND HBX

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.8E-01	D	1.2E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	118-96-7	TNT	lb/lb TNT	ND	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.0E-03	B	1.3E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	C	3.9E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.8E-02	C	1.5E-02	C
	NA	Nitrogen Oxides	lb/lb N	5.7E-02	B	1.9E-02	B
Metals(b)	7429-90-5	Al (In Energetic As Particle)	lb/lb Al	5.1E-02	D	NA	NA
	7440-50-8	Cu (In Alloy)	lb/lb Cu	3.2E-02	D	ND	NA

Table 16.2-7 EFs & EFFS FOR THE DETONATION OF COMP B AND HBX (Continued)

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-86-2	Acetylene	lb/lb C	1.0E-04	B	4.9E-05	C
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	71-43-2	Benzene	lb/lb C	2.5E-05	C	9.1E-05	C
	74-85-1	Ethylene	lb/lb C	1.1E-04	B	4.9E-05	C
	75-09-2	Methylene chloride	lb/lb C	3.2E-04	C	3.3E-04	C
	74-98-6	Propane	lb/lb C	3.0E-06	C	1.8E-06	C
	115-07-1	Propylene	lb/lb C	3.3E-05	C	1.1E-05	C
	108-88-3	Toluene	lb/lb C	1.2E-05	C	2.1E-05	C
	NA	TNMHC	lb/lb C	6.3E-04	C	3.9E-04	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.

Table 16.2-8 EFs & EFFs FOR THE DETONATION OF TNT AND AMATOL

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	7.3E-02	D	1.9E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	NA	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	NA	NA	ND	NA
	118-96-7	TNT	lb/lb TNT	BDL(b)	D	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	2.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.3E+00	C
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	C	4.6E-02	C
	NA	Nitrogen Oxides	lb/lb N	ND	NA	1.6E-01	B
Metals(c)	7440-39-3	Al (In alloy)	lb/lb Al	NA	NA	ND	NA
	7439-92-1	Cu (In Alloy)	lb/lb Cu	7.0E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	7.8E-01	D

Table 16.2-8 EFs & EFFs FOR THE DETONATION OF TNT AND AMATOL (Continued)

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(d)	107-05-1	Acetylene	lb/lb C	4.4E-05	C	4.5E-04	B
	71-43-2	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	142-29-0	Benzene	lb/lb C	1.1E-05	B	1.1E-04	B
	115-11-7	Ethylene	lb/lb C	5.7E-05	C	1.5E-04	B
	106-97-8	Methylene chloride	lb/lb C	4.7E-04	C	7.1E-04	C
	100-42-5	Propylene	lb/lb C	1.9E-05	C	2.6E-05	C
	NA	Toluene	lb/lb C	9.1E-06	C	3.1E-05	C
	624-64-6	TNMHC	lb/lb C	2.0E-04	C	2.1E-03	B

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) It is not appropriate to substitute 1/2 MDL for the energetic BDL values. The BB nominal MDL (3E-07 lb/lb energetic compound) is several orders of magnitude higher than the OTR energetic MDL and the OTR EFFs are at least an order of magnitude lower than the BB MDL.

(c) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-9 EFs & EFFs FOR THE DETONATION OF TRITONAL

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	3.7E-01	D	2.6E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	118-96-7	TNT	lb/lb TNT	ND	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.8E-05	B	1.2E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	3.8E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.3E-03	C	7.8E-03	C
	NA	Nitrogen Oxides	lb/lb N	5.4E-02	B	6.3E-02	B
Metals(b)	7429-90-5	Al (In Energetic As Particle)	lb/lb Al	1.4E-01	D	9.9E-02	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	NA	NA	4.9E-03	D
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	ND	NA

Table 16.2-9 EFs & EFFs FOR THE DETONATION OF TRITONAL (Continued)

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-86-2	Acetylene	lb/lb C	3.8E-04	B	5.5E-05	C
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	71-43-2	Benzene	lb/lb C	1.8E-05	C	9.0E-06	C
	74-85-1	Ethylene	lb/lb C	8.0E-05	C	7.3E-05	C
	75-09-2	Methylene chloride	lb/lb C	8.0E-06	D	4.6E-04	C
	115-07-1	Propylene	lb/lb C	2.3E-06	C	1.8E-05	B
	108-88-3	Toluene	lb/lb C	4.2E-06	C	BDL	D
	NA	TNMHC	lb/lb C	3.8E-03	C	6.4E-04	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-10 EFs & EFFs FOR THE DETONATION OF CANON ROUNDS

EP Category	CASRN	EP	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	ND	D	4.7E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	55-63-0	Nitroglycerin	lb/lb NG	BDL(b)	NA	BDL(b)	NA
	2691-41-0	HMX	lb/lb HMX	BDL(c)	NA	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	C	3.7E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.7E-01	C	5.8E-02	C
Metals(d)	7429-90-5	Al (In alloy)	lb/lb Al	2.9E-02	D	1.1E-02	D
	7440-39-3	Ba (In Energetic As Compound)	lb/lb Ba	3.1E-02	D	NA	D
	7440-47-3	Cr (In Alloy)	lb/lb Cr	1.7E-03	D	1.0E-02	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	1.6E-02	D	2.1E-02	D
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	D	6.4E-01	D
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	9.1E-03	D	7.0E-02	D

Table 16..2-10 EFs & EFFs FOR THE DETONATION OF CANON ROUNDS (Continued)

EP Category	CASRN	EP	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(e)	74-86-2	Acetylene	lb/lb C	2.9E-04	C	1.2E-04	C
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	71-43-2	Benzene	lb/lb C	1.8E-04	C	7.8E-05	C
	74-85-1	Ethylene	lb/lb C	4.6E-04	C	2.3E-04	C
	75-09-2	Methylene chloride	lb/lb C	7.2E-04	C	2.4E-03	C
	115-07-1	Propylene	lb/lb C	8.2E-05	C	4.5E-05	C
	108-88-3	Toluene	lb/lb C	4.8E-05	D	2.4E-05	D
	NA	TNMHC	lb/lb C	1.9E-03	C	9.2E-04	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) Even if all of the NG had entered the plume, the NG plume concentration would have been too small to measure.

(c) Even if all of the HMX had entered the plume, the HMX plume concentration would have been too small to measure.

(d) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(e) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-11 EFs & EFFs FOR THE DETONATION OF BOMB FUZES

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.3E+01	D	7.0E+00	D
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	479-45-8	TETRYL	lb/lb Tetryl	BDL(c)	D	BDL(c)	D
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.8E-03	B	4.0E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.2E+00	C
	630-08-0	Carbon monoxide	lb/lb C	6.0E-02	C	6.2E-02	C
	NA	Nitrogen oxides	lb/lb N	ND	NA	1.9E-01	B
Metals(d)	7429-90-5	Al (In alloy)	lb/lb Al	4.1E-02	D	8.8E-02	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	2.2E-02	D	5.6E-03	D
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	8.0E-02	D	ND	NA

Table 16.2-11 EFs & EFFs FOR THE DETONATION OF BOMB FUZES (Continued)

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(e)	74-86-2	Acetylene	lb/lb C	8.9E-03	C	6.1E-02	C
	107-05-1	Allyl Chloride	lb/lb C	4.6E-04	B	2.1E-03	B
	71-43-2	Benzene	lb/lb C	1.7E-03	B	1.5E-02	B
	74-85-1	Ethylene	lb/lb C	3.6E-03	B	1.5E-02	B
	75-09-2	Methylene chloride	lb/lb C	1.6E-03	B	6.2E-03	B
	115-07-1	Propylene	lb/lb C	6.0E-04	B	3.8E-03	B
	108-88-3	Toluene	lb/lb C	3.3E-04	B	4.4E-03	B
	NA	TNMHC	lb/lb C	3.8E-02	B	3.5E-01	B

(a) Even though the measurement system had a nominal MDL of 7E-11 lb/lb NEW, none of the seventeen PCDD/PCDF target analytes were detected in the detonation plumes for these test items, which had the highest chance of producing PCDDs/PCDFs EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDD/PCDF compound. The complete list of PCDF/PCDD analytes can be found in Section 2.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(c) It is not appropriate to substitute 1/2 MDL for the tetryl BDL value. The BB MDL (2E-07 lb/lb tetryl) is several orders of magnitude higher than the OTR energetic MDL and the OTR energetic EFFs are at least an order of magnitude lower than the BB MDL.

(d) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(e) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-12 EFs & EFFs FOR THE DETONATION OF IMPULSE CARTRIDGES

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E+00	D	4.9E+00	D	4.5E-01	D
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA	ND	NA
	55-63-0	Nitroglycerin	lb/lb NG	NA	NA	BDL(c)	D	BDL(d)	D
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.6E-05	B	2.8E-04	B	9.9E-05	B
	124-38-9	Carbon dioxide	lb/lb C	3.3E+00	C	3.4E+00	C	3.6E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.0E-02	C	5.8E-02	C	6.0E-02	C
	NA	Nitrogen oxides	lb/lb N	2.9E-01	B	ND	NA	ND	NA
Metals(e)	7429-90-5	Al (In alloy)	lb/lb Al	5.1E-03	D	4.2E-03	D	ND	NA
	7440-39-3	Ba (In Energetic As Compound)	lb/lb Cd	NA	NA	NA	NA	4.6E-03	D
	7440-47-3	Cr (In Alloy)	lb/lb Cr	ND	NA	ND	NA	7.2E-05	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	ND	NA	5.1E-03	D	1.6E-02	D
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	8.6E-02	D	4.4E-02	D	ND	NA
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	1.1E-02	D	1.8E-03	D	ND	D

Table 16.2-12 EFs & EFFs FOR THE DETONATION OF IMPULSE CARTRIDGES (Continued)

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(f)	74-86-2	Acetylene	lb/lb C	1.8E-02	B	3.6E-02	B	1.0E-03	B
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	5.5E-03	B	2.2E-05	C
	71-43-2	Benzene	lb/lb C	6.1E-03	B	2.4E-03	B	2.8E-04	B
	74-85-1	Ethylene	lb/lb C	1.7E-02	B	3.2E-03	B	7.7E-04	C
	75-09-2	Methylene chloride	lb/lb C	4.1E-03	C	8.9E-02	B	9.9E-04	C
	74-98-6	Propane	lb/lb C	4.0E-04	C	1.8E-04	C	6.0E-06	D
	115-07-1	Propylene	lb/lb C	3.1E-03	B	BDL	D	1.1E-04	C
	108-88-3	Toluene	lb/lb C	1.6E-03	C	3.7E-03	C	3.9E-05	D
	NA	TNMHC	lb/lb C	BDL	C	BDL	C	6.5E-03	D

(a) Even though the measurement system had a nominal MDL of 7E-11 lb/lb NEW, none of the seventeen PCDDs/PCDFs target analytes were detected in the detonation plumes for these test items, which had the highest chance of producing PCDD/PCDF EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDD/PCDF compound. The complete list of PCDF/PCDD analytes can be found in Section 2.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(c,) It is not appropriate to substitute 1/2 MDL for the NG BDL values. The BB nominal MDL (6E-07 lb/lb NG) is several orders of magnitude higher than the OTR energetic MDL and the OTR energetic EFFs are at least an order of magnitude lower than the BB MDL.

(c,) It is not appropriate to substitute 1/2 MDL for the NG BDL values. The BB nominal MDL (2E-07 lb/lb NG) is several orders of magnitude higher than the OTR energetic MDL and the OTR energetic EFFs are at least an order of magnitude lower than the BB MDL.

(e) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(f) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-13 EFs & EFFs FOR THE DETONATION OF FLARES

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	9.2E+00	D	7.1E+00	D	1.2E+00	D
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	NA	C	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.6E-03	B	ND	NA	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.5E+00	C	3.4E+00	C
	630-08-0	Carbon monoxide	lb/lb C	3.8E-02	C	7.1E-02	C	8.0E-02	C
	NA	Nitrogen Oxides	lb/lb N	2.5E-01	B	1.7E-01	B	8.9E-02	B

Table 16.2-13 EFs & EFFs FOR THE DETONATION OF FLARES (Continued)

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Metals(c)	7429-90-5	Al (In alloy)	lb/lb Al	7.7E-02	D	3.8E-02	D	9.5E-04	D
	7440-39-3	Ba (In Energetic As Compound)	lb/lb Cd	1.5E-01	D	1.4E-01	D	NA	NA
	7440-47-3	Cr (In Alloy)	lb/lb Cr	ND	NA	ND	NA	4.6E-04	D
	7440-47-3	Cr (In Protective Coating)	lb/lb Cr	3.8E-03	D	NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)	lb/lb Cu	ND	NA	8.6E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	3.2E-01	D	ND	NA
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	2.0E-01	D	8.0E-02	D	2.0E-02	D
VOCs(d)	74-86-2	Acetylene	lb/lb C	6.8E-03	B	4.4E-03	B	7.3E-03	B
	107-05-1	Allyl Chloride	lb/lb C	5.1E-04	C	3.0E-04	C	5.4E-04	C
	71-43-2	Benzene	lb/lb C	1.0E-03	B	4.1E-04	B	6.8E-04	B
	74-85-1	Ethylene	lb/lb C	BDL	D	1.3E-03	B	2.5E-03	B
	75-09-2	Methylene chloride	lb/lb C	1.1E-02	B	BDL	C	3.0E-03	B
	74-98-6	Propane	lb/lb C	BDL	D	1.5E-05	C	9.9E-05	C
	115-07-1	Propylene	lb/lb C	BDL	D	1.4E-04	C	9.1E-04	C
	108-88-3	Toluene	lb/lb C	7.5E-04	C	4.7E-04	C	7.8E-04	C
	NA	TNMHC	lb/lb C	3.0E-02	C	1.3E-02	C	1.2E-01	C

(a) Even though the measurement system had a nominal MDL of 7E-11 lb/lb NEW, none of the seventeen PCDDs/PCDFs target analytes were detected in the detonation plumes for these test items, which had the highest chance of producing PCDD/PCDF EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDDs/PCDFs compound. The complete list of PCDF/PCDD analytes can be found in Section 2.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(c) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

16.2.5 Comparability of the BangBox and Open Test Range Detonation Emissions Data Sets

A statistical comparison of means was done between the following BangBox (BB) and open test range (OTR) EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene and TNMHC. When this comparison determined that all of the pairs, except the PM-10 data sets, were statistically the same, each pair of statistically-equivalent data sets was combined and the following summary statistics determined for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev) and relative standard deviation (RSD, std dev/mean).

Table 16.2-14 presents these summary statistics along with proposed EPA quality rating codes. These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EFs or EFFs, the conformance to detonation reaction theory and representativeness to real world open detonation activities.

Table 16.2-14 also contains summary statistics for the following EP/EP categories for which there was either only BB data or the OTR open range data were judged to be far superior to the BB data.

OTR PM-10. Because the OTR and BB data sets are statistically different, they could not be combined. The OTR EFs were selected because they more closely reflect real world detonation processes than the soil-free BB detonations. However, the quality rating of D indicates that these PM-10 values are of poor quality and therefore must be used with extreme caution. (NOTE _ Summary statistics for the BB PM-10 EFs are presented in Table 21 of the background document.[4])

OTR *Energetics*. The OTR energetic EFFs were selected because all of the BB EFFs were BDL and the BB MDL was higher than the OTR EFFs.

OTR SVOCs/POMs Not In Energetic. The OTR EFs were selected because all of the BB EFs were BDL and the BB MDL was higher than the OTR EFs.

BB SO_2 There are no corresponding OTR EFs.

BB EFFs for Acetylene, Ethylene, Methylene Chloride, Allyl Chloride, Propylene and Toluene. There are no corresponding OTR EFFs

BB Metals. There are no corresponding OTR EFs.

Table 16.2-14. SUMMARY STATISTICS FOR THE DETONATION DATA SETS

EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD(a)	Quality Rating
PM-10	lb/lb NEW	5	1.1E+01	1.6E+00	9.0E+00	7.7E+00	3.6E+00	0.47	D
Carbon Monoxide	lb/lb C	23	2.0E-01	7.8E-03	6.0E-02	7.1E-02	5.7E-02	0.81	B
Carbon Dioxide	lb/lb C	22	3.9E+00	2.5E+00	3.5E+00	3.5E+00	3.0E-01	0.09	B
Nitrogen Oxides	lb/lb N	19	3.2E-01	1.7E-03	3.3E-02	5.3E-02	7.2E-02	1.36	B
Sulfur Dioxide	lb/lb NEW	12	1.4E-03	7.8E-05	3.3E-04	4.8E-04	4.2E-04	0.88	B
Energetics	lb/lb Energetic	5	2.0E-06	5.0E-10	9.3E-08	4.5E-07	8.7E-07	1.95	C
SVOCs In Energetic	lb/lb SVOC	No Data							
SVOCs Not In Energetic	lb/lb NEW	49	2.0E-06	8.5E-09	8.0E-08	2.8E-07	4.8E-07	1.71	B
Benzene	lb/lb C	23	6.0E-04	9.0E-06	1.7E-04	2.0E-04	1.6E-04	0.82	B
TNMHC	lb/lb C	23	3.4E-02	2.0E-04	7.2E-03	7.7E-03	7.9E-03	1.03	B
Acetylene	lb/lb C	18	1.8E-03	4.4E-05	7.3E-04	7.7E-04	6.1E-04	0.80	B
Ethylene	lb/lb C	18	2.3E-03	4.9E-05	6.5E-04	7.1E-04	7.4E-04	1.05	B
Methylene Chloride	lb/lb C	18	2.4E-03	8.0E-06	4.0E-04	6.2E-04	6.5E-04	1.05	B
Propylene	lb/lb C	18	4.1E-04	2.3E-06	1.1E-04	1.3E-04	1.4E-04	1.08	B
Toluene	lb/lb C	17	1.9E-04	4.2E-06	5.7E-05	6.7E-05	5.7E-05	0.85	B
Metals In Energetic As Particle	lb/lb Metal	3	1.4E-01	5.1E-02	9.9E-02	9.8E-02	4.6E-02	0.47	D
Metals In Alloys	lb/lb Metal	35	2.0E-01	7.2E-05	1.1E-02	3.1E-02	4.1E-02	1.35	D
Metals In Energetic As Compound	lb/lb Metal	10	7.8E-01	4.6E-03	1.5E-01	2.6E-01	2.7E-01	1.04	D

(a) As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

16.2.6 Application of the EFs/EFFs to Real World Open Detonation Activities

The term open detonation (OD) is commonly used to describe both open air surface detonations and buried/soil-covered detonations.

16.2.6.1 Open Air Surface Detonations

Open air surface detonations are usually done at facilities where blast noise, blast wave transmission and fragment travel are of little concern. This type of detonation promotes the formation of a full fireball and the efficient oxidation of the initial detonation products to nontoxic compounds. Any of the materials normally detonated can be destroyed through a surface detonation and the NEW of the detonation process can be thousands of pounds. Because the EFs/EFFs in this chapter of AP-42 were developed from open air detonations, they can be applied to open air detonations with confidence.

16.2.6.2 Buried and Soil-Covered Detonations

Buried and soil-covered detonations are done at facilities where blast noise, blast wave transmission and/or fragment travel can cause problems. The NEW of the detonation pile is usually less than 400 lb. When munitions are detonated under these conditions, the fireball is partially or fully suppressed, a situation that is very different from the conditions under which the EFs/EFFs in this chapter of AP-42 were derived. There are no emissions data specific to soil-covered and buried detonations, and it would not be appropriate to apply the EFs/EFFs in this chapter of AP-42 to buried and soil-covered detonations without considering the effect that suppression of the fire ball could have on the emissions. Fortunately, there are emissions data from studies in bomb calorimeters and detonation chambers that can provide insight on the effect that fireball suppression has on the emissions from detonations. These studies are discussed in Appendix A of the background document.[4]

References for Section 16.2

1a. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Field Test Series A, B and C, Volume II, Part A, Quality Assurance and Quality Control*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

1b. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Field Test Series A, B and C, Volume II, Part B, Quality Assurance and Quality Control Appendices*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

2a. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 1, Test Summary*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

2b. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 2, Test Development*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

2c. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 3, Quality Control and Quality Assurance*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

3. W. J. Mitchell and J. C. Suggs. *Emission Factors for the Disposal of Energetic Materials by Open Burning and Open Detonation (OB/OD)*. EPA Report - EPA/600/R-98/103, August 1998. 130p.

4. *Background Document for AP-42 Chapter 16 – Emission Factors for Demilitarization Processes: Open Burning and Open Detonation*. Report prepared for the U. S. Army Defense Ammunition Center, McAlester, OK by Chemical Compliance Systems, Inc. February, 2009.

5. *Procedures for Preparing EF Documents*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Durham, NC. EPA Report - EPA 454/R-95-015 (Revised), September 1997.

16.3 EMISSIONS FROM OPEN BURNING

16.3.1 Sources of the Emission Factors for Open Burning

This section of Chapter 16 contains a compilation of the emission factors obtained from series of emissions characterization studies conducted on an open test range (OTR) and in a 32,900 ft^3, 50-ft diameter hemispherical detonation chamber (BangBox). These studies were conducted at Dugway Proving Grounds, UT (DPG) between 1989 and 1995.[1-3]

In the open range study, an instrumented airplane was used to collect samples from the plumes produced when 4,600 to 7,000 lb of five individual propellant materials were burned in steel pans on a test range at DPG, UT.[1, 2] The burn pans were approximately 4 ft wide, 36 ft long, and 0.8 ft high and were placed side by side. Three pans were used in each burn trial. The propellant materials were placed in the pans to a depth of 2.5 to 3.5 inches, and the burns were initiated using black powder trains placed at both ends of
each pan. The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between three and seven seconds. For safety reasons and to allow all chemical reactions to go to completion, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted aluminum probe that outside the aircraft's boundary layer at a position forward and above the copilot's windshield. Each burn trial was comprised of two or three burn events spaced 15 to 20 minutes apart.

In the BangBox study, air sampling equipment located inside the BangBox and in a building attached to it was used to collect samples from the plumes produced when 2.2 to 5.0 lb quantities of propellants were open burned on a bed of pea gravel in a stainless steel pan sitting on a steel pad located in the center of the BangBox.[3]

Table 16.3-1 identifies the test materials whose emissions were selected for inclusion in this section of Chapter 16 of AP-42, the energetic substances in these items and the number of detonation trials conducted on each test material. The chemical composition of these test materials, the test configuration used for each test material and the sampling systems used to characterize the emissions from these test materials are described in detail in Section 3.0 of the background document.[4] This background document also describes the procedures used in selecting and grading the emission factors included in this section of Chapter 16 of AP-42.

16.3.2 Explanation of the Units of Measure Used

The emissions data are presented in two formats: (1) the traditional reporting unit (lb of emission product (EP) per lb net explosive weight (NEW) burned); and (2) an alternate reporting unit (lb EP/ lb of a specific chemical substance in the material burned). This alternate reporting unit is used when there was a known relationship between an emission product and a substance in the test material. This alternative unit is designated as the Environmental Fate Factor (EFF), and the traditional unit is designated as EF. The EF and EFF reporting units used for each EP and EP category are presented in Table 16.3-2. This alternate reporting unit was developed because there is no direct relationship between the mass of the EP and the NEW burned. But there is such a relationship between the composition of the energetic material and the mass of the metal and some of the carbon and nitrogen containing EPs. Knowing these relationships can be very important when trying to use emissions data derived from chamber-based experiments to assess the

true risk posed to human health and the environment by a specific open burn.

Table 16.3-1 TEST ITEMS USED FOR THE OPEN BURN EMISSION FACTORS

Study	Material	NSN of Test Material	Major Energetic Components	Number of Burn Trials Sampled
Open Test Range (OTR)	Waste Propellant Mix A	Unknown	AP, NC, NG, 2-Nitrodiphenylamine	2
	Waste Propellant Mix B	Unknown	NC, NG, 2-Nitrodiphenylamine	2
	M1 Propellant	Unknown	NC, 2-Nitrodiphenylamine, Dibutylphalate, 2, 4 - DNT	6
	M6 Propellant	Unknown	NC, 2-Nitrodiphenylamine, Dibutylphalate, 2, 4 - DNT	12
	M30 Propellant	Unknown	NC, NG, NQ	4
BangBox (BB)	Aluminized AP Propellant	Unknown	AP, Al, Rubberized binder	2
	AP Propellant	Unknown	AP, Rubberized binder	2
	MK-6 Propellant	Unknown	AP, Al, Rubberized binder	1
	Double Base Propellant	Unknown	NC, NG, Diphenylamine	3
	NOSIH- AA2 Propellant	Unknown	NC, NG, Ethyl centralite, Di-n-propyl- adipate	1
	M1 Propellant	Unknown	NC, 2.4-DNT, Diphenylamine	3
	M43 Propellant	Unknown	NC, RDX, polymeric binders	1
	M9 Propellant	Unknown	NC, NG, Diphenylamine	3
	M31AE1 Popellant	1376-01-213-5669	NC, NG, NQ, Ethyl centralite	3
	PBXN-110 Propellant	Unknown	HMX, Hydroxyl-terminated butadiene	1

Table 16.3-2 EF AND EFF UNITS USED

EP/EP Category	Units
Carbon dioxide, carbon monoxide and volatile organic compounds (VOCs)(a)	lb EP/total lb C in material burned
Nitrogen oxides	lb EP/total lb N in material burned
Hydrogen chloride and chlorine	lb EP/total lb Cl in material burned
Energetic compound	lb EP/total lb related energetic in material burned
PM-10	lb EP/total lb NEW burned
Semi-volatile organic compounds (SVOCs) and polycyclic organic matter (POM) in the energetic material (b)	lb EP/total lb related SVOC in material burned
SVOCs/POMs not in the energetic material	lb EP/total lb NEW burned
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs)	lb EP/total lb NEW burned
Metals(d)	lb EP/total lb related metal in material burned
Sulfur dioxide	lb EP/total lb NEW burned(c)

(a) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa.

(b) The terms SVOC (semi-volatile organic compounds) and POMs (polycyclic organic matter) apply to more than 100 organic compounds. They are defined in the Federal Clean Air Act as compounds with more than one benzene ring that also have boiling points greater than or equal to 100^0C. The terms are sometimes used interchangeably.

(c) EFF could not be calculated because sulfur content of test items is uncertain.

(d) Most alloys contain a least one metal of environmental concern. S discussed in reference 1 of the Background Document there is an extensive body of theoretical and experimental data showing that these metals are not released from the alloy during the detonation.

16.3.3 Definitions of the Letter Codes Used in the Tables

When it was either not possible or not appropriate to enter a numerical EF or EFF value, the letter codes presented in Table 16.3-3 were used.

Table 16.3-3 EXPLANATION OF THE LETTER CODES USED

Letter Code	Explanation
NS (No Sample)	Not a target analyte.
NA (Not Applicable)	There is no information available to indicate that the test material contained a substance that could produce this EP.
ND (No Data)	Sample collected but either no result reported or data generator invalidated sampling result.
	Not possible to adjust the reported value for the contribution from test chamber surfaces and/or background air.
	Not possible to adjust the reported value for an erroneous background correction adjustment.
	Not possible to convert the traditional EF to the alternate EFF because critical composition data is not available for the test material.
BDL (Below Detection Limit)	Possible emission product, but either never detected or, if detected, never detected above the background level.

16.3.4 Tabulation of the Open Burn Emission Factors

16.3.4.1 Open Test Range (OTR) Emissions Factors

The waste propellant emission factors are presented in Table 16.3-4 and the single base and triple base propellant emission factors are presented in Table 16.3-5. The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

16.3.4.2 BangBox (BB) Emissions Factors

Table 16.3-6 presents the results for the AP-propellants, Table 16.3-7 presents the results for single base and triple base propellants, Table 16.3-8 presents the results for double base propellants and Table 16.3-9 presents the results for the PBX propellants. The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

Table 16.3-4 EFs & EFFs FOR THE OPEN BURNING OF WASTE PROPELLANTS

EP Category	CASRN	EP	Units	Waste Propellant A		Waste Propellant B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.6E-02	B	1.0E-02	B
SVOC and POM(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	A	BDL	A
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	A	1.6E-07	A
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	NA	A	1.4E-07	A
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	A	BDL	A
	122-39-4	Diphenylamine	lb/lb NEW	2.0E-08	A	3.1E-07	A
	581-89-5	2-Nitronaphthalene	lb/lb NEW	3.7E-09	A	8.3E-08	A
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	A	BDL	A
	56-55-3	Benz(a)anthracene	lb/lb NEW	3.8E-08	A	1.4E-07	A
	50-32-8	Benz(a)pyrene	lb/lb NEW	2.3E-08	A	8.1E-08	A
	132-64-9	Dibenzofuran	lb/lb NEW	2.6E-07	A	1.2E-07	A
	91-20-3	Naphthalene	lb/lb NEW	1.5E-06	A	5.4E-07	A
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	1.9E-08	A	2.7E-08	A
	85-01-8	Phenanthrene	lb/lb NEW	BDL	A	BDL	A
	108-95-2	Phenol	lb/lb NEW	8.0E-06	A	BDL	A
	88-72-2	Nitrobenzene	lb/lb NEW	BDL	A	BDL	A
	110-86-1	Pyridine	lb/lb NEW	BDL	A	BDL	A
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	A	BDL	A
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	A	BDL	A
	129-00-0	Pyrene	lb/lb NEW	7.1E-09	A	3.2E-07	A
Energetics	55-63-0	Nitroglycerin	lb/lb NG	1.1E-09(b)	B	8.7E-10(b)	B
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.6E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide	lb/lb C	2.3E-03	A	2.6E-03	A
	NA	Nitrogen oxides	lb/lb N	7.1E-02	A	2.9E-02	A
VOCs(c)	71-43-2	Benzene	lb/lb C	*2.3E-06*	A	2.6E-03	A
	74-82-8	Methane	lb/lb C	*2.3E-06*	A	2.8E-03	A
	NA	TNMHC	lb/lb C	2.1E-04	A	2.1E-03	A
SVOCs in Energetic	119-75-5	2-Nitrodiphenylamine	lb/lb 2-NDPA	3.1E-08	B	9.4E-07	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 3.1.4.4 of the background document for more information.[4]

(b) EFFs derived by substituting 1/2 MDL for BDL value.

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa . The Army analyzed the plumes for 40 VOCs, but the test report contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 3.1.4.3 of the Background Document.[4]

Table 16.3-5 EFs & EFFs FOR OPEN BURNING OF SINGLE & TRIPLE BASE PROPELLANTS

EP Category	CASRN	EP	Units	M1 Propellant		M6 Propellant		M30 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	6.9E-03	B	1.1E-02	B	2.0E-02	B
SVOCs and POMs(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	A	BDL	A	BDL	A
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	A	BDL	A	BDL	A
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	A	BDL	A	BDL	A
	91-20-3	Naphthalene	lb/lb NEW	1.9E-08	A	7.5E-08	A	BDL	A
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	A	BDL	A	BDL	A
	85-01-8	Phenanthrene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	108-95-2	Phenol	lb/lb NEW	3.4E-09	A	1.5E-09	A	BDL	A
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	A	BDL	A	BDL	A
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	129-00-0	Pyrene	lb/lb NEW	BDL	A	BDL	A	BDL	A
Energetics	55-63-0	Nitroglycerin	lb/lb NG	NA	NA	NA	NA	1.5E-09(b)	B
	556-88-7	Nitroguanidine	lb/lb NQ	NA	NA	NA	NA	6.9E-10(b)	B
Iniorganic Gases	124-38-9	Carbon dioxide	lb/l. C	3.6E+00	A	3.7E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide	lb/l. C	8.2E-04	A	3.3E-04	A	1.4E-04	A
	NA	Nitrogen oxides	lb/lb N	2.0E-02	A	4.3E-02	A	2.9E-02	A
VOCs(c)	71-43-2	Benzene	lb/lb C	1.4E-05	A	5.4E-06	A	3.1E-06	A
	74-82-8	Methane	lb/lb C	2.4E-02	A	1.5E-04	A	3.1E-06	A
	NA	TNMHC	lb/lb C	1.5E-03	A	4.5E-05	A	8.4E-06	A
SVOC in Energetic	122-39-4	Diphenylamine	lb/lbDPA	9.6E-08(d)	B	5.6E-08(d)	B	NA	B
	121-14-2	2,4-Dinitrotoluene	lb/lb DNT	1.1E-08	B	1.0E-08(d)	B	NA	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 3.1.4.4 of the background document for more information.[4]

(b) EFFs derived by substituting 1/2 MDL for BDL value.

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa . The Army analyzed the plumes for 40 VOCs, but the test report

contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 3.1.4.3 of the Background Document.[4]

Table 16.3-6 EFs & EFFs FOR THE OPEN BURNING OF AP PROPELLANTS

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	4.2E-01	B	1.5E-02	B	ND	B
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
SVOC & POM(b)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol	lb/lb NEW	1.1E-05	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
VOCs(c)	74-86-2	Acetylene	lb/lb C	9.1E-05	B	BDL	B	2.1E-04	C
	71-43-2	Benzene	lb/lb C	BDL	C	BDL	C	5.7E-04	C
	74-85-1	Ethylene	lb/lb C	BDL	C	BDL	C	ND	NA
	115-11-7	Isobutene	lb/lb C	4.5E-05	C	BDL	D	ND	NA
	115-07-1	Propylene	lb/lb C	BDL	C	BDL	C	ND	NA
	NA	TNMHC	lb/lb C	4.5E-04	C	3.6E-04	C	ND	NA
	108-88-3	Toluene	lb/lb C	BDL	D	BDL	D	ND	NA

Table 16.3-6 EFs & EFFs FOR THE OPEN BURNING OF AP PROPELLANTS (Continued)

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	4.7E-05	B	1.1E-04	B	1.5E-04	B
	NA	Nitrogen oxides	lb/lb N	3.3E-02	B	8.6E-02	B	1.9E-02	B
	7782-50-5	Chlorine	lb/lb Cl	2.1E-02	B	3.5E-02	B	NS	NA
	7647-01-0	Hydrogen chloride	lb/lb Cl	9.4E-01	B	8.5E-01	B	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.0E+00	B	3.4E+00	B	4.1E+00	B
	630-08-0	Carbon monoxide	lb/lb C	1.1E-02	B	1.3E-03	B	4.1E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Al	5.5E-02	C	NA	NA	2.9E-02	C

(a) Even though the measurement system had a nominal MDL of 9E-12 lb/lb NEW, none of the seventeen PCDDs/PCDFs target analytes were detected in the detonation plumes for these test items which had the highest chance of producing PCDD/PCDF EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDDs/PCDFs compound. The complete list of PCDF/PCDD analytes can be found in Section 3.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (9E-06 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one or two orders of magnitude less than the BB MDL. The complete list of the BB SVOC/POM target analytes can be found in Table 33 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

Table 16.3-7 EFs & EFFs FOR THE OPEN BURNING OF SINGLE AND TRIPLE BASE PROPELLANTS.

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	8.6E-03	B	9.1E-01	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D
	108-95-2	Phenol	lb/lb NEW	BDL	D	BDL	D
	85-01-8	Phenanthrene	lb/lb NEW	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	D	BDL	D
	91-20-3	Naphthalene	lb/lb NEW	BDL	D	BDL	D
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	D	BDL	D
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	D	BDL	D
	95-57-8	2-Chlorophenol	lb/lb NEW	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D
VOCs(b)	74-86-2	Acetylene	lb/lb C	2.5E-05	B	BDL	C
	71-43-2	Benzene	lb/lb C	1.9E-05	B	BDL	C
	74-85-1	Ethylene	lb/lb C	1.5E-05	B	BDL	C
	115-11-7	Isobutene	lb/lb C	5.1E-07	C	BDL	D
	115-07-1	Propylene	lb/lb C	3.8E-06	B	BDL	C
	NA	TNMHC	lb/lb C	1.8E-04	C	6.7E-04	C
	108-88-3	Toluene	lb/lb C	3.4E-06	D	BDL	D
Energetics	55-63-0	Nitroglycerin	lb/lb NG	NA	NA	ND	NA
	556-88-7	Nitroguanidine	lb/lb NQ	NA	NA	ND	NA

Table 16.3-7 EFs & EFFs FOR THE OPEN BURNING OF SINGLE AND TRIPLE BASE PROPELLANTS (Continued)

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	NS	NA	1.2E-03	B
	NA	Nitrogen oxides	lb/lb N	NS	NA	6.3E-03	B
	124-38-9	Carbon dioxide	lb/lb C	2.3E+00	B	4.0E+00	B
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	B	8.7E-04	B
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb DNT	BDL(c)	D	NA	NA
	122-39-4	Diphenylamine	lb/lb DPA	BDL(c)	D	NA	NA

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (9E-06 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one or two orders of magnitude less than the BB MDL. The complete list of the BB SVOC/POM target analytes can be found in Table 33 of the background document.[4]

(b) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

(c) It is not appropriate to substitute 1/2 MDL for the DNT and DPA BDL values. The BB nominal MDL (1E-06 lb/lb) is several orders of magnitude higher than the OTR MDL and the OTR EFFs are at least an order of magnitude lower than the BB MDL.

Table 16.3-8 EFs & EFFs FPR THE OPEN BURNING OF DOUBLE BASE PROPELLANTS

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.9E-02	B	ND	NA	1.6E-02	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
VOCs(b)	74-86-2	Acetylene	lb/lb C	BDL	C	6.0E-04	B	3.5E-05	B
	71-43-2	Benzene	lb/lb C	BDL	C	6.0E-04	B	1.2E-05	B
	74-85-1	Ethylene	lb/lb C	BDL	C	NA	NA	2.5E-05	B
	115-11-7	Isobutene	lb/lb C	BDL	D	NA	NA	1.0E-06	C
	115-07-1	Propylene	lb/lb C	BDL	C	NA	NA	2.8E-06	B
	NA	TNMHC	lb/lb C	5.2E-04	C	NA	NA	5.8E-05	C
	108-88-3	Toluene	lb/lb C	BDL	D	NA	NA	BDL	D
Energetics	55-63-0	Nitroglycerin	lb/lb NG	ND	NA	BDL(b)	D	BDL(b)	D

Table 16.3-8 EFs & EFFs FPR THE OPEN BURNING OF DOUBLE BASE PROPELLANTS (Continued)

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	2.5E-05	B	3.6E-04	B	NS	NA
	NA	Nitrogen oxides	lb/lb N	9.4E-03	B	6.5E-02	B	NS	B
	124-38-9	Carbon dioxide	lb/lb C	3.2E+00	B	ND	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	7.3E-03	B	4.8E-03	B	1.0E-02	B
Metals	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	6.3E-01	C	7.2E-01	C	NA	NA

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (9E-06 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one or two orders of magnitude less than the BB MDL. The complete list of the BB SVOC/POM target analytes can be found in Table 33 of the background document.[4]

(b) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

Table 16.3-9 EFs & EFFs FOR THE OPEN BURNING OF PBX PROPELLANTS

EP Category	CASRN	EP	Units	M43 Propellant		PBXN-110 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E-03	B	4.9E-01	B
VOCs(a)	74-86-2	Acetylene	lb/lb C	3.0E-05	B	1.1E-05	B
	71-43-2	Benzene	lb/lb C	8.5E-06	B	1.8E-05	B
	115-11-7	Isobutene	lb/lb C	2.7E-06	C	4.8E-06	C
	115-07-1	Propylene	lb/lb C	5.5E-06	B	1.1E-05	B
	NA	TNMHC	lb/lb C	2.1E-04	C	1.9E-04	C
	108-88-3	Toluene	lb/lb C	2.7E-06	D	BDL	D
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.2E-04	B	3.5E-04	B
	NA	Nitrogen Oxides	lb/lb N	3.1E-02	B	1.2E-02	B
	124-38-9	Carbon dioxide	lb/lb C	3.9E+00	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	3.3E-03	B	4.4E-03	B

(a) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

16.3.5 Comparability of the BangBox and Open Test Range Detonation Emissions Data Sets

A statistical comparison of means was done between the following BangBox (BB) and open test range (OTR) EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene and TNMHC. When this comparison determined that all of the pairs were statistically the same, each pair of statistically-equivalent data sets was combined and the following summary statistics determined for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev) and relative standard deviation (RSD, std dev/mean).

Table 16.3-10 presents these summary statistics along with proposed EPA quality rating codes.[5] These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance to detonation reaction theory and representativeness to real world open burn activities.

Table 16.3-10 also contains summary statistics for the following EP/EP categories for which there was either only BB data or the OTR open range data were judged to be far superior to the BB data.

OTR *Energetics*. The OTR energetic EFFs were selected because all of the BB EFFs were BDL and the BB MDL was higher than the OTR EFFs.

OTR SVOCs/POMs Not In Energetic. The OTR EFs were selected because all of the BB EFs were BDL and the BB MDL was higher than the OTR EFs.

BB SO_2 There are no corresponding OTR EFs.

BB HCl. There are no corresponding OTR EFs

BB EFFs for Acetylene, Ethylene, Isobutene Propylene and Toluene. There are no corresponding OTR EFFs

BB Metals. There are no corresponding OTR EFs.

Table 16.3.10 SUMMARY STATISTICS FOR THE OPEN BURN DATA SETS

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD(a)	Quality Rating
PM-10	PM-10	lb/lb NEW	13	9.1E-01	1.2E-03	1.6E-02	1.5E-01	2.8E-01	1.89	B
Inorganic Gases	Sulfur Dioxide	lb/lb NEW	8	1.2E-03	2.5E-05	1.4E-04	3.0E-04	3.9E-04	1.31	B
	Nitrogen Oxides	lb/lb N	13	8.6E-02	6.3E-03	2.9E-02	3.5E-02	2.5E-02	0.71	A
	Hydrogen Chloride	lb/lb Cl	2	9.4E-01	8.5E-01	8.9E-01	8.9E-01	6.7E-02	0.07	B
	Carbon Dioxide	lb/lb C	15	4.1E+00	2.3E+00	3.7E+00	3.5E+00	4.6E-01	0.13	A
	Carbon Monoxide	lb/lb C	15	4.1E-02	1.5E-04	3.3E-03	7.8E-03	1.1E-02	1.46	B
Energetics	Energetics	lb/lb Energetic	4	1.5E-09	6.9E-10	9.7E-10	1.0E-09	3.3E-10	0.32	B
SVOCs	SVOCs in Energetics	lb/lb SVOC	6	9.4E-07	1.0E-08	4.4E-08	1.9E-07	3.7E-07	1.93	B
	SVOCs Not In Energetics	lb/lb NEW	29	8.0E-06	5.0E-10	2.7E-08	4.1E-07	1.5E-06	3.62	B
VOCs	Benzene	lb/lb C	11	6.0E-04	2.3E-06	1.6E-05	1.2E-04	2.3E-04	1.93	B
	TNMHC	lb/lb C	13	2.1E-03	8.4E-06	2.1E-04	5.0E-04	6.2E-04	1.24	B
	Acetylene	lb/lb C	7	6.0E-04	1.1E-05	3.5E-05	1.4E-04	2.1E-04	1.49	B
	Ethylene	lb/lb C	4	2.5E-05	1.5E-05	2.4E-05	2.2E-05	5.0E-06	0.22	B
	Isobutene	lb/lb C	5	4.5E-05	5.1E-07	2.7E-06	1.1E-05	1.9E-05	1.78	C
	Propylene	lb/lb C	4	1.1E-05	2.8E-06	4.6E-06	5.8E-06	3.7E-06	0.64	B
Metals In Energetic	Metal In Energetic As Particle	lb/lb Metal	2	5.5E-02	2.9E-02	4.2E-02	4.2E-02	1.8E-02	0.43	C
	Metal In Energetic As Compound	lb/lb Metal	2	7.2E-01	6.3E-01	6.7E-01	6.7E-01	6.2E-02	0.09	C

(a) As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

16.3.6 Application of the EFs/EFFs to Real World Open Burn Activities

16.3.6.1 Open Burning of Bulk Waste Propellants and High Explosives in Burn Pans.

Uncased waste propellants and high explosives comprise more than 90% of the energetic materials destroyed by open burning in burn pans. Because the EFs and EFFs in this chapter of AP-42 were derived from the open burning of bare propellants and high explosives in burn pans, they can be applied directly to these materials.

16.3.6.2 Open Burning of Missiles and Rockets

The following procedures are used to destroy missiles and rockets by open burning: (1) holding down the missile and firing it in its design mode, (2) removing the nozzle from a missile, holding it down, and igniting it, and (3) placing a shape charge along one side of a rocket motor or missile and using the initiation of that shape charge to crack open the item and ignite the energetics. Each of these processes results in different temperatures and pressures and different emissions. In general, all these burns involve a two stage decomposition process. The first stage involves a white cloud predominately composed of the substances released when the propellant deflagrates (decomposes). The second stage involves a black cloud predominately comprised of the substances released by the combustion of the liner and combustible parts of the casing.

There are no emissions data for the open burning of missiles and rockets. Because the propellant burn is essentially complete before the combustion of the liner and casing begins, one could assume that the emissions for each stage are additive. Under this assumption, one could use the EFs/EFFs in this Chapter of AP-42 to estimate the emissions from the open burning of the propellant and another source (e. g., the emissions for the combustion of materials similar in composition to the liner/casing) to estimate the emissions from the liner and casing.

16.3.6.3 Open Burning of Combustible Explosive Contaminated Waste in Burn Pans

Combustible Explosive Contaminated Waste is a byproduct of explosive loading, unloading, packaging and related activities. Usually, a weight of propellant and HE scrap equal to 30 to 60% of the weight of the combustible explosive contaminated waste is used to initiate and support the combustible explosive contaminated waste burn. Although the exact composition of the combustible explosive contaminated waste varies from day to day, it usually contains rags, cotton gloves, wood sticks, polyethylene bags, corrugated cardboard and pressed cardboard propellant cups along with 1% HE and propellant materials. There are no emissions data for the burning of combustible explosive contaminated waste. Until these data become available, the emissions data presented in Appendix B of the background document could probably be used to estimate the emissions from the open burning of combustible explosive contaminated waste.[4]

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5. *Procedures for Preparing EF Documents*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Durham, NC. EPA Report - EPA 454/R-95-015 (Revised), September 1997.

Attachment 3 Background Document for AP-42 Chapter 16 (draft)

BACKGROUND DOCUMENT

AP-42 CHAPTER 16 -

EMISSION FACTORS FOR DEMILITARIZATION PROCESSES: OPEN BURNING AND OPEN AIR DETONATION

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DEMILITARIZATION PROCESSES

1.0 INTRODUCTION

1.1 Properties of the Materials Treated by Demilitarization

When subjected to heat, impact, friction, or shock, energetic compounds undergo a very rapid, self-propagating, intramolecular oxidation-reduction reaction (combustion) that results in the formation of highly stable simple gases and the release of heat (energy). This chapter of AP-42 applies to the emissions resulting from the disposal of energetic compounds and materials containing these compounds by open burning in burn pans and surface detonation. All of the explosive and propellant (energetic) materials covered by this chapter of AP-42 are solids at normal environmental temperatures and pressures and have melting points between 120 and 400^0F and vapor pressures less than 8E-05 kilopascals (7.9E-07 atmospheres).

The materials commonly disposed of by detonation are: reclaimed high explosives that cannot be reused, cased munitions, explosively-loaded ordnance components (e.g., primers and fuzes) and detonable rocket motor propellants. The materials commonly destroyed by open burning are: propellants, reclaimed high explosives that cannot be detonated and combustible materials contaminated with energetic residues from ammunition and ordnance manufacturing processes (Explosive Contaminated Waste, ECW).

1.2 Overview of Open Detonation and Open Burn Detonation Processes

NOTE - The information presented in this section was taken primarily from three U. S. Government reports - two issued by the Naval Air Warfare Center Weapons Division (NAVAIR), China Lake, CA[1, 2] and the other by Lawrence Livermore National Laboratories (LLNL).[3] The LLNL (Ornellas) report was the primary source for the information on the initial stage of the detonation process and the NAVAIR reports were the sources for the information on the remaining four stages of the detonation process.

The initial step in both open burning and detonation processes is an adiabatic, oxidation- reduction process, which involves oxidant (e.g., $-ONO_2$, $-NO_2$, $-NHNO_2$) and reductant (e.g., C_xH_y) radicals within the energetic molecule. Once this reaction is initiated, it will proceed to completion without any additional energy being required.

The major differences between the open burning and the detonation processes are the speed with which this adiabatic, oxidation-reduction reaction proceeds through the energetic material and the pressures and temperatures involved. In open burning the oxidation-reduction reaction occurs on the surface of the energetic material at close to atmospheric pressure and takes seconds to a few minutes to go to completion. The rate determining factors in open burning are the rate of heat transfer into the material and the rate of decomposition of the energetic material itself. There is no shock wave. In contrast, in detonation processes, the oxidation-reduction reaction proceeds through the material at a velocity (detonation velocity) between 7,000 and 35,000 ft/s, and the reaction is completed within a few microseconds. Detonations produce pressures as high as 350,000 atmospheres (35,300,000 kPa) and temperatures as high as $6{,}000^0$K.

Ornellas has demonstrated through experimentation that in detonations this intramolecular

rearrangement is so fast that only a small percentage of the atoms in one molecule have time to react with atoms in adjacent energetic molecules that are decomposing at the exact same time.[3] He demonstrated this through a series of bomb calorimeter experiments in which he detonated 20:80 (w/w) mixtures of ammonium nitrate (AN) and TNT. In these experiments, Ornellas used unlabeled AN (99.8% ^{14}N), labeled AN (99.1% ^{15}N isotope) and unlabeled TNT (99.8% ^{14}N). In one of the experiments, he made a slurry of TNT and AN in toluene, dried the slurry, blended it, sieved it through a 30-mesh screen and pressed the resulting powder into one-ounce, 0.5 in- diameter pellets, which he then detonated in the calorimeter. In the other experiment he detonated 0.5 in- diameter pellets containing a 0.25 in- diameter core of labeled AN and a 0.25 in annulus of unlabeled AN. After each detonation, he measured the isotopic content of the N_2 formed, i.e., $^{14}N\,^{14}N$, $^{14}N\,^{15}N$, and $^{15}N\,^{15}N$. The two experiments yielded similar results, i.e., only about 13% of the nitrogen in the TNT and the AN mixed.

Because the detonation of explosives does not require air, it can occur in a vacuum, in an inert atmosphere, or even under water. The initial detonation products are C (soot), carbon monoxide, hydrogen, methane, ethane, formaldehyde, nitrogen, carbon dioxide, water vapor, small hydrocarbons and small C_xH_y fragments. The initial stage of the detonation process is over in less than 10 microseconds and is followed by a 2 to 10 second duration fireball (afterburn). In this second stage of the process, combustible detonation reaction products (e.g., carbon monoxide, methane, ethane, formaldehyde, hydrogen and the C_xH_y fragments) are spontaneously oxidized (combusted) to CO_2 and H_2O. Fireball temperatures are on the order of 1,700 to 3,100°F. As the plume expands it entrains additional air which allows further combustion reactions to take place until the plume temperature falls to approximately $1{,}500^0$F where these reactions stop (freeze out temperature). The air-entrainment and afterburning occur almost simultaneously and are highly coupled. As the gases rise and air is entrained, soil is pulled into the plume. This entrained soil, along with the dirt released from the crater, forms the visible plume associated with detonations. Plume formation takes seconds to hundreds of seconds to complete and the subsequent dispersion of the plume in the atmosphere can take hours.

When easy-to-detonate materials are detonated, the detonation can often be initiated using an electric blasting cap (EBC) and plastic explosives such as C4 or A-3 or blocks of TNT. These latter materials are frequently referred as the detonation initiating charge and demolition charge. However, when difficult-to detonate materials are to be destroyed by detonation, its common practice to place an easy-to-detonate material (donor material or donor charge) in close contact with the difficult-to-detonate material and to use the detonation of this donor material to detonate the difficult-to-detonate material (sympathetic detonation). The manner in which the donor charges are placed, the methods used to prime or initiate the donor charges, and the amount of confinement (tamp), can strongly influence the effectiveness in the ability of the detonation to completely destroy all of the energetics, particularly in stacks of mixed ordnance. For example, common practice is to simultaneously initiate the detonation of the donor charges from both ends and also top center of the stack to minimize the possibility of munitions being expelled from the stack instead of being destroyed.

Open burning is generally conducted using steel pans sitting on concrete pads to avoid contact with the soil surface. The pans have sufficient depth and size to contain treatment residues and are kept covered when not in use. In open burning the materials are placed in a steel burn pan to a depth of four inches or less, and the burn is initiated with an electric match or a black powder train. Open burns of propellant materials, which usually involve between 1,000 and 5,000 lb of propellant generally go to completion in less than a minute, whereas, the burns of the other materials generally take at least three minutes to go to completion. The ash is recovered and, unless chemical analysis recommends otherwise, is disposed of as a hazardous waste.

1.3 Emissions from Open Burning and Detonation Processes

Between 1961 and 1981, Ornellas conducted a series of detonation experiments in bomb calorimeters, and evaluated how the following factors affected the efficiency and effectiveness of the detonation process: explosive density, purity, and particle size; the degree of confinement; and the type of initiating charge.[3] These experiments involved detonating one ounce cylindrical pellets of 43 energetic materials in a 5.3L bomb calorimeter and determining the chemical composition of the detonation plume.

Most of the detonations were done with the calorimeter evacuated to prevent afterburn from occurring, but a few were done when the calorimeter was pressurized with either CO_2 or O_2. Some of the detonations were done with the energetic simply suspended by a string to simulate unconfined detonations, and the others were done with the energetic encased in glass or metal cylinders. Sometimes the ends of these cylinders were open to simulate partially-confined detonations, but at other times they were closed to simulate fully-confined detonations.

Approximately 90 minutes after the detonation, gas samples were taken from the bomb calorimeter and analyzed for N_2, CO, CO_2, H_2, H_2O, CH_4, NO, NO_2, HCN, HCl, HF and volatile organic compounds (VOCs). The calorimeter itself was also rinsed out and the rinse analyzed for solid carbon (particulate), and when appropriate, for Al_2O_3 and Zr_2O_3.

His experiments established that the major emission products from an unconfined detonation are N_2, CO_2, and H_2O and the minor emission products were CO, H_2, CH_4, NO, NO_2, HCN, HCl, HF and volatile organic compounds (VOCs). Generally, at least 97% of the nitrogen in the energetic was released as N_2 and the rest was released as NO and NO_2. He also showed that the [chemical] composition of the initial detonation products was not greatly affected by the degree of confinement. For example, the initial emission products formed by detonating an energetic in a pure carbon dioxide atmosphere will be essentially the same as those formed when the energetic is detonated in a vacuum, regardless of the degree the energetic is oxygen-balanced.

The first comprehensive Department of Defense (DOD) study to characterize the air emissions from real-world open burning and detonation operations was conducted at Dugway Proving Ground (DPG), UT from 1984 through 1986. In this study, helicopters equipped with standard air pollutant sampling systems attempted to identify and quantify the pollutants in the plumes produced when 2,000 to 11,000 lb of bulk high explosives and propellants were open burned and detonated on a DPG test range. The results were inconclusive.[4]

In 1988, the United States Army conducted a highly successful follow-on study.[5-7] The first stage of this follow-on study involved detonating 0.5 lb quantities of TNT and open burning 5 lb quantities of a double-base and a composite propellant in a 32,900 ft^3 hemispherical chamber (BangBox) at Sandia National Laboratories (SNL) in Albuquerque, NM. A suite of state-of-the art sampling systems was then used to characterize the identities and quantities of the emission products present in the plumes. The results from these burns and detonations were used to select the plume sampling equipment subsequently used to measure chemicals of environmental concern in the plumes produced when large quantities of energetic materials were detonated and burned on an open test range at DPG. The sampling equipment selected was installed in a twin-engine, turboprop aircraft and the aircraft was used to sample the plumes released when 2,000 lb of high explosives [contained in either wood boxes or steel barrels] were detonated and when

5,000 to 7,000 lb of propellants were open burned in steel pans at DPG.

Based on the test results, DOD concluded that the plumes released when energetic materials are destroyed by open burning and detonation processes do not contain sufficient quantities of toxic or hazardous pollutants to pose a danger to human health or the environment. For example, the average emission factors (EF) for the semi-volatile organic compounds (SVOCs) and polycyclic organic matter (POMs) detected was approximately 2E-07 lb/lb NEW detonated/burned and the average EF for benzene, the most toxic volatile organic compound (VOC) was approximately 1E-04 lb/lb NEW detonated/burned. It also concluded that the emission factors for the predominant emission products (EPs) produced in the BangBox (BB) emissions tests were statistically equivalent to those produced in the DPG open range tests and those produced in Ornellas' bomb calorimeter experiments.. That is, the EPs did not change substantially even when the quantity of energetic material detonated increased by a factor of 32,000.

In 1992, the U.S. EPA concurred with DOD's conclusions and agreed to accept BangBox-produced emission factors as representative of those that would be derived through ground level, open-air detonation and burn tests.[6] The U. S. Army then installed a BangBox at DPG and conducted a series of studies that characterized the air emissions produced when bulk and cased high explosives were detonated and bulk propellants were burned. These studies were then followed by larger scale detonation and burn experiments in a larger chamber at the Nevada Test Site that involved detonating 155MM projectiles and burning Hawk and NIKE rocket motors.[8-13] All of these studies employed plume sampling and analysis systems that were similar to those used in the earlier DPG open range studies, but also added the following target analytes: 140 additional VOCs, 100 additional SVOCs/POMs, HCl, Cl_2, metals, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDDs) and SO_2.

These follow-on studies filled in some of the major data gaps left by the open range studies and reconfirmed the conclusions of Ornellas and the DPG open range studies that the predominant emission products for open burning and detonation processes are: particulate, CO_2, N_2, soot, CO, NO_x, metals and the first members of the saturated, unsaturated and aromatic hydrocarbon series. Further, polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran compounds (PCDDs/PCDFs) were not detected in the plumes. (The nominal minimum detection limit (MDL) of the PCDD/PCDF measurement system used in the detonation trials was 7E-11 lb/ lb NEW and that used in the open burn trials was 9E-12 lb/lb NEW.)

Further, in the few instances when SVOCs/POMs were detected, the concentrations were indistinguishable from those found in ambient air and it IS very likely that these compounds were present in the ambient air when the detonation was initiated. The failure to find PCDDs/PCDFs, SVOCs and POMs might seem surprising because these compounds are detected in the combustion gases of hazardous waste incinerators and the second stage of open burn and detonation processes involves combustion reactions. The reasons they are not present are: (1) by the time the second stage begins, the energetic material has already decomposed into very small, mostly thermodynamically stable molecules, and (2) the short duration and high temperatures associated with the second stage prevent the reactions from occurring that would convert a meaningful number of these small molecules into polycyclic molecules. In contrast, the temperature associated with the combustion of hazardous wastes are on the order of 900 to $1,600^0$F, and the original waste material is held in this temperature range for more than a minute, conditions that promote the formation of polycyclic organic molecules.[14-18]

This background document to Chapter 16 of AP-42 (Demilitarization Processes) contains a compilation of the EFs produced in the above studies that were judged to be reasonably representative of real-world open burn and detonation practices. It was funded by the U.S. Army's Defense Ammunition

Center (DAC), McAlester, OK, to provide the environmental community with a database of emission factors that could be applied to: ambient air pollutant fate and transport modeling, pollutant control strategy development, permit applications, preparing Toxic Release Inventory (TRI) reports, screening detonation disposal practices to identify the materials which could be a significant source of the toxic pollutants of concern to the environmental community, demil workload planning, and developing green munitions.

The emission factors were selected and graded in accordance with the Essential Characteristics of Emission factors (Table 1) and the quality rating factors for emissions data sets (Table 2) and databases (Table 3) contained in the USEPA guidance document entitled: *Procedures for Preparing Emission Factor Documents*.[19] In carrying out this selection and grading, the composition data on the materials detonated in the individual test reports was supplemented with information in the Munitions Items Disposition Action System (MIDAS). (MIDAS is a set of relational databases that provide information on the weight and chemical composition of more than 8,500 munitions and munition components. It was developed and is continuously updated by the U.S. Army Defense Ammunition Center, McAlester, OK.)

The following procedure was used to select the emissions data contained in AP-42. First, the existing emission data sets were reviewed to identify data sets that did not meet the minimum criteria specified in the EPA guidance, and therefore, should be rejected from further consideration. Second, the data sets that passed this preliminary evaluation were entered into an Excel workbook along with information on the test conditions and chemical compositions of the energetic materials whose emissions were characterized. Third, for each individual data set the information in the Excel workbook and the test reports was then evaluated against the EPA data quality rating criteria in Section 4.4.2 of Reference 19. The results of this evaluation were used to select the emissions data selected for inclusion in Chapter 16 of AP-42.

1.4 Emission Controls

There are no emissions controls on either detonations or open burning operations per se. However, some of the engineering controls used to reduce the intensity of the propagation of the blast (sound) and pressure waves and the release of shrapnel from detonations do affect the relative ratios of the emission products released into the environment. This is especially true when the formation of a full fireball is inhibited. For example, compared to an unconfined detonation of the same material, detonating an energetic material under a light soil cover, which provides some confinement, increases the quantity of soot, CO and unsaturated hydrocarbon emission products released into the plume but decreases the quantity of CO_2 and the height to which the plume rises.

1.5 Definitions of the Units of Measure Used

The emissions data are presented in two formats: (1) the traditional reporting unit (mass released per mass of the net explosive weight (NEW) detonated or burned; and (2) an alternate reporting unit (mass released per mass of a specific chemical substance in the material detonated or burned. This alternate reporting unit was used when there was a known relationship between an emission product and a substance in the test material. This alternative unit is designated as the Environmental Fate Factor (EFF) and the traditional unit is designated as EF. The EF and EFF reporting units used for each EP and EP category are presented in Table 1.

This alternate reporting unit was developed because there is no direct relationship between the mass of the EP and the NEW detonated or burned. But there is such a relationship between the composition of the energetic material and the mass of the metal and some of the carbon and nitrogen containing EPs. Knowing these relationships can be very important when trying to use emissions data derived from chamber-based experiments to assess the true risk posed to human health and the environment by a specific detonation or burn process. For example, because of limitations on the quantity

of the energetic material that could be detonated in the BangBox, the ratio of the explosive mass used to initiate some detonations (demolition charge) to test item explosive mass was many times higher than the ratio that is used in real-world detonations.

Table 1. EF and EFF Units Used.

EP/EP Category	Units
CO_2, CO, VOCs	lb EP/ total lb C in material detonated/burned
NO_x	lb EP/ total lb N in material detonated/burned
HCl, Cl_2	lb EP/ total lb Cl in material detonated/burned
Energetics	lb EP/ total lb related energetic in material detonated/burned
PM-10	lb EP/ total lb NEW
SVOCs/POMs in the energetic material	lb EP/ total lb related SVOC in material detonated/burned
SVOCs/POMs not in the energetic material	lb EP/ total lb NEW
PCDDs/PCDFs	lb EP/ total lb NEW
Metals	lb EP/ total lb related metal in material detonated/burned
SO_2	lb EP/ total lb NEW(a)

(a) Although it would be more appropriate to use EFF values for the SO_2 emissions, it is not possible to convert the EFs to EFFs at this time due to uncertainties about the actual sulfur content of the test items.

1.6 Special Handling for Metal Emissions Data Sets

Metals of environmental concern are present in energetic materials in a wide variety of forms and matrices. For example, MIDAS shows that the 20mm HEI cartridge detonated in the DPG BangBox contained metals in the following forms and locations:

- As an energetic compound, i.e., lead styphnate in the fuze.
- As propellant and explosive performance modifiers, i.e., tin oxide in the propellant and barium nitrate in the explosive.
- As an alloy, i.e., copper, zinc, and lead in the brass casing and the primer cup and manganese in the steel projectile body.
- As a protective coating, i.e., zinc phosphate and zinc chromate in the paint on the projectile body and cadmium chromate plating on some of the internal metal parts in the fuze.

- As a particle, i.e., zirconium pellets in the incendiary material.

When the 20mm HEI round is detonated, one would intuitively expect that a significant fraction of the lead in the lead styphnate would be released into the plume, whereas only a very small fraction of the lead in the brass casing and primer cup would be. Further, because the brass would not have melted or vaporized, the lead in the brass parts would stay in the brass and this would restrict its biological availability.[2] Since the location and form of the metal in a munition can be very helpful in assessing the potential risk posed by the metals released into the detonation plume, it was decided to enter the metal EF and corresponding EFF values in AP-42 under the following categories, whenever possible:

- Metals in Alloy (includes casings and interior metal parts)
- Metals in Energetic as Particle
- Metals in Energetic as Compound
- Metals in Protective Coating (includes paints and platings)

NOTE - Most alloys contain at least one metal of environmental concern. There is an extensive body of theoretical and experimental data showing that these metals are not released from the alloy during the detonation or burn.[1]

1.7 Definitions of the Letter Codes Used

When it was not possible or not appropriate to enter a numerical EF or EFF value, the letter codes presented in Table 2 were used.

Table 2. Explanation of Letter Codes Used in This Chapter of AP-42.

Letter Code	Explanation
NS (No Sample)	Not a target analyte.
NA (Not Applicable)	There is no information available to indicate that the test material contained a substance that could produce this EP or there is no definable relationship between the traditional EF and the test material that would permit calculating the corresponding EFF value.
ND (No Data)	Sample collected but either no result reported or data generator invalidated sampling result.
	Not possible to adjust the reported value for the contribution from test chamber surfaces and/or background air.
	Not possible to adjust the reported value for an erroneous sample background correction adjustment.
	Not possible to convert the traditional EF to the alternate EFF because critical composition data is not available for the test material.
BDL (Below Detection Limit)	Possible emission product, but either never detected or, if detected, never detected above the background level.

2.0 SELECTION OF DETONATION EMISSIONS DATA

2.1 DPG Open Range Detonation Emissions Data Sets

2.1.1 Test Description

The five detonation emissions data sets were produced in 1989 and 1990 when 2,000 lb of four explosives were open detonated on a test range at DPG.[5-7] The detonations were initiated with 10 to 20 lb of either C4 or TNT block. Four of the data sets were derived from uncovered, ground-level detonation experiments (surface detonations) and the fifth was derived from a set of detonation experiments in which the explosive was suspended in a steel barrel approximately 35 feet above the ground (suspended detonation). The testing was done in three phases designated by the Army as Phase A, Phase B and Phase C. (NOTE - Below ground TNT detonations planned for Phase C were not conducted because of a lack of funds.)

Samples were collected from 43 detonation plumes by means of a twin-engine turboprop airplane that traversed the plume at 90 knots (150 ft/ second). The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between three and seven seconds. For safety reasons and to allow all chemical reactions to go to completion, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted, 10 ft long, 3-in I.D. aluminum probe, which exited into a 11 ft long, 4 in. ID sampling manifold inside the airplane. The probe extended outside the aircraft's boundary layer at a position forward and above the copilot's windshield. A sliding valve located at the union of the probe and sampling manifold directed the plume gases into either the manifold (sampling mode) or back into the atmosphere (bypass mode).

The following sampling equipment was attached to the sampling manifold: an 80 L, Tedlar bag; three high volume samplers containing Teflon-coated quartz fiber filters (sampling at a rate of three to four m^3/min); and an evacuated 6 L stainless steel canister. As the airplane approached the plume for its initial pass, the high volume sampler motors were started, but the manifold sampling valve was left in the bypass mode. When the nephelometer mounted in the front of the airplane indicated that the airplane was entering the plume (sharp increase in nephelometer reading), the manifold sliding valve was moved to the sampling mode. When the nephelometer indicated that the airplane was exiting the plume (sharp drop off in the nephelometer reading), the sliding valve was placed in the bypass mode, where it remained until the airplane was ready to make its next pass through the plume. After each pass through the plume, the VOC canister sampler was removed from the sampling manifold and replaced with a clean evacuated one while the other samplers remained unchanged. After the final pass through the plume, the high volume sampler motors were turned off and the CO_2, CO, NO and NO_2 concentrations in the Tedlar bag were determined using continuous emission monitors (CEMs) on board the aircraft. The crew then prepared to sample the next detonation plume by evacuating the 80 L Teflon bag and attaching a clean, evacuated 6 L canister to the manifold. The crew then prepared to sample the next detonation plume by evacuating the 80 L Teflon bag and attaching a clean, evacuated 6 L canister to the manifold.

Each detonation trial consisted of three to five detonation events spaced 10 to 25 minutes apart. To ensure that sufficient particulate would be collected to allow characterization of the SVOC and energetic compound content of the particulate, the same high volume filters were used for all detonations comprising a trial. This approach produced total high volume sampling volumes from 280 to 350 ft^3 (8 to 10 m^3).

No attempt was made to collect plume samples for analysis for HCl or for dioxins and furans, because detonation tests conducted in the SNL BangBox indicated that either none of these compounds would be emitted or, if they were emitted, the concentrations would be too low to detect with the available equipment. In addition, no attempt was made to sample for toxic metals, because none of the materials detonated contained them.

Each test day, before the first detonation or burn trial was conducted, the airplane collected a 20-minute background air sample 1,000 ft above the test range using the same sampling procedures and equipment that would be used to collect plume samples. The concentrations of target analytes found in these background samples were used to correct the emission factors produced that day for the contribution from ambient air pulled into the plume. (NOTE - This approach assumes that the only background air species present in the plume are those present in the air before the detonation. It ignores species knocked off surfaces by the shock wave and turbulence produced in the detonation. Because these latter materials are not included in the background sample, they become part of the reported emissions. Since many of the SVOC/POM and energetic target analytes were known to be present in the soil, and most of the particulate matter was soil.[6] Thus, it is likely that some of the SVOC/POM and energetic EPs were actually extraneous material pulled into the plume along with or from the soil.)

At the conclusion of each trial or background sample collection effort, the aircraft returned to the airfield where the high volume filters were recovered, placed in an ice-cooled container, and transported to a laboratory in Provo, UT (where they were stored in a freezer). The filters were subsequently weighed, Soxhlet-extracted, and the extract analyzed for the target SVOCs/POMs and energetics by GC/MS and Super Critical Fluid Chromatography/MS-selective ion monitoring (SFC/MS-SIM), respectively. The 6 L canisters were sent to a laboratory in Beaverton, OR for analysis for EPA Method TO-14 for volatile organic compounds (VOCs).

A description of the measurement systems used in these tests is presented in Table 3, and a list of the target analytes is presented in Table 4. Because of the prove-out nature of the project and funding limitations, the number of SVOC target analytes was kept small.

Table 3. Emissions Test Methods Used in DPG OD Field Studies.

Target Analyte or Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (CSI Model 1600) [Sampling and Analysis]
PM-10	40 CFR 50, Appendix B combined with aircraft sampling probe
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOCs/POMs	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and GC/MS [Analysis]
Energetics	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and analysis by Supercritical Fluid Chromatography/MS (SFC / MS)
CO, CO_2 (Primary CO and CO2 Sampling System)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)

Table 4. DPG Detonation Field Test Target Analytes.

Inorganic Gases and Particulate Matter	NO, NO_2, CO, CO_2 , PM-10
Volatile Organic Compounds (VOCs)	Aromatic hydrocarbons, C_1 to C_{10} saturated and unsaturated hydrocarbons and chlorinated hydrocarbons.
SVOCs/POMs	Benz(a)anthracene, benz(a)pyrene, dibenzofuran, N–nitrosodiphenylamine, 2-methylnaphthalene, naphthalene, nitrobenzene, phenol, 4-nitrophenol, phenanthrene, pyrene, pyridine, 1-nitropyrene, 1,3,5-trinitrobenzene, 2-nitrotoluene, 4-nitrotoluene; 2-nitronaphthalene, diphenylamine, 2-nitrodiphenylamine, 2,4-dinitrophenol, 2,4-dinitrotoluene and 2,6-dinitrotoluene.
Energetics	Nitroglycerine (NG), HMX, TNT, RDX, Picric acid (Surrogate for Explosive D which is ammonium picrate).

2.1.2 Description of the Test Materials and Detonation Piles

The composition of the four materials characterized and the number of plumes sampled for each are presented below.

2.1.2.1 Reclaimed TNT

Ground Level TNT (Surface) Detonations. Ground level TNT detonations were conducted in all three phases of the test series (Figure 1). Phase A contained a single trial consisting of five, 898 kg (1,975 lb) detonations, Phases B, and C each contained two, three-detonation trials that involved detonating 909 kg (2,000 lb) of TNT. The detonation events were spaced between 10 and 25 minutes apart.

Above Ground Level (Suspended) Detonations. Suspended TNT detonations were conducted in Phases B and C and involved detonating 909 kg (2,000 lb) of TNT in a barrel that was suspended approximately 35 ft above the ground (Figure 2). The Phase B suspended detonations involved two three-detonation trials and the Phase C involved one three-detonation trial. The detonation events were spaced approximately 15 minutes apart. (NOTE - Although the suspended TNT detonations did not reflect real-world detonation practice, it was decided to include their emissions data because a comparison between the suspended and surface TNT detonation data sets provides the user of AP-42 some insight into the effect of soil on the final mix of detonation EPs.)

Figure 1. 2,000 lb Surface TNT Detonation at DPG

Figure 2. Suspended TNT Detonation at DPG

2.1.2.2 Reclaimed RDX Materials

RDX. The reclaimed RDX was detonated in the pasteboard boxes in which it was received. Two three-detonation trials were conducted. The material detonated contained approximately 836 kg (1,840 lb) of RDX and 45.5 kg (100 lb) of Viton A rubber. The average NEW for the three detonations in the first trial was 875 kg (1,926 lb), and the average NEW for three detonations in the second trial was 886 kg (1,950 lb). The three detonations in the first trial and the first two in the second trial were spaced approximately 15 minutes apart. The third detonation in the second trial was initiated approximately 20 minutes after the second detonation.

Composition B. The composition B was reclaimed material in flake form and contained approximately 360 kg (790 lb) of TNT, 525 kg (1,155 lb) of RDX, and 10 kg (22 lb) of wax. Two three-detonation trials were conducted. In each trial, the detonations were spaced approximately 15 minutes apart. The NEW of each detonation was 886 kg (1,950 lb).

2.1.2.3 Reclaimed Explosive D

The reclaimed Explosive D was in granular form and contained more than 99% ammonium picrate (Explosive D). Two three-detonation trials were conducted. The NEW of each of the six detonations was approximately 916 kg (2,015 lb). During the first trial, the second detonation was initiated approximately 10 minutes after the first and the third was initiated approximately 21 minutes after the second detonation. In the second trial, the three detonations were spaced approximately 20 minutes apart.

2.1.3 Calculation of the Emission Factors

The Army used the ratio of the carbon content of the material detonated to the carbon content of the plume sample (as represented by the sum of the CO_2, CO and CH_4 concentrations) to calculate the plume volume at the time the plume samples were collected. This method for determining plume volume which is usually referred to as the Carbon Mass Balance Approach rests on the following two premises whose validity was confirmed in tests in the SNL BangBox[5] and in Ornellas' calorimeter-based detonation experiments[3] before the Phase A field tests were conducted.

- In an unconfined (open) detonation essentially all of the carbon in the materials detonated is converted to CO_2, CO and CH_4.

- The proportional distribution among the carbon-containing gaseous emission products within individual micro-regions of the detonation plume remains relatively constant, even though the individual concentrations may be different within the macro-regions of the plume.

Thus, by determining the mass of the carbon in a known volume of the plume and the total mass of carbon in the material detonated, one can determine the volume of the plume at the time the plume sample was collected. This plume volume can then be multiplied by the concentration of any target analyte in the same plume sample (or one taken at the same time and location) and divided by the NEW of the material detonated to derive an emission factor for that analyte (Equation 1).

$$EF_i = (f_c)[\text{analyte i}]/[C_j] \qquad \text{(Equation 1)}$$

where:

EF_i = EF for target analyte i (lb/lb NEW)

f_C = mass of C in the energetic divided by mass of the explosive (NEW) detonated.

[analyte i] = background-corrected concentration (lb C /ft^3) of the target analyte collected from volume element j of the plume.

$[C_j]$ = background-corrected concentration of carbon (lbC /ft^3) collected from volume element j of the plume [as represented by the CO_2, CO and CH_4 compounds found in the canister VOC sample taken from the 80L bag].

2.1.4 Identification of Emissions Data Sets Appropriate for Inclusion In AP-42

Each emissions data set was examined and evaluated to determine if the EF in the data sets were suitable for inclusion in AP-42 and the quality rating that should be assigned to it. This evaluation used the Army-derived MDL values, the compositions of the material detonated contained in the test reports, information about the pretest concentrations and distribution of VOC, energetic and SVOC compounds in the background soil and air samples at the test site, mass balance calculations, the QA and QC reports included in the Appendices of the test report, the results from Ornellas experiments and the EPA guidance

document.

Based on this evaluation, the decision was made to exclude the Phase B TNT emission test results because the test report had noted that the TNT did not meet the test specifications. It was described as being wet, nonhomogeneous, some portions were very friable and others not so friable, and the TNT was severely discolored. Even though it did not meet the test plan quality specifications, it was used for the following reasons. First, because it was not possible to obtain another batch of TNT before the test. Second, a considerable portion of the Phase II funds had already been spent preparing to conduct the Phase B tests, and postponing the tests would mean that either the Phase B test program would have to be scaled back considerably or the scope of the Phase C experiments would have to be reduced substantially.

The following decisions were made regarding the individual emissions data sets.

2.1.4.1 Inorganic Gases

CO and CO_2. For each material detonated the Army reported two sets of emission factors for CO and CO_2. Each set contained a minimum, maximum, and average emission factor. One set represented the results for the continuous emissions monitors located in the airplane, and the other set represented the analytical results from the canister samples. Although the two sets of values compared very well, the Army designated the canister results as the most representative emissions data for CO and CO2. Therefore, only the emission factors attributable to the canister samples were examined in detail. This examination showed that for the four test materials, the mass of carbon represented by the CO and CO_2 emission factors accounted for more than 99% of the mass of carbon in the test materials. Since these values are reasonable and consistent with the work of Ornellas and the results from other studies, the canister-sampling results were entered in the AP-42 Excel workbook.

NO_x. For each material detonated the Army reported only a minimum, maximum, and average EF for NO and NO_2. For all of the materials detonated, the mass of nitrogen represented by the NOx emission factors was less than 1% of the mass of nitrogen in the explosive. Because the values were reasonable and consistent with detonation reaction theory and the results from other emission characterization studies, the NO and NO_2 values for each material were converted to the equivalent NO_X EFF value (as NO_2 equivalent) and the results entered in the AP-42 Excel workbook.

2.1.4.2 Particulate Results

The Army reported the following average particulate plume concentration for each material detonated: RDX (200 mg/m^3), Composition B (200 mg/m^3), Explosive D (250 mg/m^3), TNT surface (Phase A - 45 mg/m^3, Phase C - 258 mg/m^3) and TNT suspended (Phase C - 37 mg/m^3). It noted that almost all of the particulate mass consisted of soil particles, but it did not provide detailed information on the exact percentage for each test material detonated. Further, it did not report the associated plume volumes required to convert these concentrations to the equivalent emission factors, and the original test reports were destroyed in 1998 because of the possibility that they were contaminated with the hantavirus. (Mice had made nests in the boxes containing the original data sheets and the hantavirus was known to be present in the rodent populations at DPG at the time.) However, there was a statement on page 4-2 of Volume 1 of the Field Test Report[6] that the average carbon plume concentration for one set of the TNT detonations was 34.95 mg C/ m^3 and that almost all of the carbon in the plume was in the form of CO_2. Therefore, it was decided to use this value to convert the particulate concentrations to the equivalent EF by multiplying each average particulate concentration by the mass of carbon in the material detonated and

dividing the resulting product by the NEW detonated and 34.95 mg C/ m^3.

2.1.4.3 Volatile Organic Compounds

The Army report contained emission factors for only three VOC analytes: benzene, methane, and Total Nonmethane Hydrocarbons (TNMHC). For each energetic material detonated in each phase of the testing, the Army reported only the minimum, maximum, and average emission factors for these three VOC target analytes. Since the average EF for each of these emission products was consistent with Ornellas' work and the results from other OD emission characterization studies, the values were entered in the AP-42 Excel workbook.

The Army used the following justification for not including the emissions results for the other VOC target analytes in the test report. First, the SNL BangBox and the DPG field test results had demonstrated conclusively that the VOCs emitted were almost exclusively the first members of the alkane, alkene, and alkyne classes of hydrocarbons (which are not toxic), and the first members of the aromatic hydrocarbon class, of which benzene is the most toxic. Second, it wanted to avoid overwhelming the reader with nonessential emissions data. Third, for every energetic material detonated in the BangBox and on the test range at DPG, benzene represented a substantial percentage of the total mass of the aromatic hydrocarbons found, but was only 2.0 % of the total mass for all of the nonmethane hydrocarbons (TNMHCs). Thus, the benzene EF would serve as a reasonable estimate for the toxic aromatic emissions, and the reader would realize how small the toxic VOC emissions were with respect to all the other hydrocarbons released.

2.1.4.4 Semi-Volatile Organic Compounds and Polycyclic Organic Matter (SVOCs/POMs)

For each test material, the Army reported a single, background-corrected EF for each SVOC/POM target analyte found. This value was the largest EF obtained for that analyte across all of the plumes sampled in that phase of the study. Even if the analyte was found in only one plume, it was reported as if it was a representative emission product for that test material. The Army did not provide information on the total number of plumes in which the analyte was detected for the test material. If a target analyte was detected at a concentration that was either less than the MDL of the measurement system (1E-08 lb/lb NEW) or was less than the concentration found in the background air sample, the Army reported the result as BDL. Analytical results contained in the test report and background documents[6] show that most of the SVOC/POM found in the plume were also present in either the background air sample taken 1,000 feet above the test range or the soil samples taken at the detonation sites prior to the detonations. Thus, these EFs represent very conservative emission estimates.

There are three sources for the SVOCs/POMs found in detonation plumes:

- SVOCs/POMs, such as, 2, 4-dinitrotoluene, diphenylamine, 2-nitrodiphenylamine and dioctylphthalate that were added to the energetic material during the manufacturing process. Generally, these SVOCs/POMs are added either to modify the performance of the energetic material or to inhibit degradation and separation of the ingredients.

- SVOCs/POMs pulled into the plume with the soil and the ambient air during plume rise and dilution.

- SVOCs/POMs formed by the reaction of the small molecules and molecular fragments produced in the initial stages of the detonation or burn event.

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Since there was no information in the test report to indicate that any of the SVOC target analytes were present in the energetic test materials detonated, the SVOC emissions were evaluated on the assumption that none of the SVOCs/POMs detected in the plumes were in the test material. Based on the assumption, the following decisions were made about entering the SVOC/POM results in the Excel workbook.

- For the Comp B, RDX, Explosive D, and Suspended TNT detonations for which there were only one maximum EF value, the reported EF value was entered.

- For the surface TNT detonations for which there were sometimes two maximum EF values for each target analyte (one from the Phase A detonations and the other from the Phase C detonations), the following actions were taken:

  - When there were two numerical EF values, the average EF was included.

  - When one of the two EFs was a BDL entry, the BDL entry was replaced with 5E-09 lb/lb NEW (a value equal to ½ of the MDL) and the average of the two EFs was entered.

- A value of BDL (Below Detection Limit) was entered for the target analytes that were not detected in any detonation plume for that test material.

2.1.4.5 Energetics

For each test material, the Army reported a single, background-corrected EF for each energetic target analyte found. This value was the largest EF obtained for that analyte across all of the plumes sampled in that phase of the study. Even if the analyte was found in only one plume, it was reported as if it was a representative emission product for that test material. The Army did not provide information on the number of plumes in which the analyte was detected for the test material. When an energetic target analyte was detected at a concentration that was either less than the MDL of the measurement system (1E-09) or was less than the concentration found in the background air sample, the Army reported the test result as BDL. Analytical results contained in Appendix G of the report show that most of the energetic target analytes found in the plume were also present in soil samples taken at the detonation sites prior to the detonations. Thus, these EFs represent very conservative emission estimates.

The following decisions were made regarding entering the energetic emission test results in the Excel workbook:

TNT Surface Detonations: The average of the two maximum EF values for TNT (one from the Phase A detonations and the other from the Phase C detonations) was entered.

RDX and Explosive D and Suspended TNT Detonations:

- If the Army had reported a numerical EF for an energetic target analyte that was a possible emission product, the reported value was entered.

- If the Army had reported a BDL value for an energetic target analyte that was a possible emission product, the original MDL value (1E-09 lb/lb NEW) was converted to the

equivalent EFF MDL value (lb/lb energetic compound) and 1/2 of the resulting EFF value was entered. (The EFF MDL was calculated by multiplying the EF value by 2,000 lbs and then dividing the resulting value by the lbs of the energetic in the detonation pile.)

Comp B Detonations. The numerical EF value for TNT was entered as ND and the BDL EF value for RDX was entered as 5E-10 lb RDX / lb NEW. The TNT EF value was changed to ND based on the following analysis. First, Comp B is comprised of 60% RDX, 39% TNT, and 11% wax by weight, and RDX was not detected in any of the detonation plumes even though the MDL value (1E-09 lb RDX / lb NEW) was over 100 times less than the EF value reported for TNT. Second, RDX was not found in any of the soil samples collected before the Comp B detonations were initiated but TNT was detected. Third, RDX was not found in any of the soil samples collected in the ejecta pans, but TNT was detected. Fourth, if the Comp B did not detonate completely, RDX should have been present in the plumes and soil samples at levels above those found for TNT. Therefore, it was concluded that the TNT EF was an artifact produced by TNT contaminated soil that was present before the detonations were done.

For All Detonations: If a data set contained a numerical EF or a BDL value for an energetic compound that was not a possible emission product (because it was not in the detonation pile), the emissions result was entered as NA.

2.1.5 Emissions Test Data Quality Ratings Assigned to Each EF/EFF

With the exception of the PM-10 EFs, the EFs reported by the Army possessed the following characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology under conditions representative of real-world detonation processes. Second, the test reports contained detailed descriptions of the substances in the materials detonated. Third, the assumptions underlying the plume volume calculation were sound. Fourth, the test reports showed that all field testing and laboratory analysis activities were extensively and continuously audited by an independent DPG contractor and also by the EPA over the life of the project. Fifth, although the raw data sheets are no longer available, the report shows that they were used to construct the EFs presented in the test report. Sixth, the test reports showed that before the final report was issued, the raw data and the test results had been subjected to an extensive technical peer review by a widely respected set of scientists and a comprehensive audit by an EPA Region VIII contract chemist, who had not been involved in any part of the test program.

Based on these characteristics and the quality rating criteria recommendations in Section 4.4.2 of EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of B.

2.1.5.1 Inorganic and Volatile Organic Gases

The inorganic gases were subsequently upgraded to a quality rating of A based primarily on the following: the number of plume samples collected for each material, the close agreement between the test materials and the agreement of the test results with both detonation reaction theory and the work of Ornellas.[3]

2.1.5.2 Energetics and SVOCs/POMs

The EPA quality rating of B was retained. Although the environmentally conservative nature of the results and the high sensitivity of the measurement systems (1E-08 lb/lb NEW for SVOC / POM and 1E-09 lb/lb NEW for the energetic target analytes) could justify upgrading the rating to A, the lack of information on the number of times the analyte was detected could justify lowering the rating to C.

2.1.5.3 PM-10

The PM-10 results were assigned a rating of D for the following reasons. First, the results were calculated using a single plume volume. Second, the report noted that more than 85% of the PM-10 collected was soil and, because the soil at DPG is very powdery, the results may be very specific to DPG. Third, the PM-10 values were derived by assuming that most particles above PM-10 dropped out in the sampling probe/manifold, but the researchers reported that it was likely that a meaningful number of these deposited particles were re-entrained. Fourth, the researchers also noted that the wetness of the soil also influenced the quantity of soil entrained in the detonation plume.

2.1.6 Tabulation of the Emissions Data

The TNT emissions data are presented in Table 5 and the RDX, Comp B, and Explosive D emissions data are presented in Table 6. The quality rating factor assigned to each EF/EFF value are also presented in these tables. In these tables, EFF values derived by substituting a value equal to 1/2MDL for a BDL value are in italics.

Table 5 EFs & EFFs for the Detonation of TNT.

EP Category	CASRN	EP	Units	Reclaimed TNT (Surface)		Reclaimed TNT (Suspended)	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	7.2E+00	D	1.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	B	BDL	B
	522-43-0	1-Nitropryene		BDL	B	BDL	B
	51-28-5	2,4-Dinitrophenol		BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene		7.5E-08	B	BDL	B
	606-20-2	2,6-Dinitrotoluene		8.5E-09	B	BDL	B
	91-57-6	2-Methylnaphthalene		BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine		BDL	B	BDL	B
	122-39-4	Diphenylamine		BDL	B	BDL	B
	581-89-5	2-Nitronaphthalene		4.0E-08	B	BDL	B
	88-72-2	2-Nitrotoluene		BDL	B	BDL	B
	100-02-7	4-Nitrophenol		BDL	B	BDL	B
	99-99-0	4-Nitrotoluene		BDL	B	BDL	B
	56-55-3	Benz(a)anthracene		5.0E-08	B	3.2E-07	B
	50-32-8	Benz(a)pyrene		BDL	B	BDL	B
	132-64-9	Dibenzofuran		9.0E-08	B	1.9E-07	B
	91-20-3	Naphthalene		1.3E-06	B	1.8E-06	B
	98-95-3	Nitrobenzene		BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine		BDL	B	BDL	B
	85-01-8	Phenanthrene		BDL	B	BDL	B
	108-95-2	Phenol		1.0E-06	B	1.0E-06	B
	129-00-0	Pyrene		1.1E-07	B	1.9E-08	B
	110-86-1	Pyridine		BDL	B	BDL	B
Energetics	121-82-4	RDX	lb/lb Energetic	NA	NA	NA	NA
	118-96-7	TNT		1.4E-07	B	9.3E-08	B
	88-89-1	Picric acid		NA	NA	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	A	3.8E+00	A
	630-08-0	Carbon monoxide		1.5E-01	A	1.9E-02	A
	NA	Nitrogen Oxides	lb/lb N	1.8E-02	A	2.6E-02	A
VOCs	71-43-2	Benzene	lb/lb C	2.6E-04	B	1.7E-04	B
	74-82-8	Methane		4.1E-03	B	4.0E-03	B
	NA	TNMHC		4.9E-03	B	1.3E-02	B
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA
(a) MDL = 1.0E-08 lb/lb NEW							

Table 6. EFs & EFFs for the Detonation of RDX, Comp B and Explosive D.

EP Category	CASRN	EP	Units	Reclaimed Comp B		Reclaimed Explosive D		Reclaimed RDX	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	9.0E+00	D	1.1E+01	D	9.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	5.9E-08	B	1.8E-08	B	5.0E-08	B
	522-43-0	1-Nitropryene		5.6E-08	B	1.1E-08	B	5.0E-08	B
	51-28-5	2,4-Dinitrophenol		BDL	B	BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene		4.5E-07	B	5.9E-07	B	2.1E-07	B
	606-20-2	2,6-Dinitrotoluene		2.4E-08	B	8.0E-08	B	4.1E-08	B
	91-57-6	2-Methylnaphthalene		BDL	B	BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine		7.2E-08	B	5.8E-08	B	3.4E-08	B
	122-39-4	Diphenylamine		6.6E-08	B	1.9E-08	B	3.1E-07	B
	581-89-5	2-Nitronaphthalene		8.6E-08	B	4.3E-08	B	4.9E-08	B
	88-72-2	2-Nitrotoluene		BDL	B	BDL	B	BDL	B
	100-02-7	4-Nitrophenol		BDL	B	BDL	B	BDL	B
	99-99-0	4-Nitrotoluene		BDL	B	BDL	B	BDL	B
	56-55-3	Benz(a)anthracene		BDL	B	1.9E-08	B	9.3E-08	B
	50-32-8	Benz(a)pyrene		1.4E-08	B	3.8E-08	B	1.4E-07	B
	132-64-9	Dibenzofuran		BDL	B	1.1E-07	B	2.0E-06	B
	91-20-3	Naphthalene		4.2E-07	B	6.3E-07	B	2.0E-07	B
	98-95-3	Nitrobenzene		BDL	B	BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine		3.6E-08	B	5.8E-08	B	BDL	B
	85-01-8	Phenanthrene		BDL	B	BDL	B	BDL	B
	108-95-2	Phenol		BDL	B	BDL	B	BDL	B
	129-00-0	Pyrene		2.1E-07	B	1.8E-07	B	2.2E-07	B
	110-86-1	Pyridine		BDL	B	BDL	B	BDL	B
Energetics	121-82-4	RDX	lb/lb Energetic	*8.3E-10*	B	NA	NA	2.0E-06	B
	118-96-7	TNT		ND	NA	NA	NA	NA	NA
	88-89-1	Picric acid		NA	NA	*5.0E-10*	A	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	A	3.4E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide		1.2E-01	A	1.8E-01	A	2.0E-01	A
	NA	Nitrogen Oxides	lb/lb N	6.4E-03	A	9.6E-03	A	1.7E-03	A
VOCs	71-43-2	Benzene	lb/lb C	2.4E-05	B	3.8E-04	B	4.4E-04	B
	74-82-8	Methane		2.3E-03	B	2.6E-02	B	1.3E-03	B
	NA	TNMHC		4.7E-03	B	6.8E-03	B	8.4E-03	B
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA	NA	NA

(a) MDL = 1.0E-08 lb/lb NEW

2.1.7 Discussion of the DPG Open Range Detonation Test Results

Table 7 compares the emission results for the four materials and the two test conditions for emission products of environmental concern. As discussed below, Table 7 shows definitively that the DPG open range detonation test results conform to detonation reaction theory and to the results of

Ornellas. This latter point is particularly important because the quantities detonated at DPG were 32,000 times larger than the quantities detonated by Ornellas. That is, it shows that the quantity and composition of the energetic material detonated does not substantially influence the emission products which is consistent with detonation reaction theory.

2.1.7.1 Surface Detonation Results

The high explosives (HE) in the materials detonated were TNT, RDX, and Ammonium Picrate (Explosive D). Although the formulas, carbon and nitrogen content, and structures of these compounds differed markedly, the percentage of the original carbon and nitrogen that ended up in CO_2, CO, CH_4, and nitrogen oxides for each test material were very similar. For example, essentially all of the carbon was converted to carbon oxides, and less than 0.8% of the nitrogen was converted to nitrogen oxides.

Based on Ornellas' work and detonation reaction theory, the mass of benzene emitted would be much less than the mass of methane, which is indeed the case. Also, based on detonation reaction theory, SVOCs/POMs should not form in meaningful amounts and this was indeed the case. According to the test report, benzene was the predominant aromatic hydrocarbon emitted which is consistent with Ornellas' work and detonation reaction theory. Further, because benzene would be produced by the same reaction pathways as the SVOCs/POMs, the quantity of SVOCs/POMs present in the plume should be much less than that of benzene, which is indeed the case.

2.1.7.2 Comparison of the Surface and Above Ground TNT Detonation Results

A comparison of the CO and PM-10 emissions for the surface and above ground TNT detonations (Table 7) indicates that the presence of soil increased the particulate and CO emissions and reduced the CO_2 emissions considerably. However, the presence of soil did not seem to meaningfully influence the CO_2, NO_x, benzene or methane emissions. These results are fully consistent with detonation reaction theory. (NOTE – No conclusions can be drawn from the energetic and SVOC & POM emission factors presented in Table 7 because these values represent only the maximum emission factor measured for the emission product across all of the detonations in each of the two phases.)

2.1.7.3 Selected Summary Statistics for the DPG Open Detonation Emissions Characterization Study

Table 8 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev) and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

Table 8 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the preliminary quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory, and the

representativeness of the EF/EFF values to real-world detonation activities.

Table 7. Comparison of the Emissions Produced by Each Test Material.

EP	Units	Comp B	Explosive D	RDX	TNT Surface	TNT Suspended
Energetics						
RDX	lb/lb Energetic	8.3E-10	NA	2.0E-06	NA	NA
TNT		ND	NA	NA	1.4E-07	1.4E-07
Picric acid		NA	5.0E-10	NA	NA	NA
Particulates						
PM-10	lb/lb NEW	9.0E+00	1.1E+01	9.6E+00	7.2E+00	1.6E+00
VOCs						
Benzene	lb/lb C	2.4E-05	3.8E-04	4.4E-04	2.6E-04	1.7E-04
SVOCs and POMs						
Phenol	lb/lb NEW	BDL	BDL	BDL	1.0E-06	1.0E-06
Naphthalene		4.2E-07	6.3E-07	2.0E-07	1.3E-06	1.8E-06
Dibenzofuran		BDL	1.1E-07	2.0E-06	9.0E-08	1.9E-07
Benz(a)anthracene		BDL	1.9E-08	9.3E-08	5.0E-08	3.2E-07
Benz(a)pyrene		1.4E-08	3.8E-08	1.4E-07	BDL	BDL
2-Nitronaphthalene		8.6E-08	4.3E-08	4.9E-08	4.0E-08	BDL
2,6-Dinitrotoluene		2.4E-08	8.0E-08	4.1E-08	8.5E-09	BDL
1,3,5-Trinitrobenzene		5.9E-08	1.8E-08	5.0E-08	BDL	BDL
Diphenylamine		6.6E-08	1.9E-08	9.8E-08	BDL	BDL
N-Nitrosodiphenylamine		3.6E-08	5.8E-08	BDL	BDL	BDL
Pyrene		2.1E-07	1.8E-07	2.2E-07	1.1E-07	1.9E-08
1-Nitropryene		5.6E-08	1.1E-08	5.0E-08	BDL	BDL
2,4-Dinitrotoluene		4.5E-07	5.9E-07	2.1E-07	7.5E-08	BDL
2-Nitrodiphenylamine		7.2E-08	5.8E-08	3.4E-08	1.0E-09	BDL
Inorganic and Organic Gases						
%C in CO2	%C	94.5%	92.5%	93.2%	93.6%	101.6%
% C in CO	% C	5.1%	7.7%	9.1%	6.4%	0.8%
% C in Methane	% C	0.18%	1.97%	0.10%	0.30%	0.30%
% C in Benzene	% C	0.002%	0.035%	0.041%	0.024%	0.016%
% N in NOX	% N	0.20%	0.29%	0.05%	0.53%	0.78%

Table 8. Summary Statistics for the DPG Open Range OD EFs/EFFs.

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	5	1.1E+01	1.6E+00	9.0E+00	7.7E+00	3.6E+00	0.47	D
Inorganic Gases	Carbon Monoxide	lb/lb C	5	2.0E-01	1.9E-02	1.5E-01	1.3E-01	7.1E-02	0.53	A
	Carbon Dioxide	lb/lb C	5	3.8E+00	3.4E+00	3.5E+00	3.5E+00	1.8E-01	0.05	A
	Nitrogen Oxides	lb/lb N	5	2.6E-02	1.7E-03	9.6E-03	1.2E-02	9.4E-03	0.78	A
Energetics	Energetics	lb/lb Energetic	5	2.0E-06	5.0E-10	9.3E-08	4.5E-07	8.7E-07	1.95	C
SVOCs	SVOCs In Energetic	lb/lb SVOC	No Data							
	SVOCs Not In Energetic	lb/lb NEW	49	2.0E-06	8.5E-09	8.0E-08	2.8E-07	4.8E-07	1.71	B
VOCs	Benzene	lb/lb C	5	4.4E-04	2.4E-05	2.6E-04	2.5E-04	1.7E-04	0.65	B
	TNMHC	lb/lb C	5	1.3E-02	4.7E-03	6.8E-03	7.6E-03	3.6E-03	0.47	B

2.2 BangBox Detonation Emissions Data Sets

2.2.1 Test Description

The 25 sets of emission test results were produced by detonating 0.3 to 0.5 lb of bulk explosives and munitions in a detonation chamber (BangBox) at DPG between 1993 and 1997.[8, 9] BangBoxes are air-supported, rubber-coated hemispherical chambers, which sit on concrete pads (Figure 3). Each BangBox is divided into two sections: an inflatable, 32,900 ft^3, a 50-ft diameter hemispherical test chamber made from a flexible polyvinyl-coated polyester fabric, and a 17.8 x 7.1 x 8.1 ft building (airlock) with a plywood front and a wood frame covered with the same material as the BangBox. The test chamber is kept pressured at 0.17 inches of water pressure using two high-capacity blowers and a damper. Six fans spaced 60^0 apart circulate the air in the test chamber to produce a homogeneous pollutant mix that can be sampled with instruments in the chamber and the attached air lock.

Figure 3. External View of the BangBox at DPG

The bulk high explosive materials and the munitions were detonated while suspended 1.5 to 3 ft above the bottom of a 3.2 ft square by 3.2 ft deep steel-lined cavity in the center of the concrete floor of the BangBox and the bulk propellants were detonated sitting on a steel plate in the bottom of this cavity. Before the munitions were detonated, a cylindrical steel cage constructed of three offset rows of 2-in angle iron was placed over the detonation pit. This cage was approximately 10 ft in diameter and 10 ft high. (Spaces between the angle iron allowed the detonation gases to pass freely, but stopped the shrapnel.)

The test chamber was purged with air for at least 60 minutes (two to three air exchanges) between detonations, but no attempt was made to clean the surfaces of the BangBox. When the detonation was initiated, a known quantity of SF_6 was released into the chamber from a pressured cylinder located approximately 3 meters from the detonation. The concentration of the SF_6 was then measured periodically after the detonation was initiated. A separate, evacuated canister was used each time a sample was collected. The average SF_6 concentration measured was used to calculate the extent to which the emissions plume had been diluted (due to the chamber blowers) between the detonation and the completion of the sample collection activities. This dilution factor was used to correct the measured emission product concentrations to the concentrations that were present immediately after the detonation was initiated.

The plume characterization (measurement) systems used across the 25 BangBox tests are shown in Table 9. With the exception of the SF_6 and VOC samples, the samplers were operated from 10 to 15 minutes before the detonation until 30 to 40 minutes after the detonation. The SF_6 and VOC grab samples were collected at intervals starting approximately 5-minutes after the detonation was initiated, e. g., 5, 7, 11, 19 and 35 minutes.

The EPA's Office of Research and Development (ORD) provided technical assistance and quality assurance support to the DOD project officer when 23 of the emissions data sets were collected between 1993 and 1995 and issued a summary report on the results of these emission tests.[8] EPA was not involved with the collection of the remaining two data sets which involved the detonation of C3 and C4 rocket propellants in 1997.[9]

Generally, each set of emissions data represent the results from three detonation trials. With the exception of the continuous emissions monitor (CEM) data, replicate sampling trains were used for each target analyte. For the 23 materials detonated between 1993 and 1995, background samples for all target analytes were collected in the test chamber at the beginning of each test day. In the 1997 tests, the background samples were collected the day before the first propellant detonation experiment was conducted. In all of the BangBox tests, the background samples were collected and analyzed in a manner identical to the test samples and the results were used to correct the emission factors for any contribution the background air made to the measured emission factors. Seventy-four detonation plumes were sampled across the 25 sets of emissions test results. (NOTE - This approach assumes that the only background air species present in the plume are those present in the air before the detonation. It ignores species knocked off surfaces by the shock wave and turbulence produced in the detonation. Because these latter materials are not included in the background sample, they become part of the reported emissions.)

1 Table 9. Emissions Test Methods Used in the BangBox Studies.

Target Analyte / Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (Teco Model 42) [Sampling and Analysis]
SO_2	40 CFR 60, Appendix A, EPA Method 6C (Teco Model 43A) [Sampling and
HCl	Teco Model 15 HCl Continuous Emissions Monitor (No corresponding EPA test
HCl, Cl_2	40 CFR 60, Appendix A, EPA Method 26 [Sampling and Analysis]
TSP	40 CFR 50, Appendix B [Sampling and Analysis]
PM -10	40 CFR 50, Appendix J [Sampling and Analysis]
Metals	40 CFR 50, Appendix B [Sampling], 40 CFR 60, Appendix A, EPA Method 29
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOCs/ POMs	EPA Method TO - 13 - Determination of Polycyclic Aromatic Hydrocarbons in Ambient Air Using GC/MS [Sampling and Analysis]
Energetics	EPA Method TO - 13 [Sampling] with analysis by Supercritical Fluid Chromatography/MS (SFC/MS)
PCDDs/ PCDFs	EPA Method TO - 9 - Determination of Polychlorinated, Polybrominated and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air [Sampling], EPA - SW - 846 Method 8290 [Analysis]
CO, CO_2 (Primary Sampling System for CO & CO_2)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)
SF_6	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography/Electron Capture Detection (ECD)

2.2.2 Description of the Test Materials and Detonation Piles

The air emissions from 25 energetic materials were characterized in the DPG BangBox between 1993 and 1997. The three standard components of detonation piles were characterized, i.e., demolition charge, bulk (donor) explosive and munition/munition part (cased energetic materials). The compositions of these test materials and the conditions under which they were detonated are described below under each category. For unknown reasons, in some cases a surrogate test material that was prepared on site was detonated instead of the actual bulk explosive.

The composition data were taken from the EPA report and from MIDAS. In the few cases where there was a conflict between MIDAS and the description in the EPA report, the EPA information was used. (When the BangBox emissions characterization tests were conducted, MIDAS was not available to the project personnel. Because most of the composition data was available only in hard copy and was mostly confined to the major components of the test material, it was very difficult for the project personnel to obtain accurate or detailed information on most of the minor constituents present in the test materials. This was particularly true for cased munitions.)

2.2.2.1 Demolition Charges (Detonation Initiating Charges) and Detonation Initiation Train

Detonation Initiation Charge (DIC). This initiating charge, which was comprised of a block of C4 and one EBC, was used to initiate the detonations of the 20mm and 40mm HEI rounds. The 20mm rounds were detonated using a 60 g block of C4 and the 40mm round was detonated using a 40 g block of C4. Because the DIC was not detonated as a standalone item, there are no emissions data specific to this item.

Detonation Initiation Train (DIT). This item was called the *Detonation Train* in the EPA report. It was used to initiate the detonation of the impulse cartridges and flares described in Section 2.2.2.3 below, and a scaled down version was used to initiate the detonation of the bomb fuzes that are also described in Section 2.2.2.3. Three, single-detonation trials were conducted using two DITs in each trial. Each DIT contained 57 g C4, 32 g detonation cord (PETN), and an EBC. The C4 was in the form of blocks approximately 7.7 x 2.5 x 2.5 cm, and the detonation cord was cut into three meter lengths and coiled around the polyethylene-wrapped C4. The two DITs were tied together with 16 gauge iron wire, wired in parallel to the firing line, and detonated above the floor of the detonation pit. The total NEW used in each detonation was 190 g. The purpose of the standalone detonation of this item was to obtain emission data that could be used to adjust the emissions data sets from the fuzes, impulse cartridges and flares for the contribution of the initiating charge. However, for unknown reasons, neither DOD nor EPA adjusted the emissions test results from the cased items for the contribution from the DIT.

2.2.2.2 Bulk (Donor) Energetic Test Materials

Flake TNT. Three single-detonation trials each using 226 g of flake TNT were conducted. An EBC and a 1 g block of C4 were used to initiate each detonation. The total NEW detonated was 227 g.

TNT Block. One single-detonation trial using three small blocks of TNT was conducted. The three TNT blocks (total NEW of 221 g) were tied together with 16-gauge iron wire, wrapped with 1.9 g of polyethylene sheeting and detonated (using an EBC inserted in the bottom of the assembly). The total NEW detonated was 227 g. This was an Operational Readiness Test (ORI).

Surrogate Composition B. Three single-detonation trials were conducted using 227 g quantities of Composition B in a half-gallon polyethylene food storage bag tied off with cotton cord. The Composition B was prepared on-site by mixing TNT powder (obtained by crushing a TNT block) with C4 to produce a material containing 128 g RDX, 86.3 g TNT and 12.7 g of mineral oil/polyisobutylene (from the C4). An EBC and a 6.4 g block of C4 were used to initiate each detonation. The total NEW detonated was 235 g.

Surrogate HBX. HBX is an aluminized form of Composition B. Three single-detonation trials were conducted using 227 g quantities of the surrogate HBX material contained in a half-gallon polyethylene food storage bag tied off with cotton cord bag. The HBX surrogate was prepared on-site by mixing aluminum powder with Composition B surrogate. The energetic composition of the HBX surrogate detonated consisted of 109 g RDX, 72 g TNT, 7.8 g mineral oil/ polyisobutylene, and 38.5 g Al. An EBC was used to initiate the detonation. The total NEW of the material detonated was 235 g.

*Surrogate Tritona*l. Tritonal contains 80% TNT and 20% finely powdered aluminum by weight. The surrogate was prepared on-site using crushed TNT block and aluminum powder. These components were placed in a jar and mixed until the mixture appeared to be homogeneous. This mix contained 1274 g TNT and 431 g Al. Three, 227 g portions of this mix were placed in a half-gallon polyethylene food storage bag and the bags closed with cotton string. One bag was used in each detonation. The following two detonation configurations were evaluated.

- *Unsuppressed Tritonal Detonation*. The bag was suspended approximately 3.2 ft above the concrete floor of the Bang Box. Three single-detonation trials were done. In the first two trials, a single M6 EBC was used to initiate the detonation and in the last detonation the EBC was inserted into a 6.5 g block of C4. The NEW of the material detonated in the three detonations was 229 g for the first two detonations and 235 g for the last detonation.

- *Water-Suppressed Tritonal Detona*tion. Soil-cover and below ground (buried) detonations are frequently used in the U.S. to mitigate the sound and blast waves released when military energetic materials are destroyed by detonation. Water-suppressed detonations were done primarily to assess how detonating a severely oxygen-negative energetic under a soil cover could change the emission products compared to detonating the same weight of the energetic material on the ground. (Tritonal was selected for this experiment because it contains only 20% of the oxygen required to convert all its carbon to CO_2 and H_2O.) Three water-suppressed tritonal detonations were done using 227 g of tritonal surrogate, 1,362 g of water, a 6.5 g block of C4, and an EBC. For the first two detonations, the tritonal was in contact with three quart-size food storage bags, each containing 1 lb of water. (The four bags (3 water, 1 tritonal) were placed in a half-gallon food storage plastic bag which was tied off with cotton string such that the water bags remained in contact with the tritonal-containing bag.). In the third detonation, 3 lb (1,362 g) of water was divided equally among five quart-size polyethylene food storage bags. (This was done to increase the tritonal surface area covered by the water.) In this latter detonation, three of the water bags were in the same plane as the tritonal bag, one was on top and the last was underneath. The five bags were held in a half-gallon polyethylene bag which was tied with cotton string to keep the water bags in contact with the tritonal bag. The total NEW detonated in each trial was 235 g.

*Tritonal with 2.5% Calcium Stearat*e. The calcium stearate served as a surrogate for the organic materials associated with tritonal when it is steamed out of 750 lb bombs. Three single-detonation trials were done. The material detonated was contained in half-gallon size polyethylene bags in a manner identical to the tritonal surrogate detonations. Each bag contained 216 g of the tritonal surrogate mix

described above and 11 g of calcium stearate. An EBC and 6.4 g block of C4 were used to initiate each detonation. The total NEW of the material detonated was 226 g.

*Surrogate Amato*l. Amatol contains 50% TNT and 50% ammonium nitrate (AN) by weight. The surrogate was prepared on-site by mixing crushed TNT blocks with AN powder in a manner similar to that used to prepare the tritonal. In each detonation trial, 227 g of the amatol mixture were detonated using an EBC and a 6.4 g block of C4 to initiate the detonation. Two detonation configurations were evaluated.

- *Unsuppressed Amatol Detonation*. Three single-detonation trials were conducted with the amatol using 227 g of the amatol. The amatol surrogate was placed in a half-gallon polyethylene food storage bag and detonated in the same manner as used for the tritonal detonations described above. The total NEW of the material detonated in each trial was 235 g.

- *Water-Suppressed Amatol Detonation*. Soil-cover and below ground (buried) detonations are frequently used in the U.S. to mitigate the sound and blast waves released when military energetic materials are destroyed by detonation. Water - suppressed detonations were done primarily to assess how detonating an oxygen-balanced energetic under a soil cover could change the emission products compared to detonating the same weight of the energetic material on the ground. (Amatol was selected for this experiment because it contains sufficient oxygen to convert all of its C and H to CO_2 and H_2O.) Three 227 g detonations of amatol were conducted. In each detonation, the bag containing the amatol was surrounded with five quart-size bags, each containing 0.6 lb of water. The five water bags were distributed around the amatol surrogate bag in a manner similar to that used for the third water-suppressed tritonal detonation described above. The total NEW detonated was 235 g.

C4 Propellant. C4 is a rocket propellant comprised primarily aluminum, ammonium perchlorate, nitroglycerin and nitrocellulose. Three, single-detonation trials were conducted using a 225 g cube of the propellant. An M130 EBC inserted into the cube was used to detonate it. When the cubes detonated, the shock wave cut a hole in the 12 mm thick steel plate on the floor of the pit in which the propellant cube sat. The exact composition of the propellant is classified.

C3 Propellant. C3 is a rocket propellant comprised of aluminum, ammonium perchlorate (AP), nitroglycerin (NG), and nitrocellulose (NC). Four single-detonation trials were conducted using a 225 g cube of the propellant. A M130 EBC inserted into the cube was used to detonate it. When the cube detonated, the shock wave cut a hole in the 12 mm thick steel plate on the floor of the pit in which the propellant cube sat. The exact energetic composition of the propellant is classified.

2.2.2.3 Cased Test Items

2.2.2.3.1 Canon Rounds

20mm HEI Cartridge M56A4 (NSN: 1305-01-118-9928). Three single-detonation trials were conducted. For each detonation, three, 20mm [brass] cartridges were placed on a 60 g block of C4 and tied in place with 16-gauge iron wire. Each cartridge contained 8.8 g RDX, 0.43 g HMX (explosive charge), 30.4 g NC, 3.7 g NG, 0.2 g lead, 0.44 g chromium, 93.1 g copper, 37.3 g zinc, 0.13 g aluminum, 67.3 g iron, 0.078 g cadmium, and 0.076 g of barium. An EBC inserted into the C4 block was used to initiate each detonation. The total NEW detonated in each trial was 189 g.

40mm HEI Cartridge, M384 (NSN: 1310-00-039-1254). Three single-detonation trials were conducted. For each detonation, two 40mm aluminum alloy cartridges were placed on a 40 g block of C4 and tied in place with 16-gauge iron wire. Each cartridge contained 54.4 g of RDX, 3.5 g NC, 0.9 g NG, 112 g aluminum, 24.4 g copper, 1.2 g zinc, 0.04 g lead, 109 g iron, 0.72 g chromium and 0.03 g barium. An EBC inserted into the C4 block was used to initiate each detonation. The NEW detonated in each trial was 158 g.

2.2.2.3.2 Impulse Cartridges

Cartridge, Impulse, Mod O, ARD446- (NSN: 1377-00-516-9924). This item has a NEW of 12.5 g. Three single-detonation trials were conducted. In each trial, ten aluminum alloy cartridges were tied to a 57 g block of C4 using 32 g of detonation cord and the suspended assembly was detonated using an EBC. The NEW of the assembly was 216 g. Each cartridge contained 20 g of aluminum, 0.63 g of copper, 0.29 g of zinc, 0.214 g lead, and approximately 5.8 g of smokeless powder.

Cartridge, Impulse, BBU 36B (NSN: 1377-01-037-8650). This item deploys chaff from aircraft and contains a pyrotechnic filler which readily burns when initiated. Each aluminum alloy cartridge has a NEW of 0.88 g. Three single-detonation trials were conducted. Sixty cartridges were used in each of the detonations: 42 cartridges were clustered around a 57 g block of C4, and 18 cartridges were placed on the sides of a 0.5 m length of detonation cord, which had been folded into a 0.25 m length. In trial 1, the two assemblies were hung separately with one end of the detonation cord inserted in the block of C4, and an EBC was used to detonate the C4. In trials 2 and 3, the C4 and detonation cord assemblies were bound together using 16 gauge iron wire. The NEW of the assemblies detonated was 144 g. Each cartridge contained 38 g of powdered boron, 0.15 g of potassium nitrate, 5.2 g aluminum, 0.38 g chromium, 0.3 g copper, 0.02 g lead, 0.016 g zinc. 0.6 g NC and 0.7 g NG.

Cartridge, Impulse, MK107, Mod 01 (NSN: 1377-00-779-2601). This cartridge has a NEW of 24.5 g. Three single-detonation trials were conducted. For each detonation, five steel cartridges were placed around a 57 g block of C4. They were parallel to each other, but alternated tip to base. This assembly was wrapped with 32 g of detonation cord and detonated suspended above the detonation pit using an EBC. The NEW of each assembly was 208 g. The energetic composition of the MK107 cartridge is 16 g NC, 4.1 g NG, 1 g barium nitrate, 0.2 g of potassium nitrate, 71.7 g iron, 19.3 g chromium, 0.025 g lead and a classified amount of aluminum.

2.2.2.3.3 Flares

Flare, Countermeasure, Aircraft, M206 (NSN:1370-01-048-2138). This flare is used to decoy heat-seeking missiles away from aircraft. Each flare has a NEW of 150.2 g and contains 102 g magnesium powder, 1 g potassium nitrate, 5 g NC, 1.4 g potassium perchlorate, 13 g rubber, 0.4 g chromium, 49 g aluminum, 0.18 g zinc and 0.24 g barium. Three single detonation, single flare trials were conducted The flare was prepared for detonation as follows. A 57 g block of C4 was cut in half lengthwise, and the two halves placed on the long axis of the flare such that the two halves remained in contact. This assembly was wrapped in polyethylene sheeting, and then 32 g of detonation cord was wrapped around the assembly starting at the end opposite the C4. The plastic plug in the forward end of the flare was left in place. An EBC was used to detonate the final assembly while it was suspended 1.5 ft above the floor of the detonation pit. The total NEW of the final assembly was 241 g.

Signal, Illumination, Aircraft, Red Star M43A2 (NSN: 1370-00-618-5790). This aluminum alloy-encased flare has a NEW of 56.8 g with 56.6 g of this NEW in the illuminating charge. The illuminating charge contains 10.2 g magnesium powder, 13.6 g potassium perchlorate, 24.9 g strontium nitrate, 4 g asphaltum, 0.02 g barium, 0.02 g lead, 0.36 g zinc and 0.8 g of copper. The aluminum casing weighs 45.4 g. Three single detonation trials using three flares (and their bandoliers) per detonation were conducted. The three flares were tied to a 57 g block of C4, which was then wrapped in polyethylene sheeting. Thirty-two g of detonation cord was then wrapped around this assembly and secured with 16-gauge iron wire. An EBC was used to detonate the final assembly while it was suspended 1.5 ft above the floor of the detonation pit. The NEW of each assembly detonated was 260 g.

Signal, Illumination, Ground, Red Star, M158 (NSN: 1370-00-490-7363). This flare is housed in an cylindrical aluminum alloy casing with a steel liner. It has a NEW of 36.8 g and contains 177 g aluminum, 19.9 g chromium, 1.5 g copper, 0.5 g zinc, 0.016 g lead, 102 g iron, 7 g strontium nitrate and 0.03 g barium nitrate and 27 g potassium nitrate. Three single detonation trials using four flares (and their bandoliers) per detonation were conducted. Two flares were placed on one side of a 57 g block of C4 and two were placed on the opposite side and the assembly was wrapped in polyethylene sheeting and detonated employing a procedure similar to that used for the M43A2 flares. The NEW of each assembly was 239 g. A portion of the energetic composition of the item is classified.

2.2.2.3.4 Fuzes

Fuze, Tail Bomb, Fuze Mechanical Unit, 139A/B (NSN: 1325-01-214-7311). This fuze contains 131 g of Tetryl. Three single detonation, single fuze trials were conducted. Each fuze was prepared for detonation as follows. A 28.5 g block of C4 was taped to the side of the fuze near its main explosive charge and the assembly wrapped in polyethylene sheeting. Sixteen g of detonation cord was then wrapped around the fuze and the fuze was screwed onto a threaded shaft. (The opposite end of the shaft was attached to a 1.9 cm thick by 30.5 cm diameter steel plate. The purpose of the steel plate was to break up any focused blast effect resulting from the detonation.) The fuze was detonated 0.5 m above the floor of the detonation pit using an EBC. The total NEW of the each assembly detonated was 177 g. Each fuze also contained 2.9 g lead, 139 g aluminum, 25 g chromium, 31.7 g copper, 610 g iron and 13.8 g zinc.

Fuze, Tail Bomb, Fuze Mechanical Unit FMU-54A/B (NSN: 1325-00-613-0484). This fuze contains 163 g of Tetryl. Three single detonation, single fuze trials were conducted. Each fuze was prepared for detonation as follows. A 28.5 g block of C4 was taped to the side of the fuze near its main explosive charge and the assembly wrapped in polyethylene sheeting. Sixteen g of detonation cord was then wrapped around the fuze and the fuze was screwed onto a threaded shaft. (The opposite end of the shaft was attached to a 1.9 cm thick by 30.5 cm diameter steel plate. The purpose of the steel plate was to break up any focused blast effect resulting from the detonation.) The fuze was detonated 0.5 m above the floor of the detonation pit using an EBC. The NEW detonated was 209 g. Each fuze also contained 0.09 g lead, 11.6 g copper, 108 g iron, 25 g aluminum, and 5.7 g zinc. (Note - 0.086 g of the lead is in alloy form and other 0.004 g of Pb is in the energetic)

2.2.2.3.5 Miscellaneous Cased Items

Generator, Gas Pressure, Propellant Actuated, GCU-2/A (NSN 1336-00-420-2980). This item, which is used in the Minuteman missile, has a NEW of 95.3 g. Its composition is classified. Three single detonation, single item detonation trials were conducted The gas generator was prepared for detonation by removing the outer metal jacket to expose the solid propellant which is cast as a short hollow cylinder.

Twenty-eight and a half grams of C4 was packed into the hollow cylinder and wrapped in polyethylene sheeting. This assembly was then wrapped with 1.5 meters of detonation cord, and the gas generator's plastic shipping plug was taped on top of the detonation cord. The gas generator was then oriented with its steel plug facing into the detonation pit and detonated with an EBC. The NEW of each assembly detonated was 139 g.

M18A1 (Claymore) Antipersonnel Mine (NSN: 1345-00-710-6964). Three single-detonation, single-mine trials were conducted. The NEW detonated in each trial was 227 g. Because the mine contained 681 g of C4, it was necessary to remove 454 g of the C4 before detonating it in the BangBox, which has a detonation NEW limit of approximately 230 g. The mine was opened and the seven hundred 22-caliber steel balls and 454 g of C4 were removed from the 360 g of fiberglass resin casing. The case was a composite of fiberglass and a polystyrene/polybutadiene resin. The mine was suspended in the detonation pit, an EBC inserted in the 227 g of C4 remaining and the mine was detonated. The mine also contained 1.67 g of lead (0.43 g of the Pb in the energetic and 1.24 g in alloys), 513 g copper, 20 g aluminum and 38.2 g dioctyl sebacate.

Adapter-Booster, T45E7 (NSN: 1325-00-827-3851). Three single-detonation, single-adapter-booster trials were conducted. The adapter-booster contained 73 g of Tetryl, a booster pellet, and a hollow bursted well which was closed with a 980 g steel plug and housed in a 440 g steel cylinder 17.3 cm long and 7.2 cm in diameter. It also contained two 7.5 g pressed wool wafers (to protect the booster casing), 2.9 g chromium, 1.2 g copper, 412 g aluminum, 2.0 g cadmium, 4.1 g zinc, and approximately 2 g of lead (in lead chromate). To reduce the chance for the blast pulse to become focused, a steel wool plug was placed in the large end of the burster well and the end was closed with a 31 g plastic plug. A 1.6 cm diameter x 25 cm long steel rod was screwed into the fuze well and a 2.5 cm thick x 23 cm diameter steel disk was fastened to the other end of the rod. This assembly was suspended horizontally in the detonation pit. A 10 g charge of C4 with an EBC initiated the detonation. However, significant focusing of the blast still occurred because: (1) a hole was punched through the steel plate lining of the pit; and (2) the paper on the fiberglass insulation behind the steel plate and portions of the wood witness shield approximately three meters from the pit were charred. The NEW detonated was 83 g.

2.2.3 Identification of BangBox Data Sets That Should Be Rejected In Their Entirety

The following data sets were judge unsuitable for inclusion in AP-42 for the reasons given.

TNT Block Detonation. This data set was rejected for the following reasons. First, it was comprised of only one detonation. Second, it was an operational readiness test (ORI). Third, there was another BangBox TNT detonation emissions data set available (Flake TNT) that involved three detonation trials, and there were also emissions test results for the detonation of TNT on the open range at DPG.[6, 7]

GCU-2/A Gas Pressure Generator Detonation. This data set was rejected because the composition of the test item is classified, so the accuracy and representativeness of the test results could not be determined.

Adapter-Booster, T45E7 Detonation. The test report noted that significant focusing of the blast had occurred because: (1) a hole was punched through the steel plate lining of the pit, and (2) the paper on the fiberglass insulation behind the steel plate and the top of the wood witness shield approximately 3 meters above the pit were charred. Therefore, the carbon oxide, VOC, SVOC/POM and metals emissions data was suspect.

C3 and C4 Propellant Detonations. This data set was rejected for the following reasons. First, it was the first detonation conducted in 25 months in the BangBox, and the floor was known to be a source of particulate, SVOCs/POMs, and metals. (The BangBox was kept continually inflated using a blower during this 25-month period.) Second, the exact compositions of the propellants are partially classified, so the accuracy and representativeness of the test results can not be determined. Third, the detonation experiments were designed around one specific disposal site, and it was doubtful that the data sets could be applied to other sites. Fourth, there was no evidence to show that the test results were reviewed or evaluated by a disinterested third part and the raw data sheets are no longer available. Fifth, the detonations burned holes in the steel plate on which the propellant rested, and some of the plate material entered the plume. Sixth, the sampling results had been corrected for background air concentrations using background air samples collected one and two days before the propellants were detonated, and the EPA report[7] showed that these concentrations sometimes changed markedly between days.

Water-Suppressed Amatol and Tritonal Detonations. The emissions test results were excluded because real-world detonations are not done under a water-blanket. However, because these test results do provide insight into how suppressing the formation of the fireball affects the emissions from detonations, it was decided to include the results in Appendix A (Effect of Confinement on the Emissions from Detonations).

2.2.4 Identification of BangBox Test Results Suitable for Inclusion in AP-42

The remaining 20 data sets had been produced in five studies that had been funded by different DOD units and had been conducted for a variety of reasons. After three DOD contractors had failed to accomplish the task, the EPA compiled the emissions data sets from these studies into a validated emission factors data base.[8] During its validation effort, EPA consulted the background information that was available on the emissions tests, including test design plans, final reports, field notes, calibration data, laboratory reports, and EPA and DOD contractor QA and QC reports.

Because it had provided independent QA support to these studies and because of its knowledge of the requirements for EF databases, EPA had a good understanding of the issues that needed to be addressed during its data assessment and validation effort if it was to produce a credible, validated database. For example, EPA selected only emissions data that had been collected using methods that would have produced credible and comparable data. EPA also provided a set of minimum quantitation limits (MQLs, expressed as the equivalent emission factor) for each measurement system. In addition, EPA conducted mass balance checks on the carbon, nitrogen and aluminum containing emission products to confirm that the results adhered to detonation reaction theory and to previous laboratory-based emissions characterization tests on energetic materials. Further, because most of the detonation emission products were commonly occurring air pollutants that were present in the background air samples, EPA assessed and provided information in the report on the extent to which the emission factors had been corrected for background.

Some of the conventions and procedures used by EPA in assessing and reporting the emissions test results that are pertinent to this review are:

- If the background corrected EF for a detonation trial was less than or equal to 0.0E+00, EPA reported the EF as 0.0E+00.

- If the emissions test report contained an EF that was less than the MDL of the

measurement system, EPA reported the EF as 0.0E+00.

- If the background corrected EF for an SVOC target analyte was less than 30% of the uncorrected EF, EPA reported the EF as 0.0E+00.

- In calculating the average EF for data sets containing a combination of 0.0E+00 and non-zero values, EPA did not include the 0.0E+00 values in the calculation.

- In order to conduct a statistical analysis of the data using its SAS program, EPA had to differentiate between instances where either no sample was collected (NS) or no data was available because the sampling result had been invalidated (NA) and instances where the target analyte was either never detected, or if detected, never detected above the background level (ND). Because the SAS program would not accept letter code entries, EPA substituted a period (.) for all NS and NA values and the value 0.0E+00 for all ND values.

2.2.4.1 Modifications Made to the EPA EFs to Conform to AP-42 Guidance

The following modifications were made to the metal, VOC and SVOC/POM EFs for the 20 data sets, so that they would conform to the EPA AP-42 guidance.

2.2.4.1.1 Volatile Organic Compounds

The EPA report contained numerical emission factors for 43 of the 160 plus individual VOC compounds on the BangBox target analyte list. According to the EPA report, these compounds were the only VOC target analytes measured above the background level in the emissions from at least one of the test materials. (The VOC target analytes that were either never detected or were never detected above the background level are identified in Table 10, VOC Target Analytes Not Detected in Any of the BangBox Detonation Plumes.)

EPA noted that one of the most vexing problems associated with characterizing the VOC air emissions from detonations was that most of the emission products are compounds that are commonly found in ambient air. This can be seen by examining the information in Table 11, which shows the average EF for the 43 VOCs detected in the detonation plumes along with: (1) the number of materials (N) for which the VOC was listed as an EP; (2) the number of materials for which the VOC was detected in all of the plumes; and (3) the percentage that the background air contributed to the plume concentration.

Table 10. VOC Target Analytes Not Detected in Any BangBox Detonation Plumes.

CASRN	Compound	CASRN	Compound	CASRN	Compound
7642-09-3	Cis-3-hexene	124-41-1	Dibromochloromethane	691-38-3	Cis-4-methyl-2-pentene
619-99-8	3-Ethylhexane	126-99-8	Chloroprene	71-23-8	1-Propanol
627-20-3	Cis-2-pentene	138-86-3	Methylcyclohexene	71-36-3	1-Butanol
79-09-4	Propanoic acid	141-32-2	Butyl acrylate	73513-42-5	Isohexane
83847-49-8	Bromochloromethane	141-93-5	m-Diethylbenzene	7359-72-0	Trans-1,3-trichloropropene
100-44-7	Benzyl chloride	156-60-5	Trans-1,2-dichloroethene	7443-70-1	Cis-2-octene
100-47-0	Benzonitrile	1634-04-4	Methyl t-butyl ether	74-83-9	Methyl Bromide
100-51-6	Benzyl alcohol	2198-23-4	4-Nonene	75-00-3	Chloroethane
100-52-7	Benzaldehyde	24-11-8	1-Nonene	75-05-8	Acetonitrile
10061-01-5	Cis-1,3-dichloropropene	25168-05-2	Chlorotoluenes	75-07-0	Acetaldehyde
103-65-1	N-propylbenzene	271-89-6	Benzofuran	75-25-2	Bromoform
104-51-8	N-butylbenzene	31394-54-4	Isoheptane	75-27-4	Bromodichloromethane
105-05-5	p-diethylbenzene	3522-94-9	2,2,5-trimethylhexane	75-34-3	1,1-Dichloroethane
106-42-3	p-Xylene	463-82-1	Neopentane	75-35-4	1,1-Dichloroethene
106-43-4	P-chlorotoluene	496-11-7	Indane	75-45-6	Chlorodifluoromethane
106-46-7	p-Dichlorobenzene	513-35-9	2-Methyl-2-butene	75-52-5	Nitromethane
107-02-8	Acrolein	526-73-8	1,2,3-Trimethylbenzene	75-69-4	Trichlorofluoromethane
107-05-1	Allyl Chloride	538-93-2	Isobutylbenzene	75-71-8	Dichlorodifluoromethane
107-06-2	1,2-Dichloroethane	540-59-2	Cis-1,2-dichloroethene	75-83-2	2,3-Dimethylbutane
1071-26-7	2,2-Dimethylheptane	540-84-1	2,2,4-trimethylpentane	760-21-4	2-Ethyl-1-butene
107-13-1	Acrylonitrile	541-73-1	m-Dichlorobenzene	763-29-1	2-Methyl-1-pentene
107-39-1	2,4,4-Trimethyl-l-pentene	563-45-1	3-Methyl-1-butene	7688-21-3	Cis-2-hexene
107-40-4	2,4,4-Trimethyl-2-pentene	563-46-2	2-Methyl-1-butene	78-87-5	1,2-Dichloropropane
107-85-5	2-Methylpentane	564-02-3	2,2,3-Trimethylpentane	78-93-3	2-Butanone
108-05-4	Vinyl acetate	565-59-3	2,3-Dimethylpentane	79-00-5	1,1,2-trichloroethane
108-08-7	2,4-Dimethylpentane	565-75-3	2,3,4-Trimethylpentane	79-01-6	Trichloroethene
108-10-1	Methylisobutylketone	584-94-1	2,3-Dimethylhexane	79-34-5	1,1,2,2-tetrachloroethane
108-38-3	m- Xylene	589-34-4	3-Methylhexane	821-95-4	1-Undecene
108-41-8	m-Chlorotoluene	589-81-1	3-Methylheptane	87-68-3	Hexachloro-1,3-butadiene
108-67-8	1,3,5-trimethylbenzene	590-18-1	cis-2-Butene	9003-31-0	Isoprene
108-90-7	Chlorobenzene	592-13-2	2,5-Dimethylhexane	922-62-3	Cis-3-methyl-2-pentene
110-00-9	Furan	592-27-8	2-Methylheptane	92-52-4	Biphenyl
110-62-3	Pentanal	592-76-7	1-Heptene	95-13-6.	Indene
110-83-8	Cyclohexene	60-29-7	Diethyl ether	95-47-6	o-Xylene
NA	4-methyl-2-pentanone	611-14-3	o-Ethyltoluene	95-49-8	o-Chlorotoluene
111-66-0	1-Octene	624-91-9	Methylnitrite	95-50-1	o-Dichlorobenzene
111-71-7	Heptanal	625-27-4	2-Methyl-2-pentene	95-63-6	1,2,4-Trimethylbenzene
1120-21-4	N-undecane	64-17-5	Ethanol	96-14-0	3-Methylpentane
1120-72-5	Methylcyclopentene	64-19-7	Acetic Acid	98-01-1	2-Furaldehyde
112-31-2	Decanal	66-25-1	Hexanal	98-06-6	Tert-butylbenzene
120-82-1	1,2,4-Trichlorobenzene	6747-26-2	2,2,4-Trimethylhexane	98-82-8	Isopropylbenzene
121-14-2	1,3-Dinitrobenzene	674-76-0	Trans-4-methyl-2-pentene	98-86-2	Acetophenone
123-72-8	Butyraldehyde	67-63-0	2-Propanol	99-65-0	1,3-Dinitrobenzene
123-91-1	1,4-Dioxane	67-64-1	Acetone	99-87-8	p-Isopropyltoluene
124-13-0	Octanal	68037-01-4	1-Decene		
124-19-6	Nonanal	691-37-2	4-Methyl-1-pentene		

Table 11. Average EF and Background Correction for the VOC Compounds.

EP Class	Pollutant	Background-Corrected Average EF	% Background Contributed to Uncorrected Average EF	Detected in the Plumes for N Materials	Detected in All Plumes for N Materials
Aromatic HC	Benzene	9.4E-05	24%	20	19
	Styrene	8.5E-05	8%	15	13
	Toluene	3.3E-05	58%	20	17
	p-Ethyltoluene	6.1E-06	63%	17	1
	Ethylbenzene	4.5E-06	63%	20	15
	m-Ethyltoluene	9.1E-07	74%	15	6
	i-Propylbenzene	4.0E-07	34%	6	1
Chlorinated HC	Methylenechloride	2.5E-04	48%	20	15
	Allylchloride	9.6E-06	0%	8	8
	Tetrachloroethylene	3.3E-06	40%	8	6
	Vinyl chloride	2.5E-06	0%	10	6
	Methyl chloride	2.1E-06	33%	17	14
	Methyl chloroform	1.1E-06	86%	6	3
	Carbon tetrachloride	8.8E-07	80%	10	5
	Ethyl chloride	3.7E-07	0%	3	2
	Chloroform	1.6E-07	64%	5	2
Saturated HC	Ethane	6.5E-05	50%	20	11
	Propane	1.4E-05	52%	20	16
	n-Butane	4.9E-06	58%	18	13
	n-Pentane	3.2E-06	68%	19	9
	n-Hexane	2.4E-06	63%	18	13
	Methylcyclohexane	2.3E-06	49%	14	7
	Methylcyclopentane	2.1E-06	48%	20	7
	i-Pentane	2.1E-06	66%	14	1
	n-Heptane	1.8E-06	62%	19	14
	n-Octane	1.8E-06	54%	19	7
	n-Decane	1.5E-06	55%	17	10
	i-Butane	1.2E-06	52%	18	9
	n-Nonane	9.5E-07	47%	17	8
	Cyclohexane	7.1E-07	60%	9	2
	Cyclopentane	4.6E-07	42%	10	3
Unsaturated HC	Acetylene	4.2E-04	12%	20	20
	Ethylene	2.7E-04	11%	20	20
	Propylene	5.7E-05	12%	20	20
	1-Butene	1.7E-05	0%	20	15
	1-Hexene	1.1E-05	5%	21	21
	i-Butene	9.1E-06	2%	17	13
	trans-2-Butene	9.0E-06	1%	19	18
	1-Pentene	7.5E-06	10%	20	19
	1,3-Butadiene	7.2E-06	2%	19	19
	Cyclopentene	1.9E-06	0%	18	8
	trans-2-Pentene	1.5E-06	28%	16	10
	cis-2-Pentene	9.3E-07	25%	15	11

Based on the information in the EPA report and the information in Table 11 the following modifications were made to the original EFs to ensure that the VOC EFs conform to the EPA guidance before they were entered in the AP-42 Excel workbook.

- If the average EF value for a test material had been derived from a data set that included only non-zero numeric values, the EF value was converted to the corresponding EFF value and the EFF value entered. (The EF value (lb/lb NEW) was converted to the equivalent EFF value (lb/lb C) by multiplying the EF value by the NEW detonated and then dividing by the lb of C in the detonation pile.)

- If the average EF for a test material had been derived from a data set containing a mix of 0.0E+00 and non-zero numeric values, the 0.0E+00 value was replaced with a value of 7.1E-08 lb/ lb NEW (1/2 the MDL) and the new average was calculated. This value was then converted to the equivalent EFF value and the EFF value was entered.

- If the EF for a test material was 0.0E+00 for all detonation trials, the 0.0E+00 value was changed to BDL.

- If one of the 43 VOC analytes was a target analyte in a test, but no sampling result was reported, the letter code ND was entered in the AP-42 workbook.

2.2.4.1.2 Metals

Although EPA noted that the location and chemical form of the metal influenced the quantity of the metal released into the plume, it did not provide information on the location and chemical form of most of the metals in the test materials. Therefore, it was decided to enter the metal emissions data under the following categories whenever the information on the location and form of the metal was available from MIDAS or the EPA report: *Metals in Alloy*, *Metals in Energetic as Particle*, *Metals in Energetic as Compound* and *Metals in Protective Coating*.

The EPA report contained EFs for the following nine metals: Al, Sb, Ba, Cu, Cd, Cr, Pb, Ti and Zn. (NOTE – Although some of the test materials contained alkali and alkaline earth metals, these metals were not target analytes in these studies.) In the report EPA noted that many of the metals found in the plume samples were likely metal-containing soil particles and residues (from prior detonations and burns) lifted into the plume from the concrete floor of the BangBox by turbulence from the detonation. Therefore, they were not actual emission products from the material detonated. EPA made this observation based on the many instances where metal emission factors about 1E-04 lb/ lb NEW had been produced when metal-free energetic materials had been detonated.

EPA attempted to remove some of the positive bias in the metal emissions data by calculating an EF- correction factor for the following five metals (Al, Ba, Cu, Pb and Zn) for which it felt it had sufficient data points to develop a correction factor. This *floor-residue* correction factor was calculated using the EFs from materials that EPA believed did not contain the metal. EPA calculated the following average correction factor (expressed as an emission factor) for each metal: Al (7.2E-04 lb/ NEW), Ba (3.7E-04 lb/NEW), Cu (4.8E-04 lb/NEW), Pb (5.9E-04 lb/NEW), and Zn (3.8E-04 lb/NEW). EPA then subtracted these correction factors (along with the results from the background sample collected that day) from the individual detonation trial emission factors measured for materials known to or suspected to contain that metal and placed the results in the database. When this adjustment resulted in a negative emission factor,

1 EPA entered 0.0E+00 in the database.

While this correction was probably appropriate for Ba and Zn, it was not appropriate for Al, Cu and Pb because, unbeknownst to the EPA authors, the EBCs used to initiate each BangBox detonation contained 0.74 g of Al, 25.6 g of Cu and 0.19 g of Pb (as lead azide). In an attempt to reverse the inappropriate correction for Al, Cu and Pb made by EPA, the following actions were taken regarding these three metals:

- If the average EPA EF for a material was greater than 0.0E+00, the EPA correction factor was added to the EF and the EPA value was replaced with the new value.

- If the average EPA EF for a material was 0.0E+00, it was replaced with the letter code ND. (Simply entering the correction factor was not appropriate because the original value was unknown.)

The emission factors for Sb and Ti were rejected because there were only two non-zero emission factors for each metal and, according to MIDAS, these metals were not present in the materials with which the EFs were associated.

The following actions were taken regarding the remaining four metals (Ba, Cd, Cr and Zn):

- If the detonation pile did not contain the metal, and the EPA EF was equal to or greater than 0.0E+00, the EPA EF was replaced with the letter code NA.

- If the detonation pile contained the metal, and the EPA EF was:

    - Greater than 0.0E+00, the EPA EF was not changed.

    - Equal to 0.0E+00, the EPA value was replaced with one equal to ½ of the MDL value expressed as an EF, i.e., Ba = 1.1E-04 lb/NEW, Zn = 1.5E-04 lb/NEW, Cd = 6.5E-06 lb/NEW and Cr = 6.5E-06 lb/NEW.

2.2.4.1.3 Energetics

The EPA report contained a number of 0.0E+00 entries for some of the energetic compounds that MIDAS and/or the EPA report indicated were not present in the detonation pile, so therefore, the 0.0E+00 value was misleading. In addition, the EPA report also contained EFs greater than 0.0E+00 for energetic compounds that were not present in the detonation pile. To address these misleading EF values, the following actions were taken:

- If the energetic compound was present in the detonation pile, and the EPA report contained an EF greater than 0.0E+00, the EPA value was not changed.

- If the energetic compound was present in the detonation pile and the EPA report contained an EF of 0.0E+00, the EPA value was changed to BDL. (Because the BangBox MDL for the energetic plume measurement (1.5E-07 lb/ lb NEW) was 100 times higher than that for the system used in the DPG open range tests, it was not appropriate to change a BDL value to a value equal to 1/2MDL.[19])

- If the energetic compound was not present in the detonation pile (hence not a possible emission

product), and the EPA report contained an EF equal to or greater than 0.0E+00, the EPA value was replaced with the letter code NA

- If the EPA report indicated that either no sample was collected or that the sample collected was judged to be invalid by EPA or the DOD, the letter code NS was entered in the spreadsheet.

2.2.4.1.4 SVOC/POM

SVOC/POM samples were collected from the plumes for all of the test materials and analyzed for the SVOC/POMs target analytes listed in Table 12. Phthalates were the only SVOC target analytes detected in the plumes above the background level. Further, diethylphthalte was the only phthalate detected in all detonation trials for at least one of the test materials and it was the only SVOC/POM target analyte included in the EPA report. It was also detected at concentrations equivalent to EFs between 3.8E-04 and 1.8E−06 lb/ lb NEW (median = 1.4E-05 lb/lb NEW) in the background air samples associated with four of the materials, including one of the two materials for which it was reported as an emission product. Because it was possible that one or more of the materials detonated may have contained diethylphthalate, EPA decided to include the diethylphthalte EFs in its report. However, according to information in the EPA report and in MIDAS, diethylphthalate was not present in any of the four materials for which EPA listed it as a possible EP. In addition, none of the other SVOC/POM target analytes is known to have been present in the detonation piles. Therefore, the diethylphthalate EFs and those of the other SVOC/POM target analytes were entered as BDL (MDL = 6.6E-05 lb/ lb NEW).

Table 12. BangBox SVOC/POM Detonation Target Analytes.

CASRN	Compound	CASRN	Compound
100-01-6	4-Nitroaniline	56-55-3	Benz(a)anthracene
100-02-7	4-Nitrophenol	56-57-5	4-Nitroquinoline-1-oxide
100-51-6	Benzyl alcohol	57-97-6	Dimethylbenz(a)anthracene
100-75-4	Nitrosopiperdine,N-	581-89-5	2-Nitronaphthalene
101-55-3	Bromophenylphenylether	59-50-7	4-Chloro-3-methylphenol
105-67-9	2,4-Dimethylphenol	59-89-2	N-Nitrosomorpholine
10595-95-6	Nitrosomethylethylamine,N-	59-90-2	2,3,4,6-Tetrachlorophenol
106-44-5	Methylphenol,4-	60-11-7	p-Dimethylaminoazobenzene
106-46-7	1,4-Dichlorobenzene	606-20-2	2,6-Dinitrotoluene
106-47-8	p-Chloroaniline	98-95-3	Nitrobenzene
108-39-4	3-Methylphenol	608-93-5	Pentachlorobenzene
108-95-2	Phenol	621-64-7	Nitrosodi-n-propylamine,N-
109-06-8	2-Picoline	62-44-2	Phenacetin
110-86-1	Pyridine	62-50-0	Ethyl Methanesulfonate
111-41-4	Bis(2-chloroethyl)ether	62-75-9	Nitrosodimethylamine,N-
111-91-1	Bis(2-chloroethoxy)methane	65-85-0	Benzoic acid
117-81-7	Bis(2-ethylhexyl)phthalate	66-27-3	Methyl Methanesulfonate
117-84-0	Di-n-octyl phthalate	67-72-1	Hexachloroethane
118-74-1	Hexachlorobenzene	7005-72-3	4-Chlorophenylphenyl Ether
119-75-5	2-Nitrodiphenylamine	76-01-7	Pentachloroethane
119-93-7	Dimethylbenzidine,3,3'-	77-47-4	Hexachlorocyclopentadiene
120-12-7	Anthracene	78-59-1	Isophorone
120-58-1	Isosafrole	84-66-2	Diethylphthalate
120-82-1	1,2,4-Trichlorobenzene	84-74-2	Di-n-butylphthalate
120-83-2	1-Methylnaphthalene	85-01-8	Phenanthrene
120-833-2	2,4-Dichlorophenol	85-68-7	Butyl benzyl phthalate
121-14-2	2,4-Dinitrotoluene	86-30-6	N-Nitrosodiphenylamine
122-09-8	Dimethylphenethylamine	86-73-7	Fluorene
122-39-4	Diphenylamine	87-65-1	2,6-Dichlorophenol
122-66-7	1,2 Diphenylhydrazine	87-86-5	Pentachlorophenol
126-68-1	Triethylphosphorothioate	88-06-2	2,4,6-Trichlorophenol
129-00-0	Pyrene	88-72-2	2-Nitrotoluene
130-15-4	1,4-Naphthoquinone	88-74-4	2-Nitroaniline
131-11-3	Dimethylphthalate	88-75-5	2-Nitrophenol
132-64-9	Dibenzofuran	91-20-3	Naphthalene
134-32-7	1-Naphthylamine	91-57-6	2-Methylnaphthalene
143-50-0	Kepone	91-58-7	2-Chloronaphthalene
1888-71-7	Hexachloropropene	91-59-8	2-Naphthylamine
191-24-2	Benzo(g,h,i)perylene	91-80-5	Methapyrilene
193-39-5	Indeno[1,2,3-cd]pyrene	91-94-1	3,3'-Dichlorobenzidine
19406-51-0	4-Amino-2,6-Dinitrotoluene	924-16-3	Nitrosodi-n-butylamine,N-
205-99-2	Benzo(b)fluoranthene	92-52-4	Biphenyl
206-44-0	Fluoranthene	92-67-1	Aminobiphenyl,4-
207-08-9	Benzo(k)fluoranthene	92-87-5	Benzidine
208-96-8	Acenaphthylene	930-55-2	Nitrosopyrrolidine,N-
218-01-9	Chrysene	94-59-7	Safrole
2303-16-4	Diallate	95-48-7	Methylphenol,2-
23950-58-5	Pronamide	95-50-1	1,2-Dichlorobenzene
39638-32-9	Bis(2-chloroisopropyl)ether	95-53-4	o-Toluidine
50-32-8	Benz(a)pyrene	95-57-8	2-Chlorophenol
510-15-6	Chlorobenzilate	95-57-8	2-Methylphenol
51-28-5	2,4-Dinitrophenol	95-94-3	1,2,4,5-Tetrachlorobenzene
522-43-0	1-Nitropryene	95-95-4	2,4,5-Trichlorophenol
534-52-1	4,6-Dinitro-2-methylphenol	98-86-2	Acetophenone
53-70-3	Dibenz[a,h]anthracene	98-95-3	Nitrobenzene
53-96-3	Acetylaminofluorene,2-	99-09-2	3-Nitroaniline
540-73-8	Dimethylhydrazine,1,2-	99-35-4	1,3,5-Trinitrobenzene
541-73-1	1,3-Dichlorobenzene	99-55-8	5-Nitro-o-toluidine
55-18-5	Nitrosodiethylamine,N-	99-65-0	1,3-Dinitrobenzene
56-49-5	3-Methylcholanthrene	99-99-0	4-Nitrotoluene

2.2.4.2 Adjustments Specific to the Emissions from Cased Test Materials

2.2.4.2.1 Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs)

The BangBox PCDD/PCDD target analytes were: 1,2,3,4,6,7,8,9-Octachlorodibenzodioxin, 1,2,3,4,6,7,8-Heptachlorodibenzodioxin, 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8-Pentachlorodibenzo-p-dioxin, 2,3,7,8-Tetrachlorodibenzo-p-Dioxin, 1,2,3,4,7,8,9-Heptachlorodibenzofuran, 1,2,3,4,6,7,8,9-Octachlorodibenzofuran, 1,2,3,4,6,7,8-Heptachlorodibenzofuran, 1,2,3,4,7,8-hexachlorodibenzofuran, 1,2,3,6,7,8-hexachlorodibenzofuran, 1,2,3,7,8,9-Hexachlorodibenzofuran, 1,2,3,7,8-Pentachlorodibenzofuran, 2,3,4,6,7,8-Hexachlorodibenzofuran, 2,3,4,7,8-Pentachlorodibenzofuran and 2,3,7,8-Tetrachlorodibenzofuran.

The detonation plumes from the following eight cased materials were the only ones sampled for the PCDD/PCDF analytes: M-158, M43A2 and M-206 flares, ARD-446, BBU-36B and MK-107 impulse cartridges and FMU-139A/B and FMU-54A/B tail fuzes. These items were evaluated for PCDD/PCDF emissions because they contained a combination of materials (e.g., rubber, metal chlorides, chlorinated hydrocarbons, wool and chlorinated and non-chlorinated plastics) that had the potential to produce PCDD/PCDF emission products,

No furans were detected in any of the detonation plumes and the only dioxin detected was octachlorinated dibenzo-p-dioxin (OCDD). This latter compound was detected only in the M43A2 flare detonation plumes. Because dioxins were not found in the background air sample associated with the M43A2 detonations and because the OCDD EF (1.8E-09 lb/lb NEW) was 25 times larger than the EPA-derived MQL EF for OCDD, EPA included the OCDD EF in its report.[7] But, EPA also raised the following concerns about the validity of this EF:

- It seemed highly unlikely that the fully-chlorinated OCDD molecule would be the only PCDD compound produced from a process in which the starting materials were the small molecular fragments and did not produce SVOC emission products.

- Because the OCDD EF was much larger than the MDL for the PCDD target analytes (7.0E-11 lb/lb NEW), it seemed likely that other PCDDs would have been detected if they were present.

- The GC/MS used to analyze the sample was operated in the selective ion mode which provided high sensitivity but low specificity.

- OCDD is a common contaminant in laboratories which process PCDD compounds.

Based on the above facts, it seems highly likely that the OCDD EF resulted from either sample contamination or compound misidentification. Therefore, it was decided to enter BDL in the spreadsheet for all of the PCDD and PCDF emission results for these eight materials and to enter NS for these analytes for the other test materials.

2.2.4.2.2 Adjusting the EFs for the Contribution from the DIC and DIT

The detonations of the canon rounds were initiated using an EBC and a block of C4 (Detonation

Initiating Charge, DIC) and the detonations of the fuzes, impulse cartridges and flares were initiated using detonating cord, C4, and an EBC assembly (Detonation Initiating Train, DIT).

As noted earlier, none of the data sets in the EPA report had been adjusted for the emissions contributed by these assemblies. However, in real-world practice the explosive weight (NEW) of the detonation initiating assembly usually comprises less than 1% of the total NEW of the detonation pile. For example, the initiating charges used in the DPG open range detonations comprised between 0.5 and 1% of the total NEW of the detonation pile. In addition, a review of the items detonated between 2001 and 2007 at one of DOD's largest ammunition manufacturing and demilitarizing facilities determined that over this five-year period, the detonation initiating assemblies comprised less than 0.2% of the 1,960,000 lb (NEW) detonated. In contrast, the BangBox DIC assembly comprised approximately one third of the NEW in the canon round detonation piles, and the DIT comprised between 21 and 62% of the NEW in the detonation piles for the fuzes, impulse cartridges, and flares. To make the emissions data sets more closely represent real-world practice, the emissions data sets for the ten metal-cased test materials were adjusted as described below for the contribution from the initiating assemblies (to the extent that it was possible to do so).

2.2.4.2.2.1 Canon Rounds.

Energetics. The three 20mm rounds in the detonation pile contained 26.4 g of RDX and the two, 40mm rounds contained 108.8 g of RDX, values that account for 30% of the RDX in the 20mm detonation pile and 73% of the RDX in the 40mm detonation pile. Since there were no emissions data available for the DIC, the choices were to either exclude the RDX emission results for the canon rounds from consideration for inclusion in AP-42 or to assume that the RDX in the C4 had produced an EF that was equivalent to that produced by the RDX in the rounds. There were no emission test results to support the validity of this assumption, but as discussed in Section 2.2.4.2.2.2, there was experimental data indicating that the assumption was not valid. Therefore, it was decided to exclude the RDX EFs for the canon rounds from AP-42 and enter ND instead. The only other energetic compounds in the canon rounds that could be measured were HMX (20mm only) and NG (20 and 40mm) and they were not detected in the detonation plumes. Therefore, BDL was entered on the spreadsheet for these energetic compounds.

PM-10. For the following reasons, the EPA PM-10 EFs were entered in the AP-42 spreadsheet without modification. First, the PM-10 EFs for the other cased test items indicated that the particulate produced by the casing materials far overwhelmed that produced by the DIT and the DIC contained considerably less mass than the DIT. Second, the mass of metal in the detonation piles attributable to the canon rounds was 20 to 25 times greater than that attributable to the DIC.

Inorganic and Organic Gases. Because both the DIC and the canon rounds would have produced these EPs, there was no straightforward means to use the EFs to adjust the canon round emissions data sets for the contribution from the DIC. However, based on the emissions data sets from the DPG open range detonations and the results from Ornellas, it seemed reasonable to assume that the source of the predominant carbon-containing emission products (CO_2, CO and VOCs) was the carbon in the detonation pile and to assume that the emissions attributable to the canon rounds and the DIC would be approximately proportional to the mass of carbon in each. Therefore, they would have the same EFFs. Based on this line of reasoning, the EFs for the above inorganic and organic gases were converted to the corresponding EFFs and the EFFs entered into the spreadsheet. If the EF value was BDL, BDL was entered into the spreadsheet. NOTE - SO_2 and NOx samples were not collected in the canon round detonation tests.

Metals. The EBC used in the DIC contained 0.2 g of lead azide, 25.8 g Cu and 0.7 g Al. Because

the canon rounds also contained these metals in the same matrices, it seemed highly likely that the DIC and the canon rounds both contributed to the metal EFs in the EPA report. Further, since the metals were in the same matrices (i.e., alloys and energetic), it seemed reasonable to assume that the EFFs for these metals would be approximately the same for the DIC and the canon rounds. Based on this line of reasoning and the fact that there was no way to correct for the contribution from the DIC, the total weight (mass) of Al, Pb, and Cu in the detonation pile was used when the metal EFs were converted to the corresponding EFF values. These latter values were then placed in the AP-42 Excel workbook along with the EFFs for the other metals found in the canon round plumes.

2.2.4.2.2.2 Fuzes, Impulse Cartridges and Flares

Energetics. The FMU-139A/B fuze, which was the only one of the eight test items that contained a meaningful quantity of RDX, contained twice as much RDX as the DIT. Because of this large quantity of RDX, the RDX emissions could only be adjusted if one assumed that the RDX in the C4 had produced an EFF that was equivalent to that produced by the RDX in the fuze. But the emission test results from the isolated DIT detonations and the test results for the other seven cased materials, whose emissions were characterized in the BangBox, indicated that this assumption was not valid. For example, the average RDX EFF for the DIT was ten times larger than the average RDX EFF for the FMU-139 detonation trials. Further, the RDX EFFs for three of the seven cased test materials (none of which contained meaningful amounts of RDX) were also considerably higher than the RDX EFF for the FMU-139 fuze. Therefore, it was decided to not include a numerical RDX EFF for the FMU-39A/B fuze in AP-42, and instead report it as ND and to invalidate the PETN and RDX EFs for the other seven cased test materials. One other option considered was to combine the PETN EFs into one data set and the RDX EFs into a second data set and assign the average PETN and RDX EFs to the DIT. However, this option was subsequently rejected when emissions data collected in a series of detonation studies conducted at the Naval Air Warfare Center, Weapons Division at China Lake CA indicated that the unconfined nature of the DIT would have caused some of the PETN and RDX closest to the EBC to be kicked out.[20a, 20b] Therefore, the RDX and PETN EFs were invalidated.

PM-10. The PM-10 EFs for the cased items were 10 to 25 times larger than those for the DIT and the weight of the metal in the cased items comprised more than 90% of the metal in the detonation pile. On the other hand, the DIT comprised from 25 to 50% of the NEW of the detonation pile and the NEW is the denominator for the PM-10 EF (lb PM-10 / lb NEW). Thus, if the PM-10 EFs were not corrected for the contribution from the DIT, the EFs would be biased low. Based on these considerations, it was decided to adjust the PM-10 emissions using the following five step procedure.

Step 1: The PM-10 EFs reported for the DIT and the eight cased test materials were multiplied by the detonation pile NEW to produce an estimate of the average total mass of PM-10 produced in each detonation.

Step 2. The PM-10 mass for the DIT detonation (which involved the detonation of two full DITs) was divided by two (to obtain an estimate of the PM-10 mass produced by the full DIT used in the detonations of the flares and impulse cartridges) and also by four (to obtain an estimate of the PM-10 mass produced by the scaled down DIT used in the detonations of the fuzes).

Step 3. The PM-10 mass attributable to the DIT was subtracted from the total PM-10 mass on an item by item basis to obtain an estimate of the PM-10 mass attributable to the cased test item.

Step 4. The NEW of the detonation train was subtracted from the total NEW of the detonation pile to obtain the NEW attributable to the cased item.

Step 5. The PM-10 EFs produced in Step 3 were divided by the appropriate value from Step 4 to produce an adjusted EF for each test material and the result was entered on the AP-42 spreadsheet.

Inorganic and Organic Gases. Because both the DIT and the cased test materials would have produced these EPs, there was no straightforward means to use the EFs to adjust the cased test material data sets for the contribution from the DIT. However, based on the emissions data sets from the DPG open range detonations and the results from Ornellas, it seemed reasonable to assume that the source of the predominant carbon and nitrogen-containing emission products was the carbon in the detonation pile and to assume that the emissions attributable to the cased test materials and the DIT would be approximately proportional to the mass of carbon in each. Therefore, they would have the same EFFs. Based on this line of reasoning, the EFs for these inorganic and organic gases were converted to the corresponding EFFs and the EFFs entered on the spreadsheet. If the EF value was BDL, BDL was entered into the spreadsheet. NOTE - The SO_2 EFs for the cased test materials could not be converted to EFF values because the sulfur content of the test materials was uncertain.

Metals. The EBC used in the DIT contained 0.2 g of lead azide, 25.8 g Cu and 0.7 g Al and each cased test material also contained at least one of these metals in the same matrix as the DIT. Thus, it seemed reasonable to assume that when these metals were present in both the DIT and the cased test material, both items had contributed to the metal EFs in the EPA report. Also, since the metals were in the same matrices (i.e., alloys and energetic), it seemed reasonable to assume that the EFFs for these metals would be approximately the same for the DIT and the cased test materials. Further, the EPA EFs for Al and Cu associated with the isolated DIT detonations were ND, so there was no credible means to adjust the cased test material metal EFs for the contribution from the DIT. Therefore, the total weight (mass) of Al, Pb, and Cu in the detonation pile was used when the EFs were converted to the corresponding EFF values. These latter were then placed in the AP-42 Excel workbook along with the EFFs for the other metals found in the cased test materials. (NOTE – In the few cases where the metal was present in the detonation pile in two or more matrices at levels that prevented it from being assigned to a specific matrix, the letter code ND was entered in the AP-42 workbook.

2.2.5 Emissions Test Data Quality Ratings Assigned To Each BangBox EF/EFF

All of the BangBox EF/EFFs possessed the following positive characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology. Second, because the detonations were conducted either over or in a steel-lined pit, the test conditions did not reflect real-world open detonation processes. Third, the SF6 method used to determine the volume of the detonation plumes was very reliable. Fourth, descriptions of the compositions for most of the test materials were either provided in the EPA report and/or were available in MIDAS. Fifth, documentation in the EPA report and its appendices showed that all field testing and laboratory analyses activities were extensively and continuously audited by independent DOD contractors and also by the EPA over the life of the project, and that the EPA report itself was subjected to a highly credible peer review before it was released. Sixth, although the raw data sheets are no longer available, the EPA report shows they were used to construct the EFs presented in the test report. Seventh, the test results were consistent with detonation reaction theory

and the DPG open range detonation results, which involved much larger detonations under conditions that reflected real-world OD demil operations.

Based on these characteristics and the quality rating criteria recommendations in EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of C (average). This preliminary quality rating was converted to a final rating as described below.

2.2.5.1 Inorganic Gases

The EPA quality rating of C was retained for the CO and CO_2 because the lack of soil likely biased the CO EFFs low and the CO_2 EFFs high. Because the lack of soil would not have meaningfully influenced the NO_x EFFs, these NO_x EFFs were upgraded to B.

2.2.5.2 Volatile Organic Compounds (VOCs)

Most of the VOCs measured in the plume were also detected in the background samples at concentrations often similar to those measured in the detonation plumes. As discussed in Section 2.2.4.1.1, an attempt was made to adjust the EFFs for the contribution from the background air. In fact, the EFFs for 19 of the 43 VOCs detected had been corrected by more than 50%, which raises concerns about the accuracy and representativeness of these EFFs. The extent to which the EFF value had been adjusted for the background along with the absolute value of the EFF and the number of times it was detected were used to assign the final quality rating to each VOC emission product. For example, if the EFF had either not been adjusted or had been adjusted by less than 20% and the numerical value was at least an order of magnitude above the MDL, the quality rating was upgraded to B.

2.2.5.3 Metals

The metal EFFs had been adjusted for residues from the floor of the BangBox and it was highly likely that metal residues from previous tests were entrained in the detonation plumes of many of the detonation trials. In addition, the lack of soil probably influenced the metal emissions substantially in an unpredictable way. Based on these considerations, the quality rating code was lowered to D.

2.2.5.4 Energetic Compounds

All of the EFFs were BDL. Further, the MDL of the BangBox measurement system was several orders of magnitude higher than that for the DPG open range detonation trials and the energetic EFFs associated with the DPG open range tests (Tables 5 and 6) were also orders of magnitude lower than the BangBox MDL. Therefore, the quality rating code was reduced to D.

2.2.5.5 SVOCs/POMs

All of the EFs and EFFs were BDL. The MDL of the BangBox measurement system is three orders of magnitude higher than that for the DPG open range detonation tests, and all but a few of the SVOC/POM EFFs associated with the DPG open range detonation trials (Tables 5 and 6) were at least two orders of magnitude lower than the BangBox MDL. In addition, the lack of soil should favor reducing the quantity of SVOC/POMs emissions. Based on these considerations, the preliminary quality rating was downgraded to D.

2.2.5.6 PCDDs and PCDFs

Although all the EFs were BDL, the MDL of the measurement system was very low, i.e., 7E-11 lb/lb NEW. It was decided to upgrade the quality rating to B, based primarily on this fact and the consistency of the sampling results with detonation reaction theory.

2.2.5.7 PM-10

Particulates was the one EP category that would have been strongly influenced by the lack of soil, because soil comprises most of the particulate in detonation plumes. Based on this consideration, the PM-10 EFs were downgraded to D.

2.2.6 Tabulation of the Emissions Data

The BangBox open detonation emissions data selected for inclusion in AP-42 are presented in Tables 13 through 21 along with the EPA quality rating factor assigned to each EF/EFF value. Table 13 contains the results for the DIT and the Claymore mine. Tables 14, 15 and 16 present the results for the uncased high explosives. Tables 17, 18, 19 and 20 present the results for the difficult-to-detonate metal-cased materials (canon rounds, bomb fuzes, impulse cartridges and flares).

NOTE – As discussed earlier, none of the 120 SVOC/POM target analytes identified in Table 12 were detected in the detonation plumes. To avoid cluttering the tables with 120 BDLs for the SVOCs/POMs, it was decided to list in Tables 13 through 20 only the SVOC/POM that were also target analytes in the DPG open range tests.

Table 13. EFs/EFFs for the Detonation of the Claymore Mine and DIT in the BangBox.

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	2.3E-01	D	3.6E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	NA	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NS	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	4.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	ND	NA
	630-08-0	Carbon monoxide	lb/lb C	2.2E-02	C	6.1E-02	C
	NA	Nitrogen Oxides	lb/lb N	NS	NA	3.8E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		6.3E-02	D	ND	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		ND	NA	NA	NA
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		2.2E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	4.0E-01	D
	7439-92-1	Pb (In Alloy)		ND	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		NA	NA	NA	NA

Table 13 EFs/EFFs for the Detonation of the Claymore Mine and DIT in the BangBox (continued).

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(b)	106-99-0	1,3-Butadiene	lb/lb C	2.0E-06	C	4.1E-04	B
	106-98-9	1-Butene		5.6E-06	C	5.3E-05	B
	592-41-6	1-Hexene		1.8E-06	C	1.3E-04	C
	109-67-1	1-Pentene		1.0E-06	C	7.5E-05	B
	74-86-2	Acetylene		7.3E-04	B	6.9E-04	D
	107-05-1	Allyl Chloride		BDL	D	BDL	B
	71-43-2	Benzene		6.0E-04	B	1.3E-04	C
	142-29-0	Cyclopentene		BDL	D	2.0E-05	C
	74-84-0	Ethane		3.9E-06	C	2.3E-05	D
	75-00-3	Ethyl chloride		BDL	D	3.7E-06	D
	100-41-4	Ethylbenzene		2.8E-05	C	3.2E-06	B
	74-85-1	Ethylene		1.8E-04	B	2.1E-03	B
	115-11-7	Isobutene		2.7E-06	D	1.3E-04	D
	78-78-4	Isopentane		9.6E-07	D	BDL	C
	74-87-3	Methyl chloride		3.3E-06	C	1.4E-05	C
	75-09-2	Methylene chloride		8.1E-05	C	1.5E-04	D
	106-97-8	n-Butane		1.3E-06	D	1.7E-05	D
	142-82-5	n-Heptane		2.7E-06	D	7.5E-06	D
	110-54-3	n-Hexane		9.6E-07	C	9.6E-06	D
	109-66-0	n-Pentane		6.7E-06	D	5.3E-06	D
	622-96-8	p-Ethyltoluene		1.3E-05	C	6.4E-06	C
	74-98-6	Propane		2.7E-06	C	2.5E-05	B
	115-07-1	Propylene		1.8E-05	C	3.9E-04	C
	100-42-5	Styrene		1.3E-03	B	2.2E-05	C
	127-18-4	Tetrachloroethylene		BDL	D	5.9E-05	C
	108-88-3	Toluene		1.9E-04	C	2.2E-05	B
	NA	TNMHC		4.7E-03	C	2.3E-02	C
	624-64-6	trans-2-Butene		1.3E-05	C	2.1E-05	D
	646-04-8	trans-2-Pentene		BDL	D	4.7E-06	B
	75-01-4	Vinyl chloride		8.1E-07	D	2.6E-06	C
	1330-20-7	Xylenes		ND	NA	1.1E-04	D
	56-23-5	Carbon tretrachloride		BDL	D	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	C
	627-20-3	cis-2-pentane		BDL	D	2.3E-06	C
	110-82-7	Cyclohexane		9.6E-07	D	4.2E-06	D
	287-92-3	Cyclopentane		5.3E-07	D	8.7E-07	D
	75-28-5	isobutane		3.8E-07	D	BDL	D
	92-82-8	isopropylbenzene		BDL	D	BDL	D
	71-55-6	Methylchloroform		1.7E-06	D	BDL	C
	108-87-2	Methylcyclohexane		3.9E-06	C	BDL	D
	96-37-7	Methylcyclopentane		1.2E-05	C	8.1E-07	D
	620-14-4	m-Ethyltoluene		4.1E-06	D	1.3E-06	D
	124-18-5	n-decane		7.4E-06	D	3.5E-06	D
	111-84-2	n-nonane		9.6E-07	D	4.6E-06	D
	111-65-9	n-octane		5.3E-06	D	3.2E-06	NA
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW

(b) MDL= 6.0E-07 lb/lb C

Table 14. EFs/EFFs for the Detonation of Comp B and HBX in the BangBox.

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.8E-01	D	1.2E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		ND	NA	ND	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.0E-03	B	1.3E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	C	3.9E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.8E-02	C	1.5E-02	C
	NA	Nitrogen Oxides	lb/lb N	5.7E-02	B	1.9E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	5.1E-02	D	NA	NA
	7429-90-5	Al (In alloy)		NA	NA	ND	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		NA	NA	NA	NA
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		3.2E-02	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	ND	NA
	7439-92-1	Pb (In Alloy)		NA	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		NA	NA	ND	NA

Table 14. EFs/ EFFs for the Detonation of Comp B and HBX in the BangBox (continued).

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(b)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BDL	D
	106-98-9	1-Butene		2.2E-05	C	3.0E-06	C
	592-41-6	1-Hexene		9.5E-06	C	5.6E-06	C
	109-67-1	1-Pentene		5.3E-06	C	BDL	B
	74-86-2	Acetylene		1.0E-04	B	4.9E-05	C
	107-05-1	Allyl Chloride		BDL	D	BDL	D
	71-43-2	Benzene		2.5E-05	C	9.1E-05	C
	142-29-0	Cyclopentene		1.4E-06	B	BDL	D
	74-84-0	Ethane		5.6E-06	C	3.2E-06	C
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		6.3E-06	C	7.0E-06	C
	74-85-1	Ethylene		1.1E-04	B	4.9E-05	C
	115-11-7	Isobutene		1.2E-05	C	3.4E-06	C
	78-78-4	Isopentane		BDL	D	6.0E-07	D
	74-87-3	Methyl chloride		2.2E-06	C	2.6E-06	C
	75-09-2	Methylene chloride		3.2E-04	C	3.3E-04	C
	106-97-8	n-Butane		1.8E-06	D	BDL	D
	142-82-5	n-Heptane		1.4E-06	D	1.8E-06	D
	110-54-3	n-Hexane		1.4E-06	D	1.4E-06	D
	109-66-0	n-Pentane		1.8E-06	D	9.5E-07	D
	622-96-8	p-Ethyltoluene		2.6E-06	D	3.4E-06	D
	74-98-6	Propane		3.0E-06	C	1.8E-06	C
	115-07-1	Propylene		3.3E-05	C	1.1E-05	C
	100-42-5	Styrene		BDL	D	BDL	D
	127-18-4	Tetrachloroethylene		BDL	D	6.3E-05	B
	108-88-3	Toluene		1.2E-05	C	2.1E-05	C
	NA	TNMHC		6.3E-04	C	3.9E-04	C
	624-64-6	trans-2-Butene		1.6E-05	C	BDL	D
	646-04-8	trans-2-Pentene		6.0E-07	C	BDL	D
	75-01-4	Vinyl chloride		BDL	D	BDL	D
	1330-20-7	Xylenes		2.8E-05	C	3.3E-05	C
	56-23-5	Carbon tretrachloride		9.8E-07	D	1.3E-06	C
	67-66-3	Chloroform		9.8E-07	D	BDL	D
	627-20-3	cis-2-pentane		9.8E-07	D	BDL	D
	110-82-7	Cyclohexane		BDL	D	BDL	D
	287-92-3	Cyclopentane		1.4E-06	C	BDL	D
	75-28-5	isobutane		1.4E-06	D	1.3E-06	D
	92-82-8	isopropylbenzene		BDL	D	BDL	D
	71-55-6	Methylchloroform		1.3E-06	D	BDL	D
	108-87-2	Methylcyclohexane		2.1E-06	D	8.1E-06	D
	96-37-7	Methylcyclopentane		2.2E-06	D	6.0E-07	D
	620-14-4	m-Ethyltoluene		BDL	D	9.5E-07	D
	124-18-5	n-decane		6.0E-07	D	6.0E-07	D
	111-84-2	n-nonane		BDL	D	4.6E-06	D
	111-65-9	n-octane		1.8E-06	D	1.3E-06	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA
(a) MDL = 6.6E-05 lb/lb NEW							
(b) MDL = 6.0E-07 lb/lb C							

Table 15. EFs/EFFs for the Detonation of TNT and Amatol in the BangBox.

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	7.3E-02	D	1.9E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	NA	NA	ND	NA
	121-82-4	RDX		NA	NA	ND	NA
	118-96-7	TNT		BDL(b)	D	ND	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	2.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.3E+00	C
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	C	4.6E-02	C
	NA	Nitrogen Oxides	lb/lb N	ND	NA	1.6E-01	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7440-39-3	Al (In alloy)		NA	NA	ND	NA
	7440-43-9	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-47-3	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		NA	NA	NA	NA
	7440-50-8	Cr (In Protective Coating)		NA	NA	NA	NA
	7439-92-1	Cu (In Alloy)		7.0E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	7.8E-01	D
	7440-66-6	Pb (In Alloy)		NA	NA	NA	NA
	106-99-0	Zinc (In Alloy)		ND	NA	NA	NA

Table 15. EFs/EFFs for the Detonation of TNT and Amatol in the BangBox (continued).

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
	106-98-9	1,3-Butadiene		4.4E-06	C	BDL	D
	592-41-6	1-Butene		4.9E-06	C	5.6E-06	C
	109-67-1	1-Hexene		5.7E-06	C	9.4E-06	C
	74-86-2	1-Pentene		3.6E-06	C	5.6E-06	C
	107-05-1	Acetylene		4.4E-05	C	4.5E-04	B
	71-43-2	Allyl Chloride		BDL	D	BDL	D
	142-29-0	Benzene		1.1E-05	B	1.1E-04	B
	74-84-0	Cyclopentene		1.2E-06	C	BDL	D
	75-00-3	Ethane		8.8E-07	D	1.3E-05	C
	100-41-4	Ethyl chloride		BDL	D	BDL	D
	74-85-1	Ethylbenzene		8.8E-07	D	5.6E-06	C
	115-11-7	Ethylene		5.7E-05	C	1.5E-04	B
	78-78-4	Isobutene		9.4E-06	C	4.7E-06	C
	74-87-3	Isopentane		1.3E-06	D	4.7E-06	D
	75-09-2	Methyl chloride		BDL	D	3.5E-06	C
	106-97-8	Methylene chloride		4.7E-04	C	7.1E-04	C
	142-82-5	n-Butane		BDL	D	2.9E-06	D
	110-54-3	n-Heptane		1.7E-06	D	3.5E-06	D
	109-66-0	n-Hexane		1.7E-06	D	2.6E-06	D
	622-96-8	n-Pentane		5.7E-06	D	BDL	D
	74-98-6	p-Ethyltoluene		3.1E-06	D	2.4E-05	C
	115-07-1	Propane		BDL	D	4.7E-06	C
VOCs(c)	100-42-5	Propylene	lb/lb C	1.9E-05	C	2.6E-05	C
	127-18-4	Styrene		BDL	D	BDL	D
	108-88-3	Tetrachloroethylene		BDL	D	1.7E-06	B
	NA	Toluene		9.1E-06	C	3.1E-05	C
	624-64-6	TNMHC		2.0E-04	C	2.1E-03	B
	646-04-8	trans-2-Butene		2.5E-06	C	2.6E-06	C
	75-01-4	trans-2-Pentene		5.2E-07	D	3.3E-07	D
	1330-20-7	Vinyl chloride		BDL	D	BDL	D
	56-23-5	Xylenes		ND	NA	2.4E-05	C
	67-66-3	Carbon tretrachloride		BDL	D	8.0E-07	D
	627-20-3	Chloroform		BDL	D	BDL	D
	110-82-7	cis-2-pentane		5.2E-07	D	BDL	D
	287-92-3	Cyclohexane		4.2E-07	D	BDL	D
	75-28-5	Cyclopentane		8.8E-07	D	BDL	D
	92-82-8	isobutane		5.2E-07	D	2.9E-06	D
	71-55-6	isopropylbenzene		1.7E-06	C	BDL	D
	108-87-2	Methylchloroform		BDL	D	1.7E-06	C
	96-37-7	Methylcyclohexane		8.8E-07	D	1.2E-05	C
	620-14-4	Methylcyclopentane		1.3E-06	D	8.0E-07	D
	124-18-5	m-Ethyltoluene		1.2E-06	D	8.0E-07	D
	111-84-2	n-decane		BDL	D	BDL	D
	111-65-9	n-nonane		BDL	D	1.7E-06	D
	NA	n-octane		2.6E-06	D	1.3E-06	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW

(b) MDL = 1.7E-07 lb/lb TNT

(c) MDL = 6.0E-07 lb/lb C

Table 16. EFs/EFFs for the Detonation of Tritonal in the BangBox

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	3.7E-01	D	2.6E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		ND	NA	ND	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.8E-05	B	1.2E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	3.8E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.3E-03	C	7.8E-03	C
	NA	Nitrogen Oxides	lb/lb N	5.4E-02	B	6.3E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	1.4E-01	D	9.9E-02	D
	7429-90-5	Al (In alloy)		NA	NA	NA	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		NA	NA	NA	NA
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		NA	NA	4.9E-03	D
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	ND	NA
	7439-92-1	Pb (In Alloy)		NA	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		NA	NA	NA	NA

Table 16. EFs/EFFs for the Detonation of Tritonal in the BangBox (continued).

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(b)	106-99-0	1,3-Butadiene	lb/lb C	2.1E-06	C	3.8E-06	C
	106-98-9	1-Butene		4.5E-06	C	1.1E-05	B
	592-41-6	1-Hexene		8.0E-06	C	8.1E-06	C
	109-67-1	1-Pentene		4.8E-06	C	2.6E-06	C
	74-86-2	Acetylene		3.8E-04	B	5.5E-05	C
	107-05-1	Allyl Chloride		BDL	D	BDL	D
	71-43-2	Benzene		1.8E-05	C	9.0E-06	C
	142-29-0	Cyclopentene		2.3E-06	C	1.0E-06	C
	74-84-0	Ethane		5.4E-07	D	2.1E-06	C
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		7.4E-06	C	4.6E-06	C
	74-85-1	Ethylene		8.0E-05	C	7.3E-05	C
	115-11-7	Isobutene		2.3E-06	D	5.8E-06	D
	78-78-4	Isopentane		3.5E-06	D	BDL	D
	74-87-3	Methyl chloride		1.2E-06	C	1.1E-06	C
	75-09-2	Methylene chloride		8.0E-06	D	4.6E-04	C
	106-97-8	n-Butane		2.5E-06	D	1.0E-06	D
	142-82-5	n-Heptane		BDL	D	BDL	D
	110-54-3	n-Hexane		BDL	D	BDL	D
	109-66-0	n-Pentane		9.3E-07	D	BDL	D
	622-96-8	p-Ethyltoluene		1.4E-05	C	8.4E-07	D
	74-98-6	Propane		2.3E-06	C	1.0E-06	C
	115-07-1	Propylene		2.3E-06	C	1.8E-05	B
	100-42-5	Styrene		BDL	D	BDL	D
	127-18-4	Tetrachloroethylene		9.3E-06	B	1.1E-06	B
	108-88-3	Toluene		4.2E-06	C	BDL	D
	NA	TNMHC		3.8E-03	C	6.4E-04	C
	624-64-6	trans-2-Butene		3.5E-06	C	5.2E-06	C
	646-04-8	trans-2-Pentene		8.6E-07	C	6.4E-07	C
	75-01-4	Vinyl chloride		BDL	D	BDL	D
	1330-20-7	Xylenes		4.5E-05	C	2.9E-05	C
	56-23-5	Carbon tretrachloride		5.4E-07	C	BDL	D
	67-66-3	Chloroform		1.2E-06	C	BDL	D
	627-20-3	cis-2-pentane		BDL	D	BDL	D
	110-82-7	Cyclohexane		BDL	D	BDL	D
	287-92-3	Cyclopentane		1.2E-06	D	BDL	D
	75-28-5	isobutane		1.2E-06	C	1.2E-06	C
	92-82-8	isopropylbenzene		BDL	D	1.2E-06	C
	71-55-6	Methylchloroform		BDL	D	BDL	D
	108-87-2	Methylcyclohexane		2.2E-05	C	6.4E-06	C
	96-37-7	Methylcyclopentane		1.2E-06	C	BDL	D
	620-14-4	m-Ethyltoluene		BDL	D	BDL	D
	124-18-5	n-decane		8.6E-07	D	1.0E-06	D
	111-84-2	n-nonane		4.2E-06	D	BDL	D
	111-65-9	n-octane		8.6E-07	D	BDL	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW.

(b) MDL 6.0E-07 lb/lb C

1 Table 17. EFs/EFFs for the Detonation of Canon Rounds in the BangBox.

EP Category	CASRN	EP	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	ND	D	4.7E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics(b)	78-11-5	PETN	lb/lb Energetic	NA	NA	NA	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA
	55-63-0	NG		BDL(b)	NA	BDL(b)	NA
	479-45-8	Tetryl		NA	NA	NA	NA
	2691-41-0	HMX		BDL(c)	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	ND	ND	ND
	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	C	3.7E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.7E-01	C	5.8E-02	C
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		2.9E-02	D	1.1E-02	D
	7440-39-3	Ba (In Energetic As Compound)		3.1E-02	D	NA	D
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		1.7E-03	D	1.0E-02	D
	7440-47-3	Cr (In Protective Coating)		NA	NA	ND	NA
	7440-50-8	Cu (In Alloy)		1.6E-02	D	2.1E-02	D
	7439-92-1	Pb (In Energetic As Compound)		ND	D	6.4E-01	D
	7439-92-1	Pb (In Alloy)		ND	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		9.1E-03	D	7.0E-02	D

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Table 17. EFs/EFFs for the Detonation of Canon Rounds in the BangBox (continued).

Pollutant Category	CASRN	Pollutant	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOC(d)	106-99-0	1,3-Butadiene	lb/lb C	8.2E-06	C	5.3E-06	C
	106-98-9	1-Butene		3.8E-05	C	1.4E-05	C
	592-41-6	1-Hexene		7.0E-06	C	3.9E-06	C
	109-67-1	1-Pentene		5.6E-06	C	2.4E-06	C
	74-86-2	Acetylene		2.9E-04	C	1.2E-04	C
	107-05-1	Allyl Chloride		BDL	D	BDL	D
	71-43-2	Benzene		1.8E-04	C	7.8E-05	C
	142-29-0	Cyclopentene		BDL	C	2.3E-06	C
	74-84-0	Ethane		1.5E-04	C	8.4E-05	D
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		7.4E-06	D	2.4E-06	D
	74-85-1	Ethylene		4.6E-04	C	2.3E-04	C
	115-11-7	Isobutene		3.5E-05	C	2.5E-05	C
	78-78-4	Isopentane		5.0E-06	D	2.5E-05	D
	74-87-3	Methyl chloride		2.1E-06	C	BDL	D
	75-09-2	Methylene chloride		7.2E-04	C	2.4E-03	C
	106-97-8	n-Butane		1.2E-05	D	3.9E-06	D
	142-82-5	n-Heptane		8.5E-06	D	4.8E-06	D
	110-54-3	n-Hexane		5.6E-06	D	1.8E-05	D
	109-66-0	n-Pentane		2.1E-05	D	1.2E-05	D
	622-96-8	p-Ethyltoluene		2.2E-05	D	1.5E-05	D
	74-98-6	Propane		2.1E-05	C	1.1E-05	C
	115-07-1	Propylene		8.2E-05	C	4.5E-05	C
	100-42-5	Styrene		1.9E-06	D	3.9E-05	D
	127-18-4	Tetrachloroethylene		BDL	D	BDL	D
	108-88-3	Toluene		4.8E-05	D	2.4E-05	D
	NA	TNMHC		1.9E-03	C	9.2E-04	C
	624-64-6	trans-2-Butene		1.5E-05	C	5.3E-06	C
	646-04-8	trans-2-Pentene		2.7E-06	C	1.4E-05	C
	75-01-4	Vinyl chloride		BDL	D	BDL	D
	1330-20-7	Xylenes		ND	NA	ND	NA
	56-23-5	Carbon tretrachloride		1.2E-05	D	1.3E-05	D
	67-66-3	Chloroform		BDL	D	BDL	D
	627-20-3	cis-2-pentane		4.3E-07	C	9.0E-07	C
	110-82-7	Cyclohexane		7.7E-07	D	7.0E-06	D
	287-92-3	Cyclopentane		1.1E-06	D	1.7E-06	D
	75-28-5	isobutane		2.2E-06	D	1.6E-06	D
	71-55-6	Methylchloroform		5.3E-06	D	BDL	D
	108-87-2	Methylcyclohexane		4.5E-06	D	2.5E-06	D
	96-37-7	Methylcyclopentane		4.5E-06	D	8.7E-06	D
	620-14-4	m-Ethyltoluene		5.9E-06	D	BDL	D
	124-18-5	n-decane		1.0E-05	D	1.5E-05	D
	111-84-2	n-nonane		7.7E-07	D	5.3E-06	D
	111-65-9	n-octane		1.5E-05	D	1.0E-05	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW.

(b) Even if none of the NG had detonated, the plume concentration would be too small to measure.

(c) Even if none of the HMX had detonated, the plume cocentration would be too small to measure.

(d) MDL = 6.0E-07 lb/lb C

Table 18. EFs/EFFs for the Detonation of Bomb Fuzes in the BangBox.

Pollutant Category	CASRN	Pollutant	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.3E+01	D	7.0E+00	D
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C

Table 18. EFs/EFFs for the Detonation of Bomb Fuzes in the BangBox. (continued).

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		BDL(c)	D	BDL(c)	D
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.8E-03	B	4.0E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.2E+00	C
	630-08-0	Carbon monoxide	lb/lb C	6.0E-02	C	6.2E-02	C
	NA	Nitrogen Oxides	lb/lb N	ND	NA	1.9E-01	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		4.1E-02	D	8.8E-02	D
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		ND	NA	ND	NA
	7440-47-3	Cr (In Alloy)		ND	NA	ND	NA
	7440-47-3	Cr (In Protective Coating)		ND	NA	ND	NA
	7440-50-8	Cu (In Alloy)		2.2E-02	D	5.6E-03	D
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	ND	NA
	7439-92-1	Pb (In Alloy)		ND	NA	ND	NA
	7440-66-6	Zinc (In Alloy)		8.0E-02	D	ND	NA
VOCs(d)	106-99-0	1,3-Butadiene	lb/lb C	1.0E-05	C	BDL	D
	106-98-9	1-Butene		2.0E-04	C	1.2E-03	C
	592-41-6	1-Hexene		3.6E-05	C	2.5E-04	C
	109-67-1	1-Pentene		3.7E-05	C	2.8E-04	C
	74-86-2	Acetylene		8.9E-03	C	6.1E-02	C
	107-05-1	Allyl Chloride		4.6E-04	B	2.1E-03	B
	71-43-2	Benzene		1.7E-03	B	1.5E-02	B
	142-29-0	Cyclopentene		BDL	D	6.6E-05	C
	74-84-0	Ethane		3.0E-05	C	1.4E-03	B
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		4.6E-05	B	3.2E-04	B
	74-85-1	Ethylene		3.6E-03	B	1.5E-02	B
	115-11-7	Isobutene		BDL	D	BDL	D
	78-78-4	Isopentane		3.2E-06	D	1.3E-04	C
	74-87-3	Methyl chloride		6.1E-05	C	3.6E-04	C
	75-09-2	Methylene chloride		1.6E-03	B	6.2E-03	B
	106-97-8	n-Butane		2.4E-05	C	1.4E-04	C
	142-82-5	n-Heptane		4.3E-06	D	1.5E-05	D
	110-54-3	n-Hexane		2.7E-06	D	BDL	D
	109-66-0	n-Pentane		1.1E-05	D	1.3E-05	D
	622-96-8	p-Ethyltoluene		1.2E-05	C	2.3E-04	B
	74-98-6	Propane		4.0E-05	B	6.2E-05	B
	115-07-1	Propylene		6.0E-04	B	3.8E-03	B
	100-42-5	Styrene		4.2E-04	C	9.8E-04	C

Table 18. EFs/EFFs for the Detonation of Bomb Fuzes in the BangBox. (continued).

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(d)	127-18-4	Tetrachloroethylene	lb/lb C	BDL	D	BDL	D
	108-88-3	Toluene		3.3E-04	B	4.4E-03	B
	NA	TNMHC		3.8E-02	B	3.5E-01	B
	624-64-6	trans-2-Butene		1.8E-04	C	9.8E-04	C
	646-04-8	trans-2-Pentene		2.5E-05	C	1.0E-04	C
	75-01-4	Vinyl chloride		2.5E-05	C	8.2E-05	C
	1330-20-7	Xylenes		BDL	D	BDL	D
	56-23-5	Carbon tretrachloride		1.4E-05	C	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	D
	627-20-3	cis-2-pentane		8.3E-06	C	6.2E-05	C
	110-82-7	Cyclohexane		2.6E-07	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D
	75-28-5	isobutane		3.5E-05	D	3.1E-05	D
	92-82-8	isopropylbenzene		BDL	D	2.1E-05	D
	71-55-6	Methylchloroform		2.4E-06	D	BDL	D
	108-87-2	Methylcyclohexane		BDL	D	BDL	D
	96-37-7	Methylcyclopentane		2.6E-06	D	1.4E-05	D
	620-14-4	m-Ethyltoluene		9.3E-06	D	5.0E-05	D
	124-18-5	n-decane		1.4E-05	D	BDL	D
	111-84-2	n-nonane		2.2E-06	D	3.9E-05	D
	111-65-9	n-octane		3.1E-06	D	3.9E-05	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 7.0E-11 lb/lb NEW.

(b) MDL = 6.6E-05 lb/lb NEW.

(c) MDL = 2.0E-07 lb/lb Tetryl

(d) MDL = 6.0E-07 lb/lb C

Table 19. EFs/EFFs for the Detonation of Impulse Cartridges in the BangBox.

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E+00	D	4.9E+00	D	4.5E-01	D
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C	BDL	C

Table 19. EFs/EFFs for the Detonation of Impulse Cartridges in the BangBox (continued).

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA	NA	NA
	55-63-0	NG		NA	NA	BDL(c)	D	BDL(d)	D
	479-45-8	Tetryl		NA	NA	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.6E-05	B	2.8E-04	B	9.9E-05	B
	124-38-9	Carbon dioxide	lb/lb C	3.3E+00	C	3.4E+00	C	3.6E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.0E-02	C	5.8E-02	C	6.0E-02	C
	NA	Nitrogen Oxides	lb/lb N	2.9E-01	B	ND	NA	ND	NA
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		5.1E-03	D	4.2E-03	D	ND	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA	4.6E-03	D
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA	ND	NA
	7440-47-3	Cr (In Alloy)		ND	NA	ND	NA	7.2E-05	D
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		ND	NA	5.1E-03	D	1.6E-02	D
	7439-92-1	Pb (In Energetic As Compound)		8.6E-02	D	4.4E-02	D	ND	NA
	7439-92-1	Pb (In Alloy)		ND	NA	NA	NA	ND	NA
	7440-66-6	Zinc (In Alloy)		1.1E-02	D	1.8E-03	D	ND	D
VOCs(e)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BDL	D	8.6E-06	C
	106-98-9	1-Butene		BDL	D	3.0E-04	B	4.3E-05	C
	592-41-6	1-Hexene		8.2E-04	C	1.6E-03	B	3.1E-05	C
	109-67-1	1-Pentene		3.1E-04	C	2.9E-04	C	1.9E-05	C
	74-86-2	Acetylene		1.8E-02	B	3.6E-02	B	1.0E-03	B
	107-05-1	Allyl Chloride		BDL	D	5.5E-03	B	2.2E-05	C
	71-43-2	Benzene		6.1E-03	B	2.4E-03	B	2.8E-04	B
	142-29-0	Cyclopentene		1.6E-04	B	1.1E-04	B	4.2E-06	C
	74-84-0	Ethane		2.4E-03	B	2.4E-04	B	6.9E-06	C
	75-00-3	Ethyl chloride		BDL	D	BDL	D	BDL	D
	100-41-4	Ethylbenzene		1.8E-04	C	1.2E-03	B	4.2E-06	D
	74-85-1	Ethylene		1.7E-02	B	3.2E-03	B	7.7E-04	C
	115-11-7	Isobutene		BDL	D	3.4E-03	B	2.1E-05	C
	78-78-4	Isopentane		BDL	D	4.0E-04	C	BDL	D
	74-87-3	Methyl chloride		8.3E-06	C	BDL	D	4.1E-06	C
	75-09-2	Methylene chloride		4.1E-03	C	8.9E-02	B	9.9E-04	C
	106-97-8	n-Butane		9.3E-05	C	1.6E-03	B	2.0E-06	D
	142-82-5	n-Heptane		1.3E-04	C	3.2E-04	C	4.3E-06	D
	110-54-3	n-Hexane		7.8E-05	D	2.8E-04	C	2.3E-06	D
	109-66-0	n-Pentane		7.2E-05	D	3.1E-04	C	8.6E-07	D
	622-96-8	p-Ethyltoluene		BDL	D	8.8E-04	C	BDL	D
	74-98-6	Propane		4.0E-04	C	1.8E-04	C	6.0E-06	D
	115-07-1	Propylene		3.1E-03	B	BDL	D	1.1E-04	C
	100-42-5	Styrene		3.9E-04	C	4.8E-04	C	4.0E-05	C

Table 19. EFs/EFFs for the Detonation of Impulse Cartridges in the BangBox (continued).

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(e)	127-18-4	Tetrachloroethylene	lb/lb C	3.4E-03	C	BDL	D	BDL	D
	108-88-3	Toluene		1.6E-03	C	3.7E-03	C	3.9E-05	D
	NA	TNMHC		BDL	C	BDL	C	6.5E-03	D
	624-64-6	trans-2-Butene		7.1E-04	C	BDL	D	3.6E-05	C
	646-04-8	trans-2-Pentene		2.4E-05	C	2.5E-05	C	1.1E-06	D
	75-01-4	Vinyl chloride		BDL	D	8.1E-04	C	3.7E-06	C
	1330-20-7	Xylenes		BDL	D	BDL	D	ND	NA
	56-23-5	Carbon tretrachloride		BDL	D	BDL	D	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	D	BDL	D
	627-20-3	cis-2-pentane		3.7E-05	C	6.2E-05	C	1.1E-05	C
	110-82-7	Cyclohexane		BDL	D	BDL	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D	BDL	D
	75-28-5	isobutane		1.5E-04	D	BDL	D	1.8E-06	D
	92-82-8	isopropylbenzene		BDL	D	5.4E-04	C	9.5E-07	D
	71-55-6	Methylchloroform		4.5E-05	D	BDL	D	BDL	D
	108-87-2	Methylcyclohexane		BDL	D	1.8E-04	D	2.2E-06	D
	96-37-7	Methylcyclopentane		6.4E-04	C	1.9E-04	C	9.5E-07	D
	620-14-4	m-Ethyltoluene		4.5E-05	C	5.0E-04	C	2.0E-06	D
	124-18-5	n-decane		8.7E-06	D	2.2E-03	C	1.1E-06	D
	111-84-2	n-nonane		2.7E-05	D	1.6E-03	C	1.6E-06	D
	111-65-9	n-octane		3.2E-05	D	4.9E-04	C	1.9E-06	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA	NA	NA

(a) MDL = 7.0E-11 lb/lb NEW.

(b) MDL = 6.6E-05 lb/lb NEW.

(c) MDL = 6.E-07 lbs/lb NG

(d) MDL = 2.0E-07 lb/lb NG

(e) MDL = 6.0E-07 lb/lb C

Table 20. EFs/EFFs for the Detonation of Flares in the BangBox.

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	9.2E+00	D	7.1E+00	D	1.2E+00	D
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		NA	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte		NA	C	BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C	BDL	C

Table 20. EFs/EFFs for the Detonation of Flares in the BangBox (continued).

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.6E-03	B	ND	NA	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.5E+00	C	3.4E+00	C
	630-08-0	Carbon monoxide	lb/lb C	3.8E-02	C	7.1E-02	C	8.0E-02	C
	NA	Nitrogen Oxides	lb/lb N	2.5E-01	B	1.7E-01	B	8.9E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		7.7E-02	D	3.8E-02	D	9.5E-04	D
	7440-39-3	Ba (In Energetic As Compound)		1.5E-01	D	1.4E-01	D	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	ND	NA	ND	NA
	7440-47-3	Cr (In Alloy)		ND	NA	ND	NA	4.6E-04	D
	7440-47-3	Cr (In Protective Coating)		3.8E-03	D	NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		ND	NA	8.6E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	3.2E-01	D	ND	NA
	7439-92-1	Pb (In Alloy)		NA	NA	ND	NA	ND	NA
	7440-66-6	Zinc (In Alloy)		2.0E-01	D	8.0E-02	D	2.0E-02	D
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BDL	D	BDL	D
	106-98-9	1-Butene		1.2E-04	C	1.4E-04	C	6.4E-04	C
	592-41-6	1-Hexene		BDL	D	1.2E-05	C	2.5E-04	C
	109-67-1	1-Pentene		BDL	D	BDL	D	1.5E-04	C
	74-86-2	Acetylene		6.8E-03	B	4.4E-03	B	7.3E-03	B
	107-05-1	Allyl Chloride		5.1E-04	C	3.0E-04	C	5.4E-04	C
	71-43-2	Benzene		1.0E-03	B	4.1E-04	B	6.8E-04	B
	142-29-0	Cyclopentene		BDL	D	BDL	D	3.5E-05	C
	74-84-0	Ethane		BDL	D	8.3E-05	C	3.8E-04	C
	75-00-3	Ethyl chloride		8.1E-05	C	BDL	D	BDL	D
	100-41-4	Ethylbenzene		6.2E-05	C	4.0E-06	D	8.5E-06	D
	74-85-1	Ethylene		BDL	D	1.3E-03	B	2.5E-03	B
	115-11-7	Isobutene		BDL	D	BDL	D	BDL	D
	78-78-4	Isopentane		4.6E-06	D	2.7E-06	D	BDL	D
	74-87-3	Methyl chloride		BDL	D	1.3E-05	C	BDL	D
	75-09-2	Methylene chloride		1.1E-02	B	BDL	C	3.0E-03	B
	106-97-8	n-Butane		BDL	D	1.8E-05	C	BDL	D
	142-82-5	n-Heptane		BDL	D	1.1E-06	D	1.3E-05	D
	110-54-3	n-Hexane		BDL	D	2.5E-06	D	1.3E-05	D
	109-66-0	n-Pentane		9.2E-05	D	3.6E-06	D	6.2E-06	D
	622-96-8	p-Ethyltoluene		BDL	D	BDL	D	BDL	D

Table 20. EFs/EFFs for the Detonation of Flares in the BangBox (continued).

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-98-6	Propane	lb/lb C	BDL	D	1.5E-05	C	9.9E-05	C
	115-07-1	Propylene		BDL	D	1.4E-04	C	9.1E-04	C
	100-42-5	Styrene		1.6E-04	C	5.0E-05	C	1.9E-05	C
	127-18-4	Tetrachloroethylene		BDL	D	BDL	D	BDL	D
	108-88-3	Toluene		7.5E-04	C	4.7E-04	C	7.8E-04	C
	NA	TNMHC		3.0E-02	C	1.3E-02	C	1.2E-01	C
	624-64-6	trans-2-Butene		3.5E-05	C	1.1E-04	C	1.3E-04	C
	646-04-8	trans-2-Pentene		BDL	D	2.3E-06	D	1.6E-05	D
	75-01-4	Vinyl chloride		3.7E-05	C	3.5E-05	C	3.1E-05	C
	1330-20-7	Xylenes		BDL	D	BDL	D	BDL	D
	56-23-5	Carbon tretrachloride		BDL	D	BDL	D	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	D	BDL	D
	627-20-3	cis-2-pentane		1.6E-07	D	3.5E-06	C	3.6E-06	C
	110-82-7	Cyclohexane		BDL	D	BDL	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D	BDL	D
	75-28-5	isobutane		7.7E-06	D	4.3E-06	D	5.0E-05	C
	92-82-8	isopropylbenzene		1.7E-05	C	BDL	D	BDL	D
	71-55-6	Methylchloroform		BDL	D	BDL	D	BDL	D
	108-87-2	Methylcyclohexane		4.6E-06	D	BDL	D	5.4E-06	D
	96-37-7	Methylcyclopentane		3.0E-06	D	1.8E-06	D	1.2E-05	D
	620-14-4	m-Ethyltoluene		4.7E-06	D	BDL	D	2.5E-06	D
	124-18-5	n-decane		2.9E-06	D	2.5E-06	D	1.2E-05	D
	111-84-2	n-nonane		1.0E-05	C	3.0E-06	D	2.1E-05	D
	111-65-9	n-octane		7.2E-06	D	9.8E-07	D	3.0E-05	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA	NA	NA

(a) MDL = 7.0E-11 lb/lb NEW

(b) MDL = 6.6E-05 lb/lb NEW

(c) MDL = 6.0E-07 lb/lb C

2.2.7 Discussion of the BangBox Open Detonation Test Results

Table 21 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation, of the mean (std dev) and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EP(s) that would be released into the plume.

Table 21 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory and the representativeness of the EF/EFF values to real-world detonation activities.

Inspection of the results presented in Tables 13 through 20 and Tables 5 and 6 lead to the following conclusions.

2.2.7.1 Particulate Matter

PM-10. The RSD value (0.77) for the 17 PM-10 values is rather good. However, the maximum PM-10 value is a factor of three less than the minimum PM-10 DPG value, which was associated with the suspended TNT detonation. This is not surprising because the BangBox detonations were not conducted on soil. In addition, on average, the PM-10 EFs associated with the cased test materials are a factor of three higher than those for the uncased ones. This would also be expected. At best, the BangBox PM-10 EFs provide a crude estimate of the PM-10 due to the munition itself.

2.2.7.2 Inorganic Gases

CO_2. The RSD value (0.74) for the 18 EFFs is rather good. On average, approximately 98% of the carbon in the test materials was converted to CO_2, compared to 95% in the DPG open range detonations. This is not surprising because of the lack of soil in the BangBox detonations.

CO. The RSD value (0.11) for the 18 EFFs is excellent. On average, approximately 2% of the carbon in the test materials was converted to CO compared to approximately 5% in the DPG open range detonations. This is not surprising because of the lack of soil during the BangBox detonations.

NO_x . The RSD value (1.17) for the 14 EFFs is rather good. On average, approximately 2% of the nitrogen in the test materials was converted to NO_x compared to 0.6% for the DPG open range detonations.

Table 21. Summary Statistics for the BangBox OD EFs/EFFs

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	17	6.0E-01	1.2E-02	2.3E-01	2.5E-01	1.9E-01	0.77	D
Inorganic Gases	Carbon Monoxide	lb/lbC	18	1.7E-01	7.8E-03	5.8E-02	5.3E-02	3.9E-02	0.74	B
	Carbon Dioxide	lb/lb C	17	3.9E+00	2.5E+00	3.5E+00	3.5E+00	3.4E-01	0.10	B
	Nitrogen Oxides	lb/lb N	14	3.2E-01	1.9E-02	3.8E-02	6.7E-02	7.9E-02	1.17	B
	Sulfur Dioxide	lb/lb NEW	12	1.4E-03	7.8E-05	3.3E-04	4.8E-04	4.2E-04	0.88	B
Energetics	Energetics	lb/lb Energetic	All Values BDL							
SVOCs	SVOCs In Energetic	lb/lb SVOC	No Data							
	SVOCs Not In Energetic	lb/lb NEW	All Values BDL							
VOCs	Benzene	lb/lb C	18	6.0E-04	9.0E-06	1.4E-04	1.9E-04	1.4E-04	0.74	B
	TNMHC		18	3.4E-02	2.1E-04	6.3E-03	7.9E-03	8.7E-03	1.11	B
	Acetylene		18	1.8E-03	4.4E-05	7.3E-04	7.7E-04	6.1E-04	0.80	B
	Ethylene		18	2.3E-03	4.9E-05	6.5E-04	7.1E-04	7.4E-04	1.05	B
	Methylene Chloride		18	2.4E-03	8.0E-06	4.0E-04	6.2E-04	6.5E-04	1.05	B
	Propylene		18	4.1E-04	2.3E-06	1.1E-04	1.3E-04	1.4E-04	1.08	B
	Toluene		17	1.9E-04	4.2E-06	5.7E-05	6.7E-05	5.7E-05	0.85	B
Metals	Metals In Energetic As Particle	lb/lb Metal	3	1.4E-01	5.1E-02	9.9E-02	9.8E-02	4.6E-02	0.47	D
	Metals In Alloy		35	2.0E-01	7.2E-05	1.1E-02	3.1E-02	4.1E-02	1.35	D
	Metals In Energetic As Compound		10	7.8E-01	4.6E-03	1.5E-01	2.6E-01	2.7E-01	1.04	D

2.2.7.3 Metals

As noted earlier, the location and chemical; form of the metal play a predominant role in determining the quantity of the metal released into the plume when energetic materials are detonated.[1,2, 3] The summary statistics in Table 21 assume that each metal EFF within a metal EP subcategory represents a robust estimate for all metals in that subcategory. The median EFFs (lb/lb Metal) for the three metal emissions subcategories (in decreasing order) are as follows: *Metals in Energetic As Compound* (1.5E-01), *Metals in Energetic As Particle* (9.9E-02) and *Metals in Alloys* (1.1E-02), which is consistent with what one would expect for these emission categories. For example, the *Metals In Energetic As Compound*. category has the largest median EFF value and this is not surprising because the metal compound decomposes when the detonation is initiated and this releases the metal from its chemical bonds. (NOTE – There was only one EFF (3.8E-03 lb/lb Metal) for the *Metals in Coating* subcategory. Further, it was associated with a test material containing an extremely small quantity of a cadmium chromate coating, so the EFF is rather tenuous. For these reasons, summary statistics were not calculated.)

2.2.7.4 VOCs

The EFFs for the 43 VOC emission products measured in the plume were very low and were dominated by the simplest unsaturated and aromatic hydrocarbons. In fact, on average, the following six VOC compounds account for more than 98% of the mass of carbon in the VOC analytes: benzene, acetylene, ethylene, methylene chloride, propylene and toluene. Further, the BangBox median EFFs for benzene and TNMHC (1.4E-04 lb/lb C and 6.3E-03 lb/lb C, respectively) agree well with the corresponding median for the open range study (2.6E-04 lb/lb C and 6.8E-03).

2.2.7.5 PCDDs/PCDFs

Even though the measurement system had an MDL equal to 7.0E-11 lb/lb NEW, PCDD and PCDF compounds were not detected in the plumes for the eight materials with compositions that had the highest chance to produce these compounds. (NOTE - These results also indirectly confirm the earlier conclusion that SVOC compounds did not form in meaningful amounts, because SVOCs/POMs would be intermediates in the formation of PCDDs/PCDFs.)

2.2.7.6 Energetics

All of the energetic results were either BDL or ND.

2.2.7.7 SVOCs/POMs

None of the 120 SVOC/POM target analytes were detected above either the MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes. The failure to detect SVOCs/POMs in the BangBox plumes is not surprising because: (1) benzene and toluene would be intermediate products in the formation of most of the SVOC/POM compounds; (2) the EFs for benzene and toluene were less than two orders of magnitude higher than the MDL of the BangBox SVOC/POM measurement system; and (3) the SVOC/POM EFs obtained in the open range detonations were one or two orders of magnitude below this MDL.

2.3 NTS 155MM Projectile Detonation Emissions Data Set

2.3.1 Description of the Tests

This set of emissions data was obtained from sampling the plumes released when 155MM projectiles containing Composition B were detonated at the Nevada Test Site in 1997 and 1999.[9, 10] The test chamber was a large room mined out of a volcanic ash fall tuff lying within Little Skull Mountain in Area 25 of the NTS. A 430 ft tunnel leads to the chamber, which is approximately 36 ft high by 49 ft wide by 100 ft long. The chamber has a nominal volume of 64,000 ft^3. The interior surfaces of the chamber, including the stainless steel door leading into it, are coated with fiber-reinforced shot-crete.

The 1997 tests involved four detonations. Six projectiles were detonated in the first trial (BANSHEE) , which was an operational readiness test (ORI). Twenty-four projectiles were detonated in each of the next two tests (POLARIS and BEAST), and 60 projectiles were detonated in the last test (COLOSSUS). In the POLARIS test the projectiles were lying horizontally on a steel plate, but in the BEAST AND COLOSSUS tests they were lying horizontally on the gravel that had been used to fill in the crater produced by the POLARIS test.

The 1999 tests involved three 24-projectile detonations. The first two detonations were replicates of the 1997 BEAST detonation (24 projectiles lying on a bed of gravel), and the last one involved a new stacking configuration in which 24 projectiles were placed vertically on a bed of gravel.

The detonation chamber was sealed before the projectiles were detonated, and remained sealed for a considerable period of time after plume sampling had been completed. The plume samples were collected from the sealed chamber using probes inserted through four sampling ports in the chamber door (containment plug). The measurement systems used and the suite of target analytes (CO_2, CO, NO, NO_2, HCN, N_2, O_2, VOCs, SVOCs/POMs, metals, TSP and PM-10 were similar to those used in the BangBox tests described earlier with two notable exceptions. First, a mixture of helium and neon was used as the plume (volume) tracer instead of SF_6. Second, no attempt was made to measure the energetic compounds in the detonation plumes.

Samples of the residue on the floor of the chamber were also collected after detonation. These samples were analyzed for energetics using EPA Methods SW-846 Methods 8330 and 8320, and for SVOCs/POMs using SW-846 Method 8270. The samples were also analyzed for metals using SW-846 Methods 1311, 6010 and 7470.

2.3.2 Evaluation of the NTS Detonation Test Results for Inclusion in AP-42

Between 1997 and 2000, the U.S. Army and its contractors released a number of test reports on these detonations and on some rocket motor burns that were conducted in the same chamber shortly after the 1997 projectile detonations. In all these reports, the results were reported in concentration units standardized to normal temperature and pressure. Before an evaluation of the test results for possible inclusion in this chapter of AP-42 could be initiated, it was necessary to convert the concentration units to the equivalent emission factors. This was accomplished by multiplying the concentrations by the appropriate plume volume and dividing the product by the mass of the energetic detonated. The resulting emission factors and associated test conditions under which they were derived were then evaluated to determine if the NTS detonation EFs should be included in AP-42.

The following documents were consulted in this evaluation:

- The suite of reports associated with the 1997 and 1999 detonations.[9, 10, 21 -23]

- The composition of the 155MM M107 projectile in MIDAS.

- Emission characterization study results involving the detonation of Hawk and NIKE rocket motors conducted in the same NTS chamber after the 1997 detonations.[11, 12, 24-26]

- Articles on the formation and measurement of SVOC compounds from combustion processes.[27, 28]

This evaluation determined the following:

- Stratification of both solid and gaseous EPs was present in the detonation plumes when the 1997 and 1999 plume samples were collected. For example, large differences were observed in the paired metal emission product sampling trains.

- The shot-crete coating on the chamber surfaces removed CO_2 from the detonation plume during the 1997 detonation tests and caused a rapid conversion of NO to NO_2 during the 1997 and 1999 detonation tests.

- 99% of the nitrogen in the 155MM projectiles was converted to nitrogen gas.

- Most of the VOC compounds detected are common air pollutants, and the concentrations reported were within what might be expected in a shot-crete lined chamber that is purged continuously with air collected above the dirt-covered parking lot at the entrance to the tunnel leading to the detonation chamber. In fact, the background samples collected before the rocket motor burns indicated that many of the VOC target analytes were present in the NTS chamber at concentrations much higher than found in normal ambient air. When these background VOC concentrations were converted to the equivalent emission factors, they produced values which were very similar to those reported for many of the VOC emissions products, i.e., 1E-06 to 1E-07.

- Because of the blast shielding used to protect the thermocouples in the 1997 detonations, it is very likely that the thermocouples were measuring the wall temperature and not the detonation plume temperature.

- Most of the SVOC analytes detected in the plume are commonly occurring air pollutants that were present in the chamber air and/or on the interior surfaces of the chamber.

- The five most concentrated SVOCs/POMs measured on the detonation chamber walls are the same five most concentrated SVOCs/POMs found in diesel exhaust. (Diesel-fired machinery was frequently used in the detonation chamber prior to and between the detonation and burn tests.

- Plume sampling began 15 to 18 minutes after the detonation was initiated. Based on the

results from the real-time particle concentration monitors used in the 1999 detonation tests, it is highly likely that substantial particle losses attributable to deposition and agglomeration processes occurred long before the plume sampling began in 1997 and 1999 and these losses continued throughout the 152 to 230-minute plume sampling periods.

- Hi-Vol particulate results from background air samples collected in the chamber during the 1997 detonations showed that the air in the detonation chamber contained elevated particle concentrations. For example, the average particulate mass concentration for the two Hi-Vol samples collected before the BEAST detonation was 184 mg/m^3.

- Every metal measured in the detonation plumes was already present in at least one of the following chamber materials before the detonation tests were initiated: shot-crete, concrete, and gravel. Further, the metal content of the total filterable particulate samples indicated that a substantial portion of the particulate mass came from the interior surfaces of the chamber. In addition, the concentration ratios of the metals in these materials varied from one sampling point to the next.

- Cross-contamination of metals and possibly other solid and SVOC emission products occurred from one test to the next. For example, the EFF for Pb for the HAWK rocket motor burn was three orders of magnitude higher than the amount of Pb in the rocket motor. This strongly indicates that the Pb came from the two NIKE rocket motors burns conducted several months before the Hawk burn. (The NIKE contains approximately 12 lb of Pb whereas the Hawk contains less than one lb)

Because this evaluation showed that the detonations did not reflect real-world detonation events, the decision was made to exclude the NTS emissions data from AP-42.

2.4 Summary and Conclusions

2.4.1 Comparability of the BangBox (BB) and DPG Open Detonation Emission Data Sets

A statistical comparison of means was done between the following BB and DPG EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene, and TNMHC. This comparison determined that all of the pairs except the PM-10 data sets were statistically the same. So, each pair of statistically-equivalent data sets was combined and the summary statistics calculated. Table 22 presents these summary statistics along with proposed EPA quality rating codes. These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance to detonation reaction theory and representativeness to real-world open detonation activities.

Table 22 also contains summary statistics for the following EP/EP categories for which there was either only BangBox data or the DPG open range data were far superior to the BangBox data.

PM-10. The DPG open range data set. Because the open range and BangBox data sets are statistically different, they could not be combined. The PM-10 DPG open range EF data set was selected because it more closely reflects real-world detonation processes than the soil-free BangBox detonations. However, the quality rating of D indicates that these PM-10 values are of poor quality, and therefore must be used with extreme caution.

SO_2 The BangBox SO_2 EF values.

VOCs. The BangBox EFFs for acetylene, ethylene, methylene chloride, propylene, and toluene. Together with benzene these six VOCs comprised essentially all of the carbon in the BangBox VOC emissions.

Energetics. The DPG open range energetic EFFs

SVOCs/POMs Not In Energetic. The DPG open range EFs.

Metals. The BangBox EFFs.

Table 22. Summary Statistics for the BangBox and DPG Open Range Detonation Data Sets

EP Category	EP	Units	Data Source	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	DPG	5	1.1E+01	1.6E+00	9.0E+00	7.7E+00	3.6E+00	0.47	D
Inorganic Gases	Carbon Monoxide	lb/lb C	DPG + BB	23	2.0E-01	7.8E-03	6.0E-02	7.1E-02	5.7E-02	0.81	B
	Carbon Dioxide	lb/lb C	DPG + BB	22	3.9E+00	2.5E+00	3.5E+00	3.5E+00	3.0E-01	0.09	B
	Nitrogen Oxides	lb/lb N	DPG + BB	19	3.2E-01	1.7E-03	3.3E-02	5.3E-02	7.2E-02	1.36	B
	Sulfur Dioxide	lb/lb NEW	BB	12	1.4E-03	7.8E-05	3.3E-04	4.8E-04	4.2E-04	0.88	B
Energetics	Energetics	lb/lb Energetic	DPG	5	2.0E-06	5.0E-10	9.3E-08	4.5E-07	8.7E-07	1.95	C
SVOC	SVOCs In Energetic	lb/lb SVOC	No Data								
	SVOCs Not In Energetic	lb/lb NEW	DPG	49	2.0E-06	8.5E-09	8.0E-08	2.8E-07	4.8E-07	1.71	B
VOCs	Benzene	lb/lb C	DPG + BB	23	6.0E-04	9.0E-06	1.7E-04	2.0E-04	1.6E-04	0.82	B
	TNMHC		DPG + BB	23	3.4E-02	2.0E-04	7.2E-03	7.7E-03	7.9E-03	1.03	B
	Acetylene		BB	18	1.8E-03	4.4E-05	7.3E-04	7.7E-04	6.1E-04	0.80	B
	Ethylene		BB	18	2.3E-03	4.9E-05	6.5E-04	7.1E-04	7.4E-04	1.05	B
	Methylene Chloride		BB	18	2.4E-03	8.0E-06	4.0E-04	6.2E-04	6.5E-04	1.05	B
	Propylene		BB	18	4.1E-04	2.3E-06	1.1E-04	1.3E-04	1.4E-04	1.08	B
	Toluene		BB	17	1.9E-04	4.2E-06	5.7E-05	6.7E-05	5.7E-05	0.85	B
Metals	Metals In Energetic As Particle	lb/lb Metal	BB	3	1.4E-01	5.1E-02	9.9E-02	9.8E-02	4.6E-02	0.47	D
	Metals In Alloy		BB	35	2.0E-01	7.2E-05	1.1E-02	3.1E-02	4.1E-02	1.35	D
	Metals In Energetic As Compound		BB	10	7.8E-01	4.6E-03	1.5E-01	2.6E-01	2.7E-01	1.04	D

2.4.2 Representativeness and Adequacy of the Detonation EFs/EFFs

2.4.2.1 Open Air Surface Detonations

As noted earlier, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. The RSDs for ten of the 19 data sets are less than 1.0 and the RSDs for all 19 are less than 2.0. These results show that within most of the data sets the EFs or EFFs are well correlated, i.e., that the results are of good quality. This close correlation is not surprising based on detonation reaction theory and the limited number of substances found in the explosive materials open detonated.

The vast majority of open detonation operations in the U. S. involve the disposal of aluminized and non-aluminized cased and uncased energetic materials. Although the types of items detonated number in the hundreds, the actual number of metals and explosives involved is small. That is, the casings and interior metal parts are almost exclusively aluminum, iron or copper alloys, and the high explosives are comprised of one or more of the following: TNT, RDX, aluminum particles, wax, plasticizers and performance modifiers. Thus, the actual number of uniquely different explosive–containing materials detonated is quite small. This narrow range in explosive materials can be seen by a review of the information in Table 23, which shows the major components of the explosives in the 3,500,000 lb GWT (1,960,000 lb NEW) of energetic materials detonated over a 5-year period at a large DOD ammunition manufacturing and demilitarization facility. In this 5-year period, the facility detonated: 16,700 steel-cased propelling charges, 16,800 large calibre steel cartridges, 712,000 steel or brass-cased primers, 16,200 steel-cased landmines, 750,000 steel-cased fuzes, 28,600 copper-cased blasting caps, 184,000 lbs of reclaimed aluminized explosive, 205,000 lb of reclaimed Composition B and TNT (used as donor material), and 7,500 lb of C4 (used to initiate the detonations). As a group, the 25 test materials whose emissions were selected for AP-42 include all of these explosives and metals. Thus, their emissions should cover most of the substances of environmental concern that could be released into the environment via the detonation plume.

Table 23. Compositions of the HE and Propellant Open Detonated Over Five Years.

Compound	Comp B	C-4	CXM-7	H-6	PBX	TNT	Destex	Tritonal
RDX	59.5%	91.0%	95.0%	45.1%	90.0%	.	.	.
TNT	39.5%	.	.	29.2%	.	100.0%	72.0%	80.0%
Wax	1.0%	.	.	4.7%	.	.	5.0%	.
Aluminum	.	.	.	21.0%	.	.	20.0%	20.0%
Polystyrene	.	.	.	.	8.5%	.	.	.
Dioctylphalate	.	.	.	.	1.5%	.	.	.
Dioctyladipate	.	.	5.0%	.	.	.	.	.
Graphite	.	.	.	.	.	.	3.0%	.
Plasticizers	.	9.0%	.	.	.	.	.	.

Based on the summary statistics shown in Table 22, the EFs/EFFs in the following EP/EP categories can be used with confidence for estimating the emissions from most routine open air detonation activities: CO, NO_x, SO_2, benzene, acetylene, methylene chloride, propylene, toluene, allyl chloride and *SVOCs/POMs Not In The Energetic*. This conclusion is based on the following considerations: (1) the RSDs, (2) the number of EFs / EFFs used to calculate the summary statistics, (3) the representativeness of the test conditions (under which the EF/EFFs were derived) to real-world detonation operations, (4) the EPA Quality Rating Code; (5) the absolute magnitude of the EF/EFFs, (6) the potential toxicity of exposure to the emission product via air pathways, (7) the manner in which real detonation activities are conducted (i.e., multiple detonations in the same area over a one hour timeframe) and (8) the agreement of the EF/EFF to detonation reaction theory.

Based on the very limited number of EF/.EFFs available and the EPA Quality Rating Codes assigned to them, the EFs/EFFs in the following EP/EP categories are probably not adequate for estimating the emissions from many surface open air detonations: (1) PM-10, (2) the four metal subcategories, (3)

Energetics and (4) SVOCs/POMs In Energetics. Obtaining additional emissions characterization data for these categories is recommended, particularly the effect of detonating under a soil cover.

2.4.2.2 Buried and Soil Covered Detonations

Buried and soil-covered detonations are done at facilities where blast noise, blast wave transmission and/or fragment travel can cause problems. The NEW of the detonation pile is usually less than 400 lb. When munitions are detonated under these conditions, the fireball is partially or fully suppressed, a situation that is very different from the conditions under which the EFs/EFFs in Chapter 16 of AP-42 were derived. There are no emissions data specific to soil-covered and buried detonations, and it would not be appropriate to apply the EFs/EFFs in Chapter 16 to buried and soil-covered detonations without considering the effect that suppression of the fire ball could have on the emissions. Fortunately, there are emissions data from studies in bomb calorimeters and detonation chambers that can provide insight on the effect that fireball suppression has on the emissions from detonations. These studies are discussed in Appendix A.

3.0 SELECTION OF OPEN BURN EMISSIONS DATA

3.1 DPG Open Range Open Burn Emissions Data Sets

3.1.1 Test Description

These emission data were produced in 1989 and 1990 when 4,600 to 7,000 lb of five individual propellant materials were burned in steel pans on a test range at DPG, UT. The burn pans were approximately 4 ft wide, 36 ft long, and 0.8 ft high and were placed side by side. Three pans were used in each burn trial. The propellant materials were placed in the pans to a depth of 2.5 to 3.5 inches (6-9 cm), and the burns were initiated using black powder trains placed at both ends of each pan.[6, 7] The testing was done in two phases.

Samples were collected from 28 burn plumes by means of a twin engine turboprop airplane that traversed the plume at 90 knots (150 ft/s). The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between 3 to 7 seconds. For safety reasons and also to provide time for all important chemical reactions to end, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted, 10 ft long, 3-in I.D. aluminum probe, which exited into a 11 ft long, 4 in ID sampling manifold inside the airplane. The probe extended outside the aircraft's boundary layer at a position forward and above the copilot's windshield. A sliding valve located at the union of the probe and sampling manifold directed the plume gases into either the manifold (sampling mode) or back into the atmosphere (bypass mode).

The following sampling equipment was attached to the sampling manifold: an 80 L, Tedlar bag; three high volume samplers containing Teflon-coated quartz fiber filters (sampling at a rate of 3 to 4 m^3/min); and an evacuated 6 L stainless steel canister. As the airplane approached the plume for its initial pass, the high volume sampler motors were started, but the manifold sampling valve was left in the bypass mode. When the nephelometer mounted in the front of the airplane indicated that the airplane was entering the plume (sharp increase in nephelometer reading), the manifold sliding valve was moved to the sampling mode. When the nephelometer indicated that the airplane was exiting the plume (sharp drop off in the nephelometer reading), the sliding valve was placed in the bypass mode, where it remained until the airplane was ready to make its next pass through the plume. After each pass through the plume, the VOC canister sampler was removed from the sampling manifold and replaced with a clean evacuated one while the other samplers remained unchanged. After the final pass through the plume, the high volume sampler motors were turned off and the CO_2, CO, NO, and NO_2 concentrations in the Tedlar bag were determined using continuous emission monitors (CEMs) on board the aircraft. The crew then prepared to sample the next detonation plume by evacuating the 80 L Teflon bag and attaching a clean, evacuated 6 L canister to the manifold.

Each burn trial was comprised of two or three burn events spaced 15 to 20 minutes apart. To ensure that sufficient particulate would be collected to allow characterization of the SVOC and energetic compound content of the particulate, the same high volume filters were used for all detonations comprising a trial. This approach produced total high volume sampling volumes from 280 to 350 ft^3 (8 to 10 m^3).

No attempt was made to collect plume samples for analysis for HCl or for polychlorinated dioxin and furan compounds, because an AP-propellant burn test conducted in the SNL BangBox had determined that the concentrations of any HCl or dioxin and furan compounds in the plumes would be too low to

detect with the available equipment. No attempt was made to sample for toxic metals.

Each test day before the first detonation or burn trial was conducted the airplane collected a 20-minute background air sample 1,000 ft above the test range using the same sampling procedures and equipment that would be used to collect plume samples. The concentrations of target analytes found in these background samples were used to correct the emission factors produced that day for the contribution from ambient air pulled into the plume. (NOTE - This approach assumes that the only background air species present in the plume are those present in the air before the burn. It ignores species pulled into the plume from the soil by turbulence produced by rapidly rising plume. Because these latter materials are not included in the background sample, they become part of the reported emissions. Many of the SVOC/POM and energetic target analytes were known to be present in the soil.[6] Thus, it's likely that some of the SVOC/POM and energetic EPs were actually extraneous material pulled into the plume from or with the soil.)

At the conclusion of each trial or background sample collection effort, the aircraft returned to the airfield where the high volume filters were recovered, placed in an ice-cooled container, and transported to a laboratory in Provo, UT where they were stored in a freezer. The filters were subsequently weighed, Soxhlet-extracted, and the extract was analyzed for the target SVOCs/POMs and energetics by GC/MS and Super Critical Fluid Chromatography/MS-selective ion monitoring (SFC/MS-SIM), respectively. The 6 L canisters were sent to a laboratory in Beaverton, OR for analysis for VOCs.

A description of the plume measurement systems used in these tests can be found in Table 24 and a list of the target analytes can be found in Table 25. Because of the prove-out nature of the project and funding limitations, the number of SVOC target analytes was kept small.

Samples of the materials thrown out (sputter) from the burn pan and materials which fell out of the plume (fallout) near the burn pan were also collected using one meter square aluminum pans. The 10 sputter pans were located on the outside edges of the burn pans, and the 12 fallout pans were located at 20 and 38 ft from the center of the burn pan array. At the conclusion of each trial, the materials in the burn pan (ash), sputter pans and fallout pans were recovered and placed in separate sample jars. All samples were then placed in a freezer until they could be extracted and analyzed for SVOCs/POMs and energetics using the same procedures as used for the filter samples.

Table 24. Emissions Test Methods Used in DPG OB Field Studies.

Target Analyte or Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (CSI Model 1600) [Sampling and Analysis]
PM-10	40 CFR 50, Appendix B combined with aircraft sampling probe.
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOCs/POMs	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and GC/MS [Analysis]
Energetics	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and analysis by Supercritical Fluid Chromatography/MS (SFC / MS)
CO, CO_2 (Primary CO and CO_2 Sampling System)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)

Table 25. DPG OB Field Test Target Analytes.

Inorganic Gases and Particulate Matter	NO; NO_2, CO, CO_2 , PM-10
VOCs	Aromatic hydrocarbons, C_1 to C_{10} saturated and unsaturated hydrocarbons and chlorinated hydrocarbons
SVOCs/POMs	Benz(a)anthracene; benz(a)pyrene; dibenzofuran; N−nitrosodiphenylamine; 2-methylnaphthalene; naphthalene; nitrobenzene; phenol; 2-nitrophenol; 4-nitrophenol; phenanthrene; pyrene; pyridine; 1-nitropyrene, 1,3,5-trinitrobenzene, 2-nitrotoluene, 4-nitrotoluene; 2-nitronaphthalene, diphenylamine, 2-nitrodiphenylamine, 2,4-dinitrotoluene and 2,6-dinitrotoluene
Energetics	NG, NQ, HMX and RDX

3.1.2 Description of the Test Materials and Burn Piles

The compositions of the five propellant materials used in this emissions characterization study are presented below along with information on the number of plumes sampled and the target analytes detected in the ash and throw-out pans.

3.1.2.1 Waste Propellants

Waste Propellant Mixture A. This material was comprised of four double-base propellants and one ammonium perchlorate (AP) propellant. Some of the double-base propellants were in pellet form and the others were sheet form. The AP propellant was in the form of chunks. The AP propellant, which represented approximately 25% of the material burned, was placed in the middle burn pan, and the double-base propellants were placed in the outer pans. The material burned contained 1135 kg NC, 865 kg NG, 45 kg 2-nitrodiphenylamine, 606 kg AP, 85 kg triacetin, 70 kg of Pb, and 30 kg Al. A single trial comprised two, 3,000 kg burns spaced approximately 11 minutes apart. One burn required 180 seconds to complete; the other required 240 seconds. The average mass of ash recovered from the burn pans for the two burns was 5.4kg, which is equal to 0.2% of the energetic mass burned. The ash contained 2.9mg of phenol; no other SVOC or energetic target analytes were found.

Waste Propellant Mixture B. This material was comprised of two double-base propellants in sheet form. The propellants were open burned while rolled out flat in the burn pans. The two propellants together contained 1115 kg NC, 793 kg NG, 43 kg 2-nitrodiphenylamine, 13 kg triacetin, 55 kg Pb and 184 kg dibutylphthalate. Two two-burn trials were conducted. The first trial consisted of one open burn with a NEW of 2,253 kg, and the second burn with a NEW of 2,184 kg. In the second trial, two 2,218 kg quantities of the propellant were burned. The two burns in the first trial were initiated approximately 12 minutes apart, and the two burns in the second trial were initiated approximately 15 minutes apart. The burn times for the four burns ranged from 63 to 68 seconds. The average mass of ash recovered from the burn pan for the four burns was 0.6kg, which is equal to 0.1% of the energetic mass burned. The ash contained low nanogram quantities of 2,4-DNT; no other SVOC or energetic target analytes were found.

3.1.2.2 Single-base Propellants

M1 Propellant. This single-base propellant was burned as multi-perforated pellets approximately 1 cm long and 0.4 cm in diameter. The material burned contained 2,729kg NC, 16 kg diphenylamine, 321 kg 2.4-DNT, and 160 kg dibutylphthalate. Two three-burn trials were conducted. Each trial involved the open burning of three 3,159 kg quantities of propellant. In the first trial, the second burn was initiated approximately 14 minutes after the first, and the third burn was initiated approximately 21 minutes after the second. In the second trial, the three burns were initiated approximately 13 minutes apart. The burn times for the six burns ranged from 16 to 19 seconds. The average mass of ash recovered from the burn pan for the six burns was 4.0 kg, which is equal to 0.1% of the energetic mass burned. The ash contained 76 mg of 2,4-DNT and 6 mg of 2,6-DNT; no other SVOC or energetic target analytes were found.

M6 Propellant. This single-base propellant was burned as multi-perforated pellets approximately 1.7 cm long and 0.8 cm in diameter. The material burned contained 2,793 kg NC, 28 kg diphenylamine, 309 kg 2,4-dinitrotoluene (2,4-DNT), and 80 kg dibutylphthalate. Four three-burn trials were conducted. In the first three trials, the burns were initiated approximately 12 minutes apart and in the fourth they were initiated approximately 15 minutes apart. The NEW in each of the first nine burns was 3,184 kg and in the last three burns, the NEW was 3,320 kg. The burn times for the 12 burns ranged from 12 to 20 seconds.

The average mass of ash recovered from the burn pan for the four trials was 2.6 kg, which is equal to 0.08% of the energetic mass burned. The ash contained 30 mg of 2,4-DNT and 91 mg of dibenzofuran; no other SVOC/POM or energetic target analytes were found.

3.1.2.3 Triple-base Propellant

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M30 Propellant. This triple-base rocket propellant was burned as perforated pellets. The material burned contained approximately 890 kg NC, 715 kg of NG, 1510 kg NQ, and 50 kg of ethyl centralite (N,N-diethyl-N,N-diphenylurea). Two two-burn trials were conducted. The average NEW of the first burn was 1510 kg and the average NEW of the second burn was 3,170 kg. The two burns in the first trail were initiated approximately 135 minutes apart (because there was a problem initiating the second burn event), but in the second trial the second burn event was initiated approximately 13 minutes after the first event. The burn time for each burn was approximately 20 seconds. The ash left in the burn pan contained milligram quantities of phenol, ethyl centralite, NQ, NG, and 2-nitrophenylamine. The total mass of the ash was not determined.

3.1.3 Calculation of The Emission Factors

The Army used the ratio of the carbon content of the material burned to the carbon content of the plume sample (as represented by the sum of the CO_2, CO, and CH_4 concentrations) to calculate the plume volume at the time the plume samples were collected. This method for determining plume volume which is usually referred to as the Carbon Mass Balance Approach rests on the following two premises whose validity was confirmed in tests in the SNL BangBox[5] before the propellant burn tests were conducted.

- In an open burn essentially all of the carbon in the materials burned is converted to CO_2, CO, and CH_4.

- The proportional distribution among the carbon-containing gaseous emission products within individual micro-regions of the burn plume remains relatively constant, even though the individual concentrations may be different within the macro-regions of the plume.

Thus, by determining the mass of the carbon in a known volume of the plume and the total mass of carbon in the material burned, one can determine the volume of the plume at the time the plume sample was collected. This plume volume can then be multiplied by the concentration of any target analyte in the same plume sample (or one taken at the same time and location) and divided by the NEW of the material burned to derive an EF for that analyte (Equation 2).

$$EF_i = (f_c)[\text{analyte i}]/[C_j] \qquad \text{(Equation 2)}$$

where:

EF_i = EF for target analyte i (lb/lb NEW)

f_C = mass of C in the energetic divided by mass of the explosive (NEW) burned.

[analyte i] = background-corrected concentration (lb C/ft^3) of the target analyte collected from volume element j of the plume.

[C_j] = background-corrected concentration of carbon (lb C/ft^3) collected from volume element j of the plume [as represented by the CO_2, CO, and CH_4 compounds found in the canister VOC sample taken from the 80L bag].

3.1.4 Identification of Emissions Data Sets Appropriate for Inclusion in AP-42

Each data set was examined and evaluated to determine if the EF in the data sets were suitable for inclusion in this chapter of AP-42 and the quality rating that should be assigned to it. This evaluation used the Army-derived MDL expressed as an EF values, the compositions of the material burned given in the test reports, information about the pre-test concentrations and distribution of the VOC, energetic and SVOC compounds in the background soil and air samples at the test site, mass balance calculations, the QA and QC reports included in the Appendices of the test report, and the EPA guidance document. Based on this evaluation, the following decisions were made concerning including each emissions data set in AP-42.

3.1.4.1 Inorganic Gases

CO and CO_2. For each material burned the Army reported two sets of emission factors for CO and CO_2. Each set contained a minimum, maximum, and average emission factor. One set represented the results for the continuous emissions monitors located in the airplane, and the other set represented the analytical results from the canister samples. Although the two sets of values compared very well, the Army had designated the canister results as the most representative emissions data for CO and CO2. Therefore, only the emission factors attributable to the canister samplers were examined in detail. This examination showed that for all five propellant materials, the mass of C represented by the CO and CO_2 emission factors accounted for more than 99% of the mass of C in the propellant. Since these values are reasonable and consistent with the work of Ornellas and with the results from other studies, the average canister EF for CO and CO_2 for each material was entered in the AP-42 Excel workbook.

NO_2. For each material burned the Army reported only a minimum, maximum, and average EF for NO and NO_2. For all of the materials burned, the mass of nitrogen represented by the NOx emission factors was less than 2% of the mass of nitrogen in the explosive. These values are reasonable and consistent with detonation reaction theory and the results from other emission characterization studies. Therefore, the average EFF values for NO and NO_2 for each material were converted to the equivalent NO_X EF value (as NO_2 equivalent) and this value was entered in the AP-42 workbook.

3.1.4.2 Particulate Results.

For each material burned the Army reported only the average EF. These averages were entered in the AP-42 workbook.

3.1.4.3 Volatile Organic Compounds (VOCs)

The Army report contained emission factors for only three VOC analytes: benzene, methane and Total Non-methane Hydrocarbons (TNMHC). For each energetic material burned, the Army reported only the minimum, maximum, and average emission factors for these three VOC target analytes. Since the

average EF for each of these emission products was consistent with detonation reaction theory and the results from other OB emission characterization studies, the average EF for each material was entered on the AP-42 OB spreadsheet along with the corresponding EFF.

NOTE - The Army used the following justification for not including the emissions results for the other VOC target analytes in the test report. First, the SNL BangBox and the DPG field open burn test results had demonstrated conclusively that the VOCs emitted were almost exclusively the first members of the alkane, alkene, and alkyne classes of hydrocarbons (which are not toxic), and the first members of the aromatic hydrocarbon class of which benzene is the most toxic. Second, it wanted to avoid overwhelming the reader with nonessential emissions data.

3.1.4.4 SVOCs/POMs

For each test material, the Army reported a single background-corrected EF for each SVOC target analyte found. This value was the largest EF obtained for that target analyte across all of the plumes sampled for that propellant. Even if the analyte was found in only one plume, it was reported as if it was a representative emission product for that test material. The Army did not provide information on the total number of plumes in which the analyte was detected. If a SVOC target analyte was either never detected above the background level or never detected in the plume at all (MDL = 1E-09 lb/ lb NEW), the Army reported the test result as BDL. Thus, these EFs represent very conservative emission estimates.

As discussed earlier, there are three sources for the SVOCs/POMs found in burn plumes: (1) SVOCs/POMs added to the energetic material during the manufacturing process; (2) SVOCs/POMs pulled into the plume with the soil and ambient air: and (3) SVOCs/POMs formed by the reaction of small molecules, and molecular fragments produced in the initial stages of the burn event. Three of the thirteen target analytes detected in at least one of the burn plumes fell into the first category, (*SVOCs/POMs in Energetic Material Burned*), and the remaining ten fell into the latter two categories.

Consequently, the following actions were taken concerning entering the SVOC/POM emissions data in the AP-42 workbook.

SVOCs/POMs in the Material Burned. The three compounds in this category were diphenylamine (DPA), 2-nitrodiphenylamine (2-NDPA) and 2, 4-dinitrotoluene (2, 4-DNT). When these items were present in the material burned and the Army had reported an EF value:

- Greater than the MDL, the EF value was converted to the equivalent EFF value, and the EFF value was entered. (The EFF value was calculated by multiplying the EF value by 7,000 lb and dividing by the lb of the SVOC in the burn pile.)

- If BDL, the BDL value was replaced with a value equal to 5.0E-10 lb/ lb NEW (1/2 the MDL) and this value was then converted to the equivalent EFF value, and the resulting value was entered.

*SVOCs/POMs Not in the Energetic Material Burn*ed. If the Army had reported an EF larger than the Army-derived MDL (expressed as an EF), the reported value was entered, and when the Army had reported a value of BDL, BDL was entered.

3.1.4.5 Energetics

For each test material, the Army reported a single background-corrected EF for each energetic target analyte found. This value was the largest EF obtained for that target analyte across all of the plumes sampled in that phase of the study. Even if the analyte was found in only one plume, the Army reported as if it was a representative emission product for that test material. The Army did not provide information on the total number of plumes in which the analyte was detected. When an energetic target analyte was detected at a concentration that was either less than the MDL of the measurement system (6.6E-10 lb/lb NEW) or was less than the concentration found in the background air sample, the Army reported the test result as BDL. Thus, these EFs represent very conservative emission estimates.

The following decisions were made regarding entering the energetic emission test results:

- If a data set contained a numerical EF or a BDL value for an energetic compound that was not a possible emission product (because it was not in the burn pile and would not be formed during the burn), the letter code NA was entered.

- Because the Army reported BDL values for all of the energetics that were in the materials burned and these were possible emission products, the EF MDL value of 6.6E-10 lb/lb NEW was converted to the equivalent EFF MDL value and 1/2 of the EFF MDL entered.

3.1.5 Emissions Test Data Quality Ratings Assigned to Each Data Set

All of the EF/EFFs reported by the Army possessed the following characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology under conditions representative of real-world detonation processes. Second, the test reports contained detailed descriptions of the substances in the materials detonated. Third, the assumptions underlying the plume volume calculation were sound. Fourth, the test reports showed that all field testing and laboratory analysis activities were extensively and continuously audited by an independent DPG contractor and also by the EPA over the life of the project. Fifth, although the raw data sheets are no longer available, the report shows that they were used to construct the EFs presented in the test report. Sixth, the test reports showed that before the final report was issued, the raw data and the test results had been subjected to an extensive technical peer review by a widely respected set of scientists and a comprehensive audit by an EPA Region VIII contract chemist, who had not been involved in any part of the test program.

Based on these characteristics and the quality rating criteria recommendations in EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of B. This preliminary quality rating was converted to a final rating as described below.

3.1.5.1 Inorganic and Volatile Organic Gases

The inorganic gases were subsequently upgraded to a quality rating of A based primarily on the following: the number of plume samples collected for each material, the close agreement between the emission results across the test materials, and the agreement of the test results with both detonation reaction theory and the work of Ornellas.[3]

3.1.5.2 Energetics and SVOCs/POMs

The EPA quality rating of B was retained. Although the environmentally conservative nature of the results and the high sensitivity of the measurement systems (1E-09 lb/lb NEW for SVOC/POM and 6.6E-10 lb/lb NEW for the energetic target analytes) could justify upgrading the rating to A, the lack of information on the number of times the analyte was detected could justify lowering the rating to C.

3.1.5.3 PM-10

The EPA quality rating of B was retained for the PM-10 EFs. The only issue of concern was the Army's suggestion that the PM-10 values were biased high due to re-entrainment and subsequent collection of some of the larger particles that had deposited in the probe.[6] Because there was no data to show whether or not meaningful re-entrainment occurred, it was decided to retain the quality rating of B.

3.1.6 Tabulation of the Emissions Data

The waste propellant emissions data are presented in Table 26 and the single-base and triple-base propellant emissions data are presented in Table 27**.** The quality rating factor assigned to each EF/EFF value are also presented in these tables. Values in italics were derived by replacing a BDL value with one equal to 1/2 MDL.

Table 26. EFs/EFFs for the Open Burning of Waste Propellants.

EP Category	CASRN	EP	Units	Waste Propellant A		Waste Propellant B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.6E-02	B	1.0E-02	B
SVOC and POM(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A
	522-43-0	1-Nitropryene		BDL	A	BDL	A
	121-14-2	2,4-Dinitrotoluene		BDL	A	1.6E-07	A
	606-20-2	2,6-Dinitrotoluene		NA	A	1.4E-07	A
	91-57-6	2-Methylnaphthalene		BDL	A	BDL	A
	122-39-4	Diphenylamine		2.0E-08	A	3.1E-07	A
	581-89-5	2-Nitronaphthalene		3.7E-09	A	8.3E-08	A
	100-02-7	4-Nitrophenol		BDL	A	BDL	A
	56-55-3	Benz(a)anthracene		3.8E-08	A	1.4E-07	A
	50-32-8	Benz(a)pyrene		2.3E-08	A	8.1E-08	A
	132-64-9	Dibenzofuran		2.6E-07	A	1.2E-07	A
	91-20-3	Naphthalene		1.5E-06	A	5.4E-07	A
	86-30-6	N-Nitrosodiphenylamine		1.9E-08	A	2.7E-08	A
	85-01-8	Phenanthrene		BDL	A	BDL	A
	108-95-2	Phenol		8.0E-06	A	BDL	A
	88-72-2	Nitrobenzene		BDL	A	BDL	A
	110-86-1	Pyridine		BDL	A	BDL	A
	88-75-5	2-Nitrophenol		BDL	A	BDL	A
	88-72-2	2-Nitrotoluene		BDL	A	BDL	A
	99-99-0	4-Nitrotoluene		BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene		BDL	A	BDL	A
	129-00-0	Pyrene		7.1E-09	A	3.2E-07	A
Energetics	55-63-0	NG	lb/lb Energetic	*1.1E-09*	B	*8.7E-10*	B
	556-88-7	Nitroguanidine		NA	NA	NA	NA
Inorganic Gases	124-38-9	Carbon Dioxide	lb/lb C	3.6E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide		2.3E-03	A	2.6E-03	A
	NA	Nitrogen Oxides	lb/lb N	7.1E-02	A	2.9E-02	A
VOCs	71-43-2	Benzene	lb/lb C	*2.3E-06*	A	2.6E-03	A
	74-82-8	Methane		*2.3E-06*	A	2.8E-03	A
	NA	TNMHC		2.1E-04	A	2.1E-03	A
SVOCs in Energetic	119-75-5	2-Nitrodiphenylamine	lb/lb 2-NDPA	3.1E-08	B	9.4E-07	B

(a) MDL = 1.0E-09 lb/lb NEW

Table 27. EFs/EFFs for the Open Burning of Single and Triple-base Propellants.

EP Category	CASRN	EP	Units	M1 Propellant		M6 Propellant		M30 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	6.9E-03	B	1.1E-02	B	2.0E-02	B
SVOCs and POMs(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	522-43-0	1-Nitropryene		BDL	A	BDL	A	BDL	A
	606-20-2	2,6-Dinitrotoluene		BDL	A	BDL	A	BDL	A
	91-57-6	2-Methylnaphthalene		BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine		BDL	A	BDL	A	BDL	A
	581-89-5	2-Nitronaphthalene		BDL	A	BDL	A	BDL	A
	100-02-7	4-Nitrophenol		BDL	A	BDL	A	BDL	A
	56-55-3	Benz(a)anthracene		BDL	A	BDL	A	BDL	A
	50-32-8	Benz(a)pyrene		BDL	A	BDL	A	BDL	A
	132-64-9	Dibenzofuran		BDL	A	BDL	A	BDL	A
	91-20-3	Naphthalene		1.9E-08	A	7.5E-08	A	BDL	A
	86-30-6	N-Nitrosodiphenylamine		BDL	A	BDL	A	BDL	A
	85-01-8	Phenanthrene		BDL	A	BDL	A	BDL	A
	108-95-2	Phenol		3.4E-09	A	1.5E-09	A	BDL	A
	88-75-5	2-Nitrophenol		BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine		BDL	A	BDL	A	BDL	A
	88-72-2	2-Nitrotoluene		BDL	A	BDL	A	BDL	A
	99-99-0	4-Nitrotoluene		BDL	A	BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene		BDL	A	BDL	A	BDL	A
	129-00-0	Pyrene		BDL	A	BDL	A	BDL	A
Energetics	55-63-0	NG	lb/lb Energetic	NA	NA	NA	NA	*1.5E-09*	B
	556-88-7	Nitroguanidine		NA	NA	NA	NA	*6.9E-10*	B
Iniorganic Gases	124-38-9	Carbon Dioxide	lb/lb C	3.6E+00	A	3.7E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide		8.2E-04	A	3.3E-04	A	1.4E-04	A
	NA	Nitrogen Oxides	lb/lb N	2.0E-02	A	4.3E-02	A	2.9E-02	A
VOCs	71-43-2	Benzene	lb/lb C	1.4E-05	A	5.4E-06	A	3.1E-06	A
	74-82-8	Methane		2.4E-02	A	1.5E-04	A	3.1E-06	A
	NA	TNMHC		1.5E-03	A	4.5E-05	A	8.4E-06	A
SVOC in Energetic	122-39-4	Diphenylamine	lb./lb SVOC	*9.6E-08*	B	*5.6E-08*	B	NA	B
	121-14-2	2,4-Dinitrotoluene		1.1E-08	B	*1.0E-08*	B	NA	B
(a) MDL = 1.0E-09 lb/lb NEW									

3.1.7 Discussion of the DPG Open Range Open Burn Test Results

Table 28 compares the emissions test results for the five propellant materials evaluated at DPG. Important conclusions drawn from the data in Table 28 that are relevant to the development of EFs and EFFs for the disposal of energetic materials by open burning follow. NOTE - All of these conclusions are consistent with what one would expect from an intramolecular oxidation-reduction reaction that produces small, simple, stable molecules:

- Even though the chemical compositions and physical shape varied markedly across the five propellant materials, the PM-10 EFs were very similar (6.9E-03 to 2.0E-03 lb/ lb NEW) and the percentage of the original carbon and nitrogen that ended up in CO, CH_4, benzene, and NO_x was also very similar.

- Efficient destruction of the energetic compounds is clearly demonstrated by the fact that all of the plume measurements yielded BDL results for these compounds.

- SVOCs/POMs were not produced in meaningful amounts. Nineteen of the 23 EF values were associated with the two manufacturing waste propellant materials. These burns took from 60 to 240 seconds to go to completion, whereas, all of the straight propellant burns took less than 20 seconds. Because they represent the maximum EF measured across all of the burn plumes of the test material (and may represent the one time the compound was detected across all of the plumes for that material), environmentally speaking, all of the EF and EFF values are very conservative.

- According to the test report, benzene was the predominant aromatic hydrocarbon emitted which is consistent with Ornellas' work and detonation reaction theory. Further, because benzene would be produced by the same reaction pathways as the SVOCs/POMs, the quantity of SVOCs/POMs present in the plume should be much less than that of benzene, which is indeed the case.

Table 28. Comparison of the Emissions Produced by Each Test Material.

EP	Units	Waste Propellant A	Waste Propellant B	M1 Propellant	M6 Propellant	M30 Propellant
Energetic Compounds						
Nitroglycerin	lb/lb NG	*1.1E-09*	*8.7E-10*	NA	NA	*1.5E-09*
Nitroguanadine	lb/lb NQ	NA	NA	NA	NA	*6.9E-10*
Inorganic Gases and Particulates						
Carbon Dioxide	lb/lb C	3.6E+00	3.7E+00	3.6E+00	3.7E+00	3.7E+00
Carbon monoxide		2.3E-03	2.6E-03	8.2E-04	3.3E-04	1.4E-04
Nitrogen Oxides	lb/lb N	7.1E-02	2.9E-02	2.0E-02	4.3E-02	2.9E-02
PM-10	lb/lb NEW	1.6E-02	1.0E-02	6.9E-03	1.1E-02	2.0E-02
Volatile Organic Compounds						
Benzene	lb/lb C	3.0E-06	5.4E-05	1.4E-05	5.4E-06	3.1E-06
Methane		3.0E-06	2.5E-03	2.4E-02	1.5E-04	3.1E-06
TNMHC		2.7E-04	1.9E-03	1.4E-03	4.2E-05	9.1E-06
SVOCs in Energetic						
2-Nitrodiphenylamine	lb/lb 2-NDPA	*3.1E-08*	*9.4E-07*	NA	NA	NA
Diphenylamine	lb/lb DPA	NA	NA	***9.6E-08***	***5.6E-08***	NA
2,4-Dinitrotoluene	lb/lb DNT	NA	NA	1.1E-08	***1.0E-08***	NA
SVOCs and POMs						
Pyrene	lb/lb NEW	7.1E-09	3.2E-07	BDL	BDL	BDL
2,6-Dinitrotoluene		BDL	1.4E-07	BDL	BDL	BDL
Diphenylamine		2.0E-08	3.1E-07	*NA*	*NA*	BDL
2-Nitronaphthalene		3.7E-09	8.3E-08	BDL	BDL	BDL
Benz(a)anthracene		3.8E-08	1.4E-07	BDL	BDL	BDL
Benz(a)pyrene		2.3E-08	8.1E-08	BDL	BDL	BDL
Dibenzofuran		2.6E-07	1.2E-07	BDL	BDL	BDL
Naphthalene		1.5E-06	5.4E-07	1.9E-08	7.5E-08	BDL
N-Nitrosodiphenylamine		1.9E-08	2.7E-08	BDL	BDL	BDL
Phenol		8.0E-06	BDL	3.4E-09	1.5E-09	BDL
2,4-Dinitrotoluene		BDL	1.6E-07	*NA*	*NA*	BDL
Fate of Carbon and Nitrogen in Energetic						
% C in CO2	% C	98.2%	100.9%	98.2%	100.9%	100.9%
% C in CO	% C	0.0986%	0.1114%	0.0351%	0.0141%	0.0060%
% C in Benzene		0.0003%	0.0050%	0.0013%	0.0005%	0.0003%
% N in NOX	% N	2.1498%	0.8950%	0.6055%	1.3179%	0.8853%

3.1.7.2 Summary Statistics for the DPG Open Burn Emissions Characterization Study

Table 29 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev),, and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

Table 29 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory, and the representativeness of the EF/EFF values to real-world detonation activities.

Table 29. Summary Statistics for the DPG Open Burn Test Results.

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	5	2.0E-02	6.9E-03	1.1E-02	1.3E-02	5.2E-03	0.41	B
Inorganic Gases	Nitrogen Oxides	lb/lb N	5	7.1E-02	2.0E-02	2.9E-02	3.8E-02	2.0E-02	0.52	A
	Carbon Dioxide	lb/lb C	5	3.7E+00	3.6E+00	3.7E+00	3.7E+00	6.2E-02	0.02	A
	Carbon Monoxide	lb/lb C	5	2.6E-03	1.4E-04	8.2E-04	1.2E-03	1.1E-03	0.92	A
Energetics	Energetics	lb/lb Energetic	4	1.5E-09	6.9E-10	9.7E-10	1.0E-09	3.3E-10	0.32	B
SVOCs in Energetic	SVOCs in Energetics	lb/lb SVOC	6	9.4E-07	1.0E-08	4.4E-08	1.9E-07	3.7E-07	1.93	B
SVOCs Not In Energetic	SVOCs Not In Energetics	lb/lb NEW	29	8.0E-06	5.0E-10	2.7E-08	4.1E-07	1.5E-06	3.62	B
VOCs	Benzene	lb/lb C	5	5.9E-05	2.3E-06	5.8E-06	1.7E-05	2.4E-05	1.40	B
	TNMHC	lb/lb C	5	2.1E-03	8.4E-06	2.1E-04	7.7E-04	9.6E-04	1.24	B

3.2 BangBox Open Burn Emissions Data Sets

3.2.1 Test Description

The 15 sets of emissions data had been produced by burning 2.2 to 5.0 lb quantities of propellants and a dunnage surrogate (dunnage was a material that use to be used to support the open burning of propellant-containing waste materials) in BangBoxes between 1989 and 1995.[5, 8] BangBoxes are air-supported, rubber-coated hemispherical chambers, which sit on concrete pads. Each BangBox is divided into two sections: an inflatable, 32,900 ft^3, 50-ft diameter hemispherical test chamber made from a flexible polyvinyl-coated polyester fabric and a 17.8 x 7.1 x 8.1 ft building (airlock) with a plywood front, and a wood frame covered with the same material as the BangBox. The test chamber is kept pressured at 0.17 inches of water pressure using two high-capacity blowers and a damper. Six fans spaced 60^0 apart circulate the air in the test chamber to produce a homogeneous pollutant mix that can be sampled with instruments in the chamber and the attached air lock. The materials were burned on a bed of pea gravel in a thin-wall stainless steel pan sitting on a steel pad located in the center of the BangBox. The purpose of the pea gravel was to prevent burning holes in the steel burn pans. The pea gravel was replaced each burn test day.

The test chamber was purged with air for at least 60 minutes (two to three air exchanges) between burns, but no attempt was made to clean the surfaces of the BangBox. When the burn was initiated, a known quantity of SF_6 was released into the chamber from a pressured cylinder located approximately 10 ft from the burn pan. The concentration of the SF_6 was then measured periodically after the burn was initiated. A separate, evacuated canister was used each time a sample was collected. The average SF_6 concentration measured was used to calculate the extent to which the emissions plume had been diluted (due to the chamber blowers) between the burn and the completion of the sample collection activities. This dilution factor was used to correct the measured emission product concentrations to the concentrations that were present immediately after the burn was initiated.

The sampling systems shown in Table 30 were used to characterize the plumes from the 15 test materials burned. Only the VOC, CO, CO_2 and PM-10 measurement systems were used in all 15 tests. The number of tests for which the other measurement systems were used were: NO_x (11), SO_2 (12), SVOC and energetics (11), metals (9), HCl and Cl_2 (3) and PCDDs/PCDFs (5). However, because the energetic plume samples from six of the test materials were not analyzed within the six month sample holding time specified by EPA guidance (due to problems with the analytical instrumentation), the DOD project officer invalidated these six sets of energetic results. With the exception of the SF_6 and VOC samples, the samplers were operated from 10 to 15-minutes before the burn until 30 to 40 minutes after the burn. The SF_6 and VOC grab samples were collected at intervals starting approximately 5-minutes after the burn was initiated, e. g., 5, 7, 11, 19 and 35 minutes.

The EPA's Office of Research and Development (ORD) provided technical assistance and quality assurance support to the DOD project officer when the 15 emissions data sets were collected and issued a summary report on the results of these emissions tests.[8]

Table 30. Emissions Test Methods Used in the BangBox OB Studies.

Target Analyte / Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (Teco Model 42) [Sampling and Analysis]
SO_2	40 CFR 60, Appendix A, EPA Method 6C (Teco Model 43A) [Sampling and
HCl	Teco Model 15 HCl [by Gas Filter Correlation] Continuous Emissions Monitor (No
HCl, Cl_2	40 CFR 60, Appendix A, EPA Method 26 [Sampling and Analysis]
TSP	40 CFR 50, Appendix B [Sampling and Analysis]
PM -10	40 CFR 50, Appendix J [Sampling and Analysis]
Metals	40 CFR 50, Appendix B [Sampling], 40 CFR 60, Appendix A, EPA Method 29
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOC / POM	EPA Method TO - 13 - Determination of Polycyclic Aromatic Hydrocarbons in Ambient Air Using GC/MS [Sampling and Analysis]
Energetics	EPA Method TO - 13 [Sampling] with analysis by Supercritical Fluid Chromatography/MS (SFC/MS)
PCDDs/ PCDFs	EPA Method TO - 9 - Determination of Polychlorinated, Polybrominated and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air [Sampling], EPA - SW - 846 Method 8290 [Analysis]
CO, CO_2 (Primary Sampling System for CO & CO_2)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)
SF_6	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography / Electron Capture Detection (ECD)

With the exception of the CEM data, replicate sampling trains were used for each target analyte. Background samples for all target analytes were collected in the test chamber at the beginning of each test day. The samples were analyzed in a manner identical to that used for the burn plume sample, and the results were used to correct the emission factors for any contribution the background air made to the measured emission factors. A total of 28 burn plumes were sampled across the 15 sets of emissions test results. (NOTE - This approach assumes that the only background air species present in the plume are

those present in the air before the burn. It ignores species pulled into the plume from the surfaces of the BangBox by turbulence produced by rapidly rising plume. Because these latter materials are not included in the background sample, they become part of the reported emissions.)

3.2.2 Description of the Test Materials

The air emissions from the following materials were characterized: four ammonium perchlorate (AP) propellants, two single-base propellants, three double-base propellants, one triple-base propellant, two PBX (Plastic Bonded Explosive) propellants, one smoke, one surrogate AP manufacturing waste and one energetic-free, surrogate dunnage material. The compositions of these test materials and the conditions under which they were burned are described below. The chemical composition data were taken from the EPA report and from MIDAS. (NOTE - When the BangBox emissions characterization tests were conducted, MIDAS was not available to the project personal. Because most of the composition data was available only in hard copy and was mostly confined to the major components of the test material, it was very difficult for the project personal to obtain information on most of the minor constituents present in the test materials.)

3.2.2.1 AP -Based Propellants

AP Propellant A. The AP propellant used in this test was delivered to the BangBox as blocks and was divided into pieces weighing approximately 2.2 kg for the test burn. A 2.2 kg block was burned in each trial. The block was prepared for the test as follows. First, the block was placed in a 30.5 by 50.8 by 15.2 cm deep burn pan containing a bed of pea gravel. Then a flap was cut in the top of the block and an 81-mm propellant bag containing 4 g of Hercules unique smokeless powder was placed in the hole along with two electric squibs. The flap was then placed back over the hole, and the burn was initiated. Other than the following elemental composition, no information is available for this propellant: 25.87% Cl, 11.32% C, 4.31% H, 10.35% N, 47.31%O, and 0.89% Zr. This formulation implies that the propellant was 85% AP. Two single-burn trials were conducted. The NEW burned in each of the two trials was 2,270 g, including the 4 g of smokeless powder used to initiate each burn. Based on the above elemental composition, the 2,270 g of propellant burned contained: 1946 g AP, 3.8 g NC, 0.2 g NG and 20 g Zr.

Aluminized AP Propellant. The AP propellant used in this test was delivered to the BangBox as blocks and was divided into pieces weighing approximately 1.2 kg each for the testing. A 1.2 kg block was burned in each trial. The block was prepared for the test as follows. First, the block was placed in a 30.5 by 50.8 by 15.2 cm deep burn pan containing a bed of pea gravel. Then a flap was cut in the top of the block and an 81-mm propellant bag containing 4 g of Hercules unique smokeless powder was placed in the hole along with two electric squibs. The flap was then placed back over the hole and the burn was initiated. Other than the following elemental composition, no information is available for this propellant: 19% Al, 20.8% Cl, 10.09% C, 3.7% H, 8.3% N, 38.1% O and 0.008% P. This formulation implies that the propellant contained 69% AP by weight. Two single-burn trials were conducted. The NEWs for the first and second trials were 1,216 g and 1,159 g, respectively for an average NEW of 1192 g. This average mass would contain: 3.8 g NC, 0.2 g NG, 821 g AP and 226 g Al.

MK6 Propellant. 448 g of MK6 propellant chips were placed in a stainless steel burn pan containing a bed of pea gravel and the burn was initiated using two electric matches. The NEW burned was 448 g. The major energetic constituents of the propellant were: 381 g AP, 35.9 g hydroxy-terminated polybutadiene, 20.2 g dioctyl sebacate and 4.5 g aluminum. One single-burn trial was conducted.

MK23 CTBN Propellant. One single-burn trial was conducted. The NEW of energetic material burned was 1030 g, including 30 g Hercules smokeless powder. The major energetic components of the 1000 g of MK23 burned were 800 g AP, 142 g carboxyl-terminated polybutadiene, and 20 g Al.

3.2.2.2 Single-base Propellants

M1 Propellant. Three single-burn trials were conducted. The NEW burned in each trial was 2,273 g, including 4 g of smokeless powder and 113 g of reducer charge. The M1 propellant was contained in Number 4 and Number 5 M3 propellant bags. The Number 4 bag weighed 15 g and the Number 5 bag weighed 19.5 g. Two Number 4 bags and two Number 5 bags were burned during each trial. Each Number 4 bag contained 428 g of M1 propellant and 29 g of reducer charge, and each Number 5 bag contained 650 g of M1 propellant and 27.5 g of reducer charge. The composition of the reducer charge was not given in the final report. The major energetic constituents of the 2,156 g of M1 propellant burned were: 1,815 g NC, 213 g dinitrotoluene, and 22 g diphenylamine.

3.2.2.3 Double-base Propellants

Double-Base Propellant A. 2,223 g of pelletized propellant was placed in a stainless steel burn pan containing a bed of pea gravel, along with an 81-mm propellant bag containing 4 g of smokeless powder, and the burn was initiated using an electric match. Two single-burn trials were conducted. The propellant contained NC, NG, and 2-nitrodiphenylamine. Its elemental composition was 20.36% C, 2.97% H, 28.73% N, 46.14% O, 0.89% Pb, 0.89% Zr and 0.02% Sn which corresponds to 454.4 g C, 66.1 g H, 639.8 g N, 1027.5 g O, 19.8 g Pb, 19.8 g Zr and 0.5 g Sn.

NOSIH AA2 Propellant. 454 g of propellant chips and 26.6 g of ethyl cellulose were placed in a stainless steel burn pan containing a bed of pea gravel, and the burn was initiated using an electric match. One single-burn trial was conducted. The major constituents of the propellant were: 240 g NC, 184 g NG, 26.6 g ethyl cellulose, 12.3 g triacetin, 9.1 g of di-n-propyl adipate and 8.5 g lead.

M9 Propellant. Three single-burn trials were conducted. Two hundred and thirty two (232) unopened bags of M9 propellant were placed in a burn pan containing a bed of pea gravel, and the propellant was ignited using 4 g of smokeless powder and two electric matches. Each bag weighed 11.5 g and contained approximately 10.4 g of M9 propellant. The NEW used in each burn was 2405 g, including 4 g of smokeless powder. The energetic composition of the 2,401 g of M9 propellant burned was: 1,387 g NC, 960 g NG, 36 g potassium nitrate, and 18 g 2-nitrodiphenylamine. The propellant bags were identical to those used to fire the 81 mm mortar, but their chemical composition was not given in the final report. Based on 1.1 g per bag, the total mass of the 232 bags was 255 g.

Hercules Unique Smokeless Powder. One single-burn trial was conducted. The NEW burned was 454 g and was composed of 431.3 g NC and 22.7 g NG.

3.2.2.4 Triple-base Propellant.

M31A1E1 Propellant (NSN: 1376 -01-213-5669). Three single-burn trials were conducted. During the first trial, the stick propellant was burned in an upright position on the pea gravel bed, which resulted in extensive propellant kick out. To reduce propellant kick out, in the second and third trial burns, the propellant sticks were placed horizontally on the pea gravel bed. For these latter burns, four propellant sticks were broken into fourths (18.4 cm) and placed in the pan. Then additional propellant sticks were

broken in half (36.8 cm) and placed crosswise on top of the other propellant sticks. The NEW (including the 4 g of smokeless powder) used in the three trials conducted were 2,284 g, 2,280 g, and 2,264 g, for the first, second and third burns, respectively. The major energetic constituents of the M31A1E1 propellant burned were: 492 g NC, 410 g NG, 1,245 g NQ, 34 g ethyl centralite, and 1 g of charcoal.

3.2.2.5 PBX Propellants

MK43 LOVA Propellant. A single-burn trial was conducted. The NEW of energetic material burned was 1060 g, including 40 g Hercules smokeless powder. The energetic composition of the MK43 propellant burned was: 775 g RDX, 41 g NC, 122 g cellulose acetate butyrate (CAB), and 78 g of a mix of bis(2,2-dinitropropyl)acetal, and bis(2,2-dinitropropyl)formal.

PBXN 110 Propellant. A single-burn trial was conducted. The NEW burned was 1064 g, which included 14 g of smokeless powder. The major energetic components of the 1050 g of PBXN-110 burned were: 924.1 g HMX, 53 g hydroxyl-terminated polybutadiene, and 53 g isodecyl pelargonate.

3.2.2.6 Miscellaneous Materials

Smokey Sam. The NEW of energetic material burned was 273 g, including 23 g of Hercules smokeless powder. One smokey sam was burned in the single trial conducted. The energetic components of the smokey sam were: 110.0 g AP, 100.2 g Zn, 30 g hydroxyl-terminated polybutadiene, and 7.5 g dioctyl adipate. The burn was very dirty; the BangBox airlock was filled with a pungent, noxious odor, and the BangBox test chamber was filled with a dense fog.

Aluminized Propellant Manufacturing Waste. This surrogate waste simulated the mix of plastic gloves, cotton rags, kimwipes, wood towel rods, and similar materials that result from the clean-up of the vessels used to manufacture propellants. This material is usually disposed of through open burning. The composition of the surrogate waste burned was: 65% aluminized AP (69% AP, 19% aluminum), 20% plastic material (gloves, anti-static polyethylene), 11% paper/wood/cloth and 4% diesel fuel. The propellant in one inch cubes was randomly dispersed in the combustible materials. Because the first burn resulted in a hole in the bottom of the pan, the second and third burns were done with the surrogate waste sitting on top of a 7.6 cm layer of pea gravel. At the completion of each of these last two burns, holes were found in the side of the burn pan, and melted plastic was found in the pea gravel. The weight of waste surrogate burned in the three trials was 1,139 g, including the 4 g of Hercules Unique Smokeless Powder used to initiate each burn. Since this burn was done to characterize the emissions from the waste itself, the mass of the material burned (1,139 g), rather than the mass of energetic burned (741.8 g) was used to calculate the emission factors.

Diesel Fuel and Dunnage Surrogate. A surrogate diesel fuel-soaked dunnage was burned on August 29, 1995 to determine the emissions released when dunnage is burned. Three burns were done in unlined stainless steel pans using 909 g of the surrogate material and 4 g of smokeless powder. The composition of the surrogate material, which was prepared using styrofoam, pasteboard and irregularly shaped pieces of wood, was: 87.5% cellulose (795.4 g) and 12.5% plastic/diesel fuel (114 g). Since this burn was done to characterize the emissions from the diesel fuel and dunnage mixture itself, i.e., the mixture did not contain any energetic materials, the mass of the material burned (909 g) was used to calculate the emission factors. (When this test was conducted, the USAF was sometimes using scrap wood from ammunition boxes, dead branches from bushes/trees, styrofoam packing materials, and other combustible materials (dunnage) and diesel fuel to assist in the open burning of munitions and other energetic materials found on training ranges. This practice is now prohibited by DOD.)

3.2.3 Identification of BangBox Data Sets That Should Be Rejected In Their Entirety

The first step in the assessment of the BangBox data sets was to determine if any of the 15 data sets had characteristics that made them unsuitable for inclusion in AP-42. Based on this assessment, the following data sets were judge unsuitable for inclusion for the reasons given below.

Smokey Sam Burn. The emissions data for this burn were excluded because: (1) only one Smokey Sam was burned; (2) some of the sampling equipment was overwhelmed by the emissions; and (3) DOD policy prohibits disposing of smokes by open burning.

Aluminized AP Manufacturing Waste Burn. The emissions data for this burn were excluded because both EPA and the commercial sponsor of the burn had concluded independently that the test conditions were not representative of any real-world OB process. In addition, the test sponsor, a rocket propellant manufacturer, had determined that the test protocol had not been followed.

Surrogate Diesel Fuel and Dunnage Burn. The emissions data for this burn were excluded because: (1) no energetic was burned; and (2) the EPA authors had determined that the test conditions were not representative of any real-world OB process.

Hercules Smokeless Powder Burn. This burn was excluded because only one burn was conducted and the emissions data were limited to CO_2, CO, PM-10, SO_2 and a few VOC compounds.

MK-23 Propellant Burn. This burn was excluded because: (1) only one burn was conducted; (2) the emissions data consisted of inorganic gases; and a few VOCs; and (3) the composition of the test material was deficient in several critical areas.

3.2.4 Selection of BangBox OB Emission Test Results For Inclusion in AP-42

The remaining ten materials covered in the EPA report were produced in four studies that had been funded by different DOD units for a variety of reasons. EPA compiled the emissions data sets from these studies into a validated emission factors data base after three DOD contractors had failed to accomplish the task. During its validation effort, EPA consulted the background information that was available on the emissions tests, such as, test design plans, final reports, field notes, calibration data, laboratory reports, and EPA and DOD contractor QA and QC reports.

Because it had provided independent QA support to these studies and because of its knowledge of the requirements for EF databases, EPA had a good understanding of the issues that needed to be addressed during its data assessment and validation effort if it was to produce a credible, validated database. For example, EPA selected only emissions data that had been collected using methods that would have produced credible and comparable data. EPA also provided a set of minimum quantitation limits (MQLs, expressed as the equivalent emission factor) for each measurement system. In addition, EPA conducted mass balance checks on the C, N, Cl, and Al-containing emission products to confirm that the results adhered to detonation reaction theory and to previous laboratory-based emissions characterization tests on energetic materials. Further, because most of the burn emission products were commonly occurring air pollutants that were present in the background air samples, EPA assessed and provided estimates in their report of the extent to which the emission factors had been corrected for background.

Some of the conventions and procedures used by EPA in assessing and reporting the emissions test results that are pertinent to this review are:

- If the background corrected EF for a burn trial was less than or equal to 0.0E+00, EPA reported the EF as 0.0E+00.

- If the emissions test report contained a value that was less than the MDL of the measurement system, EPA reported the EF as 0.0E+00.

- If the background corrected EF for an SVOC target analyte was less than 30% of the original (i.e., uncorrected) emission factor, EPA reported the EF as 0.0E+00.

- In calculating the average EF for data sets containing a combination of 0.0E+00 and non-zero values, EPA did not include the 0.0.E+00 values in the calculation.

- In order to conduct a statistical analysis of the data using its SAS program, EPA had to differentiate between instances where either no sample was collected (NS) or no data was available because the sampling result had been invalidated (NA) and instances where the target analyte was either never detected, or if detected, never detected above the background level (ND). Because the SAS program would not accept letter code entries, EPA substituted a period (.) for all NS and NA values and the value 0.0E+00 for all ND values.

The following decisions were then made concerning the inclusion of some or all of the EFs in the remaining 10 data sets in the AP-42 spreadsheet.

3.2.4.1 Inorganic Gases

The CO, CO_2, NO, NO_2, HCl, Cl_2, and SO_2 EF values were entered as reported and, with the exception of SO_2, also as the equivalent EFF value. (Because sulfur is present in small quantities in many energetic materials, it was likely an emission product when it was measured above the background level. However, since the mass of the sulfur in the items treated is unknown, EFF values could not be calculated.)

NOTE - The HCl results were accepted as reported because EPA had noted that a special test conducted in the BangBox in 1995 had determined that the loss of HCl to the surfaces of the BangBox would be less than 15 % over the 30-minute sampling interval.

3.2.4.2 Particulate Results

The PM-10 EF values were entered as reported. EFF values were not calculated because there is no known relationship between the composition of the energetic material and the PM-10 emissions.

3.2.4.3 Volatile Organic Compounds (VOCs)

The EPA report contained numerical emission factors for 37 of the 160 plus individual VOC compounds on the BangBox target analyte list. These compounds were the only VOC target analytes measured above the background level in the emissions from at least one of the test materials. (The VOC

target analytes that were either never detected or were never detected above the background level are identified in Table 31, *VOC Target Analytes Not Detected in Any of the BangBox Burn Plumes*.

EPA noted that one of the most vexing problems associated with characterizing the VOC air emissions from burns was that most of the emission products are compounds that are commonly found in ambient air. This can be seen by examining the information in Table 32, which shows the average EF for the 37 VOCs detected in the burn plumes along with: (1) the number of materials for which the VOC was listed as an EP; (2) the number of materials for which the VOC was detected in all of the burn plumes; and (3) the percentage that the background air contributed to the plume concentration. Based on the information in the EPA report and the information in Table 32 the following actions were taken to ensure that the VOC EFs conform to the EPA guidance before they were entered in the AP-42 Excel workbook.

- If the average EF value for a test material had been derived from a data set that included only non-zero numeric values, the EF value was converted to the corresponding EFF value and the EFF value entered. (The EF (lb/lb NEW) was converted to the equivalent EFF value (lb/lb C) by multiplying the EF value by the NEW burned and then dividing by the lb of C in the burn pile.)

- If the average EF for a test material had been derived from a data set containing a mix of 0.0E+00 and non-zero numeric values, the 0.0E+00 value was replaced with a value of 7.1E-08 lb/ lb NEW (1/2 the MDL) and the new average was calculated. This value was then converted to the equivalent EFF value and the EFF value was entered.

- If the EF for a test material was 0.0E+00 for all burn trials, the 0.0E+00 value was entered as BDL.

- If no sampling result was reported, the letter code ND was entered.

Table 31. VOC Target Analytes Not Detected in Any of the BangBox Burn Plumes.

CASRN	Compound	CASRN	Compound	CASRN	Compound
7642-09-3	Cis-3-hexene	127-18-4	Tetrachloroethylene	71-36-3	1-Butanol
619-99-8	3-Ethylhexane	138-86-3	1-Methylcyclohexene	71-55-6	Methyl chloroform
627-20-3	Cis-2-pentene	141-32-2	Butyl acrylate	73513-42-5	Isohexane
79-09-4	Propanoic acid	141-93-5	m-Diethylbenzene	7359-72-0	Trans-1,3-trichloropropene
83847-49-8	Bromochloromethane	156-60-5	Trans-1,2-dichloroethene	7443-70-1	Cis-2-octene
100-44-7	Benzyl chloride	1634-04-4	Methyl t-butyl ether	74-83-9	Methyl Bromide
100-47-0	Benzonitrile	2198-23-4	4-Nonene	75-00-3	Chloroethane
100-51-6	Benzyl alcohol	24-11-8	1-Nonene	75-05-8	Acetonitrile
100-52-7	Benzaldehyde	25168-05-2	Chlorotoluenes	75-07-0	Acetaldehyde
10061-01-5	Cis-1,3-dichloropropene	271-89-6	Benzofuran	75-25-2	Bromoform
103-65-1	N-propylbenzene	31394-54-4	Isoheptane	75-27-4	Bromodichloromethane
104-51-8	N-butylbenzene	3522-94-9	2,2,5-trimethylhexane	75-34-3	1,1-Dichloroethane
105-05-5	p-Diethylbenzene	463-82-1	Neopentane	75-35-4	1,1-Dichloroethene
106-42-3	p-Xylene	496-11-7	Indane	75-45-6	Chlorodifluoromethane
106-43-4	p-Chlorotoluene	513-35-9	2-methyl-2-butene	75-52-5	Nitromethane
106-46-7	p-Dichlorobenzene	526-73-8	1,2,3-Trimethylbenzene	75-69-4	Trichlorofluoromethane
107-02-8	Acrolein	538-93-2	Isobutylbenzene	75-71-8	Dichlorodifluoromethane
107-05-1	Allyl Chloride	540-59-2	Cis-1,2-dichloroethene	75-83-2	2,3-Dimethylbutane
107-06-2	1,2-Dichloroethane	540-84-1	2,2,4-Trimethylpentane	760-21-4	2-Ethyl-1-butene
1071-26-7	2,2-dimethylheptane	541-73-1	m-Dichlorobenzene	763-29-1	2-Methyl-1-pentene
107-13-1	Acrylonitrile	563-45-1	3-Methyl-1-butene	7688-21-3	Cis-2-hexene
107-39-1	2,4,4-Trimethyl-l-pentene	563-46-2	2-Methyl-1-butene	78-87-5	1,2-Dichloropropane
107-40-4	2,4,4-Trimethyl-2-pentene	564-02-3	2,2,3-Trimethylpentane	78-93-3	2-Butanone
107-85-5	2-Methylpentane	565-59-3	2,3-Dimethylpentane	79-00-5	1,1,2 Trichloroethane
108-05-4	Vinyl acetate	565-75-3	2,3,4-Trimethylpentane	79-01-6	Trichloroethene
108-08-7	2,4-Dimethylpentane	584-94-1	2,3-Dimethylhexane	79-34-5	1,1,2,2-Tetrachloroethane
108-10-1	Methylisobutylketone	589-34-4	3-Methylhexane	821-95-4	1-Undecene
108-38-3	m-Xylene	589-81-1	3-Methylheptane	87-68-3	Hexachloro-1,3-butadiene
108-41-8	m-Chlorotoluene	590-18-1	cis-2-Butene	9003-31-0	Isoprene
108-67-8	1,3,5-Trimethylbenzene	592-13-2	2,5-Dimethylhexane	922-62-3	Cis-3-methyl-2-pentene
108-90-7	Chlorobenzene	592-27-8	2-Methylheptane	92-52-4	Biphenyl
110-00-9	Furan	592-76-7	1-Heptene	95-13-6.	Indene
110-62-3	Pentanal	60-29-7	Diethyl ether	95-47-6	o-Xylene
110-8-27	Cyclohexane	611-14-3	o-Ethyltoluene	95-49-8	o-Chlorotoluene
110-83-8	Cyclohexene	624-91-9	Methylnitrite	95-50-1	o-Dichlorobenzene
111-66-0	1-Octene	625-27-4	2-Methyl-2-pentene	95-63-6	1,2,4-Trimethylbenzene
111-71-7	Heptanal	64-17-5	Ethanol	96-14-0	3-Methylpentane
1120-21-4	N-undecane	64-19-7	Acetic Acid	98-01-1	2-Furaldehyde
1120-72-5	Methylcyclopentene	66-25-1	Hexanal	98-06-6	Tert-butylbenzene
112-31-2	Decanal	6747-26-2	2,2,4-Trimethylhexane	98-82-8	Isopropylbenzene
120-82-1	1,2,4-Trichlorobenzene	674-76-0	Trans-4-methyl-2-pentene	98-86-2	Acetophenone
123-72-8	Butyraldehyde	67-63-0	2-Propanol	121-14-2	1,3-Dinitrobenzene
123-91-1	1,4-Dioxane	67-64-1	Acetone	99-87-8	p-Isopropyltoluene
124-13-0	Octanal	68037-01-4	1-Decene	NA	4-Methyl-2-pentanone
124-19-6	Nonanal	691-37-2	4-Methyl-1-pentene	126-99-8	Chloroprene
124-41-1	Dibromochloromethane	691-38-3	Cis-4-Methyl-2-pentene	71-23-8	1-Propanol

Table 32. Average Emission Factor and Background Correction for the VOC Compounds Detected.

Pollutant Category	Pollutant	Background Corrected Average EF	% Background Contributed to Uncorrected Average EF	Detected in Burn Plume of N Materials
Aromatic HC	Benzene	1.7E-05	3%	10
	p-Ethyltoluene	5.9E-07	56%	10
	Toluene	5.7E-07	93%	10
	Ethylbenzene	9.5E-08	83%	10
	m-Ethyltoluene	6.1E-08	89%	9
	Styrene	5.9E-08	96%	8
Chlorinated HC	Methylenechloride	2.1E-06	80%	8
	Vinyl chloride	2.2E-07	0%	7
	Carbon tetrachloride	1.3E-07	68%	9
	Methyl chloride	1.1E-07	53%	9
	Chloroform	4.2E-08	0%	9
Saturated HC	n-Hexane	2.2E-06	79%	9
	Methylcyclopentane	3.2E-07	79%	10
	Ethane	3.0E-07	70%	10
	n-Decane	2.7E-07	88%	10
	n-Pentane	1.8E-07	78%	10
	Propane	1.5E-07	80%	8
	i-Pentane	1.3E-07	79%	9
	n-Heptane	1.1E-07	79%	9
	n-Butane	8.1E-08	87%	8
	Cyclohexane	6.6E-08	80%	9
	Methylcyclohexane	5.3E-08	82%	9
	n-Octane	5.2E-08	86%	10
	n-Nonane	3.2E-08	81%	10
	Cyclopentane	4.8E-09	94%	8
	i-Butane	4.3E-09	99%	10
Unsaturated HC	Acetylene	2.2E-05	0%	10
	Ethylene	2.7E-06	0%	8
	Propylene	9.7E-07	4%	7
	i-Butene	8.8E-07	39%	9
	1-Butene	1.7E-07	0%	9
	1,3-Butadiene	1.1E-07	0%	6
	trans-2-Butene	9.7E-08	0%	9
	1-Pentene	2.9E-08	51%	10
	1-Hexene	2.7E-08	30%	10
	Cyclopentene	2.1E-08	0%	9
	cis-2-Pentene	9.1E-09	69%	10

3.2.4.4 Metals

EPA had noted that many of the plume samples had been contaminated with metals from: (a) the concrete floor of the BangBoxes, (b) residues on the BangBox floor left from earlier detonation and burn tests, (c) the decomposition of the pea gravel on which many of the test materials rested while they burned, and (d) the plated steel burn pans holding the pea gravel. However, EPA did not attempt to correct the metal emissions data for this contamination. EPA made this observation based on a number of instances where metal emission factors on the order of 1E-04 to 1E-05 had been produced when metal-free propellant materials had been burned in the Dugway Proving Ground (DPG) and Sandia National Laboratories (SNL) BangBoxes.

To remove spurious metal EFs from the data sets, all of the information available on the metals content of the materials burned was compiled using the composition data in the EPA report and in MIDAS. This review determined that Al and Pb were the only target metals definitely present in the materials burned. (NOTE – Although some of the test materials contained alkali and alkaline earth metals, these metals were not target analytes in these studies.) Based on these findings, the following actions were taken:

- The EFs for the materials containing Al and Pb were converted to the equivalent EFF values and the values entered. The Al values were entered under the Metals in Energetic as Particle category and the Pb were entered under the Metals in Energetic as Compound category.

- If EPA had reported a non-zero EF value for either Al or Pb for a test material that did not contain the metal, the letter code NA was entered in the AP-42 workbook.

- If EPA had reported an EF value of 0.0E+00 for Al or Pb for a test material that might have contained these metals, the letter code ND was entered.

- If the EPA report did not contain an entry for Al or Pb, the letter code NA was entered.

- The results for the other metals were rejected.

3.2.4.5 Energetics

The plumes from eight of the test materials were sampled for energetic compounds, but because of instrument failure, valid samples were obtained for only three of the test materials. None of the target energetic analytes were detected in the plumes for these three materials. The following actions were taken regarding entering the energetic emissions data in the workbook.

- If the energetic compound was present in the material and a valid sample was collected, BDL was entered. NOTE - Because the BangBox MDL for the energetic plume measurement (1E-08 lb/ lb NEW) was 660 times higher than that for the system used in the DPG open range burn tests (MDL = 6.6E-10 lb/ lb NEW), it was not appropriate to change a BDL value to a value equal to 1/2MDL before entering the value in the AP-42 workbook.[19]

- If the energetic compound was present in the material, but a valid sample was not collected, ND was entered.

- If the energetic compound was not present in the material (hence not a possible emission product), the letter code NA was entered.

3.2.4.6 SVOC/POM Compounds

SVOC/POM samples were collected from the plumes from eight of the ten materials and analyzed for 120 SVOCs/POMs, including two SVOCs/POMs (2,4-dinitrotoluene and diphenylamine) that were present in some of the test materials (Table 33). However, 2-chlorophenol was the only SVOC/POM target analyte detected above either the measurement system MDL (9E-06 lb/ lb NEW) or the background level. It was detected in two of the three aluminized AP propellant burn plumes. Based on these observations, the following actions were taken regarding entering the SVOC EFs on the AP-42 candidate spreadsheet:

SVOCs/POMs in the Material Burned. BDL was entered for the two compounds in this category -- diphenylamine (DPA) and 2, 4-dinitrotoluene (2, 4-DNT) -- when they were present in the test material. When they were not present, NA was entered. (NOTE - Entering a value equal to 1/2 of the MDL was not appropriate because these compounds had been detected in the open range burn study at levels 10 to 150 times lower than the BangBox SVOC MDL).

*SVOCs/POMs Not in the Energetic Material Burn*ed. The 2-chlorophenol EF value was entered as reported by EPA. To facilitate a comparison between the DPG open range and the BangBox emissions data sets, BDL (MDL = 4.5E-06 lb/ lb NEW) was entered for the BangBox SVOC analytes that were also target analytes in the DPG open range burn tests. (Entering a value equal to 1/2 of the MDL was not appropriate because these compounds had been detected in the open range burn study at levels 10 to 150 times lower than the BangBox SVOC/POM MDL.)

3.2.4.7 Polychlorinated Dioxin and Furans (PCDDs/PCDFs)

The PCDD/PCDD target analytes were: 1,2,3,4,6,7,8,9-Octachlorodibenzodioxin, 1,2,3,4,6,7,8-Heptachlorodibenzodioxin, 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8-Pentachlorodibenzo-p-dioxin, 2,3,7,8-Tetrachlorodibenzo-p-Dioxin, 1,2,3,4,7,8,9-Heptachlorodibenzofuran, 1,2,3,4,6,7,8,9-Octachlorodibenzofuran, 1,2,3,4,6,7,8-Heptachlorodibenzofuran, 1,2,3,4,7,8-hexachlorodibenzofuran, 1,2,3,6,7,8-hexachlorodibenzofuran, 1,2,3,7,8,9-Hexachlorodibenzofuran, 1,2,3,7,8-Pentachlorodibenzofuran, 2,3,4,6,7,8-Hexachlorodibenzofuran, 2,3,4,7,8-Pentachlorodibenzofuran and 2,3,7,8-Tetrachlorodibenzofuran.

` The burn plumes from the following three propellants were the only ones sampled for the PCDD/PCDF target analytes: AP propellant, Aluminized AP propellant, and MK6 propellant. These items were evaluated for PCDD/PCDF emissions because they contained the plastic and chlorine compounds necessary to produce PCDD/PCDF EPs. All sampling results were BDL. Therefore, BDL (MDL = 9.0E-12 lb/ lb NEW) was entered on the AP-42 candidate spreadsheet for the three AP-containing materials, and ND was entered for the other seven test materials.

1 Table 33. SVOC/POM Open Burn Target Analytes.

CASRN	Compound	CASRN	Compound
100-01-6	4-Nitroaniline	56-55-3	Benz(a)anthracene
100-02-7	4-Nitrophenol	56-57-5	4-Nitroquinoline-1-oxide
100-51-6	Benzyl alcohol	57-97-6	Dimethylbenz(a)anthracene
100-75-4	Nitrosopiperdine,N-	581-89-5	2-Nitronaphthalene
101-55-3	Bromophenylphenylether	59-50-7	4-Chloro-3-methylphenol
105-67-9	2,4-Dimethylphenol	59-89-2	N-Nitrosomorpholine
10595-95-6	Nitrosomethylethylamine,N-	59-90-2	2,3,4,6-Tetrachlorophenol
106-44-5	Methylphenol,4-	60-11-7	p-Dimethylaminoazobenzene
106-46-7	1,4-Dichlorobenzene	606-20-2	2,6-Dinitrotoluene
106-47-8	p-Chloroaniline	98-95-3	Nitrobenzene
108-39-4	3-Methylphenol	608-93-5	Pentachlorobenzene
108-95-2	Phenol	621-64-7	Nitrosodi-n-propylamine,N-
109-06-8	2-Picoline	62-44-2	Phenacetin
110-86-1	Pyridine	62-50-0	Ethyl Methanesulfonate
111-41-4	Bis(2-chloroethyl)ether	62-75-9	Nitrosodimethylamine,N-
111-91-1	Bis(2-chloroethoxy)methane	65-85-0	Benzoic acid
117-81-7	Bis(2-ethylhexyl)phthalate	66-27-3	Methyl Methanesulfonate
117-84-0	Di-n-octyl phthalate	67-72-1	Hexachloroethane
118-74-1	Hexachlorobenzene	7005-72-3	4-Chlorophenylphenyl Ether
119-75-5	2-Nitrodiphenylamine	76-01-7	Pentachloroethane
119-93-7	Dimethylbenzidine,3,3'-	77-47-4	Hexachlorocyclopentadiene
120-12-7	Anthracene	78-59-1	Isophorone
120-58-1	Isosafrole	84-66-2	Diethylphthalate
120-82-1	1,2,4-Trichlorobenzene	84-74-2	Di-n-butylphthalate
120-83-2	1-Methylnaphthalene	85-01-8	Phenanthrene
120-833-2	2,4-Dichlorophenol	85-68-7	Butyl benzyl phthalate
121-14-2	2,4-Dinitrotoluene	86-30-6	N-Nitrosodiphenylamine
122-09-8	Dimethylphenethylamine	86-73-7	Fluorene
122-39-4	Diphenylamine	87-65-1	2,6-Dichlorophenol
122-66-7	1,2 Diphenylhydrazine	87-86-5	Pentachlorophenol
126-68-1	Triethylphosphorothioate	88-06-2	2,4,6-Trichlorophenol
129-00-0	Pyrene	88-72-2	2-Nitrotoluene
130-15-4	1,4-Naphthoquinone	88-74-4	2-Nitroaniline
131-11-3	Dimethylphthalate	88-75-5	2-Nitrophenol
132-64-9	Dibenzofuran	91-20-3	Naphthalene
134-32-7	1-Naphthylamine	91-57-6	2-Methylnaphthalene
143-50-0	Kepone	91-58-7	2-Chloronaphthalene
1888-71-7	Hexachloropropene	91-59-8	2-Naphthylamine
191-24-2	Benzo(g,h,i)perylene	91-80-5	Methapyrilene
193-39-5	Indeno[1,2,3-cd]pyrene	91-94-1	3,3'-Dichlorobenzidine
19406-51-0	4-Amino-2,6-Dinitrotoluene	924-16-3	Nitrosodi-n-butylamine,N-
205-99-2	Benzo(b)fluoranthene	92-52-4	Biphenyl
206-44-0	Fluoranthene	92-67-1	Aminobiphenyl,4-
207-08-9	Benzo(k)fluoranthene	92-87-5	Benzidine
208-96-8	Acenaphthylene	930-55-2	Nitrosopyrrolidine,N-
218-01-9	Chrysene	94-59-7	Safrole
2303-16-4	Diallate	95-48-7	Methylphenol,2-
23950-58-5	Pronamide	95-50-1	1,2-Dichlorobenzene
39638-32-9	Bis(2-chloroisopropyl)ether	95-53-4	o-Toluidine
50-32-8	Benz(a)pyrene	95-57-8	2-Chlorophenol
510-15-6	Chlorobenzilate	95-57-8	2-Methylphenol
51-28-5	2,4-Dinitrophenol	95-94-3	1,2,4,5-Tetrachlorobenzene
522-43-0	1-Nitropryene	95-95-4	2,4,5-Trichlorophenol
534-52-1	4,6-Dinitro-2-methylphenol	98-86-2	Acetophenone
53-70-3	Dibenz[a,h]anthracene	98-95-3	Nitrobenzene
53-96-3	Acetylaminofluorene,2-	99-09-2	3-Nitroaniline
540-73-8	Dimethylhydrazine,1,2-	99-35-4	1,3,5-Trinitrobenzene
541-73-1	1,3-Dichlorobenzene	99-55-8	5-Nitro-o-toluidine
55-18-5	Nitrosodiethylamine,N-	99-65-0	1,3-Dinitrobenzene
56-49-5	3-Methylcholanthrene	99-99-0	4-Nitrotoluene

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3.2.5 Emissions Test Data Quality Ratings Assigned To Each EF/EFF

All of the BangBox EF/EFFs possessed the following positive characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology under conditions reasonably representative of real-world open burn processes. Second, the SF_6 method used to determine the burn plume volume was very reliable. Third, descriptions of the compositions for most of the test materials were either provided in the EPA report and/or were available in MIDAS. Fourth, documentation in the report and its appendices showed that all field testing and laboratory analyses activities were extensively and continuously audited by independent DOD contractors and also by the EPA over the life of the project, and that the EPA report itself was subjected to a highly credible peer review before it was released. Fifth, although the raw data sheets are no longer available, the EPA report shows they were used to construct the EFs presented in the test report. Sixth, the test results reported were consistent with detonation reaction theory and the DPG open range results, which involved much larger burns under conditions that reflected real-world OB demil operations.

Based on these characteristics and the quality rating criteria recommendations in Section 4.4.2 of EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of B. This preliminary quality rating was converted to a final rating as described below.

3.2.5.1 Inorganic Gases

The EPA quality rating of B was retained.

3.2.5.2 Volatile Organic Compounds (VOCs)

As discussed earlier, most of the VOCs measured in the plume were also detected in the background samples at concentrations often similar to those measured in the burn plumes. As discussed in Section 3.2.4.3, an attempt was made to adjust the EFFs for the contribution from the background air. In fact, the EFFs for 23 of the 37 VOCs detected had been corrected by more than 50%, which raises concerns about the accuracy and representativeness of these EFFs. The extent to which the EFF value had been adjusted for the background along with the absolute value of the EFF and the number of times it was detected were used to assign the final quality rating to each VOC EP.

3.2.5.3 Metals

The quality rating was lowered to C, primarily because of the limited number of plumes sampled. That is, three of the four values were derived through duplicate burns and the other from a single test burn.

3.2.5.4 Energetic Compounds

All of the EFFs were BDL. Further, the MDL of the BangBox measurement system was several orders of magnitude higher than that for the DPG open range burn tests and the energetic EFFs associated with the DPG open range tests (Tables 26 and 27) were also orders of magnitude lower than the BangBox MDL. Therefore, the quality rating was reduced to D.

3.2.5.5 SVOCs/POMs

All of the EFs and EFFs were BDL. Further, the MDL of the BangBox measurement system was several orders of magnitude higher than that for the DPG open range burn tests and the SVOC/POM EFFs associated with the DPG open range tests (Tables 26 and 27) were also at least an order of magnitude lower than the BangBox MDL. Therefore, the quality rating was reduced to D.

3.2.5.6 PCDDs and PCDFs

Although all the EFs were BDL, the MDL of the measurement system was very low, i.e., 9E-12 lb/lb NEW. It was decided to retain the quality rating of B based primarily on this fact and the consistency of the sampling results with detonation reaction theory.

3.2.5.7 PM-10

The EPA quality rating of B was retained.

3.2.6 Tabulation and Presentation of the Emissions Data

The BangBox open burn emissions data selected for inclusion in AP-42 are presented in Tables 34 through 37 along with the EPA quality rating factor assigned to each EF/EFF value. To facilitate comparing the EFs/EFFs for similar materials, the emissions data for similar materials were placed in the same table. Table 34 presents the results for the AP-propellants, Table 35 presents the results for single-base and triple-base propellants, Table 36 presents the results for double-base propellants and Table 37 presents the results for the PBX propellants.

NOTE – As discussed earlier, 2-chlorophenol was the only SVOC/POM detected in any burn plume and it was associated with only one test material. To avoid cluttering the tables with 120 plus BDLs for the other SVOCs/POMs, it was decided to list in Tables 34 through 37 only 2-chlorophenol and the SVOCs/POMs that were also target analytes in the DPG open range tests

Table 34. EFs/EFFs for the Open Burning of AP Propellants in the BangBox.

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	4.2E-01	B	1.5E-02	B	ND	B
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B	BDL	B
SVOC & POM(b)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol		BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene		BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine		BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene		BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran		BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene		BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene		BDL	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol		BDL	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene		BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol		1.1E-05	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene		BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol		BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene		BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene		BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D

Table 34. EFs/EFFs for the Open Burning of AP Propellants in the BangBox (continued).

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BND	D	ND	NA
	106-98-9	1-Butene		BDL	D	BDL	D	ND	NA
	592-41-6	1-Hexene		BDL	D	BDL	D	ND	NA
	109-67-1	1-Pentene		BDL	D	BDL	D	ND	NA
	74-86-2	Acetylene		9.1E-05	B	BDL	B	2.1E-04	C
	71-43-2	Benzene		BDL	C	BDL	C	5.7E-04	C
	56-23-5	Carbon tetrachloride		BDL	D	BDL	D	ND	NA
	627-20-3	cis-2-Pentene		BDL	D	BDL	D	ND	NA
	110-82-7	Cyclohexane		BDL	D	BDL	D	ND	NA
	287-92-3	Cyclopentane		BDL	D	BDL	D	ND	NA
	142-29-0	Cyclopentene		BDL	D	BDL	D	ND	NA
	74-84-0	Ethane		BDL	D	BDL	D	ND	NA
	100-41-4	Ethylbenzene		BDL	D	BDL	D	ND	NA
	74-85-1	Ethylene		BDL	C	BDL	C	ND	NA
	75-28-5	Isobutane		BDL	D	BDL	D	ND	NA
	115-11-7	Isobutene		4.5E-05	C	BDL	D	ND	NA
	78-78-4	Isopentane		BDL	D	BDL	D	ND	NA
	74-87-3	Methyl chloride		BDL	D	BDL	D	ND	NA
	108-87-2	Methylcyclohexane		BDL	D	BDL	D	ND	NA
	96-37-7	Methylcyclopentane		BDL	D	BDL	D	ND	NA
	75-09-2	Methylene chloride		BDL	D	BDL	D	ND	NA
	620-14-4	m-Ethyltoluene		BDL	D	BDL	D	ND	NA
	106-97-8	n-Butane		BDL	D	BDL	D	ND	NA
	124-18-5	n-Decane		BDL	D	BDL	D	ND	NA
	142-82-5	n-Heptane		BDL	D	BDL	D	ND	NA
	110-54-3	n-Hexane		BDL	D	BDL	D	ND	NA
	111-84-2	n-Nonane		BDL	D	BDL	D	ND	NA
	111-65-9	n-Octane		BDL	D	BDL	D	ND	NA
	109-66-0	n-Pentane		BDL	D	BDL	D	ND	NA
	622-96-8	p-Ethyltoluene		BDL	D	BDL	D	ND	NA
	74-98-6	Propane		BDL	D	BDL	D	ND	NA
	115-07-1	Propylene		BDL	C	BDL	C	ND	NA
	100-42-5	Styrene		BDL	D	BDL	D	ND	NA
	NA	TNMHC		4.5E-04	C	3.6E-04	C	ND	NA
	108-88-3	Toluene		BDL	D	BDL	D	ND	NA
	624-64-6	trans-2-Butene		BDL	D	BDL	D	ND	NA
	75-01-4	Vinyl chloride		BDL	D	BDL	D	ND	NA

Table 34. EFs/EFFs for the Open Burning of AP Propellants in the BangBox (continued).

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	121-82-4	RDX	lb/lb Energetic	NA	NA	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA	NA	NA
	556-88-7	NQ		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lbNEW	4.7E-05	B	1.1E-04	B	1.5E-04	B
	NA	Nitrogen Oxides	lb/lb N	3.3E-02	B	8.6E-02	B	1.9E-02	B
	7782-50-5	Chlorine	lb/lb Cl	2.1E-02	B	3.5E-02	B	NS	NA
	7647-01-0	Hydrogen chloride	lb/lb Cl	9.4E-01	B	8.5E-01	B	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.0E+00	B	3.4E+00	B	4.1E+00	B
	630-08-0	Carbon monoxide	lb/lb C	1.1E-02	B	1.3E-03	B	4.1E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	5.5E-02	C	NA	NA	2.9E-02	C
	7439-92-1	Pb (In Energetic As Compound)		NA	NA	NA	NA	NA	NA
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb SVOC	NA	NA	NA	NA	NA	NA
	122-39-4	Diphenylamine		NA	NA	NA	NA	NA	NA

(a) MDL = 9.0E-12 /b/lb NEW

(b) MDL = 4.5E-06 lb/lb NEW

(c) MDL = 8.0E-08 lb/lb C

1 Table 35. EFs/EFFs for the Open Burning of Single-base and Triple-base Propellants in the BangBox.

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	8.6E-03	B	9.1E-01	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D
	108-95-2	Phenol		BDL	D	BDL	D
	85-01-8	Phenanthrene		BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine		BDL	D	BDL	D
	91-20-3	Naphthalene		BDL	D	BDL	D
	132-64-9	Dibenzofuran		BDL	D	BDL	D
	50-32-8	Benz(a)pyrene		BDL	D	BDL	D
	56-55-3	Benz(a)anthracene		BDL	D	BDL	D
	100-02-7	4-Nitrophenol		BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene		BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene		BDL	D	BDL	D
	95-57-8	2-Chlorophenol		BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene		BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D
	522-43-0	1-Nitropryene		BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene		BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D
	88-75-5	2-Nitrophenol		BDL	D	BDL	D
	88-72-2	2-Nitrotoluene		BDL	D	BDL	D
	99-99-0	4-Nitrotoluene		BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene		BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D
Energetics	121-82-4	RDX	lb/lb Energetic	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
	55-63-0	NG		NA	NA	ND	NA
	556-88-7	NQ		NA	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	NS	NA	1.2E-03	B
	NA	Nitrogen Oxides	lb/lb N	NS	NA	6.3E-03	B
	124-38-9	Carbon dioxide	lb/lb C	2.3E+00	B	4.0E+00	B
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	B	8.7E-04	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7439-92-1	Pb (In Energetic As Compound)		NA	NA	NA	NA
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb SVOC	BDL(b)	D	NA	NA
	122-39-4	Diphenylamine		BDL(b)	D	NA	NA

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Table 35. EFs/EFFs for the Open Burning of Single-base and Triple-base Propellants in the BangBox (continued)

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	ND	NA	ND	NA
	106-98-9	1-Butene		BDL	C	BDL	C
	592-41-6	1-Hexene		1.2E-07	C	BDL	C
	109-67-1	1-Pentene		1.1E-07	C	BDL	C
	74-86-2	Acetylene		2.5E-05	B	BDL	C
	71-43-2	Benzene		1.9E-05	B	BDL	C
	56-23-5	Carbon tetrachloride		ND	NA	BDL	D
	627-20-3	cis-2-Pentene		BDL	D	BDL	D
	110-82-7	Cyclohexane		1.7E-06	C	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D
	142-29-0	Cyclopentene		BDL	C	BDL	C
	74-84-0	Ethane		2.5E-06	C	BDL	D
	100-41-4	Ethylbenzene		2.8E-07	D	BDL	D
	74-85-1	Ethylene		1.5E-05	B	BDL	C
	75-28-5	Isobutane		BDL	D	BDL	D
	115-11-7	Isobutene		5.1E-07	C	BDL	D
	78-78-4	Isopentane		2.5E-08	D	BDL	D
	74-87-3	Methyl chloride		1.7E-07	D	BDL	D
	108-87-2	Methylcyclohexane		1.0E-07	D	BDL	D
	96-37-7	Methylcyclopentane		4.7E-06	D	BDL	D
	75-09-2	Methylene chloride		3.6E-05	B	3.3E-08	D
	620-14-4	m-Ethyltoluene		1.2E-07	D	BDL	D
	106-97-8	n-Butane		1.7E-07	D	BDL	D
	124-18-5	n-Decane		1.1E-06	D	BDL	D
	142-82-5	n-Heptane		5.8E-07	D	BDL	D
	110-54-3	n-Hexane		3.6E-05	D	BDL	D
	111-84-2	n-Nonane		2.3E-07	D	BDL	D
	111-65-9	n-Octane		8.1E-07	D	BDL	D
	109-66-0	n-Pentane		1.6E-06	D	BDL	D
	622-96-8	p-Ethyltoluene		1.8E-06	D	BDL	D
	74-98-6	Propane		9.4E-07	D	BDL	D
	115-07-1	Propylene		3.8E-06	B	BDL	C
	100-42-5	Styrene		BDL	D	BDL	D
	NA	TNMHC		1.8E-04	C	6.7E-04	C
	108-88-3	Toluene		3.4E-06	D	BDL	D
	624-64-6	trans-2-Butene		3.6E-07	C	BDL	C
	75-01-4	Vinyl chloride		BDL	C	BDL	C

(a) MDL = 4.5E-06 lb/lb NEW

(b) MDL = 1.0E-06 lb/lb DNT

(c) MDL = 8.0E-08 lb/lb C

Table 36. EFs/EFFs for the Open Burning of Double-base Propellants in the BangBox.

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lbNEW	1.9E-02	B	ND	NA	1.6E-02	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol		BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene		BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine		BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene		BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran		BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene		BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene		ND	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol		ND	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene		BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol		BDL	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene		BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol		BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene		BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene		BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D
Energetics	121-82-4	RDX	lb/lb Energetic	ND	NA	NA	NA	NA	NA
	2691-41-0	HMX		ND	NA	NA	NA	NA	NA
	55-63-0	NG		ND	NA	BDL(b)	D	BDL(b)	D
	556-88-7	NQ		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	2.5E-05	B	3.6E-04	B	NS	NA
	NA	Nitrogen Oxides	lb/lb N	9.4E-03	B	6.5E-02	B	NS	B
	124-38-9	Carbon dioxide	lb/lb C	3.2E+00	B	ND	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	7.3E-03	B	4.8E-03	B	1.0E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA	NA	NA
	7439-92-1	Pb (In Energetic As Compound)		6.3E-01	C	7.2E-01	C	NA	NA
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb SVOC	NA	NA	NA	NA	NA	NA
	122-39-4	Diphenylamine		NA	NA	NA	NA	NA	NA

Table 36. EFs/EFFs for the Open Burning of Double-base Propellants in the BangBox (continued).

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	BDL	C	BDL	C	BDL	C
	106-98-9	1-Butene		BDL	D	NA	NA	1.0E-06	C
	592-41-6	1-Hexene		BDL	D	NA	NA	8.1E-07	C
	109-67-1	1-Pentene		BDL	D	NA	NA	1.7E-07	C
	74-86-2	Acetylene		BDL	C	6.0E-04	B	3.5E-05	B
	71-43-2	Benzene		BDL	C	6.0E-04	B	1.2E-05	B
	56-23-5	Carbon tetrachloride		BDL	D	NA	NA	7.7E-07	D
	627-20-3	cis-2-Pentene		BDL	D	NA	NA	BDL	D
	110-82-7	Cyclohexane		BDL	D	NA	NA	BDL	D
	287-92-3	Cyclopentane		BDL	D	NA	NA	1.7E-07	D
	142-29-0	Cyclopentene		BDL	C	NA	NA	BDL	C
	74-84-0	Ethane		BDL	D	NA	NA	2.2E-06	D
	100-41-4	Ethylbenzene		BDL	D	NA	NA	BDL	D
	74-85-1	Ethylene		BDL	C	NA	NA	2.5E-05	B
	75-28-5	Isobutane		BDL	D	NA	NA	1.7E-07	D
	115-11-7	Isobutene		BDL	D	NA	NA	1.0E-06	C
	78-78-4	Isopentane		BDL	D	NA	NA	BDL	D
	74-87-3	Methyl chloride		BDL	D	NA	NA	BDL	D
	108-87-2	Methylcyclohexane		BDL	D	NA	NA	BDL	D
	96-37-7	Methylcyclopentane		BDL	D	NA	NA	BDL	D
	75-09-2	Methylene chloride		BDL	D	NA	NA	1.9E-08	D
	620-14-4	m-Ethyltoluene		BDL	D	NA	NA	1.7E-07	D
	106-97-8	n-Butane		BDL	D	NA	NA	BDL	D
	124-18-5	n-Decane		BDL	D	NA	NA	BDL	D
	142-82-5	n-Heptane		BDL	D	NA	NA	BDL	D
	110-54-3	n-Hexane		BDL	D	NA	NA	BDL	D
	111-84-2	n-Nonane		BDL	D	NA	NA	BDL	D
	111-65-9	n-Octane		BDL	D	NA	NA	BDL	D
	109-66-0	n-Pentane		BDL	D	NA	NA	BDL	D
	622-96-8	p-Ethyltoluene		BDL	D	NA	NA	1.5E-05	C
	74-98-6	Propane		BDL	D	NA	NA	BDL	D
	115-07-1	Propylene		BDL	C	NA	NA	2.8E-06	B
	100-42-5	Styrene		BDL	D	NA	NA	1.8E-06	C
	NA	TNMHC		5.2E-04	C	NA	NA	5.8E-05	C
	108-88-3	Toluene		BDL	D	NA	NA	BDL	D
	624-64-6	trans-2-Butene		BDL	D	NA	NA	BDL	D
	75-01-4	Vinyl chloride		ND	NA	NA	NA	BDL	D

(a) MDL = 4.5E-06 lb/lb NEW

(b) MDL = 1E-07 lb/lb NG

(c) MDL = 8.0E-08 lb/lb C

Table 37. EFs/EFFs for the Open Burning of PBX Propellants in the BangBox.

EP Category	CASRN	EP	Units	M43 Propellant		PBXN-110 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E-03	B	4.9E-01	B
VOCs(a)	106-99-0	1,3-Butadiene	lb/lb C	4.6E-02	B	1.9E-06	B
	106-98-9	1-Butene		1.4E-06	C	2.2E-06	C
	592-41-6	1-Hexene		BDL	C	BDL	C
	109-67-1	1-Pentene		4.6E-07	D	3.7E-07	D
	74-86-2	Acetylene		3.0E-05	B	1.1E-05	B
	71-43-2	Benzene		8.5E-06	B	1.8E-05	B
	56-23-5	Carbon tetrachloride		BDL	D	BDL	D
	627-20-3	cis-2-Pentene		4.6E-07	D	BDL	D
	110-82-7	Cyclohexane		4.6E-07	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D
	142-29-0	Cyclopentene		4.6E-07	C	3.7E-07	C
	74-84-0	Ethane		9.0E-07	D	3.7E-06	D
	100-41-4	Ethylbenzene		BDL	D	3.0E-06	D
	74-85-1	Ethylene		2.4E-05	B	2.5E-05	B
	75-28-5	Isobutane		BDL	D	BDL	D
	115-11-7	Isobutene		2.7E-06	C	4.8E-06	C
	78-78-4	Isopentane		4.6E-07	D	BDL	D
	74-87-3	Methyl chloride		BDL	D	6.7E-07	D
	108-87-2	Methylcyclohexane		BDL	D	BDL	D
	96-37-7	Methylcyclopentane		BDL	D	BDL	D
	75-09-2	Methylene chloride		BDL	D	2.2E-06	D
	620-14-4	m-Ethyltoluene		BDL	D	7.4E-07	D
	106-97-8	n-Butane		4.6E-07	D	3.7E-07	D
	124-18-5	n-Decane		4.1E-06	D	4.8E-06	D
	142-82-5	n-Heptane		4.6E-07	D	BDL	D
	110-54-3	n-Hexane		4.6E-07	D	1.9E-08	D
	111-84-2	n-Nonane		BDL	D	7.4E-07	D
	111-65-9	n-Octane		4.6E-07	D	BDL	D
	109-66-0	n-Pentane		BDL	D	BDL	D
	622-96-8	p-Ethyltoluene		9.0E-07	D	1.1E-06	D
	74-98-6	Propane		BDL	D	1.1E-06	D
	115-07-1	Propylene		5.5E-06	B	1.1E-05	B
	100-42-5	Styrene		BDL	D	BDL	D
	NA	TNMHC		2.1E-04	C	1.9E-04	C
	108-88-3	Toluene		2.7E-06	D	BDL	D
	624-64-6	trans-2-Butene		9.0E-07	C	1.5E-06	B
	75-01-4	Vinyl chloride		BDL	D	8.1E-07	C
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.2E-04	B	3.5E-04	B
	NA	Nitrogen Oxides	lb/lb N	3.1E-02	B	1.2E-02	B
	124-38-9	Carbon dioxide	lb/lb C	3.9E+00	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	3.3E-03	B	4.4E-03	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7439-92-1	Pb (In Energetic As Compound)		NA	NA	NA	NA

(a) MDL = 8.0E-08 lb/lb C

3.2.7 Discussion of the BangBox Open Burn Test Results

Table 38 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev), and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

Table 38 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory and the representativeness of the EF/EFF values to real-world detonation activities.

Table 38. Summary Statistics for the BangBox Open Burn EFs/EFFs

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	8	9.1E-01	1.2E-03	1.8E-02	2.3E-01	3.4E-01	1.44	B
Inorganic Gases	Sulfur Dioxide	lb/lb NEW	8	1.2E-03	2.5E-05	1.4E-04	3.0E-04	3.9E-04	1.31	B
	Nitrogen Oxides	lb/lb N	8	8.6E-02	6.3E-03	2.5E-02	3.3E-02	2.9E-02	0.87	B
	Hydrogen Chloride	lb/lb Cl	2	9.4E-01	8.5E-01	8.9E-01	8.9E-01	6.7E-02	0.07	B
	Carbon Dioxide	lb/lb C	10	4.1E+00	2.3E+00	3.7E+00	3.5E+00	5.8E-01	0.17	B
	Carbon Monoxide	lb/lb C	10	4.1E-02	8.7E-04	6.0E-03	1.1E-02	1.3E-02	1.16	B
VOCs	Benzene	lb/lb C	6	6.0E-04	8.5E-06	1.9E-05	2.0E-04	2.9E-04	1.44	B
	TNMHC		8	6.7E-04	5.8E-05	2.8E-04	3.3E-04	2.1E-04	0.63	B
	Acetylene		7	6.0E-04	1.1E-05	3.5E-05	1.4E-04	2.1E-04	1.49	B
	Ethylene		4	2.5E-05	1.5E-05	2.4E-05	2.2E-05	5.0E-06	0.22	B
	Isobutene		5	4.5E-05	5.1E-07	2.7E-06	1.1E-05	1.9E-05	1.78	C
	Propylene		4	1.1E-05	2.8E-06	4.6E-06	5.8E-06	3.7E-06	0.64	B
Metals In Energetic	Metal In Energetic As Particle	lb/lb Metal	2	5.5E-02	2.9E-02	4.2E-02	4.2E-02	1.8E-02	0.43	C
	Metal In Energetic As Compound		2	7.2E-01	6.3E-01	6.7E-01	6.7E-01	6.2E-02	0.09	C
SVOCs in Energetic	SVOCs in Energetics	lb/lb SVOC	1	NM	NM	NM	NM	NM	NM	NM

Inspection of the results presented in Tables 34 through 37 and Tables 26 and 27 lead to the following conclusions.

3.2.7.1 Particulate Matter

PM-10. The PM-10 EFs for the single, double and triple-base propellants are not markedly different from those for the AP and PBX propellants. In addition, the median BangBox PM-10 EF for these materials (1.8E-02 lb/lb NEW) agrees well with the corresponding median DPG open range PM-10 EF (1.1E-02 lb/lb NEW).

3.2.7.2 Inorganic Gases

CO_2. Essentially all of the carbon in the test materials was converted to CO_2 and the median EFF value for the BangBox tests (3.7E+00 lb/lb C) is identical to that from the DPG open range tests.

CO. Only a very small percentage of the carbon in the test material was converted to CO and the median for these materials (6.0E-03 lb/lb C) agrees reasonably well with the median EFF (8.2E-04 lb/lb C) for the five materials that were open burned on the DPG test range.

NO_x . Only a very small percentage of the nitrogen in the test material was converted to NO_x and the median for these materials (2.5E-02 lb/lb N) agrees well with the median DPG EFF (2.9E-02 lbs/lb N).

HCl and Cl_2. The median EFFs for HCl and Cl_2 indicate that 90 % of the Cl in the AP propellant materials was converted to HCl and 3% was converted to Cl_2. Based on the results from an HCl-loss study conducted in the DPG BangBox before the AP burns, it's likely that the missing 7% of the original Cl was lost through the reaction of HCl with particulate and the surfaces of the BangBox. Thus, it would be reasonable to assume going forward that essentially all of the Cl in AP propellants is released as HCl when they are open burned.

3.2.7.3 Metals

The EFF values indicate that approximately 4% of the Al and 70% of the Pb in the propellant were released into the plume. This large difference between the Al and Pb EFFs is not surprising because the Al was present as 50 to 200 micron-sized particles, whereas the Pb was present as an energetic compound.

3.2.7.4 VOCs

The EFFs for the 37 VOC emission products measured in the plume were very low and were dominated by the simplest unsaturated and aromatic hydrocarbons. In fact, the following five compounds, account for more than 97.5% of the carbon in the VOC emission products: benzene, acetylene, ethylene, isobutene, and propylene.

3.2.7.5 PCDDs/PCDFs

Even though the MDL of the measurement system was 9.0E-12 lb/ lb NEW, PCDD and PCDF compounds were not detected in the plumes for the three materials with chemical compositions that had the highest chance to produce these compounds. The failure to detect these compounds in the plumes was expected, because the reaction conditions present in open burns are not conducive to the formation of these

compounds. These compounds were not target analytes in the DPG open range study.

3.2.7.6 Energetics

All of the energetic results were BDL. This result is consistent with the results from the DPG open range burn study, which produced energetic emission factors that were much lower than the BangBox energetic MDL.

3.2.7.6 SVOCs/POMs

Although the plumes from eight of the ten test materials were sampled for more than 120 SVOCs/POMs of environmental concern, 2-chlorophenol was the only SVOC detected above the background level, and it was associated with only one of the eight materials. The failure to find these SVOCs/POMs is consistent with the results from the DPG open range burn study, which produced SVOC/POM EFs that were much lower than the BangBox SVOC MDL.

3.3 NTS Rocket Motor Burn Emissions Data Sets

3.3.1 Description of the Tests

This set of emissions data was obtained from sampling the plumes released when NIKE and Hawk rocket motors were open burned at the Nevada Test Site in 1997.[11, 12] The test chamber was a large room mined out of a volcanic ash fall tuff lying within Little Skull Mountain in Area 25 of the NTS. A 430 ft tunnel leads to the chamber, which is approximately 36 ft high by 49 ft wide by 100 ft long. The chamber has a nominal volume of 64,000 ft^3. The interior surfaces of the chamber, including the stainless steel door leading into it are coated with fiber-reinforced shot-crete.

Three rocket motor burn events were conducted. One (DAZZLER) involved two Improved HAWK rocket motors (composite propellant). The other two (SUNSPOT AND THUNDERBIRD) involved two and four NIKE HERCULES M88 (NIKE) rocket motors (double-base propellant), respectively. These two types of rocket motors were selected for evaluation because they represent the two most common rocket motor propellant formulations in the demilitarization inventory.

The chamber was sealed before the rocket motor burn was initiated and remained sealed for a considerable period of time after plume sampling had been completed. The plume samples were collected from the sealed chamber using probes inserted through four sampling ports in the chamber door (containment plug). The measurement systems used and the suite of target analytes (CO_2, CO, NO,NO_2, VOCs, SVOCs/POMs, polychlorinated dioxins and furans, TSP, PM-10, HCl and metals) were similar to those used in the BangBox tests described earlier with two notable exceptions. First, a mixture of helium and neon was used as the plume (volume) tracer instead of SF6 . Second, no attempt was made to measure the energetic compounds in the plumes.

Samples of the residue on the floor of the chamber were also collected after each burn. These samples were analyzed for energetics using EPA Methods SW-846 Methods 8330 and 8320, and for SVOCs/POMs using SW-846 Method 8270. The samples were also analyzed for metals using SW-846 Methods 1311, 6010 and 7470.

3.3.2 Evaluation of the NTS Rocket Motor Burn Test Results for Inclusion in AP-42

Between 1997 and 2000, the U.S. Army and its contractors released a number of test reports on these burns and on some 155MM projectile detonations that were conducted in the same chamber in 1997 and 1999. In all these reports, the results were reported in concentration units standardized to normal temperature and pressure. Before an evaluation of the test results for possible inclusion in this chapter of AP-42 could be initiated, it was necessary to convert the concentration units to the equivalent emission factors. This was accomplished by multiplying the concentrations by the appropriate plume volume and dividing the product by the mass of the energetic detonated. The resulting emission factors and associated test conditions under which they were derived were then evaluated to determine if the NTS burn EFs should be included in AP-42.

The following documents were consulted in this evaluation:

- The suite of reports associated with the projectile detonations and the rocket motor burns.[9-12, 21-26]

- The composition of the Hawk rocket motor contained in MIDAS. (The NIKE rocket motor is not

in MIDAS.)

- Articles on the formation and measurement of PCDD, PCDF and SVOC compounds from combustion processes.[13-17, 27, 28]

This evaluation determined the following:

- Plume sampling did not begin until 10 to 22 minutes after the burn was initiated. Based on the results from the real-time particle concentration monitors used in the 1999 detonation tests, it is highly likely that substantial particle losses attributable to deposition and agglomeration processes occurred long before plume sampling began and continued throughout the 65 to 90 minute plume sample collection period.

- More than 99% of the nitrogen in the rocket motors was converted to nitrogen gas

- Stratification of the gaseous and solid EPs was likely present in the burn plumes when the plume samples were collected and the plumes were held in a hot, pressurized environment for the entire sample collection period.

- The shot-crete coating on the chamber surfaces removed CO2 from the burn plume and caused a rapid conversion of NO to NO2.

- Most of the VOC compounds detected are common air pollutants and the concentrations reported were within what might be expected in a shot-crete lined chamber that is purged continuously with air collected above the dirt-covered parking lot at the entrance to the tunnel leading to the chamber. In fact, the background samples collected before the rocket motor burns indicated that many of the VOC target analytes were present in the NTS chamber at concentrations much higher than found in normal ambient air. When these background VOC concentrations were converted to the equivalent emission factors, they produced values which were very similar to those reported for many of the VOC emissions products, i.e., 1E-06 to 1E-07.

- Because of the blast shielding used to protect the thermocouples it is very likely that the thermocouples were measuring the wall temperature and not the burn plume temperature.

- Thermocouples and pressure sensors installed inside the chamber showed that the burn plumes were held at elevated temperatures and pressures in an hot, humid alkaline and carbonaceous - particle laden environment from the initiation of the burn until plume sampling was completed 80 to 100 minutes later. These conditions would promote the formation of SVOC and dioxin and furan compounds and are not representative of real-world OB processes where the plume is always at atmospheric pressure and reaches ambient temperature in less than two minutes.

- Most of the SVOC analytes detected in the plume are commonly occurring air pollutants that were present in the chamber air and/or on the interior surfaces of the chamber before the burns were initiated.

- Hi-volume particulate results from background air samples collected in the chamber several months before the rocket motor burns showed that the air in the chamber contained elevated particle concentrations. For example, the average particulate mass concentration for the two hi-

volume samples collected before the February 26, 1997, 155MM projectile detonation test was 184 mg/m^3. This concentration was equal to 20% of the TSP concentrations measured for the NIKE and HAWK burns and only slightly less than the PM-10 Micron value for the NIKE burn.

- Every metal measured in the burn plumes was present in at least one of the following chamber materials before the burn tests were initiated: shot-crete, concrete and gravel. Further, the metal content of the FPM samples indicated that a substantial portion of the particulate mass came from the interior surfaces of the chamber. In addition, the concentration rations of the metals in the shotcrete varied from one sampling point to the next.

- Cross-contamination of metals and possibly other solid and SVOC emission products occurred from one test to the next. For example, the EF for Pb for the HAWK rocket motor burn was three orders of magnitude higher than the amount of Pb in the rocket motor. This strongly indicates that the Pb came from the two NIKE rocket motors burns conducted several months before the Hawk burn. (The NIKE contains approximately 12 lb of Pb whereas the Hawk contains less than one lb.)

Because this evaluation showed that the burns did not reflect real-world burn events, the decision was made to exclude the NTS emissions data from AP-42.

3.4 Summary and Conclusions

3.4.1 Comparability of the BangBox (BB) and DPG Open Burn Emission Data Sets

A statistical comparison of means was done between the following BB and DPG EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene, and TNMHC. When this comparison showed that the six pairs of data sets were statistically the same, each pair was combined and the summary statistics calculated. Table 39 presents these summary statistics along with proposed EPA quality rating codes. These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance to detonation (burn) reaction theory, and representativeness to real-world open burn activities.

Table 39. Combined Summary Statistics for the DPG and BangBox OB EFs/EFFs

EP Category	EP	Units	Data Source	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	DPG + BB	13	9.1E-01	1.2E-03	1.6E-02	1.5E-01	2.8E-01	1.89	B
Inorganic Gases	Sulfur Dioxide	lb/lb NEW	BB	8	1.2E-03	2.5E-05	1.4E-04	3.0E-04	3.9E-04	1.31	B
	Nitrogen Oxides	lb/lb N	DPG + BB	13	8.6E-02	6.3E-03	2.9E-02	3.5E-02	2.5E-02	0.71	A
	Hydrogen Chloride	lb/lb Cl	BB	2	9.4E-01	8.5E-01	8.9E-01	8.9E-01	6.7E-02	0.07	B
	Carbon Dioxide	lb/lb C	DPG + BB	15	4.1E+00	2.3E+00	3.7E+00	3.5E+00	4.6E-01	0.13	A
	Carbon Monoxide	lb/lb C	DPG + BB	15	4.1E-02	1.5E-04	3.3E-03	7.8E-03	1.1E-02	1.46	B
Energetics	Energetics	lb/lb Energetic	DPG	4	1.5E-09	6.9E-10	9.7E-10	1.0E-09	3.3E-10	0.32	B
SVOCs	SVOCs in Energetics	lb/lb SVOC	DPG	6	9.4E-07	1.0E-08	4.4E-08	1.9E-07	3.7E-07	1.93	B
	SVOCs Not In Energetics	lb/lb NEW	DPG	29	8.0E-06	5.0E-10	2.7E-08	4.1E-07	1.5E-06	3.62	B
VOCs	Benzene	lb/lb C	DPG + BB	11	6.0E-04	2.3E-06	1.6E-05	1.2E-04	2.3E-04	1.93	B
	TNMHC		DPG + BB	13	2.1E-03	8.4E-06	2.1E-04	5.0E-04	6.2E-04	1.24	B
	Acetylene		BB	7	6.0E-04	1.1E-05	3.5E-05	1.4E-04	2.1E-04	1.49	B
	Ethylene		BB	4	2.5E-05	1.5E-05	2.4E-05	2.2E-05	5.0E-06	0.22	B
	Isobutene		BB	5	4.5E-05	5.1E-07	2.7E-06	1.1E-05	1.9E-05	1.78	C
	Propylene		BB	4	1.1E-05	2.8E-06	4.6E-06	5.8E-06	3.7E-06	0.64	B
Metals In Energetic	Metal In Energetic As Particle	lb/lb Metal	BB	2	5.5E-02	2.9E-02	4.2E-02	4.2E-02	1.8E-02	0.43	C
	Metal In Energetic As Compound		BB	2	7.2E-01	6.3E-01	6.7E-01	6.7E-01	6.2E-02	0.09	C

Table 39 also contains summary statistics for the following EP/EP categories for which there was either only BangBox data or the DPG open range data were judged to be far superior to the BangBox data.

SO_2 The BangBox SO_2 EF values.

VOCs. The BangBox EFFs for acetylene, ethylene, isobutane and propylene, which together with benzene accounted for essentially all of the carbon in the BangBox VOC emissions. (NOTE – There were many BDL values associated with these VOCs. Because these BDL values were not included in the summary statistics, the average and median EFFs in Table 39 are definitely biased high.)

Energetics. The DPG open range energetic EFFs

SVOCs/POMs in Energetic. The DPG open range EFFs. (NOTE – There were many BDL values associated with the SVOC/POM target analytes. Because these BDL values were not included in the summary statistics and only the maximum EF value measured for each test material was used, the average and median EFFs in Table 39 are definitely biased high.)

SVOCs/POMs Not In Energetic. The DPG open range EFs. (The 2-chlorophenol value from the BangBox was excluded because had a quality rating of D and because it could not be statistically compared to the DPG data set.)

Metals. The BangBox EFFs.

3.4.2 Representativeness, Adequacy, and Limitations of the Open Burn EF/EFFs

3.4.2.1 Open Burning of Propellants and HE in Pans

As noted earlier, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. The RSDs for eight of the 17 data sets are less than 1.0 and the RSDs for 16 are less than 2.0. These results show that within most of the data sets the EFs or EFFs are well correlated, i.e., that the results are of good quality. This close correlation is not surprising based on detonation reaction theory and the limited number of substances found in the explosive materials open burned.

The vast majority of open burning operations in the U. S. involve the disposal of single-base (NC) and double-base (NC + NG) propellants, and most of the remainder involve the disposal of triple-base (NC + NG + NQ) and PBX (plastic bonded explosive) propellants, waste high explosives that cannot be detonated and combustible explosive contaminated waste. If we exclude the burning of combustible explosive contaminated waste (which usually comprises less than 2% of the weight of the materials open burned annually), the number of explosive compositions demilled by open burning is quite limited. This limited range can be seen by a review of the information in Tables 40 and 41 which show the compositions of the 14,000,000 pounds of propellant and 1,100,000 pounds of explosive materials, respectively that were open burned over a five year period at a large DOD ammunition manufacturing and demilitarization facility. As a group the 15 test materials whose open burn emissions were selected for AP-42 include almost all of these explosives and propellants. Thus, their emissions data sets cover most of the substances of environmental concern that could be released into the environment via the burn plume.

Most demil activities in the U. S. are associated with facilities that are testing, manufacturing, and/or assembling energetic-containing materials, such as propellants, munitions and ammunition. Consequently, most demil facilities will open burn a variety of propellant and HE materials in any twelve month period. Further, most open burn activities involve conducting a number of independent burns over a short time period (e.g., one hour) in the same area and one hour is the shortest air pathway exposure time

interval used in environmental assessments.

Table 40. Compositions of the Propellants Open Burned Over a Five Year Period

Compound	Single Base Propellants				Double Base Propellants		Triple Base Propellants		
	SB-1	SB-2	SB-3	SB-4	DB-1	DB-2	TB-1	TB-2	TB-3
Nitrocellulose	82.5%	84.0%	85.3%	94.0%	57.8%	78.1%	19.0%	21.5%	27.0%
Nitroglycerine	.	.	.	.	40.0%	9.5%	18.7%	18.0%	22.5%
Nitroguanidine	.	.	.	.	.	.	55.0%	54.7%	46.2%
Potassium Nitrate	.	.	.	.	1.5%	0.8%	.	.	2.8%
Dinitrotoluene	9.2%	10.0%	9.8%	.			.	.	.
Dibutylphthalate	4.9%	5.0%	2.9%	.	.	7.5%	.	3.0%	.
Diphenylamine	1.0%	1.0%	1.0%	.	.	1.1%	.	.	.
Butyl Stearate				3.0%			.	.	.
Potassium Sulfate	1.2%	.	1.0%	1.0%	.		.	1.3%	.
Calcium Carbonate	.	.	.	.	.	1.0%	.	.	.
Ethyl Centralite	.	.	.	1.0%	0.8%	.	7.3%	1.5%	1.5%
Sodium Sulfate	.	.	.	.	.	0.5%	.	.	.
Graphite	.	.	.	.	.	0.4%	.	0.1%	0.2%
Lead Carbonate	1.1%	1.0%	.	.	.	.	.	.	.
Stannic Oxide	.	.	.	.	.	1.1%	.	.	.

Table 41. Compositions of the Explosives Open Burned Over a Five Year Period

Compound	Comp B	CXM-7	H-6	PBX	TNT	Destex	Tritonal
RDX	59.5%	95.0%	45.1%	90.0%	.	.	.
TNT	39.5%	.	29.2%	.	100.0%	72.0%	80.0%
Wax	1.0%	.	4.7%	.	.	5.0%	.
Aluminum	.	.	21.0%	.	.	20.0%	20.0%
Polystyrene	.	.	.	8.5%	.	.	.
Dioctylphalate	.	.	.	1.5%	.	.	.
Dioctyladipate	.	5.0%	.	.	.	.	.
Graphite	.	.	.	.	.	3.0%	.

The summary statistics associated with the following EP/EP categories in Table 38 can be used with confidence for estimating the emissions from the routine open burning of propellants in burn pans: PM-10, HCl, CO, NO_x, SO_2, benzene, acetylene, ethylene, propylene, isobutene, and *SVOCs/POMs Not In Energetic*. This conclusion is based on the following considerations: (1) the RSDs, (2) the number of values used to calculate the summary statistics, (3) the representativeness of the test conditions (under which the EF/EFFs were derived) to real-world open burn operations, (4) the EPA Quality Rating Code; (5) the magnitude of the EF/EFFs, (6) the potential toxicity of exposure to the emission product via air pathways, (7) the manner in which real-world burn activities are conducted (i.e., multiple open burns in the same area over a one hour timeframe) and (8) the agreement of the EF/EFF to detonation reaction theory.

The summary statistics associated with the following EP/EP categories are not adequate for estimating the emissions from the open burning of propellants: *Energetics, Metals In Energetic As Compound, Metals In Energetic As Particle and SVOCs/POMs In Energetics.* Obtaining additional

3.4.2.2 Open burning of Combustible Explosive Contaminated Waste

There are no emissions data for the burning of combustible explosive contaminated waste per se and the emissions data for the open burning of HE is very limited. Until these data become available, the emissions data presented in Appendix B could probably be used to estimate the emissions from combustible explosive contaminated waste and the emissions data for the open burning of propellants should be used as the default values for the burning of HE.

3.4.2.3 Open Burning of Missiles and Rocket Motors

The following procedures are used to destroy missiles and rockets by open burning: (1) holding down the missile and firing it in its design mode, (2) removing the nozzle from a missile, holding it down, and igniting it and (3) placing a shape charge along one side of a rocket motor or missile and using the initiation of that shape charge to crack open the item and ignite the energetics. Each of these processes results in different temperatures and pressures and, hence, different emissions. In general, all these burns involve a two stage decomposition process. The first stage involves a white cloud predominately composed of the substances released when the propellant deflagrates (decomposes). The second stage involves a black cloud predominately comprised of the substances released by the combustion of the liner and combustible parts of the casing.

There are no emissions data for the open burning of missiles and rockets. Because the propellant burn is essentially complete before the combustion of the liner and casing begins, one could assume that the emissions for each stage are additive. Under this assumption, one could use the EFs/EFFs in this Chapter of AP-42 to estimate the emissions from the open burning of the propellant and another source (e. g., the emissions for the combustion of materials similar in composition to the liner/casing) to estimate the emissions from the liner and casing.

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APPENDIX A

Effect of Confinement on the Air Emissions from Detonations

To reduce noise and shrapnel travel, its standard practice at many demilitarization facilities to detonate energetic materials under a soil cover, which can inhibit the formation of a full fireball. When munitions are detonated under these conditions, the fireball is partially or fully suppressed. Because the emissions from these types of detonations have never been studied, there are no emissions data available. But, as discussed more fully below, there are data from studies in bomb calorimeters and detonation chambers that provide some insight on the emissions that will result when munitions are detonated under a soil covering. For example, compared to the equivalent surface detonation, the plume will be cooler and the conversion of the combustible detonation products will also be reduced as will the PM-10 emissions. Until emissions data from actual buried detonations becomes available, the insights provided by these confined-detonation studies in conjunction with numerical modeling should be helpful in using the surface detonation EF/EFFs in this background document for estimating the emissions from soil-covered and buried detonations.

Bomb Calorimeter Detonations Experiments

Ornellas showed that completely suppressing the fireball produces a cooler plume, decreases the CO2 emissions and increases the soot, CO and soot emissions.[1] He showed this by detonating TNT under the following conditions: (1) in an oxygen–rich environment, (2) in a 100% CO_2 environment and (3) in a vacuum. In the oxygen-rich environment, approximately 97% of the carbon was converted to CO_2 and the remaining was converted to CO. The results from the vacuum and CO_2-atmosphere detonation were very similar to each other, but noticeably different from the results from the oxygen-rich detonation. That is, approximately 18% of the carbon ended up as CO_2, 29% ended up as CO and an additional 52% ended up as soot. These results are fully consistent with detonation reaction theory.

BangBox Water-Suppressed Detonation Experiments

A set of experiment was conducted in the BB at DPG that involved partial suppression of the fireball. The goal of these water-suppressed detonation experiments was to obtain a robust assessment of the impact that fireball suppression had on the emissions from the detonation of oxygen-balanced (amatol) and oxygen-negative (tritonal) HE. These experiments involved detonating amatol (an oxygen-rich HE) and tritonal (a severely oxygen-negative HE) in the presence and absence of water bags. The compositions of these materials and the test conditions are described in Section 2.2.3 of this background document.

Table A-1 compares the average EFs produced by the water-suppressed detonation to those produced by the corresponding unsuppressed detonation. This table was constructed by dividing each suppressed detonation EF by the corresponding unsuppressed EF.

Table A-1. Comparison of Water Suppressed and Unsuppressed Detonation Emissions Results.

Pollutant Category	Pollutant	Supressed Detontion EF / Unsuppressed Detonation EF	
		Amatol	Tritonal
PM-10	PM -10	1.68	0.51
Metals	Al (In Energetic As Particle)	NA	0.03
Inorganic gases	Carbon dioxide	0.44	0.23
	Carbon monoxide	23.71	93.10
	Nitrogen Oxides	0.46	0.68
Aromatic HC	Benzene	11.7	35.1
	Toluene	17.9	56.2
	p-Ethyltoluene	6.3	6.3
	Ethylbenzene	13.3	2.7
Unsaturated HC	Acetylene	1.5	36.7
	Ethylene	31.6	44.0
	Propylene	65.5	219.2
	1-Butene	83.3	17.9
Saturated HC	Ethane	392.9	705.9
	Propane	190.0	75.3
	n-Butane	83.9	19.2
	isobutane	10.3	10.8
TNMHC	TNMHC	8.4	6.0
SVOCs & POMs(a)	Phenol	BDL	BDL
	Naphthalene	BDL	BDL
	2-Methylnaphthalene	BDL	BDL
	Dibenzofuran	BDL	BDL
	Benz(a)anthracene	BDL	BDL
	Benz(a)pyrene	BDL	BDL
	2-Nitronaphthalene	BDL	BDL
	2,6-Dinitrotoluene	BDL	BDL
	1,3,5-Trinitrobenzene	BDL	BDL
	N-Nitrosodiphenylamine	BDL	BDL
	Hexachlorobenzene	BDL	BDL
	Pyrene	BDL	BDL
	2,4-Dinitrophenol	BDL	BDL
	2-Nitrotoluene	BDL	BDL
	4-Nitrophenol	BDL	BDL
	4-Nitrotoluene	BDL	BDL
	Nitrobenzene	BDL	BDL
	Phenanthrene	BDL	BDL
	Pyridine	BDL	BDL
	2,4-Dinitrotoluene	BDL	BDL
	Diphenylamine	BDL	BDL

(a) MDL = 6.6E-05 lb/lb NEW

Inspection of the results in Table A-1 shows the following:

Carbon Dioxide. The CO_2 emissions decreased sharply for both materials, but the decrease for the severely oxygen-negative tritonal was twice that for the oxygen-balanced amatol. (Tritonal contains only 24% of the oxygen required to convert all of its carbon and hydrogen to CO_2 and H_2O, so it's considerably more dependent on the fireball to accomplish these conversions than amatol.)

Carbon Monoxide. The CO emissions increased for both materials, but the increase for the severely oxygen-deficient tritonal was 20 times larger than that for amatol.

Nitrogen Oxides. Although The NOx emissions decreased by 50 to 65%, they still accounted for only a very small amount of the original mass of N in the test materials.

VOC*s*. The aromatic and unsaturated hydrocarbon emissions increased substantially for both materials, but the increase for the severely oxygen-deficient tritonal was much larger than for the oxygen-balanced amatol.

SVOCs/POMs. There was no detectable increase in the SVOC emissions, all values remained below the MDL of the measurement system (6.6E-05 lb / lb NEW).

PM-10. At first glance the increase in the PM-10 emissions for amatol and the decrease in those for tritonal might seem an anomaly. However, upon reflection, one finds that the results are consistent with detonation reaction theory. That is, although the PM-10 EF for the unsuppressed amatol (1.9E-02 lb/ lb NEW) is 20 times lower than that for the unsuppressed tritonal (3.7E-01 lb/lb NEW), the absolute increase in the amatol EF was only 1.3E-02 lb/lb NEW and likely resulted from an increase in soot. It's likely that this increase in soot emissions also occurred in tritonal, but it was masked by the 35-fold decrease in the aluminum emissions (the aluminum EF went from 2.6E-02 to 7.6E-04 lb/ lb NEW).

ODOBI Detonation Chamber Experiments

The ODOBi detonation chamber is located at Dugway proving ground, UT. It comprises of a one-inch thick, 12 ft. diameter steel cylinder and two one-inch thick, hemispherical end caps. The top end cap has a 5 ft opening through which the energetic material to be detonated is lowered. There is also a 5 ft diameter, 12 ft long stack that can be attached to the top cap of the ODOBi. The ODOBi stands approximately 12 ft high, has an internal volume of 36 m^3 and has an explosive capacity rating of 33 lb NEW. It also has 21 sampling ports.

In June 1997, the U.S. Army conducted a series of TNT detonations in the ODOBi to accomplish the following goals.[2] First, to evaluate the structural integrity of the ODOBi to confirm that it met the explosive performance criteria specified in the contract for its construction. Second, to obtain more information on the potential for replacing soil-covered detonations with detonations in vented chambers as a means of reducing the pollutants released to the environment. Third, to determine if the emissions from vented detonation chambers would scale as a function of the net explosive weight (NEW) of energetic material detonated, i.e., determine if the emission factors would remain constant as the NEW detonated changed.

To accomplish these goals, the Army detonated flaked-TNT in the ODOBi and measured the quantities of CO_2, CO, NOx and selected VOC and SVOC compounds in the portion of the detonation

plume that remained in the ODOBi. (PM-10 was not measured.) After the 0.5 lb TNT detonation Operational Readiness Test was completed, the Army detonated the following quantities of TNT in the ODOBi and measured the emission products: 5, 10, 15, 20, 15, 20 lb. The TNT was contained in clear plastic bags that were wrapped in a copper mesh-type screen. This screen provided both structural strength and a location for attaching the wire that was used to lower the bag into the ODOBi test chamber, and to hold it approximately 6 ft above the floor of the ODOBi. The items detonated ranged from 20 to 100 inches in diameter. Before each detonation, a Tedlar bag containing a known quantity of a 50:50 He/Ne mix was placed approximately 6 ft from the center of the TNT-containing bag. When the TNT was detonated, the Tedlar bag ruptured releasing the He and Ne into the detonation plume. The concentration of Ne in each plume sample was subsequently used to determine the plume volume and to derive the emission factors for the detonation. The inorganic gases were measured on-site with continuous emission monitors and the VOC emission products were collected in evacuated canisters and analyzed off-site using EPA TO-14 (GC/FID). The SVOC emissions were collected using EPA SW-846 Method 0010 and analyzed using EPA SW-846 Method 8270 (Soxhlet extraction followed by analysis by GC/MS.

TNT is severely oxygen deficient. Based on the TNT quantities used, the fireball should have been fully suppressed for at least the 15 and 20 lb detonations. In addition, the ODOBi was observed to flex and lift slightly off the ground at the instant of detonation even for the smaller charges. This indicates that a meaningful amount of the detonation energy was absorbed by the steel walls of the 90,000 lb ODOBi. In buried and soil covered detonations, fireball formation is also partially or fully suppressed and a meaningful amount of the detonation energy is used up pushing soil out of the way. This is why the ODOBi emissions test results can provide some insight into the affect that soil covering has on the emissions from detonations.

Table A-2 presents summary statistics for the emissions from the ODOBi that provide insight into the effect that the degree of confinement has on the emissions. A comparison of the results in Table A-2 to the corresponding results for unconfined open test range TNT detonations presented in Table 4 of this background document yields the following conclusions.

Carbon Oxides. The average ODOBi EFFs for CO_2 and CO indicate that 32% of the carbon in the TNT was converted to CO_2, whereas in the unconfined detonations approximately 97% of the carbon was converted to CO_2. In contrast, the amount of carbon converted to CO in the ODOBi (0.2%) was not markedly different from the value of 0.03% associated with the unconfined detonations.

Nitrogen Oxides. The average ODOBi EFF for NOx (3.4E-02 lb / lb N) agrees very closely with the corresponding value of 5.3E-02 lb / lb N) for the unconfined TNT detonations.

VOCs. As was the case for the unconfined detonations, the amount of carbon converted to benzene was greater than the sum of the carbon converted to toluene and xylenes. Even more interesting is the finding the ODOBi benzene and toluene EFFs are lower than the corresponding values for the unconfined TNT detonation. Another interesting finding is the observation that the ODOBi EFF values for the predominant unsaturated hydrocarbons are higher than those for the unconfined detonations. This indicates that there was insufficient detonation energy to convert the unsaturated hydrocarbons to aromatic saturated hydrocarbon compounds.

Energetics. The ODOBi TNT results agree very well across the six detonations and the average EFF value (7.3E-05 lb/lb TNT) is approximately 500 times larger than the corresponding value for the surface detonation shown in Table 5 of this background document (1.4E-07 lb/lb TNT).

Table A-2. Summary Statistics for the Emissions from the ODOBi TNT Detonation Study.

EP Category	EP	Units	N(a)	Maximum	Minimum	Median	Mean	RSD(b)
Inorganic Gases	Carbon dioxide	lb/lb C	6	1.4E+00	1.0E+00	1.2E+00	1.2E+00	0.17
	Carbon monoxide		6	1.7E-02	2.4E-03	6.9E-03	8.2E-03	0.80
	Cyanogen		5	9.5E-06	BDL	1.3E-07	3.2E-06	1.68
	NOx	lb/lb N	6	7.6E-02	6.5E-03	2.6E-02	3.4E-02	0.89
TNT	TNT	lb/lb TNT	6	1.8E-04	1.7E-05	4.8E-05	7.3E-05	1.01
SVOCs & POMs	Naphthalene	lb/lb TNT	6	1.5E-05	3.5E-06	7.4E-06	8.3E-06	0.61
	2-Amino-4,6-Dinitrotoluene		6	8.9E-06	2.3E-07	3.6E-07	2.5E-06	1.74
	4-Amino-2,6-Dinitrotoluene		6	2.3E-06	1.0E-06	1.6E-06	1.6E-06	0.36
	1,3,5-Trinitrobenzene		6	5.5E-06	9.6E-08	1.6E-07	1.5E-06	1.82
	2,4-Dinitrotoluene		6	1.0E-06	2.1E-07	2.3E-07	4.2E-07	0.94
	2,6-Dinitrotoluene		6	1.3E-07	4.8E-08	7.7E-08	8.3E-08	0.41
	4-Nitrotoluene		6	4.3E-08	1.9E-08	4.0E-08	3.6E-08	0.32
	2-Nitrotoluene		6	2.4E-08	1.1E-08	1.6E-08	1.7E-08	0.38
Aromatic VOCs	Benzene	lb/lb C	6	8.4E-05	2.7E-05	6.8E-05	6.2E-05	0.40
	Toluene		6	3.2E-06	1.3E-06	2.6E-06	2.4E-06	0.34
	m,p Xylenes		6	3.8E-06	6.0E-07	1.0E-06	1.6E-06	0.94
	o-Xylene		6	2.2E-06	4.6E-07	7.2E-07	1.0E-06	0.79
	1,3-Dinitrobenzene		3	6.8E-07	4.6E-07	5.7E-07	5.7E-07	0.27
	Phenol		4	1.1E-06	5.4E-07	6.2E-07	7.6E-07	0.41
	Ethylbenzene		6	1.1E-06	3.0E-07	4.7E-07	5.9E-07	0.63
	Nitrobenzene		6	2.1E-07	4.3E-08	9.2E-08	1.1E-07	0.65
	p-Ethyltoluene		6	BDL	BDL	BDL	BDL	NM
Aldehydes and Ketones	Benzaldehyde	lb/lb C	6	1.2E-05	3.0E-06	7.7E-06	7.7E-06	0.50
	Benzoic acid		6	2.6E-05	2.1E-06	8.1E-06	1.2E-05	1.03
	Acetone		6	4.6E-06	1.4E-06	2.2E-06	2.6E-06	0.56
	Acrolein		3	2.5E-06	BDL	1.7E-06	1.5E-06	0.73
	Acrylonitrile		6	2.1E-05	4.6E-07	1.2E-06	5.9E-06	1.67
	Benzofuran		6	6.0E-06	1.9E-07	9.6E-07	2.0E-06	1.32
	Acetaldehyde		3	3.0E-06	BDL	9.9E-07	1.4E-06	0.81
	Benzonitrile		6	1.0E-06	2.0E-07	5.1E-07	5.7E-07	0.71
	Acetonitrile		6	1.0E-05	1.9E-07	4.1E-07	2.8E-06	1.76
	Furan		6	4.6E-07	6.5E-08	3.2E-07	2.9E-07	0.60
Unsaturated VOCs	Ethane	lb/lb C	6	BDL	BDL	BDL	BDL	NM
	Propane		6	BDL	BDL	BDL	BDL	NM
	n-Butane		6	BDL	BDL	BDL	BDL	NM
	n-Heptane		6	BDL	BDL	BDL	BDL	NM
	n-Hexane		6	BDL	BDL	BDL	BDL	NM
	n-Pentane		6	BDL	BDL	BDL	BDL	NM

Table A-2. Summary Statistics for the Emissions from the ODOBi TNT Detonation Study (continued).

EP Category	EP	Units	N(a)	Maximum	Minimum	Median	Mean	RSD(b)
Unsaturated VOCs	Acetylene	lb/lb C	6	1.3E-04	1.1E-05	3.9E-05	5.5E-05	0.95
	Ethylene		6	5.1E-05	2.3E-05	3.1E-05	3.4E-05	0.35
	Propylene		6	6.8E-06	3.8E-06	6.0E-06	5.6E-06	0.26
	Isobutene		6	1.2E-06	3.8E-07	6.0E-07	6.8E-07	0.49
	trans-2-Butene		6	BDL	BDL	BDL	BDL	NM
	1-Butene/ I-Butene		6	BDL	BDL	BDL	BDL	NM
	1-Hexene		6	BDL	BDL	BDL	BDL	NM
	1-Pentene		6	BDL	BDL	BDL	BDL	NM
	1,3-Butadiene		6	BDL	BDL	BDL	BDL	NM
	trans-2-Pentene		6	BDL	BDL	BDL	BDL	NM
	cis-2-Pentene		6	BDL	BDL	BDL	BDL	NM
TNMHC	TNMHC	lb/lb C	6	7.3E-04	1.1E-04	2.6E-04	3.4E-04	0.78

(a) N = the number of EFs/EFFs used to calculate the summary statistics.

(b) RSD is obtained by dividing the standard deviation by the corresponding mean (average). As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation.

SVOCs/POMs. The eight SVOCs/POMs presented in Table 6 are all possible decomposition products of TNT and they were found in all of the detonation plumes. All but one of the RSD's are less than one. In addition, the tracer gas results showed that between 20 and 30% of the detonation plume remained in the ODOBi after the detonation gases had vented. Thus, it's unlikely that these SVOC compounds came from the ambient air. Further, three of the eight SVOCs (2,4- DNT, 2,6-DNT and naphthalene) were also detected in at least one of the detonation plumes for each of the four HE materials detonated on soil in the DPG open range tests and the corresponding emissions factors agree closely between the two data sets. The NEW detonated in these unconfined open range tests (in which more than 99.8% of the carbon was released as carbon oxides) was 100 to 400 times larger than that used in the partially-confined ODOBi tests (where only 32% of the carbon was released as carbon oxides). These observations lead to the following tentative conclusions. First, fireball suppression does not substantially increase the SVOC/POM EFs. Second, the SVOC/POM emissions scale with the NEW detonated. Third, these SVOC/POM compounds would not have been detected in the BangBox detonation plumes where the MDL of the SVOC measurement system was at least an order of magnitude higher than even the largest ODOBi and open range EF values. Together, these observations provide strong evidence that the SVOCs/POMs are actual emission products from the decomposition of the TNT

Conclusions

At this point it's not clear exactly how credible it would be to use the bomb calorimeter and detonation chamber data presented above for estimating the emissions from buried and soil covered detonations. The results from the suppressed-fireball detonations are certainly consistent with detonation reaction theory. For the simple gaseous species, similar results might be produced using DOD numerical models. Perhaps, the most useful conclusions from the studies described above is the observation that the SVOC emissions do not seem to increase significantly when the fireball is suppressed.

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2. ODOBi Interim Initial Air Sampling Report, Volume 1-Summary. Prepared by Radian International LLC, Oak Ridge, TN for the U.S. Army, Dugway Proving ground, UT. Copies available from R.J. Black, U.S. Army West Desert Test Center, (Attention STEDP-WD-M-OE), Dugway, UT.

APPENDIX B

Estimating the Emissions from the Burning of Combustible Explosive Contaminated Waste

Combustible explosive contaminated waste is a byproduct of explosive loading, unloading, packaging and related activities. The combustible explosive contaminated waste is burned in burn pans. Usually, a weight of propellant and HE scrap equal to 30 to 60% of the weight of the combustible explosive contaminated is used to initiate and support the burn. Although the exact composition of this material varies from day to day, it usually contains rags, cotton gloves, wood sticks, polyethylene bags, corrugated cardboard and pressed cardboard propellant cups along with 1% HE and propellant materials.

At this time there are no emissions data available for the open burning of explosive contaminated waste. However, since the burns are initiated and supported using a large quantity of HE or propellant, the 1% of energetic material in the explosive contaminated waste itself will be an insignificant source of emissions. Thus, if we ignore these latter energetic materials, the composition of the waste is similar to that from a household that recycles the glass, metal and plastic materials commonly found in household waste -- a material for which EPA characterized the emission products through a two-part study[1-4]

The EPA study used burn times and burn conditions that are similar to those used when combustible explosive contaminated waste is burned, i.e., initial flame followed by smoldering fire and total burn times of 60 to 100 minutes. EPA evaluated how the following factors affected the POM (Polycyclic Organic Matter), potentially hazardous VOC, PCDD/PCDF and PCB emissions from the burning of household waste from households that recycled and those that did not recycle: availability of combustion air, density of the waste, unconfined (open burning) versus confined burning (open top barrel), chlorine content, metal content, and wetness of the waste. These experiments showed that none of the experimental variables affected the VOC, POM, PCDD/PCDF and PCB emissions in a meaningful way.

The first part of the study produced credible emission factors for the POM and VOC emission products, but not for the PCDD/PCDF and PCB emission products. So, the second part of the EPA study focused on these latter emission products. Combining the POM and VOC EFs for recycler household waste from the first part of the study with the PCDD/PCDF and PCB EFs for the recycler household waste from the second part of the study yields the EFs presented in Table B.1.

Table B.1 EFs from the EPA Waste Burn Study.[1-4]

	A	C
3	Emission Product	lb/lb Waste
4	1,2, 3 trichlorobenzene	1.10E-07
5	1,2, 4-Trichlorobenzene	9.80E-08
6	1,2,3,4 tetrachlorobenzene	4.00E-08
7	1,2,4,5-Tetrachlorobenzene	2.10E-08
8	1,2,4-Trichlorobenzene	5.30E-06
9	1,3, 5- trichlorobenzene	1.50E-08
10	1,3-Butadiene	1.41E-04
11	2-Methyl phenol	2.10E-05
12	4-Methylphenol	4.50E-05
13	Acenaphthene	6.40E-07
14	Acenaphthylene	1.80E-05
15	Acetaldehyde	4.30E-07
16	Anthacene	1.30E-06
17	Benzo(a)anthracene	1.50E-06
18	Benz(a)pyrene	1.40E-06
19	Benzaldehyde	1.50E-07
20	Benzene	9.80E-04
21	Benzo(b)fluoranthene	1.80E-06
22	Benzo(k)fluoranthene	6.70E-07
23	Chloromethane	1.63E-04
24	Chrysene	1.80E-06
25	Dibenzo(a,h)anthacene	4.20E-07
26	Dioxin/Furan (as TEQ)	2.65E-09
27	Ethylbenzene	1.82E-04
28	PM-10	1.20E-02
29	Fluoranthene	2.80E-06
30	Fluorene	3.00E-06
31	Formaldehyde	4.30E-07
32	Hexachlorobenzene	3.50E-07
33	Hydrogen chloride	1.34E-03
34	Hydrogen Cyanide	3.34E-04
35	Indo(1,2,3 cd)pyrene	1.30E-06
36	m-Dichlorobenzene	1.60E-07
37	Naphthalene	1.43E-04
38	o-Dichlorobenzene	8.20E-08
39	PCB (as TEQ)	1.1E-10(a)
40	p-Dichlorobenzene	3.00E-08
41	Pentachlorobenzene	7.60E-08
42	Phenanthrene	5.30E-06
43	Phenol	4.02E-04
44	Pyrene	3.20E-06
45	Toluene	3.72E-04

(a) Value is the average EF from four PVC –spiked waste burns

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APPENDIX C

List of Acronyms

AN	Ammonium nitrate
Analyte	Emission product being measured
AP	Ammonium perchlorate
BDL	Below method detection limit
Comp B	High explosive containing 60% RDX, 39% TNT and 1% wax
CEM	Continuous emission monitor
DAC	U. S. Army Defense Ammunition Center, McAlester, OK
DPG	Dugway Proving Ground, UT
DOD	U. S. Department of Defense
Explosive D	Ammonium picrate
EF	Emission factor (lb/lb NEW)
EFF	Environmental fate factor (lb/lb of related substance in material treated)
EP	Emission product
HE	High explosive
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
MDL	Minimum detection limit (EF/EFF below which the analytical result is suspect or otherwise unreliable.
MIDAS	Munitions Items Disposition Action System
NC	Nitrocellulose
NG	Nitroglycerin
NQ	Nitroguanidine
NEW	Net explosive weight
OB	Open burning
OD	Open air detonation
PAH	Polycyclic aromatic hydrocarbon – substances containing two or more benzene rings with all lying in the same plane with the electron cloud above and below this plane. PAHs are a subset of POM.

PCDD	Polychlorinated Dibenzo-p-Dioxin
PCDF	Polychlorinated Dibenzofurans
POM	Polycyclic organic matter. The term POM applies to more than 100 compounds. It's defined by the Federal Clean Air Act as organic compounds with more than one benzene ring that have a boiling point greater than or equal to 100^0C. In general, POM with molecular weights less than or equal to 230 g/mol are found in the gaseous state in the atmosphere and those with molecular weights greater than this are partitioned between the gaseous and solid states.
PM-10	Particulate matter with an aerodynamic diameter equal or less than 10 microns.
RDX	Cyclotrimethylene trinitramine
RSD	Standard deviation divided by the mean
SVOC	Semi-volatile organic compound. This is an alternate term for POM.
TNT	Trinitrotoluene
TPM	Total particulate matter
TNMHC	Total nonmethane hydrocarbons
Tritonal	High explosive comprised of 20-% aluminum and 80% TNT
VOC	Volatile organic compound (any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa)

Attachment 4 Metals Analysis for Waste in Explosives Treated in 2006

DE Interim OD TSD Waste Treatment CY 2006
TA36-8 Minie

Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
Excess HE	34760	D003	No		0.03			95% HMX, 5% carbon black		0.03	-						Shot contained classified plastic shapes for	(1) det; (1) pellet, 122 lbs. ANFO; (4) PBX-9501 cylinders = 17.2 lbs.
Classified explosives	34760	D003	Yes	02/21/06	1.00	<1	CHNO detonators			1.00	-							
HE on cellulosics	28345	D003	No		0.33					0.33	-	PETN on filter cartridge						
Excess Baratol	35762	D001, D003, D005, D030	No		21.90	Baratol, 21.9 lbs.				5.26	16.64						Barium Content	
Excess HE	35763	D003, D030	Yes		289.40	PBX-9501, 15.6 lbs.	CHNO Dets, <1 lb.			289.40					Octol, 2.18 lbs.		Shot contained classified HE shapes	
						PBX-9502, 33.26 lbs.												
						PBX-9404, 0.66 lbs.												
				03/08/06		PBX-9407, 0.01 lbs.												
						PBX-9205, 11.02 lbs.												(1) det; (7) pellets
						PBXN-9, 33 lbs.												
						Comp B, 52.8 lbs												
						Detasheet, 12.58 lbs												
						RDX, 5 lbs.												
						TNT, 76.91 lbs.												
						CHNO HE, 41.38 lbs.												
						Black Powder, 5.0 lbs.												
Excess HE	35763	D003, D030	Yes		429.97	Comp B, 35.11 lbs.	CHNO Dets, <1 lb.			429.97					RDX, 13.0 lbs.			
						Nitroguanidine, 49.90 lbs.									MDF (PETN), 5.0 lbs.			
						PBX-9205, 26.03 lbs.												
						PBX-9404, 0.66 lbs.												(1) det; (8) pellets; (11) PBX-9501 cylinders = 46.2 lbs.; 103 lbs. PBX-9501 bulk material
				03/09/06		PBX-9407, 0.04 lbs.												
						PBX-9501, 238.08 lbs.												
						PBX-9502, 23.76 lbs.												
						TNT, 1.87lbs.												
						X-0533, 35.9 lbs.												
						Primacord (CHNO), 0.62 lbs.												
Excess Baratol	35762	D001, D003, D005, D030	No		34.21	Baratol, 34.21 lbs.				8.21	26.00						Barium content	
Excess HE	35763	D003, D030	Yes		650.89					650.89							Shot contained classified HE shapes	
						ANFO, 13.56 lbs.	PETN/HMX, 33.16 lbs.											
						CHNO Classified, 11.18 lbs.												
						Comp. B, 82.94 lbs.												
				05/03/06		Comp. C-4, 4.98 lbs.												(1) det; (7) pellets
						Cyclotol, 30.00 lbs.												
						Detasheet, 0.26 lbs.												
						LX-14, 170.61 lbs.												
						Octol, 1.10 lbs.												
						PBX-9404, 192.29 lbs.												
						PBX-9407, 0.24 lbs.												
						PBX-9501, 95.61 lbs.												
						PBX-9502, 10.01 lbs.												
						XTX-8003, 4.89 lbs.												
						XTX-8004, 0.04 lbs.												

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
M-100, M-105 Electric Matches	37092	D003, D008	No	05/04/06	11.00		(50) M-105 (Lead azide, RDX) (50) M-100 (Lead azide, lead styphnate, HMX)				11.00						Lead based primary HE, RDX, HMX. SENSITIVE	(1) det; (6) pellets; 19 lbs. PBX-9501 bulk material; (1) PBX-9501 cylinder = 4.2 lbs.
HE contaminated debris	28345	D003	No		0.01					0.01		PETN on filter cartridge						
HE contaminated debris w/ ethanol	39254	D001, D003	No	05/11/06	2.00					2.00		HE contaminated lab debris with trace ethanol (kimwipes, swabs, weigh boats)						(1) det; (1) pellet; 21 lbs. PBX-9501 bulk material; (1) PBX-9501 cylinder = 4.2 lbs.
Classified explosives	34760	D003	YES		2.00	<2.0	Classified CHNO dets			2.00								
HE contaminated debris	30373	D003	No		0.53					0.53		CHNO contaminated lab debris (kimwipes, swabs, weigh boats)						
Excess HE	37560	D003, D030	No	05/16/06	39.81	AN, 29.93 lbs.	Black powder dets, 0.002 lbs.	Total lab quantity HE in this section = 9.677 lbs.	PLG/UW (RDX/AP/Al), 0.05 lbs.	39.81		Nitroguanidine, 0.11 lbs + 40 lb Fiberboard drum	Developmental propellant HMX/NC/NG/Al/AP, 0.04 lbs.					(2) dets; (1) pellet; 50 lbs. PBX-9501 bulk material; (1) PBX-9501 cylinder = 4.2 lbs.
								Bullseye Powder, 0.29 lbs.	DNAZ/DNPA/EtGDMA, 0.002 lbs.									
								Comp. B, 0.02 lbs.										
								Cyclotol, 0.01 lbs.										
								DAAF, 0.02 lbs.										
								HMX, 4.602 lbs.										
								IMR Smokeless Powder, 0.084 lbs.										
								PETN, 0.123 lbs.										
								RDX, 0.032 lbs.										
								TATB, 0.12 lbs.										
								Tetryl, 0.02 lbs.										
								Tetrytol, 0.292 lbs.										
								TNT, 0.002 lbs.										
								Semtex 10, 0.070 lbs.										
								Semtex 1A, 0.13 lbs.										
								LX-04, 0.01 lbs.										
								LX-07, 0.007 lbs.										
								LX-14, 0.01 lbs.										
								LX-16, 0.001 lbs.										
								PBX-9404, 0.011 lbs.										
								PBX-9407, 0.113 lbs.										
								PBX-9501, 2.25 lbs.										
								PBX-9502, 0.616 lbs.										
								X-0298, 0.066 lbs.										
								X-0319, 0.015 lbs.										
								X-0407, 0.055 lbs.										
								X-0557, 0.075 lbs.										
								X-0564, 0.012 lbs.										
								X-0565, 0.011 lbs.										
								X-0567, 0.002 lbs.										
								X-0569, 0.062										
								XTX-8003, 0.037 lbs.										
								XTX-8004, 0.509 lbs.										
Excess HE	37845	D003	No		0.21			Total lab quantity HE in this section = 0.21 lbs. .		0.21								
								HMX, 0.002 lbs.										
								PBX-9501, 0.137 lbs.										

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
								PBX-9502, 0.07 lbs.										
Excess HE	37560	D003, D030	No		0.04			Total lab quantity HE in this section = 0.04 lbs. .		0.04								
								Explosive D, 0.012 lbs.										
								BP, 0.011 lbs.										
								PETN, 0.002 lbs.										
								TNT, 0.011 lbs.										
PBX-9501 on brass bar	37446	D003	No		0.55						0.55					PBX-9501, PBX-9502 bonded to brass		
HE (PETN) on cellulosics	28345	D003, D030	No	06/14/06	0.10					0.10		PETN on filter cartridge						(1) det; (1) pellet; 25 lbs. ANFO; (1) PBX-9501 cylinder = 4.2#
Classified explosives	34760	D003, D030	Yes		2.00	<2.0	CHNO Dets, 1.03 lbs.			2.00								
Type 6S Primaries	34760	D003	No		2.22		HMX Primaries, 2.00 lbs.			2.22								
Lead-based Primaries	37092	D003, D008	No		1.00		Lead Primaries, 1.00 lbs.				1.00						Lead styphnate, lead azide	
HE Contaminated Debris	30373	D003, D030	No		0.61					0.61		CHNO contaminated lab debris (kimwipes, swabs, weigh boats)						
Excess HE	37560	D003, D030	No	06/27/06	175.36	Total quantity HE in this section = 151.61 lbs.		Total lab quantity HE in this section = 19.45 lbs.		175.36			Gun Propellant (NC/NG/NQ/DNT), 0.52 lb.			PBX-9501 HE from Spigot Gun Targets, Modified Stevens Targets, 3.78 lbs.		(1) det; (4) pellets; 50 lbs. PBX-9501 bulk material; 50lbs. ANFO; 10 ft Primacord; (2) PBX-9501 cylinders = 8.4 lbs.
						ANFO, 1.0 lbs.												
						Comp A, 0.77 lb												
						Comp B		Comp B, 0.07 lb.										
						Comp. C-4, 0.73 lb.												
						Cyclotol, 0.33 lb.		Cyclotol, 0.71 lb.										
						DINGU, 0.62		DINGU										
						EDC-32		EDC-32, 0.11 lb.										
						EDC-35		EDC-35, 0.22 lb.										
						EDC-37		EDC-37, 5.14 lb.										
						Exp. D, 2.0 lb.		Exp D, 0.06 lb.										
						Octol, 0.55 lb.												
						Pentolite, 1.5 lb.		Pentolite, 0.49										
						PYX		PYX, 0.19 lb.										
						TATB, 15.55lb.		TATB										
						Tetryl		Tetryl, 0.30 lbs.										
						TNT, 2.26 lb.		TNT										
						PBX-9010, 0.56 lbs.		08/31/24										
						PBX-9404		PBX-9404, 0.08 lb.										
						PBX-9501, 89.57 lbs.		PBX-9501, 10.81										
						PBX-9502, 14.37 lbs.		PBX-9502										
						LX-10		LX-10, 0.04 lb.										
						LX-14		LX-14, 0.04 lb.										
						LX-17		LX-17, 0.24 lb.										
						X-0211		X-0211, 0.04 lb.										
						X-0233,		X-0233, 0.01 lb.										
						X-0242, 19.6		X-0242, 0.03 lb.										
						X-0523,		X-0523, 0.02 lb.										
						X-0527,		X-0527, 0.77 lb.										
						X-0533		X-0533, 0.04 lb.										

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
						X-0534		X-0534, 0.03 lb.										
						X-0544, 2.2 lb.												
						XTX-8003		XTX-8003, 0.01 lb.										
HE	37560	D003, D030	No		172.99	Total HE this section = 142.93 lbs.		Total Lab Quantity this section = 30.06 lbs.		172.99								
				08/02/06		PBX-9501, 129.02 lbs.		PBX-9501, 28.58 lbs.										(1) det; (1) pellet; (1) PBX-9501 cylinder = 2 lbs.; 45 lbs. PBX-9501 bulk material
						PBX-9502, 11.88 lbs.		PBX-9502, 0.91 lbs.										
						TATB, 0.88 lbs.		TATB, 0.29 lbs.										
						X-0562, 0.50 lbs.		PBX-9407, 0.28 lbs.										
						X-0563, 065 lbs.												
PBX 9501 on brass	37446	D003, D030	No		0.01						0.01					5 grams PBX-9501 bonded to brass piece		
				08/10/06												(10) PBX 9501 charges, each 6" dia. X 10" tall encased in welded steel cylinders. 10 pounds each.		(3) dets; (1) PBX-9407 pellet; 22 lbs. PBX-9501 hemi; 135 lbs. PBX-9501 bulk material
Excess HE in metal cylinders	37560	D003, D030	No		100.00						100.00							
Classified explosives	34760	D003	YES		1.00	<1.0	CHNO Dets, 0.16 lbs.			1.00								
HE contaminated debris	28345	D003	No		0.32					0.32		PETN on filter cartridge; CHNO contaminated lab debris (kimwipes, swabs, weigh boats)						(1) det; (4) pellets; (2) PBX-9501 boosters = 10 lbs.; 1 lb. LX17 booster; 1 lb PBX-9404 booster; (2) PBX-9502 cylinders = 16 lbs.;164 lbs. PBX-9501 bulk material; 5 lbs. TNT
				08/28/06								CHNO contaminated lab debris (kimwipes, swabs, gloves, adhesives, paper, weigh boats)						
HE contaminated debris	39522	D003, D030	No		4.50					4.50								
HE contaminated debris	39521	D003, D030	No		4.00					4.00		CHNO contaminated lab debris (kimwipes, swabs, gloves, adhesives, paper, weigh boats)						
Excess HE in metal cylinders	37560	D003, D030	No		110.00						110.00	Not applicable for metals analysis?				(11) PBX 9501 charges, each 6" dia. X 10" tall encased in welded steel cylinders. 10 pounds each.		(1) det; (1) pellet; (1) PBX-9501 hemi = 22 lbs.; 140 lbs. PBX-9501 bulk material
				08/30/06													EXTREME CAUTION--in jar, wetted Handle as 1.1 D	
Picric acid, partially wetted	37560	D003, D030	No		1.10	Picric Acid, partially wetted, 1.10 lbs.				1.10								
Box 4220 TA09 Magazine 0208A	37560	D003, D030	No		1.11			Total Lab Quantity this section = 1.11 lbs.		1.11								

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
								PBX-9404, 0.12 lbs.										
								PBX-9407, 0.09 lbs.										
								PBX-9501, 0.65 lbs.										
								PBX-9502, 0.22 lbs.										
								TNT, 0.03 lbs.										
Damaged HE from compression testing, spigot gun tests, and impact samples. L category	37560	D003, D030	No		4.04					4.04						PBX-9502, 2.31 lbs. PBX-9501, 1.73 lbs.		
Excess HE in metal boxes	37560	D003, D030	No		0.28						0.28					Black Powder in metal box, 0.22 lbs.; Mixed DINGU/TNT/ TATB in metal box, 0.06 lbs.		
Excess HE and mixed propellants	37560	D003, D030	No		230.92	Total HE this section = 213.68 lbs.		Total Lab Quantity HE this section = 17.24 lbs.		230.92							Propellants and smokeless powders appeared to have been mixed with other materials for	(1) det; (3) pellets; (1) PBX-9501 hemi = 22 lbs.; (2) PBX-9501 cylinders = 4 lbs.; 148 lbs. PBX-9502 bulk material; 80 lbs. PBX-9501 bulk material; 52 lbs. Comp B; 46 lbs. X-0557 .
				08/31/06		M1 Propellant, 28.39 lbs.		M1 Propellant, 1.424 lbs.										
						M8 Propellant, 2.0 lbs.		PBX-9501, 6.727 lbs.										
						PBX-9501, 5.11 lbs.	5.11	PBX-9502, 1.285 lbs.										
						PBX-9502, 24.21 lbs.	24.21	Tetritol, 2.0 lbs.										
						TATB, 40.87 lbs.	40.87	Tritonal, 0.17 lbs.										
						Smokeless Powder, 7.97 lbs.		TATB, 0.22 lbs.										
						X-0407, 62.63 lbs.		X-0407, 1.97 lbs.										
						X-0450, 19.50 lbs.		HMX/RDX/PETN Mixed, 1.35 lbs.										
						X-0541, 23.00 lbs.		DAAF, 0.006 lbs.										
								PBXN-110, 0.55 lbs.										
								PBXN-9, 0.06 lbs.										
								Comp B, 0.522 lbs.										
								Semtex, 0.008 lbs.										
								ANFO, 0.68 lbs.										
								EDC-29, 0.06										
								LAX-112, 0.01 lbs.										
								PBX-9404, 0.075 lbs.										
								X-0541, 0.06 lbs.										
								EDC-37, 0.06 lbs.										

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
Excess HE, lab quantity, and mixed HE samples from TA37 Magazines	39555	D003, D030	No		221.98	Total HE this section = 203.30 lbs.		Total Lab Quantity and HE Samples this section = 18.68 lbs.		221.98							Some of this HE originated in TA16-340, TA16-430, and TA16-460 and was transferred to TA37 magazines when facilities were vacated	
						PBX-9501, 16.5 lbs.		HNS Mixed, 0.25 lbs.										
						PBX-9502, 11.5 lbs.		Tripeon, 0.27 lbs.										
						PBX-9205, 3.0 lbs.		NC/TNT Mixed, 0.06 lbs.										
						LX-07, 3.0 lbs.		NC, 0.06 lbs.										
						PBX-9501 Mixed, 20 lbs.		TNT, 0.81 lbs.										
						PBX-9502 Mixed, 16 lbs.		TNT Mixed, 0.61 lbs.										
						TNT Mixed, 5.0 lbs.		1,3,5-Trinitrobenzene / HE Samples, 0.03 lbs.										
						DAAF, 0.8 lbs.		2,4,6-Trinitrobenzoic Acid / HE Samples, 0.23 lbs.										
						XTX-8003 Mixed, 3.5 lbs.		1,3 Dichloro-2,4,6-Trinitrobenzene / HE Samples, 0.17 lbs.										
						XTX-8004, 10 lbs.		2,4,6-Trinitroanisole / HE Samples, 0.22 lbs.										
						9007, 1 lbs.		2,4,6-Trinitroresorcinol / HE Samples, 0.06 lbs.										
						NQ, 11.5 lbs.		Nitroguanidine Mixed , 0.25 lbs.										
						AN, 1.25 lbs.		PBX-9501, 13.3 lbs.										
						9001, 1 lbs.		PBX-9502, 0.2 lbs.										
				10/04/06		PBX-9404, 0.5 lbs.		Comp B Mixed, 0.06 lbs.										(1) det, (5) pellets, 20 feet Primacord
						PBX-9407, 1.0 lbs.		Dipicrylamine Mixed, 0.02 lbs.										
						RDX, 0.5 lbs.		DINGU, 0.01 lbs.										
						TATB, 4.5 lbs.		X-0290, 0.75 lbs.										
						X-0182, 2.0 lbs.		LX-07, 0.17 lbs.										
						X-0224, 8.25 lbs.		Nitro Urea/Urea Nitrate, 0.03 lbs.										
						X-0228, 2.5 lbs.		PBX-9407, 0.06 lbs.										
						X-0233, 3.5 lbs.		2,4,6-Trinitrometaxylene Samples, 0.11 lbs.										
						X-0234, 5 lbs.		DATB, 0.25 lbs.										
						X-0242, 3 lbs.		(6) Vials Mixed HE Samples										
						X-0280, 10 lbs.		RDX, 0.2 lbs.										
						X-0282, 2.5 lbs.												
						X-0283, 6.0 lbs.												
						X-0286, 1.5 lbs.												
						X-0298, 22 lbs.												
						X-0301, 1 lbs.												
						X-0303, 1.5 lbs.												
						X-0306, 4.5 lbs.												
						X-0308, 3.25 lbs.												
						X-0312, 1 lbs.												
						X-0406, 1 lbs.												

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
						X-0409, 0.5 lbs.												
						X-0410, 0.5 lbs.												
						X-0418, 1 lbs.												
						X-0419, 0.5 lbs.												
						X-0430, 0.5 lbs.												
						X-0438, 0.5 lbs.												
						X-0444, 1.5 lbs.												
						X-0463, 3.0 lbs.												
						X-0464, 0.5 lbs.												
						X-0513, 1.0 lbs.												
						X-0515, 1 lbs.												
						X-0516, 1.25 lbs.												
						X-0517, 1 lbs.												
						X-0521, 1 lbs.												
						RX-03-AT, 0.5 lbs.												
Excess HE and HE samples	39555	D003, D030	No		6.50	Total HE this section = 4.5 lbs.		Total Lab quantity HE and HE samples this section = 2.0 lbs.		6.50								
						X-0233, 0.5 lbs.		(28) Misc HE Samples, 2.0 lbs. HE										
						X-0298, 1.5 lbs.												
						X-0407, 0.5 lbs.												
				10/20/06		PBX-9407, 0.5 lbs.												(1) det; (1) pellet; 83 lbs. PBX-9501 pieces; 135 lbs. PBX-9501 bulk material; 9 lbs. PBX-9502 pieces; 46.5 lbs. TNT
						PBX-9502, 1 lbs.												
						EDD, 0.5 lbs.												
Excess Barium-based HE	39554	D001, D003, D005, D030	No		52.70	Total HE this section = 52.7 lbs.												
						X-0256, 0.50 lbs.				0.50								
						X-0262, 7.10 lbs.				7.10								
						X-0264, 7.10 lbs.				7.10								
						Baratol, 38 lbs.				9.12	28.88							
												-						
HE-contaminated shot debris B/C 10055613	30373	D003	YES		1.06						1.06	Polyamide film, cellulosics, copper, wood, plastics, 5% CHNO dets						
HE and ethanol contaminated lab cleaning debris	39254	D001, D003	No	11/17/06	0.66					0.66		HE contaminated lab debris with trace ethanol (kimwipes, swabs, weigh boats)						(1) det; (1) pellet; 2 lbs. PBX-9501 piece; 45 lbs. PBX-9501 bulk material
Classified explosives	34760	D003	YES		1.00	<1.0	CHNO dets			1.00								
HE contaminated cellulosics (PETN filter)	28345	D003	No		0.15					0.15		PETN on filter cartridge						
Excess explosives	39693	D003, D030	No		13.53	Total HE this section = 1 lbs.		Total lab quantity HE this section = 0.48 lbs.		1.48						Total HE Assemblies this section = 12.05 lbs.		
						IMR 4198 Powder (NC / 2,4-DNT), 1.0 lbs.		IMR 4198 Powder (NC/2,4-DNT), 0.33 lbs.								LX-07/PBX-9502 Assemblies, 12 lbs.		
								TATB, 0.04 lbs.								DAAF Assemblies, 0.05 lbs.		
								Aluminum powder/HE/oil, 0.06 lbs.										
								Comp C-4, 0.02 lbs.										
								PBX-9502, 0.03 lbs.										
						Total HE Assemblies				12.05								

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
HE contaminated debris	39611	D003, D030	No		15.98					15.98		Total HE contaminated debris this section = 15.98 lbs.						
				12/06/06								HE contaminated debris with PBX-9501 chips and PBX-9502 pieces, 1.0 lbs.						(1) det; (1) pellet; (1) PBX-9501 disc, 2 lbs.; 172.7 lbs. PBX-9501 bulk material; 102.5 lbs. PBX-9502 bulk material; 10 lbs. Octol; 2.5 lbs. PBX-9407; 24 lbs. TNT; 8 lbs. Comp B; 7 lbs. LX-07
												HE contaminated debris with PBX-9502 pieces, 0.54 lbs.						
												HE contaminated debris (primarily cellulosics) with chunks of PBX-9501, PBX-9502, TATB, and PETN, 5.42 lbs.						
												HE contaminated debris, PETN and C-4, 0.06 lbs.						
												HE contaminated debris and sweepings TATB, LX-07, PBX-9501, PETN , C-4 8.75 lbs.						
												HE contaminated debris TATB, 0.06 lbs.						
												HE contaminated debris, X-0565, 0.06 lbs.						
Excess barium-based HE	39554	D001, D003, D005, D030	No	12/13/06	116.50	Baratol, 56.5 lbs.	56.50			**13.56**	**42.94**							(1) det; (1) pellet; 67 lbs. PBX-9502 bulk material; 45 lbs. PBX-9501 bulk material; 8 lbs. X-0242; 12 lbs. PBX-9501 pieces
						LX-10, 60 lbs.	60.00			**60.00**								
Totals		**LBS.**			**2725.50**					**2387.13**	**338.36**							
									Potential Metal Waste - lbs	**338.36**	**210.28**	**From steel cylinders**						
									Factor for Metal containing waste	**0.124**	**0.077**	**Factor for Metal containing waste (minus Ba,Cu,Pb)**						
									Barium compound (based on Baratol)		**114.46**							
									Factor for Barium containing waste		**0.042**							
									Lead compound fraction		**12.00**							
									Factor for Lead containing waste		**0.0044**							
									Copper compound/brass alloy fraction		**1.62**							
									Factor for copper (brass containing waste)		**0.00059**							

Supplement 4-4

Air Sampling at Open Detonation Units

Open Detonation Air Sampling Summary for Resource Conservation and Recovery Act (RCRA) Permitting at Los Alamos National Laboratory

Andrew Green and Shannon Allen
WES-EDA

During 2010 and 2011 the Environmental Data and Analysis Group (WES-EDA) AIRNET team conducted sampling of suites of dioxins, furans and metals in support of the RCRA permit for Los Alamos National Laboratory (LANL) operated by LANS, LLC.

This document is a brief description of the work that was performed by the AIRNET team. Shannon Allen headed up the field team of Joan Lujan, William Smith and Louis Naranjo. Shannon coordinated the equipment purchase and sample analysis. Andrew Green performed the data analysis with support from Luciana Vigil-Holterman.

Dioxin and Furan Detection Equipment and Methodology

Thirty samples were collected for analysis using the EPA TO-9A method. The samples were collected using appropriate specialized high volume air samplers (Model TE-1000 PUF Poly-Urethane Foam) which were purchased from Tisch Environmental, Inc.

Prior to sample collection the sampling equipment was calibrated as described in the Operations Manual for the TE-1000 PUF. Sample flow volumes were calculated as described in the manual. Average atmospheric pressure and temperature data used in the calculation were obtained from LANL's meteorological tower at TA-54.

Pre-prepared sample media for TO-9A was obtained from Test America. TO-9A filters included a poly-urethane foam filter in a glass cartridge, and an airborne particulate filter. The glass PUF cartridge and the particulate filter were installed in series into the PUF sample module and connected to the sampler.

After collection, samples were returned for analysis to Test America in the original pre-cleaned packaging which consisted of aluminum foil and zip lock bags. Samples were shipped from the LANL Sample Management Office using coolers and ice to preserve samples as required by the TO-9A method.

One field blank was collected for each day of sampling, for a total of 8 blank samples.

Nitrile gloves were used whenever sample media were handled.

Metals Detection Equipment and Methodology

Thirty metals samples were collected using high volume air samplers (Hi-Q Environmental Model HVP-3000 BRL). Polypropylene 8"x10" filters were used, which were pre-cut and sold by Hi-Q Environmental.

Three field blank samples were collected, one for every ten field samples.

Field samples were collected per SOP-5174 Rev. 1, "AIRNET – Using High Volume Samplers". Samples were shipped by LANL's Sample Management Office to the analytical laboratory, ALS.

Sampling Location Selection and Methodology

For each shot, two locations were sampled. Each location had one TE-1000 PUF sampler and one high-volume sampler from Hi-Q. Sampler locations were chosen the morning of each shot after observing the predominant wind direction at the site and looking at the wind direction reported on the LANL meteorology site. Samplers were set as closely as possible to the shot location in a down wind direction. Sampling equipment was started approximately 10 to 15 minutes prior to the shot, and run for at least 15 minutes after the shot. All samplers were powered with extension cords; no gas generators were used. Vehicles were not operated in the immediate area (within the shot exclusion zone) during the sampling period. Shots were monitored from inside the bunker, and any observed plume or wind direction during collection was documented in the field notes.

Data Analysis

The field data were coordinated with the data analysis results to derive volume concentrations which were then compared to acute air inhalation exposure concentrations listed in the companion database of the 2005 US Environmental Protection Agency (EPA) *Human Health Hazard Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA530-R-05-006) when available. Other acute inhalation screening levels were identified within the 1999 *Air Toxics Hot Spots Program Risk Assessment Guidelines Part I The Determination of Acute Reference Exposure Levels for Airborne Toxicants,* drafted by the Office of Environmental Health Hazard Assessment of the California Environmental Protection Agency. These comparisons are attached to this document.

Concluding Remarks

Data were collected following the standard protocol for such measurements.

Comparisons with identified screening levels indicate operations that were monitored did not exceed any appropriate state or federal levels specified for the analytes monitored.

==========end of document==========

Attachment

Summary of Analytical Results for Air Samples Collected at TA-36 and TA-39 Open Detonation Treatment Operations

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2834	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	1.2	pg/Filter	0.198	27	5.346	2.24E-01						
RE39-11-2842	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.93	pg/Filter	0.198	36.6	7.2468	1.28E-01						
RE39-11-4518	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzodioxins (Total)	50	pg/Filter			10.18	4.91E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2826	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzodioxins (Total)	2	pg/Filter	0.198	27	5.346	3.74E-01						
RE39-11-2842	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzodioxins (Total)	0.93	pg/Filter	0.198	36.6	7.2468	1.28E-01						
RE39-11-4518	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	1	pg/Filter			10.18	9.82E-02						
RE36-11-2826	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2830	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	1.3	pg/Filter	0.198	27	5.346	2.43E-01						
RE39-11-2842	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2844	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzofurans (Total)	1	pg/Filter			10.18	9.82E-02						
RE36-11-2826	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2836	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzofurans (Total)	1.3	pg/Filter	0.198	27	5.346	2.43E-01						
RE39-11-2842	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2840	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4193	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4195	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxins (Total)	4	pg/Filter	0.153	39.6	6.0588	6.60E-01						
RE39-11-2845	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxins (Total)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxins (Total)	1.3	pg/Filter	0.189	44.4	8.3916	1.55E-01						
RE36-11-2833	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxins (Total)	1.5	pg/Filter	0.193	27.6	5.3268	2.82E-01						
RE39-11-2836	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxins (Total)	2.3	pg/Filter	0.189	25.2	4.7628	4.83E-01						
RE39-11-2839	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxins (Total)	2.1	pg/Filter	0.198	27	5.346	3.93E-01						
RE39-11-2842	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzodioxins (Total)	4.4	pg/Filter	0.168	36	6.048	7.28E-01						
RE36-11-4194	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxins (Total)	2.3	pg/Filter	0.198	36.6	7.2468	3.17E-01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4518	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxins (Total)	1.3	pg/Filter	0.202	30.6	6.1812	2.10E-01						
RE39-11-4520	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxins (Total)	2.3	pg/Filter	0.211	28.8	6.0768	3.78E-01		0				0
RE39-11-2834	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4522	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2824	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2828	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofurans (Total)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2832	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	5.9	pg/Filter	0.153	39.6	6.0588	9.74E-01						
RE39-11-2845	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.8	pg/Filter			0							
RE36-11-2824	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	4	pg/Filter	0.183	33	6.039	6.62E-01						
RE36-11-2825	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.1	pg/Filter			10.18	2.06E-01						
RE36-11-2826	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.4	pg/Filter			0							
RE36-11-2827	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.7	pg/Filter	0.188	29.4	5.5272	6.69E-01						
RE36-11-2828	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.8	pg/Filter	0.186	37.8	7.0308	5.40E-01						
RE36-11-2829	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	4.3	pg/Filter	0.19	22.2	4.218	1.02E+00						
RE36-11-2830	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.178	45	8.01	1.25E+01						
RE36-11-2831	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2	pg/Filter	0.167	28.2	4.7094	4.25E-01						
RE36-11-2832	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	44.4	8.3916	1.19E+01						
RE36-11-2833	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.3	pg/Filter			0							
RE36-11-2844	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.5	pg/Filter			0							
RE36-11-4185	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.6	pg/Filter	0.178	36	6.408	4.06E-01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4186	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.7	pg/Filter	0.194	40.8	7.9152	3.41E-01						
RE39-11-2835	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.5	pg/Filter	0.193	27.6	5.3268	6.57E-01						
RE39-11-2836	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3	pg/Filter	0.192	19.2	3.6864	8.14E-01						
RE39-11-2837	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.1	pg/Filter	0.197	31.2	6.1464	5.04E-01						
RE39-11-2838	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.4	pg/Filter	0.189	25.2	4.7628	7.14E-01						
RE39-11-2839	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2	pg/Filter	0.198	30.6	6.0588	3.30E-01						
RE39-11-2840	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.7	pg/Filter	0.191	24	4.584	5.89E-01						
RE39-11-2841	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.4	pg/Filter	0.198	27	5.346	6.36E-01						
RE39-11-2842	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4191	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.196	33	6.468	1.55E+01						
RE36-11-4193	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.3	pg/Filter	0.168	36	6.048	3.80E-01						
RE36-11-4194	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4187	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	8.6	pg/Filter	0.198	23.4	4.6332	1.86E+00						
RE36-11-4188	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	38.4	7.2576	1.38E+01						
RE36-11-4195	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4196	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	7.9	pg/Filter	0.197	101.4	19.9758	3.95E-01						
RE36-11-4198	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.169	111	18.759	5.33E+00						
RE39-11-2843	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.7	pg/Filter	0.198	36.6	7.2468	5.11E-01						
RE39-11-4518	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	4.1	pg/Filter	0.197	34.8	6.8556	5.98E-01						
RE39-11-4519	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.5	pg/Filter	0.202	30.6	6.1812	5.66E-01						
RE39-11-4520	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.2	pg/Filter	0.189	31.8	6.0102	5.32E-01						
RE39-11-4521	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE39-11-4522	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.6	pg/Filter	0.186	25.8	4.7988	3.33E-01						
RE39-11-4523	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.8	pg/Filter	0.211	28.8	6.0768	4.61E-01		0				0
RE39-11-2834	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.153	39.6	6.0588	1.65E+01						
RE39-11-2845	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-2824	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.183	33	6.039	1.66E+01						
RE36-11-2825	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			10.18	9.82E+00						
RE36-11-2826	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-2827	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.188	29.4	5.5272	1.81E+01						
RE36-11-2828	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.186	37.8	7.0308	1.42E+01						
RE36-11-2829	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.19	22.2	4.218	2.37E+01						
RE36-11-2830	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.178	45	8.01	1.25E+01						
RE36-11-2831	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.167	28.2	4.7094	2.12E+01						
RE36-11-2832	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	44.4	8.3916	1.19E+01						
RE36-11-2833	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-2844	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1.6	pg/Filter			0							
RE36-11-4185	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.178	36	6.408	1.56E+01						
RE36-11-4186	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.194	40.8	7.9152	1.26E+01						
RE39-11-2835	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1.6	pg/Filter	0.193	27.6	5.3268	3.00E-01						
RE39-11-2836	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.192	19.2	3.6864	2.71E+01						
RE39-11-2837	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.197	31.2	6.1464	1.63E+01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2838	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	25.2	4.7628	2.10E+01						
RE39-11-2839	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	30.6	6.0588	1.65E+01						
RE39-11-2840	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.191	24	4.584	2.18E+01						
RE39-11-2841	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	27	5.346	1.87E+01						
RE39-11-2842	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4191	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.196	33	6.468	1.55E+01						
RE36-11-4193	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.168	36	6.048	1.65E+01						
RE36-11-4194	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4187	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	23.4	4.6332	2.16E+01						
RE36-11-4188	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	38.4	7.2576	1.38E+01						
RE36-11-4195	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4196	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.197	101.4	19.9758	5.01E+00						
RE36-11-4198	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.169	111	18.759	5.33E+00						
RE39-11-2843	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	36.6	7.2468	1.38E+01						
RE39-11-4518	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.197	34.8	6.8556	1.46E+01						
RE39-11-4519	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.202	30.6	6.1812	1.62E+01						
RE39-11-4520	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	31.8	6.0102	1.66E+01						
RE39-11-4521	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE39-11-4522	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.186	25.8	4.7988	2.08E+01						
RE39-11-4523	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.211	28.8	6.0768	1.65E+01		0				0
RE39-11-2834	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2842	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzodioxins (Total)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzodioxins (Total)	1.8	pg/Filter	0.198	27	5.346	3.37E-01						
RE39-11-2842	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4187	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzodioxins (Total)	1.5	pg/Filter	0.169	111	18.759	8.00E-02						
RE39-11-2843	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4198	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4520	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzofurans (Totals)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzofurans (Totals)	2.6	pg/Filter	0.192	19.2	3.6864	7.05E-01						
RE39-11-2837	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2834	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.153	39.6	6.0588	1.65E+00						
RE39-11-2845	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			10.18	9.82E-01						
RE36-11-2826	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.19	22.2	4.218	2.37E+00						
RE36-11-2830	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2844	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.192	19.2	3.6864	2.71E+00						
RE39-11-2837	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.168	36	6.048	1.65E+00						
RE36-11-4194	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		0				0
RE39-11-2834	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.153	39.6	6.0588	1.65E+00						
RE39-11-2845	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			10.18	9.82E-01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2826	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.19	22.2	4.218	2.37E+00						
RE36-11-2830	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-2844	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.192	19.2	3.6864	2.71E+00						
RE39-11-2837	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.168	36	6.048	1.65E+00						
RE36-11-4194	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		0				0
RE39-11-2834	Tetrachlorodibenzofuran[2,3,7,8-]	2.4	pg/Filter	0.153	39.6	6.0588	3.96E-01						
RE39-11-2845	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			10.18	9.82E-01						
RE36-11-2826	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.19	22.2	4.218	2.37E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2830	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2844	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzofuran[2,3,7,8-]	1.8	pg/Filter	0.192	19.2	3.6864	4.88E-01						
RE39-11-2837	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.168	36	6.048	1.65E+00						
RE36-11-4194	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzofuran[2,3,7,8-]	2.1	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		0				0
RE39-11-2834	Tetrachlorodibenzofurans (Totals)	2.4	pg/Filter	0.153	39.6	6.0588	3.96E-01						
RE39-11-2845	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			10.18	9.82E-01						
RE36-11-2826	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.19	22.2	4.218	2.37E+00						
RE36-11-2830	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2844	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzofurans (Totals)	49	pg/Filter	0.192	19.2	3.6864	1.33E+01	detect		1.50E-03		1.50E+06	
RE39-11-2837	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzofurans (Totals)	11	pg/Filter	0.168	36	6.048	1.82E+00						
RE36-11-4194	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzofurans (Totals)	2.1	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		1				0
RE39-11-2936	Aluminum	230	ug/FILTER	1.11851544	36	40.26656	5.71E+00	detect		none specified			
RE39-11-2945	Aluminum	41	ug/FILTER			0		detect		none specified			
RE36-11-2914	Aluminum	34	ug/FILTER	1.104357017	30	33.13071	1.03E+00	detect		none specified			
RE36-11-2915	Aluminum	41	ug/FILTER	1.132673864	54	61.16439	6.70E-01	detect		none specified			
RE36-11-2916	Aluminum	39	ug/FILTER	1.132673864	30	33.98022	1.15E+00	detect		none specified			
RE36-11-2917	Aluminum	32	ug/FILTER	1.132673864	36	40.77626	7.85E-01	detect		none specified			
RE36-11-2918	Aluminum	65	ug/FILTER	1.104357017	18	19.87843	3.27E+00	detect		none specified			
RE36-11-2919	Aluminum	68	ug/FILTER	1.132673864	42	47.5723	1.43E+00	detect		none specified			
RE36-11-2920	Aluminum	100	ug/FILTER	1.132673864	24	27.18417	3.68E+00	detect		none specified			
RE36-11-2921	Aluminum	89	ug/FILTER	1.132673864	42	47.5723	1.87E+00	detect		none specified			
RE36-11-2922	Aluminum	54	ug/FILTER	1.104357017	36	39.75685	1.36E+00	detect		none specified			
RE36-11-2923	Aluminum	46	ug/FILTER	1.104357017	36	39.75685	1.16E+00	detect		none specified			
RE39-11-2935	Aluminum	47	ug/FILTER	1.132673864	30	33.98022	1.38E+00	detect		none specified			
RE39-11-2937	Aluminum	38	ug/FILTER	1.132673864	18	20.38813	1.86E+00	detect		none specified			
RE39-11-2938	Aluminum	190	ug/FILTER	1.132673864	30	33.98022	5.59E+00	detect		none specified			
RE39-11-2939	Aluminum	110	ug/FILTER	1.104357017	24	26.50457	4.15E+00	detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2940	Aluminum	300	ug/FILTER	1.104357017	30	33.13071	9.06E+00	detect		none specified			
RE39-11-2941	Aluminum	62	ug/FILTER	1.132673864	24	27.18417	2.28E+00	detect		none specified			
RE39-11-2942	Aluminum	250	ug/FILTER	1.132673864	24	27.18417	9.20E+00	detect		none specified			
RE36-11-4184	Aluminum	42	ug/FILTER	1.132673864	30	33.98022	1.24E+00	detect		none specified			
RE36-11-4189	Aluminum	49	ug/FILTER	1.132673864	30	33.98022	1.44E+00	detect		none specified			
RE36-11-4190	Aluminum	81	ug/FILTER			0		detect		none specified			
RE36-11-2934	Aluminum	32	ug/FILTER	1.132673864	42	47.5723	6.73E-01	detect		none specified			
RE36-11-4192	Aluminum	36	ug/FILTER	1.132673864	96	108.7367	3.31E-01	detect		none specified			
RE36-11-4197	Aluminum	74	ug/FILTER	1.061881747	108	114.6832	6.45E-01	detect		none specified			
RE36-11-4503	Aluminum	57	ug/FILTER	1.132673864	30	33.98022	1.68E+00	detect		none specified			
RE39-11-2943	Aluminum	45	ug/FILTER	1.132673864	30	33.98022	1.32E+00	detect		none specified			
RE39-11-2944	Aluminum	200	ug/FILTER	1.132673864	36	40.77626	4.90E+00	detect		none specified			
RE39-11-4524	Aluminum	46	ug/FILTER	1.104357017	30	33.13071	1.39E+00	detect		none specified			
RE39-11-4525	Aluminum	28	ug/FILTER	1.104357017	30	33.13071	8.45E-01	detect		none specified			
RE39-11-4526	Aluminum	5.5	ug/FILTER			0				none specified			
RE39-11-4527	Aluminum	9.7	ug/FILTER	1.132673864	24	27.18417	3.57E-01			none specified			
RE39-11-4528	Aluminum	38	ug/FILTER	1.132673864	24	27.18417	1.40E+00	detect	31	none specified			0
RE39-11-2936	Antimony	0.16	ug/FILTER	1.11851544	36	40.26656	3.97E-03	detect		1.5		1.50E+03	
RE39-11-2945	Antimony	0.024	ug/FILTER			0				1.5		1.50E+03	
RE36-11-2914	Antimony	0.08	ug/FILTER	1.104357017	30	33.13071	2.41E-03	detect		1.5		1.50E+03	
RE36-11-2915	Antimony	0.076	ug/FILTER	1.132673864	54	61.16439	1.24E-03	detect		1.5		1.50E+03	
RE36-11-2916	Antimony	0.044	ug/FILTER	1.132673864	30	33.98022	1.29E-03			1.5		1.50E+03	
RE36-11-2917	Antimony	0.042	ug/FILTER	1.132673864	36	40.77626	1.03E-03			1.5		1.50E+03	
RE36-11-2918	Antimony	0.038	ug/FILTER	1.104357017	18	19.87843	1.91E-03			1.5		1.50E+03	
RE36-11-2919	Antimony	0.028	ug/FILTER	1.132673864	42	47.5723	5.89E-04			1.5		1.50E+03	
RE36-11-2920	Antimony	0.044	ug/FILTER	1.132673864	24	27.18417	1.62E-03			1.5		1.50E+03	
RE36-11-2921	Antimony	0.046	ug/FILTER	1.132673864	42	47.5723	9.67E-04			1.5		1.50E+03	
RE36-11-2922	Antimony	0.06	ug/FILTER	1.104357017	36	39.75685	1.51E-03			1.5		1.50E+03	
RE36-11-2923	Antimony	0.06	ug/FILTER	1.104357017	36	39.75685	1.51E-03			1.5		1.50E+03	
RE39-11-2935	Antimony	0.034	ug/FILTER	1.132673864	30	33.98022	1.00E-03			1.5		1.50E+03	
RE39-11-2937	Antimony	0.05	ug/FILTER	1.132673864	18	20.38813	2.45E-03			1.5		1.50E+03	
RE39-11-2938	Antimony	0.14	ug/FILTER	1.132673864	30	33.98022	4.12E-03	detect		1.5		1.50E+03	
RE39-11-2939	Antimony	0.046	ug/FILTER	1.104357017	24	26.50457	1.74E-03			1.5		1.50E+03	
RE39-11-2940	Antimony	0.32	ug/FILTER	1.104357017	30	33.13071	9.66E-03	detect		1.5		1.50E+03	
RE39-11-2941	Antimony	0.06	ug/FILTER	1.132673864	24	27.18417	2.21E-03			1.5		1.50E+03	
RE39-11-2942	Antimony	0.16	ug/FILTER	1.132673864	24	27.18417	5.89E-03	detect		1.5		1.50E+03	
RE36-11-4184	Antimony	0.026	ug/FILTER	1.132673864	30	33.98022	7.65E-04			1.5		1.50E+03	
RE36-11-4189	Antimony	0.038	ug/FILTER	1.132673864	30	33.98022	1.12E-03			1.5		1.50E+03	
RE36-11-4190	Antimony	0.044	ug/FILTER			0				1.5		1.50E+03	
RE36-11-2934	Antimony	0.06	ug/FILTER	1.132673864	42	47.5723	1.26E-03			1.5		1.50E+03	
RE36-11-4192	Antimony	0.06	ug/FILTER	1.132673864	96	108.7367	5.52E-04			1.5		1.50E+03	
RE36-11-4197	Antimony	0.036	ug/FILTER	1.061881747	108	114.6832	3.14E-04			1.5		1.50E+03	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4503	Antimony	0.06	ug/FILTER	1.132673864	30	33.98022	1.77E-03			1.5		1.50E+03	
RE39-11-2943	Antimony	0.048	ug/FILTER	1.132673864	30	33.98022	1.41E-03			1.5		1.50E+03	
RE39-11-2944	Antimony	0.07	ug/FILTER	1.132673864	36	40.77626	1.72E-03	detect		1.5		1.50E+03	
RE39-11-4524	Antimony	0.036	ug/FILTER	1.104357017	30	33.13071	1.09E-03			1.5		1.50E+03	
RE39-11-4525	Antimony	0.06	ug/FILTER	1.104357017	30	33.13071	1.81E-03			1.5		1.50E+03	
RE39-11-4526	Antimony	0.06	ug/FILTER			0				1.5		1.50E+03	
RE39-11-4527	Antimony	0.06	ug/FILTER	1.132673864	24	27.18417	2.21E-03			1.5		1.50E+03	
RE39-11-4528	Antimony	0.032	ug/FILTER	1.132673864	24	27.18417	1.18E-03		7	1.5		1.50E+03	0
RE39-11-2936	Arsenic	0.052	ug/FILTER	1.11851544	36	40.26656	1.29E-03			1.90E-04		1.90E-01	
RE39-11-2945	Arsenic	0.4	ug/FILTER			0				1.90E-04		1.90E-01	
RE36-11-2914	Arsenic	0.052	ug/FILTER	1.104357017	30	33.13071	1.57E-03			1.90E-04		1.90E-01	
RE36-11-2915	Arsenic	0.034	ug/FILTER	1.132673864	54	61.16439	5.56E-04			1.90E-04		1.90E-01	
RE36-11-2916	Arsenic	0.042	ug/FILTER	1.132673864	30	33.98022	1.24E-03			1.90E-04		1.90E-01	
RE36-11-2917	Arsenic	0.4	ug/FILTER	1.132673864	36	40.77626	9.81E-03			1.90E-04		1.90E-01	
RE36-11-2918	Arsenic	0.044	ug/FILTER	1.104357017	18	19.87843	2.21E-03			1.90E-04		1.90E-01	
RE36-11-2919	Arsenic	0.4	ug/FILTER	1.132673864	42	47.5723	8.41E-03			1.90E-04		1.90E-01	
RE36-11-2920	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02			1.90E-04		1.90E-01	
RE36-11-2921	Arsenic	0.4	ug/FILTER	1.132673864	42	47.5723	8.41E-03			1.90E-04		1.90E-01	
RE36-11-2922	Arsenic	0.4	ug/FILTER	1.104357017	36	39.75685	1.01E-02			1.90E-04		1.90E-01	
RE36-11-2923	Arsenic	0.4	ug/FILTER	1.104357017	36	39.75685	1.01E-02			1.90E-04		1.90E-01	
RE39-11-2935	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE39-11-2937	Arsenic	0.4	ug/FILTER	1.132673864	18	20.38813	1.96E-02			1.90E-04		1.90E-01	
RE39-11-2938	Arsenic	0.068	ug/FILTER	1.132673864	30	33.98022	2.00E-03			1.90E-04		1.90E-01	
RE39-11-2939	Arsenic	0.048	ug/FILTER	1.104357017	24	26.50457	1.81E-03			1.90E-04		1.90E-01	
RE39-11-2940	Arsenic	0.11	ug/FILTER	1.104357017	30	33.13071	3.32E-03			1.90E-04		1.90E-01	
RE39-11-2941	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02			1.90E-04		1.90E-01	
RE39-11-2942	Arsenic	0.14	ug/FILTER	1.132673864	24	27.18417	5.15E-03			1.90E-04		1.90E-01	
RE36-11-4184	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE36-11-4189	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE36-11-4190	Arsenic	0.4	ug/FILTER			0				1.90E-04		1.90E-01	
RE36-11-2934	Arsenic	0.4	ug/FILTER	1.132673864	42	47.5723	8.41E-03			1.90E-04		1.90E-01	
RE36-11-4192	Arsenic	0.4	ug/FILTER	1.132673864	96	108.7367	3.68E-03			1.90E-04		1.90E-01	
RE36-11-4197	Arsenic	0.4	ug/FILTER	1.061881747	108	114.6832	3.49E-03			1.90E-04		1.90E-01	
RE36-11-4503	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE39-11-2943	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE39-11-2944	Arsenic	0.068	ug/FILTER	1.132673864	36	40.77626	1.67E-03			1.90E-04		1.90E-01	
RE39-11-4524	Arsenic	0.4	ug/FILTER	1.104357017	30	33.13071	1.21E-02			1.90E-04		1.90E-01	
RE39-11-4525	Arsenic	0.4	ug/FILTER	1.104357017	30	33.13071	1.21E-02			1.90E-04		1.90E-01	
RE39-11-4526	Arsenic	0.4	ug/FILTER			0				1.90E-04		1.90E-01	
RE39-11-4527	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02			1.90E-04		1.90E-01	
RE39-11-4528	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02		0	1.90E-04		1.90E-01	0
RE39-11-2936	Barium	3.8	ug/FILTER	1.11851544	36	40.26656	9.44E-02	detect		1.50E+00		1.50E+03	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2945	Barium	1.8	ug/FILTER			0		detect		1.50E+00		1.50E+03	
RE36-11-2914	Barium	0.97	ug/FILTER	1.104357017	30	33.13071	2.93E-02	detect		1.50E+00		1.50E+03	
RE36-11-2915	Barium	0.79	ug/FILTER	1.132673864	54	61.16439	1.29E-02	detect		1.50E+00		1.50E+03	
RE36-11-2916	Barium	0.95	ug/FILTER	1.132673864	30	33.98022	2.80E-02	detect		1.50E+00		1.50E+03	
RE36-11-2917	Barium	0.54	ug/FILTER	1.132673864	36	40.77626	1.32E-02	detect		1.50E+00		1.50E+03	
RE36-11-2918	Barium	1.1	ug/FILTER	1.104357017	18	19.87843	5.53E-02	detect		1.50E+00		1.50E+03	
RE36-11-2919	Barium	0.74	ug/FILTER	1.132673864	42	47.5723	1.56E-02	detect		1.50E+00		1.50E+03	
RE36-11-2920	Barium	0.69	ug/FILTER	1.132673864	24	27.18417	2.54E-02	detect		1.50E+00		1.50E+03	
RE36-11-2921	Barium	0.79	ug/FILTER	1.132673864	42	47.5723	1.66E-02	detect		1.50E+00		1.50E+03	
RE36-11-2922	Barium	0.47	ug/FILTER	1.104357017	36	39.75685	1.18E-02	detect		1.50E+00		1.50E+03	
RE36-11-2923	Barium	1.2	ug/FILTER	1.104357017	36	39.75685	3.02E-02	detect		1.50E+00		1.50E+03	
RE39-11-2935	Barium	1.8	ug/FILTER	1.132673864	30	33.98022	5.30E-02	detect		1.50E+00		1.50E+03	
RE39-11-2937	Barium	0.88	ug/FILTER	1.132673864	18	20.38813	4.32E-02	detect		1.50E+00		1.50E+03	
RE39-11-2938	Barium	3.8	ug/FILTER	1.132673864	30	33.98022	1.12E-01	detect		1.50E+00		1.50E+03	
RE39-11-2939	Barium	1.1	ug/FILTER	1.104357017	24	26.50457	4.15E-02	detect		1.50E+00		1.50E+03	
RE39-11-2940	Barium	7	ug/FILTER	1.104357017	30	33.13071	2.11E-01	detect		1.50E+00		1.50E+03	
RE39-11-2941	Barium	0.74	ug/FILTER	1.132673864	24	27.18417	2.72E-02	detect		1.50E+00		1.50E+03	
RE39-11-2942	Barium	5.6	ug/FILTER	1.132673864	24	27.18417	2.06E-01	detect		1.50E+00		1.50E+03	
RE36-11-4184	Barium	0.48	ug/FILTER	1.132673864	30	33.98022	1.41E-02	detect		1.50E+00		1.50E+03	
RE36-11-4189	Barium	0.98	ug/FILTER	1.132673864	30	33.98022	2.88E-02	detect		1.50E+00		1.50E+03	
RE36-11-4190	Barium	0.45	ug/FILTER			0		detect		1.50E+00		1.50E+03	
RE36-11-2934	Barium	0.89	ug/FILTER	1.132673864	42	47.5723	1.87E-02	detect		1.50E+00		1.50E+03	
RE36-11-4192	Barium	0.49	ug/FILTER	1.132673864	96	108.7367	4.51E-03	detect		1.50E+00		1.50E+03	
RE36-11-4197	Barium	0.74	ug/FILTER	1.061881747	108	114.6832	6.45E-03	detect		1.50E+00		1.50E+03	
RE36-11-4503	Barium	0.56	ug/FILTER	1.132673864	30	33.98022	1.65E-02	detect		1.50E+00		1.50E+03	
RE39-11-2943	Barium	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02	detect		1.50E+00		1.50E+03	
RE39-11-2944	Barium	2.9	ug/FILTER	1.132673864	36	40.77626	7.11E-02	detect		1.50E+00		1.50E+03	
RE39-11-4524	Barium	0.64	ug/FILTER	1.104357017	30	33.13071	1.93E-02	detect		1.50E+00		1.50E+03	
RE39-11-4525	Barium	0.28	ug/FILTER	1.104357017	30	33.13071	8.45E-03	detect		1.50E+00		1.50E+03	
RE39-11-4526	Barium	0.094	ug/FILTER			0				1.50E+00		1.50E+03	
RE39-11-4527	Barium	0.28	ug/FILTER	1.132673864	24	27.18417	1.03E-02	detect		1.50E+00		1.50E+03	
RE39-11-4528	Barium	0.65	ug/FILTER	1.132673864	24	27.18417	2.39E-02	detect	32	1.50E+00		1.50E+03	0
RE39-11-2936	Beryllium	0.1	ug/FILTER	1.11851544	36	40.26656	2.48E-03			5.00E-03		5.00E+00	
RE39-11-2945	Beryllium	0.1	ug/FILTER			0				5.00E-03		5.00E+00	
RE36-11-2914	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE36-11-2915	Beryllium	0.1	ug/FILTER	1.132673864	54	61.16439	1.63E-03			5.00E-03		5.00E+00	
RE36-11-2916	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE36-11-2917	Beryllium	0.1	ug/FILTER	1.132673864	36	40.77626	2.45E-03			5.00E-03		5.00E+00	
RE36-11-2918	Beryllium	0.1	ug/FILTER	1.104357017	18	19.87843	5.03E-03			5.00E-03		5.00E+00	
RE36-11-2919	Beryllium	0.1	ug/FILTER	1.132673864	42	47.5723	2.10E-03			5.00E-03		5.00E+00	
RE36-11-2920	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE36-11-2921	Beryllium	0.1	ug/FILTER	1.132673864	42	47.5723	2.10E-03			5.00E-03		5.00E+00	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2922	Beryllium	0.1	ug/FILTER	1.104357017	36	39.75685	2.52E-03			5.00E-03		5.00E+00	
RE36-11-2923	Beryllium	0.1	ug/FILTER	1.104357017	36	39.75685	2.52E-03			5.00E-03		5.00E+00	
RE39-11-2935	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2937	Beryllium	0.1	ug/FILTER	1.132673864	18	20.38813	4.90E-03			5.00E-03		5.00E+00	
RE39-11-2938	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2939	Beryllium	0.1	ug/FILTER	1.104357017	24	26.50457	3.77E-03			5.00E-03		5.00E+00	
RE39-11-2940	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE39-11-2941	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE39-11-2942	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE36-11-4184	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE36-11-4189	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE36-11-4190	Beryllium	0.1	ug/FILTER			0				5.00E-03		5.00E+00	
RE36-11-2934	Beryllium	0.1	ug/FILTER	1.132673864	42	47.5723	2.10E-03			5.00E-03		5.00E+00	
RE36-11-4192	Beryllium	0.1	ug/FILTER	1.132673864	96	108.7367	9.20E-04			5.00E-03		5.00E+00	
RE36-11-4197	Beryllium	0.1	ug/FILTER	1.061881747	108	114.6832	8.72E-04			5.00E-03		5.00E+00	
RE36-11-4503	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2943	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2944	Beryllium	0.1	ug/FILTER	1.132673864	36	40.77626	2.45E-03			5.00E-03		5.00E+00	
RE39-11-4524	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE39-11-4525	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE39-11-4526	Beryllium	0.1	ug/FILTER			0				5.00E-03		5.00E+00	
RE39-11-4527	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE39-11-4528	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03		0	5.00E-03		5.00E+00	0
RE39-11-2936	Cadmium	0.37	ug/FILTER	1.11851544	36	40.26656	9.19E-03	detect		3.00E-02		3.00E+01	
RE39-11-2945	Cadmium	1.2	ug/FILTER			0		detect		3.00E-02		3.00E+01	
RE36-11-2914	Cadmium	0.15	ug/FILTER	1.104357017	30	33.13071	4.53E-03	detect		3.00E-02		3.00E+01	
RE36-11-2915	Cadmium	0.26	ug/FILTER	1.132673864	54	61.16439	4.25E-03	detect		3.00E-02		3.00E+01	
RE36-11-2916	Cadmium	1.3	ug/FILTER	1.132673864	30	33.98022	3.83E-02	detect		3.00E-02		3.00E+01	
RE36-11-2917	Cadmium	0.12	ug/FILTER	1.132673864	36	40.77626	2.94E-03	detect		3.00E-02		3.00E+01	
RE36-11-2918	Cadmium	0.64	ug/FILTER	1.104357017	18	19.87843	3.22E-02	detect		3.00E-02		3.00E+01	
RE36-11-2919	Cadmium	17	ug/FILTER	1.132673864	42	47.5723	3.57E-01	detect		3.00E-02		3.00E+01	
RE36-11-2920	Cadmium	2.3	ug/FILTER	1.132673864	24	27.18417	8.46E-02	detect		3.00E-02		3.00E+01	
RE36-11-2921	Cadmium	0.49	ug/FILTER	1.132673864	42	47.5723	1.03E-02	detect		3.00E-02		3.00E+01	
RE36-11-2922	Cadmium	0.46	ug/FILTER	1.104357017	36	39.75685	1.16E-02	detect		3.00E-02		3.00E+01	
RE36-11-2923	Cadmium	1.1	ug/FILTER	1.104357017	36	39.75685	2.77E-02	detect		3.00E-02		3.00E+01	
RE39-11-2935	Cadmium	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		3.00E-02		3.00E+01	
RE39-11-2937	Cadmium	0.72	ug/FILTER	1.132673864	18	20.38813	3.53E-02	detect		3.00E-02		3.00E+01	
RE39-11-2938	Cadmium	2.3	ug/FILTER	1.132673864	30	33.98022	6.77E-02	detect		3.00E-02		3.00E+01	
RE39-11-2939	Cadmium	0.72	ug/FILTER	1.104357017	24	26.50457	2.72E-02	detect		3.00E-02		3.00E+01	
RE39-11-2940	Cadmium	4.1	ug/FILTER	1.104357017	30	33.13071	1.24E-01	detect		3.00E-02		3.00E+01	
RE39-11-2941	Cadmium	0.97	ug/FILTER	1.132673864	24	27.18417	3.57E-02	detect		3.00E-02		3.00E+01	
RE39-11-2942	Cadmium	7.1	ug/FILTER	1.132673864	24	27.18417	2.61E-01	detect		3.00E-02		3.00E+01	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4184	Cadmium	0.66	ug/FILTER	1.132673864	30	33.98022	1.94E-02	detect		3.00E-02		3.00E+01	
RE36-11-4189	Cadmium	3	ug/FILTER	1.132673864	30	33.98022	8.83E-02	detect		3.00E-02		3.00E+01	
RE36-11-4190	Cadmium	0.98	ug/FILTER			0		detect		3.00E-02		3.00E+01	
RE36-11-2934	Cadmium	2.2	ug/FILTER	1.132673864	42	47.5723	4.62E-02	detect		3.00E-02		3.00E+01	
RE36-11-4192	Cadmium	8.9	ug/FILTER	1.132673864	96	108.7367	8.18E-02	detect		3.00E-02		3.00E+01	
RE36-11-4197	Cadmium	2.5	ug/FILTER	1.061881747	108	114.6832	2.18E-02	detect		3.00E-02		3.00E+01	
RE36-11-4503	Cadmium	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02	detect		3.00E-02		3.00E+01	
RE39-11-2943	Cadmium	3.3	ug/FILTER	1.132673864	30	33.98022	9.71E-02	detect		3.00E-02		3.00E+01	
RE39-11-2944	Cadmium	0.19	ug/FILTER	1.132673864	36	40.77626	4.66E-03	detect		3.00E-02		3.00E+01	
RE39-11-4524	Cadmium	1.4	ug/FILTER	1.104357017	30	33.13071	4.23E-02	detect		3.00E-02		3.00E+01	
RE39-11-4525	Cadmium	0.46	ug/FILTER	1.104357017	30	33.13071	1.39E-02	detect		3.00E-02		3.00E+01	
RE39-11-4526	Cadmium	2	ug/FILTER			0		detect		3.00E-02		3.00E+01	
RE39-11-4527	Cadmium	0.36	ug/FILTER	1.132673864	24	27.18417	1.32E-02	detect		3.00E-02		3.00E+01	
RE39-11-4528	Cadmium	0.12	ug/FILTER	1.132673864	24	27.18417	4.41E-03	detect	33	3.00E-02		3.00E+01	0
RE39-11-2936	Calcium	230	ug/FILTER	1.11851544	36	40.26656	5.71E+00	detect		none specified			
RE39-11-2945	Calcium	110	ug/FILTER			0				none specified			
RE36-11-2914	Calcium	110	ug/FILTER	1.104357017	30	33.13071	3.32E+00			none specified			
RE36-11-2915	Calcium	94	ug/FILTER	1.132673864	54	61.16439	1.54E+00			none specified			
RE36-11-2916	Calcium	98	ug/FILTER	1.132673864	30	33.98022	2.88E+00			none specified			
RE36-11-2917	Calcium	71	ug/FILTER	1.132673864	36	40.77626	1.74E+00			none specified			
RE36-11-2918	Calcium	160	ug/FILTER	1.104357017	18	19.87843	8.05E+00			none specified			
RE36-11-2919	Calcium	84	ug/FILTER	1.132673864	42	47.5723	1.77E+00			none specified			
RE36-11-2920	Calcium	65	ug/FILTER	1.132673864	24	27.18417	2.39E+00			none specified			
RE36-11-2921	Calcium	60	ug/FILTER	1.132673864	42	47.5723	1.26E+00			none specified			
RE36-11-2922	Calcium	130	ug/FILTER	1.104357017	36	39.75685	3.27E+00			none specified			
RE36-11-2923	Calcium	140	ug/FILTER	1.104357017	36	39.75685	3.52E+00			none specified			
RE39-11-2935	Calcium	70	ug/FILTER	1.132673864	30	33.98022	2.06E+00			none specified			
RE39-11-2937	Calcium	140	ug/FILTER	1.132673864	18	20.38813	6.87E+00			none specified			
RE39-11-2938	Calcium	230	ug/FILTER	1.132673864	30	33.98022	6.77E+00	detect		none specified			
RE39-11-2939	Calcium	120	ug/FILTER	1.104357017	24	26.50457	4.53E+00			none specified			
RE39-11-2940	Calcium	450	ug/FILTER	1.104357017	30	33.13071	1.36E+01	detect		none specified			
RE39-11-2941	Calcium	86	ug/FILTER	1.132673864	24	27.18417	3.16E+00			none specified			
RE39-11-2942	Calcium	340	ug/FILTER	1.132673864	24	27.18417	1.25E+01	detect		none specified			
RE36-11-4184	Calcium	84	ug/FILTER	1.132673864	30	33.98022	2.47E+00			none specified			
RE36-11-4189	Calcium	100	ug/FILTER	1.132673864	30	33.98022	2.94E+00			none specified			
RE36-11-4190	Calcium	91	ug/FILTER			0				none specified			
RE36-11-2934	Calcium	71	ug/FILTER	1.132673864	42	47.5723	1.49E+00			none specified			
RE36-11-4192	Calcium	60	ug/FILTER	1.132673864	96	108.7367	5.52E-01			none specified			
RE36-11-4197	Calcium	71	ug/FILTER	1.061881747	108	114.6832	6.19E-01			none specified			
RE36-11-4503	Calcium	84	ug/FILTER	1.132673864	30	33.98022	2.47E+00			none specified			
RE39-11-2943	Calcium	110	ug/FILTER	1.132673864	30	33.98022	3.24E+00			none specified			
RE39-11-2944	Calcium	280	ug/FILTER	1.132673864	36	40.77626	6.87E+00	detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4524	Calcium	130	ug/FILTER	1.104357017	30	33.13071	3.92E+00			none specified			
RE39-11-4525	Calcium	41	ug/FILTER	1.104357017	30	33.13071	1.24E+00			none specified			
RE39-11-4526	Calcium	47	ug/FILTER			0				none specified			
RE39-11-4527	Calcium	53	ug/FILTER	1.132673864	24	27.18417	1.95E+00			none specified			
RE39-11-4528	Calcium	200	ug/FILTER	1.132673864	24	27.18417	7.36E+00		5	none specified			0
RE39-11-2936	Chromium	4.2	ug/FILTER	1.11851544	36	40.26656	1.04E-01	detect		1.5		1500	
RE39-11-2945	Chromium	2.1	ug/FILTER			0		detect		1.5		1500	
RE36-11-2914	Chromium	2.8	ug/FILTER	1.104357017	30	33.13071	8.45E-02	detect		1.5		1500	
RE36-11-2915	Chromium	0.81	ug/FILTER	1.132673864	54	61.16439	1.32E-02			1.5		1500	
RE36-11-2916	Chromium	0.78	ug/FILTER	1.132673864	30	33.98022	2.30E-02			1.5		1500	
RE36-11-2917	Chromium	0.5	ug/FILTER	1.132673864	36	40.77626	1.23E-02			1.5		1500	
RE36-11-2918	Chromium	2.1	ug/FILTER	1.104357017	18	19.87843	1.06E-01	detect		1.5		1500	
RE36-11-2919	Chromium	0.83	ug/FILTER	1.132673864	42	47.5723	1.74E-02			1.5		1500	
RE36-11-2920	Chromium	5	ug/FILTER	1.132673864	24	27.18417	1.84E-01	detect		1.5		1500	
RE36-11-2921	Chromium	7.9	ug/FILTER	1.132673864	42	47.5723	1.66E-01	detect		1.5		1500	
RE36-11-2922	Chromium	2.5	ug/FILTER	1.104357017	36	39.75685	6.29E-02	detect		1.5		1500	
RE36-11-2923	Chromium	1	ug/FILTER	1.104357017	36	39.75685	2.52E-02			1.5		1500	
RE39-11-2935	Chromium	0.67	ug/FILTER	1.132673864	30	33.98022	1.97E-02			1.5		1500	
RE39-11-2937	Chromium	1.1	ug/FILTER	1.132673864	18	20.38813	5.40E-02			1.5		1500	
RE39-11-2938	Chromium	2.4	ug/FILTER	1.132673864	30	33.98022	7.06E-02	detect		1.5		1500	
RE39-11-2939	Chromium	1.2	ug/FILTER	1.104357017	24	26.50457	4.53E-02			1.5		1500	
RE39-11-2940	Chromium	2.4	ug/FILTER	1.104357017	30	33.13071	7.24E-02	detect		1.5		1500	
RE39-11-2941	Chromium	0.67	ug/FILTER	1.132673864	24	27.18417	2.46E-02			1.5		1500	
RE39-11-2942	Chromium	2.3	ug/FILTER	1.132673864	24	27.18417	8.46E-02	detect		1.5		1500	
RE36-11-4184	Chromium	1.3	ug/FILTER	1.132673864	30	33.98022	3.83E-02			1.5		1500	
RE36-11-4189	Chromium	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02			1.5		1500	
RE36-11-4190	Chromium	2.8	ug/FILTER			0		detect		1.5		1500	
RE36-11-2934	Chromium	1.2	ug/FILTER	1.132673864	42	47.5723	2.52E-02			1.5		1500	
RE36-11-4192	Chromium	1	ug/FILTER	1.132673864	96	108.7367	9.20E-03			1.5		1500	
RE36-11-4197	Chromium	0.96	ug/FILTER	1.061881747	108	114.6832	8.37E-03			1.5		1500	
RE36-11-4503	Chromium	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02			1.5		1500	
RE39-11-2943	Chromium	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02			1.5		1500	
RE39-11-2944	Chromium	1.1	ug/FILTER	1.132673864	36	40.77626	2.70E-02			1.5		1500	
RE39-11-4524	Chromium	0.74	ug/FILTER	1.104357017	30	33.13071	2.23E-02			1.5		1500	
RE39-11-4525	Chromium	0.46	ug/FILTER	1.104357017	30	33.13071	1.39E-02			1.5		1500	
RE39-11-4526	Chromium	0.23	ug/FILTER			0				1.5		1500	
RE39-11-4527	Chromium	0.25	ug/FILTER	1.132673864	24	27.18417	9.20E-03			1.5		1500	
RE39-11-4528	Chromium	0.83	ug/FILTER	1.132673864	24	27.18417	3.05E-02		11	1.5		1500	0
RE39-11-2936	Cobalt	0.15	ug/FILTER	1.11851544	36	40.26656	3.73E-03			none specified			
RE39-11-2945	Cobalt	0.058	ug/FILTER			0				none specified			
RE36-11-2914	Cobalt	0.034	ug/FILTER	1.104357017	30	33.13071	1.03E-03			none specified			
RE36-11-2915	Cobalt	0.2	ug/FILTER	1.132673864	54	61.16439	3.27E-03			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2916	Cobalt	0.04	ug/FILTER	1.132673864	30	33.98022	1.18E-03			none specified			
RE36-11-2917	Cobalt	0.032	ug/FILTER	1.132673864	36	40.77626	7.85E-04			none specified			
RE36-11-2918	Cobalt	0.066	ug/FILTER	1.104357017	18	19.87843	3.32E-03			none specified			
RE36-11-2919	Cobalt	0.026	ug/FILTER	1.132673864	42	47.5723	5.47E-04			none specified			
RE36-11-2920	Cobalt	0.15	ug/FILTER	1.132673864	24	27.18417	5.52E-03			none specified			
RE36-11-2921	Cobalt	0.17	ug/FILTER	1.132673864	42	47.5723	3.57E-03			none specified			
RE36-11-2922	Cobalt	0.072	ug/FILTER	1.104357017	36	39.75685	1.81E-03			none specified			
RE36-11-2923	Cobalt	0.038	ug/FILTER	1.104357017	36	39.75685	9.56E-04			none specified			
RE39-11-2935	Cobalt	0.036	ug/FILTER	1.132673864	30	33.98022	1.06E-03			none specified			
RE39-11-2937	Cobalt	0.028	ug/FILTER	1.132673864	18	20.38813	1.37E-03			none specified			
RE39-11-2938	Cobalt	0.12	ug/FILTER	1.132673864	30	33.98022	3.53E-03			none specified			
RE39-11-2939	Cobalt	0.054	ug/FILTER	1.104357017	24	26.50457	2.04E-03			none specified			
RE39-11-2940	Cobalt	0.16	ug/FILTER	1.104357017	30	33.13071	4.83E-03			none specified			
RE39-11-2941	Cobalt	0.054	ug/FILTER	1.132673864	24	27.18417	1.99E-03			none specified			
RE39-11-2942	Cobalt	0.28	ug/FILTER	1.132673864	24	27.18417	1.03E-02	detect		none specified			
RE36-11-4184	Cobalt	0.024	ug/FILTER	1.132673864	30	33.98022	7.06E-04			none specified			
RE36-11-4189	Cobalt	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE36-11-4190	Cobalt	0.07	ug/FILTER			0				none specified			
RE36-11-2934	Cobalt	0.03	ug/FILTER	1.132673864	42	47.5723	6.31E-04			none specified			
RE36-11-4192	Cobalt	0.028	ug/FILTER	1.132673864	96	108.7367	2.58E-04			none specified			
RE36-11-4197	Cobalt	0.02	ug/FILTER	1.061881747	108	114.6832	1.74E-04			none specified			
RE36-11-4503	Cobalt	0.078	ug/FILTER	1.132673864	30	33.98022	2.30E-03			none specified			
RE39-11-2943	Cobalt	0.03	ug/FILTER	1.132673864	30	33.98022	8.83E-04			none specified			
RE39-11-2944	Cobalt	0.096	ug/FILTER	1.132673864	36	40.77626	2.35E-03			none specified			
RE39-11-4524	Cobalt	0.022	ug/FILTER	1.104357017	30	33.13071	6.64E-04			none specified			
RE39-11-4525	Cobalt	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			none specified			
RE39-11-4526	Cobalt	0.2	ug/FILTER			0				none specified			
RE39-11-4527	Cobalt	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			none specified			
RE39-11-4528	Cobalt	0.026	ug/FILTER	1.132673864	24	27.18417	9.56E-04		1	none specified			0
RE39-11-2936	Copper	22	ug/FILTER	1.11851544	36	40.26656	5.46E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2945	Copper	4.3	ug/FILTER			0		detect		none specified	1.00E+02	1.00E+02	
RE36-11-2914	Copper	8.5	ug/FILTER	1.104357017	30	33.13071	2.57E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2915	Copper	8.8	ug/FILTER	1.132673864	54	61.16439	1.44E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2916	Copper	9.4	ug/FILTER	1.132673864	30	33.98022	2.77E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2917	Copper	10	ug/FILTER	1.132673864	36	40.77626	2.45E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2918	Copper	7.7	ug/FILTER	1.104357017	18	19.87843	3.87E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2919	Copper	6.2	ug/FILTER	1.132673864	42	47.5723	1.30E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2920	Copper	3.6	ug/FILTER	1.132673864	24	27.18417	1.32E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2921	Copper	6.4	ug/FILTER	1.132673864	42	47.5723	1.35E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2922	Copper	3.6	ug/FILTER	1.104357017	36	39.75685	9.06E-02	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2923	Copper	3.5	ug/FILTER	1.104357017	36	39.75685	8.80E-02	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2935	Copper	6.2	ug/FILTER	1.132673864	30	33.98022	1.82E-01	detect		none specified	1.00E+02	1.00E+02	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2937	Copper	9.4	ug/FILTER	1.132673864	18	20.38813	4.61E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2938	Copper	24	ug/FILTER	1.132673864	30	33.98022	7.06E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2939	Copper	18	ug/FILTER	1.104357017	24	26.50457	6.79E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2940	Copper	46	ug/FILTER	1.104357017	30	33.13071	1.39E+00	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2941	Copper	7.7	ug/FILTER	1.132673864	24	27.18417	2.83E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2942	Copper	28	ug/FILTER	1.132673864	24	27.18417	1.03E+00	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4184	Copper	6.1	ug/FILTER	1.132673864	30	33.98022	1.80E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4189	Copper	3.9	ug/FILTER	1.132673864	30	33.98022	1.15E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4190	Copper	2.5	ug/FILTER			0		detect		none specified	1.00E+02	1.00E+02	
RE36-11-2934	Copper	6	ug/FILTER	1.132673864	42	47.5723	1.26E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4192	Copper	4	ug/FILTER	1.132673864	96	108.7367	3.68E-02	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4197	Copper	5.3	ug/FILTER	1.061881747	108	114.6832	4.62E-02	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4503	Copper	10	ug/FILTER	1.132673864	30	33.98022	2.94E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2943	Copper	12	ug/FILTER	1.132673864	30	33.98022	3.53E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2944	Copper	40	ug/FILTER	1.132673864	36	40.77626	9.81E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4524	Copper	8.9	ug/FILTER	1.104357017	30	33.13071	2.69E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4525	Copper	3.4	ug/FILTER	1.104357017	30	33.13071	1.03E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4526	Copper	0.39	ug/FILTER			0				none specified	1.00E+02	1.00E+02	
RE39-11-4527	Copper	2.3	ug/FILTER	1.132673864	24	27.18417	8.46E-02	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4528	Copper	12	ug/FILTER	1.132673864	24	27.18417	4.41E-01	detect	32	none specified	1.00E+02	1.00E+02	0
RE39-11-2936	Iron	270	ug/FILTER	1.11851544	36	40.26656	6.71E+00	detect		none specified			
RE39-11-2945	Iron	44	ug/FILTER			0		detect		none specified			
RE36-11-2914	Iron	99	ug/FILTER	1.104357017	30	33.13071	2.99E+00	detect		none specified			
RE36-11-2915	Iron	89	ug/FILTER	1.132673864	54	61.16439	1.46E+00	detect		none specified			
RE36-11-2916	Iron	67	ug/FILTER	1.132673864	30	33.98022	1.97E+00	detect		none specified			
RE36-11-2917	Iron	74	ug/FILTER	1.132673864	36	40.77626	1.81E+00	detect		none specified			
RE36-11-2918	Iron	74	ug/FILTER	1.104357017	18	19.87843	3.72E+00	detect		none specified			
RE36-11-2919	Iron	57	ug/FILTER	1.132673864	42	47.5723	1.20E+00	detect		none specified			
RE36-11-2920	Iron	77	ug/FILTER	1.132673864	24	27.18417	2.83E+00	detect		none specified			
RE36-11-2921	Iron	110	ug/FILTER	1.132673864	42	47.5723	2.31E+00	detect		none specified			
RE36-11-2922	Iron	36	ug/FILTER	1.104357017	36	39.75685	9.06E-01	detect		none specified			
RE36-11-2923	Iron	50	ug/FILTER	1.104357017	36	39.75685	1.26E+00	detect		none specified			
RE39-11-2935	Iron	56	ug/FILTER	1.132673864	30	33.98022	1.65E+00	detect		none specified			
RE39-11-2937	Iron	51	ug/FILTER	1.132673864	18	20.38813	2.50E+00	detect		none specified			
RE39-11-2938	Iron	190	ug/FILTER	1.132673864	30	33.98022	5.59E+00	detect		none specified			
RE39-11-2939	Iron	90	ug/FILTER	1.104357017	24	26.50457	3.40E+00	detect		none specified			
RE39-11-2940	Iron	390	ug/FILTER	1.104357017	30	33.13071	1.18E+01	detect		none specified			
RE39-11-2941	Iron	73	ug/FILTER	1.132673864	24	27.18417	2.69E+00	detect		none specified			
RE39-11-2942	Iron	340	ug/FILTER	1.132673864	24	27.18417	1.25E+01	detect		none specified			
RE36-11-4184	Iron	41	ug/FILTER	1.132673864	30	33.98022	1.21E+00	detect		none specified			
RE36-11-4189	Iron	43	ug/FILTER	1.132673864	30	33.98022	1.27E+00	detect		none specified			
RE36-11-4190	Iron	75	ug/FILTER			0		detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2934	Iron	43	ug/FILTER	1.132673864	42	47.5723	9.04E-01	detect		none specified			
RE36-11-4192	Iron	30	ug/FILTER	1.132673864	96	108.7367	2.76E-01	detect		none specified			
RE36-11-4197	Iron	48	ug/FILTER	1.061881747	108	114.6832	4.19E-01	detect		none specified			
RE36-11-4503	Iron	61	ug/FILTER	1.132673864	30	33.98022	1.80E+00	detect		none specified			
RE39-11-2943	Iron	61	ug/FILTER	1.132673864	30	33.98022	1.80E+00	detect		none specified			
RE39-11-2944	Iron	180	ug/FILTER	1.132673864	36	40.77626	4.41E+00	detect		none specified			
RE39-11-4524	Iron	55	ug/FILTER	1.104357017	30	33.13071	1.66E+00	detect		none specified			
RE39-11-4525	Iron	19	ug/FILTER	1.104357017	30	33.13071	5.73E-01			none specified			
RE39-11-4526	Iron	5.9	ug/FILTER			0				none specified			
RE39-11-4527	Iron	14	ug/FILTER	1.132673864	24	27.18417	5.15E-01			none specified			
RE39-11-4528	Iron	55	ug/FILTER	1.132673864	24	27.18417	2.02E+00	detect	30	none specified			0
RE39-11-2936	Lead	3.9	ug/FILTER	1.11851544	36	40.26656	9.69E-02	detect		0.15		150	
RE39-11-2945	Lead	0.49	ug/FILTER			0		detect		0.15		150	
RE36-11-2914	Lead	1.4	ug/FILTER	1.104357017	30	33.13071	4.23E-02	detect		0.15		150	
RE36-11-2915	Lead	3.5	ug/FILTER	1.132673864	54	61.16439	5.72E-02	detect		0.15		150	
RE36-11-2916	Lead	12	ug/FILTER	1.132673864	30	33.98022	3.53E-01	detect		0.15		150	
RE36-11-2917	Lead	2.3	ug/FILTER	1.132673864	36	40.77626	5.64E-02	detect		0.15		150	
RE36-11-2918	Lead	6.3	ug/FILTER	1.104357017	18	19.87843	3.17E-01	detect		0.15		150	
RE36-11-2919	Lead	26	ug/FILTER	1.132673864	42	47.5723	5.47E-01	detect		0.15		150	
RE36-11-2920	Lead	18	ug/FILTER	1.132673864	24	27.18417	6.62E-01	detect		0.15		150	
RE36-11-2921	Lead	1.9	ug/FILTER	1.132673864	42	47.5723	3.99E-02	detect		0.15		150	
RE36-11-2922	Lead	8.2	ug/FILTER	1.104357017	36	39.75685	2.06E-01	detect		0.15		150	
RE36-11-2923	Lead	5.9	ug/FILTER	1.104357017	36	39.75685	1.48E-01	detect		0.15		150	
RE39-11-2935	Lead	14	ug/FILTER	1.132673864	30	33.98022	4.12E-01	detect		0.15		150	
RE39-11-2937	Lead	1.8	ug/FILTER	1.132673864	18	20.38813	8.83E-02	detect		0.15		150	
RE39-11-2938	Lead	15	ug/FILTER	1.132673864	30	33.98022	4.41E-01	detect		0.15		150	
RE39-11-2939	Lead	6.9	ug/FILTER	1.104357017	24	26.50457	2.60E-01	detect		0.15		150	
RE39-11-2940	Lead	22	ug/FILTER	1.104357017	30	33.13071	6.64E-01	detect		0.15		150	
RE39-11-2941	Lead	22	ug/FILTER	1.132673864	24	27.18417	8.09E-01	detect		0.15		150	
RE39-11-2942	Lead	63	ug/FILTER	1.132673864	24	27.18417	2.32E+00	detect		0.15		150	
RE36-11-4184	Lead	13	ug/FILTER	1.132673864	30	33.98022	3.83E-01	detect		0.15		150	
RE36-11-4189	Lead	13	ug/FILTER	1.132673864	30	33.98022	3.83E-01	detect		0.15		150	
RE36-11-4190	Lead	8.3	ug/FILTER			0		detect		0.15		150	
RE36-11-2934	Lead	17	ug/FILTER	1.132673864	42	47.5723	3.57E-01	detect		0.15		150	
RE36-11-4192	Lead	120	ug/FILTER	1.132673864	96	108.7367	1.10E+00	detect		0.15		150	
RE36-11-4197	Lead	41	ug/FILTER	1.061881747	108	114.6832	3.58E-01	detect		0.15		150	
RE36-11-4503	Lead	2.1	ug/FILTER	1.132673864	30	33.98022	6.18E-02	detect		0.15		150	
RE39-11-2943	Lead	19	ug/FILTER	1.132673864	30	33.98022	5.59E-01	detect		0.15		150	
RE39-11-2944	Lead	4.5	ug/FILTER	1.132673864	36	40.77626	1.10E-01	detect		0.15		150	
RE39-11-4524	Lead	28	ug/FILTER	1.104357017	30	33.13071	8.45E-01	detect		0.15		150	
RE39-11-4525	Lead	3.7	ug/FILTER	1.104357017	30	33.13071	1.12E-01	detect		0.15		150	
RE39-11-4526	Lead	32	ug/FILTER			0		detect		0.15		150	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4527	Lead	2	ug/FILTER	1.132673864	24	27.18417	7.36E-02	detect		0.15		150	
RE39-11-4528	Lead	1.5	ug/FILTER	1.132673864	24	27.18417	5.52E-02	detect	33	0.15		150	0
RE39-11-2936	Magnesium	36	ug/FILTER	1.11851544	36	40.26656	8.94E-01	detect		none specified			
RE39-11-2945	Magnesium	6.8	ug/FILTER			0				none specified			
RE36-11-2914	Magnesium	12	ug/FILTER	1.104357017	30	33.13071	3.62E-01			none specified			
RE36-11-2915	Magnesium	6.7	ug/FILTER	1.132673864	54	61.16439	1.10E-01			none specified			
RE36-11-2916	Magnesium	9.8	ug/FILTER	1.132673864	30	33.98022	2.88E-01			none specified			
RE36-11-2917	Magnesium	10	ug/FILTER	1.132673864	36	40.77626	2.45E-01			none specified			
RE36-11-2918	Magnesium	15	ug/FILTER	1.104357017	18	19.87843	7.55E-01			none specified			
RE36-11-2919	Magnesium	8.2	ug/FILTER	1.132673864	42	47.5723	1.72E-01			none specified			
RE36-11-2920	Magnesium	6.5	ug/FILTER	1.132673864	24	27.18417	2.39E-01			none specified			
RE36-11-2921	Magnesium	11	ug/FILTER	1.132673864	42	47.5723	2.31E-01			none specified			
RE36-11-2922	Magnesium	6.1	ug/FILTER	1.104357017	36	39.75685	1.53E-01			none specified			
RE36-11-2923	Magnesium	7.2	ug/FILTER	1.104357017	36	39.75685	1.81E-01			none specified			
RE39-11-2935	Magnesium	12	ug/FILTER	1.132673864	30	33.98022	3.53E-01			none specified			
RE39-11-2937	Magnesium	5.8	ug/FILTER	1.132673864	18	20.38813	2.84E-01			none specified			
RE39-11-2938	Magnesium	36	ug/FILTER	1.132673864	30	33.98022	1.06E+00	detect		none specified			
RE39-11-2939	Magnesium	21	ug/FILTER	1.104357017	24	26.50457	7.92E-01	detect		none specified			
RE39-11-2940	Magnesium	53	ug/FILTER	1.104357017	30	33.13071	1.60E+00	detect		none specified			
RE39-11-2941	Magnesium	11	ug/FILTER	1.132673864	24	27.18417	4.05E-01			none specified			
RE39-11-2942	Magnesium	46	ug/FILTER	1.132673864	24	27.18417	1.69E+00	detect		none specified			
RE36-11-4184	Magnesium	8.9	ug/FILTER	1.132673864	30	33.98022	2.62E-01			none specified			
RE36-11-4189	Magnesium	6.7	ug/FILTER	1.132673864	30	33.98022	1.97E-01			none specified			
RE36-11-4190	Magnesium	4.6	ug/FILTER			0				none specified			
RE36-11-2934	Magnesium	7.4	ug/FILTER	1.132673864	42	47.5723	1.56E-01			none specified			
RE36-11-4192	Magnesium	20	ug/FILTER	1.132673864	96	108.7367	1.84E-01			none specified			
RE36-11-4197	Magnesium	7.6	ug/FILTER	1.061881747	108	114.6832	6.63E-02			none specified			
RE36-11-4503	Magnesium	13	ug/FILTER	1.132673864	30	33.98022	3.83E-01			none specified			
RE39-11-2943	Magnesium	8	ug/FILTER	1.132673864	30	33.98022	2.35E-01			none specified			
RE39-11-2944	Magnesium	30	ug/FILTER	1.132673864	36	40.77626	7.36E-01	detect		none specified			
RE39-11-4524	Magnesium	8.1	ug/FILTER	1.104357017	30	33.13071	2.44E-01			none specified			
RE39-11-4525	Magnesium	20	ug/FILTER	1.104357017	30	33.13071	6.04E-01			none specified			
RE39-11-4526	Magnesium	20	ug/FILTER			0				none specified			
RE39-11-4527	Magnesium	20	ug/FILTER	1.132673864	24	27.18417	7.36E-01			none specified			
RE39-11-4528	Magnesium	11	ug/FILTER	1.132673864	24	27.18417	4.05E-01		6	none specified			0
RE39-11-2936	Manganese	5.5	ug/FILTER	1.11851544	36	40.26656	1.37E-01	detect		none specified			
RE39-11-2945	Manganese	0.95	ug/FILTER			0		detect		none specified			
RE36-11-2914	Manganese	1.3	ug/FILTER	1.104357017	30	33.13071	3.92E-02	detect		none specified			
RE36-11-2915	Manganese	1.1	ug/FILTER	1.132673864	54	61.16439	1.80E-02	detect		none specified			
RE36-11-2916	Manganese	1.3	ug/FILTER	1.132673864	30	33.98022	3.83E-02	detect		none specified			
RE36-11-2917	Manganese	1	ug/FILTER	1.132673864	36	40.77626	2.45E-02	detect		none specified			
RE36-11-2918	Manganese	1.9	ug/FILTER	1.104357017	18	19.87843	9.56E-02	detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2919	Manganese	0.73	ug/FILTER	1.132673864	42	47.5723	1.53E-02	detect		none specified			
RE36-11-2920	Manganese	1	ug/FILTER	1.132673864	24	27.18417	3.68E-02	detect		none specified			
RE36-11-2921	Manganese	1.6	ug/FILTER	1.132673864	42	47.5723	3.36E-02	detect		none specified			
RE36-11-2922	Manganese	0.77	ug/FILTER	1.104357017	36	39.75685	1.94E-02	detect		none specified			
RE36-11-2923	Manganese	1.2	ug/FILTER	1.104357017	36	39.75685	3.02E-02	detect		none specified			
RE39-11-2935	Manganese	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		none specified			
RE39-11-2937	Manganese	0.9	ug/FILTER	1.132673864	18	20.38813	4.41E-02	detect		none specified			
RE39-11-2938	Manganese	4.7	ug/FILTER	1.132673864	30	33.98022	1.38E-01	detect		none specified			
RE39-11-2939	Manganese	2.6	ug/FILTER	1.104357017	24	26.50457	9.81E-02	detect		none specified			
RE39-11-2940	Manganese	11	ug/FILTER	1.104357017	30	33.13071	3.32E-01	detect		none specified			
RE39-11-2941	Manganese	1.6	ug/FILTER	1.132673864	24	27.18417	5.89E-02	detect		none specified			
RE39-11-2942	Manganese	6.7	ug/FILTER	1.132673864	24	27.18417	2.46E-01	detect		none specified			
RE36-11-4184	Manganese	1.5	ug/FILTER	1.132673864	30	33.98022	4.41E-02	detect		none specified			
RE36-11-4189	Manganese	1.6	ug/FILTER	1.132673864	30	33.98022	4.71E-02	detect		none specified			
RE36-11-4190	Manganese	1	ug/FILTER			0		detect		none specified			
RE36-11-2934	Manganese	0.81	ug/FILTER	1.132673864	42	47.5723	1.70E-02	detect		none specified			
RE36-11-4192	Manganese	0.51	ug/FILTER	1.132673864	96	108.7367	4.69E-03	detect		none specified			
RE36-11-4197	Manganese	0.93	ug/FILTER	1.061881747	108	114.6832	8.11E-03	detect		none specified			
RE36-11-4503	Manganese	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		none specified			
RE39-11-2943	Manganese	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02	detect		none specified			
RE39-11-2944	Manganese	3.8	ug/FILTER	1.132673864	36	40.77626	9.32E-02	detect		none specified			
RE39-11-4524	Manganese	1.2	ug/FILTER	1.104357017	30	33.13071	3.62E-02	detect		none specified			
RE39-11-4525	Manganese	0.3	ug/FILTER	1.104357017	30	33.13071	9.06E-03			none specified			
RE39-11-4526	Manganese	0.084	ug/FILTER			0				none specified			
RE39-11-4527	Manganese	0.21	ug/FILTER	1.132673864	24	27.18417	7.73E-03			none specified			
RE39-11-4528	Manganese	1.1	ug/FILTER	1.132673864	24	27.18417	4.05E-02	detect	30	none specified			0
RE39-11-2936	Nickel	8.6	ug/FILTER	1.11851544	36	40.26656	2.14E-01	detect		6.00E-03		6.00E+00	
RE39-11-2945	Nickel	1.3	ug/FILTER			0		detect		6.00E-03		6.00E+00	
RE36-11-2914	Nickel	4.9	ug/FILTER	1.104357017	30	33.13071	1.48E-01	detect		6.00E-03		6.00E+00	
RE36-11-2915	Nickel	0.16	ug/FILTER	1.132673864	54	61.16439	2.62E-03			6.00E-03		6.00E+00	
RE36-11-2916	Nickel	1.9	ug/FILTER	1.132673864	30	33.98022	5.59E-02	detect		6.00E-03		6.00E+00	
RE36-11-2917	Nickel	2	ug/FILTER	1.132673864	36	40.77626	4.90E-02	detect		6.00E-03		6.00E+00	
RE36-11-2918	Nickel	1.7	ug/FILTER	1.104357017	18	19.87843	8.55E-02	detect		6.00E-03		6.00E+00	
RE36-11-2919	Nickel	3.6	ug/FILTER	1.132673864	42	47.5723	7.57E-02	detect		6.00E-03		6.00E+00	
RE36-11-2920	Nickel	8.5	ug/FILTER	1.132673864	24	27.18417	3.13E-01	detect		6.00E-03		6.00E+00	
RE36-11-2921	Nickel	7	ug/FILTER	1.132673864	42	47.5723	1.47E-01	detect		6.00E-03		6.00E+00	
RE36-11-2922	Nickel	1	ug/FILTER	1.104357017	36	39.75685	2.52E-02			6.00E-03		6.00E+00	
RE36-11-2923	Nickel	0.58	ug/FILTER	1.104357017	36	39.75685	1.46E-02			6.00E-03		6.00E+00	
RE39-11-2935	Nickel	0.33	ug/FILTER	1.132673864	30	33.98022	9.71E-03			6.00E-03		6.00E+00	
RE39-11-2937	Nickel	0.8	ug/FILTER	1.132673864	18	20.38813	3.92E-02			6.00E-03		6.00E+00	
RE39-11-2938	Nickel	6	ug/FILTER	1.132673864	30	33.98022	1.77E-01	detect		6.00E-03		6.00E+00	
RE39-11-2939	Nickel	0.83	ug/FILTER	1.104357017	24	26.50457	3.13E-02			6.00E-03		6.00E+00	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2940	Nickel	9.3	ug/FILTER	1.104357017	30	33.13071	2.81E-01	detect		6.00E-03		6.00E+00	
RE39-11-2941	Nickel	0.86	ug/FILTER	1.132673864	24	27.18417	3.16E-02			6.00E-03		6.00E+00	
RE39-11-2942	Nickel	13	ug/FILTER	1.132673864	24	27.18417	4.78E-01	detect		6.00E-03		6.00E+00	
RE36-11-4184	Nickel	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		6.00E-03		6.00E+00	
RE36-11-4189	Nickel	0.71	ug/FILTER	1.132673864	30	33.98022	2.09E-02			6.00E-03		6.00E+00	
RE36-11-4190	Nickel	1.9	ug/FILTER			0		detect		6.00E-03		6.00E+00	
RE36-11-2934	Nickel	0.82	ug/FILTER	1.132673864	42	47.5723	1.72E-02			6.00E-03		6.00E+00	
RE36-11-4192	Nickel	0.39	ug/FILTER	1.132673864	96	108.7367	3.59E-03			6.00E-03		6.00E+00	
RE36-11-4197	Nickel	0.91	ug/FILTER	1.061881747	108	114.6832	7.93E-03			6.00E-03		6.00E+00	
RE36-11-4503	Nickel	0.46	ug/FILTER	1.132673864	30	33.98022	1.35E-02			6.00E-03		6.00E+00	
RE39-11-2943	Nickel	4.7	ug/FILTER	1.132673864	30	33.98022	1.38E-01	detect		6.00E-03		6.00E+00	
RE39-11-2944	Nickel	8.6	ug/FILTER	1.132673864	36	40.77626	2.11E-01	detect		6.00E-03		6.00E+00	
RE39-11-4524	Nickel	1.4	ug/FILTER	1.104357017	30	33.13071	4.23E-02	detect		6.00E-03		6.00E+00	
RE39-11-4525	Nickel	1.2	ug/FILTER	1.104357017	30	33.13071	3.62E-02	detect		6.00E-03		6.00E+00	
RE39-11-4526	Nickel	1	ug/FILTER			0				6.00E-03		6.00E+00	
RE39-11-4527	Nickel	0.5	ug/FILTER	1.132673864	24	27.18417	1.84E-02			6.00E-03		6.00E+00	
RE39-11-4528	Nickel	2.4	ug/FILTER	1.132673864	24	27.18417	8.83E-02	detect	19	6.00E-03		6.00E+00	0
RE39-11-2936	Potassium	42	ug/FILTER	1.11851544	36	40.26656	1.04E+00			none specified			
RE39-11-2945	Potassium	200	ug/FILTER			0				none specified			
RE36-11-2914	Potassium	47	ug/FILTER	1.104357017	30	33.13071	1.42E+00			none specified			
RE36-11-2915	Potassium	81	ug/FILTER	1.132673864	54	61.16439	1.32E+00			none specified			
RE36-11-2916	Potassium	76	ug/FILTER	1.132673864	30	33.98022	2.24E+00			none specified			
RE36-11-2917	Potassium	24	ug/FILTER	1.132673864	36	40.77626	5.89E-01			none specified			
RE36-11-2918	Potassium	200	ug/FILTER	1.104357017	18	19.87843	1.01E+01			none specified			
RE36-11-2919	Potassium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-2920	Potassium	24	ug/FILTER	1.132673864	24	27.18417	8.83E-01			none specified			
RE36-11-2921	Potassium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-2922	Potassium	200	ug/FILTER	1.104357017	36	39.75685	5.03E+00			none specified			
RE36-11-2923	Potassium	200	ug/FILTER	1.104357017	36	39.75685	5.03E+00			none specified			
RE39-11-2935	Potassium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE39-11-2937	Potassium	35	ug/FILTER	1.132673864	18	20.38813	1.72E+00			none specified			
RE39-11-2938	Potassium	81	ug/FILTER	1.132673864	30	33.98022	2.38E+00			none specified			
RE39-11-2939	Potassium	24	ug/FILTER	1.104357017	24	26.50457	9.06E-01			none specified			
RE39-11-2940	Potassium	130	ug/FILTER	1.104357017	30	33.13071	3.92E+00			none specified			
RE39-11-2941	Potassium	32	ug/FILTER	1.132673864	24	27.18417	1.18E+00			none specified			
RE39-11-2942	Potassium	93	ug/FILTER	1.132673864	24	27.18417	3.42E+00			none specified			
RE36-11-4184	Potassium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE36-11-4189	Potassium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE36-11-4190	Potassium	200	ug/FILTER			0				none specified			
RE36-11-2934	Potassium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-4192	Potassium	200	ug/FILTER	1.132673864	96	108.7367	1.84E+00			none specified			
RE36-11-4197	Potassium	200	ug/FILTER	1.061881747	108	114.6832	1.74E+00			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4503	Potassium	23	ug/FILTER	1.132673864	30	33.98022	6.77E-01			none specified			
RE39-11-2943	Potassium	17	ug/FILTER	1.132673864	30	33.98022	5.00E-01			none specified			
RE39-11-2944	Potassium	62	ug/FILTER	1.132673864	36	40.77626	1.52E+00			none specified			
RE39-11-4524	Potassium	21	ug/FILTER	1.104357017	30	33.13071	6.34E-01			none specified			
RE39-11-4525	Potassium	16	ug/FILTER	1.104357017	30	33.13071	4.83E-01			none specified			
RE39-11-4526	Potassium	16	ug/FILTER			0				none specified			
RE39-11-4527	Potassium	17	ug/FILTER	1.132673864	24	27.18417	6.25E-01			none specified			
RE39-11-4528	Potassium	19	ug/FILTER	1.132673864	24	27.18417	6.99E-01		0	none specified			0
RE39-11-2936	Selenium	0.2	ug/FILTER	1.11851544	36	40.26656	4.97E-03			1.47E+00		1.47E+03	
RE39-11-2945	Selenium	0.2	ug/FILTER			0				1.47E+00		1.47E+03	
RE36-11-2914	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE36-11-2915	Selenium	0.2	ug/FILTER	1.132673864	54	61.16439	3.27E-03			1.47E+00		1.47E+03	
RE36-11-2916	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE36-11-2917	Selenium	0.2	ug/FILTER	1.132673864	36	40.77626	4.90E-03			1.47E+00		1.47E+03	
RE36-11-2918	Selenium	0.2	ug/FILTER	1.104357017	18	19.87843	1.01E-02			1.47E+00		1.47E+03	
RE36-11-2919	Selenium	0.2	ug/FILTER	1.132673864	42	47.5723	4.20E-03			1.47E+00		1.47E+03	
RE36-11-2920	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE36-11-2921	Selenium	0.2	ug/FILTER	1.132673864	42	47.5723	4.20E-03			1.47E+00		1.47E+03	
RE36-11-2922	Selenium	0.072	ug/FILTER	1.104357017	36	39.75685	1.81E-03			1.47E+00		1.47E+03	
RE36-11-2923	Selenium	0.2	ug/FILTER	1.104357017	36	39.75685	5.03E-03			1.47E+00		1.47E+03	
RE39-11-2935	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2937	Selenium	0.2	ug/FILTER	1.132673864	18	20.38813	9.81E-03			1.47E+00		1.47E+03	
RE39-11-2938	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2939	Selenium	0.2	ug/FILTER	1.104357017	24	26.50457	7.55E-03			1.47E+00		1.47E+03	
RE39-11-2940	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE39-11-2941	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE39-11-2942	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE36-11-4184	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE36-11-4189	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE36-11-4190	Selenium	0.2	ug/FILTER			0				1.47E+00		1.47E+03	
RE36-11-2934	Selenium	0.2	ug/FILTER	1.132673864	42	47.5723	4.20E-03			1.47E+00		1.47E+03	
RE36-11-4192	Selenium	0.2	ug/FILTER	1.132673864	96	108.7367	1.84E-03			1.47E+00		1.47E+03	
RE36-11-4197	Selenium	0.2	ug/FILTER	1.061881747	108	114.6832	1.74E-03			1.47E+00		1.47E+03	
RE36-11-4503	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2943	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2944	Selenium	0.2	ug/FILTER	1.132673864	36	40.77626	4.90E-03			1.47E+00		1.47E+03	
RE39-11-4524	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE39-11-4525	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE39-11-4526	Selenium	0.2	ug/FILTER			0				1.47E+00		1.47E+03	
RE39-11-4527	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE39-11-4528	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03		0	1.47E+00		1.47E+03	0
RE39-11-2936	Silver	0.19	ug/FILTER	1.11851544	36	40.26656	4.72E-03	detect		0.3		300	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2945	Silver	0.15	ug/FILTER			0		detect		0.3		300	
RE36-11-2914	Silver	0.038	ug/FILTER	1.104357017	30	33.13071	1.15E-03	detect		0.3		300	
RE36-11-2915	Silver	0.03	ug/FILTER	1.132673864	54	61.16439	4.90E-04	detect		0.3		300	
RE36-11-2916	Silver	0.05	ug/FILTER	1.132673864	30	33.98022	1.47E-03	detect		0.3		300	
RE36-11-2917	Silver	0.016	ug/FILTER	1.132673864	36	40.77626	3.92E-04			0.3		300	
RE36-11-2918	Silver	0.088	ug/FILTER	1.104357017	18	19.87843	4.43E-03	detect		0.3		300	
RE36-11-2919	Silver	0.06	ug/FILTER	1.132673864	42	47.5723	1.26E-03	detect		0.3		300	
RE36-11-2920	Silver	0.22	ug/FILTER	1.132673864	24	27.18417	8.09E-03	detect		0.3		300	
RE36-11-2921	Silver	0.34	ug/FILTER	1.132673864	42	47.5723	7.15E-03	detect		0.3		300	
RE36-11-2922	Silver	0.064	ug/FILTER	1.104357017	36	39.75685	1.61E-03	detect		0.3		300	
RE36-11-2923	Silver	0.032	ug/FILTER	1.104357017	36	39.75685	8.05E-04	detect		0.3		300	
RE39-11-2935	Silver	0.038	ug/FILTER	1.132673864	30	33.98022	1.12E-03	detect		0.3		300	
RE39-11-2937	Silver	0.026	ug/FILTER	1.132673864	18	20.38813	1.28E-03	detect		0.3		300	
RE39-11-2938	Silver	0.092	ug/FILTER	1.132673864	30	33.98022	2.71E-03	detect		0.3		300	
RE39-11-2939	Silver	0.076	ug/FILTER	1.104357017	24	26.50457	2.87E-03	detect		0.3		300	
RE39-11-2940	Silver	0.13	ug/FILTER	1.104357017	30	33.13071	3.92E-03	detect		0.3		300	
RE39-11-2941	Silver	0.094	ug/FILTER	1.132673864	24	27.18417	3.46E-03	detect		0.3		300	
RE39-11-2942	Silver	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03	detect		0.3		300	
RE36-11-4184	Silver	0.048	ug/FILTER	1.132673864	30	33.98022	1.41E-03	detect		0.3		300	
RE36-11-4189	Silver	0.074	ug/FILTER	1.132673864	30	33.98022	2.18E-03	detect		0.3		300	
RE36-11-4190	Silver	0.15	ug/FILTER			0		detect		0.3		300	
RE36-11-2934	Silver	0.026	ug/FILTER	1.132673864	42	47.5723	5.47E-04	detect		0.3		300	
RE36-11-4192	Silver	0.072	ug/FILTER	1.132673864	96	108.7367	6.62E-04	detect		0.3		300	
RE36-11-4197	Silver	0.068	ug/FILTER	1.061881747	108	114.6832	5.93E-04	detect		0.3		300	
RE36-11-4503	Silver	0.074	ug/FILTER	1.132673864	30	33.98022	2.18E-03	detect		0.3		300	
RE39-11-2943	Silver	0.05	ug/FILTER	1.132673864	30	33.98022	1.47E-03	detect		0.3		300	
RE39-11-2944	Silver	0.04	ug/FILTER	1.132673864	36	40.77626	9.81E-04	detect		0.3		300	
RE39-11-4524	Silver	0.028	ug/FILTER	1.104357017	30	33.13071	8.45E-04	detect		0.3		300	
RE39-11-4525	Silver	0.01	ug/FILTER	1.104357017	30	33.13071	3.02E-04			0.3		300	
RE39-11-4526	Silver	0.01	ug/FILTER			0				0.3		300	
RE39-11-4527	Silver	0.02	ug/FILTER	1.132673864	24	27.18417	7.36E-04			0.3		300	
RE39-11-4528	Silver	0.014	ug/FILTER	1.132673864	24	27.18417	5.15E-04		28	0.3		300	0
RE39-11-2936	Sodium	62	ug/FILTER	1.11851544	36	40.26656	1.54E+00			none specified			
RE39-11-2945	Sodium	47	ug/FILTER			0				none specified			
RE36-11-2914	Sodium	70	ug/FILTER	1.104357017	30	33.13071	2.11E+00			none specified			
RE36-11-2915	Sodium	280	ug/FILTER	1.132673864	54	61.16439	4.58E+00	detect		none specified			
RE36-11-2916	Sodium	120	ug/FILTER	1.132673864	30	33.98022	3.53E+00			none specified			
RE36-11-2917	Sodium	48	ug/FILTER	1.132673864	36	40.77626	1.18E+00			none specified			
RE36-11-2918	Sodium	32	ug/FILTER	1.104357017	18	19.87843	1.61E+00			none specified			
RE36-11-2919	Sodium	51	ug/FILTER	1.132673864	42	47.5723	1.07E+00			none specified			
RE36-11-2920	Sodium	92	ug/FILTER	1.132673864	24	27.18417	3.38E+00			none specified			
RE36-11-2921	Sodium	31	ug/FILTER	1.132673864	42	47.5723	6.52E-01			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2922	Sodium	22	ug/FILTER	1.104357017	36	39.75685	5.53E-01			none specified			
RE36-11-2923	Sodium	20	ug/FILTER	1.104357017	36	39.75685	5.03E-01			none specified			
RE39-11-2935	Sodium	34	ug/FILTER	1.132673864	30	33.98022	1.00E+00			none specified			
RE39-11-2937	Sodium	22	ug/FILTER	1.132673864	18	20.38813	1.08E+00			none specified			
RE39-11-2938	Sodium	70	ug/FILTER	1.132673864	30	33.98022	2.06E+00			none specified			
RE39-11-2939	Sodium	37	ug/FILTER	1.104357017	24	26.50457	1.40E+00			none specified			
RE39-11-2940	Sodium	170	ug/FILTER	1.104357017	30	33.13071	5.13E+00			none specified			
RE39-11-2941	Sodium	32	ug/FILTER	1.132673864	24	27.18417	1.18E+00			none specified			
RE39-11-2942	Sodium	110	ug/FILTER	1.132673864	24	27.18417	4.05E+00			none specified			
RE36-11-4184	Sodium	51	ug/FILTER	1.132673864	30	33.98022	1.50E+00			none specified			
RE36-11-4189	Sodium	38	ug/FILTER	1.132673864	30	33.98022	1.12E+00			none specified			
RE36-11-4190	Sodium	33	ug/FILTER			0				none specified			
RE36-11-2934	Sodium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-4192	Sodium	43	ug/FILTER	1.132673864	96	108.7367	3.95E-01			none specified			
RE36-11-4197	Sodium	30	ug/FILTER	1.061881747	108	114.6832	2.62E-01			none specified			
RE36-11-4503	Sodium	30	ug/FILTER	1.132673864	30	33.98022	8.83E-01			none specified			
RE39-11-2943	Sodium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE39-11-2944	Sodium	230	ug/FILTER	1.132673864	36	40.77626	5.64E+00	detect		none specified			
RE39-11-4524	Sodium	200	ug/FILTER	1.104357017	30	33.13071	6.04E+00			none specified			
RE39-11-4525	Sodium	200	ug/FILTER	1.104357017	30	33.13071	6.04E+00			none specified			
RE39-11-4526	Sodium	200	ug/FILTER			0				none specified			
RE39-11-4527	Sodium	200	ug/FILTER	1.132673864	24	27.18417	7.36E+00			none specified			
RE39-11-4528	Sodium	200	ug/FILTER	1.132673864	24	27.18417	7.36E+00		2	none specified			0
RE39-11-2936	Thallium	0.02	ug/FILTER	1.11851544	36	40.26656	4.97E-04			0.3		300	
RE39-11-2945	Thallium	0.006	ug/FILTER			0				0.3		300	
RE36-11-2914	Thallium	0.01	ug/FILTER	1.104357017	30	33.13071	3.02E-04			0.3		300	
RE36-11-2915	Thallium	0.04	ug/FILTER	1.132673864	54	61.16439	6.54E-04			0.3		300	
RE36-11-2916	Thallium	0.006	ug/FILTER	1.132673864	30	33.98022	1.77E-04			0.3		300	
RE36-11-2917	Thallium	0.04	ug/FILTER	1.132673864	36	40.77626	9.81E-04			0.3		300	
RE36-11-2918	Thallium	0.006	ug/FILTER	1.104357017	18	19.87843	3.02E-04			0.3		300	
RE36-11-2919	Thallium	0.01	ug/FILTER	1.132673864	42	47.5723	2.10E-04			0.3		300	
RE36-11-2920	Thallium	0.04	ug/FILTER	1.132673864	24	27.18417	1.47E-03			0.3		300	
RE36-11-2921	Thallium	0.04	ug/FILTER	1.132673864	42	47.5723	8.41E-04			0.3		300	
RE36-11-2922	Thallium	0.008	ug/FILTER	1.104357017	36	39.75685	2.01E-04			0.3		300	
RE36-11-2923	Thallium	0.008	ug/FILTER	1.104357017	36	39.75685	2.01E-04			0.3		300	
RE39-11-2935	Thallium	0.004	ug/FILTER	1.132673864	30	33.98022	1.18E-04			0.3		300	
RE39-11-2937	Thallium	0.016	ug/FILTER	1.132673864	18	20.38813	7.85E-04			0.3		300	
RE39-11-2938	Thallium	0.008	ug/FILTER	1.132673864	30	33.98022	2.35E-04			0.3		300	
RE39-11-2939	Thallium	0.006	ug/FILTER	1.104357017	24	26.50457	2.26E-04			0.3		300	
RE39-11-2940	Thallium	0.008	ug/FILTER	1.104357017	30	33.13071	2.41E-04			0.3		300	
RE39-11-2941	Thallium	0.056	ug/FILTER	1.132673864	24	27.18417	2.06E-03	detect		0.3		300	
RE39-11-2942	Thallium	0.012	ug/FILTER	1.132673864	24	27.18417	4.41E-04			0.3		300	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4184	Thallium	0.046	ug/FILTER	1.132673864	30	33.98022	1.35E-03	detect		0.3		300	
RE36-11-4189	Thallium	0.01	ug/FILTER	1.132673864	30	33.98022	2.94E-04			0.3		300	
RE36-11-4190	Thallium	0.04	ug/FILTER			0				0.3		300	
RE36-11-2934	Thallium	0.026	ug/FILTER	1.132673864	42	47.5723	5.47E-04			0.3		300	
RE36-11-4192	Thallium	0.01	ug/FILTER	1.132673864	96	108.7367	9.20E-05			0.3		300	
RE36-11-4197	Thallium	0.006	ug/FILTER	1.061881747	108	114.6832	5.23E-05			0.3		300	
RE36-11-4503	Thallium	0.04	ug/FILTER	1.132673864	30	33.98022	1.18E-03			0.3		300	
RE39-11-2943	Thallium	0.04	ug/FILTER	1.132673864	30	33.98022	1.18E-03			0.3		300	
RE39-11-2944	Thallium	0.04	ug/FILTER	1.132673864	36	40.77626	9.81E-04			0.3		300	
RE39-11-4524	Thallium	0.01	ug/FILTER	1.104357017	30	33.13071	3.02E-04			0.3		300	
RE39-11-4525	Thallium	0.04	ug/FILTER	1.104357017	30	33.13071	1.21E-03			0.3		300	
RE39-11-4526	Thallium	0.008	ug/FILTER			0				0.3		300	
RE39-11-4527	Thallium	0.04	ug/FILTER	1.132673864	24	27.18417	1.47E-03			0.3		300	
RE39-11-4528	Thallium	0.014	ug/FILTER	1.132673864	24	27.18417	5.15E-04		2	0.3		300	0
RE39-11-2936	Vanadium	0.15	ug/FILTER	1.11851544	36	40.26656	3.73E-03			none specified			
RE39-11-2945	Vanadium	0.2	ug/FILTER			0				none specified			
RE36-11-2914	Vanadium	0.082	ug/FILTER	1.104357017	30	33.13071	2.48E-03			none specified			
RE36-11-2915	Vanadium	0.092	ug/FILTER	1.132673864	54	61.16439	1.50E-03			none specified			
RE36-11-2916	Vanadium	0.06	ug/FILTER	1.132673864	30	33.98022	1.77E-03			none specified			
RE36-11-2917	Vanadium	0.058	ug/FILTER	1.132673864	36	40.77626	1.42E-03			none specified			
RE36-11-2918	Vanadium	0.14	ug/FILTER	1.104357017	18	19.87843	7.04E-03			none specified			
RE36-11-2919	Vanadium	0.052	ug/FILTER	1.132673864	42	47.5723	1.09E-03			none specified			
RE36-11-2920	Vanadium	0.17	ug/FILTER	1.132673864	24	27.18417	6.25E-03			none specified			
RE36-11-2921	Vanadium	0.15	ug/FILTER	1.132673864	42	47.5723	3.15E-03			none specified			
RE36-11-2922	Vanadium	0.11	ug/FILTER	1.104357017	36	39.75685	2.77E-03			none specified			
RE36-11-2923	Vanadium	0.12	ug/FILTER	1.104357017	36	39.75685	3.02E-03			none specified			
RE39-11-2935	Vanadium	0.22	ug/FILTER	1.132673864	30	33.98022	6.47E-03	detect		none specified			
RE39-11-2937	Vanadium	0.2	ug/FILTER	1.132673864	18	20.38813	9.81E-03			none specified			
RE39-11-2938	Vanadium	0.38	ug/FILTER	1.132673864	30	33.98022	1.12E-02	detect		none specified			
RE39-11-2939	Vanadium	0.27	ug/FILTER	1.104357017	24	26.50457	1.02E-02	detect		none specified			
RE39-11-2940	Vanadium	0.58	ug/FILTER	1.104357017	30	33.13071	1.75E-02	detect		none specified			
RE39-11-2941	Vanadium	0.26	ug/FILTER	1.132673864	24	27.18417	9.56E-03	detect		none specified			
RE39-11-2942	Vanadium	0.5	ug/FILTER	1.132673864	24	27.18417	1.84E-02	detect		none specified			
RE36-11-4184	Vanadium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE36-11-4189	Vanadium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE36-11-4190	Vanadium	0.2	ug/FILTER			0				none specified			
RE36-11-2934	Vanadium	0.084	ug/FILTER	1.132673864	42	47.5723	1.77E-03			none specified			
RE36-11-4192	Vanadium	0.11	ug/FILTER	1.132673864	96	108.7367	1.01E-03			none specified			
RE36-11-4197	Vanadium	0.12	ug/FILTER	1.061881747	108	114.6832	1.05E-03			none specified			
RE36-11-4503	Vanadium	0.13	ug/FILTER	1.132673864	30	33.98022	3.83E-03			none specified			
RE39-11-2943	Vanadium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE39-11-2944	Vanadium	0.076	ug/FILTER	1.132673864	36	40.77626	1.86E-03			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4524	Vanadium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			none specified			
RE39-11-4525	Vanadium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			none specified			
RE39-11-4526	Vanadium	0.2	ug/FILTER			0				none specified			
RE39-11-4527	Vanadium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			none specified			
RE39-11-4528	Vanadium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03		6	none specified			0
RE39-11-2936	Zinc	33	ug/FILTER	1.11851544	36	40.26656	8.20E-01	detect		3.00E+01		3.00E+04	
RE39-11-2945	Zinc	11	ug/FILTER			0		detect		3.00E+01		3.00E+04	
RE36-11-2914	Zinc	20	ug/FILTER	1.104357017	30	33.13071	6.04E-01	detect		3.00E+01		3.00E+04	
RE36-11-2915	Zinc	21	ug/FILTER	1.132673864	54	61.16439	3.43E-01	detect		3.00E+01		3.00E+04	
RE36-11-2916	Zinc	14	ug/FILTER	1.132673864	30	33.98022	4.12E-01	detect		3.00E+01		3.00E+04	
RE36-11-2917	Zinc	15	ug/FILTER	1.132673864	36	40.77626	3.68E-01	detect		3.00E+01		3.00E+04	
RE36-11-2918	Zinc	12	ug/FILTER	1.104357017	18	19.87843	6.04E-01	detect		3.00E+01		3.00E+04	
RE36-11-2919	Zinc	18	ug/FILTER	1.132673864	42	47.5723	3.78E-01	detect		3.00E+01		3.00E+04	
RE36-11-2920	Zinc	10	ug/FILTER	1.132673864	24	27.18417	3.68E-01	detect		3.00E+01		3.00E+04	
RE36-11-2921	Zinc	15	ug/FILTER	1.132673864	42	47.5723	3.15E-01	detect		3.00E+01		3.00E+04	
RE36-11-2922	Zinc	11	ug/FILTER	1.104357017	36	39.75685	2.77E-01	detect		3.00E+01		3.00E+04	
RE36-11-2923	Zinc	11	ug/FILTER	1.104357017	36	39.75685	2.77E-01	detect		3.00E+01		3.00E+04	
RE39-11-2935	Zinc	15	ug/FILTER	1.132673864	30	33.98022	4.41E-01	detect		3.00E+01		3.00E+04	
RE39-11-2937	Zinc	20	ug/FILTER	1.132673864	18	20.38813	9.81E-01	detect		3.00E+01		3.00E+04	
RE39-11-2938	Zinc	40	ug/FILTER	1.132673864	30	33.98022	1.18E+00	detect		3.00E+01		3.00E+04	
RE39-11-2939	Zinc	16	ug/FILTER	1.104357017	24	26.50457	6.04E-01	detect		3.00E+01		3.00E+04	
RE39-11-2940	Zinc	46	ug/FILTER	1.104357017	30	33.13071	1.39E+00	detect		3.00E+01		3.00E+04	
RE39-11-2941	Zinc	14	ug/FILTER	1.132673864	24	27.18417	5.15E-01	detect		3.00E+01		3.00E+04	
RE39-11-2942	Zinc	35	ug/FILTER	1.132673864	24	27.18417	1.29E+00	detect		3.00E+01		3.00E+04	
RE36-11-4184	Zinc	19	ug/FILTER	1.132673864	30	33.98022	5.59E-01	detect		3.00E+01		3.00E+04	
RE36-11-4189	Zinc	11	ug/FILTER	1.132673864	30	33.98022	3.24E-01	detect		3.00E+01		3.00E+04	
RE36-11-4190	Zinc	12	ug/FILTER			0		detect		3.00E+01		3.00E+04	
RE36-11-2934	Zinc	9.8	ug/FILTER	1.132673864	42	47.5723	2.06E-01	detect		3.00E+01		3.00E+04	
RE36-11-4192	Zinc	12	ug/FILTER	1.132673864	96	108.7367	1.10E-01	detect		3.00E+01		3.00E+04	
RE36-11-4197	Zinc	15	ug/FILTER	1.061881747	108	114.6832	1.31E-01	detect		3.00E+01		3.00E+04	
RE36-11-4503	Zinc	22	ug/FILTER	1.132673864	30	33.98022	6.47E-01	detect		3.00E+01		3.00E+04	
RE39-11-2943	Zinc	18	ug/FILTER	1.132673864	30	33.98022	5.30E-01	detect		3.00E+01		3.00E+04	
RE39-11-2944	Zinc	42	ug/FILTER	1.132673864	36	40.77626	1.03E+00	detect		3.00E+01		3.00E+04	
RE39-11-4524	Zinc	17	ug/FILTER	1.104357017	30	33.13071	5.13E-01	detect		3.00E+01		3.00E+04	
RE39-11-4525	Zinc	6.4	ug/FILTER	1.104357017	30	33.13071	1.93E-01	detect		3.00E+01		3.00E+04	
RE39-11-4526	Zinc	2.1	ug/FILTER			0				3.00E+01		3.00E+04	
RE39-11-4527	Zinc	3.6	ug/FILTER	1.132673864	24	27.18417	1.32E-01			3.00E+01		3.00E+04	
RE39-11-4528	Zinc	17	ug/FILTER	1.132673864	24	27.18417	6.25E-01	detect	31	3.00E+01		3.00E+04	0

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte

ug = micrograms
m^3/min = cubic meters per minute
min = minute
pg or ug /m^3 = picograms or micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
ug/m^3 = microgams per cubic meter
CA Acute RELs = California Acute Reference Exposure Levels
Note: Blank samples have a flow volume of 0 m^3
Screening levels taken from:
EPA, 2005. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities," Office of Solid Waste and Emergency Response, EPA530-R-05-006, September 2005. EPA, 2010, "Environmental Protection Agency Region 6 Regional Screening Levels," November November 2010.
and
Office of Environmental Health Hazard Assessment (OEHHA), 1999. Air Toxics Hot Spots Program Risk Assessment Guidelines Part I The Determination of Acute Reference Exposure Levels for Airborne Toxicants. California Environmental Protection Agency, Air Toxicology and Epidemiology Section, Office of Environmental Health Hazard Assessment. March 1999.

Supplement 4-5

Soil Sampling Results Summary Report for the Open Detonation Unit at Technical Area (TA) 36-8

TA-36-8 Open Detonation Unit

This summary report includes discussion of the analytical results associated with soil sampling conducted at the Technical Area 36, Building 8 (TA-36-8) open detonation unit on September 19, 2018. Fifteen soil samples were collected from pre-selected locations (Figure 1) based on a defined area where deposition of particulates from air to soil, including predominant downwind locations, and areas of potential storm water runoff, is most likely to occur. Soil samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total metals, dioxins/furans, perchlorates, and high explosives, gross alpha and beta and isotopic plutonium. Soil samples were collected as grab samples from a depth of 0 to 2 inches below the ground surface.

In 2010 and early 2011, soil data were previously collected to determine the baseline soil constituent of concern concentrations at the unit after more than 50 years of use. A summary of the soil analytical results for the sample collection events is included in Attachment D of the *Los Alamos National Laboratory Permit Modification Request for Open Detonation Units at Technical Areas 36 and 39 (TA-36-8 & TA-39-6), Revision 0* (Los Alamos National Laboratory [LANL], 2011). Soil samples were analyzed for high explosives, metals, dioxins/furans, SVOCs, VOCs, polychlorinated biphenyls (PCBs), perchlorates, and radiological constituents (gross alpha, gross beta, and isotopic uranium). Those analytical results indicate that the average soil constituent concentrations in and around the TA-36-8 open detonation unit were less than the New Mexico Environment Department (NMED) Residential Soil Screening Levels (RSSLs) (NMED, 2019).

PCB soil data was collected in 2010 and 2011, because the soil monitoring conducted at that time was designed to be a baseline data set to begin an assumed soil monitoring program at the detonation unit. Constituents chosen for the 2018 sampling effort were based on the likelihood that current operational activities may contribute to deposition of the constituents.

PCB waste is not treated or used in association with the current operational activities at either of the units; therefore, PCBs should not be added to the soil surface since initial detection. At the time of closure of the units, PCBs should be evaluated based on the sites historic use.

The results of the 2018 soil sampling event, discussed in detail below, indicate that current active operations at the unit also do not pose an unnecessary risk to human health based on the soil sample analytical results. Any potential contamination at the site is believed to be primarily limited to the surface (i.e., the first few inches in depth) of the site.

Laboratory Analysis and Reporting

The soil samples collected in 2018 were analyzed at a qualified offsite laboratory. The LANL Sample Management Office qualifies contract laboratories and ensures these laboratories adhere to U.S. Environmental Protection Agency (EPA) quality assurance and quality control (QA/QC) requirements. All sampling and analyses were conducted in accordance with QA/QC procedures defined by the latest revision of SW-846 (EPA 1986) or other NMED-approved procedures. Field sampling procedures and laboratory analyses are evaluated through the use of QA/QC samples to assess the overall quality of the

data produced. The field QC samples included trip blanks, field blanks, field duplicates, and equipment rinsate blanks. Field QC samples were given a unique sample identification number and submitted to the analytical laboratory as blind samples. Laboratory QC samples include calibrations, blanks, duplicates, and spike samples. QC sample results are included in the analytical results received from the laboratory so the results can be applied to the associated samples.

Samples were analyzed for the following constituents using the methods indicated in the parentheses:

- High explosives (SW-846-8330B)
- Metals (SW-846-6020, SW-846-6010C, and SW-846-7471A)
- Dioxins/Furans (SW-846-8290A)
- SVOCs (SW-846-8270D)
- VOCs (SW-846-8260B)
- Perchlorates (SW-846-6850)
- Gross alpha and beta (EPA Method 900)
- Isotopic plutonium (HASL-300:ISOPU)

Complete analytical results for this sampling are included in Table 1, *TA-36-8 Analytical Data Summary*. Data are reported with qualifiers that denote the following analytical situations:

- <u>For Dioxins/Furans</u>
    - U – Compound analyzed for, but not detected, reported quantity equals the contract required quantitation limit (CRQL)
    - J - Estimated value; the analyte is present, but at a concentration below the CRQL
    - B – Analyte detected in associated blank
    - K – Estimated Maximum Possible Concentration
    - NQ – No qualification
- <u>For Metals and Isotopic Plutonium</u>
    - U – reading was less than the method detection limit (MDL); reported value equals the CRQL
    - J – The reported value was obtained from a reading less than the CRQL but greater than or equal to the MDL
        - J+ – percent recovery is over the qualification standard
        - J- – percent recovery is below the qualification standard
    - B – Analyte detected in associated blank
    - NQ – No qualification
- <u>For VOCs and SVOCs</u>
    - U – Compound analyzed for, but not detected; reported value equals the CRQL
    - J – Estimated value; the analyte is present, but at a concentration below the CRQL
        - J+ – percent recovery is over the qualification standard
        - J- – percent recovery is below the qualification standard
    - B – Analyte detected in associated blank

- For Explosives
    - U – Compound analyzed for, but not detected; reported value equals the CRQL
    - J – Estimated value; the analyte is present, but at a concentration below the CRQL
        - J+ – percent recovery is over the qualification standard
        - J- – percent recovery is below the qualification standard
    - B – Analyte detected in associated blank
    - NQ – No qualification

Soil samples collected in 2018 were intended to be analyzed for isotopic uranium, but were analyzed for isotopic plutonium instead, which is not a constituent that should be present at the site. A miscommunication on the chain of custody forms for the sample suites led to analysis for isotopic plutonium and as expected, there was no plutonium detected at the site. However, previously collected data regarding isotopic uranium (the applicable constituent) concentration information, were included in the earlier 2011 sampling report (LANL 2011). The isotopic uranium data were also evaluated within the 2013 revised risk assessment included as Permit Application Supplement 4-9, *Revision of 2011 Open Detonation Risk Assessment*.

Summary of Results

Compiled data were compared to NMED RSSLs. It is important to note that very few constituents, when compared to the constituents that the soil was tested for, were detected. The compounds detected within the soil are presented below as well as other information about the analytical data that provide a more in depth discussion regarding the results.

Organic constituents detected within the soils at the TA-36-8 open detonation unit include:

- 2 of the 62 VOCs analyzed;
- 17 of the 69 SVOCs analyzed;
- 3 of the 20 explosives compounds analyzed; and
- 16 of the 25 dioxin or furan compounds analyzed.

All of the VOCs and SVOCs that were detected at the unit were detected below applicable NMED RSSLs. However, when a constituent concentration is reported as a CRQL which is greater than the screening level, it appears that the constituent is detected above the NMED RSSL. This is the case for n-nitrosodimethylamine within this dataset. It is not detected in any of the samples analyzed and is included within the 'U' qualifier. However, because the reported results are the same as the CRQL, and the CRQL is greater than the NMED RSSL, n- nitrosodimethylamine appears to be detected at a concentration higher than the NMED RSSLs. The method utilized by the analytical laboratory for the SVOC analysis can detect the presence of nitrosamines; however, it is not the most sensitive method and therefore, the detection limit is higher than the soil screening level.

The presence of n-nitrosodimethylamine due to operations at the TA-36-8 open detonation is not likely and a more focused analytical validation was deemed not necessary. N-nitrosodimethylamine is produced by industry only in small amounts for research. It was used to make rocket fuel, but this use was stopped after unusually high levels of the chemical were found in air, water, and soil samples collected near a rocket fuel manufacturing plant. It is currently used in some cosmetic and toiletry products and in cleansers. N-nitrosodimethylamine is unintentionally formed during various manufacturing processes and in air, water, and soil from reactions involving alkylamines. It is also found

in some foods and may be formed in the body. When released to the air, it is broken down by sunlight in a matter of minutes. When released to soil, it may evaporate into air or could sink down into deeper soil. It is unlikely that n-nitrosodimethylamine was deposited by past or current activities at the TA-36-8 open detonation unit as rocket fuel was never manufactured at LANL.

The three explosives compounds (HMX, RDX, and TATB) detected within the soil at the TA-36-8 open detonation unit were all found at concentrations below NMED RSSLs.

EPA has established 50 parts per trillion (ppt) Toxic Equivalency Quantity (TEQ) as being an acceptable limit for residential contamination for dioxins and furans. The TEQ system was developed for the purpose of comparing the relative risk of exposure in areas of contamination that vary widely in the composition and level of most toxic dioxins and furans. Each of the 17 highly toxic dioxins/furans are assigned a Toxic Equivalency Factor (TEF) based on a particular chemical's toxicity relative to 2,3,7,8-tetrachlorodibenzodioxin (TCDD), with the toxicity of TCDD being equal to 1.0. The concentration of each dioxin/furan is multiplied by its respective TEF and the results are summed. The summed results give the TEQ of the sample and it is this value that is compared to the 50 ppt screening level. This analysis is conducted as part of the health and ecological risk assessment included with this application and is included within Permit Application Supplement 4-7, *Technical Area 36 - Open Burn/Open Detonation (OB/OD) Area - Technical Area 36-8 Open Detonation Unit Human Health and Ecological Risk- Screening Assessments*.

Perchlorate was detected at 11 of the 15 soil sample locations. All detections were below NMED RSSLs.

Twenty-two (22) of the 23 analyzed metals were detected in the sampled soil at the TA-36-8 open detonation unit. Most of the detected metal concentrations are below the established background levels for Los Alamos National Laboratory. Eight of the metals detected are present at concentrations above background values.

- Cadmium (1 location)
- Chromium (1 location)
- Copper (13 locations)
- Lead (1 location)
- Mercury (1 location)
- Silver (2 locations)
- Thallium (1 location)
- Zinc (1 location)

The single detection of thallium is also above the NMED RSSL at that location. Human health and ecological risks associated with these detections are included in Permit Application Supplement 4-7, *Technical Area 36 - Open Burn/Open Detonation (OB/OD) Area - Technical Area 36-8 Open Detonation Unit Human Health and Ecological Risk- Screening Assessments*.

Conclusion

Soil sampling and analysis results indicate that the average soil constituent concentration in and around the TA-36-8 open detonation unit are generally less than the NMED RSSLs. Metal constituent concentrations greater than the screening levels (see Table 1) are indicated for a single soil sample when compared directly to the NMED RSSLs. The analytical results for high explosives, perchlorates, VOCs, SVOCs and dioxins/furans did not indicate the presence of any constituents greater than the selected screening levels. Detected metals at 13 soil sample locations were measured above established background values.

References

EPA, 1986 (and all approved updates). *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* SW-846, U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response, U.S Government Printing Office, Washington D.C.

LANL, 2011. *Los Alamos National Laboratory Permit Modification Request for Open Detonation Units at Technical Areas 36 and 39 (TA-36-8 & TA-39-6), Revision 0*. Los Alamos National Laboratory. July 2011. (http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-11-04739)

NMED, 2010. *Los Alamos National Laboratory Hazardous Waste Facility Permit,* EPA ID# NM0890010515, New Mexico Environment Department, Santa Fe, New Mexico.

NMED, 2019. *New Mexico Environment Department Risk Assessment guidance for Site Investigations and Remediation*, February 2019 (Revision 2, 6/19/19).

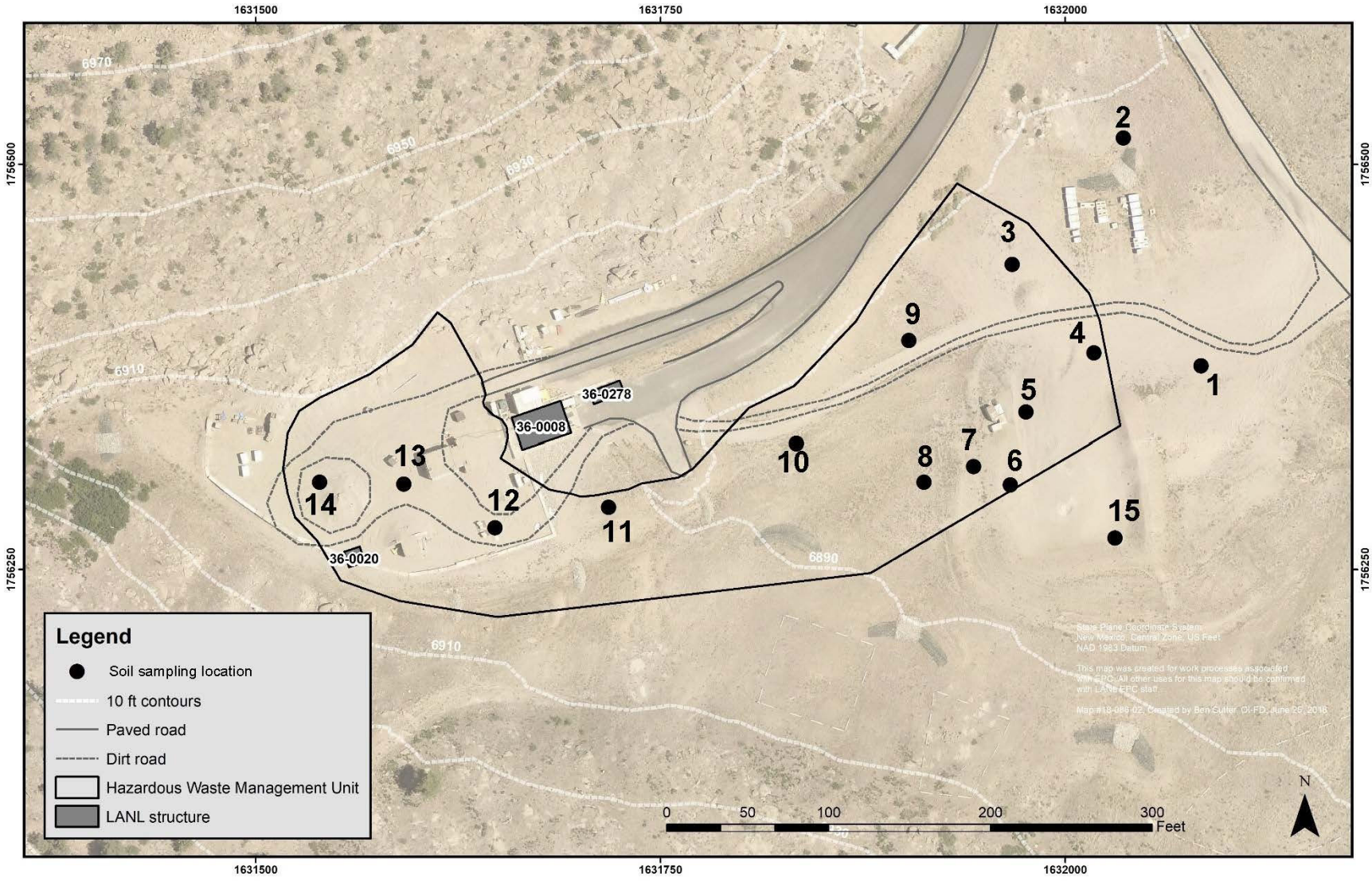

Figure 1. TA-36-8 Soil Sample Locations

Table 1. TA-36-8 2018 Analytical Data Summary

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**8.40E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Heptachlorodibenzodioxins (Total)**	**1.22E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**5.61E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzofuran[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzofuran[2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Tetrachlorodibenzodioxin[2,3,7,8-]	9.99E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
1	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.10E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
1	**Tetrachlorodibenzofurans (Totals)**	**1.10E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Aluminum**	**2.35E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
1	Antimony	3.14E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
1	**Arsenic**	**8.44E-01**	mg/kg	**Y**	J	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
1	**Barium**	**2.64E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
1	**Beryllium**	**2.09E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
1	Cadmium	9.52E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
1	**Calcium**	**4.49E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
1	**Chromium**	**7.38E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
1	**Cobalt**	**3.32E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
1	**Copper**	**1.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	FALSE
1	**Iron**	**9.51E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	**Lead**	**4.17E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
1	**Magnesium**	**2.58E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
1	**Manganese**	**1.43E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
1	Mercury	3.64E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
1	**Nickel**	**5.29E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
1	**Potassium**	**4.03E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
1	**Selenium**	**4.78E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
1	**Silver**	**2.95E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
1	**Sodium**	**4.14E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
1	Thallium	1.35E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
1	**Vanadium**	**2.13E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
1	**Zinc**	**2.01E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
1	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/Ap	FALSE	N/A	FALSE	N/A	FALSE
1	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1	HMX	1.49E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
1	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
1	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
1	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
1	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**RDX**	**2.27E-01**	mg/kg	**Y**	J	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
1	**TATB**	**1.27E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
1	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Perchlorate	4.98E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
1	**Gross alpha**	**1.24E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Gross beta**	**2.14E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Plutonium-238	1.36E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
1	Plutonium-239/240	-1.09E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
1	Acenaphthene	1.00E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Acenaphthylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Aniline	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Anthracene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
1	Azobenzene	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(a)anthracene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(a)pyrene	1.00E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
1	Benzo(b)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(g,h,i)perylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(k)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
1	Benzoic Acid	1.67E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Benzyl Alcohol	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bis(2-chloroethoxy)methane	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bis(2-chloroethyl)ether	1.00E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Bis(2-ethylhexyl)phthalate	1.00E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Bromophenyl-phenylether[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Butylbenzylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chloroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chloronaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
1	Chlorophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
1	Chlorophenyl-phenyl[4-] Ether	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chrysene	1.00E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
1	Dibenz(a,h)anthracene	1.00E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
1	Dibenzofuran	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorobenzene[1,2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1	Dichlorobenzene[1,3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorobenzene[1,4-]	1.00E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1	Dichlorobenzidine[3,3'-]	1.00E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
1	Diethylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
1	Dimethyl Phthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
1	Dimethylphenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Di-n-butylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1	Dinitro-2-methylphenol[4,6-]	1.00E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
1	Dinitrophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
1	Dinitrotoluene[2,4-]	1.00E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1	Dinitrotoluene[2,6-]	1.00E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1	Di-n-octylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Diphenylamine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Fluoranthene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
1	Fluorene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
1	Hexachlorobenzene	1.00E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
1	Hexachlorobutadiene	1.00E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
1	Hexachlorocyclopentadiene	1.00E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
1	Hexachloroethane	1.00E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
1	Indeno(1,2,3-cd)pyrene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Isophorone	1.00E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
1	Methylnaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
1	Methylphenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Methylphenol[3-,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Naphthalene	1.00E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
1	Nitroaniline[2-]	1.10E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitroaniline[3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitrobenzene	1.00E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1	Nitrophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitrophenol[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitrosodimethylamine[N-]	1.00E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
1	Nitroso-di-n-propylamine[N-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Oxybis(1-chloropropane)[2,2'-]	1.00E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorophenol	1.00E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
1	Phenanthrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1	Phenol	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
1	Pyrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1	Pyridine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Trichlorobenzene[1,2,4-]	1.00E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
1	Trichlorophenol[2,4,5-]	1.00E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1	Trichlorophenol[2,4,6-]	1.00E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
1	Acetone	1.55E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
1	Benzene	3.10E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
1	Bromobenzene	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bromochloromethane	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bromodichloromethane	3.10E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1	Bromoform	3.10E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Bromomethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
1	Butanone[2-]	1.55E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Butylbenzene[n-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Butylbenzene[sec-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Butylbenzene[tert-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Carbon Disulfide	1.55E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
1	Carbon Tetrachloride	3.10E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
1	Chlorobenzene	3.10E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
1	Chlorodibromomethane	3.10E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Chloroethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
1	Chloroform	3.10E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
1	Chloromethane	3.10E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
1	Chlorotoluene[2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
1	Chlorotoluene[4-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dibromo-3-Chloropropane[1,2-]	4.66E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
1	Dibromoethane[1,2-]	3.10E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
1	Dibromomethane	3.10E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
1	Dichlorobenzene[1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1	Dichlorobenzene[1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorobenzene[1,4-]	3.10E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1	Dichlorodifluoromethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
1	Dichloroethane[1,1-]	3.10E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
1	Dichloroethane[1,2-]	3.10E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
1	Dichloroethene[1,1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
1	Dichloroethene[cis-1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1	Dichloroethene[trans-1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
1	Dichloropropane[1,2-]	3.10E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
1	Dichloropropane[1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropane[2,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropene[1,1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropene[cis-1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropene[trans-1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Ethylbenzene	3.10E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
1	Hexanone[2-]	1.55E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Iodomethane	1.55E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Isopropylbenzene	3.10E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
1	Isopropyltoluene[4-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Methyl-2-pentanone[4-]	1.55E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
1	Methylene Chloride	1.55E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
1	Propylbenzene[1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Styrene	3.10E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
1	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Tetrachloroethane[1,1,1,2-]	3.10E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
1	Tetrachloroethane[1,1,2,2-]	3.10E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1	Tetrachloroethene	3.10E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
1	Toluene	3.10E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
1	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.55E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
1	Trichloroethane[1,1,1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
1	Trichloroethane[1,1,2-]	3.10E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
1	Trichloroethene	3.10E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
1	Trichlorofluoromethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Trichloropropane[1,2,3-]	3.10E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
1	Trimethylbenzene[1,2,4-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Trimethylbenzene[1,3,5-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Vinyl Chloride	3.10E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
1	Xylene[1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	8.05E+02	FALSE	N/A	FALSE
1	Xylene[1,3-]+Xylene[1,4-]	6.21E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
2	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**3.68E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Heptachlorodibenzodioxins (Total)**	**1.11E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**8.20E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Heptachlorodibenzofurans (Total)**	**8.20E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Hexachlorodibenzodioxins (Total)**	**5.77E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**3.41E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**2.54E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
2	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.31E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
2	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Aluminum**	**3.75E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
2	Antimony	3.24E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
2	**Arsenic**	**1.43E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
2	**Barium**	**7.34E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
2	**Beryllium**	**4.55E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
2	Cadmium	9.81E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
2	**Calcium**	**2.76E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
2	**Chromium**	**5.37E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
2	**Cobalt**	**3.06E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
2	**Copper**	**1.48E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
2	**Iron**	**1.09E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
2	**Lead**	**1.26E+01**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
2	**Magnesium**	**1.09E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
2	**Manganese**	**2.99E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
2	**Mercury**	**5.52E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
2	**Nickel**	**4.17E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
2	**Potassium**	**7.96E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
2	**Selenium**	**8.41E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
2	**Silver**	**1.25E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
2	**Sodium**	**5.06E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
2	Thallium	1.36E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
2	**Vanadium**	**1.37E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
2	**Zinc**	**4.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
2	2,4-Diamino-6-nitrotoluene	4.95E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	2,6-Diamino-4-nitrotoluene	6.53E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	3,5-Dinitroaniline	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
2	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
2	HMX	1.49E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
2	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
2	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
2	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
2	PETN	2.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	RDX	1.49E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
2	**TATB**	**1.40E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
2	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
2	Tris (o-cresyl) phosphate	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Perchlorate	5.04E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
2	**Gross alpha**	**1.69E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Gross beta**	**3.27E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Plutonium-238	1.16E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
2	Plutonium-239/240	7.22E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
2	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
2	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
2	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Benzo(a)anthracene**	**1.58E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
2	**Benzo(a)pyrene**	**1.34E-02**	mg/kg	**Y**	J	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
2	**Benzo(b)fluoranthene**	**1.61E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
2	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
2	**Benzoic Acid**	**4.58E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
2	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
2	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
2	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Chrysene**	**1.38E-02**	mg/kg	**Y**	J	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
2	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
2	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
2	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
2	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
2	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
2	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
2	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
2	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
2	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
2	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
2	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Fluoranthene**	**2.58E-02**	mg/kg	**Y**	J	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
2	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
2	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
2	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
2	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
2	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
2	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
2	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
2	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
2	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
2	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
2	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
2	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
2	**Phenanthrene**	**1.54E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
2	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
2	**Pyrene**	**2.58E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
2	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
2	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
2	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
2	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
2	Benzene	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
2	Bromobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bromochloromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bromodichloromethane	3.23E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
2	Bromoform	3.23E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Bromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
2	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
2	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[tert-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
2	Carbon Tetrachloride	3.23E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
2	Chlorobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
2	Chlorodibromomethane	3.23E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Chloroethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
2	Chloroform	3.23E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
2	Chloromethane	3.23E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
2	Chlorotoluene[2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
2	Chlorotoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dibromo-3-Chloropropane[1,2-]	4.85E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
2	Dibromoethane[1,2-]	3.23E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
2	Dibromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
2	Dichlorobenzene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
2	Dichlorobenzene[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorobenzene[1,4-]	3.23E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
2	Dichlorodifluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
2	Dichloroethane[1,1-]	3.23E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
2	Dichloroethane[1,2-]	3.23E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
2	Dichloroethene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Dichloroethene[cis-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
2	Dichloroethene[trans-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
2	Dichloropropane[1,2-]	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
2	Dichloropropane[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropane[2,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropene[cis-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropene[trans-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Ethylbenzene	3.23E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
2	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Isopropylbenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
2	Isopropyltoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
2	Methylene Chloride	1.62E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
2	Propylbenzene[1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Styrene	3.23E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
2	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Tetrachloroethane[1,1,1,2-]	3.23E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
2	Tetrachloroethane[1,1,2,2-]	3.23E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
2	Tetrachloroethene	3.23E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
2	**Toluene**	**2.23E-03**	mg/kg	**Y**	NQ	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
2	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
2	Trichloroethane[1,1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
2	Trichloroethane[1,1,2-]	3.23E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
2	Trichloroethene	3.23E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
2	Trichlorofluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Trichloropropane[1,2,3-]	3.23E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
2	Trimethylbenzene[1,2,4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Trimethylbenzene[1,3,5-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Vinyl Chloride	3.23E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
2	Xylene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	8.07E+02	FALSE	N/A	FALSE
2	Xylene[1,3-]+Xylene[1,4-]	6.47E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
3	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**7.96E-06**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Heptachlorodibenzodioxins (Total)**	**3.17E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**1.49E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	**Heptachlorodibenzofurans (Total)**	**5.35E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Hexachlorodibenzodioxins (Total)**	**2.86E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**7.74E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**5.55E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzofuran[1,2,3,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzofuran[2,3,4,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Tetrachlorodibenzodioxin[2,3,7,8-]	1.01E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
3	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Tetrachlorodibenzofuran[2,3,7,8-]**	**2.27E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
3	**Tetrachlorodibenzofurans (Totals)**	**2.27E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Aluminum**	**2.95E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
3	Antimony	4.32E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
3	**Arsenic**	**1.95E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
3	**Barium**	**1.15E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
3	**Beryllium**	**3.50E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
3	Cadmium	9.18E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
3	**Calcium**	**3.50E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
3	**Chromium**	**4.92E+01**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	TRUE
3	**Cobalt**	**4.12E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
3	**Copper**	**5.97E+02**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
3	**Iron**	**1.02E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
3	**Lead**	**3.52E+01**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	TRUE
3	**Magnesium**	**1.45E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
3	**Manganese**	**1.94E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
3	Mercury	3.43E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
3	**Nickel**	**7.70E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
3	**Potassium**	**8.10E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	**Selenium**	**6.31E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
3	**Silver**	**4.94E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
3	**Sodium**	**6.05E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
3	Thallium	1.41E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
3	**Vanadium**	**2.07E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
3	**Zinc**	**4.84E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
3	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
3	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
3	**HMX**	**1.45E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
3	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
3	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
3	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
3	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
3	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
3	**TATB**	**2.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
3	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
3	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Perchlorate**	**7.69E-04**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
3	**Gross alpha**	**1.24E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Gross beta**	**2.56E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Plutonium-238	-5.73E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
3	Plutonium-239/240	-1.00E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
3	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
3	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
3	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
3	**Benzoic Acid**	**4.97E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Benzyl Alcohol**	**1.46E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
3	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
3	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
3	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
3	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
3	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
3	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
3	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
3	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
3	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
3	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
3	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
3	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
3	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
3	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
3	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
3	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
3	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
3	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
3	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
3	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
3	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
3	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
3	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
3	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
3	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
3	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
3	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
3	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
3	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
3	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
3	Acetone	1.59E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
3	Benzene	3.17E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
3	Bromobenzene	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bromochloromethane	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bromodichloromethane	3.17E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
3	Bromoform	3.17E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Bromomethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
3	Butanone[2-]	1.59E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
3	Butylbenzene[n-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Butylbenzene[sec-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Butylbenzene[tert-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Carbon Disulfide	1.59E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
3	Carbon Tetrachloride	3.17E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
3	Chlorobenzene	3.17E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Chlorodibromomethane	3.17E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Chloroethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
3	Chloroform	3.17E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
3	Chloromethane	3.17E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
3	Chlorotoluene[2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
3	Chlorotoluene[4-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dibromo-3-Chloropropane[1,2-]	4.75E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
3	Dibromoethane[1,2-]	3.17E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
3	Dibromomethane	3.17E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
3	Dichlorobenzene[1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
3	Dichlorobenzene[1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorobenzene[1,4-]	3.17E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
3	Dichlorodifluoromethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
3	Dichloroethane[1,1-]	3.17E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
3	Dichloroethane[1,2-]	3.17E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
3	Dichloroethene[1,1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
3	Dichloroethene[cis-1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
3	Dichloroethene[trans-1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
3	Dichloropropane[1,2-]	3.17E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
3	Dichloropropane[1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropane[2,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropene[1,1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropene[cis-1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropene[trans-1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Ethylbenzene	3.17E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
3	Hexanone[2-]	1.59E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Iodomethane	1.59E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Isopropylbenzene	3.17E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
3	Isopropyltoluene[4-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Methyl-2-pentanone[4-]	1.59E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
3	**Methylene Chloride**	**4.16E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
3	Propylbenzene[1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Styrene	3.17E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
3	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Tetrachloroethane[1,1,1,2-]	3.17E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
3	Tetrachloroethane[1,1,2,2-]	3.17E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
3	Tetrachloroethene	3.17E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Toluene	3.17E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
3	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.59E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
3	Trichloroethane[1,1,1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
3	Trichloroethane[1,1,2-]	3.17E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
3	Trichloroethene	3.17E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
3	Trichlorofluoromethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Trichloropropane[1,2,3-]	3.17E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
3	Trimethylbenzene[1,2,4-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Trimethylbenzene[1,3,5-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Vinyl Chloride	3.17E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
3	Xylene[1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	8.08E+02	FALSE	N/A	FALSE
3	Xylene[1,3-]+Xylene[1,4-]	6.34E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
4	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.74E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Heptachlorodibenzodioxins (Total)**	**6.18E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Heptachlorodibenzofurans (Total)**	**5.37E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.40E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.94E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Tetrachlorodibenzodioxin[2,3,7,8-]	9.94E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
4	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.79E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
4	**Tetrachlorodibenzofurans (Totals)**	**3.36E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Aluminum**	**2.30E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Antimony	3.16E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
4	**Arsenic**	**1.30E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
4	**Barium**	**2.58E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
4	**Beryllium**	**2.47E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
4	Cadmium	9.58E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
4	**Calcium**	**3.29E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
4	**Chromium**	**6.17E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
4	**Cobalt**	**2.83E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
4	**Copper**	**1.29E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	FALSE
4	**Iron**	**7.68E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
4	**Lead**	**4.13E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
4	**Magnesium**	**1.39E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
4	**Manganese**	**1.19E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
4	Mercury	3.66E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
4	**Nickel**	**6.65E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
4	**Potassium**	**4.45E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
4	**Selenium**	**5.59E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
4	**Silver**	**1.81E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
4	**Sodium**	**4.73E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
4	Thallium	1.36E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
4	**Vanadium**	**1.49E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
4	**Zinc**	**1.85E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
4	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
4	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
4	**HMX**	**1.58E-01**	mg/kg	**Y**	J	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
4	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
4	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
4	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
4	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
4	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**RDX**	**6.08E-01**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
4	**TATB**	**1.48E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
4	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
4	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Perchlorate**	**1.31E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
4	**Gross alpha**	**9.87E+00**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Gross beta**	**2.25E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Plutonium-238	-2.04E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
4	Plutonium-239/240	-1.02E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
4	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
4	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
4	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
4	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
4	Benzoic Acid	1.69E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
4	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
4	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
4	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
4	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
4	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
4	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
4	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
4	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
4	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
4	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
4	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
4	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
4	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
4	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
4	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
4	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
4	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
4	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
4	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
4	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
4	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
4	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
4	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
4	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
4	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
4	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
4	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
4	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
4	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
4	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
4	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
4	Benzene	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
4	Bromobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bromochloromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bromodichloromethane	3.30E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
4	Bromoform	3.30E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Bromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
4	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
4	Butylbenzene[n-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Butylbenzene[sec-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Butylbenzene[tert-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
4	Carbon Tetrachloride	3.30E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
4	Chlorobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
4	Chlorodibromomethane	3.30E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Chloroethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
4	Chloroform	3.30E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
4	Chloromethane	3.30E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
4	Chlorotoluene[2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
4	Chlorotoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dibromo-3-Chloropropane[1,2-]	4.96E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
4	Dibromoethane[1,2-]	3.30E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
4	Dibromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
4	Dichlorobenzene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
4	Dichlorobenzene[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichlorobenzene[1,4-]	3.30E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
4	Dichlorodifluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
4	Dichloroethane[1,1-]	3.30E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
4	Dichloroethane[1,2-]	3.30E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
4	Dichloroethene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
4	Dichloroethene[cis-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
4	Dichloroethene[trans-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
4	Dichloropropane[1,2-]	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
4	Dichloropropane[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichloropropane[2,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichloropropene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Dichloropropene[cis-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichloropropene[trans-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Ethylbenzene	3.30E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
4	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Isopropylbenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
4	Isopropyltoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
4	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
4	Propylbenzene[1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Styrene	3.30E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
4	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Tetrachloroethane[1,1,1,2-]	3.30E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
4	Tetrachloroethane[1,1,2,2-]	3.30E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
4	Tetrachloroethene	3.30E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
4	Toluene	3.30E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
4	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
4	Trichloroethane[1,1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
4	Trichloroethane[1,1,2-]	3.30E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
4	Trichloroethene	3.30E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
4	Trichlorofluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Trichloropropane[1,2,3-]	3.30E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
4	Trimethylbenzene[1,2,4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Trimethylbenzene[1,3,5-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Vinyl Chloride	3.30E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
4	Xylene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	8.09E+02	FALSE	N/A	FALSE
4	Xylene[1,3-]+Xylene[1,4-]	6.61E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
5	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**8.19E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Heptachlorodibenzodioxins (Total)**	**2.69E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**8.29E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1.00E-06	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzofuran[1,2,3,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzofuran[2,3,4,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetrachlorodibenzodioxin[2,3,7,8-]	1.00E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
5	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetrachlorodibenzofuran[2,3,7,8-]	2.36E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
5	**Tetrachlorodibenzofurans (Totals)**	**2.36E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Aluminum**	**3.16E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
5	Antimony	3.17E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
5	**Arsenic**	**1.17E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
5	**Barium**	**4.28E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
5	**Beryllium**	**2.68E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
5	Cadmium	9.60E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
5	**Calcium**	**4.04E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
5	**Chromium**	**1.01E+01**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
5	**Cobalt**	**4.49E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
5	**Copper**	**4.48E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
5	**Iron**	**1.29E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
5	**Lead**	**6.52E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
5	**Magnesium**	**1.74E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
5	**Manganese**	**1.90E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
5	Mercury	3.66E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
5	**Nickel**	**6.93E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
5	**Potassium**	**6.12E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
5	**Selenium**	**5.13E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
5	**Silver**	**4.14E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
5	**Sodium**	**9.85E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
5	Thallium	1.37E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
5	**Vanadium**	**2.90E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	N/A	FALSE
5	**Zinc**	**2.58E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
5	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
5	**HMX**	**3.79E-01**	mg/kg	**Y**	J	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
5	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
5	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
5	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
5	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
5	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**RDX**	**4.23E-01**	mg/kg	**Y**	J	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
5	**TATB**	**1.38E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
5	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
5	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Perchlorate**	**1.32E-02**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
5	**Gross alpha**	**1.38E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Gross beta**	**2.36E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Plutonium-238	-1.27E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
5	Plutonium-239/240	-8.49E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
5	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
5	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
5	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
5	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
5	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
5	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
5	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
5	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
5	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
5	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
5	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
5	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
5	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
5	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
5	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
5	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
5	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
5	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
5	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
5	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
5	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
5	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
5	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
5	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
5	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
5	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
5	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
5	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
5	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
5	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
5	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
5	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
5	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
5	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
5	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
5	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
5	Acetone	1.69E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
5	Benzene	3.37E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
5	Bromobenzene	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Bromochloromethane	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Bromodichloromethane	3.37E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
5	Bromoform	3.37E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Bromomethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
5	Butanone[2-]	1.69E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
5	Butylbenzene[n-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Butylbenzene[sec-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Butylbenzene[tert-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Carbon Disulfide	1.69E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
5	Carbon Tetrachloride	3.37E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
5	Chlorobenzene	3.37E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
5	Chlorodibromomethane	3.37E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Chloroethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
5	Chloroform	3.37E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
5	Chloromethane	3.37E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
5	Chlorotoluene[2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
5	Chlorotoluene[4-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Dibromo-3-Chloropropane[1,2-]	5.06E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
5	Dibromoethane[1,2-]	3.37E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
5	Dibromomethane	3.37E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
5	Dichlorobenzene[1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
5	Dichlorobenzene[1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorobenzene[1,4-]	3.37E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
5	Dichlorodifluoromethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
5	Dichloroethane[1,1-]	3.37E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
5	Dichloroethane[1,2-]	3.37E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
5	Dichloroethene[1,1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
5	Dichloroethene[cis-1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
5	Dichloroethene[trans-1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
5	Dichloropropane[1,2-]	3.37E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
5	Dichloropropane[1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropane[2,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropene[1,1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropene[cis-1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropene[trans-1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Ethylbenzene	3.37E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
5	Hexanone[2-]	1.69E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Iodomethane	1.69E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Isopropylbenzene	3.37E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
5	Isopropyltoluene[4-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Methyl-2-pentanone[4-]	1.69E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
5	Methylene Chloride	1.69E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
5	Propylbenzene[1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Styrene	3.37E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
5	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetrachloroethane[1,1,1,2-]	3.37E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
5	Tetrachloroethane[1,1,2,2-]	3.37E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
5	Tetrachloroethene	3.37E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
5	Toluene	3.37E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
5	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.69E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
5	Trichloroethane[1,1,1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
5	Trichloroethane[1,1,2-]	3.37E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
5	Trichloroethene	3.37E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
5	Trichlorofluoromethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Trichloropropane[1,2,3-]	3.37E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
5	Trimethylbenzene[1,2,4-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Trimethylbenzene[1,3,5-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Vinyl Chloride	3.37E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
5	Xylene[1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	8.20E+02	FALSE	N/A	FALSE
5	Xylene[1,3-]+Xylene[1,4-]	6.75E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
6	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.06E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Heptachlorodibenzodioxins (Total)**	**4.75E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.02E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.94E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Tetrachlorodibenzodioxin[2,3,7,8-]	9.94E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
6	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.87E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
6	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Aluminum**	**3.06E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
6	Antimony	3.15E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
6	**Arsenic**	**1.29E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
6	**Barium**	**4.59E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
6	**Beryllium**	**3.82E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
6	Cadmium	9.56E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
6	**Calcium**	**2.15E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	**Chromium**	**6.90E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
6	**Cobalt**	**8.44E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
6	**Copper**	**6.72E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
6	**Iron**	**8.05E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
6	**Lead**	**5.42E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
6	**Magnesium**	**1.09E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
6	**Manganese**	**1.46E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
6	Mercury	3.68E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
6	**Nickel**	**7.27E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
6	**Potassium**	**6.54E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
6	**Selenium**	**5.57E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
6	**Silver**	**3.31E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
6	**Sodium**	**5.90E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
6	Thallium	1.29E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
6	**Vanadium**	**1.66E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
6	**Zinc**	**2.08E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
6	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
6	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
6	**HMX**	**2.10E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
6	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
6	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
6	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
6	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
6	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**RDX**	**2.57E+00**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
6	**TATB**	**1.01E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
6	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
6	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Perchlorate**	**6.37E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
6	**Gross alpha**	**1.49E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	**Gross beta**	**2.86E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Plutonium-238	-7.06E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
6	Plutonium-239/240	-7.06E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
6	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
6	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
6	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
6	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
6	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Benzyl Alcohol**	**3.11E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
6	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
6	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
6	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
6	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
6	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
6	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
6	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
6	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
6	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
6	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
6	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
6	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
6	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
6	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
6	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
6	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
6	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
6	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
6	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
6	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
6	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Naphthalene**	**1.51E-02**	mg/kg	**Y**	J	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
6	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
6	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
6	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
6	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
6	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
6	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
6	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
6	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
6	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
6	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
6	Benzene	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
6	Bromobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Bromochloromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	Bromodichloromethane	3.29E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
6	Bromoform	3.29E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Bromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
6	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
6	Butylbenzene[n-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Butylbenzene[sec-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Butylbenzene[tert-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
6	Carbon Tetrachloride	3.29E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
6	Chlorobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
6	Chlorodibromomethane	3.29E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Chloroethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
6	Chloroform	3.29E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
6	Chloromethane	3.29E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
6	Chlorotoluene[2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
6	Chlorotoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dibromo-3-Chloropropane[1,2-]	4.94E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
6	Dibromoethane[1,2-]	3.29E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
6	Dibromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
6	Dichlorobenzene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
6	Dichlorobenzene[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorobenzene[1,4-]	3.29E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
6	Dichlorodifluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
6	Dichloroethane[1,1-]	3.29E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
6	Dichloroethane[1,2-]	3.29E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
6	Dichloroethene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
6	Dichloroethene[cis-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
6	Dichloroethene[trans-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
6	Dichloropropane[1,2-]	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
6	Dichloropropane[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropane[2,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropene[cis-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropene[trans-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Ethylbenzene	3.29E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
6	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Isopropylbenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	Isopropyltoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
6	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
6	Propylbenzene[1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Styrene	3.29E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
6	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Tetrachloroethane[1,1,1,2-]	3.29E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
6	Tetrachloroethane[1,1,2,2-]	3.29E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
6	Tetrachloroethene	3.29E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
6	**Toluene**	**3.95E-04**	mg/kg	**Y**	J	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
6	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
6	Trichloroethane[1,1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
6	Trichloroethane[1,1,2-]	3.29E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
6	Trichloroethene	3.29E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
6	Trichlorofluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Trichloropropane[1,2,3-]	3.29E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
6	Trimethylbenzene[1,2,4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Trimethylbenzene[1,3,5-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Vinyl Chloride	3.29E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
6	Xylene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	8.10E+02	FALSE	N/A	FALSE
6	Xylene[1,3-]+Xylene[1,4-]	6.59E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
7	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.11E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Heptachlorodibenzodioxins (Total)**	**2.68E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.01E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.95E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
7	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.71E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
7	**Tetrachlorodibenzofurans (Totals)**	**1.71E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Aluminum**	**3.76E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
7	Antimony	3.08E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
7	**Arsenic**	**1.44E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
7	**Barium**	**5.99E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
7	**Beryllium**	**4.53E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
7	Cadmium	9.32E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
7	**Calcium**	**2.24E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
7	**Chromium**	**6.86E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
7	**Cobalt**	**3.27E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
7	**Copper**	**9.02E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
7	**Iron**	**8.42E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
7	**Lead**	**6.49E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
7	**Magnesium**	**1.28E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
7	**Manganese**	**1.74E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
7	**Mercury**	**4.76E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
7	**Nickel**	**7.98E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
7	**Potassium**	**9.29E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
7	**Selenium**	**6.10E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
7	**Silver**	**2.19E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.91E+02	FALSE	1.00E+00	TRUE
7	**Sodium**	**5.98E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
7	Thallium	1.41E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
7	**Vanadium**	**1.64E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
7	**Zinc**	**2.53E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
7	2,4-Diamino-6-nitrotoluene	4.95E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	2,6-Diamino-4-nitrotoluene	6.53E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	3,5-Dinitroaniline	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
7	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
7	**HMX**	**9.78E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
7	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
7	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
7	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
7	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
7	PETN	2.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**RDX**	**2.49E+00**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
7	**TATB**	**1.13E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
7	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
7	Tris (o-cresyl) phosphate	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Perchlorate**	**2.01E-02**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
7	**Gross alpha**	**1.62E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Gross beta**	**2.49E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Plutonium-238	-2.62E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
7	Plutonium-239/240	-6.55E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
7	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
7	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
7	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
7	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
7	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
7	**Bis(2-ethylhexyl)phthalate**	**2.52E-01**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
7	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
7	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
7	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
7	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
7	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
7	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
7	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
7	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
7	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
7	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
7	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
7	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
7	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
7	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
7	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
7	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
7	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
7	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
7	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
7	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
7	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
7	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
7	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
7	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
7	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
7	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
7	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
7	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
7	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
7	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
7	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
7	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
7	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
7	Benzene	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
7	Bromobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bromochloromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bromodichloromethane	3.30E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
7	Bromoform	3.30E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Bromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
7	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
7	Butylbenzene[n-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Butylbenzene[sec-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Butylbenzene[tert-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
7	Carbon Tetrachloride	3.30E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
7	Chlorobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
7	Chlorodibromomethane	3.30E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Chloroethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
7	Chloroform	3.30E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
7	Chloromethane	3.30E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
7	Chlorotoluene[2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
7	Chlorotoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dibromo-3-Chloropropane[1,2-]	4.95E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
7	Dibromoethane[1,2-]	3.30E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
7	Dibromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
7	Dichlorobenzene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
7	Dichlorobenzene[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorobenzene[1,4-]	3.30E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Dichlorodifluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
7	Dichloroethane[1,1-]	3.30E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
7	Dichloroethane[1,2-]	3.30E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
7	Dichloroethene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
7	Dichloroethene[cis-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
7	Dichloroethene[trans-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
7	Dichloropropane[1,2-]	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
7	Dichloropropane[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropane[2,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropene[cis-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropene[trans-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Ethylbenzene	3.30E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
7	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Isopropylbenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
7	Isopropyltoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
7	**Methylene Chloride**	**3.51E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
7	Propylbenzene[1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Styrene	3.30E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
7	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Tetrachloroethane[1,1,1,2-]	3.30E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
7	Tetrachloroethane[1,1,2,2-]	3.30E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
7	Tetrachloroethene	3.30E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
7	Toluene	3.30E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
7	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
7	Trichloroethane[1,1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
7	Trichloroethane[1,1,2-]	3.30E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
7	Trichloroethene	3.30E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
7	Trichlorofluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Trichloropropane[1,2,3-]	3.30E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
7	Trimethylbenzene[1,2,4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Trimethylbenzene[1,3,5-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Vinyl Chloride	3.30E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
7	Xylene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	8.11E+02	FALSE	N/A	FALSE
7	Xylene[1,3-]+Xylene[1,4-]	6.61E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**4.67E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Heptachlorodibenzodioxins (Total)**	**3.56E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Heptachlorodibenzofurans (Total)**	**8.79E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Hexachlorodibenzodioxins (Total)**	**1.46E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**4.30E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.33E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzofuran[1,2,3,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzofuran[2,3,4,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Tetrachlorodibenzodioxin[2,3,7,8-]	9.99E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
8	**Tetrachlorodibenzodioxins (Total)**	**2.42E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.44E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
8	**Tetrachlorodibenzofurans (Totals)**	**3.04E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Aluminum**	**4.14E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
8	Antimony	3.18E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
8	**Arsenic**	**1.63E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
8	**Barium**	**8.20E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
8	**Beryllium**	**5.30E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
8	Cadmium	9.64E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
8	**Calcium**	**2.62E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
8	**Chromium**	**6.67E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
8	**Cobalt**	**3.74E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
8	**Copper**	**3.72E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
8	**Iron**	**9.21E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
8	**Lead**	**8.26E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
8	**Magnesium**	**1.27E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	**Manganese**	**2.05E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
8	Mercury	3.96E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
8	**Nickel**	**6.45E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
8	**Potassium**	**1.26E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
8	**Selenium**	**7.73E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
8	**Silver**	**2.57E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
8	**Sodium**	**5.09E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
8	Thallium	1.37E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
8	**Vanadium**	**1.69E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
8	**Zinc**	**2.89E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
8	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
8	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
8	**HMX**	**5.91E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
8	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
8	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
8	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
8	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
8	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**RDX**	**4.76E+00**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
8	**TATB**	**1.62E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
8	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
8	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Perchlorate**	**2.96E-02**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
8	**Gross alpha**	**1.50E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Gross beta**	**2.98E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Plutonium-238	-3.05E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
8	Plutonium-239/240	-1.52E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
8	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
8	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
8	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
8	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
8	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
8	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
8	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
8	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
8	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
8	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
8	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
8	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
8	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
8	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
8	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
8	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
8	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
8	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
8	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
8	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
8	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
8	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
8	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
8	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
8	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
8	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
8	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
8	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
8	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
8	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
8	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
8	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
8	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
8	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
8	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
8	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
8	Benzene	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
8	Bromobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bromochloromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bromodichloromethane	3.23E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
8	Bromoform	3.23E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Bromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
8	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
8	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Butylbenzene[tert-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
8	Carbon Tetrachloride	3.23E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
8	Chlorobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
8	Chlorodibromomethane	3.23E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Chloroethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
8	Chloroform	3.23E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
8	Chloromethane	3.23E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
8	Chlorotoluene[2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
8	Chlorotoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dibromo-3-Chloropropane[1,2-]	4.85E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
8	Dibromoethane[1,2-]	3.23E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
8	Dibromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
8	Dichlorobenzene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
8	Dichlorobenzene[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorobenzene[1,4-]	3.23E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
8	Dichlorodifluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
8	Dichloroethane[1,1-]	3.23E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
8	Dichloroethane[1,2-]	3.23E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
8	Dichloroethene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
8	Dichloroethene[cis-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
8	Dichloroethene[trans-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
8	Dichloropropane[1,2-]	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
8	Dichloropropane[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropane[2,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropene[cis-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropene[trans-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Ethylbenzene	3.23E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
8	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Isopropylbenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
8	Isopropyltoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
8	**Methylene Chloride**	**4.70E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
8	Propylbenzene[1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Styrene	3.23E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
8	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Tetrachloroethane[1,1,1,2-]	3.23E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
8	Tetrachloroethane[1,1,2,2-]	3.23E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
8	Tetrachloroethene	3.23E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
8	**Toluene**	**5.63E-04**	mg/kg	**Y**	J	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
8	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
8	Trichloroethane[1,1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
8	Trichloroethane[1,1,2-]	3.23E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
8	Trichloroethene	3.23E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
8	Trichlorofluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Trichloropropane[1,2,3-]	3.23E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
8	Trimethylbenzene[1,2,4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Trimethylbenzene[1,3,5-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Vinyl Chloride	3.23E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
8	Xylene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	8.12E+02	FALSE	N/A	FALSE
8	Xylene[1,3-]+Xylene[1,4-]	6.48E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
9	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**2.20E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Heptachlorodibenzodioxins (Total)**	**1.75E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**3.44E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Heptachlorodibenzofurans (Total)**	**1.36E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**6.27E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Hexachlorodibenzodioxins (Total)**	**9.82E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Hexachlorodibenzofurans (Total)**	**3.52E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.82E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.01E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetrachlorodibenzodioxin[2,3,7,8-]	9.96E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetrachlorodibenzofuran[2,3,7,8-]	1.73E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
9	**Tetrachlorodibenzofurans (Totals)**	**1.55E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Aluminum**	**2.69E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
9	Antimony	3.25E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
9	**Arsenic**	**1.08E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
9	**Barium**	**7.05E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
9	**Beryllium**	**3.68E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
9	Cadmium	9.84E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
9	**Calcium**	**1.68E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
9	**Chromium**	**3.82E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
9	**Cobalt**	**2.28E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
9	**Copper**	**1.70E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
9	**Iron**	**6.94E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
9	**Lead**	**9.73E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
9	**Magnesium**	**8.53E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
9	**Manganese**	**2.10E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
9	Mercury	3.53E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
9	**Nickel**	**3.35E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
9	**Potassium**	**9.28E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
9	**Selenium**	**6.57E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
9	**Silver**	**1.58E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
9	**Sodium**	**4.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
9	Thallium	1.35E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
9	**Vanadium**	**9.50E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
9	**Zinc**	**3.69E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
9	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
9	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
9	HMX	1.48E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
9	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
9	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
9	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
9	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
9	**TATB**	**7.06E+00**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
9	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
9	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Perchlorate**	**3.21E-03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
9	**Gross alpha**	**2.10E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Gross beta**	**9.72E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Plutonium-238	1.32E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
9	Plutonium-239/240	-1.32E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
9	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
9	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
9	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(a)anthracene**	**1.98E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(a)pyrene**	**2.18E-02**	mg/kg	**Y**	J	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
9	**Benzo(b)fluoranthene**	**3.15E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(g,h,i)perylene**	**1.31E-02**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(k)fluoranthene**	**1.11E-02**	mg/kg	**Y**	J	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
9	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
9	**Bis(2-ethylhexyl)phthalate**	**1.16E+00**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
9	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
9	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Chrysene**	**1.88E-02**	mg/kg	**Y**	J	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
9	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
9	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
9	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
9	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
9	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
9	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
9	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
9	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
9	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
9	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
9	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
9	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
9	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Fluoranthene**	**3.38E-02**	mg/kg	**Y**	NQ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
9	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
9	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
9	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
9	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
9	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
9	**Indeno(1,2,3-cd)pyrene**	**1.31E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
9	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
9	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
9	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
9	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
9	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
9	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
9	**Phenanthrene**	**1.51E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
9	**Pyrene**	**3.12E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
9	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
9	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
9	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
9	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
9	Benzene	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
9	Bromobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bromochloromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bromodichloromethane	3.23E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
9	Bromoform	3.23E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Bromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
9	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
9	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Butylbenzene[tert-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
9	Carbon Tetrachloride	3.23E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
9	Chlorobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
9	Chlorodibromomethane	3.23E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Chloroethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
9	Chloroform	3.23E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
9	Chloromethane	3.23E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
9	Chlorotoluene[2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
9	Chlorotoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dibromo-3-Chloropropane[1,2-]	4.84E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
9	Dibromoethane[1,2-]	3.23E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
9	Dibromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
9	Dichlorobenzene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
9	Dichlorobenzene[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichlorobenzene[1,4-]	3.23E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
9	Dichlorodifluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
9	Dichloroethane[1,1-]	3.23E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
9	Dichloroethane[1,2-]	3.23E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
9	Dichloroethene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
9	Dichloroethene[cis-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
9	Dichloroethene[trans-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Dichloropropane[1,2-]	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
9	Dichloropropane[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropane[2,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropene[cis-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropene[trans-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Ethylbenzene	3.23E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
9	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Isopropylbenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
9	Isopropyltoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
9	**Methylene Chloride**	**5.73E-03**	mg/kg	**Y**	NQ	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
9	Propylbenzene[1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Styrene	3.23E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
9	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetrachloroethane[1,1,1,2-]	3.23E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
9	Tetrachloroethane[1,1,2,2-]	3.23E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
9	Tetrachloroethene	3.23E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
9	**Toluene**	**2.09E-03**	mg/kg	**Y**	NQ	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
9	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
9	Trichloroethane[1,1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
9	Trichloroethane[1,1,2-]	3.23E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
9	Trichloroethene	3.23E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
9	Trichlorofluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Trichloropropane[1,2,3-]	3.23E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
9	Trimethylbenzene[1,2,4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Trimethylbenzene[1,3,5-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Vinyl Chloride	3.23E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
9	Xylene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	8.13E+02	FALSE	N/A	FALSE
9	Xylene[1,3-]+Xylene[1,4-]	6.46E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
10	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**8.35E-06**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Heptachlorodibenzodioxins (Total)**	**2.44E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**1.29E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Heptachlorodibenzofurans (Total)**	**1.29E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Hexachlorodibenzodioxins (Total)**	**1.04E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Hexachlorodibenzofurans (Total)**	**1.36E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**6.93E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**3.95E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachlorodibenzodioxin[2,3,7,8-]	9.97E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
10	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachlorodibenzofuran[2,3,7,8-]	1.67E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Aluminum**	**3.30E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
10	Antimony	3.32E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
10	**Arsenic**	**2.28E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
10	**Barium**	**4.92E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
10	**Beryllium**	**5.88E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
10	Cadmium	1.01E-01	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
10	**Calcium**	**2.35E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
10	**Chromium**	**4.43E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
10	**Cobalt**	**2.77E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
10	**Copper**	**8.21E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	FALSE
10	**Iron**	**6.62E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
10	**Lead**	**6.38E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
10	**Magnesium**	**1.12E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
10	**Manganese**	**1.51E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
10	Mercury	3.71E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
10	**Nickel**	**8.01E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
10	**Potassium**	**6.99E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
10	**Selenium**	**9.37E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
10	**Silver**	**1.55E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	**Sodium**	**4.06E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
10	**Thallium**	**1.58E-01**	mg/kg	**Y**	J	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
10	**Vanadium**	**1.20E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
10	**Zinc**	**1.88E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
10	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
10	HMX	1.48E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
10	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
10	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
10	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
10	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
10	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
10	**TATB**	**3.93E+00**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
10	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
10	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Perchlorate**	**1.07E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
10	**Gross alpha**	**1.54E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Gross beta**	**2.94E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Plutonium-238	1.05E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
10	Plutonium-239/240	9.04E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
10	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
10	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
10	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
10	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
10	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(a)anthracene**	**1.04E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(a)anthracene**	**2.95E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Benzo(a)pyrene	1.01E-02	mg/kg	N	UJ	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
10	**Benzo(a)pyrene**	**2.72E-02**	mg/kg	**Y**	J-	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
10	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(b)fluoranthene**	**3.25E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(g,h,i)perylene**	**2.21E-02**	mg/kg	**Y**	J-	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(k)fluoranthene**	**1.48E-02**	mg/kg	**Y**	J-	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	UJ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	UJ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
10	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
10	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
10	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
10	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
10	**Chrysene**	**2.95E-02**	mg/kg	**Y**	J-	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
10	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
10	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
10	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
10	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
10	Diethylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
10	Diethylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
10	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
10	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
10	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Di-n-butylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	**Di-n-butylphthalate**	**3.29E-02**	mg/kg	**Y**	J-	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
10	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
10	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
10	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
10	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Fluoranthene**	**1.55E-02**	mg/kg	**Y**	J-	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	**Fluoranthene**	**5.33E-02**	mg/kg	**Y**	J-	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
10	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
10	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
10	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
10	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
10	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	**Indeno(1,2,3-cd)pyrene**	**2.05E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Isophorone	1.01E-01	mg/kg	N	UJ	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
10	Isophorone	1.01E-01	mg/kg	N	UJ	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
10	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
10	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
10	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
10	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
10	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
10	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
10	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
10	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
10	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
10	**Phenanthrene**	**1.14E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	**Phenanthrene**	**2.78E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
10	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
10	**Pyrene**	**1.51E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	**Pyrene**	**5.57E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
10	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
10	Benzene	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
10	Bromobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bromochloromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bromodichloromethane	3.30E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
10	Bromoform	3.30E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Bromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
10	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
10	Butylbenzene[n-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzene[sec-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzene[tert-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
10	Carbon Tetrachloride	3.30E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
10	Chlorobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
10	Chlorodibromomethane	3.30E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Chloroethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
10	Chloroform	3.30E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
10	Chloromethane	3.30E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
10	Chlorotoluene[2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
10	Chlorotoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dibromo-3-Chloropropane[1,2-]	4.95E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
10	Dibromoethane[1,2-]	3.30E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
10	Dibromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Dichlorobenzene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,4-]	3.30E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
10	Dichlorodifluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
10	Dichloroethane[1,1-]	3.30E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
10	Dichloroethane[1,2-]	3.30E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
10	Dichloroethene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
10	Dichloroethene[cis-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
10	Dichloroethene[trans-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
10	Dichloropropane[1,2-]	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
10	Dichloropropane[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropane[2,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropene[cis-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropene[trans-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Ethylbenzene	3.30E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
10	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Isopropylbenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
10	Isopropyltoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
10	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
10	Propylbenzene[1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Styrene	3.30E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
10	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachloroethane[1,1,1,2-]	3.30E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
10	Tetrachloroethane[1,1,2,2-]	3.30E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
10	Tetrachloroethene	3.30E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
10	Toluene	3.30E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
10	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
10	Trichloroethane[1,1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
10	Trichloroethane[1,1,2-]	3.30E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
10	Trichloroethene	3.30E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
10	Trichlorofluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Trichloropropane[1,2,3-]	3.30E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
10	Trimethylbenzene[1,2,4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Trimethylbenzene[1,3,5-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Vinyl Chloride	3.30E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
10	Xylene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	8.14E+02	FALSE	N/A	FALSE
10	Xylene[1,3-]+Xylene[1,4-]	6.61E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
11	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**4.84E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Heptachlorodibenzodioxins (Total)**	**1.54E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**4.02E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Heptachlorodibenzofurans (Total)**	**1.55E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxin[1,2,3,4,7,8-]**	**5.85E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**1.09E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxin[1,2,3,7,8,9-]**	**1.11E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxins (Total)**	**1.73E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzofurans (Total)**	**4.93E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**3.90E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.39E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Pentachlorodibenzodioxins (Total)**	**6.85E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Pentachlorodibenzofurans (Totals)**	**1.17E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetrachlorodibenzodioxin[2,3,7,8-]	1.05E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
11	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetrachlorodibenzofuran[2,3,7,8-]	2.19E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
11	**Tetrachlorodibenzofurans (Totals)**	**4.42E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Aluminum**	**3.54E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
11	Antimony	3.16E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
11	**Arsenic**	**1.47E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
11	**Barium**	**9.85E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
11	**Beryllium**	**4.43E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
11	Cadmium	9.57E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
11	**Calcium**	**2.05E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
11	**Chromium**	**4.93E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
11	**Cobalt**	**3.04E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
11	**Copper**	**2.10E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	**Iron**	**7.50E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
11	**Lead**	**1.44E+01**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
11	**Magnesium**	**1.14E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
11	**Manganese**	**1.95E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
11	**Mercury**	**5.90E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
11	**Nickel**	**4.85E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
11	**Potassium**	**1.16E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
11	**Selenium**	**5.83E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
11	**Silver**	**1.04E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.91E+02	FALSE	1.00E+00	TRUE
11	**Sodium**	**3.73E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
11	Thallium	1.30E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
11	**Vanadium**	**1.23E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
11	**Zinc**	**3.66E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
11	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
11	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
11	**HMX**	**1.26E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
11	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
11	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
11	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
11	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
11	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
11	**TATB**	**3.33E+00**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
11	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
11	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Perchlorate**	**4.16E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
11	**Gross alpha**	**2.26E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Gross beta**	**3.84E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Plutonium-238	5.70E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
11	Plutonium-239/240	1.71E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
11	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
11	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
11	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
11	Benzoic Acid	1.69E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Benzyl Alcohol**	**4.98E-01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
11	**Bis(2-ethylhexyl)phthalate**	**9.79E-01**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
11	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
11	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
11	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
11	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
11	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
11	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
11	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
11	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
11	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
11	**Di-n-butylphthalate**	**7.44E-01**	mg/kg	**Y**	NQ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
11	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
11	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
11	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
11	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
11	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
11	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
11	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
11	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
11	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
11	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
11	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
11	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
11	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
11	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
11	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
11	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
11	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
11	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
11	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
11	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
11	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
11	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
11	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
11	Benzene	3.31E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
11	Bromobenzene	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bromochloromethane	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bromodichloromethane	3.31E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
11	Bromoform	3.31E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Bromomethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
11	Butylbenzene[n-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Butylbenzene[sec-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Butylbenzene[tert-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
11	Carbon Tetrachloride	3.31E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
11	Chlorobenzene	3.31E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
11	Chlorodibromomethane	3.31E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Chloroethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
11	Chloroform	3.31E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
11	Chloromethane	3.31E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
11	Chlorotoluene[2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
11	Chlorotoluene[4-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dibromo-3-Chloropropane[1,2-]	4.96E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
11	Dibromoethane[1,2-]	3.31E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
11	Dibromomethane	3.31E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
11	Dichlorobenzene[1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
11	Dichlorobenzene[1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorobenzene[1,4-]	3.31E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
11	Dichlorodifluoromethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
11	Dichloroethane[1,1-]	3.31E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
11	Dichloroethane[1,2-]	3.31E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
11	Dichloroethene[1,1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
11	Dichloroethene[cis-1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
11	Dichloroethene[trans-1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
11	Dichloropropane[1,2-]	3.31E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
11	Dichloropropane[1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropane[2,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropene[1,1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropene[cis-1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropene[trans-1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Ethylbenzene	3.31E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
11	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Isopropylbenzene	3.31E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
11	Isopropyltoluene[4-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
11	**Methylene Chloride**	**4.68E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Propylbenzene[1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Styrene	3.31E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
11	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetrachloroethane[1,1,1,2-]	3.31E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
11	Tetrachloroethane[1,1,2,2-]	3.31E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
11	Tetrachloroethene	3.31E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
11	Toluene	3.31E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
11	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
11	Trichloroethane[1,1,1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
11	Trichloroethane[1,1,2-]	3.31E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
11	Trichloroethene	3.31E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
11	Trichlorofluoromethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Trichloropropane[1,2,3-]	3.31E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
11	Trimethylbenzene[1,2,4-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Trimethylbenzene[1,3,5-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Vinyl Chloride	3.31E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
11	Xylene[1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	8.15E+02	FALSE	N/A	FALSE
11	Xylene[1,3-]+Xylene[1,4-]	6.62E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
12	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.13E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Heptachlorodibenzodioxins (Total)**	**8.48E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**3.66E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Heptachlorodibenzofurans (Total)**	**1.80E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxin[1,2,3,4,7,8-]**	**6.79E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**1.45E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxin[1,2,3,7,8,9-]**	**9.91E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxins (Total)**	**5.36E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzofurans (Total)**	**1.49E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**9.20E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.63E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Pentachlorodibenzofurans (Totals)**	**7.66E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
12	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachlorodibenzofuran[2,3,7,8-]	1.59E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Aluminum**	**1.77E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
12	Antimony	3.08E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
12	**Arsenic**	**1.21E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
12	**Barium**	**4.87E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
12	**Beryllium**	**2.49E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
12	**Cadmium**	**2.80E-01**	mg/kg	**Y**	J	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
12	**Calcium**	**2.12E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
12	**Chromium**	**4.66E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
12	**Cobalt**	**2.42E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
12	**Copper**	**2.54E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
12	**Iron**	**6.51E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
12	**Lead**	**6.36E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
12	**Magnesium**	**1.19E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
12	**Manganese**	**1.19E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
12	**Mercury**	**7.75E-01**	mg/kg	**Y**	NQ	N/A	FALSE	2.38E+01	FALSE	1.00E-01	TRUE
12	**Nickel**	**7.38E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
12	**Potassium**	**4.31E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
12	**Selenium**	**5.18E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
12	**Silver**	**1.26E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
12	**Sodium**	**3.81E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
12	**Thallium**	**2.22E+00**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E-01	TRUE	7.30E-01	TRUE
12	**Vanadium**	**1.36E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
12	**Zinc**	**2.16E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
12	2,4-Diamino-6-nitrotoluene	5.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	2,6-Diamino-4-nitrotoluene	6.60E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	3,5-Dinitroaniline	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Amino-2,6-dinitrotoluene[4-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Amino-4,6-dinitrotoluene[2-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dinitrobenzene[1,3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dinitrotoluene[2,4-]	1.50E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
12	Dinitrotoluene[2,6-]	1.50E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
12	**HMX**	**8.52E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Nitrobenzene	1.50E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
12	Nitrotoluene[2-]	1.50E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
12	Nitrotoluene[3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
12	Nitrotoluene[4-]	1.50E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
12	PETN	2.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	RDX	1.50E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
12	**TATB**	**1.70E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetryl	1.50E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
12	Trinitrobenzene[1,3,5-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Trinitrotoluene[2,4,6-]	1.50E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
12	Tris (o-cresyl) phosphate	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Perchlorate	5.05E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
12	**Gross alpha**	**2.48E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Gross beta**	**3.52E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Plutonium-238	4.66E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
12	Plutonium-239/240	-1.09E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
12	Acenaphthene	1.02E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
12	Acenaphthylene	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Aniline	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Anthracene	1.02E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
12	Azobenzene	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Benzo(a)anthracene**	**1.15E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
12	**Benzo(a)pyrene**	**1.02E-02**	mg/kg	**Y**	J	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
12	**Benzo(b)fluoranthene**	**1.87E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
12	Benzo(g,h,i)perylene	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Benzo(k)fluoranthene	1.02E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
12	Benzoic Acid	1.70E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Benzyl Alcohol	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bis(2-chloroethoxy)methane	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bis(2-chloroethyl)ether	1.02E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
12	Bis(2-ethylhexyl)phthalate	1.02E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Bromophenyl-phenylether[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Butylbenzylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Chloro-3-methylphenol[4-]	1.36E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Chloroaniline[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Chloronaphthalene[2-]	1.02E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
12	Chlorophenol[2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
12	Chlorophenyl-phenyl[4-] Ether	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Chrysene	1.02E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
12	Dibenz(a,h)anthracene	1.02E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
12	Dibenzofuran	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorobenzene[1,2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
12	Dichlorobenzene[1,3-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorobenzene[1,4-]	1.02E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
12	Dichlorobenzidine[3,3'-]	1.02E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorophenol[2,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
12	Diethylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
12	Dimethyl Phthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
12	Dimethylphenol[2,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Di-n-butylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
12	Dinitro-2-methylphenol[4,6-]	1.02E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
12	Dinitrophenol[2,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
12	Dinitrotoluene[2,4-]	1.02E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
12	Dinitrotoluene[2,6-]	1.02E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
12	Di-n-octylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Diphenylamine	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Fluoranthene	1.02E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
12	Fluorene	1.02E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
12	Hexachlorobenzene	1.02E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
12	Hexachlorobutadiene	1.02E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
12	Hexachlorocyclopentadiene	1.02E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
12	Hexachloroethane	1.02E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
12	Indeno(1,2,3-cd)pyrene	1.02E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
12	Isophorone	1.02E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
12	Methylnaphthalene[2-]	1.02E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
12	Methylphenol[2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Methylphenol[3-,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Naphthalene	1.02E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
12	Nitroaniline[2-]	1.12E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitroaniline[3-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitroaniline[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitrobenzene	1.02E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
12	Nitrophenol[2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitrophenol[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitrosodimethylamine[N-]	1.02E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
12	Nitroso-di-n-propylamine[N-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Oxybis(1-chloropropane)[2,2'-]	1.02E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorophenol	1.02E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
12	Phenanthrene	1.02E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
12	Phenol	1.02E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
12	Pyrene	1.02E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
12	Pyridine	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Trichlorobenzene[1,2,4-]	1.02E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
12	Trichlorophenol[2,4,5-]	1.02E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
12	Trichlorophenol[2,4,6-]	1.02E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
12	Acetone	1.67E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
12	Benzene	3.33E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
12	Bromobenzene	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bromochloromethane	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bromodichloromethane	3.33E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
12	Bromoform	3.33E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Bromomethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
12	Butanone[2-]	1.67E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
12	Butylbenzene[n-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Butylbenzene[sec-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Butylbenzene[tert-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Carbon Disulfide	1.67E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
12	Carbon Tetrachloride	3.33E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
12	Chlorobenzene	3.33E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
12	Chlorodibromomethane	3.33E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Chloroethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
12	Chloroform	3.33E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
12	Chloromethane	3.33E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
12	Chlorotoluene[2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
12	Chlorotoluene[4-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dibromo-3-Chloropropane[1,2-]	5.00E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
12	Dibromoethane[1,2-]	3.33E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
12	Dibromomethane	3.33E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
12	Dichlorobenzene[1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
12	Dichlorobenzene[1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorobenzene[1,4-]	3.33E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
12	Dichlorodifluoromethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
12	Dichloroethane[1,1-]	3.33E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
12	Dichloroethane[1,2-]	3.33E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Dichloroethene[1,1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
12	Dichloroethene[cis-1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
12	Dichloroethene[trans-1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
12	Dichloropropane[1,2-]	3.33E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
12	Dichloropropane[1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropane[2,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropene[1,1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropene[cis-1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropene[trans-1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Ethylbenzene	3.33E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
12	Hexanone[2-]	1.67E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Iodomethane	1.67E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Isopropylbenzene	3.33E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
12	Isopropyltoluene[4-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Methyl-2-pentanone[4-]	1.67E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
12	Methylene Chloride	1.67E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
12	Propylbenzene[1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Styrene	3.33E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
12	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachloroethane[1,1,1,2-]	3.33E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
12	Tetrachloroethane[1,1,2,2-]	3.33E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
12	Tetrachloroethene	3.33E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
12	Toluene	3.33E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
12	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.67E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
12	Trichloroethane[1,1,1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
12	Trichloroethane[1,1,2-]	3.33E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
12	Trichloroethene	3.33E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
12	Trichlorofluoromethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Trichloropropane[1,2,3-]	3.33E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
12	Trimethylbenzene[1,2,4-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Trimethylbenzene[1,3,5-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Vinyl Chloride	3.33E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
12	Xylene[1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	8.16E+02	FALSE	N/A	FALSE
12	Xylene[1,3-]+Xylene[1,4-]	6.67E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
13	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**4.70E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Heptachlorodibenzodioxins (Total)**	**1.52E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**2.48E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Heptachlorodibenzofurans (Total)**	**1.03E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**8.22E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzodioxin[1,2,3,7,8,9-]**	**6.55E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzodioxins (Total)**	**1.08E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzofurans (Total)**	**3.10E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**3.40E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**8.97E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Pentachlorodibenzofurans (Totals)**	**6.71E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Pentachlorodibenzofurans (Totals)**	**6.71E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
13	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetrachlorodibenzofuran[2,3,7,8-]	2.51E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
13	**Tetrachlorodibenzofurans (Totals)**	**2.51E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Aluminum**	**1.90E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
13	Antimony	3.09E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
13	**Arsenic**	**1.45E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
13	**Barium**	**6.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
13	**Beryllium**	**2.08E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
13	**Cadmium**	**4.67E-01**	mg/kg	**Y**	J	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	TRUE
13	**Calcium**	**3.43E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
13	**Chromium**	**6.10E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
13	**Cobalt**	**2.90E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
13	**Copper**	**2.79E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
13	**Iron**	**7.73E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
13	**Lead**	**6.96E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
13	**Magnesium**	**1.48E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
13	**Manganese**	**1.19E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
13	**Mercury**	**4.67E-02**	mg/kg	**Y**	NQ	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
13	**Nickel**	**5.52E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	**Potassium**	**3.58E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
13	**Selenium**	**5.48E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
13	**Silver**	**2.00E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
13	**Sodium**	**6.60E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
13	**Thallium**	**2.82E-01**	mg/kg	**Y**	J	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
13	**Vanadium**	**1.69E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
13	**Zinc**	**2.41E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
13	2,4-Diamino-6-nitrotoluene	5.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	2,6-Diamino-4-nitrotoluene	6.60E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	3,5-Dinitroaniline	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Amino-2,6-dinitrotoluene[4-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Amino-4,6-dinitrotoluene[2-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dinitrobenzene[1,3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dinitrotoluene[2,4-]	1.50E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
13	Dinitrotoluene[2,6-]	1.50E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
13	**HMX**	**3.87E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
13	Nitrobenzene	1.50E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
13	Nitrotoluene[2-]	1.50E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
13	Nitrotoluene[3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
13	Nitrotoluene[4-]	1.50E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
13	PETN	2.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**RDX**	**1.96E-01**	mg/kg	**Y**	J	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
13	**TATB**	**1.42E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetryl	1.50E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
13	Trinitrobenzene[1,3,5-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Trinitrotoluene[2,4,6-]	1.50E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
13	Tris (o-cresyl) phosphate	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Perchlorate**	**5.72E-04**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
13	**Gross alpha**	**1.94E+01**	pCi/g	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Gross beta**	**3.32E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Plutonium-238	4.61E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
13	Plutonium-239/240	7.67E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
13	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
13	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
13	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
13	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
13	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
13	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
13	**Bis(2-ethylhexyl)phthalate**	**1.91E-01**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
13	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
13	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
13	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
13	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
13	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
13	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
13	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
13	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
13	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
13	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
13	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
13	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
13	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
13	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
13	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
13	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
13	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
13	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
13	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
13	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
13	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
13	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
13	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
13	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
13	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
13	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
13	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
13	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
13	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
13	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
13	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
13	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
13	Benzene	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
13	Bromobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bromochloromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bromodichloromethane	3.29E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
13	Bromoform	3.29E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Bromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
13	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
13	Butylbenzene[n-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Butylbenzene[sec-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Butylbenzene[tert-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
13	Carbon Tetrachloride	3.29E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Chlorobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
13	Chlorodibromomethane	3.29E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Chloroethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
13	Chloroform	3.29E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
13	Chloromethane	3.29E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
13	Chlorotoluene[2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
13	Chlorotoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dibromo-3-Chloropropane[1,2-]	4.94E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
13	Dibromoethane[1,2-]	3.29E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
13	Dibromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
13	Dichlorobenzene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
13	Dichlorobenzene[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorobenzene[1,4-]	3.29E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
13	Dichlorodifluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
13	Dichloroethane[1,1-]	3.29E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
13	Dichloroethane[1,2-]	3.29E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
13	Dichloroethene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
13	Dichloroethene[cis-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
13	Dichloroethene[trans-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
13	Dichloropropane[1,2-]	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
13	Dichloropropane[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropane[2,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropene[cis-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropene[trans-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Ethylbenzene	3.29E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
13	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Isopropylbenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
13	Isopropyltoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
13	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
13	Propylbenzene[1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Styrene	3.29E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
13	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetrachloroethane[1,1,1,2-]	3.29E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
13	Tetrachloroethane[1,1,2,2-]	3.29E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Tetrachloroethene	3.29E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
13	Toluene	3.29E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
13	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
13	Trichloroethane[1,1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
13	Trichloroethane[1,1,2-]	3.29E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
13	Trichloroethene	3.29E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
13	Trichlorofluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Trichloropropane[1,2,3-]	3.29E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
13	Trimethylbenzene[1,2,4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Trimethylbenzene[1,3,5-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Vinyl Chloride	3.29E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
13	Xylene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	8.17E+02	FALSE	N/A	FALSE
13	Xylene[1,3-]+Xylene[1,4-]	6.59E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
14	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.59E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Heptachlorodibenzodioxins (Total)**	**5.98E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**9.11E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Heptachlorodibenzofurans (Total)**	**2.52E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Hexachlorodibenzodioxins (Total)**	**2.77E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Hexachlorodibenzofurans (Total)**	**7.43E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.14E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**2.47E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzofuran[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzofuran[2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachlorodibenzodioxin[2,3,7,8-]	9.99E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
14	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachlorodibenzofuran[2,3,7,8-]	1.78E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	**Aluminum**	**2.46E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
14	Antimony	3.20E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
14	**Arsenic**	**1.19E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
14	**Barium**	**5.56E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
14	**Beryllium**	**2.13E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
14	**Cadmium**	**2.52E-01**	mg/kg	**Y**	J	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
14	**Calcium**	**3.17E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
14	**Chromium**	**8.55E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
14	**Cobalt**	**3.83E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
14	**Copper**	**2.77E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
14	**Iron**	**1.10E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
14	**Lead**	**9.29E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
14	**Magnesium**	**1.56E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
14	**Manganese**	**1.61E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
14	**Mercury**	**6.49E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
14	**Nickel**	**4.97E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
14	**Potassium**	**4.58E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
14	**Selenium**	**5.49E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
14	**Silver**	**3.26E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
14	**Sodium**	**6.90E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
14	Thallium	1.36E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
14	**Vanadium**	**2.38E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
14	**Zinc**	**5.32E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	TRUE
14	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
14	**HMX**	**1.01E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
14	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
14	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
14	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
14	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
14	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	RDX	1.49E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	**TATB**	**1.11E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
14	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
14	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Perchlorate	4.99E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
14	**Gross alpha**	**1.73E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Gross beta**	**3.01E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Plutonium-238	-1.29E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
14	Plutonium-239/240	6.44E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
14	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
14	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
14	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
14	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
14	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
14	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(a)anthracene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(a)anthracene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(a)pyrene	1.01E-02	mg/kg	N	UJ	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
14	Benzo(a)pyrene	1.01E-02	mg/kg	N	UJ	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
14	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	UJ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
14	**Bis(2-ethylhexyl)phthalate**	**2.55E-02**	mg/kg	**Y**	J-	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
14	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
14	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
14	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
14	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
14	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
14	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
14	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
14	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
14	Diethylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
14	**Diethylphthalate**	**1.44E-02**	mg/kg	**Y**	J-	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
14	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
14	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
14	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Di-n-butylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	**Di-n-butylphthalate**	**1.31E-02**	mg/kg	**Y**	J-	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
14	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
14	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
14	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
14	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Fluoranthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluoranthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
14	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
14	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
14	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
14	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
14	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
14	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Isophorone	1.01E-01	mg/kg	N	UJ	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
14	**Isophorone**	**3.24E-01**	mg/kg	**Y**	J-	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
14	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
14	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
14	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
14	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
14	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
14	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
14	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
14	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
14	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
14	Phenanthrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Phenanthrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
14	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
14	Pyrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Pyrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
14	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
14	Benzene	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
14	Bromobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bromochloromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Bromodichloromethane	3.29E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
14	Bromoform	3.29E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Bromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
14	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
14	Butylbenzene[n-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzene[sec-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzene[tert-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
14	Carbon Tetrachloride	3.29E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
14	Chlorobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
14	Chlorodibromomethane	3.29E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Chloroethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
14	Chloroform	3.29E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
14	Chloromethane	3.29E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
14	Chlorotoluene[2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
14	Chlorotoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dibromo-3-Chloropropane[1,2-]	4.94E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
14	Dibromoethane[1,2-]	3.29E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
14	Dibromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
14	Dichlorobenzene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,4-]	3.29E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
14	Dichlorodifluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
14	Dichloroethane[1,1-]	3.29E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
14	Dichloroethane[1,2-]	3.29E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
14	Dichloroethene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
14	Dichloroethene[cis-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
14	Dichloroethene[trans-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
14	Dichloropropane[1,2-]	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
14	Dichloropropane[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropane[2,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropene[cis-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropene[trans-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Ethylbenzene	3.29E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
14	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Isopropylbenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Isopropyltoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
14	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
14	Propylbenzene[1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Styrene	3.29E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
14	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachloroethane[1,1,1,2-]	3.29E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
14	Tetrachloroethane[1,1,2,2-]	3.29E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
14	Tetrachloroethene	3.29E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
14	Toluene	3.29E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
14	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
14	Trichloroethane[1,1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
14	Trichloroethane[1,1,2-]	3.29E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
14	Trichloroethene	3.29E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
14	Trichlorofluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Trichloropropane[1,2,3-]	3.29E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
14	Trimethylbenzene[1,2,4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Trimethylbenzene[1,3,5-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Vinyl Chloride	3.29E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
14	Xylene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	8.18E+02	FALSE	N/A	FALSE
14	Xylene[1,3-]+Xylene[1,4-]	6.59E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
15	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**7.51E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Heptachlorodibenzodioxins (Total)**	**1.67E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**5.49E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.93E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachlorodibenzodioxin[2,3,7,8-]	1.12E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
15	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachlorodibenzofuran[2,3,7,8-]	2.13E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Aluminum**	**2.90E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
15	Antimony	3.23E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
15	**Arsenic**	**1.41E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
15	**Barium**	**4.44E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
15	**Beryllium**	**3.31E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
15	Cadmium	9.77E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
15	**Calcium**	**2.28E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
15	**Chromium**	**7.33E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
15	**Cobalt**	**3.23E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
15	**Copper**	**2.30E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
15	**Iron**	**8.63E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
15	**Lead**	**5.39E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
15	**Magnesium**	**1.17E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
15	**Manganese**	**1.55E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
15	Mercury	3.83E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
15	**Nickel**	**7.63E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
15	**Potassium**	**6.91E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
15	**Selenium**	**5.71E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
15	**Silver**	**2.70E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
15	**Sodium**	**4.51E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
15	Thallium	1.41E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
15	**Vanadium**	**1.86E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
15	**Zinc**	**2.19E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
15	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
15	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
15	HMX	1.49E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
15	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
15	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
15	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
15	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
15	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	RDX	1.49E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
15	**TATB**	**1.26E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
15	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
15	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Perchlorate**	**1.10E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
15	**Gross alpha**	**1.52E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Gross beta**	**2.63E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Plutonium-238	4.88E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
15	Plutonium-239/240	-7.31E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
15	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
15	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
15	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
15	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
15	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Benzyl Alcohol**	**1.18E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
15	**Bis(2-ethylhexyl)phthalate**	**1.32E+00**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
15	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
15	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
15	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
15	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
15	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
15	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
15	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
15	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
15	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
15	**Di-n-butylphthalate**	**1.67E-01**	mg/kg	**Y**	NQ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
15	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
15	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
15	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
15	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
15	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
15	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
15	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
15	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
15	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
15	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
15	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
15	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
15	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
15	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
15	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
15	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
15	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
15	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
15	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
15	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
15	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
15	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
15	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
15	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
15	Benzene	3.24E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
15	Bromobenzene	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bromochloromethane	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bromodichloromethane	3.24E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
15	Bromoform	3.24E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Bromomethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
15	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
15	Butylbenzene[n-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Butylbenzene[sec-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Butylbenzene[tert-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
15	Carbon Tetrachloride	3.24E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
15	Chlorobenzene	3.24E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
15	Chlorodibromomethane	3.24E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Chloroethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
15	Chloroform	3.24E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
15	Chloromethane	3.24E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
15	Chlorotoluene[2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
15	Chlorotoluene[4-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dibromo-3-Chloropropane[1,2-]	4.87E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
15	Dibromoethane[1,2-]	3.24E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
15	Dibromomethane	3.24E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
15	Dichlorobenzene[1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
15	Dichlorobenzene[1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorobenzene[1,4-]	3.24E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Dichlorodifluoromethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
15	Dichloroethane[1,1-]	3.24E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
15	Dichloroethane[1,2-]	3.24E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
15	Dichloroethene[1,1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
15	Dichloroethene[cis-1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
15	Dichloroethene[trans-1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
15	Dichloropropane[1,2-]	3.24E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
15	Dichloropropane[1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropane[2,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropene[1,1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropene[cis-1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropene[trans-1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Ethylbenzene	3.24E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
15	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Isopropylbenzene	3.24E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
15	Isopropyltoluene[4-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
15	Methylene Chloride	1.62E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
15	Propylbenzene[1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Styrene	3.24E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
15	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachloroethane[1,1,1,2-]	3.24E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
15	Tetrachloroethane[1,1,2,2-]	3.24E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
15	Tetrachloroethene	3.24E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
15	Toluene	3.24E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
15	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
15	Trichloroethane[1,1,1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
15	Trichloroethane[1,1,2-]	3.24E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
15	Trichloroethene	3.24E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
15	Trichlorofluoromethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Trichloropropane[1,2,3-]	3.24E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
15	Trimethylbenzene[1,2,4-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Trimethylbenzene[1,3,5-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Vinyl Chloride	3.24E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
15	Xylene[1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	8.19E+02	FALSE	N/A	FALSE
15	Xylene[1,3-]+Xylene[1,4-]	6.49E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**6.82E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**4.56E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.94E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Tetrachlorodibenzodioxin[2,3,7,8-]	9.94E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
1 dup	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.75E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Tetrachlorodibenzofurans (Totals)**	**1.75E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Aluminum**	**2.19E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
1 dup	Antimony	3.16E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
1 dup	**Arsenic**	**1.44E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
1 dup	**Barium**	**2.70E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
1 dup	**Beryllium**	**2.68E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
1 dup	Cadmium	9.57E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
1 dup	**Calcium**	**5.74E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
1 dup	**Chromium**	**6.25E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
1 dup	**Cobalt**	**3.14E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
1 dup	**Copper**	**1.03E+02**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
1 dup	**Iron**	**9.24E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
1 dup	**Lead**	**4.00E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
1 dup	**Magnesium**	**1.34E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	**Manganese**	**1.42E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
1 dup	Mercury	3.53E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
1 dup	**Nickel**	**6.34E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
1 dup	**Potassium**	**3.90E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
1 dup	**Selenium**	**5.07E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
1 dup	**Silver**	**2.37E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
1 dup	**Sodium**	**4.71E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
1 dup	Thallium	1.34E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
1 dup	**Vanadium**	**2.09E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
1 dup	**Zinc**	**1.96E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
1 dup	2,4-Diamino-6-nitrotoluene	5.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	2,6-Diamino-4-nitrotoluene	6.60E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	3,5-Dinitroaniline	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Amino-2,6-dinitrotoluene[4-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Amino-4,6-dinitrotoluene[2-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dinitrobenzene[1,3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,4-]	1.50E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,6-]	1.50E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1 dup	**HMX**	**6.52E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
1 dup	Nitrobenzene	1.50E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1 dup	Nitrotoluene[2-]	1.50E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
1 dup	Nitrotoluene[3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
1 dup	Nitrotoluene[4-]	1.50E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
1 dup	PETN	2.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	RDX	1.50E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
1 dup	**TATB**	**1.16E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Tetryl	1.50E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1 dup	Trinitrobenzene[1,3,5-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Trinitrotoluene[2,4,6-]	1.50E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
1 dup	Tris (o-cresyl) phosphate	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Perchlorate	5.03E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
1 dup	**Gross alpha**	**9.73E+00**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Gross beta**	**2.04E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Plutonium-238	1.60E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
1 dup	Plutonium-239/240	-6.41E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
1 dup	Acenaphthene	1.00E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
1 dup	Acenaphthylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Aniline	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Anthracene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
1 dup	Azobenzene	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(a)anthracene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(a)pyrene	1.00E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
1 dup	Benzo(b)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(g,h,i)perylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(k)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzoic Acid	1.67E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzyl Alcohol	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bis(2-chloroethoxy)methane	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bis(2-chloroethyl)ether	1.00E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bis(2-ethylhexyl)phthalate	1.00E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Bromophenyl-phenylether[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Butylbenzylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chloroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chloronaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
1 dup	Chlorophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
1 dup	Chlorophenyl-phenyl[4-] Ether	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chrysene	1.00E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dibenz(a,h)anthracene	1.00E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dibenzofuran	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,4-]	1.00E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1 dup	Dichlorobenzidine[3,3'-]	1.00E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
1 dup	Diethylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
1 dup	Dimethyl Phthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
1 dup	Dimethylphenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Di-n-butylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1 dup	Dinitro-2-methylphenol[4,6-]	1.00E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
1 dup	Dinitrophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,4-]	1.00E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,6-]	1.00E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1 dup	Di-n-octylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Diphenylamine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Fluoranthene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Fluorene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
1 dup	Hexachlorobenzene	1.00E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
1 dup	Hexachlorobutadiene	1.00E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
1 dup	Hexachlorocyclopentadiene	1.00E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
1 dup	Hexachloroethane	1.00E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
1 dup	Indeno(1,2,3-cd)pyrene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Isophorone	1.00E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
1 dup	Methylnaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
1 dup	Methylphenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Methylphenol[3-,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Naphthalene	1.00E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
1 dup	Nitroaniline[2-]	1.10E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitroaniline[3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitrobenzene	1.00E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1 dup	Nitrophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitrophenol[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitrosodimethylamine[N-]	1.00E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
1 dup	Nitroso-di-n-propylamine[N-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Oxybis(1-chloropropane)[2,2'-]	1.00E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorophenol	1.00E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
1 dup	Phenanthrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1 dup	Phenol	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
1 dup	Pyrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1 dup	Pyridine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Trichlorobenzene[1,2,4-]	1.00E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
1 dup	Trichlorophenol[2,4,5-]	1.00E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1 dup	Trichlorophenol[2,4,6-]	1.00E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
1 dup	Acetone	1.58E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
1 dup	Benzene	3.16E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
1 dup	Bromobenzene	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bromochloromethane	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bromodichloromethane	3.16E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1 dup	Bromoform	3.16E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Bromomethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
1 dup	Butanone[2-]	1.58E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
1 dup	Butylbenzene[n-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Butylbenzene[sec-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Butylbenzene[tert-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Carbon Disulfide	1.58E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
1 dup	Carbon Tetrachloride	3.16E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
1 dup	Chlorobenzene	3.16E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
1 dup	Chlorodibromomethane	3.16E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Chloroethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
1 dup	Chloroform	3.16E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
1 dup	Chloromethane	3.16E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
1 dup	Chlorotoluene[2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
1 dup	Chlorotoluene[4-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dibromo-3-Chloropropane[1,2-]	4.74E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
1 dup	Dibromoethane[1,2-]	3.16E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
1 dup	Dibromomethane	3.16E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,4-]	3.16E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1 dup	Dichlorodifluoromethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
1 dup	Dichloroethane[1,1-]	3.16E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
1 dup	Dichloroethane[1,2-]	3.16E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
1 dup	Dichloroethene[1,1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
1 dup	Dichloroethene[cis-1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1 dup	Dichloroethene[trans-1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
1 dup	Dichloropropane[1,2-]	3.16E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
1 dup	Dichloropropane[1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropane[2,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropene[1,1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropene[cis-1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropene[trans-1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Ethylbenzene	3.16E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
1 dup	Hexanone[2-]	1.58E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Iodomethane	1.58E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Isopropylbenzene	3.16E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
1 dup	Isopropyltoluene[4-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Methyl-2-pentanone[4-]	1.58E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
1 dup	Methylene Chloride	1.58E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
1 dup	Propylbenzene[1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Styrene	3.16E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
1 dup	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Tetrachloroethane[1,1,1,2-]	3.16E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
1 dup	Tetrachloroethane[1,1,2,2-]	3.16E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1 dup	Tetrachloroethene	3.16E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
1 dup	Toluene	3.16E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
1 dup	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.58E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
1 dup	Trichloroethane[1,1,1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
1 dup	Trichloroethane[1,1,2-]	3.16E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
1 dup	Trichloroethene	3.16E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
1 dup	Trichlorofluoromethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Trichloropropane[1,2,3-]	3.16E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
1 dup	Trimethylbenzene[1,2,4-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Trimethylbenzene[1,3,5-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Vinyl Chloride	3.16E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
1 dup	Xylene[1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	8.06E+02	FALSE	N/A	FALSE
1 dup	Xylene[1,3-]+Xylene[1,4-]	6.33E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
Trip Blank	**Acetone**	**2.99E-02**	mg/kg	**Y**	NQ	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
Trip Blank	Benzene	3.20E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
Trip Blank	Bromobenzene	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Bromochloromethane	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Bromodichloromethane	3.20E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
Trip Blank	Bromoform	3.20E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
Trip Blank	Bromomethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
Trip Blank	**Butanone[2-]**	**3.03E-03**	mg/kg	**Y**	J	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
Trip Blank	Butylbenzene[n-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Butylbenzene[sec-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Butylbenzene[tert-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Carbon Disulfide	1.60E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
Trip Blank	Carbon Tetrachloride	3.20E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
Trip Blank	Chlorobenzene	3.20E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
Trip Blank	Chlorodibromomethane	3.20E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
Trip Blank	Chloroethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
Trip Blank	Chloroform	3.20E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
Trip Blank	Chloromethane	3.20E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
Trip Blank	Chlorotoluene[2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
Trip Blank	Chlorotoluene[4-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dibromo-3-Chloropropane[1,2-]	4.81E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
Trip Blank	Dibromoethane[1,2-]	3.20E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
Trip Blank	Dibromomethane	3.20E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
Trip Blank	Dichlorobenzene[1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
Trip Blank	Dichlorobenzene[1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichlorobenzene[1,4-]	3.20E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
Trip Blank	Dichlorodifluoromethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
Trip Blank	Dichloroethane[1,1-]	3.20E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
Trip Blank	Dichloroethane[1,2-]	3.20E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
Trip Blank	Dichloroethene[1,1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
Trip Blank	Dichloroethene[cis-1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
Trip Blank	Dichloroethene[trans-1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
Trip Blank	Dichloropropane[1,2-]	3.20E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
Trip Blank	Dichloropropane[1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropane[2,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropene[1,1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropene[cis-1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropene[trans-1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Ethylbenzene	3.20E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
Trip Blank	**Hexanone[2-]**	**1.71E-03**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Iodomethane	1.60E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Isopropylbenzene	3.20E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
Trip Blank	Isopropyltoluene[4-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Methyl-2-pentanone[4-]	1.60E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
Trip Blank	Methylene Chloride	1.60E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
Trip Blank	Propylbenzene[1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Styrene	3.20E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
Trip Blank	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Tetrachloroethane[1,1,1,2-]	3.20E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
Trip Blank	Tetrachloroethane[1,1,2,2-]	3.20E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
Trip Blank	Tetrachloroethene	3.20E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
Trip Blank	Toluene	3.20E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
Trip Blank	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.60E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
Trip Blank	Trichloroethane[1,1,1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
Trip Blank	Trichloroethane[1,1,2-]	3.20E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
Trip Blank	Trichloroethene	3.20E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
Trip Blank	Trichlorofluoromethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
Trip Blank	Trichloropropane[1,2,3-]	3.20E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
Trip Blank	Trimethylbenzene[1,2,4-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Trimethylbenzene[1,3,5-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
Trip Blank	Vinyl Chloride	3.20E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
Trip Blank	Xylene[1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	8.21E+02	FALSE	N/A	FALSE
Trip Blank	Xylene[1,3-]+Xylene[1,4-]	6.41E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE

BOLD TEXT Constituent detected above the detection limit, but below the select soil screening limit

Highlighted “TRUE” value – constituent detected above either the selected soil screening level or above the background value

Enclosure 1

Part B Permit Application for Renewal of the Los Alamos National Laboratory Hazardous Waste Facility Permit, Revision 1.0

Volume 2

EPA ID# NM0890010515

Includes:

Appendix 4, Supplements 4-1 through 4-5

Prepared by:

Los Alamos National Laboratory
Environmental Protection and Compliance Division
Los Alamos, New Mexico 87545

Appendix 4

Open Detonation and Open Burning Information

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APPENDIX 4: OPEN DETONATION AND OPEN BURNING INFORMATION

The information provided in this appendix is submitted to address the applicable miscellaneous treatment unit application requirements of Title 40 of the Code of Federal Regulations (40 CFR) 270.23; Part 264, Subpart X; and Part 265, Subpart P not otherwise addressed within Sections 1 through 8 of the Permit Renewal Application. This appendix provides additional descriptions, where necessary, of the open detonation and open burning treatment units located at Los Alamos National Laboratory.

4.1. OPEN DETONATION AND OPEN BURNING UNITS AT LOS ALAMOS NATIONAL LABORATORY

Locations and site plans for the open detonation units located at Technical Area (TA) 36 and 39, and the open burning treatment unit located at TA-16 are included within Section 4.1, *Description of Open Detonation Treatment Units*, and 5.1, *Description of Open Burning Treatment Unit* of the Permit Renewal Application. Operations, authorized wastes, and waste handling information is included in Section 4.0, *Open Detonation Treatment* and Section 5.0, *Open Burning Treatment*. The following sections and supplemental documents provide specific information necessary to satisfy the requirements of 40 CFR 270.23(a-e), in a more detailed manner than within the main portions of the Permit Renewal Application. A summary of design capacities for the units are included in Table 4-1.

4.2. CONTAINMENT SYSTEMS

To meet the requirements at 40 CFR 270.15(a) and 264.175, the Permittees will ensure that secondary containment is provided as required. Existing storm water controls are discussed within Section 4.12.1 and 5.12.1, *Containment Systems*. Upgrades at all three units have been implemented since the previous applications to better ensure that migration of storm water from units is prevented to the extent possible. Specific information regarding the requirements of 40 CFR 264.601, the effectiveness and reliability of containment, confinement, and collection systems and structures that are utilized to protect human health and the environment at the open detonation and open burning units are evaluated in Sections 4.18 and 5.16, *Environmental Performance Standards*. Specific supplemental information associated with the evaluations used to ensure protection of human health and the environment, are discussed in Appendix Section 4.4, *Environmental Performance Standards*, and included as Supplements 4-2 through 4-16.

4.3. ALTERNATIVES ASSESSMENT

To provide justification for the continued use of the open detonation and open burning treatment technologies at the Los Alamos National Laboratory, an assessment was developed that explores waste minimization efforts, operational practice changes, alternative technologies, and process efficiencies that have occurred to decrease the amount and types of waste that require treatment through open detonation and open burning activities. The evaluation is included as Supplement 4-1, *Assessment of Alternatives for Open Detonation and Open Burning Activities*.

4.4. ENVIRONMENTAL PERFORMANCE STANDARDS

As referenced in Sections 4.18 and 5.16, *Environmental Performance Standards* of this permit application there were multiple evaluations and assessments that needed to be conducted in order to provide information as required by 40 CFR 264.601 to ensure protection of human health and the environment. Evaluations that were

developed/revised for this Permit Renewal Application are summarized in Sections 4.18 and 5.16 of the Permit Renewal Application and are included as follows:

- Supplement 4-2, *Open Detonation Unit Groundwater Monitoring and Surface Drainage Information*
- Supplement 4-3, *Hybrid Air Modeling Analysis and Ecological and Health Risk Assessment for Open Burning and Open Detonation Operations at Los Alamos National Laboratory*
- Supplement 4-4, *Air Sampling at Open Detonation Units*
- Supplement 4-5, *Soil Sampling Results Summary Report for the Open Detonation Unit at Technical Area (TA) 36-8*
- Supplement 4-6, *Soil Sampling Results Summary Report for the Open Detonation Unit at Technical Area (TA) 39-6*
- Supplement 4-7, *Open Detonation Unit at Technical Area 36 Human Health and Ecological Risk-Screening Assessments*
- Supplement 4-8, *Open Detonation Unit at Technical Area 39 Human Health and Ecological Risk-Screening Assessments*
- Supplement 4-9, *Revision of 2011 Open Detonation Risk Assessment*
- Supplement 4-10, *Predicting and Controlling Noise from Detonation Activities*
- Supplement 4-11, *Open Burning Unit Groundwater Monitoring and Surface Drainage Information*
- Supplement 4-12, *Air Sampling at Open Burning Treatment Unit*
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- Supplement 4-14, *2018 Soil Sampling Results Summary Report For the Open Burning Unit at Technical Area (TA) 16-388 Flash Pad*
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4.5. FACILITY LOCATION STANDARDS

At the request of the NMED-HWB, seismic location standard information for the three interim status units (TA-16-388 Flash Pad, TA-36-8, and TA-39-6) is included as part of the Permittees' response to a letter received from the NMED-HWB on January 25, 2022. The seismic investigation demonstrates that there has been no direct evidence observed for Holocene faulting within the noted radius of the facility. The report is included as Supplement 4-16, *Revision 1: Seismic Location Standards Evaluation for Three Open Burning/Open Detonation Locations under Consideration for Permitting under the Resource Conservation and Recovery Act at Los Alamos National Laboratory: Technical Areas 16, 36, and 39*.

Table 4-1
Open Burning and Open Detonation Hazardous Waste Management Unit Summary

Hazardous Waste Management Unit	Maximum Capacity	Type of Unit	Area
TA-16-388 Flash Pad	200 pounds per day (lbs/day)	Open burning	484 square feet (ft^2)
TA-36-8 "Minie"	2000 lbs/day	Open detonation	150,000 ft^2
TA-39-6 "Point 6"	1000 lbs/day	Open detonation	1,600 ft^2

Supplement 4-1

Assessment of Alternatives for Open Detonation and Open Burning Activities

Revised Supplement 4-1 2024 Alternative Technology (Alt Tech) Evaluation

Supporting the Los Alamos National Laboratory Part B Permit Application for Renewal of the LANL Hazardous Waste Facility Permit

May 2024

Los Alamos NATIONAL LABORATORY

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Attachment 16 – Gaulker & Stanek 2021

Attachment 17 – Gaulker & Stanek 2022

EXECUTIVE SUMMARY

In connection with its Part B Permit Application for Renewal of the Los Alamos National Laboratory Hazardous Waste Facility Permit submitted to the New Mexico Environment Department – Hazardous Waste Bureau (NMED-HWB), the Los Alamos National Laboratory (Laboratory or LANL) seeks to permit three thermal treatment interim status hazardous waste management units (HWMUs), namely TA-16-388 (Flash Pad), TA-36-8 (Minie Site), and TA-39-6 (Point 6) (collectively the Units). In support of obtaining permit coverage for the Laboratory's thermal treatment Units, the Laboratory submits this Revised Supplement 4-1 – 2024 Alternative Technology (Alt Tech) Evaluation. The Alt Tech Evaluation evaluates whether safe alternative technologies are available to treat some or all of the explosives waste treated at the Laboratory's thermal treatment Units.

The Laboratory's thermal treatment Units safely and compliantly treat the Laboratory's specialized explosives waste in a manner protective of human health and the environment. Specialized explosives waste, which is waste having the potential to detonate, is generated in small volumes in connection with the Laboratory's vital national security missions, including mission-critical specialized explosives research, development, testing, evaluation, and post-manufacture work. Specialized explosives waste is highly energetic, heterogenous, and potentially unstable and unpredictable. Its treatment presents unique safety, transportation, and environmental protection considerations.

The Laboratory implements processes and technologies at its thermal treatment Units that result in the safe, highly controlled, and environmentally protective thermal treatment of the Laboratory's specialized explosives waste. Each thermal treatment is designed to completely combust or consume the waste and to prevent potential air emissions and surface or groundwater contamination. Emissions are monitored and sampling occurs. The thermal treatment operations produce no secondary waste stream and effectively produce no byproducts, residuals, or emissions. Site studies confirm no environmental impact from the Laboratory's thermal treatment operations. Through proactive pollution prevention and waste minimization efforts, moreover, the Laboratory has been able to reduce its present-day generation of explosives waste by over 80%. The Laboratory's thermal treatment operations are safe, highly controlled, and protective of human health and the environment.

The Alt Tech Evaluation evaluates whether safe alternative technologies are available to treat the Laboratory's specialized explosives waste. Although the open burning (OB) and open detonation (OD) of hazardous waste is generally prohibited, EPA regulations allow for the OB/OD of "waste explosives." 40 C.F.R. § 265.382. Specifically, 40 C.F.R. § 265.382 provides that the "[o]pen burning or open detonation of hazardous waste is prohibited *except* for the open burning and detonation of waste explosives." Waste explosives "include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment." *Id.* Under this exemption, the OB/OD treatment of waste explosives may occur, but it must occur "in a manner that does not threaten human health or the environment." *Id*. An evaluation of potentially safe and available alternative technologies can inform the analysis of the appropriateness of the OB/OD treatment of waste explosives. *See* EPA 2022(b).

The Alt Tech Evaluation first describes the Laboratory's thermal treatment Units and addresses the thermal treatment conducted at the Units. The thermal treatment conducted at the Flash Pad *is, itself, an alternative technology to* the OB/OD of explosives waste. The Laboratory's thermal treatment operations are highly controlled, efficient, designed to completely combust or consume the waste, monitored and sampled, and right sized for the Laboratory's specialized explosives waste. The Laboratory's thermal treatment operations are *nothing like* stereotypical OB/OD operations, which lack the controls needed for the efficient and complete combustion of wastes and the ability to control and monitor emissions.

The Alt Tech Evaluation then addresses the site-specific factors that must be considered in evaluating any potential alternative technology. These factors are generally encompassed within the concepts of operational safety, monitorability, and toxic byproducts. Site-specific factors of particular importance are: (1) the Laboratory's generation and treatment of *specialized* explosives waste; (2) safety; (3) the Laboratory's national security mission and its unique explosives expertise; and (4) byproducts (and protection of human health and the environment).

The Laboratory generates, in small volumes, explosives waste that is highly energetic and heterogenous, and that is potentially unstable and unpredictable (*i.e.*, *specialized* explosives waste). The specialized explosives waste presents unique treatment and safety considerations. The specialized explosives waste *is* capable of detonation (it is D003 waste characteristic for reactivity), but its exact morphology and properties are difficult to discern. It is *not susceptible to conventional assumptions* about the treatment of explosives waste. The Laboratory's thermal treatment Units are specifically designed to address the unique risks posed by, and to safely treat, the specialized explosives waste. Whether an alternative to the Laboratory's thermal treatment of specialized explosives waste is safe and available requires careful analysis of the unique treatment and safety considerations presented by specialized explosives waste.

Safety is of preeminent importance to the Laboratory. Safety considerations impact acutely not only the treatment of specialized explosives waste, but also its generation, handling, storage, and transportation. An alternative technology is not safe if it cannot address the unique risks posed by and safely treat specialized explosives waste. But an alternative technology is also not safe if it materially increases the handling or storage of the specialized explosives waste, or if off-site transport to the alternative technology is prohibited.

Safety determinations are made by explosives safety experts. The Laboratory is a Federally Funded Research and Development Center (FFRDC) and National Security Laboratory with national security missions and specialized expertise related to the research, development, testing, and evaluation of explosives. The Laboratory also conducts work supporting the United States nuclear weapons stockpile, which includes specialized expertise in explosives peculiar to nuclear weapons. The Laboratory's explosives expertise is specialized, unique, and relevant to this Alt Tech Evaluation.

The Laboratory thermally treats its specialized explosives waste in a manner protective of human health and the environment. With respect to byproducts, the Laboratory's Flash Pad thermal treatment Unit fits only incongruously into the definition of an open burn or open detonation unit.[1] Stereotypical OB/OD units "lack the controls needed for the efficient and complete combustion of wastes and the ability to control and measure the emissions of combustion products." EPA 2022(b); *see also* 40 C.F.R. § 260.10. All the Laboratory's thermal treatment Units, however, possess numerous controls, are designed and/or operated to efficiently and completely combust or consume the waste, and monitor for emissions. Various potential alternative technologies, in contrast, generate potentially toxic byproducts and secondary waste streams.

After addressing these site-specific factors, potential alternative technologies are identified, and an initial screening is conducted. The Alt Tech Evaluation is conducted on a waste stream-by-waste stream, technology-by-technology basis. Through initial screening, alternative technologies that may be potentially applicable treatment options are evaluated in greater detail. This more detailed analysis

[1] To facilitate compliance and to ensure its thermal treatment operations are protective of human health and the environment, the Laboratory has *presumed* its thermal treatment operations constitute OB and/or OD. The Laboratory's thermal treatment operations, however, are more appropriately identified as an alternative technology to OB and/or OD. The Laboratory reserves its right to argue that its thermal treatment operations do not constitute OB and/or OD.

focusses on whether a particular alternative technology is safe and available, while considering site-specific factors.

The Alt Tech Evaluation concludes that, at present, there are no safe alternative technologies available to treat the Laboratory's specialized explosives waste. The Laboratory's specialized explosives waste is treated at the thermal treatment Units safely, compliantly, and in a manner protective of human health and the environment. The Laboratory remains committed to continuing its proactive approach to pollution prevention and waste minimization, and to analyzing in the future potential alternative technologies that may one day be proven to safely, effectively, and in an environmentally protective manner treat the Laboratory's specialized explosives waste, considering site-specific factors.

1 Introduction

Los Alamos National Laboratory, by and through the U.S. Department of Energy (DOE), including its field offices, the National Nuclear Security Administration (NNSA) Los Alamos Field Office (NA-LA) and the DOE Office of Environmental Management (DOE-EM) Los Alamos Field Office (EM-LA), Triad National Security, LLC (Triad), and Newport News Nuclear BWXT-Los Alamos, LLC (N3B) (collectively, the Permittees) provide this *2024 Alternative Technology (Alt Tech) Evaluation* in support of the Part B Permit Application for Renewal of the Los Alamos National Laboratory Hazardous Waste Facility Permit submitted to the New Mexico Environment Department – Hazardous Waste Bureau (Permit Renewal Application).

The Laboratory is a Federally Funded Research and Development Center that has been operating for approximately 80 years in Northern New Mexico. Today, the Laboratory is a national security laboratory, as defined by 50 *United States Code* (U.S.C.) 2471, operated by a Management and Operating (M&O) contractor, Triad, on behalf of NNSA. The Laboratory is charged with missions related to high explosives research and development and, as an FFRDC, possesses special expertise in these materials. DOE also has a legacy waste remediation mission at LANL, which is executed by N3B on behalf of DOE-EM.

The Laboratory exists to support NNSA missions, which are established by law, including: (1) to enhance U.S. national security through the military application of nuclear energy; (2) to maintain and enhance the safety, reliability, and performance of the U.S. nuclear weapons stockpile, including the ability to design, produce, and test, in order to meet national security requirements; (3) to promote international nuclear safety and nonproliferation; (4) to reduce global danger from weapons of mass destruction; and (5) to support U.S. leadership in science and technology. NNSA missions are carried out in a manner that is consistent with the principles of: (1) protecting the environment; (2) safeguarding the safety and health of the public and of the workforce; and (3) ensuring the security of the nuclear weapons, nuclear material, and classified information. The Laboratory also does work for other federal agencies and partners with a wide variety of other entities.

To achieve the Laboratory's national security-related missions, the Laboratory must generate a very small volume of specialized explosives waste. Specialized explosives waste is unique, heterogenous, highly energetic, potentially unstable, and possesses properties, morphologies, or characteristics that are difficult to discern and can be unpredictable. The specialized explosives waste is capable of detonation (it is D003 waste characteristic for reactivity), and, in fact, risks deflagration transition to detonation if heated and confined.

Specialized explosives waste is treated on site via thermal treatment, either through open burning (OB) or open detonation (OD).[2] The Laboratory currently conducts thermal treatment at the Flash Pad located at Technical Area (TA) 16-388 (Flash Pad), the OD unit at TA-36-8 (Minie Site), and the OD unit at TA-39-6 (Point 6). The Laboratory implements processes and technologies at its thermal treatment Units that result in the safe, highly controlled, and environmentally protective thermal treatment of the Laboratory's specialized explosives waste. Since 1980, these thermal treatment units at the Laboratory have operated under the interim status requirements of the New Mexico Hazardous Waste Act (HWA) and 40 CFR Part

[2] For simplicity, the Laboratory refers to its thermal treatment operations as open burning (OB) (Flash Pad) or open detonation (OD) (Minie Site and Point 6). However, the Laboratory's thermal treatment operations only incongruously fit the definition of OB and/or OD. Stereotypical OB/OD units "lack the controls needed for the efficient and complete combustion of wastes and the ability to control and measure the emissions of combustion products." EPA 2022(b); *see also* 40 C.F.R. § 260.10. The Laboratory's Units, however, possess numerous controls, are designed to efficiently and completely combust the waste, and monitor for emissions. Please *see also* n. 1.

265, Subpart P. Interim status is a designation given to facilities in existence before 1980. Interim status units must follow requirements that apply until issuance of a final permit or unit closure.

The Permit Renewal Application seeks to permit the thermal treatment Units under LANL's Hazardous Waste Facility Permit (Permit), consistent with 40 CFR Part 264, Subpart X. In seeking to permit the thermal treatment Units, the Laboratory has submitted supporting documents and analysis, including evaluations of alternatives to OB and OD. Permittees included an Alternatives Assessment with their June 2020 Permit Renewal Application.[3] After several rounds of review, comments, and responses, including a revised Alternatives Assessment submitted in May 2022, the NMED-HWB requested that the Laboratory provide a revised and integrated permit package in support of the Permit Renewal Application. This Revised Supplement 4-1 – 2024 Alternative Technology (Alt Tech) Evaluation is provided as part of the revised and integrated permit package for the Permit Renewal Application.

This Alt Tech Evaluation analyzes whether there are alternative treatment technologies that are safe and available to treat the specialized explosives waste treated at the Units. Although the OB/OD of hazardous waste is generally prohibited, EPA regulations allow for the OB/OD of "waste explosives." 40 C.F.R. § 265.382. Specifically, 40 C.F.R. § 265.382 provides that the "[o]pen burning or open detonation of hazardous waste is prohibited *except* for the open burning and detonation of waste explosives." Waste explosives "include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment." *Id.* Under this exemption, the OB/OD treatment of waste explosives may occur, but it must occur "in a manner that does not threaten human health or the environment." *Id*. An evaluation of potentially safe and available alternative technologies can inform the analysis of the appropriateness of the OB/OD treatment of waste explosives. *See* EPA 2022(b).

This Alt Tech Evaluation has been prepared consistent with applicable regulatory requirements and administrative guidance issued for permitting OB/OD units, including the permitting requirements of the HWA and 40 CFR Parts 264 and 265, comments received from NMED-HWB, and formal and informal administrative guidance issued by EPA (Tetra Tech 2002, EPA 2022a, EPA 2022b, EPA 2022c).

To identify potential Alt Tech that may be available to treat the explosives waste currently treated at the Units, the Permittees also considered the reports published in 2019 by EPA and the National Academies of Sciences, Engineering, and Medicine (NASEM) regarding the potential availability of Alt Tech for explosives waste, the EPA's September 12, 2023 Compendium of Alternative Technologies to Open Burning and Open Detonation of Energetic Hazardous Wastes (EPA Compendium), as well as other sources of information on technologies developed for the treatment of explosives waste (EPA 2019, EPA 2023, NASEM 2019,). This Alt Tech Evaluation considers potentially available alternative treatment technologies on a waste-stream by waste-stream, alternative technology-by-technology basis.

As an initial consideration in evaluating Alt Tech, the Laboratory assessed whether the waste requiring treatment is explosives waste characteristic for reactivity (D003). *See* 40 C.F.R. §§ 261.23(a)(6-8) (characteristic of reactivity); 265.382 (defining waste explosives to "include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment"). The Laboratory's detailed waste characterization for each waste stream confirms that the waste is explosives waste that has the potential to detonate and is characteristic for reactivity (D003 waste). Further, the Laboratory identified, where applicable, the potential contaminants of concern, the amount of each waste, its chemical composition, its hazardous waste code, net explosive weight, and U.S. Department of Transportation hazard class.

[3] Assessments and re-assessments of alternative treatment technologies previously submitted by LANL to NMED-HWB include evaluations completed in 2002, 2007, 2011, 2013, and 2020.

The Laboratory's explosives waste, moreover, is *specialized* explosives waste. The specialized explosives waste is unique, heterogenous, highly energetic, and potentially unstable. Its exact morphology and properties are difficult to discern and can be unpredictable. It presents deflagration transition to detonation risks when heated and confined. The specialized explosives waste is not susceptible to conventional assumptions about the treatment of explosives waste, and what technology can treat this specialized explosives waste safely and in an environmentally protective manner requires careful analysis. Prompt treatment of the specialized explosives waste at the Units, moreover, is necessary to avoid uncontrolled or unanticipated detonation.

The Laboratory then considered the following factors when evaluating Alt Tech, consistent with applicable regulatory requirements and recent administrative guidance, as more specifically described below:

- Operational safety;
- Monitorability;
- Toxic by-products;
- Site specific factors, including safety;
- Transportation hazard potential;[4]
- Offsite treatment options; and
- Availability/feasibility of a potential Alt Tech.

This Alt Tech Evaluation concludes that, at this time, there is no Alt Tech that is safe and available that can treat the Laboratory's specialized explosives waste streams. Continued thermal treatment at the Units is the only safe mode of treatment currently available. Ongoing thermal treatment at the Units is also the most environmentally protective treatment approach at this time. The thermal treatment operations produce no secondary hazardous waste stream and effectively produce no byproducts, residuals, or emissions. Site studies confirm no environmental impact from the Laboratory's thermal treatment operations. The conclusions of this Alt Tech Evaluation reflect the specialized nature of the Laboratory's explosives waste streams, site-specific operational and safety factors, and considerations related to the Laboratory's national security-related missions.

As a general matter, current Alt Techs that are utilized for conventional munitions disposal are not safe for the Laboratory's specialized explosives waste because, among other reasons, they necessitate increased waste storage periods and/or waste handling, and fail to account for the specialized nature of the Laboratory's explosives waste. Implementing such Alt Tech at the Laboratory would violate the cardinal rule of explosives safety, which is to limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives, consistent with safe and efficient operations (DOE 2021). The Alt Tech would introduce significant and unnecessary additional health and safety risks to workers, the public, facilities, and the environment. The Alt Techs are unable to safely treat, or are of uncertain efficacy in safely treating (*i.e.*, they are unproven), the Laboratory's specialized explosives waste. Such Alt Techs are also unproven in treating the Laboratory's specialized explosives waste streams in an environmentally more protective way and would generally create toxic byproducts or secondary waste streams.

[4] When considering any Alt Tech, an important consideration is that the Laboratory's specialized explosives waste that is treated at the Units must be treated onsite because, among other reasons, transportation of explosives waste with indeterminate characteristics offsite on public roadways is illegal under federal law, would pose a large risk to the public and the environment, and could present a significant national security risk.

Supporting the conclusions of this Alt Tech Evaluation, and as set forth in the Permit Renewal Application and further below, the Units treat the specialized explosives waste in a manner that ensures protection of human health and the environment. *See* 40 C.F.R. § 264.601. The Units are located, designed, constructed, operated, maintained, and will be closed in a manner that ensures protection of human health and the environment. *See* Permit Renewal Application, Sections 4 and 5. The Units are designed to achieve complete combustion and do not generate secondary hazardous waste streams or toxic by-products. Treatment at the Units is controlled and monitored, and is proven to be a safe, effective, and environmentally protective method of treatment.

2 LANL's National Security Missions and Specialized Explosives Waste

The Laboratory's national security-related missions include supporting the annual assessment of the United States' nuclear weapons stockpile. As one of three national security laboratories, pursuant to 50 U.S.C. § 2525, LANL is required to conduct such annual assessments. To fulfill this mandate, the Laboratory performs assessment activities, including modeling and testing of weapons components. Historically, the reliability and effectiveness of the nuclear weapons stockpile was assessed through underground testing of nuclear weapons, including at the Nevada Test Site. Modern assessment activities, including those performed by the Laboratory, allow the NNSA to evaluate the reliability and effectiveness of the nuclear weapons stockpile without having to conduct underground nuclear weapons testing.

The Laboratory also performs national security-related missions involving explosives development, characterization, testing, modeling, and simulation. One of the most crucial of these missions is the manufacturing of Pentaerythritol tetranitrate (PETN) Detonators. The PETN Detonator is a critical component of the United States' nuclear weapons stockpile, and LANL is unique in its creation of this Detonator. The Laboratory's PETN Detonator research includes breaching or insulting the PETN Detonator with various stimuli including electrical, chemical, mechanical, thermal, impact, shock, and laser interactions to determine if a specific breach or insult causes detonation. The Laboratory is also responsible for manufacturing certain precision high explosives and for performing a variety of scientific experiments on energetic, hazardous, and complex system and subsystem components at various high explosives firing sites at LANL. This includes research on explosives detection technology and improvised explosive device (IED) detection and defeat. These vital research activities can generate specialized high explosives waste streams.

LANL also performs research and development on high[5] explosives specifically developed for nuclear weapon system applications. LANL-designed high explosives are normally significantly more energetic and sensitive to insult than conventional explosives and are many orders of magnitude more violent than modern propellants. The explosives materials developed at LANL are often Polymer Bonded eXplosives (PBX) that are specifically formulated to meet requirements such as energy output (metal pushing ability), structural integrity, machinability, thermal stability, as well as improved application specific safety considerations. The development, fabrication, and testing of PBXs are the primary feeders of the Laboratory's specialized explosives waste streams. By design, due to their application in nuclear weapons

[5] Chemical explosives may be divided into the categories of low explosives and high explosives. Low explosives can burn rather quickly but react subsonically (rather than supersonically) and are designed to *deflagrate*. An example of a low explosive is the black powder contained in fireworks. High explosives react much, much faster at supersonic scales and are designed to *detonate*. (McDonough 2017) Under Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE) regulations, for storage purposes the three classes of explosives are considered high explosives, low explosives, and blasting agents. 27 CFR 555.202. There are significant differences, moreover, between types of high explosives and their applications.7

systems, these specific PBX explosives are highly energetic and cannot be treated safely in confined environments due to the potential for transition from deflagration to detonation if heated and confined.

The Laboratory's research and development work and national security-related missions described above generate small volumes of specialized explosives waste that are unique, heterogenous, highly energetic, potentially unstable, and possess properties, morphologies, or characteristics that are difficult to discern or can be unpredictable.[6] For example, research and development work involves intentionally damaging or insulting high explosives with impact, electrical discharge, or high temperature. Intentionally damaging or insulting high explosives may change their morphology, which may increase the sensitivity and alter other characteristics of the explosives materials. Therefore, while the characteristics of an explosives materials may be understood prior to damage or insult, once the material has been subjected to insult, it may not be possible to reliably predict the behavior of that material. Accordingly, assumptions regarding the applicability and availability of alternative treatment technologies based on studies performed on conventional munitions and explosives waste, such as the 2019 EPA and NASEM reports and EPA Compendium, do not directly inform alternative treatment decisions for the specialized and intentionally altered or insulted high explosives and associated waste that the Laboratory generates.

Similarly, LANL's responsibilities with respect to the United States' nuclear weapons stockpile involve both the surveillance of high explosives in deployed systems and the development of new high explosives with improved physical properties. The Laboratory regularly investigates new high explosives materials, new formulations, and new precursor materials. Improvements in the characteristics of high explosives may change the way the explosive behaves, such as an improvement to the resilience of the high explosives when exposed to insults like temperature, mechanical impulse, or electrical discharge. Therefore, because LANL's waste includes specialized high explosives, conclusions about the applicability and availability of alternative treatment technologies derived from studies performed on conventional munitions and explosives do not necessarily inform alternative treatment decisions for the specialized high explosives and associated wastes generated at LANL.

The 2019 EPA and 2019 NASEM reports on potential alternative treatment technologies for OB/OD focus on treatment of conventional munitions and explosives waste and do not consider the specialized and unique explosives waste generated at LANL. However, the conclusions of this Alt Tech Evaluation are consistent with these EPA and NASEM reports, as well as recent guidance, which recognize that OB/OD treatment will remain the only safe mode of treatment for certain types of explosives waste. For example, EPA's 2022 policy memorandum on OB/OD treatment of waste explosives acknowledges that OB/OD treatment "will still be needed to treat waste explosives that do not yet have other safe modes of treatment." (EPA 2022b). Similarly, the NASEM report recognizes that for certain wastes, based on site-specific factors, "[t]he capability for OB/OD will always be needed." (NASEM 2019). The EPA further acknowledges the continued viability of OB/OD for the treatment of certain types of highly energetic explosives waste, stating that "even though there are many alternative treatment technologies today . . . OB/OD will remain as the only option for certain energetic hazardous wastes until additional viable alternatives are developed or existing technologies are modified or improved upon." (EPA 2019).

Similarly, EPA's Compendium of Alternative Technologies to Open Burning and Open Detonation of Energetic Hazardous Wastes recognizes that a "technology that has been identified or implemented for a

[6] The specialized explosives waste has the potential to detonate and is characteristic for reactivity (D003 waste). Reference to indiscernible or difficult to determine characteristics of the specialized explosives waste does not change this. Rather, this recognizes that while the specialized explosives waste has the potential to detonate and is characteristic for reactivity, how, when, and under what conditions the specialized explosives waste will detonate can be indiscernible, difficult to determine, or unpredictable. This is a key consideration in evaluating whether any alternative technology is safe and available.

particular waste stream at one facility may not be suitable for another facility with a similar waste stream," and this is "more likely at Research, Development, Test, and Evaluation facilities where standard formulations may have been modified resulting in increased sensitivity and explosive risk and perform stress testing that reduces explosives and munitions stability." (EPA 2023).

The specialized explosives waste generated by LANL is the type of waste that, because of its highly energetic and unstable nature and other site-specific factors, must be treated on-site at the Units. There are no Alt Techs or combination of technologies available that are proven to safely treat LANL's specialized explosives waste streams. The Units are the only safe and proven mode of treatment available.

3 Conceptual Approach to the Laboratory's Specialized Explosives Waste Management

The Laboratory's overall explosives waste management approach is based on the following hierarchy of consideration:

1. **Pollution prevention** and **waste minimization activities** are first identified and implemented to the maximum extent practicable, to avoid generating waste in the first place. When feasible, based on safety concerns, programmatic effectiveness, and other factors, the Laboratory strives to eliminate and/or reduce the volume of explosives waste that must be treated and disposed. For further discussion of these efforts, please see Section 6.0.
2. Explosives waste is next reviewed waste stream-by-waste stream to **identify candidates for offsite treatment.** The Laboratory identifies wastes that can be safely and legally transported offsite to permitted facilities for treatment and disposal. LANL continually tries to identify new opportunities for safe and legal offsite shipment of waste for treatment. Many of the specialized explosives waste generated at the Laboratory are considered uncharacterized,[7] new waste explosives under U.S. Department of Transportation (DOT) regulations and DOE safety and control standards and cannot be legally transported offsite for treatment and disposal. For further discussion, please see Section 7.4.
3. Only when waste generation cannot be avoided and no safe and available offsite treatment option is identified, is onsite treatment required. While the Laboratory safely and effectively treats specialized explosives waste streams onsite, subject matter experts continually work to evaluate whether safe alternative technologies are available to treat the specialized explosives waste currently treated at the Units.

4 Description of the Laboratory's Thermal Treatment Units

Only those specialized explosives waste that must be generated by the Laboratory and that cannot be shipped offsite or treated by other means are treated at either the Flash Pad, located at TA-16-388, or the OD units, located at TA-36-8 and TA-39-6.[8] In other words, the Units only treat those wastes that must be generated and treated onsite. While treatment can occur throughout the year, with many treatments occurring, the overall treatment volumes even on an annual basis are small.

[7] "Uncharacterized" in this context means a material whose hazard classification cannot be determined within the meaning of 49 CFR § 171.8 and 49 CFR § 173.56 (*i.e.*, is unclassified and unapproved). This is not a reference to "uncharacterized" waste within the meaning of 40 CFR § 262.11 under RCRA.

[8] The TA-36-8 OD unit is known as the Minie Site, and the TA-39-6 OD unit is known as Point 6.

4.1 The Flash Pad (TA-16-388)

The Flash Pad is located in the northeast corner of TA-16. TA-16 is a security area that is situated on a broad mesa that is bounded on the north by Canon de Valle, on the south by State Road 4, and on the west by West Jemez Road (State Road 501) and the Santa Fe National Forest. TA-16 elevations range from approximately 7,700 ft. at the west to approximately 6,800 ft. at the lower east end. Topography is varied, ranging from steep canyon walls to sloping mesa tops. Access into the security area can be gained only through controlled entry stations by persons possessing an appropriate security clearance and site-specific training. Entry into the secured area is controlled.

The Flash Pad is located in a remote high explosives exclusion area within TA-16 that has additional access controls. Entry into the high explosives exclusion area is controlled through an industrial fence, with access granted through an access control station or a locked access gate. Such access is tied to the individual's badge credentials and if a person lacks the requisite credentials to access the area, access is denied.

The Flash Pad is an engineered thermal treatment unit that utilizes a concrete pad and propane enhanced controlled open oxidation. The Flash Pad consists of a 22 by 22 foot (ft.) concrete pad located within an area that provides secondary containment to prevent hazardous constituents from leaving the area. The Flash Pad has a concrete base that is 12 inches (in.) thick. The entire concrete pad is over a 45-mil Hypalon liner, which is six inches below grade underneath the bottom of the pad, and the liner extends out 2 ft. from the pad perimeter and curves up to ground level on all four sides. Hypalon is a chlorosulfonated polyethylene synthetic rubber, exhibiting resistance to ultraviolet light, heat, and many chemicals (*e.g.*, ozone and oxidizing chemicals).

Along the two sides and back of the Flash Pad's concrete pad, and inset 12 in., is a 3 ft. high, eight-inch-thick concrete wall that prevents any potential runoff from leaving the Flash Pad. The area around the Flash Pad is relatively level. The Flash Pad is equipped with a retractable steel cover, which covers the area when the Flash Pad is not in use. Three 5 ft. long forced air propane burners provide the heat source for treatment activities at the Flash Pad. A chain-link fence and brick retaining wall surround the Flash Pad.

Figure 1: Los Alamos National Laboratory engineered Flash Pad

The Flash Pad is used exclusively for the controlled treatment of the Laboratory's specialized explosives waste—it is not used for any other activities. Once waste is placed on the Flash Pad for treatment, operations are controlled and monitored remotely from a control building.

The quantity and configuration of the material to be treated at the Flash Pad determines the number of burners used. Temperature and time are controlled for efficient and complete combustion. The burners provide adequate heat to bring the material being flashed to a temperature sufficient to destroy the explosives material and maintains a temperature sufficient to prevent formation of incomplete combustion products for the duration of the treatment. This minimizes potential emissions from combustion (*see, e.g.,* LANL 2020l at p. 5). The treatment of explosives waste at the Flash Pad does not create any measurable or modeled toxic by-products (*see, e.g.,* LANL 2020k, LANL 2020l at p. 5).

Operations at the Flash Pad require post-treatment visual surveys of the area in and around the Flash Pad and post-burn covering of the Flash Pad. This practice minimizes the potential for precipitation contacting residuals, should they exist. Residuals are very uncommon, and should they occur consist of non-hazardous ash residuals. Any residuals identified during post-treatment visual surveys are cleaned up, binned, and then disposed of as New Mexico Special Waste. Post-burn covering of the Flash Pad further reduces the chance of any residual migration off the Flash Pad.

Conservative air modeling conducted for the Flash Pad concluded that no ambient air-quality standards are exceed. Calculated air-concentration results were compared to the air-quality standards and the appropriate human health screening levels, where available, and the predicted impacts are all below the appropriate screening levels. Additionally, predicted soil deposition (over a 10-year period) demonstrates that added impacts to soil concentrations are less than the human health and ecological screening levels. Air monitoring conducted in 2011 and 2022 indicate the operations monitored did not exceed any appropriate state or federal levels specified for the analytes monitored.

In 2022 and 2023, at the Flash Pad, the average quantity per treatment was approximately 40 lbs. Most treatment events are conducted in the morning when the wind is generally at its lowest. Technical standards prohibit more than one planned treatment in a twenty-four hour period. Most treatment events at the Flash Pad are conducted in a single treatment that is approximately 60 minutes or less. In 2022 and 2023, the Laboratory conducted a total of 80 and 84 treatments, respectively, at the Flash Pad.

An application of the Flash Pad is when explosive material has become entrained within the interstitials of fabrication machines that are used to machine high explosives into necessary forms. To safely recycle the metal from these machines, the Laboratory must first "flash" (or burn) off any residual explosives waste particles. Some single steel components treated in this manner can weigh up to 2000 lbs. and measure 5 x 4 x 3 ft. Without flashing, small volumes of residual high explosives material would prevent the Laboratory from recycling many tons of steel. Because it is able to flash, the Laboratory has recycled over 100,000 lbs. of steel after treatment at the Flash Pad in the past few years alone.

4.2 The TA-36-8 OD Unit (Minie Site)

TA-36 contains the TA-36-8 OD unit (Minie Site), several other firing sites used in research activities, and supporting offices where research is conducted with various types of explosives. Located in the east central portion of the Laboratory, TA-36 is spread over several mesa tops between a branch of Pajarito Canyon to the north and Water Canyon to the south. Mesa-top elevations at TA-36 range from approximately 6,380 to 7,120 ft. above mean sea level.

The Minie Site is used primarily for non-waste-related experimental test detonations. The Minie Site is only occasionally used to treat specialized explosives waste. The TA-36-8 OD unit is located in the southern portion of TA-36. The unit consists of an irregularly shaped area near Building TA-36-8, which is the control building. The Minie Site is a sandy area that measures approximately 500 ft. east to west and 300 ft. north to south. The western portion is relatively flat; the eastern portion is concave to minimize fragment dispersion.

The Minie Site has a maximum treatment capacity of 2,000 lbs. of explosives waste per detonation and an annual treatment limit of 15,000 lbs. Waste treatments at the Minie Site are by design complete detonations. Explosives material is destroyed and there are no measured or modeled toxic byproducts. Operations require post-detonation visual surveys as soon as practical for any materials not consumed by detonation, which minimizes the potential for precipitation contacting any residuals that could ever be present.

The Minie Site is located in a remote, security-controlled location within TA-36. Entry is controlled through an industrial fence with access granted through an access control station or a locked access gate. Access into the security area through the fence can only be gained by persons possessing an appropriate security clearance and site-specific training. Entry into the secured area is controlled via a combination of an entry station that is manned by security personnel or by badge readers on gates 24 hours per day. Unescorted access to the area is granted only to persons possessing appropriate security clearance and meeting site-specific training requirements. Visitors must check in at the appropriate access control station to be added to the site-specific badge-reader system to gain access to the area.

4.3 The TA-39-6 OD Unit (Point 6)

TA-39 contains the TA-39-6 OD unit (Point 6) and other explosives testing sites. TA-39 is located in the southern portion of the Laboratory and includes much of the mesa between Water Canyon to the north and Ancho Canyon to the south.

Point 6 is only occasionally used to treat specialized explosives waste. The Point 6 site is used primarily for non-waste-related experimental test detonations. Point 6 is located near Control Building 6 and is a relatively flat, sand covered area that measures approximately 40 by 40 ft. in a canyon bottom. Steep canyon walls rise 100 ft. or more in the immediate vicinity of Point 6 and, along with a retaining wall that has been installed, form a rough semi-circle around the unit. Point 6 is used to treat only explosives waste. Point 6 is used to open air detonate waste-excess explosives and explosive-contaminated combustible waste. Experiments conducted at this firing site are designed to expend all high explosives in the device. Waste treatments are by design complete detonations. Explosives materials is destroyed and there are no measured or modeled toxic byproducts.

Point 6 has a maximum treatment capacity of 1,000 lbs. of explosives waste per detonation and an annual treatment limit of 15,000 lbs.

Point 6 is located in a remote, security-controlled location within TA-39. Entry is controlled through an industrial fence with access granted through an access control station or a locked access gate. Access into the security area through the fence can only be gained by persons possessing an appropriate security clearance and site-specific training. Entry into the secured area is controlled via a combination of an entry station that is manned by LANL security personnel or by badge readers on gates 24 hours per day. Unescorted access to the area is granted only to persons possessing appropriate security clearance and meeting site-specific training requirements. Visitors must check in at the appropriate access control station to be added to the site-specific badge-reader system to gain access to the area.

5 Waste Streams Treated at the Thermal Treatment Units

This section describes the waste streams treated at the Laboratory's Units and provides a summary of the historic and current quantities of waste treated by the Units.

Each waste stream described in this Section and treated at the Units meets the definition of waste explosives under 40 CFR § 265.382. Each waste stream exhibits characteristics of reactivity, as defined in 40 CFR § 261.23, and is capable of detonation or explosive reaction if subjected to a strong initiating source or if heated under confinement. Each thermal treatment of the specialized explosives waste removes the characteristic of reactivity, and any other hazardous characteristic or constituent.

As discussed in greater detail in Section 7.2, the Laboratory's specialized explosives waste streams are generated from national security related missions addressing specialized high explosives. The specialized explosives waste is unique, heterogenous, highly energetic, and, under some conditions, potentially unstable. Furthermore, unlike facilities that generate and treat conventional munitions and explosives materials, LANL's explosives waste streams often have indeterminate morphologies and properties. The Laboratory's ongoing cutting-edge scientific research and development work involves both development of new explosives materials and intentionally damaging or insulting explosives materials. This research and development work results in the generation of specialized explosives waste with complex behaviors and indeterminate morphologies and properties.

5.1 Waste Streams Treated at the Flash Pad

The specialized explosives waste streams treated at the Flash Pad consist of the following:

- Explosives machining waste – This waste stream consists of explosives machining chips, and some filters, filter solids, and water that result primarily from the filtration of water used during the machining activities. Cloth filters, plastic bags, and wrapping are sometimes present in the waste.

- Over the past 5 years, this waste stream constitutes 29 to 51% of the total waste treated, with an average of 80%, through flashing.
- Potential explosives in this waste stream include: PETN; Cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX); Octahydro, 1,3,5,7-tetranitro; 1,3,5,7-tetrazocine (HMX); plastic-bonded explosives (PBX's or LX's); 4,4-diamino-3,3-azoxyfurazan (DAAF); 2,4,6-trinitrotoluene (TNT); Comp B; triamino trinitrobenzene (TATB); Baratol (including TNT and barium nitrate); and Cyclotol (a mixture of RDX and TNT).
- Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, Barium, Lead, and 2,4-Dinitrotoluene.
- Potential EPA hazardous waste codes include D003, D005, D008, and D030.

- Explosives-contaminated combustible debris – This waste stream includes explosives-contaminated debris generated in research laboratories and processing operations. Debris can involve filters removed from laboratories or processing bays, or may contain very small amounts of solvent. The most common solvents used are ethanol and acetone.
  - Over the past 5 years, this waste stream constitutes 90 to 32% of the total waste treated, with an average of 6.8%, through flashing.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, Cyclotol, Octol, TATB, DAAF, 2,6-Bis(picrylamino)-3,5-dinitropyridine (PYX), TNT, PBXs, and LXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene, spent halogenated solvents, and spent non-halogenated solvents.
  - Potential EPA hazardous waste codes include: D001, D003, D018, D022, D028, D029, D030, D035, D040, F001, F002, F003, F004, and F005.
- Explosives contaminated noncombustible debris – Most often this waste stream consists of metal equipment or sand/carbon from water filtration activities or maintenance and decommissioning and demolition activities. When metal, this waste stream is typically recycled after treatment when treated by flashing. This waste stream consists of explosives-contaminated equipment, including discarded, noncombustible equipment; debris from firing sites; noncombustible material from decommissioning and demolition activities; and material from explosives processing areas such as carbon or sand from filtering processes.
  - Over the past ten years, this waste stream constitutes <1 to 58% of the total waste treated, with an average of 11%, through flashing.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, PYX, Nitroguanidine (NQ), Nitrocellulose, PBXs, LXs, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal (a mixture of TNT and aluminum), and Baratol.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, Barium, Lead, Silver, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene, spent halogenated solvents, and spent non-halogenated solvents.
  - Potential EPA hazardous waste codes include: D003, D005, D008, D011, D018, D022, D028, D029, D030, D035, D040, F001, F002, F003, F004, and F005.
- Excess explosives – This waste stream includes either large or small (*i.e.*, laboratory-scale) amounts of excess explosives. Explosives may be in the form of flakes, granules, crystals,

powders, pressings, plastic bonded, putties, rubberized solids, or extrudable solids. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances.

  - This waste stream constitutes <1% of the total waste treated through flashing and has not been treated since 2014.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, PYX, NQ, Nitrocellulose, PBX's and LX's, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, and Baratol.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Barium, and 2,4-Dinitrotoluene.
  - Potential EPA hazardous waste codes include: D001, D003, D005, D030.

- Explosives-contaminated solvent waste – This waste stream consists of dimethyl sulfoxide (DMSO) containing dissolved explosives.
  - This waste stream constitutes 0 to <1% of the total waste treated through flashing and has not been treated since 2008.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, PBXs, and LXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity and 2,4-Dinitrotoluene.
  - Potential EPA hazardous waste codes include: D003 and D030.

Additional information and discussion regarding the waste streams treated at the Flash Pad is available within Permittees' revised Waste Analysis Plan. *See* Permit Renewal Application, Revised Supplement 1-3, Permittees' Proposed Changes to Attachment C, Waste Analysis Plan.

The Flash Pad generates no secondary hazardous waste stream. At the conclusion of flashing operations there is only ash residuals, whose waste stream is non-hazardous and disposed of as New Mexico Special Waste in a solid waste landfill (*see*, *e.g.*, LANL 202k, LANL 2020l). Recent waste stream profiles for ash shipped offsite has been provided in Attachment 1. The waste stream profiles demonstrated that most waste generated by the treatment process is non-hazardous and the lesser quantity of hazardous waste is due to metal (barium) toxicity, that burning of the waste does not destroy.

5.1.1 Historic and Current Waste Treatment Volumes for the Flash Pad

The quantities of specialized explosives waste treated at the Flash Pad are small, especially when compared to quantities treated at other sites or from historic sites (*see* DOD 2021, noting that at DOD's 34 locations, from 2014 to 2017 approximately 17,000,000 lbs. of explosives waste were treated per year, which equates to an average to 500,000 lbs. per site each year. Since 2013, LANL has treated only about 0.5% of this amount per year on average). **Table 5-1** lists, by waste stream, the quantities of explosives waste treated at the Flash Pad from 2013 to 2023.

The Laboratory has worked hard to achieve a high degree of pollution prevention and waste minimization (see Section 6) through the years. These efforts have resulted in the reduced generation of each of the waste streams described above, by eliminating some activities that generated portions of the waste streams and/or through substitution, segregation, or other waste minimization activities. In the past

decade, the Laboratory reduced treatment volumes at the Flash Pad by nearly 80% as compared with historic operations.

From 1996 to 2000, annual treatment volumes for the waste streams treated at the Flash Pad were on average 10,833 lbs. per year (excluding non-combustible materials). Since 2013, the Flash Pad has treated an average of approximately 2,250 lbs. per year, which represents an approximately 80% reduction. Although the Laboratory has reduced treatment volumes at the Flash Pad, mission requirements may result in fluctuations in the amount of specialized explosives waste treated at the Flash Pad in the future.

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Table 5-1 Annual Amount of Explosives Waste Treated at the Flash Pad from 2013-2023 by Waste Stream, *in pounds (lbs.)* (with approximate % of yearly total noted)

	Explosives Machining Waste	Explosives-Contaminated Combustible Debris	Explosives Contaminated Noncombustible Debris		Excess Explosives[3]	Explosives-Contaminated Solvents[4]	Total (lbs.)
			Metal[1]	Sand[2]			
2013	**2,283** (99.5%)	**11** (0.48%)	**5** (0.02%)	0	0	0	**2,299**
2014	**935** (97%)	0	**4** (0.04%)	0	**21** (2.2%)	0	**960**
2015	**1,665** (90%)	0	0	**195** (10%)	0	0	**1,860**
2016	**1,465** (88%)	**71** (4%)	**3** (0.2%)	**130** (7.8%)	0	0	**1,669**
2017	**1,671** (96%)	**30** (2%)	**32** (2%)	0	0	0	**1,733**
2018	**1,538** (97%)	**29** (2%)	**21** (1%)	0	0	0	**1,588**
2019	**1,130** (88.6%)	**10** (0.8%)	**36** (2.8%)	**100** (7.8%)	0	0	**1,276**
2020	**1,670** (41%)	**10** (0.2%)	**31** (0.8%)	**2,400** (58%)	0	0	**4,111**
2021	**2,113** (67%)	**810** (26%)	**58** (2%)	**170** (5%)	0	0	**3,152**
2022	**2,110** (53.5%)	**1,306** (33.1%)	**7** (0.2%)	**520** (13.2%)	0	0	**3,943**
2023	**1,190** (55%)	**24** (1%)	**27** (1.25%)	**920** (42.5%)	0	0	**2,161**

[1] The weight listed is the weight (in lbs.) of the estimated explosives content that is suspected to contaminate the equipment not the total weight of the equipment or debris in the case of noncombustible metals. Only the explosive is being treated, therefore, it is what is counted and represents the number of times noncombustible debris was treated during the year.

[2] Sand is no longer reused and is sent offsite as waste; therefore, the total weight of sand and explosives is included in the quantity of waste treated, instead of only the estimated explosives content.

[3] Generation rates of this waste stream are significantly decreased due to identification of alternative beneficial uses for excess explosives.

[4] This waste stream has largely been eliminated from being generated due to improvements in processes that must be treated as explosives waste and can be shipped offsite for disposal.

5.2 Waste Streams Treated by Open Detonation

The waste streams treated at the Laboratory by OD consist of the following:

- Excess explosives – This waste stream includes either large or small (*i.e.*, laboratory-scale) amounts of excess explosives. Explosives may be in the form of flakes, granules, crystals, powders, pressings, plastic bonded, putties, rubberized solids, or extrudable solids. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances.

- Over the past ten years, this waste stream constitutes 71 to 95% of the total waste, with an average of 83% treated through open detonation.
- Potential explosives in this waste stream include: HMX, RDX, PETN, TATB, DAAF, 2,6-Bis[picrylamino]-3, PYX, NQ, Nitrocellulose, PBX's and LX's, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, and Baratol.
- Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Barium, and 2,4-Dinitrotoluene.
- Potential EPA hazardous waste codes include: D001, D003, D005, D030.

- Explosives-contaminated combustible debris – This waste stream includes heterogeneous explosives-contaminated debris generated in research laboratories, processing areas, and prep rooms. Debris may include trace amounts of solvents. Other materials that may be present in this waste stream include plastic pieces, bags, fiber cloth, wrapping, and tubing; weigh boats; latex or nitrile gloves; glass or plastic vials; cardboard and paper; fiberboard containers; paper cleaning wipes, rags, and swabs. Metal constituents may include aluminum, stainless steel, steel, brass, and copper. Small quantities of solvents such as ethanol, acetone methanol, ethyl acetate, and toluene may also be present.
  - Over the past ten years, this waste stream constitutes 0 to 29% of the total waste treated through open detonation.
  - Potential explosives in this waste stream include: HMX, RDX, PETN, Cyclotol, Octol, TATB, DAAF, PYX, TNT, PBXs, and LXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Ignitability, Reactivity, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene, spent halogenated solvents, and spent non-halogenated solvents.
  - Potential EPA hazardous waste codes include: D001, D003, D018, D022, D028, D029, D030, D035, D040, F001, F002, F003, F004, and F005.
- Detonators, initiators, mild detonating fuses, and blasting caps – This waste stream includes detonators, initiators, and/or mild detonating fuses containing explosives. Explosives may be in metal or plastic casings and may contain lead- based primaries or be in a lead sheath. Typically, nitromethane is used as fuel for treatment activities. This waste stream may include manufactured articles removed from fire protection systems.
  - This waste stream constitutes approximately 1 to 2% of the total waste treated through open detonation.
  - Potential explosives in this waste stream include: PETN, HMX, RDX, TATB, lead azide, lead styphnate, and PBXs.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity and Lead.
  - Potential EPA hazardous waste codes include: D003 and D008.
- Shaped charges and test assemblies – This waste stream includes shaped charges consisting of cores of explosives with metal sheaths or metal liners or high explosives test assemblies consisting of explosives in plastic or metal holders. Assemblies may contain lead or silver metal. This waste stream may include manufactured articles removed from fire protection systems.

- This waste stream constitutes approximately 1 to 2% of the total waste treated through open detonation.
- Potential explosives in this waste stream include: PETN, RDX, HMX, PBXs, and LXs.
- Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, Lead, Silver, 2,4-Dinitrotoluene.
- Potential EPA hazardous waste codes include: D003, D008, D011, and D030.

- Projectiles and munitions larger than 0.50 caliber – This waste stream includes projectiles and munitions larger than 0.50 caliber (0.50-inch diameter). This waste stream may include manufactured articles removed from fire protection systems.
  - This waste stream constitutes approximately 1 to 2% of the total waste treated through open detonation.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity and Lead.
  - Potential explosives in this waste stream include: munitions/projectiles.
  - Potential EPA hazardous waste codes include: D003 and D008.
- Pressing Molds – This waste stream includes adiprene (urethane) pressing molds contaminated with explosives.
  - This waste stream constitutes approximately 1-2% of the total waste treated through open detonation.
  - Potential hazardous characteristics and/or constituents in this waste stream include: Reactivity, 2,4-Dinotrotoluene.
  - Potential explosives in this waste stream include: TNT.
  - Potential EPA hazardous waste codes include: D003 and D030.

Additional information and discussion regarding the waste streams treated by OD at LANL is available within the revised Waste Analysis Plan submitted in support of the Permittees' Permit Renewal Application. *See* Permit Renewal Application, Revised Supplement 1-3, Permittees' Proposed Changes to Attachment C, Waste Analysis Plan.

5.2.1 Historic and Current Waste Treatment Volumes for Wastes Treated by OD

Table 5-2 lists, by waste stream, the quantities of specialized explosives waste treated at the Laboratory's OD units for the past decade, from 2013 through 2022. Pollution prevention and waste minimization activities, *see* Section 6, have reduced the routine generation of each of the waste streams by eliminating some activities that generated portions of the waste streams and/or through substitution, segregation, or other waste minimization practices.

As shown in **Table 5-2**, the Laboratory's treatment activities at the OD units have decreased significantly over the last several years. This reduction is due to pollution prevention and waste minimization measures, including the beneficial reuse of materials for other mission requirements. The Laboratory has not performed OD treatments since 2014, however, mission requirements may result in fluctuations in the amount of specialized explosives waste treated at the Minie Site or at Point 6 in the future. To ensure that LANL can execute its mission and as mission needs change, both the TA-36-9 and TA-39-6 OD units must continue to be available either under interim status or as permitted units.

Table 5-2 Cumulative Amounts of Explosives Waste Treated at the OD Units from 2013-2023 by Waste Stream, *in pounds (lbs.)* (with approximate % of yearly total noted)

	Individual units annual amount excess explosives[1]		Individual units annual amount explosives contaminated debris[2]		Individual units annual amount black powder or gunpowder[3]		**Treatment annual totals (per OD unit)**		Cumulative annual total amounts (in lbs.)
	TA-36-8	TA-39-6	TA-36-8	TA-39-6	TA-36-8	TA-39-6	TA-36-8	TA-39-6	
2013	274 (72.9%)	82 (21.8%)	0	0	20 (5.3%)	0	294	82	376
2014	5 (71%)	0	2 (29%)	0	0	0	7	0	7
2015	-	-	-	-	-	-	-	-	0
2016	-	-	-	-	-	-	-	-	0
2017	-	-	-	-	-	-	-	-	0
2018	-	-	-	-	-	-	-	-	0
2019	-	-	-	-	-	-	-	-	0
2020	-	-	-	-	-	-	-	-	0
2021	-	-	-	-	-	-	-	-	0
2022	-	-	-	-	-	-	-	-	0
2023	-	-	-	-	-	-	-	-	0

[1] This waste stream has been significantly decreased in generation rates due to identification of alternative use.

[2] This waste has been significantly decreased due to process improvements that decrease the quantity and rate of generation of this type of waste.

[3] This waste stream has been eliminated.

Note: The waste streams representing (1) detonators, initiators, mild detonating fuses, and blasting caps; (2) shaped charges and test assemblies; (3) projectiles and munitions larger than 0.50 caliber; and (4) pressing molds have not been treated in this timeframe, but are preserved due to potential for future generation.

6 The Laboratory's Proactive Pollution Prevention and Waste Minimization

The first step in assuring the Laboratory is conducting safe and effective thermal treatment at the Units is to avoid waste generation whenever possible. As such, the first step in the Laboratory's waste management conceptual approach is to identify and implement waste minimization activities to the maximum extent practicable.

Waste minimization requires implementation of processes, practices, and procedures to reduce the volume of explosives and explosives contaminated waste that must be managed as hazardous waste. Through the years, the Laboratory has made considerable effort to eliminate or minimize wastes, or beneficially reuse materials that would otherwise be treated/disposed as wastes. Operations and waste management personnel rigorously apply waste minimization principles to significantly reduce the quantity of explosives waste treated at the Units. Some specific pollution prevention practices and waste reduction efforts applicable to the waste steams treated at the Units are discussed below.

6.1 Pollution Prevention Practices and Waste Minimization Efforts Implemented at LANL

Waste generators and waste professionals at the Laboratory work continuously to improve the management of regulated and non-regulated wastes. With respect to wastes treated at the Units, waste minimization is achieved by implementing the following pollution prevention and waste minimization practices:

- **Robust site-wide pollution prevention program and services**. The goal of the Laboratory's pollution prevention efforts is to reduce or eliminate waste whenever possible. However, when waste elimination is not possible, the Laboratory reduces potential adverse environmental impacts by treating waste to reduce its toxicity, segregating waste (separating it into different types) to reduce its overall volume, and disposing of waste in a responsible manner. The Laboratory's pollution prevention program provides a number of services, including:
  - opportunity assessments, which systematically evaluate existing processes and provide solutions to eliminate or reduce waste;
  - engineering and technical support to individuals or operations that generate waste;
  - funding for innovative projects that eliminate or substantially reduce waste or conserve natural resources;
  - recognition of individuals and projects that exemplify the goals of the program;
  - communicating pollution prevention success stories and best practices; and
  - facilitating process improvements to avoid or reduce the generation of waste.
- **Robust site-wide Environmental Management System (EMS).** The Laboratory's EMS is certified under ISO Standard 14001, and it provides a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvement, and measuring results. The EMS covers every program at the Laboratory and examines means by which a program impacts the environment.
- **Carefully assessing potential waste**. Policies and procedures at LANL require generators of explosives contaminated combustible debris to carefully assess whether wastes generated from production and research activities are hazardous waste. Segregating explosives contaminated debris from non-detonable contaminated debris ensures minimization of combustible debris that must be treated onsite.
- **Updating work approaches to minimize waste generation.** Explosives parts can be pressed into their near final shapes using previously unavailable isostatic presses, which have reduced the amount of explosives machining wastes generated. New technology allows for pressing a cone directly, so that the shape requires only minimal finishing through machining, thereby minimizing machining wastes.
- **Identifying beneficial uses for materials.** Alternative uses are found for explosive pieces that do not meet quality specifications, rather than treating them as waste. Furthermore, the operation of a solvent recovery system for the process generating the highest quantity of explosives contaminated solvents treated onsite. After recovery, the recovered and purified solvents are reused in experimental processes rather than disposed.
- **Shipping offsite whenever possible.** Explosives contaminated oils and solvents that are contaminated with less than 25% explosives are shipped offsite for treatment and disposal. Contaminated oils and solvents with less than 25% explosives in solution are not considered an

explosive hazard (DOE 2019). In addition, although the Laboratory does not currently generate bulk propellants and munitions containing propellants, if generated, they would be shipped to an offsite facility for treatment and disposal.

- **Employing other modes of treatment for equipment whenever possible.** Excess explosives processing equipment resulting from decommissioning or maintenance activities that is potentially contaminated with explosives is steam cleaned or pressure washed instead of being treated with flashing when safe to do so. Water generated as part of the process is sent to the High Explosives Wastewater Treatment Facility. In addition, when safe to do so, plastics are steam cleaned and disposed of or recycled offsite as non-hazardous waste.
- **Managing the operational footprint to minimize potential contamination.** Explosives machining operations, as well as most explosives pressing operations, have been consolidated into one building, thereby reducing the potential for explosives contamination at many locations.
- **Utilizing the appropriate thermal treatment options to minimize impacts.** Highly contaminated molds that cannot be steam cleaned are treated by OD rather than flashing because the products of combustion are more complete due to the higher temperature and pressure present during OD reactions.
- **Managing inventory.** Implementation of a centralized explosive inventory system that is available to all explosives custodians provides the opportunity for owners and users to search a common inventory system for in-stock explosives materials before ordering new materials. The explosive inventory system further reduces unnecessary explosives waste.
- **Employing technological solutions whenever feasible.** The implementation of mercury/explosives separation technology has reduced the amount of toxicity in waste streams and of excess explosives contaminated wastes.

In addition, the Laboratory systematically and successfully applies pollution prevention principles to reduce the toxicity of the explosives waste streams and the amounts of excess explosives and explosives contaminated waste treated onsite. These principles have been demonstrated with the reuse of machining sludge and the reduction of overall treatment at the OD units.

6.2 Anticipated Waste Generation Practices and the Laboratory's Commitment to Continual Improvement

The Laboratory's waste minimization efforts have significantly reduced the quantity of waste that is treated onsite at the Units. Current onsite waste treatment activities at the Units are less than in the past because of careful evaluation of waste generating practices. From 2013 through 2022, the Laboratory has treated an average of approximately 2,259 lbs. per year at the Flash Pad and 38 lbs. per year by OD. The Laboratory anticipates that future waste treatment quantities will remain at, or be less than, the current quantities. However, risk reduction efforts or changes in mission requirements at LANL may increase the overall amounts of waste needing treatment in specific years and may increase the annual quantity of waste to be thermally treated in the future.

Explosive inventory reduction efforts at the Laboratory will continue to reduce the explosives waste inventory. These efforts have included the increased shipment of explosives offsite for disposal where safe and lawful, as well as onsite reuse and onsite treatment of excess explosives as necessary. Explosives are only treated at the Units when other options have not proved safe or available. Although mission requirements will continue to drive the use of thermal treatment, the Laboratory remains committed to continuously improving its approaches to pollution prevention, waste minimization, and safe and effective waste treatment.

7 General and Site-Specific Factors Relevant to Consideration of Alt Tech at LANL

7.1 EPA General Criteria for Alt Tech Evaluations

EPA regulations authorize the permitting of open burning and open detonation units for the treatment of waste explosives. Waste explosives means "waste which has the potential to detonate and bulk military propellants which cannot be safely disposed of through other modes of treatment."[9]

EPA has interpreted this regulation as authorizing the permitting and operation of OB/OD units where no alternative mode of treatment is *safe* and *available* (EPA 2022b, EPA 2022c). For determining whether a technology is safe, EPA has provided that the following factors should be considered:

- **Operational safety** – whether the technology creates unreasonable risk of injury (*i.e.*, by substantially increasing the likelihood of unintentional explosion) to personnel operating the unit.
- **Monitorability** – whether the technology must be monitorable both in terms of operational controls and effluents/emissions resulting from treatment operations to ensure protection of human health and the environment.
- **Toxic by-products** – whether the technology must be able to treat any toxic by-products to levels that are protective of human health and the environment before release (EPA 2022c).

In addition, EPA Region III Draft Guidance for the permitting and operation of OB/OD treatment units states that the selection and appropriateness of OB/OD treatment should be based upon the following factors: (1) site specific safety; (2) transportation hazard potential; (3) offsite treatment options; and (4) feasibility of Alt Tech considerations (EPA 2002). EPA provides that to identify whether alternative technologies are available, the 2019 EPA and NASEM reports on Alt Tech should be considered, as well as other sources of information on technologies that have been developed to date for certain waste streams (EPA 2022b, EPA 2022c).

The 2019 EPA and NASEM reports focus on Alt Tech available for treating conventional munitions, which are different types of explosives waste streams than the Laboratory's specialized explosives waste. As discussed below, the Laboratory's explosives waste are associated with nuclear weapons applications. Significantly, the 2019 EPA and NASEM reports both acknowledge that there are circumstances and types of energetic waste that necessitate the continued use of OB/OD treatment based upon safety hazards and other site-specific feasibility factors (EPA 2019, NASEM 2019). Section 7.2 discusses such LANL-specific factors relevant to the consideration of Alt Tech for the specialized explosives waste treated at the thermal treatment Units.

Additionally, EPA's Compendium of Alternative Technologies to Open Burning and Open Detonation of Energetic Hazardous Wastes includes about 130 pages of matrixes that summarize key aspects of alternative OB/OD technologies, based on a review of 37 reference documents (EPA 2023). The facilities and waste types covered by the EPA Compendium focus on conventional munitions and ordnance wastes. The wastes include complete assemblies (*e.g.*, projectiles, ammunition, grenades, rockets, mines, flares, *etc*.) and components of assemblies' items (*e.g.*, rocket motors, charges, detonators, detonating cord, fuses, primers, blasting caps, warheads, *etc*.). The vast majority of the treatment technologies included in the EPA Compendium can be classified as either contained burn units (potential alternatives for open

[9] 40 CFR § 265.382 ("Open burning of hazardous waste is prohibited **except for the open burning and detonation of waste explosives**.") (emphasis added).

burning) or contained detonation units (potential alternatives for open detonation).[10] Contained burn and contained detonation units are addressed in Section 8 of this Alt Tech Evaluation.

The EPA Compendium does not identify technologies applicable to the unique wastes generated by LANL. Significantly, as the EPA Compendium recognizes, the selection of appropriate alternative technologies is facility-specific and waste-specific. The EPA Compendium also recognizes that the alternative technologies may not be applicable to unique and sensitive waste streams, such as those generated at research and development facilities. As the EPA Compendium states: "A technology that has been identified or implemented for a particular waste stream at one facility may not be suitable for another facility with a similar waste stream. This may be encountered across all OB/OD facilities, and more likely at Research, Development, Test, and Evaluation facilities where standard formulations may have been modified resulting in increased sensitivity and explosive risk and perform stress testing that reduces explosives and munitions stability." (EPA 2023).

7.2 Site-Specific Considerations

7.2.1 *The Laboratory Utilizes Operational Safety Controls*

In support of national defense, DOE has an active role in research and development of explosive formulations, explosives synthesis, charge geometry, and explosive assemblies. DOE and operating organizations maintain explosives safety standards that fully address potential risks. Maintaining worker and public safety is paramount in all DOE explosives handling operations.

The most important consideration when managing explosives waste streams is to minimize or eliminate, if possible, the danger and exposure to workers and the public from accidental ignition of the waste. At the Laboratory, all work activities associated with explosives and other energetic materials are carefully controlled, and safety is maintained through compliance with the requirements outlined in the *DOE Standard for Explosives Safety* (DOE 2021).

Site-specific safety and security are important concerns in every decision to treat explosives waste on- or offsite at LANL. Each onsite waste treatment activity at LANL is carefully planned to minimize worker exposure and handling of explosives. Personnel trained in explosives handling and familiar with the explosives' characteristics conduct the onsite waste treatment operations. This reduces the potential for compromising the energetic material and reduces the likelihood of serious injury or death. LANL explosives waste streams vary widely in form and constituents. Onsite explosives professionals are familiar with the specific types of explosives waste generated at LANL, the processes that generate them, and the processes for treating them. This includes familiarity with the unique, complex, and difficult to discern properties or attributes of the specialized explosives waste, and how to address and treat them.

Additionally, operational restrictions self-imposed by the Laboratory during thermal treatment operations further provide for safe treatment of waste and reduce the effects to human health and the environment. As discussed in Sections 7.4 and 7.5, the Units are designed to achieve complete combustion and prevent

[10] Such units are referred to by various names. Contained Burn Technologies: contained burn chamber; static kiln, contained thermal treatment chamber; international thermal convection system; contained burn chamber in static burn/static firing configuration; rotary kiln incinerator; decineration; thermal convection system; car bottom furnace. Contained Detonation Technologies: controlled detonation chamber, static detonation chamber; static kiln incinerator, contained thermal treatment chamber; controlled detonation chamber (transportable).

potential air, groundwater, or other environmental impacts. Routine thermal treatment operations occur only during daylight hours (*i.e.*, one hour after sunrise or one hour before sunset) and in appropriate weather conditions, which are checked before any waste treatment operation. Transportation of, or routine operations with, explosives waste at the Units may not occur during the following severe conditions:

- Lightning within a six-mile radius;
- Bounding conditions as detailed in the LANL Fire Danger Matrix maintained by emergency operations personnel at the Facility;
- Icy roads (for transport);
- During precipitation events;
- Any time winds are greater than 20 miles per hour and winds that are greater than 10 miles per hour in drier weather conditions, such as in the spring and summer seasons when fire danger rating is deemed to be "Very High" or "Extreme."

Site-specific safety concerns are critically important in the Laboratory's decisions regarding waste storage. Explosives waste must be stored for a time to accumulate sufficient quantities for treatment or disposal, whether on- or offsite. Rigorous administrative processes are used to maintain explosives safety at LANL. Specific safety procedures address the precautions routinely taken in order to ensure compliance with established explosives weight limits in each explosives work area, in order to prevent overloading a facility or area. The Laboratory has used multiple generator accumulation locations for explosives waste in smaller quantities to prevent propagation of accidental explosions.

Any decision to further increase the types or quantities of explosives waste streams shipped offsite, or to adopt other onsite treatment technologies, would require additional storage areas and/or longer-term storage of explosives waste streams. These factors would increase site-specific and operational safety risks at LANL. Any increase in site-specific safety risks at the Laboratory is not acceptable. Therefore, the additional safety hazards due to requiring additional storage and handling must be considered when evaluating Alt Tech.

7.2.2 *LANL's Specialized High Explosives Waste Streams Are Unique*

The Laboratory's specialized explosives, and the associated waste streams, are specific to explosives used *in nuclear weapons applications*, and associated research and development activities, which directly informs assumptions about the applicability and availability of Alt Tech options. These specialized explosives are different from explosives used in conventional munitions in important ways. The Laboratory's research and development of high explosives have led to a unique, specialized assortment of very high-performance explosives with very high detonation velocities, high energy content, and efficient energy conversion and release.

LANL performs research and development on explosives specifically developed for nuclear weapon systems. The explosive materials are PBXs and are specifically formulated to meet requirements such as structural integrity, machinability, and thermal stability, as well as improved safety characteristics. Development, fabrication, and testing of PBXs are the primary feeders for the Laboratory's explosives waste streams. These explosives wastes generated at the Laboratory possess unique and potentially unpredictable properties. Furthermore, the research and development activities performed on PBX explosives include tests and experiments that intentionally detonate these explosives or subject them to insults, such as thermal or mechanical environments. Insulting explosives in this manner can change their sensitivity; thus, any remaining explosives waste is unique, has difficult to discern properties, and is potentially in a less safe or unstable condition, and is not susceptible to certain kinds of treatment.

Therefore, even when the Laboratory receives a commercial explosive or an explosive from another facility (where that facility may be able to implement an Alt Tech option for some of its explosives waste streams), it does not follow that LANL would be able to implement the same (or any) Alt Tech.

The Laboratory's specialized high explosives waste cannot be treated in a confined environment due to the potential for detonation. The *burning* of a high explosive is known as *deflagration*, which is simply a combustion process that can take place in a time scale from seconds to milliseconds (10^{-3} seconds). The *detonation* process is significantly more violent and rapid and takes place as a molecular chain reaction which travels many times faster than the speed of sound, measured in microseconds (10^{-6} seconds), and results in very high energy. The specialized explosives used at the Laboratory transition from deflagration to detonation when exposed to an open flame in a confined environment. Critical to the application of alternative technologies to treat LANL's specialized high explosives waste is the propensity and potential for detonation if confined and brought to an elevated temperature. Temperature plus confinement of modern high explosives results in detonation (Leininger 2020).

LANL also maintains and develops a portion of the United States' nuclear stockpile. Safety of these nuclear weapons is a responsibility that often involves surveillance of the high explosives in deployed systems and development of high explosives with improved physical properties. Surveillance involves the physical inspection of weapons systems, including the high explosives, and sometimes requires investigations to understand issues that are observed, for example aging of high explosives that results in requirements no longer being met. Such a situation is addressed by development of improvements to the high explosives themselves. New high explosives formulations are researched, investigated, and developed at LANL, and subsequent improvements in characteristics of the high explosives may result in changing the way the explosive behaves, such as an improvement to the resilience of the high explosives when exposed to insults like temperature or shock.

In addition to working with high explosives materials to generate specialized high explosives and unique high explosives waste, LANL intentionally damages, or insults, high explosives as part of its research and development work. Insulting or damaging high explosives materials changes the morphology of the material and the morphology impacts the sensitivity of the high explosives. Insulted or damaged explosives are defined as Storage Compatibility Group L in the *DOE Standard for Explosive Safety* (DOE 2021). Group L also includes experimental explosives, explosives of temporary interests, newly synthesized compounds, and new mixtures, all of which the Laboratory generates (DOE 2021).

Prior to insult, the high explosives materials may be well understood, but once the morphology of a high explosives has been changed it is not possible to reliably predict the behavior of the material. This is an important consideration in the context of assumptions about the availability of Alt Techs for treating the Laboratory's explosives waste. The explosives waste streams generated at LANL are unique, constantly changing, and heterogeneous. Therefore, studies performed on munitions wastes or other conventional types of explosives waste, such as the 2019 EPA and 2019 NASEM reports and EPA Compendium, cannot directly inform whether Alt Techs are available that can safely treat the Laboratory's explosives waste.

Uncontrolled and unanticipated detonation of the Laboratory's specialized high explosives waste would present exceptional health and safety risks to workers, the public, facilities, and the environment. These risks are mitigated through treatment of the waste at the Laboratory's thermal treatment Units, which provide for treatment in an unconfined environment, while minimizing waste storage periods and waste handling.

7.2.3 *The Thermal Treatment Units Treat Small Volumes of Specialized Explosives Waste in a Highly Controlled Manner*

The Units treat, in a designed and highly controlled manner, the limited and discrete quantities of specialized explosives waste that the Laboratory must generate to fulfill its research, development, and national security–related missions. The Units are designed to treat the Laboratory's specialized explosives waste streams. The Units do not treat any other types of wastes, such as large-scale or conventional munitions . The Units are geographically isolated, access restricted, and are not continuously operated. The Units are designed to enhance safety and to protect human health and the environment. The Units efficiently and completely combust the specialized explosives waste and do not generate secondary hazardous waste streams or any measurable or modeled toxic by-products.

Data Sheet 7-1 and **Data Sheet 7-2** provide a summary of the current treatment technology used at the Laboratory, for the Flash Pad and the TA-36-8 (Minie Site) and TA-39-6 (Point 6) OD units. The thermal treatment conducted at the Units is, itself, an alternative technology to the OB/OD of explosives waste. The Laboratory's thermal treatment operations are highly controlled, efficient, designed to completely combust or consume the waste, monitored and sampled, and right sized for the Laboratory's specialized explosives waste. The data sheets present an organized and detailed rationale for why these current treatment approaches are utilized, in a manner that allows for comparison with **Data Sheet 8-1** through **Data Sheet 8-17** provided below in Section 8, in the discussion of the Alt Tech Evaluation process.

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Data Sheet 7-1. Existing Treatment Technology: Flash Pad

Existing Treatment Technology: Flash Pad (OB)		
Flash Pad Technology Description	Flashing or burning explosives waste destroys waste by self-sustained combustion after being ignited or by controlled burning using supplemental fuel in an open environment. The Flash Pad is designed to attain temperatures that result in the complete combustion and decomposition of the explosives waste stream and byproducts. This technology best serves waste generated during machining of explosives, excess explosive powders and pieces, explosive contaminated combustible wastes, laboratory samples of experimental explosives, and large pieces of equipment that must be flashed prior to shipment offsite for recycle or disposal.	
Treatment Type	OB	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – All**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Applicable to combustible wastes and small quantities of explosives waste.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**No**
	Revision to CWA – NPDES:	**No**
	Other:	
Safety Risk Considerations	Specific training for operators and explosives safety personnel are required and the area must be secured. The burn is monitored remotely through cameras. Specific operating parameters are invoked for open burning to assure the safety of personnel and protect human health and the environment.	
Human Health and Environmental Impact Considerations	Residual ash is contained within the lined burn area, collected, and analyzed for hazardous constituents; generally disposed as non-hazardous. Secondary thermal treatment provided if necessary. Air emissions include CO, CO_2, H_2O, NO & N_2; little or no secondary combustion products due to short residence time. The Flash Pad is subject to ongoing LANL environmental monitoring programs.	
Energy Resource Demands of Operation	Heat generated by oxidation of combustible wastes and supplemental fuel (propane).	
Secondary Waste Streams Generated by Technology	Residual ash is analyzed for hazardous constituents (none are present and the residual ash can be disposed of as NM special waste). Expected emissions are CO, CO_2, H_2O, NO_2, N_2, and little to no secondary combustion products due to short residence time.	
Operations/Treatment Capability Uncertainty	Proven technology.	
Relative Cost Range	*Capital:* No change.	
	Operations and MTCE: No change.	

Data Sheet 7-2. Existing Treatment Technology: TA-36-8 and TA-39-6 Open Detonation Units

Existing Treatment Technology: TA-36-8 and TA-39-6 Open Detonation Units		
TA-36-8 and TA-39-6 OD Technology Description:	Open detonation involves the detonation of explosives waste in an open air environment. Detonation treatment is designed to achieve complete consumption of the waste stream and byproducts. This technology is best suited for small or large pieces of explosives. OD is especially appropriate for aged explosive material with difficult to predict properties because OD requires a minimum of moving and handling, and avoids explosive concerns associated with technologies that require waste containment.	
Treatment Type	OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**Yes – All**
Principal/Treatment Capability Limitations	Applicable to explosives waste; not suitable for combustible waste.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**No**
	Revision to CWA – NPDES:	**No**
	Other:	
Safety Risk Considerations	Larger detonations for explosives pieces that are greater than the capacity of a confined detonation chamber. This requires less handling for workers. Also, the explosive would not have to be size-reduced prior to treatment by OD. LANL conducts detonations from a remote location inside the control building following specific operating procedures for OD to assure the safety of human health and the environment.	
Human Health and Environmental Impact Considerations	CO_2, H_2O, and N_2 emissions. OD units are subject to ongoing LANL environmental monitoring programs.	
Energy Resource Demands of Operation	Energy provided by waste explosives being treated; supplemental fuel is not required.	
Secondary Waste Streams Generated by Technology	Process effluents include metal fragments, CO_2, H_2O, and N_2.	
Operations/Treatment Capability Uncertainty	Proven technology	
Relative Cost Range:	*Capital:* No change.	
	Operations and MTCE: No change.	

7.2.4 *The Thermal Treatment Units Safely Treat Specialized Explosives Waste Streams Without Generating Toxic By Products Generated by Alternative Technologies*

The Laboratory's thermal treatment Units are located, designed, constructed, operated, and maintained in a manner that ensures protection of human health and the environment. *See* Permit Renewal Application, Sections 4 and 5. The safety of the Units has been proven through extensive data and analysis.

The Flash Pad is designed and operated to achieve the complete combustion of explosives waste materials and no measurable or modeled toxic by-products (*see*, *e.g.*, LANL 2020k). Thermal treatment analysis demonstrates that specialized explosives waste is fully treated in the Flash Pad (*see* LANL 2020l). The analysis shows that the temperatures attained at the unit exceed 1500°F within 60 seconds of the start of the burn and temperatures above 1500°F (>2000°F routinely) are maintained continuously for the duration of the burn (often 60 minutes) while the propane burners are in operation. These temperatures result in complete decomposition of the explosives waste streams and potential toxic byproducts, including dioxins and furan congeners, which are destroyed at temperatures above 1400°F (Kulkarni 2008, LANL 2020l at p.5).

The Laboratory's Flash Pad is a modern, engineered approach to open burning. The Flash Pad uses propane enhanced controlled burning that by design achieves complete combustion and prevents potential air emissions and constituent migration to groundwater due to the Flash Pad's design (including advanced liner, secondary containment, and storm water controls). The Flash Pad provides the right-sized treatment unit for LANL's heterogeneous explosives waste streams. *See* Permit Renewal Application, Section 5.1.2.

The Laboratory's OD units have also been designed to achieve complete consumption and prevent potential air emissions and groundwater contamination. PBX explosives, like those used at LANL, fully detonate leaving little or no residual constituents when initiated with correct shock inputs. When performing an open detonation treatment of specialized explosives waste at LANL, the high explosive is configured in such a manner to ensure shock transmission from an in-contact initiation system. Such a system involves a detonator and a new pristine high explosive that is applied to the specialized explosives waste. Controlled initiation ensures complete consumption of the waste material regardless of any indiscernible properties of the waste.

To further address concerns about the potential release of toxic contaminates, the explosives waste streams treated at the Units have been carefully assessed to ensure metal contents are minimized to the extent possible (as a component of a combustible waste) and to ensure that materials that may release toxic contaminants are not included within the waste stream. The materials currently prohibited from open burning at LANL include: radiological constituents; biologic or chemical warfare weaponry; small arms ammunition up to 50 calibers; beryllium; ammonium perchlorate; polyvinyl chloride (PVC); small control boxes or electronic equipment; blasting caps, electric detonators, explosives units containing electric detonators, and mild detonating fuse arrays.

The Laboratory's Units have been shown to be effective treatment technologies for the specialized explosives waste streams generated from LANL's explosives research and development and national security-related missions.

7.2.5 *The Thermal Treatment Units Do Not Pose a Threat to Human Health or the Environment*

The Laboratory performs environmental monitoring specific to each of the Units. This monitoring spans several years and is ongoing. Results from this enduring environmental monitoring demonstrates that the Units do not pose a threat to either human health or the environment. *See* Permit Renewal Application, Sections 4.18 and 5.16. There are no discernable adverse impacts to small mammals and avian populations proximate to the Units, to soils in any manner that would pose risk to residents or workers (including cancer risks), or to the air, surface, or groundwater.

For example, small mammal population and chemical concentration research finds that analyzed constituents in whole body field mice samples are either not detected or are detected below reference and

screening levels (Fresquez 2011, Fresquez *et al*. 2013). Similarly, ongoing decadal avian population monitoring indicates that the Units have no negative effect on bird populations (Hathcock & Fair 2013, Hathcock 2014, Hathcock 2015, Hathcock *et al*. 2017, Hathcock *et al*. 2018, Hathcock *et al*. 2019, Sanchez *et al*. 2020, Rodriguez & Abeyta 2021, Gadeck & Velardi 2021, Gadek Velardi & Abeyta 2022, Mason et. al. 2023). Studies include ongoing monitoring of nest eggs, specifically for impacts from dioxins and furans among other metals. Over approximately a decade, no adverse impacts from operating the Units have been found (Gaulker & Stanek 2019, Gaulker & Stanek 2020, Gaulker & Stanek 2021, Gaulker & Stanek 2022, Gaulker & Stanek 2023, Mason et. al. 2023).

Small mammals and avian populations would be expected to demonstrate impacts if the operation of the Units were adversely impacting the environment as these populations are most proximate to the Units. The lack of impacts on the receptors most proximate to the Units means that inferences about impacts to receptors much further away from the Units are not be supported.

Multiple years of soil monitoring also serve to assess and support understanding of the current status of soil chemical concentrations at the Units. Soil monitoring conducted prior to each application for the Units utilized risk assessment guidance from the New Mexico Environment Department (NMED). Risk assessments for the Units resulted in human health risk calculations indicating no risk to residents and workers from exposure to soils.

Human health cumulative cancer risk and noncancer screening level Hazard Indices for hypothetical residents and industrial workers are also below threshold levels. Additionally, after application of site-specific population area use factors and low-effect factors, ecological risk assessments conclude that there is likely no risk to ecological receptors. Impact to the vegetative or invertebrate soil fauna community (plants and earthworms) is not expected to occur due to intended use and bare ground. Avian and mammalian population information indicates that neither birds nor mammals are adversely affected (*see, e.g.,* LANL 2020f, LANL 2020g, LANL 2020n).

Extensive air modeling also demonstrates that operation of the Units is not predicted to result in exceedances of applicable human health and ecological screening levels. Predicted soil deposition (over a 10-year period) also demonstrates that impacts to soil concentrations are less than human health and ecological screening levels (*see* LANL 2020c, LANL 2020k). Atmospheric monitoring efforts supplement and reinforce this modeling and analyses. Each sample is collected downwind of the Units and is analyzed for metals and dioxins/furans. The results are then compared to acute air-inhalation exposure concentration screening levels, where screening levels could be identified. As with past monitoring efforts, more recent monitoring results support that there are no dioxins or furan compounds detected within air samples. Comparisons of metals detected within the samples are also below acute inhalation-exposure screening levels (*see* LANL 2020c, Green & Allen 2011).

Finally, institutional monitoring is conducted at LANL for storm water, groundwater, and air. Monitoring networks are located across the Laboratory and are designed to inform the conditions of water and air as described in the Annual Site Environment Report (ASER). Results of all site monitoring indicate and support that there is no adverse effect to human health and the environment due to operation of the Units (*see, e.g.,* LANL 2020c, LANL 2020k).

7.2.6 *As a National Security Laboratory, Requirements for Implementing Potential Alt Tech that Could Meet Screening Criteria May Impact Availability for LANL*

Even when there may be an Alt Tech that is potentially available, and even where the Laboratory can secure any necessary waivers or federal approvals to implement a specific Alt Tech, vendors themselves

may not prioritize federal research and development facilities such as LANL. These considerations are not hypothetical in nature. The Laboratory faces challenges with vendor and product availability and approval in many commercial products, as do all federal research and development facilities.

7.3 Specific Transportation and Storage Considerations & Restrictions

Sections 5 and 6 describe the composition of the Laboratory's explosives waste streams and efforts to avoid or minimize the generation of these wastes to the maximum extent practicable. The remaining wastes must be treated or disposed of in accordance with applicable requirements. As described in Section 3, the second step in LANL's waste management conceptual approach is to review the remaining explosives waste, on a waste stream-by-waste stream basis, to identify candidate wastes that could be safely transported offsite to permitted facilities for treatment and disposal.

Most of the Laboratory's wastes can be safely and securely shipped offsite. For the Laboratory's specialized explosives waste, which is subject to greater shipping limitations, ongoing review occurs to identify additional opportunities for increased offsite shipment where feasible and where it can be done safely. This is complicated by the fact that as energetic materials age or are subjected to testing, the resulting explosives waste may develop properties that are unpredictable. For this reason, the Laboratory's explosives waste that are aged, sensitive, or otherwise-unstable and cannot be stabilized are legally prohibited from transportation on public roadways, in accordance with DOT regulations. *See* 49 CFR § 173.53.

When stabilized through desensitization, or another process, to lower the sensitivity, energy output, and flame temperature of the composition, the Laboratory's explosives waste can be transported on public roadways and, whenever possible and practical, this is LANL's practice. For those explosives waste that cannot be stabilized for offsite transportation because the transportation hazard potential is too great or is legally prohibited, the wastes are accumulated onsite in compliance with generator accumulation requirements until they can be safely and effectively treated. For these explosives waste, storage and handling hazards are minimized by performing treatment onsite at the Units as often as needed to avoid accumulating excess waste inventory and exceeding the work areas' explosives safety limits.

7.3.1 Transportation Safety and DOT Transportation Requirements

Shipments of numerous types of hazardous materials (including explosives) on public roads pose hazards and risks for both public and worker safety. Because of this, the DOT and States have imposed restrictions and prohibitions on transport of explosives and explosives waste. Some waste streams generated at the Laboratory cannot be legally or safely transported on public roadways to offsite commercial facilities. Explosives waste streams that cannot be safely transported on public roadways are those that cannot be properly stabilized or that do not meet offsite facilities' waste acceptance criteria. In some cases, noncombustible debris contaminated with explosives cannot be released from the Laboratory's explosives areas without being flashed.

DOT specifies explosives transportation requirements within the hazardous materials requirements in Title 49 of the Code of Federal Regulations. The list of "Forbidden Explosives" under 49 CFR § 173.54 that may not be offered for transport or transported includes:

- New explosives[11] that have not been examined, classified, and approved for transport;

[11] New explosives include explosives that have not been previously produced, or those that have been previously produced, but whose formulation, design, or process has been changed so as to alter any of the properties of the explosive. *See* 40 CFR § 173.56.

- Explosives containing chlorates either as an ammonium salt or an acidic substance;
- Damaged packages or articles;
- Propellants that are unstable, condemned or deteriorated;
- Explosives specifically forbidden in the Table of Hazardous Materials (49 CFR § 172.101); and
- Explosives that fail to pass specified sensitivity, stability and burning tests.

In addition, each of the Laboratory's explosives waste streams that have not been previously shipped offsite must be tested, classified, and assigned proper shipping names and an EX-ID number[12] by the DOT Associate Administrator in accordance with DOT requirements in 49 CFR § 173.56 through § 173.58 to transport explosives waste on public roads or highways. Any explosives waste streams that fail the required testing series cannot be assigned numbers or transported to commercial facilities. There is currently a substantial backlog of new explosives document requests pending review by the DOT Associate Administrator's office. Review of new requests may take several years.[13]

To the maximum extent possible, the Laboratory ships offsite for treatment its explosives waste. Only that waste that cannot be shipped offsite is treated at the Units. None of the Laboratory's specialized explosives waste currently treated at the Units may be shipped offsite. None of the specialized explosives waste have been examined, classified, and approved for transport. Further complicating any approval for transport is the unique nature of the specialized explosives waste, and the complex morphology, properties, and potential unpredictability of the explosives waste. Certain of the specialized explosives waste streams, moreover, contain explosives materials that are prohibited from transport.

If the Laboratory were required to hold its specialized explosives waste to complete this lengthy process, rather than safely and effectively treating it at the Units, additional onsite storage and handling of explosives waste would be required.[14] This additional onsite storage and handling of explosives waste would pose a serious risk to both the environment and human health. The potential for degradation of explosives during the extended storage period would result in unnecessary additional risk to workers and the environment. This does not limit exposure to a minimum number of personnel, for a minimum amount of time, to a minimum amount of explosives. In addition to the shipping considerations described above, explosives that present export complications pursuant to 22 CFR §§ 120-130 cannot be shipped offsite for treatment. Furthermore, all explosives contaminated noncombustible debris that cannot be steam cleaned must undergo treatment per Section 18 of the DOE Explosives Safety Standard (DOE 2021).

Therefore, because of the transportation, storage, and handling hazards, the Laboratory will need to maintain onsite explosives waste treatment capability to safely disposition specialized explosives waste.

[12] An EX-ID number is issued by DOT to identify an explosive that has been tested and classified by DOT (49 CFR § 171.8 and 49 CFR § 173.56).

[13] Also problematic is that the changed nature of stored explosives material through the lengthy DOT process could result in a never-ending "do loop" where the authorization, once received, may no longer be utilized for the aged material, so the explosives waste would have to be stored for an ever longer period as new authorizations are pursued with DOT.

[14] The potential need to stockpile explosives waste to meet minimum treatment quantity requirements for transporting waste to offsite treatment facilities, likewise, would result in unnecessary additional risk to workers and the environment.

7.3.2 Federal Requirements for Transfer of Weapons Materials and Explosive Material to Commercial Facilities

Federal security and property requirements for classified waste and military munitions (as applicable) add to the complexity of handling, transport, and treatment of explosives waste generated at LANL. Many of the Laboratory's explosives waste streams that require thermal treatment, when unreacted, may contain classified components or features. These components or features complicate the Laboratory's ability to transport an explosives hazardous waste offsite and add to the transportation hazard. Some explosives waste-items may be controlled property according to DOE or U.S. Department of Defense (DoD) requirements and may not be eligible for release to an offsite disposal facility, even for purposes of destruction. Likewise, offsite treatment may be entirely prohibited or may be significantly delayed due to prohibitions and restrictions on transportation of that waste to an offsite facility.

7.4 Offsite Treatment Considerations

The Laboratory maintains the capability to ship certain explosives waste offsite to RCRA-permitted commercial treatment facilities. Whenever feasible, the Laboratory ships permissible bulk propellants, munitions containing propellants, and excess explosives to offsite facilities for treatment, storage, and disposal. In order to make these shipments, the waste must meet the offsite facility's waste acceptance criteria (WAC) and the waste must be able to be safely and legally transported.

The majority of the Laboratory's explosives waste, however, cannot be safely transported and stored offsite. In order to be sent to an offsite permitted commercial treatment, storage, and disposal facility (TSDF), any explosives waste candidates must meet the following requirements:

- The TSDF's WAC must comply with applicable Land Disposal Restriction (LDR) requirements;
- DOE requirements which prohibit the transportation offsite of experimental explosives, explosives of temporary interests, newly synthesized compounds, and new mixtures, all of which the Laboratory generates;
- DOT requirements which prohibit the transportation of new and/or uncharacterized[15] explosives waste;[16] and
- Federal requirements for transfer of weapons materials and explosive materials to commercial facilities, including security and property requirements for classified waste and military munitions (as applicable).

Offsite treatment decreases the overall quantity of explosives waste that must be treated onsite at the Units. However, explosives waste awaiting shipment must be accumulated and stored onsite until the treatment facility approves the waste shipments which, as noted above, is a significant site-specific safety consideration.

[15] "Uncharacterized" in this context means a material whose hazard classification cannot be determined within the meaning of 49 CFR § 171.8 and 49 CFR § 173.56 (*i.e.*, is unclassified and unapproved). This is not a reference to "uncharacterized" waste within the meaning of 40 CFR § 262.11 under RCRA.

[16] In addition to the DOT requirements and restrictions discussed in Sections 7 and 8, the DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) recently terminated Explosive (EX) classification approvals for dozens of previously approved shippers of explosives waste, further restricting the options for shipment of explosives waste to offsite TSDFs. *See* PHMSA, Hazardous Materials: Notification of Termination of Certain Explosive Classification Approvals Due to Non-Compliance with the UN Model Regulation Test Series 6(d) Requirements, 88 Fed. Reg. 38935 (June 14, 2023).

7.4.1 Offsite Facilities' Waste Acceptance Criteria and Acceptance Process

Offsite commercial TSDFs establish criteria to ensure that explosives waste streams accepted for disposition meet the facility's individual RCRA permit requirements and can be safely handled and properly treated by the facility (*i.e.*, to ensure compliance with applicable LDR standards). Requests for treatment and disposal must include documentation that confirms compliance with the facility's WAC, including a description of the physical form, chemical constituents, EPA Hazardous Waste Numbers (EPA HW No.), DOT Proper Shipping Name (PSN), and explosive ID number.

Shipments of the Laboratory's explosives waste offsite are also subject to the availability of appropriate storage and treatment capacity at the receiving facility. Wastes cannot be transported until shipments are approved by the receiving facility. The elapsed time between submitting a request for transport and receiving authorization to ship can sometimes be significant (*e.g.*, up to six months).

7.4.2 Current Offsite Treatment Options

Options for waste treatment offsite are limited because explosives waste streams that are considered detonable, or have the capability of exploding, require a special permit to be shipped as non-regulated waste. Furthermore, operations at offsite treatment facilities may not be as controlled as the treatment that occurs at the Units. There are currently three commercial facilities capable of accepting and/or treating some of the explosives waste streams generated at the Laboratory, including:

- the Clean Harbors, Colfax Facility;
- the General Dynamics Ordnance and Tactical Systems, Main Office and Disposal Facility;
- and the Veolia ES Technical Solutions-Trade Waste Incineration (Veolia-TWI).

At this time, the Laboratory will typically send explosive-contaminated waste streams to Veolia-TWI and Clean Harbors, Colfax Facility.

The Clean Harbors, Colfax Facility, located in Colfax, Louisiana, consists of twenty separate treatment units (40 CFR Part 264, Subpart X, Thermal Treatment Units) with the capability of treating reactive (D003) characteristic hazardous wastes through OB processes. The facility is capable of treating up to 480,000 lbs. of explosives waste annually and has the capability of storing up to 50,000 lbs. of explosives (Clean Harbors 2023). In 2023, the Louisiana Department of Environmental Quality released a preliminary draft RCRA renewal permit for Clean Harbors that would result in the cessation of OB treatment. While Clean Harbors is confident that it can implement Alt Tech to continue at least some amount of treatment of explosives waste (Clean Harbors 2023), the timeline for implementation and what explosives waste will be able to be processed at this facility in the future remains uncertain.

The General Dynamics Ordnance and Tactical Systems facility, located in Joplin, Missouri, consists of two RCRA Part B permitted and maximum achievable control technology (MACT) compliant incinerators (one of which is a rotary kiln incinerator) and a car bottom furnace (General Dynamics 2023).

Veolia-TWI, located in Sauget, Illinois, consists of three permitted treatment units (two fixed hearth thermal treatment units and one rotary kiln thermal treatment unit) with the capability of treating explosives waste that has been properly characterized; provided that the waste does not contain any prohibited wastes as listed within the facility permit (Veolia 2023). The facility includes a magazine that is used to store up to 100,000 lbs. of Bureau of Alcohol, Tobacco, Firearms and Explosives (BATFE) low

explosives. The facility has no capability to store BATF high explosives or detonators, but it can process them.

7.4.3 Public and Worker Safety Issues with Offsite Treatment

Each of the offsite facilities currently available is located at some distance from the Laboratory. Clean Harbors, Colfax Facility is located 842 miles east of LANL; General Dynamics Ordnance and Tactical Systems, Carthage, is located approximately 800 miles east of LANL; and Veolia-Trade Waste Incineration Facility is located 1,084 miles northeast of LANL. Transportation of waste from the Laboratory to any of these facilities would be via motor carrier over public roads.

Transportation of explosives by motor carrier occurs nationwide on a daily basis, but not without risk to the public. In contrast, the public has limited contact with or access to explosives transported for onsite treatment at the Units. By treating onsite, the Laboratory can control the transportation of the waste by controlling the traffic in the area, the speed at which it can travel, and can limit the area within which the waste is moved. Treatment of waste onsite decreases the potential for the public to be exposed to these hazards.

Onsite treatment of the Laboratory's explosives waste also decreases the handling of waste required by workers. Packaging and transport for onsite treatment are conducted by explosives personnel that have experience handling the specific wastes generated at LANL, including those that are not in pristine condition, have been subjected to damage, and/or are generated from unique processes. Shipment to offsite facilities increases the number of persons handling these explosives and requires that explosives waste be handled at the receiving facility by personnel who are less knowledgeable and experienced with these particular explosives waste streams.

In addition, offsite transportation increases offsite human and environmental impact along the transportation route, the overall carbon emissions from transport vehicles, and the increased risk of transportation incidents, theft, or diversion.

Most TSDFs require a minimum volume per shipment, as specified in the facility's WAC. Quantities of explosives waste streams generated at the Laboratory have been generally decreasing with the implementation of pollution prevention and waste reduction initiatives; however, generation rates are not consistent because they are based on programmatic activities that vary from year to year. Coupling minimum shipment volumes with generally decreasing explosives waste generation results in increased storage time for explosives waste. The Laboratory's explosives waste treated onsite at the Units, by contrast, is currently treated within days or weeks of generation.

Without the treatment capabilities at the Units, any shippable wastes would have to be accumulated until the minimum volume accepted by an offsite treatment facility was reached or a lesser quantity for transport can be brokered with the receiving facility (*see* Sections 7.2 and 7.3 for additional discussion on the hazards of increased storage). Explosives may deteriorate or become unsuitable for transport while waiting for disposal approval. The inability to promptly remove and dispose of excess, aging, or insulted explosives and minimize time and amounts in storage unnecessarily exposes workers to greater hazards.

7.4.4 National Security Considerations for Offsite Treatment

As part of its national security mission, the Laboratory will continue to develop explosive formulations and assemblies that may be related to threat reduction, homeland security, and enhanced security projects. At times of heightened security risk, shipment of certain explosives waste that are candidates for offsite shipment can be prohibited because of the increased risk of transportation-related incidents, theft, or

diversion. In the wrong hands, the Laboratory's explosives waste would not only present a risk of detonation and immediate physical harm to the public, but the waste itself could reveal highly classified information related to the United States' nuclear weapons programs and related research and development. These national security concerns must be considered when considering whether Alt Techs are available to safely treat the explosives waste treated at the Units.

7.4.5 Summary of Offsite Treatment Considerations

Although the Laboratory has worked to increase the amounts and types of explosives waste streams shipped offsite for treatment and disposal and further to reduce the overall quantity of explosives waste treated onsite, increased offsite treatment and disposal is not safe or available at this time. LANL employs offsite treatment whenever practicable. However, options for increased offsite treatment are often limited and the following factors are considered:

- DOE Explosives Safety requirements prohibit the transportation offsite of experimental explosives, explosives of temporary interests, newly synthesized compounds, and new mixtures, all of which the Laboratory generates;
- DOT regulations prohibit the transportation of new and/or uncharacterized[17] explosives waste;
- Explosives may deteriorate or become unsuitable for transport while waiting for disposal approval, presenting site-specific safety considerations;
- Additional storage and handling requirements would pose increased safety and environmental risk and increased permitting liability risk;
- Offsite transportation of LANL's explosives waste can raise national security concerns; and
- Under any scenario involving offsite shipment, the Units must still be able to continue onsite treatment to treat explosives waste having no safe or available alternative, non-shippable explosives waste, and classified wastes, including noncombustible debris wastes that cannot be shipped offsite for disposal without prior treatment.

8 Assessment of Alternative Treatment Technologies

This section describes the Laboratory's Alt Tech Evaluation process, which is utilized to determine whether any Alt Tech may be available that could safely treat the Laboratory's explosives waste currently treated at the thermal treatment Units. This analysis is performed consistent with the approach outlined in EPA's 2022 OB/OD policy memo (EPA 2022b), EPA's December 2022 webinar presentation (EPA 2022c), and EPA Region III Draft Guidance (Tetra Tech 2002). The steps involved in this approach include:

1. **Alt Tech Identification**. Identify Alt Techs that could potentially be used to treat the Laboratory's explosives waste streams in lieu of the current thermal treatment at the Units.
2. **Initial Screening of Identified Alt Tech.** Screen each candidate Alt Tech for its potential applicability to treat the Laboratory's explosives waste streams, conducting the analysis on a waste stream by waste stream basis.

[17] "Uncharacterized" in this context means a material whose hazard classification cannot be determined within the meaning of 49 CFR § 171.8 and 49 CFR § 173.56 (*i.e.*, is unclassified and unapproved). This is not a reference to "uncharacterized" waste within the meaning of 40 CFR § 262.11 under RCRA.

3. **Detailed Screening of Potentially Applicable Alt Tech**. Perform more detailed evaluation for any potentially applicable Alt Tech, including evaluating site-specific safety factors and proven availability, and conducting the analysis on a waste stream by waste stream basis. Then, if any Alt Tech meets these thresholds, also consider other criteria suggested by guidance and experience.

As part of the considerations of various Alt Techs, the ability to implement any potentially applicable Alt Tech at the Laboratory is an important consideration. As discussed above, to ship the Laboratory's explosives waste offsite, the shipment must conform to both DOE Explosives Safety requirements and DOT regulations. Accordingly, LANL may only ship explosives waste offsite if it has obtained at least the following three types of approvals for such explosives waste shipments:

1. DOT-EX Number for the shipment;

2. DOT Special Permit; or

3. Approved Interim Hazard Classification (IHC).

A significant portion of the specialized explosives waste that the Laboratory treats at the Flash Pad consists of the following types of waste: (1) machining waste; (2) laboratory waste, such as contaminated gloves, wipes, cotton swabs, and weigh boats from chemistry operations; and (3) high explosives wastewater filters and nylon socks (*see* Section 5). These waste types are difficult—if not impossible—to evaluate and classify in accordance with DOE Explosives Safety Standards and DOT Transportation Standards for sensitivity or other physical/mechanical/performance properties, as their shape and form vary, making such evaluations constantly changing. Additionally, such wastes are not homogenous, which further complicates the ability to conduct the necessary DOE Explosives Safety Standards and DOT Transportation Standards assessments to obtain the requisite approval to ship such wastes offsite.

To ensure the safety of workers, drivers, and the general public from hazards, the transportation requirements in 49 CFR Part 173 mandate that all hazardous materials undergo specific testing and analysis and be approved on a case-by-case basis. For explosives, the Laboratory must submit data based on UN Series 1-6 tests. Unfortunately, due to the lack of a consistent form for machining waste and inadequate quantities of laboratory waste, discussed below, the Laboratory does not meet the material and packaging requirements for the UN Series tests.

Machining waste from high explosives machining operations is generally mixed with water at varying levels of dilution, and chips of varying high explosives and sizes suspend and/or dissolve in the water. Accordingly, this machining slurry waste is not homogenous; its dilution varies depending on the amount of water in the slurry; and its high explosive chemical constituents vary depending on the types of high explosives or mixes of high explosives (*e.g.*, PBX, 9501, 9502, *etc*.) contained in the slurry waste from the given high explosive machining that created the waste in the first instance. These varying factors can drastically change the sensitivity of the high explosives waste and, therefore, make it difficult, if not impossible, to conduct the necessary analysis to determine if such waste could meet DOT and DOE requirements for safe offsite shipment and treatment. Consequently, it is unlikely that machining waste would ever be eligible for shipment offsite.

Regarding lab waste, LANL relies on acceptable generator knowledge to determine if this waste stream is detonable. Once a generator determines that waste is detonable, it is unlikely that the Laboratory could obtain the necessary approval to send the waste offsite for treatment. Similar to the machining waste described in the preceding paragraph, this waste stream is not homogenous. It would be difficult or impossible to conduct the necessary analysis to determine whether such waste could be eligible for shipment offsite. Additionally, some of this waste stream may contain unique high explosives waste

created at LANL for which the sensitivity or other physical/mechanical/performance properties would be unknown for purposes of DOE and DOT analysis. Thus, it would be unlikely that the Laboratory could obtain the necessary approvals to ship this waste stream offsite.

High explosives wastewater filters and nylon socks would similarly not likely be approved for shipment for offsite treatment, as these wastes are also not homogenous. Because these filters/nylon socks can be entrained with a variety of high explosives materials, it would be difficult, or impossible, to conduct the required analysis to obtain a DOT-Ex Number, DOT Special Permit, or IHC to ship this waste offsite.

As noted throughout EPA guidance, an Alt Tech must be shown to be safe and available. The Laboratory's specialized explosives waste are often unique, potentially unstable, and possess difficult to discern morphologies and properties. They are unlike the known explosives waste treated at other facilities, such as ordinance, munitions, rocket motors, and igniters. The Laboratory's specialized explosives waste often cannot be legally transported offsite for treatment under DOT and DOE restrictions. Furthermore, the Laboratory's national security mission means that even if offsite transport could be done safely, national security concerns may preclude such transport. For these reasons, any Alt Tech for the explosives waste treated at the Units, that can safely treat the Laboratory's specialized explosives waste streams, would have to be installed onsite.[18]

8.1 Step One: Alt Tech Identification

Alternatives to OB/OD have been researched for nearly three decades, primarily by the DoD military munitions community in support of global demilitarization efforts. Most research on Alt Tech has been oriented toward the disposition of excess military munitions due to the volumes of unwanted excess munitions stockpiled at DoD facilities throughout the world and the cleanup of firing ranges. Waste munitions consist primarily of encased weapons, such as rockets, missiles, bombs, mortar rounds, artillery ammunition, grenades, cluster munitions, and land mines. Technology development has focused mainly on production-scale demilitarization activities, with little consideration of specialized explosives waste from high explosives research and development activities.

To exercise due diligence in considering all possible alternatives, the Laboratory sought to obtain information from all likely sources concerning candidate Alt Techs, including those focused more on demilitarization of waste munitions. Publicly available information was collected and reviewed from the national and global demilitarization communities, including from organizations such as the Defense Technical Information Center (DTIC 2019), the DoD facilities and programs recent reviews of alternatives (*see, e.g.*, NAVAIR 2004, NASEM 2019, EPA 2019, EPA 2023, JOCG 2010, JOCG 2011, ETSCP 2006, SERDP 2023); and from private industry (Eldorado 2023, Dynasafe 2023, General Dynamics 2023). The Laboratory considered each candidate Alt Tech for its state of development and for its applicability to treat the Laboratory's explosives waste streams.

During initial screening, candidate Alt Techs were evaluated to eliminate methods or technologies that are: inapplicable to the Laboratory's explosives waste streams; those that are pre- or post-processing steps in a treatment train rather than primary treatment processes; and those that have not been demonstrated to be effective for treating the types of explosives waste streams generated at the Laboratory. Therefore, treatment technologies that were identified as pre-treatment, mitigation methods, or *in-situ* techniques

[18] The Laboratory recognizes that, in the future, there may be treatment options that involve permitted mobile treatment units. At this time, however, there are no mobile treatment units that are safe and available to treat the specialized explosives waste generated by the Laboratory, nor are there any such units available in New Mexico for thermal treatment of any type of explosives waste. Mobile treatment units, moreover, may present unique security concerns for the Laboratory.

were screened out from identified candidate Alt Techs. The rationale for this screening approach is described further below:

> **Demilitarization/pre-treatment methods.** Demilitarization/pre-treatment methods are not applicable to the Laboratory's explosives waste. Demilitarization focuses on reclaiming and recovering the explosives from munitions for sale or reuse, and on disassembling surplus military equipment for recycling and disposal. At the Laboratory, explosives encased in metal or plastic comprise an extremely small amount of LANL's explosives waste stream and cannot be recovered or reclaimed for sale or reuse.

> **Mitigation technologies.** Mitigation technologies do not destroy the explosive, but rather mitigate effects of the primary treatment activity taking place. For example, foam may be used with OD to prevent fragment dispersal and mitigate the sound of the destruction technology (*i.e.*, sometimes, earth fill has been placed atop an OD shot for this purpose). As such, mitigation technologies are not Alt Tech. While mitigation technologies are not themselves Alt Tech, the Laboratory does investigate and apply these technologies as applicable.

> ***In-situ* technologies**. *In-situ* technologies, such as biodegradation, are applied to environmental media (soils and groundwater) as part of remedial actions. As such, while important for the role they provide, they are not applicable as Alt Tech for the Laboratory's explosives waste streams, which do not include explosives-contaminated environmental media.

After the initial screening, the Laboratory compiled a list of seventeen Alt Techs that could potentially treat the Laboratory's explosives waste to meet LDRs and that should go through additional screening.

The potentially applicable Alt Techs identified for further evaluation are listed in **Table 8-1**. These Alt Techs include potential alternatives for both the Flash Pad and the OD units. Some listed Alt Techs are potential alternatives for only the Flash Pad, such as a contaminated waste processor, cryofracture, flashing furnace, open detonation, and oxidation (cerium-catalyzed). Other Alt Techs are potential alternatives for only the OD units, such as cryogenic cutting, hydromilling, liquid ammonia extraction, and open burning.

Data sheets for each Alt Tech option are included below, at **Data Sheet 8-1** to **Data Sheet 8-17**. These data sheets are structured to provide a comparison against the data sheets for the Flash Pad and OD units, at **Data Sheet 7-1** and **Data Sheet 7-2**. The data sheets provided below explain in greater detail each Alt Tech and related considerations for each technology.

It should be noted that **Table 8-1** does not list OB as an alternative to the Flash Pad or OD as an alternative to the Laboratory's OD units, since the table includes only other Alt Techs to these proven technologies. However, the Laboratory's Flash Pad is nothing like stereotypical open burning operations, which lack the controls needed for the efficient and complete combustion of wastes and the ability to control and monitor emissions. The Flash Pad could reasonably be considered an alternative to the kind of OB technology used by others, which exhibit a less controlled process.

As described above in Sections 5 and 7, the Laboratory's customized Flash Pad system uses controlled propane-fueled flames to rapidly oxidize energetic waste streams and minimize environmental impacts. Similarly, OD at the Laboratory is tailored to each unique energetic waste stream managed using that technology. Also not shown in **Table 8-1** are modifications to the Laboratory's current treatment

technologies, such as collection hoods or structures to collect a portion of any air emissions for possible subsequent treatment. Such add-on technologies could be considered in the future, if measurable adverse environmental effects of operating the Units are identified.

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Table 8-1 Alt Tech Candidate List

	Candidate Alt Tech	Potential Alternative For	Alt Tech Description
1	**Case Opening**	OB, OD	Case opening involves a variety of techniques to separate a munitions' body (projectile) from the cartridge case. The remaining energetic material will need to be treated and/or destroyed using alternative technologies.
2	**Chemical Conversion**	OB, OD	Chemical conversion involves using processes such as solvent extraction and solvolytic extraction to convert recovered explosives and propellants to other products. This technology can only treat specific types of explosives waste based upon the specific chemical makeup of the explosive. Extraction technologies frequently create a secondary hazardous waste stream consisting of organic solvents.
3	**Co-firing in Boilers**	OB, OD	Co-firing in boilers can be utilized for explosives that can be desensitized so that they can be co-fired with traditional fuels in commercial boilers for heating. For co-firing in boilers to be effective, the explosives waste must be soluble in fuel oil #2.
4	**Contained Burn (#1), at a Confined Burn Facility**	OB, OD	Contained burn at a confined burn facility consists of treating explosives contaminated wastes in blast-reinforced chambers. In some cases, additional fuel (such as kerosene) must be added to the waste stream. The combustion gases are contained and processed through air emissions control equipment. This treatment is frequently used by the military to destroy small caliber ammunition and bulk explosives. Small-scale confined burn facilities are currently in use by law enforcement agencies nationwide. The waste is ignited using a squib and allowed to burn of its own accord.
5	**Contained Burn (#2), Energetic-Contaminated Waste**	OB, OD	Energetic-contaminated waste technology is designed for wastes contaminated with small amounts of explosive material. It is similar to contained burning, but is targeted more toward burning combustible wastes contaminated with explosives rather than ammunition or bulk explosives. It is used mostly for combustible wastes (*e.g.*, rags, gloves, wipes, plastic, etc.) that are contaminated with small amounts of explosives. Because there is no controlled fuel supply or "controlled flame device," a contained burn unit may be permitted as a miscellaneous unit under RCRA Subpart X, rather than being permitted as an incinerator. Waste is ignited using a squib and is allowed to burn of its own accord, with the aid of added fuel (*e.g.*, kerosene) in some cases.
6	**Contained Detonation**	OB, OD	Contained detonation involves the detonation of waste inside a steel chamber constructed to dampen the blast. After burning reactions are suppressed to protect the integrity of the chamber. Particulates are filtered from the detonation gases. This technology is best suited for small pieces of explosives, and residuals may transform into toxic or more complex compounds than those created when treating the same waste by OB or OD.

	Candidate Alt Tech	Potential Alternative For	Alt Tech Description
7	**Contaminated Waste Processor**	OB	A contaminated waste processor (CWP) consists of a car bottom furnace that treats contaminated combustible waste, such as rags, gloves, wipes, fiber drums, pallets, plastic, coveralls, *etc*. Typically, the CWP is capable of batch or continuous feed operations.
8	**Cryofracture**	OB	The cryofracture process is used to cool ferrous munition bodies below their embrittlement temperature and allow the munitions to be fractured in a hydraulic press. This process allows access to and segregation of the energetics so they can be treated by thermal destruction. This technology is suitable for size reduction prior to a thermal treatment.
9	**Cryogenic cutting**	OD	Cryogenic cutting technology uses liquid nitrogen that is pressurized and then ejected through a small orifice at high velocities. The system includes a cryogenic fluid supply system, a pressurization system, a temperature control system, a nozzle system, a recovery system, and a manipulation system. This treatment is effective as a pre-treatment to cut through casings for the purpose of removing the casing from the explosive prior to treatment; however, a static charge can build up under certain circumstances and is a safety concern. Secondary materials spray is an additional waste stream.
10	**Flashing Furnace**	OB	A flashing furnace thermally decontaminates metal parts with explosive contamination. Up to 10,000 lbs. of contaminated metal can be flashed per hour. The furnace can be installed in a fixed location or can be trailer mounted for field applications. This technology is enclosed and has a controlled flame device.
11	**Incinerator, Fluidized Bed**	OB, OD	A fluidized bed incineration is an enclosed incinerator that utilizes the injection of explosives waste into a turbulent bed of hot sand, created by forced air. Emissions are filtered prior to release to the environment. This treatment technology is only effective for certain liquids, slurries, and powders with low organic content. The powders must be homogeneous in size.
12	**Incinerator, Plasma Arc**	OB, OD	A plasma arc incineration uses molten slag (*i.e.*, soil with iron fluxing agent) which destroys organic compounds. The technology encapsulates inorganic toxic solid wastes in the molten slag and when hardened is disposed. Emissions are filtered prior to release to the atmosphere. This is an enclosed alternative to incineration that can be utilized for explosives waste that are high in organic compounds (*e.g.*, paint, solvents).

	Candidate Alt Tech	Potential Alternative For	Alt Tech Description
13	**Incinerator, Rotary Kiln**	OB, OD	A rotary kiln incineration is an enclosed incinerator treatment technology. The rotary kiln slowly moves waste from one end to the other and waste detonates or combusts within the chamber; therefore, only small amounts of explosives waste can be treated at one time. Emissions are filtered prior to release to the atmosphere. Small explosive items with casings (<40 grams of select energetic material) can also be treated with this technology. Uniform explosives waste streams are treated most efficiently.
14	**Hydromilling**	OD	Hydromilling of explosives waste uses high pressure water jets to "cut" through the material. This is a pre-treatment technology that is not conducive for experimental and specialized explosives waste streams with indeterminate characteristics. A secondary hazardous waste stream of water and explosives is created by this process.
15	**Liquid Ammonia Extraction**	OD	Liquid ammonia extraction uses propellant, explosive fuel, and oxidizer ingredients to extract, separate, and recover the explosive using liquid ammonia. This treatment method can treat explosives waste that has a plastic binder associated with the waste in a limited capacity.
16	**Oxidation, Cerium-catalyzed**	OB	Cerium-catalyzed electrochemical oxidation operates at atmospheric pressure and can convert organic hazardous waste materials into carbon dioxide and water. This technology is used to treat organic pumpable fluids.
17	**Oxidation, Base Hydrolysis**	OB, OD	Base hydrolysis oxidation heats waste to mild temperatures (90 to 150 ˚C) and usually elevated pressures (200 lbs. per square in. gauge) with a strong base (pH>12). The explosives waste is converted to water-soluble, non-energetic products. The resulting solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation.

8.2 Step Two: Initial Screening of Identified Alt Tech (Candidate Alt Tech)

EPA guidance suggests evaluating Alt Tech on a waste stream by waste stream basis. **Table 8-2** is based on the revised Waste Analysis Plan submitted in support of the Permittees' Permit Renewal Application (*see* Permit Renewal Application, Revised Supplement 1-3, Permittees' Proposed Changes to Attachment C, Waste Analysis Plan). This table lists the nine categories of explosives waste streams generated by the Laboratory and correspond to the categories of wastes described in Sections 5.1 and 5.2 above.

The categories of explosives waste streams listed in **Table 8-2** are broad. As discussed above, each explosives waste stream produced at the Laboratory can contain a combination of explosives including specific high explosives, some of which are only generally described in the table. Also shown in **Table 8-2** are the typical and maximum loads currently treated, a description of the typical and maximum physical size of the waste stream, known hazardous contaminants present in the waste stream, and other materials typically contained in the waste stream.

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Table 8-2 Detailed Information Concerning Waste Streams Treated at the Units

	Waste Stream	Waste Stream Description	% of Total Waste Treated[1]	Max. Explosive Load (lbs.)	Max. Waste Volume (cubic ft.)	Potential Explosives[2]	Potential Hazardous Constituents	Other Potential Materials
1	Explosives machining waste	Explosives machining chips, filters, filter solids, and water	74%	200 (OB)	~50	Pentaerythritol tetranitrate (PETN), Cyclo-1,3,5-trimethylene-2,4,6- trinitramine (RDX), Octahydro, 1,3,5,7-tetranitro, 1,3,5,7- tetrazocine (HMX), plastic-bonded explosives (PBXs or LXs), 4,4-diamino-3,3- azoxyfurazan (DAAF), 2,4,6- trinitrotoluene (TNT), Comp B, and triamino trinitrobenzene (TATB), Baratol, Cyclotol	Barium, Lead, 2,4-Dinitrotoluene	Plastic bags
2	Excess explosives	Large or small (*i.e.*, laboratory-scale) amounts of excess explosives. Explosives may be in the form of flakes, granules, crystals, powders, pressings, plastic bonded, putties, rubberized solids, or extrudable solids. Explosives infrequently contain barium or ammonium nitrate mixed with more than 0.2% combustible substances.	11%	200 (OB) 2,000 (OD)	~0.5	HMX, RDX, PETN, TATB, DAAF, (2,6- Bis[picrylamino]-3,5- dinitropyridine (PYX), Nitroguanidine (NQ), Nitrocellulose, PBXs and LXs, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, Baratol	Barium, 2,4-Dinitrotoluene	Plastic bags, plastic wrapping, plastic casings, cardboard, paper, paper bags, and/or fiberboard containers. Small potential for aluminum, stainless steel, steel, and/or copper.

	Waste Stream	Waste Stream Description	% of Total Waste Treated[1]	Max. Explosive Load (lbs.)	Max. Waste Volume (cubic ft.)	Potential Explosives[2]	Potential Hazardous Constituents	Other Potential Materials
3	Explosives-contaminated combustible debris	Explosives-contaminated combustible debris generated in research laboratories and processing operations. Debris can involve filters removed from laboratories or processing bays or may contain very small amounts of solvent. The most common solvents used are ethanol and acetone.	6%	200 (OB) <55 (OD)	~10	HMX, RDX, PETN, Cyclotol, Octol, TATB, DAAF, PYX, TNT, PBXs, and LXs	Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4- Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene	Plastic bags, plastic wrapping, weigh boats, gloves, vials, cardboard, paper, paper bags, fiberboard containers, kimwipes, rags, swabs, flasks, watch glasses, tubing, and/or rods. Possible aluminum, stainless steel, steel, and/or copper. When solvents are present, may contain trace amounts of ethanol, acetone, methanol, ethyl acetate, toluene, cyclohexanone, benzene, chloroform, 1,2-dichloroethane, 1,2-dichloroethylene, methyl ethyl ketone, or trichloroethylene. Noncombustible portions of waste are minimized as much as possible.
4	Explosives-contaminated solvent waste	Dimethyl sulfoxide (DMSO) containing dissolved explosives	<1%	200 (OB)	NA	HMX, RDX, PETN, TATB, DAAF, PBXs, and LXs	2,4-Dinitrotoluene	
5	Explosives-contaminated noncombustible debris	Explosives-contaminated equipment including discarded, noncombustible equipment; debris from firing sites; noncombustible material from decommissioning and demolition activities; and material from explosives processing areas such as carbon or sand from filtering processes	9%	200 (OB) <55 (OD)	~10	HMX, RDX, PETN, TATB, DAAF, PYX, NQ, Nitrocellulose, PBXs, LXs, Comp B, TNT, Boracitol, Cyclotol, HBX-1, Octol, Pentolite, Tritonal, Baratol	Barium, Lead, Silver, Benzene, Chloroform, 1,2-Dichloroethane, 1,1-Dichloroethylene, 2,4-Dinitrotoluene, Methyl ethyl ketone, Trichloroethylene	Noncombustible material may include glass, ceramic, or metal piping or equipment. Rarely when solvents are present, they may include trace amounts of ethanol, acetone, methanol, ethyl acetate, toluene, cyclohexanone, benzene, chloroform, 1,2- dichloroethane, 1,2-dichloroethylene, methyl ethyl ketone, or trichloroethylene.

	Waste Stream	Waste Stream Description	% of Total Waste Treated[1]	Max. Explosive Load (lbs.)	Max. Waste Volume (cubic ft.)	Potential Explosives[2]	Potential Hazardous Constituents	Other Potential Materials
6	Detonators, initiators, and mild detonating fuses	Detonators, initiators, and/or mild detonating fuses containing explosives. Explosives may be in metal or plastic casings and may contain lead-based primaries or be in a lead sheath. Typically nitromethane is used as fuel for treatment activities. This waste stream may include manufactured articles removed from fire protection systems.	<1%	<55 (OD)		PETN, HMX, RDX, TATB, lead azide, lead styphnate, PBXs	Lead	Plastic bags, plastic wrapping, cardboard, paper, paper bags, and/or fiberboard containers. Aluminum, lead, stainless steel, steel, or copper may be present.
7	Shaped charges and test assemblies	Shaped charges consisting of cores of explosives with metal sheaths or metal liners or high-explosives test assemblies consisting of explosives in plastic or metal holders. Assemblies may contain lead or silver metal.	<1%	<55 (OD)		PETN, RDX, HMX, PBXs, and LXs	Lead, Silver, 2,4-Dinitrotoluene	Plastic components, plastic bags, plastic wrapping, cardboard, paper, paper bags, and/or fiberboard containers. Aluminum, copper, lead, stainless steel, brass, and/or copper may be present.
8	Projectiles and munitions larger than 0.50 caliber	Projectiles and munitions larger than 0.50 caliber	<1%	<55 (OD)		Munitions/ projectiles	Lead	Plastic bags, plastic wrapping, fiberglass, cardboard, paper, fiberboard drums, lead, brass, steel, stainless steel, copper, depleted uranium, and/or aluminum.
9	Pressing molds	Adiprene (urethane) pressing molds contaminated with explosives	<1%	<55 (OD)		TNT	2,4-Dinotrotoluene	Adiprene, plastic bags, plastic wrapping, cardboard, paper, and/or paper bags.

[1] The average for Table 8-2 include information for the 2005-2022 period of OB/OD combined, compared to the averages reflected Tables 5-1 and 5-2 (which provide annual averages for OB and OD separately). Total percentage may not add to 100% due to rounding.

[2] Potential explosives do not include all of the possible explosives that may be treated at the unit, only those currently expected to be treated as part of the waste stream. The nature of LANL's work produces new high explosives that are described only generally here. Note also that explosives in many waste streams have been insulted or are otherwise rendered unstable (unable to be transported offsite safely).

The initial screening of seventeen identified Alt Techs evaluates whether any of these candidate Alt Techs have the potential ability to treat each explosives waste stream generated, or potentially generated, at the Laboratory. This screening is summarized in **Table 8-3**. The Laboratory's specialized explosives waste streams are not approved by DOT to be transported offsite and, therefore, must be treated onsite. So, if an Alt Tech were proven to be safe for treating one or more of the Laboratory's explosives waste streams and it were available, then implementation of that Alt Tech would require onsite installation.

The majority of the identified Alt Techs in **Table 8-3** through initial screening are not applicable (noted with a dash) to the categories of explosives waste streams generated at the Laboratory. Eight Alt Techs are *potentially able* (or potentially applicable, noted with **PA**) to possibly treat at least some portion of each of the Laboratory's nine waste streams treated at the Units. Of these eight Alt Techs that may be potentially able to treat, two have limitations concerning the size of treatable wastes (small portions only) and two have limitations as to the form of the waste (powder only). Three candidate Alt Techs are shown as having unknown applicability (noted with *Unknown*) with respect to applicability to two of the Laboratory's explosives waste stream categories.

Providing further basis for the summary provided in **Table 8-3**, data sheets for each identified Alt Tech are also given. **Data Sheet 8-1** through **Data Sheet 8-17** appear at the end of this Section 8.2. These data sheets provide additional discussion of each candidate Alt Tech. The data sheets also provide more detailed rationale for why a given Alt Tech is potentially applicable, or not, as a candidate for treating the Laboratory's explosives waste streams.

The majority of the candidate Alt Techs listed in **Table 8-3** were developed for conventional munitions or waste streams associated with the production and/or demilitarization of conventional munitions. The explosives waste associated with conventional munitions are different than the explosives waste associated with nuclear weapons applications and research. While a few of these Alt Techs may *theoretically* have the potential to be adapted to treat the Laboratory's specialized explosives waste, the technologies have not been tested or proven with such waste streams. Thus, significant technology development and testing would be necessary to evaluate whether such Alt Techs could be effective, or whether modifications would be necessary to safely treat the Laboratory's specialized explosives waste streams.

The Alt Tech Evaluation is further complicated by the fact that the specialized explosives waste that LANL generates from its research, development, and national security missions are of varying composition and nature, as opposed to conventional energetics associated with conventional munitions. The explosives waste associated with conventional munitions are far more homogeneous in nature than found in any of the Laboratory's nine explosives waste streams. Indeed, if an Alt Tech were developed and tested for a current explosives waste stream generated by the Laboratory, because of the changing nature of the Laboratory's operations and missions, there is no certainty that it would be possible to use that Alt Tech into the future on a changed explosives waste. Technology evaluation, technology development, and testing for the LANL explosives waste streams currently generated may not be applicable to future waste streams.

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Table 8-3 Initial Screening of Candidate Alt Tech for Potential Ability (or Potential Applicability, PA) to Treat the Laboratory's Specialized Explosives Waste

Waste Stream:	1. Explosives machining waste	2. Excess explosives	3. Explosives-contaminated combustible debris	4. Explosives-contaminated solvent waste	5. Explosives-contaminated noncombustible debris	6. Detonators, initiators, and mild detonating fuses	7. Shaped charges and test assemblies	8. Projectiles and munitions (> 0.50 caliber)	9. Pressing molds
Waste Must Be Treated Onsite Only? **(Yes or No)**	Yes (PBX)	Yes (PBX)	Yes (PBX)	Yes (PBX)	Yes (PBX)	Yes	Yes (PBX)	Yes	Yes
Treated at the LANL Flash Pad?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	-	-	-	-
Treated at the LANL OD Units?	-	**Yes**	-	-	-	**Yes**	**Yes**	**Yes**	**Yes**
Alt Tech Candidate and the <u>Potential Ability</u> ("PA") to Treat LANL Waste Streams Nos. 1 through 9									
Case Opening	-	-	-	-	-	-	-	*Unknown*	-
Chemical Conversion	-	-	-	-	-	-	-	-	-
Co-firing in Boilers	-	-	-	-	-	-	-	-	-
Contained Burn (#1), at a Confined Burn Facility	-	**PA (small quantities only)**	-	-	-	-	-	-	-
Contained Burn (#2), Energetic-Contaminated Waste	-	-	**PA**	-	-	-	-	-	-
Contained Detonation	-	**PA**	**PA (small debris only)**	-	-	-	-	-	-
Contaminated Waste Processor	-	-	**PA**	-	-	-	-	-	-
Cryofracture	-	-	-	-	-	-	-	-	-
Cryogenic cutting	-	-	-	-	-	-	-	-	-

Waste Stream:	1. Explosives machining waste	2. Excess explosives	3. Explosives-contaminated combustible debris	4. Explosives-contaminated solvent waste	5. Explosives-contaminated noncombustible debris	6. Detonators, initiators, and mild detonating fuses	7. Shaped charges and test assemblies	8. Projectiles and munitions (> 0.50 caliber)	9. Pressing molds
Flashing Furnace	-	-	-	-	**PA**	-	-	-	-
Incinerator, Fluidized Bed	**PA (powdered only)**	-	-	-	-	-	-	-	-
Incinerator, Plasma Arc	-	-	-	**PA**	-	-	-	-	-
Incinerator, Rotary Kiln	**PA (powdered only)**	-	-	-	-	-	-	-	-
Hydromilling	-	-	-	-	-	-	-	-	-
Liquid Ammonia Extraction	-	-	-	-	-	-	-	*Unknown*	-
Oxidation, Cerium-catalyzed	-	-	-	*Unknown*	-	-	-	-	-
Oxidation, Base Hydrolysis	-	-	-	-	-	-	-	-	-

Data Sheet 8-1. Treatment Technology: Case Opening

Identified Candidate: Case Opening		
Description	Case opening involves a variety of techniques to separate a munitions' body (projectile) from the cartridge case. The remaining energetic material removed from the case will need to be treated and/or destroyed using alternative technologies.	
Treatment Type	**Pre-treatment.** Removed energetic requires subsequent treatment by alternative method, *e.g.*, OB/OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Only used for treating thinned-and thick cased munitions. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	No
	Revision to CWA – NPDES:	May generate wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-2. Alt Tech: Chemical Conversion

Identified Alt Tech Candidate: Chemical Conversion		
Alt Tech Description	Chemical conversion involves using processes such as solvent extraction and solvolytic extraction to convert recovered explosives and propellants to other products. This technology can only treat specific types of explosives waste based upon the specific chemical makeup of the explosive.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Requires chemical solvents; creates a secondary waste stream that would require additional treatment, storage, or disposal at a permitted hazardous waste facility. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	Yes, assuming chemical conversion chamber is vented
	Revision to CWA – NPDES:	May generate cooling water and/or wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units. Extraction technologies frequently create a secondary hazardous waste stream consisting of organic solvents.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-3. Alt Tech: Co-firing in Boilers

Identified Alt Tech Candidate: Co-firing in Boilers		
Alt Tech Description	Co-firing in boilers can be utilized for explosives that can be desensitized so that they can be co-fired with traditional fuels in commercial boilers for heating. The explosive must be soluble in fuel oil #2.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Limited to explosives that are soluble in Fuel Oil #2. Not suitable for any explosives waste treated at Units, because they are not soluble in oil.	
Permits Required	*RCRA Part B*	**Yes**
	Revision to CAA Title V	**Yes**, emissions from boiler fuel combustion
	Revision to CWA – NPDES	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other	Modification of air permits for existing commercial boilers
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-4. Alt Tech: Contained Burn (#1), at a Confined Facility

Identified Alt Tech Candidate: Contained Burn (#1), at a Confined Facility		
Alt Tech Description	Contained burn at a confined burn facility consists of explosives contaminated wastes that are treated in blast-reinforced chambers. In some cases, additional fuel (such as kerosene) must be added to the waste stream. The combustion gases are contained and processed through air emissions control equipment. This treatment is frequently used by the military to destroy small caliber ammunition and bulk explosives. Small-scale confined burn facilities are currently in use by law enforcement agencies nationwide. The waste is ignited using a squib and allowed to burn of its own accord.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~7%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (~50%); would require treatment in small batches**
Principal/Treatment Capability Limitations	Potentially applicable to small caliber munitions and small quantities of some excess explosives.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. With explosives waste possessing indeterminate characteristics or that was insulted, a contained burn is an unacceptable risk to personnel. There is no controlled flame to ensure complete detonation or burn of the explosive, and typically no capability to view if the explosive has been fully treated prior to opening the chamber. Unit increases the potential for catastrophic failure (explosion) when compared to current treatment technique.	
Human Health and Environmental Impact Considerations	Combustion and waste degradation gases emitted from air pollution control equipment.	
Energy Resource Demands of Operation	Requires supplemental fuel for contained burn chamber. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include scrubber waste and baghouse dust. Process effluents include emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters. Emissions scrubbing system must be designed to capture dioxins/furans that may be generated during the process, as the temperature is not controlled. Periodic replacement of air pollution control system components such as cloth bags and filter media.	
Operations/Treatment Capability Uncertainty	Limited to small caliber munitions and small quantities of some excess explosives.	
Relative Cost Range	*Capital:* + Construction of blast chambers, air pollution control equipment. Cost is very high considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: + O&M of air pollution control equipment; supplemental fuel cost; management, treatment & disposal of secondary waste streams; employee training for contained burn facility. Must include costs for existing LANL OB/OD activities, as blast chamber can potentially handle only a small portion of LANL energetic wastes.	

Data Sheet 8-5. Alt Tech: Contained Burn (#2), Energetic-Contaminated Waste

Identified Alt Tech Candidate: Co-firing in Boilers		
Alt Tech Description	Energetic-contaminated waste technology is designed for wastes contaminated with small amounts of explosive material. It is similar to contained burning, but is *targeted more toward burning combustible wastes contaminated* with explosives rather than ammunition or bulk explosives. It is used mostly for combustible wastes (*e.g.*, rags, gloves, wipes, plastic, *etc*.) that are contaminated with small amounts of explosives. Because there is no controlled fuel supply or "controlled flame device", a contained burn unit may be permitted as a miscellaneous unit under RCRA Subpart X, rather than being permitted as an incinerator. This waste is ignited using a squib and is allowed to burn of its own accord, with the aid of added fuel (*e.g.*, kerosene) in some cases.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (<1%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (<1%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated combustible debris, which is an exceptionally small fraction of explosives waste treated at Units	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers.	
Human Health and Environmental Impact Considerations	Combustion and waste degradation gases emitted from air pollution control equipment.	
Energy Resource Demands of Operation	Requires fuel for ignition only. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams may include scrubber waste and bag house dust. Process effluents include emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters. Emissions scrubbing system must be designed to capture dioxins/furans that may be generated during the process, as the temperature is not controlled. Periodic replacement of air pollution control system components such as cloth bags and filter media. Due to absence of supplemental fuel throughout the burn, residual waste (ash) may require supplemental treatment.	
Operations/Treatment Capability Uncertainty	Limited to a very small fraction of LANL energetic wastes. Due to absence of supplemental fuel throughout the burn, residual waste (ash) may require supplemental treatment.	
Relative Cost Range	*Capital:* + Construction of contained burn chambers, air pollution control equipment. Cost is very high considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: + O&M of air pollution control equipment; management, treatment & disposal of secondary waste streams; employee training for contained burn facility. Must include costs for existing LANL OB/OD activities, as contained burn chamber can potentially handle only a very small fraction of LANL energetic wastes.	

Data Sheet 8-6. Alt Tech: Contained Detonation

Identified Alt Tech Candidate: Contained Detonation		
Alt Tech Description	Contained detonation involves the detonation of explosives waste inside a steel chamber constructed to dampen the blast. After burning reactions are suppressed to protect the integrity of the chamber. Particulates are filtered from the detonation gases. This technology is best suited for small pieces of explosives, and residuals may transform into toxic or more complex compounds than those created when treating the same waste by OB or OD.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~5%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (~50%)**
Principal/Treatment Capability Limitations	Limited to small bulk explosives and combustible debris Limited lifetime on number of detonations the chamber can treat Chamber becomes difficult to dispose of as hazardous waste	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Large pieces of explosives may require size reduction prior to treatment in order to meet the operating capacity of the unit. This requires more handling by the worker and subsequent safety concerns. There is a potential for catastrophic failure.	
Human Health and Environmental Impact Considerations	Air emissions *(e.g.*, CO_2, H_2O and N_2) from detonation chamber. Metal fragments (contained near unit).	
Energy Resource Demands of Operation	May require supplemental fuel for detonation chamber. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	The secondary waste stream consists of ash and fragments. Process effluents include metal fragments, pulverized gravel, air pollution control unit residue, major burn emissions including CO, CO_2, H_2O, NO_x, N_2; secondary combustion products due to residence time; and limited lifetime of chamber with replacement required and disposal of used chamber.	
Operations/Treatment Capability Uncertainty	Limited to a fraction of LANL energetic wastes.	
Relative Cost Range	*Capital:* + Construction of contained burn chambers, air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: + O&M of air pollution control equipment; management, treatment & disposal of secondary waste streams; employee training for contained detonation facility. Must include costs for existing LANL OB/OD activities, as contained detonation chamber can potentially handle only a small portion of LANL energetic wastes.	

Data Sheet 8-7. Alt Tech: Contaminated Waste Processor

Identified Alt Tech Candidate: Contaminated Waste Processor (CWP)		
Alt Tech Description	A CWP consists of a car bottom furnace that treats (*i.e.*, combusts/oxidizes) contaminated combustible waste, such as rags, gloves, wipes, fiber drums, pallets, plastic, coveralls, *etc*. CWPs may operate in batch or continuous feed modes.	
Treatment Type	OB Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (<1%)**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated combustible debris and residues, which comprise an exceptionally small fraction of the LANL OB/OD waste stream.	
Permits Required	*RCRA Part B:*	Subpart O
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from combustion of fuel and waste.	
Energy Resource Demands of Operation	CWP is typically heated via fuel combustion. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash, baghouse particulate and scrubber residues. Process effluents are emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters.	
Operations/Treatment Capability Uncertainty	Only proven for limited waste types; potentially applicable to some explosives-contaminated combustible debris and residues.	
Relative Cost Range	*Capital:* ++ Construction of CWP and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a very small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of CWP and air pollution control equipment; fuel for CWP; employee training for CWP. Must include costs for existing LANL OB/OD activities, as CWP can potentially handle only a very small fraction of LANL energetic wastes.	

Data Sheet 8-8. Treatment Technology: Cryofracture

Identified Candidate: Cryofracture		
Description	Cryofracture process is used to cool ferrous munition bodies below their embrittlement temperature and allow the munitions to be fractured in a hydraulic press. This process allows access to the energetics so they can be subsequently treated by thermal destruction. This technology is suitable for size reduction prior to a thermal treatment. This treatment method has mostly been used for projectile explosives and is not suitable for explosive materials at LANL.	
Treatment Type	**Pretreatment method**, removed material requires treatment by OB	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Energetics contained in ferrous munitions bodies. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-9. Treatment Technology: Cryogenic Cutting

Identified Candidate: Cryogenic Cutting		
Description	Cryogenic cutting technology uses liquid nitrogen that is pressurized and then ejected through a small orifice at high velocities. The system includes a cryogenic fluid supply system, a pressurization system, a temperature control system, a nozzle system, a recovery system, and a manipulation system. This treatment is effective as a pre-treatment to cut through casings for the purpose of removing the casing from the explosive prior to treatment; however, a static charge can build up under certain circumstances and is a safety concern. This treatment method is not suitable for explosive materials at LANL.	
Treatment Type	**Pre-treatment**, removed material requires treatment by OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Not applicable to any LANL OB/OD waste streams	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units. Secondary materials spray is an additional waste stream.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units	

Data Sheet 8-10. Alt Tech: Flashing Furnace

Identified Alt Tech Candidate: Flashing Furnace		
Alt Tech Description	A flashing furnace thermally decontaminates metal parts with explosive contamination. Up to 10,000 lbs. of contaminated metal can be flashed per hour. The furnace can be installed in a fixed location or can be trailer mounted for field applications. Because this technology is enclosed and has a controlled flame device, permitting of the unit may require adherence to 40 CFR 264, Subpart O (incinerator) requirements.	
Treatment Type	OB Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~3%)**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated noncombustible debris, typically metal, which is a very small fraction of the LANL OB waste stream	
Permits Required	*RCRA Part B:*	Need for Subpart X permit questioned. Maybe – Subpart O
	Revision to CAA Title V:	40 CFR 264, Subpart O (incinerator) requirements
	Revision to CWA – NPDES:	No
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	If the unit is mobile, precautions will have to be in place to ensure that fuel can be located at each specific location within the explosives area. Increased waste handling by workers. Trained personnel would be required to conduct treatment activities. In addition, use of mobile unit within LANL HE exclusion area may present additional site-specific safety concerns. Roads within LANL will not accommodate large mobile unit, and presence of HE storage magazines would create additional risks to workers.	
Human Health and Environmental Impact Considerations	Emissions from fuel combustion and waste flashing – CO, CO_2, H_2O, NO_2, N_2.	
Energy Resource Demands of Operation	Requires fuel to heat flash furnace. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	The secondary waste streams include explosives contaminated non-combustible debris. Expected emissions are CO, CO_2, H_2O, NO_x, N_2, and little to no secondary combustion products due to short residence. Residual ash is not expected.	
Operations/Treatment Capability Uncertainty	Limited to a very small fraction of LANL energetic wastes – *i.e.*, explosives-contaminated noncombustible debris, typically metal.	
Relative Cost Range	*Capital:* ++ Construction of flash furnace facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of flash furnace and air pollution control equipment; fuel for flash furnace; employee training for flash furnace. Must include costs for existing LANL OB/OD activities, as CWP can potentially handle only a very small fraction of LANL energetic wastes. Must include costs for existing LANL OB/OD activities, as flashing furnace can only treat a portion of LANL energetic wastes.	

Data Sheet 8-11. Alt Tech: Incinerator, Fluidized Bed

Identified Alt Tech Candidate: Incinerator, Fluidized Bed		
Alt Tech Description	A fluidized bed incineration is an enclosed incinerator that utilizes the injection of explosives waste into a turbulent bed of hot sand, created by forced air. Emissions are filtered prior to release to the environment. This process is limited to liquids, slurries, and powders with low organic content. The powders must be homogeneous in size.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~70%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (<1%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives machining waste (powdered only) Limited to treating powders, liquids and slurries Cannot treat most bulk explosives or noncombustible debris	
Permits Required	*RCRA Part B:*	Yes – Subpart O
	Revision to CAA Title V:	Yes
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from heat (combustion) source Requires power for operation of air emissions collection and treatment system	
Energy Resource Demands of Operation	Energy source (*e.g.*, fuel combustion, electricity) required to heat fluidized bed	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash and scrubber residues; periodic replacement of fluidized bed media.	
Operations/Treatment Capability Uncertainty	Limited to a fraction of LANL energetic wastes.	
Relative Cost Range	*Capital:* ++ Construction of fluidized bed incinerator facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a fraction of LANL energetic wastes	
	Operations and MTCE: ++ Operation of fluidized bed incinerator and air pollution control equipment; fuel for incinerator; treatment & disposal of secondary waste streams; employee training for fluidized bed incinerator facility. Must include costs for existing LANL OB/OD activities, as fluidized bed incinerator can potentially treat only a portion of LANL energetic wastes.	

Data Sheet 8-12. Alt Tech: Incinerator, Plasma Arc

Identified Alt Tech Candidate: Incinerator, Plasma Arc		
Alt Tech Description	A plasma arc incineration uses molten slag (*i.e.*, soil with iron fluxing agent) which destroys organic compounds. The technology encapsulates inorganic toxic solid wastes in the molten slag and when hardened is disposed. Emissions are filtered prior to release to the atmosphere. This is an enclosed alternative to incineration that can be utilized for explosive wastes that are high in organic compounds (*e.g.*, paint, solvents).	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~5%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (~50%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives-contaminated solvents Limited to bulk explosives and solvent waste	
Permits Required	*RCRA Part B:*	**Yes** – Subpart O
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from heat (combustion) source.	
Energy Resource Demands of Operation	Energy source (*e.g.*, fuel combustion, electricity) required to heat plasma arc furnace Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash, scrubber residue, and slag.	
Operations/Treatment Capability Uncertainty	Limited to a small fraction of LANL energetic wastes.	
Relative Cost Range	*Capital:* ++ Construction of plasma incinerator facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of plasma arc incinerator facility and air pollution control equipment; fuel for incinerator treatment & disposal of secondary waste streams (*e.g.*, slag); employee training for plasma arc facility. Must include costs for existing LANL OB/OD activities, as plasma arc incinerator can potentially treat only a portion of LANL energetic wastes.	

Data Sheet 8-13. Alt Tech: Incinerator, Rotary Kiln

Identified Alt Tech Candidate: Incinerator, Rotary Kiln		
Alt Tech Description	A rotary kiln incineration is an enclosed incinerator treatment technology. The rotary kiln slowly moves waste from one end to the other and waste detonates or combusts within the heated chamber; therefore, only small amounts of explosives waste can be treated at one time. Emissions are treated (*i.e.*, filtered and/or neutralized) prior to release to the atmosphere. Small explosive items with casings (<40 grams energetic material) can also be treated with this technology. Uniform explosives waste streams are treated most efficiently.	
Treatment Type	OB, OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**Yes – Partial (~95%)**
	***LANL OD Waste Stream*:**	**Yes – Partial (<1%)**
Principal/Treatment Capability Limitations	Potentially applicable to some explosives machining waste (powdered only) Limited types and amounts of explosives that can be treated at one time Cannot treat most bulk explosives or noncombustible debris	
Permits Required	*RCRA Part B:*	**Yes** – Subpart O
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers. Specific training for operators and explosives safety personnel would be required and would have to be conducted within a secure area. Training on treatment techniques for limited waste streams would also be necessary. Confinement of explosives within a treatment unit could additionally lead to a build-up of residual pressure from breakdown products within the unit—a potential explosion hazard.	
Human Health and Environmental Impact Considerations	Emissions from combustion of fuel and waste routed through air pollution control equipment – *e.g.*, particulate collection and scrubbing.	
Energy Resource Demands of Operation	Kiln is typically heated via fuel combustion. Requires power for operation of air emissions collection and treatment system.	
Secondary Waste Streams Generated by Technology	Secondary waste streams include ash, baghouse particulate and scrubber residues. Process effluents are emissions from scrubbing system, burn and scrubber residue, residues from quench rinse, and decontamination waters.	
Operations/Treatment Capability Uncertainty	Proven for limited waste types.	
Relative Cost Range	*Capital:* ++ Construction of rotary kiln incinerator facility and air pollution control equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a portion of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of rotary kiln incinerator facility and air pollution control equipment; fuel for incinerator treatment & disposal of secondary waste streams; employee training for rotary kiln incinerator. Must include costs for existing LANL OB/OD activities, as rotary kiln incinerator can potentially treat only a portion of LANL energetic wastes.	

Data Sheet 8-14. Treatment Technology: Hydromilling

Identified Candidate: Hydromilling		
Description	Hydromilling of explosives waste uses high pressure water jets to "cut" through the material. This is a pre-treatment technology that is not conducive for experimental explosives waste streams.	
Treatment Type	**Pre-treatment**; removed material requires treatment by OD	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units.	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units.	
Secondary Waste Streams Generated by Technology	NA – A secondary hazardous waste stream of water and explosives is created by this process.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units.	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units.	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units.	

Data Sheet 8-15. Alt Tech: Liquid Ammonia Extraction

Identified Alt Tech Candidate: Liquid Ammonia Extraction		
Alt Tech Description	Liquid ammonia extraction uses propellant, explosive fuel and oxidizer ingredients to extract, separate, and recover the explosive using liquid ammonia. This treatment method can treat explosives waste that have a plastic binder associated with the waste in a limited capacity.	
Treatment Type	OD Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Used only for treatment of explosives waste that have a plastic binder. Not suitable for any explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units.	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units.	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units.	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units.	

Data Sheet 8-16. Alt Tech: Oxidation, Cerium-catalyzed

Identified Alt Tech Candidate: Oxidation, Cerium-catalyzed		
Alt Tech Description	Cerium-catalyzed electrochemical oxidation operates at atmospheric pressure and can convert organic hazardous waste materials into carbon dioxide and water. This technology is used to treat organic pumpable fluids.	
Treatment Type	OB Alternative	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**No – None**
Principal/Treatment Capability Limitations	Applicability limited to pumpable organic fluids. Not applicable to the explosives waste treated at Units.	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**; produces oxidation emissions.
	Revision to CWA – NPDES:	May generate cooling water and wastewater subject to treatment and/or discharge permitting
	Other:	General and stormwater permits for facility construction
Safety Risk Considerations	NA – Not applicable to explosives waste treated at Units.	
Human Health and Environmental Impact Considerations	NA – Not applicable to explosives waste treated at Units.	
Energy Resource Demands of Operation	NA – Not applicable to explosives waste treated at Units.	
Secondary Waste Streams Generated by Technology	NA – Not applicable to explosives waste treated at Units. Cesium catalyst requires periodic replacement; spent catalyst subject to offsite treatment/disposal.	
Operations/Treatment Capability Uncertainty	NA – Not applicable to explosives waste treated at Units.	
Relative Cost Range	*Capital:* NA – Not applicable to explosives waste treated at Units.	
	Operations and MTCE: NA – Not applicable to explosives waste treated at Units.	

Data Sheet 8-17. Treatment Technology: Oxidation, Base Hydrolysis

Identified Candidate: Oxidation, Base Hydrolysis		
Alt Tech Description	Base hydrolysis oxidation heats waste to mild temperatures (90 to 150 ˚C) and usually elevated pressures (200 lbs. per square in. gauge) with a strong base (pH>12). The explosives waste is converted to water-soluble, non-energetic products. The resulting solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation.	
Treatment Type	**Pre-treatment** OD Alternative; additional treatment of resulting solution is required	
Waste Stream Treatment Capability	***LANL OB Waste Stream*:**	**No – None**
	***LANL OD Waste Stream*:**	**Yes – Partial (~25%)**
Principal/Treatment Capability Limitations	Limited to organic waste streams with no plastic, which comprise a small fraction of the LANL OD waste stream	
Permits Required	*RCRA Part B:*	**Yes** – Subpart X
	Revision to CAA Title V:	**Yes**, emissions from oxidation chamber and heat (combustion) source
	Revision to CWA – NPDES:	**Yes**, generates cooling water and/or wastewater subject to treatment and/or discharge permitting
	Other:	Supplemental treatment – *e.g.*, bioremediation, supercritical water extraction – likely requires additional permitting; general and stormwater permits for facility construction
Safety Risk Considerations	Increased waste handling by workers increases risks associated with handling strong base (pH>12) and high pressure equipment. Supplemental treatment – *e.g.*, bioremediation, supercritical water extraction – may pose additional risks.	
Human Health and Environmental Impact Considerations	Varies depending upon supplemental treatment method – *e.g.*, bioremediation, supercritical water extraction	
Energy Resource Demands of Operation	Energy (fuel or electricity) required to heat aqueous base-reaction vessel.	
Secondary Waste Streams Generated by Technology	Aqueous solution is hazardous and must be further treated using bio-remediation or supercritical water oxidation. Emissions from fuel combustion.	
Operations/Treatment Capability Uncertainty	Has not been employed for LANL's unique energetic wastes. Therefore treatability studies would be required.	
Relative Cost Range	*Capital:* ++ Base hydrolysis treatment system equipment, plus supplemental treatment system equipment. Cost is exorbitant considering the low volume of LANL energetic waste generation, and that the technology is potentially applicable to only a small fraction of LANL energetic wastes.	
	Operations and MTCE: ++ Operation of base hydrolysis treatment facility and air pollution control equipment; chemicals; transportation to and operation of supplemental treatment system; treatment & disposal of secondary waste streams; employee training for base hydrolysis system. Must include costs for existing LANL OB/OD activities, as base hydrolysis treatment can potentially treat only a portion of LANL energetic wastes.	

8.3 Step Three: Further Screening of Potentially Applicable Alt Techs

After performing an initial screening for candidate Alt Techs, the next step is to take the potentially applicable (PA) Alt Techs that may be candidates for treating at least some portion of the Laboratory's explosives waste and conduct a more detailed evaluation.

Only the eight potentially applicable Alt Techs that passed initial screening received more detailed screening. This more detailed screening of remaining potentially applicable Alt Techs is shown in **Table 8-4** to **Table 8-8**. The criteria used for the more detailed screening in **Table 8-4** are those emphasized by EPA (EPA 2022b, EPA 2022c). Safety and availability are considered *threshold screening criteria*. If an Alt Tech, or multiple Alt Techs, meet the threshold screening criteria of safety and availability, then additional criteria may be considered to assist with evaluation and decision-making.

As a threshold matter, an Alt Tech must, first, be safe to use, as determined by explosives safety experts and considering site-specific factors. Safe includes operational safety, monitorability, and environmental protection (produces no toxic by-products). To be a viable option, the operational safety for a given Alt Tech must be either greater, or at least neutral, compared to current operations. If an Alt Tech is determined to be safe for use at the Laboratory, the next threshold evaluation criterion in the detailed screening is availability of the Alt Tech.

None of the potentially applicable Alt Techs meet the threshold screening criteria for the Laboratory's explosives waste. It must be noted that even if one or all of the potentially applicable Alt Techs met the threshold screening criteria, which they fail to do, only some portions of the Laboratory's explosives waste would be able to be treated by these Alt Techs. In other words, the Laboratory's thermal treatment Units would still be required to operate even if all the Alt Techs met the threshold screening criteria and each could be implemented.

Table 8-4 addresses threshold screening criteria for each explosives waste stream currently treated at the Units. In summary, none of the potential Alt Tech candidates have been developed and demonstrated for the Laboratory's specialized explosives waste streams. Significant research and development efforts would be required to support the customized demonstration, development, design, and construction of potentially applicable Alt Techs. At this time, no proven technology is currently available that could safely treat the explosives waste stream currently treated at the Laboratory's Units.

If, however, an Alt Tech were determined to meet the threshold screening criteria and was both safe and available for use at the Laboratory, the remaining screening criteria would be further considered. These additional criteria are intended to help select among multiple safe and available Alt Techs. In the future, these remaining criteria may be applied to provide a deeper evaluation:

- throughput (*i.e.*, treatment) capacity of the Alt Tech;
- energy consumption of the Alt Tech;
- water consumption of the Alt Tech;
- air impacts and wastewater generation and discharges for the Alt Tech;
- reliability, maintainability, and cost.

At the Laboratory, considering the very low quantities of specialized explosives waste treated at the thermal treatment Units, and the Laboratory's ability to treat specialized explosives waste streams safely, efficiently, and with no adverse effect on human health or the environment (*i.e.*, lack of a demonstrated harmful environmental impact from operation of the Units), it is highly questionable whether these additional criterion would favor consideration of some other alternative technology, even if it were to be proven safe and available. Considering the nature of the Laboratory's research, development, and national security missions, and that the composition and characteristics of its specialized explosives waste streams are constantly evolving and changing, moreover,

even if an alternative technology were determined to be capable of handling a current waste stream, that is no guarantee that the alternative technology could treat future permutations of that waste stream. The Laboratory's thermal treatment operations are highly controlled, safe, efficient, designed, and operated to completely combust or consume the waste, monitored and sampled, and right sized for the Laboratory's specialized explosives waste. No alternative, even if safe and available, possesses a similar mix of safety, efficiency, and human health and environmental protectiveness.

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Table 8-4. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives Machining Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
1. Explosives Machining Waste (wet only with filter socks)	**Incinerator, Fluidized Bed**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more handling of energetic and potentially unstable waste than current LANL practices, so **increases safety concerns**. Injection of potentially unstable energetic waste into an enclosed fluidized bed incinerator **poses safety** concerns. Considerable operator training required. Confinement of explosives within the fluidized bed could lead to a buildup of residual pressure from breakdown products generated within the system – a **potential explosion hazard**.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fluidized bed heat source. Secondary waste streams include ash, scrubber residues and baghouse dust. Periodic replacement of fluidized bed media, scrubber solution and baghouse bags. Contaminated wastewaters also generated.
		Is Technology Proven Effective & Available?		**No.** Fluidized bed incineration has not been proven for the Laboratory's specialized explosives waste. **No.** Fluidized bed incineration is not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized fluidized bed incineration system for LANL's explosives machining waste. Uncertain application if waste composition were to change.
	Incinerator, Rotary Kiln	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (rotary kiln incinerator) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by incinerator heat source. Secondary waste streams include ash, scrubber residues and baghouse dust. Periodic replacement of fluidized bed media, scrubber solution, and baghouse bags. Contaminated wastewaters.
		Is Technology Proven & Available?		**No.** Rotary kiln incineration has not been proven for the Laboratory's specialized explosives waste. **No.** Rotary kiln incineration is not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized rotary kiln incineration system for LANL's explosives machining waste. Uncertain application if waste composition were to change.

Table 8-5. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Excess Explosives Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
Excess explosives (small quantities only)	**Contained Burn (#1), at a Confined Burn Facility**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (confined burn facility) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by contained burns system heat source and supplemental fuel (if required). Secondary waste streams include ash, scrubber residues and baghouse dust. Periodic replacement of scrubber solution and bags for baghouse. Contaminated wastewaters.
		Is Alt Tech Proven Effective & Available?		**No.** Contained burn treatment has not been proven for LANL's specialized explosives waste. **No.** Contained burn treatment systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained burn treatment system for small quantities of LANL's excess explosives. Uncertain application if waste composition were to change.
	Contained Detonation	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (containment system) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Air emissions from waste detonation. Scrubber residues and baghouse dust from air emissions control system. Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) from supplemental fuel, if used. Toxic byproducts may be generated due to confinement and associated residence time. Periodic decontamination of containment system will generate decontamination wastes (*e.g.*, wastewater, solvents).
		Is Alt Tech Proven Effective & Available?		**No.** Contained detonation has not been proven for LANL's specialized explosives waste. **No.** Contained detonation systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained detonation system for small quantities of LANL's excess explosives. Uncertain application if waste composition were to change.

Table 8-6. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives-Contaminated Combustible Debris Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
3. Explosives-contaminated combustible debris (small debris only)	**Contained Burn (#2), Energetic-Contaminated Waste**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (contained burn system) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fuel used for ignition. Secondary waste streams may include ash, scrubber waste and baghouse dust, decontamination wastewaters. Emissions scrubbing system must be designed to capture dioxins/furans that may be generated during the process, as the temperature is not controlled.
		Is Technology Proven Effective & Available?		**No.** Contained burn treatment has not been proven for LANL's specialized explosives waste. **No.** Contained burn treatment systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained burn treatment system for LANL's explosives-contaminated combustible debris (small debris only). Uncertain application if waste composition were to change.
	Contained Detonation	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (contained detonation system) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Secondary waste streams may include ash and fragments. Air emissions control system (if employed) wastes include scrubber waste and baghouse dust.
		Is Technology Proven Effective & Available?		**No.** Contained detonation has not been proven for LANL's specialized explosives waste. **No.** Contained detonation systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained detonation system for LANL's explosives-contaminated combustible debris (small debris only). Uncertain application if waste composition changes.
	Contaminated Waste Processor	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (contaminated waste processor) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fuel used for contaminated waste processor car bottom furnace. Secondary waste streams include ash, baghouse dust, scrubber wastes and wastewater.
		Is Technology Proven Effective & Available?		**No.** Contaminated waste processing has not been proven for LANL's specialized explosives waste. **No.** Contaminated waste processing systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized contained detonation system for LANL's explosives-contaminated combustible debris (small debris only). Uncertain application if waste composition changes.

Table 8-7. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives-Contaminated Solvent Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
4. Explosives-contaminated solvent waste	**Incinerator, Plasma Arc**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (plasma arc incinerator) also so **increases safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO2, H2O, NO2, N2 and others) generated by fuel used to provide heat to the plasma arc incinerator. Secondary waste streams include ash, molten slag and scrubber wastes.
		Is Technology Proven Effective & Available?		**No.** Plasma arc incineration has not been proven for LANL's specialized explosives waste. **No.** Plasma arc incineration systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design, and construction of a customized plasma arc incineration system for LANL's explosive contaminated solvent waste. Uncertain application if waste composition changes.

Table 8-8. Detailed Screening: Potentially Applicable Candidate Alt Tech for the Explosives-Contaminated Noncombustible Debris Waste Stream

	Alt Tech Potentially Applicable	Threshold Evaluation Criteria (Safe and Available, considering site-specific factors)		Analysis
5. Explosives-contaminated noncombustible debris	**Flashing Furnace**	**Safety Factors**	Operational Safety (Increases or is Neutral)	**No.** Requires more waste handling than current LANL practices, so **increases safety concerns**. Placement of LANL explosives waste in an enclosed system (flashing furnace) also **poses safety concerns**. Considerable operator training required.
			Monitorability	Yes, monitorable. Air emissions stack can be equipped with real-time monitoring systems, and stack testing ports. Ash, baghouse dust, and scrubber residues can be characterized via sampling and laboratory analysis.
			Toxic Byproducts	**Toxic byproducts.** Combustion byproducts (*e.g.*, CO, CO_2, H_2O, NO_2, N_2 and others) generated by fuel used to provide heat to the flashing furnace. Secondary waste streams include residual metals parts and scrubber wastes.
		Is Technology Proven Effective & Available?		**No.** Flashing furnace treatment has not been proven for LANL's specialized explosives waste. **No.** Flashing furnace systems are not readily available; *i.e.*, off-the-shelf systems are not available. Significant future R&D would be required to support the development, design and construction of a customized flashing furnace system for LANL's explosive-contaminated non-combustible debris. Uncertain application if waste composition changes.

8.4 Alt Tech Evaluation Supports Continued Operation of the Flash Pad and OD Units

The Alt Tech Evaluation process identified seventeen candidate Alt Techs. After an initial screening, the Alt Tech Evaluation process eliminated nine of the identified candidate Alt Techs and focused additional screening on eight potentially applicable Alt Techs. The additional screening was focused on the threshold criteria, which consider whether potentially applicable Alt Techs are both safe and available, considering site-specific factors. All potentially applicable Alt Techs fail to meet the threshold criteria of safe and available.

Based on the Alt Tech Evaluation, it is not appropriate nor feasible to transition from the Laboratory's use of the thermal treatment Units. There are no safe and available Alt Techs available for any of the Laboratory's specialized explosives waste streams. Even if all of the potentially applicable Alt Techs were to become both safe and available, and even if the additional screening criteria were to weigh in favor of their adoption, implementation of the Alt Techs would still not alleviate the need for the thermal treatment Units to continue to treat significant portions of the Laboratory's specialized explosives waste.

The Laboratory's thermal treatment Units continue to be the only safe and available mode of treatment for the Laboratory's specialized explosives waste. The thermal treatment Units treat the waste safely, efficiently, and in a manner protective of human health and the environment. With its continued commitment to pollution prevention and waste minimization, the Laboratory will continue to minimize explosives waste and to evaluate alternative treatment technologies. However, onsite treatment at the thermal treatment Units continues to be the only safe and available mode of treatment.

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9 Conclusions

To achieve its scientific research and development and national security-related missions, the Laboratory develops specialized high explosives and also intentionally alters and insults explosives materials. These mission critical activities generate small volumes of specialized explosives waste. This specialized explosives waste is unique, heterogenous, highly energetic, potentially unstable, and often possesses indeterminate properties and characteristics. The properties and expected behaviors of the Laboratory's explosives waste streams, moreover, are constantly changing in nature.

The Laboratory's specialized explosives waste is dissimilar from the homogenous conventional munitions and waste explosives generated at other facilities. Studies performed by EPA and NASEM on potential Alt Tech for OB/OD focus on treatment of conventional munitions and waste explosives, and do not consider the specialized, intentionally altered, and insulted explosives and associated waste generated at LANL (EPA 2019, EPA 2023, NASEM 2019). Therefore, these studies do not provide a sound basis to inform Alt Tech decisions for the Laboratory's specialized explosives waste.

The Laboratory safely, efficiently, and in a manner protective of human health and the environment treats its specialized explosives waste at the Units . The Units treat, in a specifically designed and highly controlled manner, the limited and discrete quantities of specialized explosives waste that the Laboratory must generate to fulfill its research, development, and national security–related missions. The Units are designed to achieve efficient and complete combustion of the waste, and they do not generate secondary hazardous waste streams or any measurable or modeled toxic by-products. The Units have been shown to be safe and effective treatment technologies for the Laboratory's specialized explosives waste.

The Units are protective of human health and the environment. Environmental monitoring specific to the Units has demonstrated that they do not pose a threat to either human health or the environment. Notably, risk-screening assessments of the Units' operations demonstrate that there is no unacceptable risk to either human health or ecological receptors from the operations (LANL 2020f, LANL 2020g).

The Units also provide a "right-sized treatment unit" for the varying specialized explosives waste streams requiring treatment. The Units allow for prompt treatment of the Laboratory's specialized explosives waste streams, which increases safety by minimizing worker exposure and onsite storage needs, and also avoids the increased risks caused by transport of explosives waste. The Units can also address the unique risks posed by the specialized explosives waste, and can adapt to changes in the specialized waste's composition or size.

The Laboratory's Flash Pad is a modern, controlled approach to open burning, and it should be considered a safe and effective Alt Tech to conventional open burning. The Flash Pad utilizes propane-enhanced controlled open oxidation and other controls to achieve complete combustion without generating toxic by-products. The Laboratory's OD units are also designed and operated to achieve complete consumption without generating toxic by-products. Additional controls and monitoring at the Units furthers their safe and environmentally protective operations.

This Alt Tech Evaluation analyzed whether Alt Techs are available that can safely treat the specialized explosives waste streams currently treated at the Laboratory's thermal treatment Units. As detailed in Sections 7 and 8, there are no Alt Techs available that have been proven capable of safely treating the specialized explosives waste streams currently treated at the Units. The Units are the only proven safe mode of treatment available. The Units are protective of human health and the environment. EPA

regulations allow for the OB/OD of waste explosives. 40 C.F.R. § 265.382. Where there are no safe and available alternatives, it is appropriate to continue to use OB/OD for waste explosives. EPA 2022(b).

This conclusion is predicated on a robust analysis of the factors considered in an Alt Tech evaluation, including operational safety, monitorability, and toxic by-products. This conclusion also reflects the specialized nature of the explosives waste that the Laboratory generates, site-specific operational and safety factors, and considerations related to LANL's national security-related missions. Transportation of the Laboratory's specialized explosives waste offsite on public roadways, moreover, is not allowed or authorized under federal law (*see* 49 CFR § 173.53), would pose a significant risk to the public and the environment, and could present a national security risk.

Furthermore, given the highly energetic and heterogenous and potentially unstable and unpredictable nature of the Laboratory's explosives waste streams, the potential for degradation of explosives materials and unanticipated detonation exists during storage and handling. Therefore, any treatment technology that requires additional onsite storage and handling is necessarily unsafe because it introduces significant and unnecessary additional health and safety risks to workers, the public, facilities, and the environment. Each of the potentially applicable alternative treatment technologies analyzed in Section 8 and **Table 8-4** of this Alt Tech Evaluation would require increased waste storage periods and/or waste handling, resulting in increased health, safety, and environmental risks.

Section 6 of this Alt Tech Evaluation describes the Laboratory's proactive pollution prevention and waste minimization efforts, operational practice changes, and process efficiencies. These processes have enabled the Laboratory to significantly decrease the overall volume of explosives waste generated by roughly 80% during routine operations. These efforts are effective and are continuing, but they also cannot eliminate the need for continued thermal treatment at the Units into the foreseeable future.

For all of these reasons, and for those reasons previously submitted to the NMED, continued operation of the Laboratory's thermal treatment Units is the only safe and available treatment option for the Laboratory's specialized explosives waste at this time.

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11 Acronyms and Abbreviations

Acronym	Definition
ASER	Annual Site Environment Report
BATFE	Bureau of Alcohol, Tobacco, Firearms and Explosives
CFR	Code of Federal Regulations
CWP	contaminated waste processor
DAAF	4,4- diamino-3,3-azoxyfurazan
DOE	U.S. Department of Energy
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
EMS	Environmental Management System
EWI	El Dorado Engineering Explosive Waste Incinerator
EPA	U.S. Environmental Protection Agency
ETSCP	Environmental Security Technology Certification Program
FFRDC	Federally Funded Research and Development Center

Acronym	Definition
HMX	1,3,5,7-tetrazocine
HWA	New Mexico Hazardous Waste Act
IED	improvised explosive device
IHC	Interim Hazard Classification
JOCG	Joint Ordinance Commanders Group
LDR	Land Disposal Restriction
LANL	Los Alamos National Laboratory
MACT	maximum achievable control technology
N3B	Newport News Nuclear BWXT-Los Alamos, LLC
NASEM	National Academies of Sciences, Engineering, and Medicine
NAVAIR	Naval Air Systems Command
NMED-HWB	New Mexico Environment Department-Hazardous Waste Bureau
NNSA	National Nuclear Security Administration
NQ	Nitroguanidine
OB	Open Burning
OD	Open Detonation
PBX	Plastic Bonded eXplosives
PETN	Pentaerythritol tetranitrate
PHMSA	Pipeline and Hazardous Materials Safety Administration
PSN	Proper Shipping Name
PVC	polyvinyl chloride
PYX	2,6-Bis(picrylamino)-3,5-dinitropyridine
RCRA	Resource Conservation and Recovery Act
RDX	Cyclo-1,3,5-trimethylene-2,4,6-trinitramine
SERDP	Strategic Environmental Research and Development Program
TA	Technical Area
TATB	triamino trinitrobenzene
TNT	2,4,6- trinitrotoluene
TSDF	treatment, storage, and disposal facilities
WAC	waste acceptance criteria

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 1 – Waste Stream Profiles for Ash/Sand Residue

.

WASTE PROFILE FORM
COVER SHEET

44544
APPROVED

Waste Stream ID:	44544
WPF ID (Legacy):	
Waste Stream Name:	ASH FROM BURNING GROUND TREATMENT OPERATIONS.
Expiration Date:	09/18/2020
Waste Type:	Hazardous Waste
Radiological Type:	Non Radioactive
RCRA Category:	RCRA Solid Hazardous
Ancillary Types:	
Primary Composition:	Other [Describe]
Composition (other):	Ash
EPA Codes:	D007
Waste Acceptance:	
EPA Form Code:	W303
	Inorganic Solids: Ash (from any type of burning of hazardous waste)
EPA Source Code:	G19
	Other Intermittent Events or Processes: Other one-time or intermittent processes (specify in comments)

Waste Generation Estimates

YEAR	VOLUME
2021	15.00 gal
2020	15.00 gal
2019	15.00 gal
2018	15.00 gal
2017	5.00 gal

WASTE PROFILE FORM

Reference Number

WCATS ID	Legacy WPF ID
44544	

Generator's Z Number	Waste Generator's Name *(print)*	WMC's Z Number	WMC's Name *(print)*		Generator's Phone
313872	HANSON, DARREN	169004	GONZALES, PAUL		5056675527
Generator's Mail Stop	**Waste Generating Group**	**Waste Stream Technical Area**	**Building**	**Room**	**WMC Phone**
D471	J-8	16	000441	N/A	5056658812

Waste Accumulation *(check only one)*

- ☑ Satellite Accumulation Area — Site No: 6509
- ☐ Less-than-90 Days Storage Area — Site No:
- ☐ TSDF — Site No:
- ☐ Universal Waste Storage Area — Site No:
- ☐ Used Oil for Recycle — Site No:

ER Use Only

- ☐ ER Site — SWMU/AOC No.

- ☐ PCBs Storage Area — Site No:
- ☐ NM Special Waste — Site No:
- ☐ Rad Staging Area — Site No:
- ☐ Rad Storage Area — Site No:
- ☐ None of the Above — Site No:
- ☐ Central Accumulation Area — Site No:

Method of Characterization *(check as many as apply)*

☑ Chemical/Physical Analysis	☑ Attached	Sample No: Event 11418 RFA 3947 Burn Site
☑ Acceptable Knowledge Documentation	☑ Attached	Documentation No: HE burning operations at 16-388
☐ PCB Analysis	☐ Attached	Sample No:
☐ Radiological Analysis	☐ Attached	Sample No:
☐ Material Safety Data Sheet (MSDS)	☐ Attached	

Section 1 - Waste Prevention/Minimization *(answer all questions)*

Can hazard segregation, elimination, or material substitution be used?	☐ Yes *(provide comments)*	☑ No	
Can any of the materials in the waste stream be recycled or reused?	☐ Yes *(provide comments)*	☑ No	
Has waste minimization been incorporated into procedures or other process controls?	☑ Yes	☐ No *(provide comments)*	
Can this waste be generated outside a RCA?	☐ Yes *(provide comments)*	☐ No	☑ N/A

Comments:

Section 2 - Chemical and Physical Information

Waste Type *(check only one)*

- ☐ Unused/Unspent Chemical
- ☑ Process Waste/Spent Chemical/Other

Radiological Information

Was Waste generated in a RCA?

- ☐ Yes ☑ No
- ☑ Non-radioactive
- ☐ Radioactive - Low Level
- ☐ Radioactive - Transuranic

Waste Destination *(check one)*

- ☐ SWWS
- ☐ RLWTF
- ☐ RLWTP
- ☐ TA-16/HE
- ☐ NTS

Classified Information

- ☑ Unclassified
- ☐ Classified/Sensitive

Waste Category *(check all that apply)*

- ☑ Inorganic
- ☐ Organic
- ☐ Solvent (see instructions)
- ☐ Degreaser (see instructions)
- ☐ Dioxin
- ☐ Electroplating
- ☑ Treated Hazardous Waste or Residue
- ☐ No-Longer Contained-In
- ☑ Explosive Process
- ☐ Infectious/Medical
- ☐ Biological
- ☐ Beryllium
- ☐ Empty Container (see instructions)
- ☐ Battery (see instructions)

Asbestos

- ☐ Friable
- ☐ Non-Friable

PCB Source Concentration

- ☐ PCB < 50 ppm
- ☐ PCB >= 50 - < 500 ppm
- ☐ PCB >= 500 ppm
- ☐ Hazardous Waste Contaminated Soil
- ☐ Untreated Hazardous Debris
- ☐ Commercial Solid Waste
- ☐ Other [Describe]

Other:

Waste Source *(check only one)*

Waste Source A

- ☐ Decon
- ☐ Materials Processing/Production
- ☐ Research/Development/Testing
- ☐ Scheduled Maintenance
- ☐ Housekeeping - Routine
- ☐ Spill Cleanup - Routine
- ☐ Sampling - Routine Monitoring
- ☑ Other (describe)

Waste Source B

- ☐ Abatement
- ☐ Construction/Upgrades
- ☐ Demolition
- ☐ Decon/Decom
- ☐ Investigative Derived
- ☐ Orphan/Legacy
- ☐ Remediation/Restoration
- ☐ Repacking (secondary)
- ☐ Unscheduled Maintenance
- ☐ Housekeeping (non-routine)
- ☐ Spill Cleanup (non-routine)
- ☐ Non-Petroleum Tanks
- ☐ Petroleum Tanks
- ☐ Other (describe)

Other: Treatment

Waste Matrix *(check only one)*

Gas

- ☐ ≤1.5 Atmospheres Pressure
- ☐ >1.5 Atmospheres Pressure
- ☐ Liquified Compressed Gas

Liquid

- ☐ Aqueous
- ☐ Non-Aqueous
- ☐ Suspended Solids/Aqueous
- ☐ Suspended Solids/Non-Aqueous

Solid

- ☑ Powder/Ash/Dust
- ☐ Solid
- ☐ Sludge
- ☐ Absorbed/Solidified Liquid
- ☐ Debris

Matrix Type *(check only one)*

- ☐ Homogeneous
- ☑ Heterogeneous

Estimate Annual Volume (m^3):

Section 3 - Process and Waste Description

Process Description:
ASH from Burning Ground treatment operations. Ash is generated from the treatment of materials that containe or could potentially containe detonable amounts of high explosives (HE). Once treated, all HE is incinerated. Waste is non-explosive, therefore non-RCRA-D003 reactive and non-DOT Hazard Class 1 explosive.

The 16-388 flash pad is outfitted with electronically ignited propane burners and no longer use benzene, toluene or kerosene as an ignition source. The propane burners efficiently render explosive residues to a non-explosive, non-RCRA reactive state.

Waste Description:
Waste will consist of Ash from Burning Ground operations.

Section 4 - Characteristics

Ignitability *(check only one)*	**Corrosivity** *(check only one)* (pH)	**Reactivity** *(check as many as apply)*	**Boiling Point** *(check only one)*
☐ < 73 F (< 22.8 C)	☐ <= 2.0	☐ RCRA Unstable	☐ <= 95 F (<= 35 C)
☐ 73 - 99 F (22.8 - 37.2 C)	☐ 2.1 - 4.0	☐ Water Reactive	☐ >95 F (> 35 C)
☐ 100 - 139 F (37.8 - 59.4 C)	☐ 4.1 - 6.0	☐ Cyanide Bearing	☑ Not Applicable
☐ 140 - 200 F (60.0 - 99.3 C)	☐ 6.1 - 9.0	☐ Sulfide Bearing	
☐ > 200 (> 99.3 C)	☐ 9.1 - 12.4	☐ Pyrophoric	
☐ EPA Ignitable - Non-liquid	☐ >= 12.5	☐ Shock Sensitive	
☐ DOT Flammable Gas	☐ Liquid Corrosive to Steel	☐ Explosive [Specify DOT Div.]	
☐ DOT Oxidizer	☑ Non-aqueous	☑ Non-Reactive	
☑ Not Ignitable			

	Characterization Method				Concentration of Contaminants		
Identify for all contaminants listed	**AK**	**TCLP**	**Total**	**None or Non-detect**	**Contaminant present at Minimum**	**Maxiumum**	**Regulatory Limit**
Toxicity Characteristic Metals					(10,000 ppm = 1%)		
Arsenic	☐	☐	☑	☐	0.001 to	42.1 ppm	5.0 ppm
Barium	☐	☐	☑	☐	0.01 to	136 ppm	100.0 ppm
Cadmium	☐	☐	☑	☑	to	ppm	1.0 ppm
Chromium	☐	☐	☑	☐	0.1 to	1110 ppm	5.0 ppm
Lead	☐	☐	☑	☑	to	ppm	5.0 ppm
Mercury	☐	☐	☑	☑	to	ppm	0.2 ppm
Selenium	☐	☐	☑	☐	0.0001 to	0.368 ppm	1.0 ppm
Silver	☐	☐	☑	☑	to	ppm	5.0 ppm
Toxicity Characteristic Organics							
Benzene	☑	☐	☐	☑	to	ppm	0.5 ppm
Carbon tetrachloride	☑	☐	☐	☑	to	ppm	0.5 ppm
Chlorobenzene	☑	☐	☐	☑	to	ppm	100.0 ppm
Chloroform	☑	☐	☐	☑	to	ppm	6.0 ppm
Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
p-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
m-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
o-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
1,4-Dichlorobenzene	☑	☐	☐	☑	to	ppm	7.5 ppm
1,2-Dichloroethane	☑	☐	☐	☑	to	ppm	0.5 ppm
1,1-Dichloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
2,4-Dinitrotoluene	☑	☐	☐	☑	to	ppm	0.13 ppm
Hexachlorobenzene	☑	☐	☐	☑	to	ppm	0.13 ppm
Hexachlorobutadiene	☑	☐	☐	☑	to	ppm	0.5 ppm
Hexachloroethane	☑	☐	☐	☑	to	ppm	3.0 ppm
Methyl ethyl ketone	☑	☐	☐	☑	to	ppm	200.0 ppm
Nitrobenzene	☑	☐	☐	☑	to	ppm	2.0 ppm
Pentachlorophenol	☑	☐	☐	☑	to	ppm	100.0 ppm
Pyridine	☑	☐	☐	☑	to	ppm	5.0 ppm
Tetrachloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
Trichloroethylene	☑	☐	☐	☑	to	ppm	0.5 ppm
2,4,6-Trichlorophenol	☑	☐	☐	☑	to	ppm	2.0 ppm
2,4,5-Trichlorophenol	☑	☐	☐	☑	to	ppm	400.0 ppm
Vinyl chloride	☑	☐	☐	☑	to	ppm	0.2 ppm
Herbicides and Pesticides							
Chlordane	☑	☐	☐	☑	to	ppm	0.03 ppm
2,4-D	☑	☐	☐	☑	to	ppm	10.0 ppm
Endrin	☑	☐	☐	☑	to	ppm	0.02 ppm
Heptachlor (& its epoxide)	☑	☐	☐	☑	to	ppm	0.008 ppm
Lindane (gamma-BHC)	☑	☐	☐	☑	to	ppm	0.4 ppm
Methoxychlor	☑	☐	☐	☑	to	ppm	10.0 ppm
2,4,5-TP (Silvex)	☑	☐	☐	☑	to	ppm	1.0 ppm
Toxaphene	☑	☐	☐	☑	to	ppm	0.5 ppm

Section 5 - Additional Constituents and Contaminants

Additional Constituents and Contaminants. Please account for 100% of waste. Range should be given within guidelines of individual constituents. List all other constients (including inerts) not identified above and attach any applicable analysis. No chemical formula allowed in this field. Continue in Section 3 Additional information as necessary. CAS numbers are needed for all chemical constituents, for material without a CAS number, enter "No CAS Number".

CAS No.	Name of constituent	Minimum (ppm)		Maximum (ppm)
-----	Ash	1000000	to	1000000
7429-90-5	Aluminum	0.1	to	1970
7440-41-7	Beryllium	0.0001	to	0.0325
7440-70-2	Calcium	1	to	22900
7440-48-4	Cobalt	0.01	to	418
7440-50-8	Copper	0.01	to	498
7439-89-6	Iron	10	to	168000
7440-09-7	Potassium	0.01	to	101
7439-95-4	Magnesium	0.01	to	894
7439-96-5	Manganese	0.1	to	2230
7440-23-5	Sodium	0.01	to	499
7440-02-0	Nickel	1	to	32400
7440-36-0	Antimony	0.001	to	86
7440-62-2	Vanadium	0.001	to	30.6
7440-66-6	Zinc	0.01	to	670
	Total of max. ranges of this section and page 2			123.20 in %

Additional Information

If additional information is available on the chemical, physical, or radiological character of the waste not covered on this form, provide it below

No compatibility issues. The waste is compatible with High Density Polythylene (HDPE) containers.

Per the data, the ash waste failed for Chromium and will be managed as hazardous waste (SAA site ID 6509)

Section 6 - Work Control Documentation

Do the procedures for this process cover how to manage this waste? ☑ Yes ☐ No *(provide comments)*

Do the procedures for this process address controls to prevent changes to waste constituents and concentrations or addition or removal of waste to/from containers? ☑ Yes ☐ No *(provide comments)*

Comments:

Section 7 - Packaging and Storage Control

Describe how the waste will be packaged in according to the applicable WAC.

DOT compliant container

No compatibility issues. The waste is compatible with High Density Polythylene (HDPE) containers

Identify the storage management controls that will be used for this waste stream: *(check all that apply)*

☐ Tamper Indication Devices ☐ Limited use locks with log-in for waste ☑ Locked cabinet or building ☐ Other (describe)

Section 8 - Waste Certification Statements

☑ Waste appears to meet WAC attachment for: HAZ

☐ Waste stream needs exception/exemption for treatment, storage, or disposal.

☐ Waste does not meet the criteria for any known TSDF. (DOE approval is required. Contact the office of the Principle Associate Director for Weapons Programs [PADWP] for assistance.)

Waste Generator Certification: Based on my knowledge of the waste and/or chemical/physical analysis, I certify that the waste characterization information on this form is correct and that it meets the requirements of the applicable waste acceptance criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: *JOHN MORRIS (109712)* Date: *09/18/17 12:53 PM*

Waste Management Approval: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *JEFFREY LEE (217511)* Date: *09/18/17 12:54 PM*

RCRA Review: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *ANDY ELICIO (118692)* Date: *09/18/17 01:06 PM*

Attachment 4 - LDR and UHC

Identify category and presence of any constituents listed below *(equal to or above limit)*.

Non-Wastewater/Wastewater Category *(check only one)*

☑ Non Wastewater ☐ Wastewater [as defined by 40 CFR 268.2(f)] ☐ Lab Pack [40 CFR 268.2(f)] **Sign Certification #1**

Notifications and Certifications - Check the appilcable boxes

Generator Requirements:

☐ This shipment contains hazardous waste contaminated soil that does not meet treatment standards **Sign Certification #2**
☐ This shipment contains untreated hazardous debris to be treated to 40 CFR 268.45 treatment standards **(No certification)**
☐ Hazardous wastes (except soil) meeting treatment standards at point of generation **Sign Certification #3**
☐ Hazardous wastes contaminated soil meeting treatment standards at point of generation **Sign Certification #4**

TSDF or Generator Treatment:

☐ TSDF treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #5**
☐ Generator treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #6**
☐ Hazardous wastes contaminated soil treated to 40 CFR 268.49 **Sign Certification #7**
☐ Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS **Sign Certification #8**
☑ Wastes or residues from characteristic hazardous waste treatment not meeting UTS **Sign Certification #9**
☐ Other TSDF wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #10**
☐ Other generator wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #11**

Notification of Underlying Hazardous Constituents

(Check the applicable underlying constituents above the concentration levels for D001 through D043 characterstic wastes only)

☐ ***No Underlying Hazardous Constituents in this waste stream.***

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Acenaphthene	83-32-9	0.059	3.4	34.0
☐	Acenaphthylene	208-96-8	0.059	3.4	34.0
☐	Acetone	67-64-1	0.28	160.0	1600.0
☐	Acetonitrile	75-05-8	5.6	38.0	380.0
☐	Acetophenone	98-86-2	0.01	9.7	97.0
☐	2-Acetylaminofluorene	53-96-3	0.059	140.0	1400.0
☐	Acrolein	107-02-8	0.29	N/A	N/A
☐	Acrylamide	79-06-1	19.0	23.0	230.0
☐	Acrylonitrile	107-13-1	0.24	84.0	840.0
☐	Aldicarb sulfone	1646-88-4	0.056	0.28	2.8
☐	Aldrin	309-00-2	0.021	0.066	0.66
☐	4-Aminobiphenyl	92-67-1	0.13	N/A	N/A
☐	Aniline	62-53-3	0.81	14.0	140.0
☐	o-Anisidine	90-04-0	0.01	0.66	6.6
☐	Anthracene	120-12-7	0.059	3.4	34.0
☐	Aramite	140-57-8	0.36	N/A	N/A
☐	alpha-BHC	319-84-6	0.00014	0.066	0.66
☐	beta-BHC	319-85-7	0.00014	0.066	0.66
☐	delta-BHC	319-86-8	0.023	0.066	0.66
☐	Barban	101-27-9	0.056	1.4	14.0
☐	Bendiocarb	22781-23-3	0.056	1.4	14.0
☐	Benomyl	17804-35-2	0.056	1.4	14.0
☐	Benz[a]anthracene	56-55-3	0.059	3.4	34.0
☐	Benzal chloride	98-87-3	0.055	6.0	60.0
☐	Benzene	71-43-2	0.14	10.0	100.0
☐	Benzo(b)fluoranthene	205-99-2	0.11	6.8	68.0
☐	Benzo[a]pyrene	50-32-8	0.061	3.4	34.0
☐	Benzo[ghi]perylene	191-24-2	0.0055	1.8	18.0
☐	Benzo[k]fluoranthene	207-08-9	0.11	6.8	68.0
☐	Bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	72.0
☐	Bis(2-chloroethyl) ether	111-44-4	0.033	6.0	60.0
☐	Bis(2-chloroisopropyl) ether	39638-32-9	0.055	7.2	72.0
☐	Bis(2-ethylhexyl) phthalate	117-81-7	0.28	28.0	280.0
☐	Bromodichloromethane	75-27-4	0.35	15.0	150.0
☐	Bromomethane	74-83-9	0.11	15.0	150.0
☐	4-Bromophenyl phenyl ether	101-55-3	0.055	15.0	150.0
☐	n-Butyl alchohol	71-36-3	5.6	2.6	26.0
☐	Butyl benzyl phthalate	85-68-7	0.017	28.0	280.0
☐	Butylate	2008-41-5	0.042	1.4	14.0
☐	Carbaryl	63-25-2	0.006	0.14	1.4

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Carbendazim	10605-21-7	0.056	1.4	14.0
☐	Carbofuran	1563-66-2	0.006	0.14	1.4
☐	Carbofuran phenol	1563-38-8	0.056	1.4	14.0
☐	Carbon disulfide	75-15-0	3.8	4.8	48.0
☐	Carbon tetrachloride	56-23-5	0.057	6.0	60.0
☐	Carbosulfan	55285-14-8	0.028	1.4	14.0
☐	Chlordane	57-74-9	0.0033	0.26	2.6
☐	p-Chloro-m-cresol	59-50-7	0.018	14.0	140.0
☐	p-Chloroaniline	106-47-8	0.46	16.0	160.0
☐	Chlorobenzene	108-90-7	0.057	6.0	60.0
☐	Chlorobenzilate	510-15-6	0.1	N/A	N/A
☐	Chlorodibromomethane	124-48-1	0.057	15.0	150.0
☐	Chloroethane	75-00-3	0.27	6.0	60.0
☐	2-Chloroethyl vinyl ether	110-75-8	0.062	N/A	N/A
☐	Chloroform	67-66-3	0.046	6.0	60.0
☐	Chloromethane	74-87-3	0.19	30.0	300.0
☐	2-Chloronaphthalene	91-58-7	0.055	5.6	56.0
☐	2-Chlorophenol	95-57-8	0.044	5.7	57.0
☐	Chloroprene	126-99-8	0.057	0.28	2.8
☐	3-Chloropropylene	107-05-1	0.036	30.0	300.0
☐	Chrysene	218-01-9	0.059	3.4	34.0
☐	p-Cresidine	120-71-8	0.01	0.66	6.6
☐	m-Cresol	108-39-4	0.77	5.6	56.0
☐	o-Cresol	95-48-7	0.11	5.6	56.0
☐	p-Cresol	106-44-5	0.77	5.6	56.0
☐	m-Cumenyl methylcarbamate	64-00-6	0.056	1.4	14.0
☐	Cyanide (Amenable)	57-12-5*	0.86	30.0	300.0
☐	Cyanide (Total)	57-12-5	1.2	590.0	5900.0
☐	Cyclohexanone	108-94-1	0.36	0.75	7.5
☐	2,4-D	94-75-7	0.72	10.0	100.0
☐	o,p'-DDD	53-19-0	0.023	0.087	0.87
☐	p,p'-DDD	72-54-8	0.023	0.087	0.87
☐	o,p'-DDE	3424-82-6	0.031	0.087	0.87
☐	p,p'-DDE	72-55-9	0.031	0.087	0.87
☐	o,p'-DDT	789-02-6	0.0039	0.087	0.87
☐	p,p'-DDT	50-29-3	0.0039	0.087	0.87
☐	Di-n-butyl phthalate	84-74-2	0.057	28.0	280.0
☐	Di-n-octyl phthalate	117-84-0	0.017	28.0	280.0
☐	Di-n-propylnitrosamine	621-64-7	0.4	14.0	140.0
☐	Dibenz[a,h]anthracene	53-70-3	0.055	8.2	82.0
☐	Dibenzo[a,e]pyrene	192-65-4	0.061	N/A	N/A
☐	1,2-Dibromo-3-chloropropane	96-12-8	0.11	15.0	150.0
☐	1,2-Dibromoethane	106-93-4	0.028	15.0	150.0
☐	Dibromomethane	74-95-3	0.11	15.0	150.0
☐	1,4-Dichlorobenzene	106-46-7	0.09	6.0	60.0
☐	m-Dichlorobenzene	541-73-1	0.036	6.0	60.0
☐	o-Dichlorobenzene	95-50-1	0.088	6.0	60.0
☐	Dichlorodifluoromethane	75-71-8	0.23	7.2	72.0
☐	1,1-Dichloroethane	75-34-3	0.059	6.0	60.0
☐	1,2-Dichloroethane	107-06-2	0.21	6.0	60.0
☐	1,1-Dichloroethylene	75-35-4	0.025	6.0	60.0
☐	trans-1,2-Dichloroethylene	156-60-5	0.054	30.0	300.0
☐	2,4-Dichlorophenol	120-83-2	0.044	14.0	140.0
☐	2,6-Dichlorophenol	87-65-0	0.044	14.0	140.0
☐	1,2-Dichloropropane	78-87-5	0.85	18.0	180.0
☐	trans-1,3-Dichloropropene	10061-02-6	0.036	18.0	180.0
☐	cis-1,3-Dichloropropylene	10061-01-5	0.036	18.0	180.0
☐	Dieldrin	60-57-1	0.017	0.13	1.3
☐	Diethyl phthalate	84-66-2	0.2	28.0	280.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Dimethyl phthalate	131-11-3	0.047	28.0	280.0
☐	p-Dimethylaminoazobenzene	60-11-7	0.13	N/A	N/A
☐	2,4-Dimethylphenol	105-67-9	0.036	14.0	140.0
☐	4,6-Dinitro-o-cresol	534-52-1	0.28	160.0	1600.0
☐	1,4-Dinitrobenzene	100-25-4	0.32	2.3	23.0
☐	2,4-Dinitrophenol	51-28-5	0.12	160.0	1600.0
☐	2,4-Dinitrotoluene	121-14-2	0.32	140.0	1400.0
☐	2,6-Dinitrotoluene	606-20-2	0.55	28.0	280.0
☐	Dinoseb	88-85-7	0.066	2.5	25.0
☐	1,4-Dioxane	123-91-1	12.0	170.0	1700.0
☐	Diphenylamine	122-39-4	0.92	13.0	130.0
☐	1,2-Diphenylhydrazine	122-66-7	0.087	N/A	N/A
☐	Disulfoton	298-04-4	0.017	6.2	62.0
☐	Dithiocarbamates (total)	WCATS-001	0.028	28.0	280.0
☐	EPTC	759-94-4	0.042	1.4	14.0
☐	Endosulfan I	959-98-8	0.023	0.066	0.66
☐	Endosulfan II	33213-65-9	0.029	0.13	1.3
☐	Endosulfan sulfate	1031-07-8	0.029	0.13	1.3
☐	Endrin	72-20-8	0.0028	0.13	1.3
☐	Endrin aldehyde	7421-93-4	0.025	0.13	1.3
☐	Ethyl acetate	141-78-6	0.34	33.0	330.0
☐	Ethyl benzene	100-41-4	0.057	10.0	100.0
☐	Ethyl ether	60-29-7	0.12	160.0	1600.0
☐	Ethyl methacrylate	97-63-2	0.14	160.0	1600.0
☐	Ethylene oxide	75-21-8	0.12	N/A	N/A
☐	Famphur	52-85-7	0.017	15.0	150.0
☐	Fluoranthene	206-44-0	0.068	3.4	34.0
☐	Fluorene	86-73-7	0.059	3.4	34.0
☐	Fluoride	16984-48-8	35.0	N/A	N/A
☐	Formetanate hydrochloride	23422-53-9	0.056	1.4	14.0
☐	Heptachlor (& its epoxide)	76-44-8	0.0012	0.066	0.66
☐	Heptachlor epoxide	1024-57-3	0.016	0.066	0.66
☐	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	0.025
☐	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	0.025
☐	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	0.025
☐	Hexachlorobenzene	118-74-1	0.055	10.0	100.0
☐	Hexachlorobutadiene	87-68-3	0.055	5.6	56.0
☐	Hexachlorocyclopentadiene	77-47-4	0.057	2.4	24.0
☐	Hexachloroethane	67-72-1	0.055	30.0	300.0
☐	Hexachloropropene	1888-71-7	0.035	30.0	300.0
☐	HxCDDs (All Hexachlorodibenzo-p-dioxins)	34465-46-8	0.000063	0.001	0.01
☐	HxCDFs (All Hexachlorodibenzo-furans)	55684-94-1	0.000063	0.001	0.01
☐	Indeno[1,2,3-cd]pyrene	193-39-5	0.0055	3.4	34.0
☐	Iodomethane	74-88-4	0.19	65.0	650.0
☐	Isobutyl alcohol	78-83-1	5.6	170.0	1700.0
☐	Isodrin	465-73-6	0.021	0.066	0.66
☐	Isosafrole	120-58-1	0.081	2.6	26.0
☐	Kepone	143-50-0	0.0011	0.13	1.3
☐	Lindane (gamma-BHC)	58-89-9	0.0017	0.066	0.66
☐	Mercury (Retort Residues)	7439-97-6*	N/A	0.2	2.0
☐	Methacrylonitrile	126-98-7	0.24	84.0	840.0
☐	Methanol	67-56-1	5.6	0.75	7.5
☐	Methapyrilene	91-80-5	0.081	1.5	15.0
☐	Methiocarb	2032-65-7	0.056	1.4	14.0
☐	Methomyl	16752-77-5	0.028	0.14	1.4
☐	Methoxychlor	72-43-5	0.25	0.18	1.8
☐	Methyl ethyl ketone	78-93-3	0.28	36.0	360.0
☐	Methyl isobutyl ketone	108-10-1	0.14	33.0	330.0
☐	Methyl methacrylate	80-62-6	0.14	160.0	1600.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Methyl methanesulfonate	66-27-3	0.018	N/A	N/A
☐	Methyl parathion	298-00-0	0.014	4.6	46.0
☐	3-Methylcholanthrene	56-49-5	0.0055	15.0	150.0
☐	4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.5	30.0	300.0
☐	Methylene chloride	75-09-2	0.089	30.0	300.0
☐	Metolcarb	1129-41-5	0.056	1.4	14.0
☐	Mexacarbate	315-18-4	0.056	1.4	14.0
☐	Molinate	2212-67-1	0.042	1.4	14.0
☐	N-Nitroso-di-n-butylamine	924-16-3	0.4	17.0	170.0
☐	N-Nitrosodiethylamine	55-18-5	0.4	28.0	280.0
☐	N-Nitrosodimethylamine	62-75-9	0.4	2.3	23.0
☐	N-Nitrosodiphenylamine	86-30-6	0.92	13.0	130.0
☐	N-Nitrosomethylethylamine	10595-95-6	0.4	2.3	23.0
☐	N-Nitrosomorpholine	59-89-2	0.4	2.3	23.0
☐	N-Nitrosopiperidine	100-75-4	0.013	35.0	350.0
☐	N-Nitrosopyrrolidine	930-55-2	0.013	35.0	350.0
☐	Naphthalene	91-20-3	0.059	5.6	56.0
☐	2-Naphthylamine	91-59-8	0.52	N/A	N/A
☐	5-Nitro-o-toluidine	99-55-8	0.32	28.0	280.0
☐	o-Nitroaniline	88-74-4	0.27	14.0	140.0
☐	p-Nitroaniline	100-01-6	0.028	28.0	280.0
☐	Nitrobenzene	98-95-3	0.068	14.0	140.0
☐	o-Nitrophenol	88-75-5	0.028	13.0	130.0
☐	p-Nitrophenol	100-02-7	0.12	29.0	290.0
☐	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	0.05
☐	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	0.05
☐	Oxamyl	23135-22-0	0.056	0.28	2.8
☐	Parathion	56-38-2	0.014	4.6	46.0
☐	PeCDDs (All Pentachlorodibenzo-p-dioxins)	36088-22-9	0.000063	0.001	0.01
☐	PeCDFs (All Pentachlorodibenzo-furans)	30402-15-4	0.000035	0.001	0.01
☐	Pebulate	1114-71-2	0.042	1.4	14.0
☐	Pentachlorobenzene	608-93-5	0.055	10.0	100.0
☐	Pentachloroethane	76-01-7	0.055	6.0	60.0
☐	Pentachloronitrobenzene	82-68-8	0.055	4.8	48.0
☐	Pentachlorophenol	87-86-5	0.089	7.4	74.0
☐	Phenacetin	62-44-2	0.081	16.0	160.0
☐	Phenanthrene	85-01-8	0.059	5.6	56.0
☐	Phenol	108-95-2	0.039	6.2	62.0
☐	1,3-Phenylenediamine	108-45-2	N/A	N/A	N/A
☐	o-Phenylenediamine	95-54-5	N/A	N/A	N/A
☐	Phorate	298-02-2	0.021	4.6	46.0
☐	Phthalic acid	100-21-0	0.055	28.0	280.0
☐	Phthalic anhydride	85-44-9	0.055	28.0	280.0
☐	Physostigmine	57-47-6	0.056	1.4	14.0
☐	Physostigmine salicylate	57-64-7	0.056	1.4	14.0
☐	Promecarb	2631-37-0	0.056	1.4	14.0
☐	Pronamide	23950-58-5	0.093	1.5	15.0
☐	Propanenitrile	107-12-0	0.24	360.0	3600.0
☐	Propham	122-42-9	0.056	1.4	14.0
☐	Propoxur	114-26-1	0.056	1.4	14.0
☐	Prosulfocarb	52888-80-9	0.042	1.4	14.0
☐	Pyrene	129-00-0	0.067	8.2	82.0
☐	Pyridine	110-86-1	0.014	16.0	160.0
☐	Safrole	94-59-7	0.081	22.0	220.0
☐	Sulfide	18496-25-8	14.0	N/A	N/A
☐	2,4,5-T	93-76-5	0.72	7.9	79.0
☐	TCDDs (All Tetrachlorodi-benzo-p-dioxins)	41903-57-5	0.000063	0.001	0.01
☐	TCDFs (All Tetrachlorodibenzofurans)	30402-14-3	0.000063	0.001	0.01
☐	2,4,5-TP (Silvex)	93-72-1	0.72	7.9	79.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14.0	140.0
☐	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6.0	60.0
☐	1,1,2,2-Tetrachloroethane	79-34-5	0.057	6.0	60.0
☐	Tetrachloroethylene	127-18-4	0.056	6.0	60.0
☐	2,3,4,6-Tetrachlorophenol	58-90-2	0.03	7.4	74.0
☐	Thiodicarb	59669-26-0	0.019	1.4	14.0
☐	Thiophanate-methyl	23564-05-8	0.056	1.4	14.0
☐	Toluene	108-88-3	0.08	10.0	100.0
☐	Total PCBs (Polychlorinated biphenyls)	1336-36-3	0.1	10.0	100.0
☐	Toxaphene	8001-35-2	0.0095	2.6	26.0
☐	Triallate	2303-17-5	0.042	1.4	14.0
☐	Tribromomethane	75-25-2	0.63	15.0	150.0
☐	2,4,6-Tribromophenol	118-79-6	0.035	7.4	74.0
☐	1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	0.057	30.0	300.0
☐	1,2,4-Trichlorobenzene	120-82-1	0.055	19.0	190.0
☐	1,1,1-Trichloroethane	71-55-6	0.054	6.0	60.0
☐	1,1,2-Trichloroethane	79-00-5	0.054	6.0	60.0
☐	Trichloroethylene	79-01-6	0.054	6.0	60.0
☐	Trichloromonofluoromethane (R11)	75-69-4	0.02	30.0	300.0
☐	2,4,5-Trichlorophenol	95-95-4	0.18	7.4	74.0
☐	2,4,6-Trichlorophenol	88-06-2	0.035	7.4	74.0
☐	1,2,3-Trichloropropane	96-18-4	0.85	30.0	300.0
☐	Triethylamine	121-44-8	0.081	1.5	15.0
☐	Tris(2,3-dibromopropyl) phosphate	126-72-7	0.11	0.1	1.0
☐	Vernolate	1929-77-7	0.042	1.4	14.0
☐	Vinyl chloride	75-01-4	0.27	6.0	60.0
☐	Xylene	1330-20-7	0.32	30.0	300.0
☐	2,4-Xylidine	95-68-1	0.01	0.66	6.6
☑	Antimony	7440-36-0	1.9	1.15	11.5
☐	Arsenic	7440-38-2	1.4	5.0	50.0
☐	Barium	7440-39-3	1.2	21.0	210.0
☐	Beryllium	7440-41-7	0.82	1.22	12.2
☐	Cadmium	7440-43-9	0.69	0.11	1.1
☑	Chromium	7440-47-3	2.77	0.6	6.0
☐	Lead	7439-92-1	0.69	0.75	7.5
☐	Mercury	7439-97-6	0.15	0.025	0.25
☑	Nickel	7440-02-0	3.98	11.0	110.0
☐	Selenium	7782-49-2	0.82	5.7	57.0
☐	Silver	7440-22-4	0.43	0.14	1.4
☐	Thallium	7440-28-0	1.4	0.2	2.0
☐	Vanadium	7440-62-2	4.3	1.6	16.0
☐	Zinc	7440-66-6	2.61	4.3	43.0

Notifications/Certifications #9

WPF # _____

Wastes or residues from characteristic hazardous waste treatment not meeting UTS

I certify under penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification. Based on my inquiry of those individuals immediately responsible for obtain this information, I believe that the treatment process has been operated and maintained properly so as to comply with the treatment standards in 40 CFR 268.40 without impremissible dilution of the prohibited waste. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

JEFFREY LEE (217511)
Authorized Signature

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.40 or 268.49 to remove the hazardous characteristic. This decharacterized waste contains underlying hazardous constituents that require further treatment to meet treatment standards. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

JEFFREY LEE (217511)
Authorized Signature

Attachment 1 - Additional Radionuclides

Please list the supplimentary radionuclides and their concentration values.

WASTE PROFILE FORM
COVER SHEET

49597
APPROVED

Waste Characterization Information

Waste Stream ID:	49597
WPF ID (Legacy):	
Waste Stream Name:	ASH
Expiration Date:	09/21/2023
Waste Type:	New Mexico Special Waste
Radiological Type:	Non Radioactive
RCRA Category:	RCRA Solid Non-hazardous
Ancillary Types:	TREATED FORMERLY CHARACTERISTIC HAZARDOUS WASTE
Primary Composition:	Other [Describe]
Composition (other):	ash
EPA Codes:	
Waste Acceptance:	
EPA Form Code:	NA
	Not Applicable: Not Applicable
EPA Source Code:	NA
	Not Applicable: Not Applicable

Waste Generation Estimates

YEAR	VOLUME
2024	0.00 CM
2023	0.00 gal
2022	0.00 gal
2021	220.00 gal

WASTE PROFILE FORM

Reference Number

WCATS ID	Legacy WPF ID
49597	

Generator's Z Number	Waste Generator's Name *(print)*	WMC's Z Number	WMC's Name *(print)*		Generator's Phone
317357	BAILON, JESSE	169004	GONZALES, PAUL		5056673133
Generator's Mail Stop	**Waste Generating Group**	**Waste Stream Technical Area**	**Building**	**Room**	**WMC Phone**
C936	M-8	16	000441		5056658812

Waste Accumulation *(check only one)*

- ☐ Satellite Accumulation Area — Site No: _____
- ☐ Less-than-90 Days Storage Area — Site No: _____
- ☐ TSDF — Site No: _____
- ☐ Universal Waste Storage Area — Site No: _____
- ☐ Used Oil for Recycle — Site No: _____

ER Use Only

- ☐ ER Site — SWMU/AOC No. _____

- ☐ PCBs Storage Area — Site No: _____
- ☑ NM Special Waste — Site No: 6614
- ☐ Rad Staging Area — Site No: _____
- ☐ Rad Storage Area — Site No: _____
- ☐ None of the Above — Site No: _____
- ☐ Central Accumulation Area — Site No: _____

Method of Characterization *(check as many as apply)*

☑ Chemical/Physical Analysis	☑ Attached	Sample No: 1 & 2
☐ Material Safety Data Sheet (MSDS)	☐ Attached	
☐ Radiological Analysis	☐ Attached	Sample No: _____
☐ Acceptable Knowledge Documentation	☐ Attached	Documentation No: _____
☐ PCB Analysis	☐ Attached	Sample No: _____

Section 1 - Waste Prevention/Minimization *(answer all questions)*

Can hazard segregation, elimination, or material substitution be used?	☐ Yes *(provide comments)*	☑ No	
Can any of the materials in the waste stream be recycled or reused?	☐ Yes *(provide comments)*	☑ No	
Has waste minimization been incorporated into procedures or other process controls?	☑ Yes	☐ No *(provide comments)*	
Can this waste be generated outside a RCA?	☐ Yes *(provide comments)*	☐ No	☑ N/A

Comments:

Section 2 - Chemical and Physical Information

Waste Type *(check only one)*

- ☐ Unused/Unspent Chemical
- ☑ Process Waste/Spent Chemical/Other

Radiological Information

Was Waste generated in a RCA?

- ☐ Yes ☑ No
- ☑ Non-radioactive
- ☐ Radioactive - Low Level
- ☐ Radioactive - Transuranic

Waste Destination *(check one)*

- ☐ SWWS
- ☐ RLWTF
- ☐ RLWTP
- ☐ TA-16/HE
- ☐ NTS

Classified Information

- ☑ Unclassified
- ☐ Classified/Sensitive

Waste Category *(check all that apply)*

- ☑ Inorganic
- ☑ Organic
- ☐ Solvent (see instructions)
- ☐ Degreaser (see instructions)
- ☐ Dioxin
- ☐ Electroplating
- ☐ Treated Hazardous Waste or Residue
- ☐ No-Longer Contained-In
- ☑ Explosive Process
- ☐ Infectious/Medical
- ☐ Biological
- ☐ Beryllium
- ☐ Empty Container (see instructions)
- ☐ Battery (see instructions)

Asbestos

- ☐ Friable
- ☐ Non-Friable

PCB Source Concentration

- ☐ PCB < 50 ppm
- ☐ PCB >= 50 - < 500 ppm
- ☐ PCB >= 500 ppm
- ☐ Hazardous Waste Contaminated Soil
- ☐ Untreated Hazardous Debris
- ☐ Commercial Solid Waste
- ☐ Other [Describe]

Other:

Waste Source *(check only one)*

Waste Source A

- ☑ Decon
- ☐ Materials Processing/Production
- ☐ Research/Development/Testing
- ☐ Scheduled Maintenance
- ☐ Housekeeping - Routine
- ☐ Spill Cleanup - Routine
- ☐ Sampling - Routine Monitoring
- ☐ Other (describe)

Waste Source B

- ☐ Abatement
- ☐ Construction/Upgrades
- ☐ Demolition
- ☐ Decon/Decom
- ☐ Investigative Derived
- ☐ Orphan/Legacy
- ☐ Remediation/Restoration
- ☐ Repacking (secondary)
- ☐ Unscheduled Maintenance
- ☐ Housekeeping (non-routine)
- ☐ Spill Cleanup (non-routine)
- ☐ Non-Petroleum Tanks
- ☐ Petroleum Tanks
- ☐ Other (describe)

Other:

Waste Matrix *(check only one)*

Gas

- ☐ ≤1.5 Atmospheres Pressure
- ☐ >1.5 Atmospheres Pressure
- ☐ Liquified Compressed Gas

Liquid

- ☐ Aqueous
- ☐ Non-Aqueous
- ☐ Suspended Solids/Aqueous
- ☐ Suspended Solids/Non-Aqueous

Solid

- ☐ Powder/Ash/Dust
- ☑ Solid
- ☐ Sludge
- ☐ Absorbed/Solidified Liquid
- ☐ Debris

Matrix Type *(check only one)*

- ☑ Homogeneous
- ☐ Heterogeneous

Estimate Annual Volume (m^3):

0.8328

Section 3 - Process and Waste Description

Process Description:
Ash from the TA-16 flash pad from flash pad. Sand had previously tested positive to containing HE prior to flashing.

Waste Description:
Treated sand with trace metals.

Section 4 - Characteristics

Ignitability *(check only one)*	**Corrosivity** *(check only one)* (pH)	**Reactivity** *(check as many as apply)*	**Boiling Point** *(check only one)*
☐ < 73 F (< 22.8 C)	☐ <= 2.0	☐ RCRA Unstable	☐ <= 95 F (<= 35 C)
☐ 73 - 99 F (22.8 - 37.2 C)	☐ 2.1 - 4.0	☐ Water Reactive	☐ >95 F (> 35 C)
☐ 100 - 139 F (37.8 - 59.4 C)	☐ 4.1 - 6.0	☐ Cyanide Bearing	☑ Not Applicable
☐ 140 - 200 F (60.0 - 99.3 C)	☐ 6.1 - 9.0	☐ Sulfide Bearing	
☐ > 200 (> 99.3 C)	☐ 9.1 - 12.4	☐ Pyrophoric	
☐ EPA Ignitable - Non-liquid	☐ >= 12.5	☐ Shock Sensitive	
☐ DOT Flammable Gas	☐ Liquid Corrosive to Steel	☐ Explosive [Specify DOT Div.]	
☐ DOT Oxidizer	☑ Non-aqueous	☑ Non-Reactive	
☑ Not Ignitable			

	Characterization Method				Concentration of Contaminants		
				None or	Contaminant present at		
Identify for all contaminants listed	**AK**	**TCLP**	**Total**	**Non-detect**	**Minimum**	**Maxiumum**	**Regulatory Limit**
Toxicity Characteristic Metals					(10,000 ppm = 1%)		
Arsenic	☐	☑	☐	☑	to	ppm	5.0 ppm
Barium	☐	☑	☐	☐	0 to	27.3 ppm	100.0 ppm
Cadmium	☐	☑	☐	☐	0 to	0.00682 ppm	1.0 ppm
Chromium	☐	☑	☐	☑	to	ppm	5.0 ppm
Lead	☐	☑	☐	☐	0 to	0.948 ppm	5.0 ppm
Mercury	☐	☑	☐	☑	to	ppm	0.2 ppm
Selenium	☐	☑	☐	☐	0 to	0.562 ppm	1.0 ppm
Silver	☐	☑	☐	☑	to	ppm	5.0 ppm
Toxicity Characteristic Organics							
Benzene	☐	☐	☑	☑	to	ppm	0.5 ppm
Carbon tetrachloride	☐	☐	☑	☑	to	ppm	0.5 ppm
Chlorobenzene	☐	☐	☑	☑	to	ppm	100.0 ppm
Chloroform	☐	☐	☑	☑	to	ppm	6.0 ppm
Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
p-Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
m-Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
o-Cresol	☐	☐	☑	☑	to	ppm	200.0 ppm
1,4-Dichlorobenzene	☐	☐	☑	☑	to	ppm	7.5 ppm
1,2-Dichloroethane	☐	☐	☑	☑	to	ppm	0.5 ppm
1,1-Dichloroethylene	☐	☐	☑	☑	to	ppm	0.7 ppm
2,4-Dinitrotoluene	☐	☐	☑	☑	to	ppm	0.13 ppm
Hexachlorobenzene	☐	☐	☑	☑	to	ppm	0.13 ppm
Hexachlorobutadiene	☐	☐	☑	☑	to	ppm	0.5 ppm
Hexachloroethane	☐	☐	☑	☑	to	ppm	3.0 ppm
Methyl ethyl ketone	☐	☐	☑	☐	0 to	0.0001815 ppm	200.0 ppm
Nitrobenzene	☐	☐	☑	☑	to	ppm	2.0 ppm
Pentachlorophenol	☐	☐	☑	☑	to	ppm	100.0 ppm
Pyridine	☐	☐	☑	☑	to	ppm	5.0 ppm
Tetrachloroethylene	☐	☐	☑	☑	to	ppm	0.7 ppm
Trichloroethylene	☐	☐	☑	☑	to	ppm	0.5 ppm
2,4,6-Trichlorophenol	☐	☐	☑	☑	to	ppm	2.0 ppm
2,4,5-Trichlorophenol	☐	☐	☑	☑	to	ppm	400.0 ppm
Vinyl chloride	☐	☐	☑	☑	to	ppm	0.2 ppm
Herbicides and Pesticides							
Chlordane	☑	☐	☐	☑	to	ppm	0.03 ppm
2,4-D	☑	☐	☐	☑	to	ppm	10.0 ppm
Endrin	☑	☐	☐	☑	to	ppm	0.02 ppm
Heptachlor (& its epoxide)	☑	☐	☐	☑	to	ppm	0.008 ppm
Lindane (gamma-BHC)	☑	☐	☐	☑	to	ppm	0.4 ppm
Methoxychlor	☑	☐	☐	☑	to	ppm	10.0 ppm
2,4,5-TP (Silvex)	☑	☐	☐	☑	to	ppm	1.0 ppm
Toxaphene	☑	☐	☐	☑	to	ppm	0.5 ppm

Section 5 - Additional Constituents and Contaminants

Additional Constituents and Contaminants. Please account for 100% of waste. Range should be given within guidelines of individual constituents. List all other constients (including inerts) not identified above and attach any applicable analysis. No chemical formula allowed in this field. Continue in Section 3 Additional information as necessary. CAS numbers are needed for all chemical constituents, for material without a CAS number, enter "No CAS Number".

CAS No.	Name of constituent	Minimum (ppm)		Maximum (ppm)
67-64-1	Acetone	0	to	0.05
117-81-7	Bis(2-ethylhexyl) phthalate	0	to	0.0151
-----	Butanone[2-]	0	to	0.00363
84-74-2	Di-n-butyl phthalate	0	to	0.0762
75-09-2	Methylene chloride	0	to	0.01
-----	Ash	950000	to	1000000
	Total of max. ranges of this section and page 2			100.00 in %

Additional Information

If additional information is available on the chemical, physical, or radiological character of the waste not covered on this form, provide it below

Methylene chloride, acetone and MEK detectes are not from a known or suspected usage as solvents.

Section 6 - Work Control Documentation

Do the procedures for this process cover how to manage this waste? ☑ Yes ☐ No *(provide comments)*

Do the procedures for this process address controls to prevent changes to waste constituents and concentrations or addition or removal of waste to/from containers? ☑ Yes ☐ No *(provide comments)*

Comments:

Section 7 - Packaging and Storage Control

Describe how the waste will be packaged in according to the applicable WAC.

Waste will be packaged into a compatible DOT approved poly drums.

Waste is compatible with itself

Identify the storage management controls that will be used for this waste stream: *(check all that apply)*

☑ Tamper Indication Devices ☐ Limited use locks with log-in for waste ☑ Locked cabinet or building ☐ Other (describe)

Section 8 - Waste Certification Statements

☑ Waste appears to meet WAC attachment for: NMSW

☐ Waste stream needs exception/exemption for treatment, storage, or disposal.

☐ Waste does not meet the criteria for any known TSDF. (DOE approval is required. Contact the office of the Principle Associate Director for Weapons Programs [PADWP] for assistance.)

Waste Generator Certification: Based on my knowledge of the waste and/or chemical/physical analysis, I certify that the waste characterization information on this form is correct and that it meets the requirements of the applicable waste acceptance criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: *JESSE BAILON (317357)* Date: *09/21/21 08:37 AM*

Waste Management Approval: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *PAUL GONZALES (169004)* Date: *09/22/21 10:08 AM*

RCRA Review: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *ROBERT MOLTER (239137)* Date: *09/22/21 10:58 AM*

Attachment 4 - LDR and UHC

Identify category and presence of any constituents listed below *(equal to or above limit)*.

Non-Wastewater/Wastewater Category *(check only one)*

☐ Non Wastewater ☐ Wastewater [as defined by 40 CFR 268.2(f)] ☐ Lab Pack [40 CFR 268.2(f)] **Sign Certification #1**

Notifications and Certifications - Check the appilcable boxes

Generator Requirements:

☐ This shipment contains hazardous waste contaminated soil that does not meet treatment standards **Sign Certification #2**
☐ This shipment contains untreated hazardous debris to be treated to 40 CFR 268.45 treatment standards **(No certification)**
☐ Hazardous wastes (except soil) meeting treatment standards at point of generation **Sign Certification #3**
☐ Hazardous wastes contaminated soil meeting treatment standards at point of generation **Sign Certification #4**

TSDF or Generator Treatment:

☐ TSDF treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #5**
☐ Generator treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #6**
☐ Hazardous wastes contaminated soil treated to 40 CFR 268.49 **Sign Certification #7**
☐ Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS **Sign Certification #8**
☑ Wastes or residues from characteristic hazardous waste treatment not meeting UTS **Sign Certification #9**
☐ Other TSDF wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #10**
☐ Other generator wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #11**

Notification of Underlying Hazardous Constituents

(Check the applicable underlying constituents above the concentration levels for D001 through D043 characterstic wastes only)

☐ ***No Underlying Hazardous Constituents in this waste stream.***

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Acenaphthene	83-32-9	0.059	3.4	34.0
☐	Acenaphthylene	208-96-8	0.059	3.4	34.0
☐	Acetone	67-64-1	0.28	160.0	1600.0
☐	Acetonitrile	75-05-8	5.6	38.0	380.0
☐	Acetophenone	98-86-2	0.01	9.7	97.0
☐	2-Acetylaminofluorene	53-96-3	0.059	140.0	1400.0
☐	Acrolein	107-02-8	0.29	N/A	N/A
☐	Acrylamide	79-06-1	19.0	23.0	230.0
☐	Acrylonitrile	107-13-1	0.24	84.0	840.0
☐	Aldicarb sulfone	1646-88-4	0.056	0.28	2.8
☐	Aldrin	309-00-2	0.021	0.066	0.66
☐	4-Aminobiphenyl	92-67-1	0.13	N/A	N/A
☐	Aniline	62-53-3	0.81	14.0	140.0
☐	o-Anisidine	90-04-0	0.01	0.66	6.6
☐	Anthracene	120-12-7	0.059	3.4	34.0
☐	Aramite	140-57-8	0.36	N/A	N/A
☐	alpha-BHC	319-84-6	0.00014	0.066	0.66
☐	beta-BHC	319-85-7	0.00014	0.066	0.66
☐	delta-BHC	319-86-8	0.023	0.066	0.66
☐	Barban	101-27-9	0.056	1.4	14.0
☐	Bendiocarb	22781-23-3	0.056	1.4	14.0
☐	Benomyl	17804-35-2	0.056	1.4	14.0
☐	Benz[a]anthracene	56-55-3	0.059	3.4	34.0
☐	Benzal chloride	98-87-3	0.055	6.0	60.0
☐	Benzene	71-43-2	0.14	10.0	100.0
☐	Benzo(b)fluoranthene	205-99-2	0.11	6.8	68.0
☐	Benzo[a]pyrene	50-32-8	0.061	3.4	34.0
☐	Benzo[ghi]perylene	191-24-2	0.0055	1.8	18.0
☐	Benzo[k]fluoranthene	207-08-9	0.11	6.8	68.0
☐	Bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	72.0
☐	Bis(2-chloroethyl) ether	111-44-4	0.033	6.0	60.0
☐	Bis(2-chloroisopropyl) ether	39638-32-9	0.055	7.2	72.0
☐	Bis(2-ethylhexyl) phthalate	117-81-7	0.28	28.0	280.0
☐	Bromodichloromethane	75-27-4	0.35	15.0	150.0
☐	Bromomethane	74-83-9	0.11	15.0	150.0
☐	4-Bromophenyl phenyl ether	101-55-3	0.055	15.0	150.0
☐	n-Butyl alchohol	71-36-3	5.6	2.6	26.0
☐	Butyl benzyl phthalate	85-68-7	0.017	28.0	280.0
☐	Butylate	2008-41-5	0.042	1.4	14.0
☐	Carbaryl	63-25-2	0.006	0.14	1.4

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Carbendazim	10605-21-7	0.056	1.4	14.0
☐	Carbofuran	1563-66-2	0.006	0.14	1.4
☐	Carbofuran phenol	1563-38-8	0.056	1.4	14.0
☐	Carbon disulfide	75-15-0	3.8	4.8	48.0
☐	Carbon tetrachloride	56-23-5	0.057	6.0	60.0
☐	Carbosulfan	55285-14-8	0.028	1.4	14.0
☐	Chlordane	57-74-9	0.0033	0.26	2.6
☐	p-Chloro-m-cresol	59-50-7	0.018	14.0	140.0
☐	p-Chloroaniline	106-47-8	0.46	16.0	160.0
☐	Chlorobenzene	108-90-7	0.057	6.0	60.0
☐	Chlorobenzilate	510-15-6	0.1	N/A	N/A
☐	Chlorodibromomethane	124-48-1	0.057	15.0	150.0
☐	Chloroethane	75-00-3	0.27	6.0	60.0
☐	2-Chloroethyl vinyl ether	110-75-8	0.062	N/A	N/A
☐	Chloroform	67-66-3	0.046	6.0	60.0
☐	Chloromethane	74-87-3	0.19	30.0	300.0
☐	2-Chloronaphthalene	91-58-7	0.055	5.6	56.0
☐	2-Chlorophenol	95-57-8	0.044	5.7	57.0
☐	Chloroprene	126-99-8	0.057	0.28	2.8
☐	3-Chloropropylene	107-05-1	0.036	30.0	300.0
☐	Chrysene	218-01-9	0.059	3.4	34.0
☐	p-Cresidine	120-71-8	0.01	0.66	6.6
☐	m-Cresol	108-39-4	0.77	5.6	56.0
☐	o-Cresol	95-48-7	0.11	5.6	56.0
☐	p-Cresol	106-44-5	0.77	5.6	56.0
☐	m-Cumenyl methylcarbamate	64-00-6	0.056	1.4	14.0
☐	Cyanide (Amenable)	57-12-5*	0.86	30.0	300.0
☐	Cyanide (Total)	57-12-5	1.2	590.0	5900.0
☐	Cyclohexanone	108-94-1	0.36	0.75	7.5
☐	2,4-D	94-75-7	0.72	10.0	100.0
☐	o,p'-DDD	53-19-0	0.023	0.087	0.87
☐	p,p'-DDD	72-54-8	0.023	0.087	0.87
☐	o,p'-DDE	3424-82-6	0.031	0.087	0.87
☐	p,p'-DDE	72-55-9	0.031	0.087	0.87
☐	o,p'-DDT	789-02-6	0.0039	0.087	0.87
☐	p,p'-DDT	50-29-3	0.0039	0.087	0.87
☐	Di-n-butyl phthalate	84-74-2	0.057	28.0	280.0
☐	Di-n-octyl phthalate	117-84-0	0.017	28.0	280.0
☐	Di-n-propylnitrosamine	621-64-7	0.4	14.0	140.0
☐	Dibenz[a,h]anthracene	53-70-3	0.055	8.2	82.0
☐	Dibenzo[a,e]pyrene	192-65-4	0.061	N/A	N/A
☐	1,2-Dibromo-3-chloropropane	96-12-8	0.11	15.0	150.0
☐	1,2-Dibromoethane	106-93-4	0.028	15.0	150.0
☐	Dibromomethane	74-95-3	0.11	15.0	150.0
☐	1,4-Dichlorobenzene	106-46-7	0.09	6.0	60.0
☐	m-Dichlorobenzene	541-73-1	0.036	6.0	60.0
☐	o-Dichlorobenzene	95-50-1	0.088	6.0	60.0
☐	Dichlorodifluoromethane	75-71-8	0.23	7.2	72.0
☐	1,1-Dichloroethane	75-34-3	0.059	6.0	60.0
☐	1,2-Dichloroethane	107-06-2	0.21	6.0	60.0
☐	1,1-Dichloroethylene	75-35-4	0.025	6.0	60.0
☐	trans-1,2-Dichloroethylene	156-60-5	0.054	30.0	300.0
☐	2,4-Dichlorophenol	120-83-2	0.044	14.0	140.0
☐	2,6-Dichlorophenol	87-65-0	0.044	14.0	140.0
☐	1,2-Dichloropropane	78-87-5	0.85	18.0	180.0
☐	trans-1,3-Dichloropropene	10061-02-6	0.036	18.0	180.0
☐	cis-1,3-Dichloropropylene	10061-01-5	0.036	18.0	180.0
☐	Dieldrin	60-57-1	0.017	0.13	1.3
☐	Diethyl phthalate	84-66-2	0.2	28.0	280.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Dimethyl phthalate	131-11-3	0.047	28.0	280.0
☐	p-Dimethylaminoazobenzene	60-11-7	0.13	N/A	N/A
☐	2,4-Dimethylphenol	105-67-9	0.036	14.0	140.0
☐	4,6-Dinitro-o-cresol	534-52-1	0.28	160.0	1600.0
☐	1,4-Dinitrobenzene	100-25-4	0.32	2.3	23.0
☐	2,4-Dinitrophenol	51-28-5	0.12	160.0	1600.0
☐	2,4-Dinitrotoluene	121-14-2	0.32	140.0	1400.0
☐	2,6-Dinitrotoluene	606-20-2	0.55	28.0	280.0
☐	Dinoseb	88-85-7	0.066	2.5	25.0
☐	1,4-Dioxane	123-91-1	12.0	170.0	1700.0
☐	Diphenylamine	122-39-4	0.92	13.0	130.0
☐	1,2-Diphenylhydrazine	122-66-7	0.087	N/A	N/A
☐	Disulfoton	298-04-4	0.017	6.2	62.0
☐	Dithiocarbamates (total)	WCATS-001	0.028	28.0	280.0
☐	EPTC	759-94-4	0.042	1.4	14.0
☐	Endosulfan I	959-98-8	0.023	0.066	0.66
☐	Endosulfan II	33213-65-9	0.029	0.13	1.3
☐	Endosulfan sulfate	1031-07-8	0.029	0.13	1.3
☐	Endrin	72-20-8	0.0028	0.13	1.3
☐	Endrin aldehyde	7421-93-4	0.025	0.13	1.3
☐	Ethyl acetate	141-78-6	0.34	33.0	330.0
☐	Ethyl benzene	100-41-4	0.057	10.0	100.0
☐	Ethyl ether	60-29-7	0.12	160.0	1600.0
☐	Ethyl methacrylate	97-63-2	0.14	160.0	1600.0
☐	Ethylene oxide	75-21-8	0.12	N/A	N/A
☐	Famphur	52-85-7	0.017	15.0	150.0
☐	Fluoranthene	206-44-0	0.068	3.4	34.0
☐	Fluorene	86-73-7	0.059	3.4	34.0
☐	Fluoride	16984-48-8	35.0	N/A	N/A
☐	Formetanate hydrochloride	23422-53-9	0.056	1.4	14.0
☐	Heptachlor (& its epoxide)	76-44-8	0.0012	0.066	0.66
☐	Heptachlor epoxide	1024-57-3	0.016	0.066	0.66
☐	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	0.025
☐	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	0.025
☐	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	0.025
☐	Hexachlorobenzene	118-74-1	0.055	10.0	100.0
☐	Hexachlorobutadiene	87-68-3	0.055	5.6	56.0
☐	Hexachlorocyclopentadiene	77-47-4	0.057	2.4	24.0
☐	Hexachloroethane	67-72-1	0.055	30.0	300.0
☐	Hexachloropropene	1888-71-7	0.035	30.0	300.0
☐	HxCDDs (All Hexachlorodibenzo-p-dioxins)	34465-46-8	0.000063	0.001	0.01
☐	HxCDFs (All Hexachlorodibenzo-furans)	55684-94-1	0.000063	0.001	0.01
☐	Indeno[1,2,3-cd]pyrene	193-39-5	0.0055	3.4	34.0
☐	Iodomethane	74-88-4	0.19	65.0	650.0
☐	Isobutyl alcohol	78-83-1	5.6	170.0	1700.0
☐	Isodrin	465-73-6	0.021	0.066	0.66
☐	Isosafrole	120-58-1	0.081	2.6	26.0
☐	Kepone	143-50-0	0.0011	0.13	1.3
☐	Lindane (gamma-BHC)	58-89-9	0.0017	0.066	0.66
☐	Mercury (Retort Residues)	7439-97-6*	N/A	0.2	2.0
☐	Methacrylonitrile	126-98-7	0.24	84.0	840.0
☐	Methanol	67-56-1	5.6	0.75	7.5
☐	Methapyrilene	91-80-5	0.081	1.5	15.0
☐	Methiocarb	2032-65-7	0.056	1.4	14.0
☐	Methomyl	16752-77-5	0.028	0.14	1.4
☐	Methoxychlor	72-43-5	0.25	0.18	1.8
☐	Methyl ethyl ketone	78-93-3	0.28	36.0	360.0
☐	Methyl isobutyl ketone	108-10-1	0.14	33.0	330.0
☐	Methyl methacrylate	80-62-6	0.14	160.0	1600.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Methyl methanesulfonate	66-27-3	0.018	N/A	N/A
☐	Methyl parathion	298-00-0	0.014	4.6	46.0
☐	3-Methylcholanthrene	56-49-5	0.0055	15.0	150.0
☐	4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.5	30.0	300.0
☐	Methylene chloride	75-09-2	0.089	30.0	300.0
☐	Metolcarb	1129-41-5	0.056	1.4	14.0
☐	Mexacarbate	315-18-4	0.056	1.4	14.0
☐	Molinate	2212-67-1	0.042	1.4	14.0
☐	N-Nitroso-di-n-butylamine	924-16-3	0.4	17.0	170.0
☐	N-Nitrosodiethylamine	55-18-5	0.4	28.0	280.0
☐	N-Nitrosodimethylamine	62-75-9	0.4	2.3	23.0
☐	N-Nitrosodiphenylamine	86-30-6	0.92	13.0	130.0
☐	N-Nitrosomethylethylamine	10595-95-6	0.4	2.3	23.0
☐	N-Nitrosomorpholine	59-89-2	0.4	2.3	23.0
☐	N-Nitrosopiperidine	100-75-4	0.013	35.0	350.0
☐	N-Nitrosopyrrolidine	930-55-2	0.013	35.0	350.0
☐	Naphthalene	91-20-3	0.059	5.6	56.0
☐	2-Naphthylamine	91-59-8	0.52	N/A	N/A
☐	5-Nitro-o-toluidine	99-55-8	0.32	28.0	280.0
☐	o-Nitroaniline	88-74-4	0.27	14.0	140.0
☐	p-Nitroaniline	100-01-6	0.028	28.0	280.0
☐	Nitrobenzene	98-95-3	0.068	14.0	140.0
☐	o-Nitrophenol	88-75-5	0.028	13.0	130.0
☐	p-Nitrophenol	100-02-7	0.12	29.0	290.0
☐	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	0.05
☐	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	0.05
☐	Oxamyl	23135-22-0	0.056	0.28	2.8
☐	Parathion	56-38-2	0.014	4.6	46.0
☐	PeCDDs (All Pentachlorodibenzo-p-dioxins)	36088-22-9	0.000063	0.001	0.01
☐	PeCDFs (All Pentachlorodibenzo-furans)	30402-15-4	0.000035	0.001	0.01
☐	Pebulate	1114-71-2	0.042	1.4	14.0
☐	Pentachlorobenzene	608-93-5	0.055	10.0	100.0
☐	Pentachloroethane	76-01-7	0.055	6.0	60.0
☐	Pentachloronitrobenzene	82-68-8	0.055	4.8	48.0
☐	Pentachlorophenol	87-86-5	0.089	7.4	74.0
☐	Phenacetin	62-44-2	0.081	16.0	160.0
☐	Phenanthrene	85-01-8	0.059	5.6	56.0
☐	Phenol	108-95-2	0.039	6.2	62.0
☐	1,3-Phenylenediamine	108-45-2	N/A	N/A	N/A
☐	o-Phenylenediamine	95-54-5	N/A	N/A	N/A
☐	Phorate	298-02-2	0.021	4.6	46.0
☐	Phthalic acid	100-21-0	0.055	28.0	280.0
☐	Phthalic anhydride	85-44-9	0.055	28.0	280.0
☐	Physostigmine	57-47-6	0.056	1.4	14.0
☐	Physostigmine salicylate	57-64-7	0.056	1.4	14.0
☐	Promecarb	2631-37-0	0.056	1.4	14.0
☐	Pronamide	23950-58-5	0.093	1.5	15.0
☐	Propanenitrile	107-12-0	0.24	360.0	3600.0
☐	Propham	122-42-9	0.056	1.4	14.0
☐	Propoxur	114-26-1	0.056	1.4	14.0
☐	Prosulfocarb	52888-80-9	0.042	1.4	14.0
☐	Pyrene	129-00-0	0.067	8.2	82.0
☐	Pyridine	110-86-1	0.014	16.0	160.0
☐	Safrole	94-59-7	0.081	22.0	220.0
☐	Sulfide	18496-25-8	14.0	N/A	N/A
☐	2,4,5-T	93-76-5	0.72	7.9	79.0
☐	TCDDs (All Tetrachlorodi-benzo-p-dioxins)	41903-57-5	0.000063	0.001	0.01
☐	TCDFs (All Tetrachlorodibenzofurans)	30402-14-3	0.000063	0.001	0.01
☐	2,4,5-TP (Silvex)	93-72-1	0.72	7.9	79.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14.0	140.0
☐	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6.0	60.0
☐	1,1,2,2-Tetrachloroethane	79-34-5	0.057	6.0	60.0
☐	Tetrachloroethylene	127-18-4	0.056	6.0	60.0
☐	2,3,4,6-Tetrachlorophenol	58-90-2	0.03	7.4	74.0
☐	Thiodicarb	59669-26-0	0.019	1.4	14.0
☐	Thiophanate-methyl	23564-05-8	0.056	1.4	14.0
☐	Toluene	108-88-3	0.08	10.0	100.0
☐	Total PCBs (Polychlorinated biphenyls)	1336-36-3	0.1	10.0	100.0
☐	Toxaphene	8001-35-2	0.0095	2.6	26.0
☐	Triallate	2303-17-5	0.042	1.4	14.0
☐	Tribromomethane	75-25-2	0.63	15.0	150.0
☐	2,4,6-Tribromophenol	118-79-6	0.035	7.4	74.0
☐	1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	0.057	30.0	300.0
☐	1,2,4-Trichlorobenzene	120-82-1	0.055	19.0	190.0
☐	1,1,1-Trichloroethane	71-55-6	0.054	6.0	60.0
☐	1,1,2-Trichloroethane	79-00-5	0.054	6.0	60.0
☐	Trichloroethylene	79-01-6	0.054	6.0	60.0
☐	Trichloromonofluoromethane (R11)	75-69-4	0.02	30.0	300.0
☐	2,4,5-Trichlorophenol	95-95-4	0.18	7.4	74.0
☐	2,4,6-Trichlorophenol	88-06-2	0.035	7.4	74.0
☐	1,2,3-Trichloropropane	96-18-4	0.85	30.0	300.0
☐	Triethylamine	121-44-8	0.081	1.5	15.0
☐	Tris(2,3-dibromopropyl) phosphate	126-72-7	0.11	0.1	1.0
☐	Vernolate	1929-77-7	0.042	1.4	14.0
☐	Vinyl chloride	75-01-4	0.27	6.0	60.0
☐	Xylene	1330-20-7	0.32	30.0	300.0
☐	2,4-Xylidine	95-68-1	0.01	0.66	6.6
☐	Antimony	7440-36-0	1.9	1.15	11.5
☐	Arsenic	7440-38-2	1.4	5.0	50.0
☐	Barium	7440-39-3	1.2	21.0	210.0
☐	Beryllium	7440-41-7	0.82	1.22	12.2
☐	Cadmium	7440-43-9	0.69	0.11	1.1
☐	Chromium	7440-47-3	2.77	0.6	6.0
☐	Lead	7439-92-1	0.69	0.75	7.5
☐	Mercury	7439-97-6	0.15	0.025	0.25
☐	Nickel	7440-02-0	3.98	11.0	110.0
☐	Selenium	7782-49-2	0.82	5.7	57.0
☐	Silver	7440-22-4	0.43	0.14	1.4
☐	Thallium	7440-28-0	1.4	0.2	2.0
☐	Vanadium	7440-62-2	4.3	1.6	16.0
☐	Zinc	7440-66-6	2.61	4.3	43.0

Notifications/Certifications #9

WPF # _____

Wastes or residues from characteristic hazardous waste treatment not meeting UTS

I certify under penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification. Based on my inquiry of those individuals immediately responsible for obtain this information, I believe that the treatment process has been operated and maintained properly so as to comply with the treatment standards in 40 CFR 268.40 without impremissible dilution of the prohibited waste. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

ROBERT MOLTER (239137)
Authorized Signature

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.40 or 268.49 to remove the hazardous characteristic. This decharacterized waste contains underlying hazardous constituents that require further treatment to meet treatment standards. I am aware that there are significant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

ROBERT MOLTER (239137)
Authorized Signature

Attachment 1 - Additional Radionuclides

Please list the supplimentary radionuclides and their concentration values.

WASTE PROFILE FORM
COVER SHEET

52250
APPROVED

Waste Characterization Information

Waste Stream ID:	52250
WPF ID (Legacy):	
Waste Stream Name:	ASH II
Expiration Date:	11/17/2023
Waste Type:	New Mexico Special Waste
Radiological Type:	Non Radioactive
RCRA Category:	RCRA Solid Non-hazardous
Ancillary Types:	TREATED FORMERLY CHARACTERISTIC HAZARDOUS WASTE
Primary Composition:	Other [Describe]
Composition (other):	Ash
EPA Codes:	
Waste Acceptance:	
EPA Form Code:	NA
	Not Applicable: Not Applicable
EPA Source Code:	NA
	Not Applicable: Not Applicable

Waste Generation Estimates

YEAR	VOLUME
2024	500.00 gal
2023	500.00 gal
2022	500.00 gal

Los Alamos NATIONAL LABORATORY EST.1943

WASTE PROFILE FORM

Reference Number

WCATS ID	Legacy WPF ID
52250	

Generator's Z Number	Waste Generator's Name *(print)*	WMC's Z Number	WMC's Name *(print)*		Generator's Phone
317357	BAILON, JESSE	169004	GONZALES, PAUL		5056673133
Generator's Mail Stop	**Waste Generating Group**	**Waste Stream Technical Area**	**Building**	**Room**	**WMC Phone**
C936	M-8	16	000441		5056658812

Waste Accumulation *(check only one)*

- ☐ Satellite Accumulation Area — Site No: _____
- ☐ Less-than-90 Days Storage Area — Site No: _____
- ☐ TSDF — Site No: _____
- ☐ Universal Waste Storage Area — Site No: _____
- ☐ Used Oil for Recycle — Site No: _____

ER Use Only

- ☐ ER Site — SWMU/AOC No. _____

- ☐ PCBs Storage Area — Site No: _____
- ☑ NM Special Waste — Site No: 6614
- ☐ Rad Staging Area — Site No: _____
- ☐ Rad Storage Area — Site No: _____
- ☐ None of the Above — Site No: _____
- ☐ Central Accumulation Area — Site No: _____

Method of Characterization *(check as many as apply)*

☑ Chemical/Physical Analysis	☑ Attached	Sample No: 1
☐ Radiological Analysis	☐ Attached	Sample No: _____
☐ Acceptable Knowledge Documentation	☐ Attached	Documentation No: _____
☐ PCB Analysis	☐ Attached	Sample No: _____
☐ Material Safety Data Sheet (MSDS)	☐ Attached	

Section 1 - Waste Prevention/Minimization *(answer all questions)*

Can hazard segregation, elimination, or material substitution be used?	☐ Yes *(provide comments)*	☑ No	
Can any of the materials in the waste stream be recycled or reused?	☐ Yes *(provide comments)*	☑ No	
Has waste minimization been incorporated into procedures or other process controls?	☑ Yes	☐ No *(provide comments)*	
Can this waste be generated outside a RCA?	☐ Yes *(provide comments)*	☐ No	☑ N/A

Comments:

Section 2 - Chemical and Physical Information

Waste Type *(check only one)*

- ☐ Unused/Unspent Chemical
- ☑ Process Waste/Spent Chemical/Other

Radiological Information

Was Waste generated in a RCA?

- ☐ Yes ☑ No
- ☑ Non-radioactive
- ☐ Radioactive - Low Level
- ☐ Radioactive - Transuranic

Waste Destination *(check one)*

- ☐ SWWS
- ☐ RLWTF
- ☐ RLWTP
- ☐ TA-16/HE
- ☐ NTS

Classified Information

- ☑ Unclassified
- ☐ Classified/Sensitive

Waste Category *(check all that apply)*

- ☑ Inorganic
- ☑ Organic
- ☐ Solvent (see instructions)
- ☐ Degreaser (see instructions)
- ☐ Dioxin
- ☐ Electroplating
- ☑ Treated Hazardous Waste or Residue
- ☐ No-Longer Contained-In
- ☑ Explosive Process
- ☐ Infectious/Medical
- ☐ Biological
- ☐ Beryllium
- ☐ Empty Container (see instructions)
- ☐ Battery (see instructions)

Asbestos

- ☐ Friable
- ☐ Non-Friable

PCB Source Concentration

- ☐ PCB < 50 ppm
- ☐ PCB >= 50 - < 500 ppm
- ☐ PCB >= 500 ppm
- ☐ Hazardous Waste Contaminated Soil
- ☐ Untreated Hazardous Debris
- ☐ Commercial Solid Waste
- ☐ Other [Describe]

Other:

Waste Source *(check only one)*

Waste Source A

- ☑ Decon
- ☐ Materials Processing/Production
- ☐ Research/Development/Testing
- ☐ Scheduled Maintenance
- ☐ Housekeeping - Routine
- ☐ Spill Cleanup - Routine
- ☐ Sampling - Routine Monitoring
- ☐ Other (describe)

Waste Source B

- ☐ Abatement
- ☐ Construction/Upgrades
- ☐ Demolition
- ☐ Decon/Decom
- ☐ Investigative Derived
- ☐ Orphan/Legacy
- ☐ Remediation/Restoration
- ☐ Repacking (secondary)
- ☐ Unscheduled Maintenance
- ☐ Housekeeping (non-routine)
- ☐ Spill Cleanup (non-routine)
- ☐ Non-Petroleum Tanks
- ☐ Petroleum Tanks
- ☐ Other (describe)

Other:

Waste Matrix *(check only one)*

Gas

- ☐ ≤1.5 Atmospheres Pressure
- ☐ >1.5 Atmospheres Pressure
- ☐ Liquified Compressed Gas

Liquid

- ☐ Aqueous
- ☐ Non-Aqueous
- ☐ Suspended Solids/Aqueous
- ☐ Suspended Solids/Non-Aqueous

Solid

- ☐ Powder/Ash/Dust
- ☑ Solid
- ☐ Sludge
- ☐ Absorbed/Solidified Liquid
- ☐ Debris

Matrix Type *(check only one)*

- ☑ Homogeneous
- ☐ Heterogeneous

Estimate Annual Volume (m^3):

1.8927

Section 3 - Process and Waste Description

Process Description:
Waste is generated from treatment waste with High Explosive (HE) at the TA-16 flash pad.

Waste Description:
Ash as a result from treated HE waste with trace metals and non-detonable amounts of high explosives.

Section 4 - Characteristics

Ignitability *(check only one)*	**Corrosivity** *(check only one)* (pH)	**Reactivity** *(check as many as apply)*	**Boiling Point** *(check only one)*
☐ < 73 F (< 22.8 C)	☐ <= 2.0	☐ RCRA Unstable	☐ <= 95 F (<= 35 C)
☐ 73 - 99 F (22.8 - 37.2 C)	☐ 2.1 - 4.0	☐ Water Reactive	☐ >95 F (> 35 C)
☐ 100 - 139 F (37.8 - 59.4 C)	☐ 4.1 - 6.0	☐ Cyanide Bearing	☑ Not Applicable
☐ 140 - 200 F (60.0 - 99.3 C)	☐ 6.1 - 9.0	☐ Sulfide Bearing	
☐ > 200 (> 99.3 C)	☐ 9.1 - 12.4	☐ Pyrophoric	
☐ EPA Ignitable - Non-liquid	☐ >= 12.5	☐ Shock Sensitive	
☐ DOT Flammable Gas	☐ Liquid Corrosive to Steel	☐ Explosive [Specify DOT Div.]	
☐ DOT Oxidizer	☑ Non-aqueous	☑ Non-Reactive	
☑ Not Ignitable			

	Characterization Method				Concentration of Contaminants		
				None or	Contaminant present at		
Identify for all contaminants listed	**AK**	**TCLP**	**Total**	**Non-detect**	**Minimum**	**Maxiumum**	**Regulatory Limit**
Toxicity Characteristic Metals					(10,000 ppm = 1%)		
Arsenic	☐	☑	☐	☐	0 to	0.026 ppm	5.0 ppm
Barium	☐	☑	☐	☐	0 to	10.9 ppm	100.0 ppm
Cadmium	☐	☑	☐	☐	0 to	0.00309 ppm	1.0 ppm
Chromium	☐	☑	☐	☑	to	ppm	5.0 ppm
Lead	☐	☑	☐	☐	0 to	0.0136 ppm	5.0 ppm
Mercury	☐	☑	☐	☑	to	ppm	0.2 ppm
Selenium	☐	☑	☐	☑	to	ppm	1.0 ppm
Silver	☐	☑	☐	☑	to	ppm	5.0 ppm
Toxicity Characteristic Organics							
Benzene	☑	☐	☐	☑	to	ppm	0.5 ppm
Carbon tetrachloride	☑	☐	☐	☑	to	ppm	0.5 ppm
Chlorobenzene	☑	☐	☐	☑	to	ppm	100.0 ppm
Chloroform	☑	☐	☐	☑	to	ppm	6.0 ppm
Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
p-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
m-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
o-Cresol	☑	☐	☐	☑	to	ppm	200.0 ppm
1,4-Dichlorobenzene	☑	☐	☐	☑	to	ppm	7.5 ppm
1,2-Dichloroethane	☑	☐	☐	☑	to	ppm	0.5 ppm
1,1-Dichloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
2,4-Dinitrotoluene	☐	☑	☐	☑	to	ppm	0.13 ppm
Hexachlorobenzene	☑	☐	☐	☑	to	ppm	0.13 ppm
Hexachlorobutadiene	☑	☐	☐	☑	to	ppm	0.5 ppm
Hexachloroethane	☑	☐	☐	☑	to	ppm	3.0 ppm
Methyl ethyl ketone	☑	☐	☐	☑	to	ppm	200.0 ppm
Nitrobenzene	☐	☑	☐	☑	to	ppm	2.0 ppm
Pentachlorophenol	☑	☐	☐	☑	to	ppm	100.0 ppm
Pyridine	☑	☐	☐	☑	to	ppm	5.0 ppm
Tetrachloroethylene	☑	☐	☐	☑	to	ppm	0.7 ppm
Trichloroethylene	☑	☐	☐	☑	to	ppm	0.5 ppm
2,4,6-Trichlorophenol	☑	☐	☐	☑	to	ppm	2.0 ppm
2,4,5-Trichlorophenol	☑	☐	☐	☑	to	ppm	400.0 ppm
Vinyl chloride	☑	☐	☐	☑	to	ppm	0.2 ppm
Herbicides and Pesticides							
Chlordane	☑	☐	☐	☑	to	ppm	0.03 ppm
2,4-D	☑	☐	☐	☑	to	ppm	10.0 ppm
Endrin	☑	☐	☐	☑	to	ppm	0.02 ppm
Heptachlor (& its epoxide)	☑	☐	☐	☑	to	ppm	0.008 ppm
Lindane (gamma-BHC)	☑	☐	☐	☑	to	ppm	0.4 ppm
Methoxychlor	☑	☐	☐	☑	to	ppm	10.0 ppm
2,4,5-TP (Silvex)	☑	☐	☐	☑	to	ppm	1.0 ppm
Toxaphene	☑	☐	☐	☑	to	ppm	0.5 ppm

Section 5 - Additional Constituents and Contaminants

Additional Constituents and Contaminants. Please account for 100% of waste. Range should be given within guidelines of individual constituents. List all other constients (including inerts) not identified above and attach any applicable analysis. No chemical formula allowed in this field. Continue in Section 3 Additional information as necessary. CAS numbers are needed for all chemical constituents, for material without a CAS number, enter "No CAS Number".

CAS No.	Name of constituent	Minimum (ppm)		Maximum (ppm)
-----	Ash	990000	to	1000000
2691-41-0	HMX	0	to	75.2
121-82-4	RDX	0	to	2.63
-----	TATB	0	to	5.64
	Total of max. ranges of this section and page 2			100.01 in %

Additional Information

If additional information is available on the chemical, physical, or radiological character of the waste not covered on this form, provide it below

HE in this waste stream is non detonable and will not carry a D003 waste code.

Section 6 - Work Control Documentation

Do the procedures for this process cover how to manage this waste? ☑ Yes ☐ No *(provide comments)*

Do the procedures for this process address controls to prevent changes to waste constituents and concentrations or addition or removal of waste to/from containers? ☑ Yes ☐ No *(provide comments)*

Comments:

Section 7 - Packaging and Storage Control

Describe how the waste will be packaged in according to the applicable WAC.

Waste will be packaged into a compatible DOT approved poly drums.

Waste is compatible with itself

Identify the storage management controls that will be used for this waste stream: *(check all that apply)*

☑ Tamper Indication Devices ☐ Limited use locks with log-in for waste ☐ Locked cabinet or building ☐ Other (describe)

Section 8 - Waste Certification Statements

☑ Waste appears to meet WAC attachment for: NMSW

☐ Waste stream needs exception/exemption for treatment, storage, or disposal.

☐ Waste does not meet the criteria for any known TSDF. (DOE approval is required. Contact the office of the Principle Associate Director for Weapons Programs [PADWP] for assistance.)

Waste Generator Certification: Based on my knowledge of the waste and/or chemical/physical analysis, I certify that the waste characterization information on this form is correct and that it meets the requirements of the applicable waste acceptance criteria. I understand that this information will be made available to regulatory agencies and that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Signature: *JESSE BAILON (317357)* Date: *11/17/22 04:08 PM*

Waste Management Approval: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *PAUL GONZALES (169004)* Date: *11/17/22 04:09 PM*

RCRA Review: I have reviewed this form and any associated attachments and the characterization information provided appears to be complete and accurate. I certify, to the best of my knowledge, that the waste characterization information provided by the waste generator meets the requirements of the applicable WAC.

Signature: *ANDY ELICIO (118692)* Date: *11/17/22 04:14 PM*

Attachment 4 - LDR and UHC

Identify category and presence of any constituents listed below *(equal to or above limit)*.

Non-Wastewater/Wastewater Category *(check only one)*

☑ Non Wastewater ☐ Wastewater [as defined by 40 CFR 268.2(f)] ☐ Lab Pack [40 CFR 268.2(f)] **Sign Certification #1**

Notifications and Certifications - Check the appilcable boxes

Generator Requirements:

☐ This shipment contains hazardous waste contaminated soil that does not meet treatment standards **Sign Certification #2**
☐ This shipment contains untreated hazardous debris to be treated to 40 CFR 268.45 treatment standards **(No certification)**
☐ Hazardous wastes (except soil) meeting treatment standards at point of generation **Sign Certification #3**
☐ Hazardous wastes contaminated soil meeting treatment standards at point of generation **Sign Certification #4**

TSDF or Generator Treatment:

☐ TSDF treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #5**
☐ Generator treated hazardous debris meeting the alternative treatment standards of 40 CFR 268.45 **Sign Certification #6**
☐ Hazardous wastes contaminated soil treated to 40 CFR 268.49 **Sign Certification #7**
☑ Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS **Sign Certification #8**
☐ Wastes or residues from characteristic hazardous waste treatment not meeting UTS **Sign Certification #9**
☐ Other TSDF wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #10**
☐ Other generator wastes meeting the more stringent 40 CFR 268.40 treatment standards to be land disposed **Sign Certification #11**

Notification of Underlying Hazardous Constituents

(Check the applicable underlying constituents above the concentration levels for D001 through D043 characterstic wastes only)

☑ ***No Underlying Hazardous Constituents in this waste stream.***

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Acenaphthene	83-32-9	0.059	3.4	34.0
☐	Acenaphthylene	208-96-8	0.059	3.4	34.0
☐	Acetone	67-64-1	0.28	160.0	1600.0
☐	Acetonitrile	75-05-8	5.6	38.0	380.0
☐	Acetophenone	98-86-2	0.01	9.7	97.0
☐	2-Acetylaminofluorene	53-96-3	0.059	140.0	1400.0
☐	Acrolein	107-02-8	0.29	N/A	N/A
☐	Acrylamide	79-06-1	19.0	23.0	230.0
☐	Acrylonitrile	107-13-1	0.24	84.0	840.0
☐	Aldicarb sulfone	1646-88-4	0.056	0.28	2.8
☐	Aldrin	309-00-2	0.021	0.066	0.66
☐	4-Aminobiphenyl	92-67-1	0.13	N/A	N/A
☐	Aniline	62-53-3	0.81	14.0	140.0
☐	o-Anisidine	90-04-0	0.01	0.66	6.6
☐	Anthracene	120-12-7	0.059	3.4	34.0
☐	Aramite	140-57-8	0.36	N/A	N/A
☐	alpha-BHC	319-84-6	0.00014	0.066	0.66
☐	beta-BHC	319-85-7	0.00014	0.066	0.66
☐	delta-BHC	319-86-8	0.023	0.066	0.66
☐	Barban	101-27-9	0.056	1.4	14.0
☐	Bendiocarb	22781-23-3	0.056	1.4	14.0
☐	Benomyl	17804-35-2	0.056	1.4	14.0
☐	Benz[a]anthracene	56-55-3	0.059	3.4	34.0
☐	Benzal chloride	98-87-3	0.055	6.0	60.0
☐	Benzene	71-43-2	0.14	10.0	100.0
☐	Benzo(b)fluoranthene	205-99-2	0.11	6.8	68.0
☐	Benzo[a]pyrene	50-32-8	0.061	3.4	34.0
☐	Benzo[ghi]perylene	191-24-2	0.0055	1.8	18.0
☐	Benzo[k]fluoranthene	207-08-9	0.11	6.8	68.0
☐	Bis(2-Chloroethoxy)methane	111-91-1	0.036	7.2	72.0
☐	Bis(2-chloroethyl) ether	111-44-4	0.033	6.0	60.0
☐	Bis(2-chloroisopropyl) ether	39638-32-9	0.055	7.2	72.0
☐	Bis(2-ethylhexyl) phthalate	117-81-7	0.28	28.0	280.0
☐	Bromodichloromethane	75-27-4	0.35	15.0	150.0
☐	Bromomethane	74-83-9	0.11	15.0	150.0
☐	4-Bromophenyl phenyl ether	101-55-3	0.055	15.0	150.0
☐	n-Butyl alchohol	71-36-3	5.6	2.6	26.0
☐	Butyl benzyl phthalate	85-68-7	0.017	28.0	280.0
☐	Butylate	2008-41-5	0.042	1.4	14.0
☐	Carbaryl	63-25-2	0.006	0.14	1.4

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Carbendazim	10605-21-7	0.056	1.4	14.0
☐	Carbofuran	1563-66-2	0.006	0.14	1.4
☐	Carbofuran phenol	1563-38-8	0.056	1.4	14.0
☐	Carbon disulfide	75-15-0	3.8	4.8	48.0
☐	Carbon tetrachloride	56-23-5	0.057	6.0	60.0
☐	Carbosulfan	55285-14-8	0.028	1.4	14.0
☐	Chlordane	57-74-9	0.0033	0.26	2.6
☐	p-Chloro-m-cresol	59-50-7	0.018	14.0	140.0
☐	p-Chloroaniline	106-47-8	0.46	16.0	160.0
☐	Chlorobenzene	108-90-7	0.057	6.0	60.0
☐	Chlorobenzilate	510-15-6	0.1	N/A	N/A
☐	Chlorodibromomethane	124-48-1	0.057	15.0	150.0
☐	Chloroethane	75-00-3	0.27	6.0	60.0
☐	2-Chloroethyl vinyl ether	110-75-8	0.062	N/A	N/A
☐	Chloroform	67-66-3	0.046	6.0	60.0
☐	Chloromethane	74-87-3	0.19	30.0	300.0
☐	2-Chloronaphthalene	91-58-7	0.055	5.6	56.0
☐	2-Chlorophenol	95-57-8	0.044	5.7	57.0
☐	Chloroprene	126-99-8	0.057	0.28	2.8
☐	3-Chloropropylene	107-05-1	0.036	30.0	300.0
☐	Chrysene	218-01-9	0.059	3.4	34.0
☐	p-Cresidine	120-71-8	0.01	0.66	6.6
☐	m-Cresol	108-39-4	0.77	5.6	56.0
☐	o-Cresol	95-48-7	0.11	5.6	56.0
☐	p-Cresol	106-44-5	0.77	5.6	56.0
☐	m-Cumenyl methylcarbamate	64-00-6	0.056	1.4	14.0
☐	Cyanide (Amenable)	57-12-5*	0.86	30.0	300.0
☐	Cyanide (Total)	57-12-5	1.2	590.0	5900.0
☐	Cyclohexanone	108-94-1	0.36	0.75	7.5
☐	2,4-D	94-75-7	0.72	10.0	100.0
☐	o,p'-DDD	53-19-0	0.023	0.087	0.87
☐	p,p'-DDD	72-54-8	0.023	0.087	0.87
☐	o,p'-DDE	3424-82-6	0.031	0.087	0.87
☐	p,p'-DDE	72-55-9	0.031	0.087	0.87
☐	o,p'-DDT	789-02-6	0.0039	0.087	0.87
☐	p,p'-DDT	50-29-3	0.0039	0.087	0.87
☐	Di-n-butyl phthalate	84-74-2	0.057	28.0	280.0
☐	Di-n-octyl phthalate	117-84-0	0.017	28.0	280.0
☐	Di-n-propylnitrosamine	621-64-7	0.4	14.0	140.0
☐	Dibenz[a,h]anthracene	53-70-3	0.055	8.2	82.0
☐	Dibenzo[a,e]pyrene	192-65-4	0.061	N/A	N/A
☐	1,2-Dibromo-3-chloropropane	96-12-8	0.11	15.0	150.0
☐	1,2-Dibromoethane	106-93-4	0.028	15.0	150.0
☐	Dibromomethane	74-95-3	0.11	15.0	150.0
☐	1,4-Dichlorobenzene	106-46-7	0.09	6.0	60.0
☐	m-Dichlorobenzene	541-73-1	0.036	6.0	60.0
☐	o-Dichlorobenzene	95-50-1	0.088	6.0	60.0
☐	Dichlorodifluoromethane	75-71-8	0.23	7.2	72.0
☐	1,1-Dichloroethane	75-34-3	0.059	6.0	60.0
☐	1,2-Dichloroethane	107-06-2	0.21	6.0	60.0
☐	1,1-Dichloroethylene	75-35-4	0.025	6.0	60.0
☐	trans-1,2-Dichloroethylene	156-60-5	0.054	30.0	300.0
☐	2,4-Dichlorophenol	120-83-2	0.044	14.0	140.0
☐	2,6-Dichlorophenol	87-65-0	0.044	14.0	140.0
☐	1,2-Dichloropropane	78-87-5	0.85	18.0	180.0
☐	trans-1,3-Dichloropropene	10061-02-6	0.036	18.0	180.0
☐	cis-1,3-Dichloropropylene	10061-01-5	0.036	18.0	180.0
☐	Dieldrin	60-57-1	0.017	0.13	1.3
☐	Diethyl phthalate	84-66-2	0.2	28.0	280.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Dimethyl phthalate	131-11-3	0.047	28.0	280.0
☐	p-Dimethylaminoazobenzene	60-11-7	0.13	N/A	N/A
☐	2,4-Dimethylphenol	105-67-9	0.036	14.0	140.0
☐	4,6-Dinitro-o-cresol	534-52-1	0.28	160.0	1600.0
☐	1,4-Dinitrobenzene	100-25-4	0.32	2.3	23.0
☐	2,4-Dinitrophenol	51-28-5	0.12	160.0	1600.0
☐	2,4-Dinitrotoluene	121-14-2	0.32	140.0	1400.0
☐	2,6-Dinitrotoluene	606-20-2	0.55	28.0	280.0
☐	Dinoseb	88-85-7	0.066	2.5	25.0
☐	1,4-Dioxane	123-91-1	12.0	170.0	1700.0
☐	Diphenylamine	122-39-4	0.92	13.0	130.0
☐	1,2-Diphenylhydrazine	122-66-7	0.087	N/A	N/A
☐	Disulfoton	298-04-4	0.017	6.2	62.0
☐	Dithiocarbamates (total)	WCATS-001	0.028	28.0	280.0
☐	EPTC	759-94-4	0.042	1.4	14.0
☐	Endosulfan I	959-98-8	0.023	0.066	0.66
☐	Endosulfan II	33213-65-9	0.029	0.13	1.3
☐	Endosulfan sulfate	1031-07-8	0.029	0.13	1.3
☐	Endrin	72-20-8	0.0028	0.13	1.3
☐	Endrin aldehyde	7421-93-4	0.025	0.13	1.3
☐	Ethyl acetate	141-78-6	0.34	33.0	330.0
☐	Ethyl benzene	100-41-4	0.057	10.0	100.0
☐	Ethyl ether	60-29-7	0.12	160.0	1600.0
☐	Ethyl methacrylate	97-63-2	0.14	160.0	1600.0
☐	Ethylene oxide	75-21-8	0.12	N/A	N/A
☐	Famphur	52-85-7	0.017	15.0	150.0
☐	Fluoranthene	206-44-0	0.068	3.4	34.0
☐	Fluorene	86-73-7	0.059	3.4	34.0
☐	Fluoride	16984-48-8	35.0	N/A	N/A
☐	Formetanate hydrochloride	23422-53-9	0.056	1.4	14.0
☐	Heptachlor (& its epoxide)	76-44-8	0.0012	0.066	0.66
☐	Heptachlor epoxide	1024-57-3	0.016	0.066	0.66
☐	1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	35822-46-9	0.000035	0.0025	0.025
☐	1,2,3,4,6,7,8-Heptachlorodibenzofuran	67562-39-4	0.000035	0.0025	0.025
☐	1,2,3,4,7,8,9-Heptachlorodibenzofuran	55673-89-7	0.000035	0.0025	0.025
☐	Hexachlorobenzene	118-74-1	0.055	10.0	100.0
☐	Hexachlorobutadiene	87-68-3	0.055	5.6	56.0
☐	Hexachlorocyclopentadiene	77-47-4	0.057	2.4	24.0
☐	Hexachloroethane	67-72-1	0.055	30.0	300.0
☐	Hexachloropropene	1888-71-7	0.035	30.0	300.0
☐	HxCDDs (All Hexachlorodibenzo-p-dioxins)	34465-46-8	0.000063	0.001	0.01
☐	HxCDFs (All Hexachlorodibenzo-furans)	55684-94-1	0.000063	0.001	0.01
☐	Indeno[1,2,3-cd]pyrene	193-39-5	0.0055	3.4	34.0
☐	Iodomethane	74-88-4	0.19	65.0	650.0
☐	Isobutyl alcohol	78-83-1	5.6	170.0	1700.0
☐	Isodrin	465-73-6	0.021	0.066	0.66
☐	Isosafrole	120-58-1	0.081	2.6	26.0
☐	Kepone	143-50-0	0.0011	0.13	1.3
☐	Lindane (gamma-BHC)	58-89-9	0.0017	0.066	0.66
☐	Mercury (Retort Residues)	7439-97-6*	N/A	0.2	2.0
☐	Methacrylonitrile	126-98-7	0.24	84.0	840.0
☐	Methanol	67-56-1	5.6	0.75	7.5
☐	Methapyrilene	91-80-5	0.081	1.5	15.0
☐	Methiocarb	2032-65-7	0.056	1.4	14.0
☐	Methomyl	16752-77-5	0.028	0.14	1.4
☐	Methoxychlor	72-43-5	0.25	0.18	1.8
☐	Methyl ethyl ketone	78-93-3	0.28	36.0	360.0
☐	Methyl isobutyl ketone	108-10-1	0.14	33.0	330.0
☐	Methyl methacrylate	80-62-6	0.14	160.0	1600.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	Methyl methanesulfonate	66-27-3	0.018	N/A	N/A
☐	Methyl parathion	298-00-0	0.014	4.6	46.0
☐	3-Methylcholanthrene	56-49-5	0.0055	15.0	150.0
☐	4,4'-Methylene bis(2-chloroaniline)	101-14-4	0.5	30.0	300.0
☐	Methylene chloride	75-09-2	0.089	30.0	300.0
☐	Metolcarb	1129-41-5	0.056	1.4	14.0
☐	Mexacarbate	315-18-4	0.056	1.4	14.0
☐	Molinate	2212-67-1	0.042	1.4	14.0
☐	N-Nitroso-di-n-butylamine	924-16-3	0.4	17.0	170.0
☐	N-Nitrosodiethylamine	55-18-5	0.4	28.0	280.0
☐	N-Nitrosodimethylamine	62-75-9	0.4	2.3	23.0
☐	N-Nitrosodiphenylamine	86-30-6	0.92	13.0	130.0
☐	N-Nitrosomethylethylamine	10595-95-6	0.4	2.3	23.0
☐	N-Nitrosomorpholine	59-89-2	0.4	2.3	23.0
☐	N-Nitrosopiperidine	100-75-4	0.013	35.0	350.0
☐	N-Nitrosopyrrolidine	930-55-2	0.013	35.0	350.0
☐	Naphthalene	91-20-3	0.059	5.6	56.0
☐	2-Naphthylamine	91-59-8	0.52	N/A	N/A
☐	5-Nitro-o-toluidine	99-55-8	0.32	28.0	280.0
☐	o-Nitroaniline	88-74-4	0.27	14.0	140.0
☐	p-Nitroaniline	100-01-6	0.028	28.0	280.0
☐	Nitrobenzene	98-95-3	0.068	14.0	140.0
☐	o-Nitrophenol	88-75-5	0.028	13.0	130.0
☐	p-Nitrophenol	100-02-7	0.12	29.0	290.0
☐	1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	3268-87-9	0.000063	0.005	0.05
☐	1,2,3,4,6,7,8,9-Octachlorodibenzofuran	39001-02-0	0.000063	0.005	0.05
☐	Oxamyl	23135-22-0	0.056	0.28	2.8
☐	Parathion	56-38-2	0.014	4.6	46.0
☐	PeCDDs (All Pentachlorodibenzo-p-dioxins)	36088-22-9	0.000063	0.001	0.01
☐	PeCDFs (All Pentachlorodibenzo-furans)	30402-15-4	0.000035	0.001	0.01
☐	Pebulate	1114-71-2	0.042	1.4	14.0
☐	Pentachlorobenzene	608-93-5	0.055	10.0	100.0
☐	Pentachloroethane	76-01-7	0.055	6.0	60.0
☐	Pentachloronitrobenzene	82-68-8	0.055	4.8	48.0
☐	Pentachlorophenol	87-86-5	0.089	7.4	74.0
☐	Phenacetin	62-44-2	0.081	16.0	160.0
☐	Phenanthrene	85-01-8	0.059	5.6	56.0
☐	Phenol	108-95-2	0.039	6.2	62.0
☐	1,3-Phenylenediamine	108-45-2	N/A	N/A	N/A
☐	o-Phenylenediamine	95-54-5	N/A	N/A	N/A
☐	Phorate	298-02-2	0.021	4.6	46.0
☐	Phthalic acid	100-21-0	0.055	28.0	280.0
☐	Phthalic anhydride	85-44-9	0.055	28.0	280.0
☐	Physostigmine	57-47-6	0.056	1.4	14.0
☐	Physostigmine salicylate	57-64-7	0.056	1.4	14.0
☐	Promecarb	2631-37-0	0.056	1.4	14.0
☐	Pronamide	23950-58-5	0.093	1.5	15.0
☐	Propanenitrile	107-12-0	0.24	360.0	3600.0
☐	Propham	122-42-9	0.056	1.4	14.0
☐	Propoxur	114-26-1	0.056	1.4	14.0
☐	Prosulfocarb	52888-80-9	0.042	1.4	14.0
☐	Pyrene	129-00-0	0.067	8.2	82.0
☐	Pyridine	110-86-1	0.014	16.0	160.0
☐	Safrole	94-59-7	0.081	22.0	220.0
☐	Sulfide	18496-25-8	14.0	N/A	N/A
☐	2,4,5-T	93-76-5	0.72	7.9	79.0
☐	TCDDs (All Tetrachlorodi-benzo-p-dioxins)	41903-57-5	0.000063	0.001	0.01
☐	TCDFs (All Tetrachlorodibenzofurans)	30402-14-3	0.000063	0.001	0.01
☐	2,4,5-TP (Silvex)	93-72-1	0.72	7.9	79.0

	Organic Constituents	CASRN	Wastewater Standard (mg/L)	Non Wastewater Standard (mg/kg unless noted otherwise)	Hazardous Soil 10Xs UTS (mg/kg unless noted otherwise)
☐	1,2,4,5-Tetrachlorobenzene	95-94-3	0.055	14.0	140.0
☐	1,1,1,2-Tetrachloroethane	630-20-6	0.057	6.0	60.0
☐	1,1,2,2-Tetrachloroethane	79-34-5	0.057	6.0	60.0
☐	Tetrachloroethylene	127-18-4	0.056	6.0	60.0
☐	2,3,4,6-Tetrachlorophenol	58-90-2	0.03	7.4	74.0
☐	Thiodicarb	59669-26-0	0.019	1.4	14.0
☐	Thiophanate-methyl	23564-05-8	0.056	1.4	14.0
☐	Toluene	108-88-3	0.08	10.0	100.0
☐	Total PCBs (Polychlorinated biphenyls)	1336-36-3	0.1	10.0	100.0
☐	Toxaphene	8001-35-2	0.0095	2.6	26.0
☐	Triallate	2303-17-5	0.042	1.4	14.0
☐	Tribromomethane	75-25-2	0.63	15.0	150.0
☐	2,4,6-Tribromophenol	118-79-6	0.035	7.4	74.0
☐	1,1,2-Trichloro-1,2,2,-trifluoroethane	76-13-1	0.057	30.0	300.0
☐	1,2,4-Trichlorobenzene	120-82-1	0.055	19.0	190.0
☐	1,1,1-Trichloroethane	71-55-6	0.054	6.0	60.0
☐	1,1,2-Trichloroethane	79-00-5	0.054	6.0	60.0
☐	Trichloroethylene	79-01-6	0.054	6.0	60.0
☐	Trichloromonofluoromethane (R11)	75-69-4	0.02	30.0	300.0
☐	2,4,5-Trichlorophenol	95-95-4	0.18	7.4	74.0
☐	2,4,6-Trichlorophenol	88-06-2	0.035	7.4	74.0
☐	1,2,3-Trichloropropane	96-18-4	0.85	30.0	300.0
☐	Triethylamine	121-44-8	0.081	1.5	15.0
☐	Tris(2,3-dibromopropyl) phosphate	126-72-7	0.11	0.1	1.0
☐	Vernolate	1929-77-7	0.042	1.4	14.0
☐	Vinyl chloride	75-01-4	0.27	6.0	60.0
☐	Xylene	1330-20-7	0.32	30.0	300.0
☐	2,4-Xylidine	95-68-1	0.01	0.66	6.6
☐	Antimony	7440-36-0	1.9	1.15	11.5
☐	Arsenic	7440-38-2	1.4	5.0	50.0
☐	Barium	7440-39-3	1.2	21.0	210.0
☐	Beryllium	7440-41-7	0.82	1.22	12.2
☐	Cadmium	7440-43-9	0.69	0.11	1.1
☐	Chromium	7440-47-3	2.77	0.6	6.0
☐	Lead	7439-92-1	0.69	0.75	7.5
☐	Mercury	7439-97-6	0.15	0.025	0.25
☐	Nickel	7440-02-0	3.98	11.0	110.0
☐	Selenium	7782-49-2	0.82	5.7	57.0
☐	Silver	7440-22-4	0.43	0.14	1.4
☐	Thallium	7440-28-0	1.4	0.2	2.0
☐	Vanadium	7440-62-2	4.3	1.6	16.0
☐	Zinc	7440-66-6	2.61	4.3	43.0

Notifications/Certifications #8

WPF # _____

Wastes or residues from characteristic hazardous waste treatment meeting treatment standards and UTS

I certify under penalty of law that the waste has been treated in accordance with the requirements of 40 CFR 268.40 to remove the hazardous characteristic and that underlying hazardous constituents, as defined in 268.2(i) have been treated on-site to meet the 268.48 universal treatment standards. I am aware that there are significant penalties for submitting a false certification, including the possibility of fine and imprisonment.

PAUL GONZALES (169004)
Authorized Signature

I certify under the penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification. Based on my inquiry of those individuals immediately responsible for obtaining this information, I believe that the treatment process has been operated and maintained properly so as to comply with the treatment standards specified in 40 CFR 268.40 without impermissible dilution of the prohibited waste. I am aware that there are signficant penalties for submitting a false certification, including the possiblity of fine and imprisonment.

PAUL GONZALES (169004)
Authorized Signature

Attachment 1 - Additional Radionuclides

Please list the supplimentary radionuclides and their concentration values.

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 2 – Leininger 2020

High Explosives Report:

Leininger, L.D., *et al.*, May 2020. *IHE Material and IHE Subassembly Qualification Test Description and Criteria*, Vol. 14.7.

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IHE Material and IHE Subassembly Qualification Test Description and Criteria

May 14, 2020
Version 14.7

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LLNL-TR-679331 LA-UR-15-29238 (version 13.5)	November 17, 2015 (Updated June 7, 2016)	Initial Release
LLNL-TR-679331-REV-1 LA-UR-15-29238 (version 14.7)	May 14, 2020	• Test details of the Deflagration to Detonation Transition (DDT) experiment specified. • High temperature Shock to Detonation (SDT) experiment temperature setpoint from DDT high temperature experiment, instead of from an additional cookoff test. • No substantive changes to the Skid Test • Number of Bullet Tests reduced from 6 to 3 for each of 2 bullet types. • No substantive changes to IHE Subassembly Definitions

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Insensitive High Explosive (IHE) Materials and Subassemblies

As defined in Chapter 16 of the DOE Explosive Safety Standard (DOE-STD-1212), IHE Materials are mass-detonable explosives that are so insensitive that the probability of accidental initiation or transition from burning to detonation is negligible. The test series to qualify an IHE material contains the following elements:

1. Deflagration-to-Detonation Transition (DDT)
2. Shock-to-Detonation Transition (SDT)
3. Skid Test
4. Bullet Test

For explosives that do not meet the qualification criteria of an IHE material, there is a test series to qualify as an IHE subassembly in a smaller, weapon-system relevant, configuration. The IHE Subassembly Qualification Test Series contains the following elements:

1. DDT of individual subassembly materials in relevant, conservative, scales to application
2. SDT material test of the main charge only
3. Skid Test
4. Multiple Bullet Impact Test

The first section of this document defines the DDT, SDT, Skid, and Bullet tests that comprise the IHE Material Qualification Test Series.

The second section of this document describes the tests that are required for the IHE Subassembly Qualification Test Series. These tests are described in more general terms, as some details will depend on the configuration and materials of the specific IHE subassembly being tested.

The qualification and approval process described herein is limited to the Department of Energy (DOE) and nuclear weapons applications.

These definitions were approved by vote of the DOE/NNSA Explosive Safety Committee in May 2016 and are required for any new material or subassembly proposed that is not already noted as approved in DOE-STD-1212.

Section 1

IHE Material Qualification Test Series

2.1 Deflagration-to-Detonation Experiment

1.1.1 Introduction

The purpose of the deflagration-to-detonation test is to demonstrate that an IHE material will not undergo deflagration-to-detonation transition (DDT) under stockpile relevant conditions of scale, confinement, and material condition. Inherent in this test design is the assumption that ignition does occur, with onset of deflagration. The test design will incorporate large margins and replicates to account for the stochastic nature of DDT events.

1.1.2 Underlying Physics

DDT in condensed-phase, inhomogeneous, explosives is a significantly more complex process than shock-to-detonation transition (SDT), comprising a number of distinct steps:

1. Ignition of reaction.
2. Conductive burning, in which the ignition front advances by thermal conduction.
3. Convective burning, in which the ignition front advances by penetration of hot, gaseous, products.
4. Compaction of the unreacted explosive ahead of the ignition front by pressurization due to the reaction products, choking off the convective process.
5. Downstream plug formation.
6. Shock formation at the downstream plug boundary.
7. SDT

This process is dependent on:

1. Decomposition chemistry and kinetics: intrinsic properties that control pre-ignition decomposition, which affect the degree of porosity developed at elevated temperature prior to ignition and, consequently, the compaction characteristics of the material. They also determine deflagration rate as a function of pressure; faster favors reaction build up and shorter run-to-detonation distances.

2. Mechanical properties: rate-dependent intensive intrinsic properties that control deflagration rate as a function of accessible surface area via strain-rate-dependent fracture properties, and also determine compaction and plug formation.

This combination of complex factors puts a quantitative understanding of the phenomenon beyond our current modeling capabilities but, since we understand the trends arising from each factor, we can bound the problem by experimental exploration of worst-case scenarios with a limited number of replicates.

Accordingly, the proposed DDT test is highly conservative in terms of the external (to the explosive) parameters of importance, specifically confinement and charge size. The metric is the absence of transition to detonation in a charge size and geometry that permits a significantly longer run distance, and which is subject to much stronger and more massive confinement, than any configuration of relevance to a nuclear weapon.

1.1.3 DDT Test Configuration and Diagnostics

A representative apparatus is shown in Figure 1, and described as follows:

- Heavily confined explosive samples with long run length.
    - Confinement is provided by a thick-walled steel cylinder (yield strength of the steel to be ~36 ksi (or larger); should be widely-available commercially:
        - 3 inch nominal internal diameter,
        - 2 inch wall thickness, and
        - ~40 inches long to accommodate explosive column, head space, and end caps
    - Both ends are sealed with threaded end caps. End cap shall be 2 inches thick in the axial direction and 1.5 inch thick in the radial direction. Length of thread engagement shall be 4 inches. If threaded end caps are undesirable, alternate closure hardware may be used instead, provided confinement is demonstrated to be equivalent (if alternate end cap design is employed, justification demonstrating confinement equivalence must be approved by the DOE/NNSA IHE Qualification Update Group).
    - One end cap possesses an igniter system, typically comprised of a hot-wire embedded in pyrotechnic. The gap between the ignitor and the explosive column should not exceed ¼ inch to ensure the system can reliably ignite deflagration in the explosive; failure to ignite the explosive does not constitute a “passing”. In the event that the igniter fails to ignite deflagration in the explosive, re-ignition may be attempted on the assembly.
    - The other end cap possesses a vent hole; ~1/8 inch diameter. This vent hole permits slow gas products to escape, avoiding quasi-static pre-pressurization of the tube, but is too small of a diameter to provide significant venting when cookoff occurs (a choked flow condition is attained when the explosive deflagrates).
    - Length of the explosive column is 36 inches and shorter than the bore length, to leave an initial axial ullage of ~1/2 ± 0.1 inch. This ullage allows for thermal expansion of the explosive column, permitting porosity to develop that might increase the likelihood of DDT. Alternate ullage lengths are permissible if they meet the intent.

  - Additional penetrations of the tube are permissible (e.g. for internal thermocouple or pressure diagnostics) provided they do not compromise the mechanical confinement of the tube. If postmortem analysis reveals failure of confinement at the feedthrough location, the validity of the test confinement must be justified.

- Externally heated tube with external temperatures recorded during the long-duration thermal heating of the assembly, at a rate ≥ 0.25 Hz (the temperature rise during dynamic event does not need to be resolved).
- Test may be executed with tube in any orientation (horizontal, igniter on top, igniter on bottom). If the test is oriented with the igniter on top, care must be taken that explosive successfully ignites even if internal slumping takes place during the thermal conditioning and there is a gap between the ignitor system and the explosive column.
- Two material states examined are (1) typical charge density and (2) surrogate damaged material utilizing pressing prills (molding powder) of the candidate material.
    1. Consolidated explosive can be in the form of multiple stacked uniaxially pressed pellets, provided the pellet density is within ±1% of production density material. The diametral clearance between explosive pellets and bore at ambient temperature shall be small enough so that thermal expansion during heating develops an interference fit once the explosive reaches 10°C below the critical temperature for the experiment, with consideration given to the Coefficient of Thermal Expansion (CTE) of the explosive being tested. This interference fit prevents gas flow between the explosive and the wall of the tube, so burning will progress through the bulk explosive and not at the edges.
    2. Pressing prills (molding powder) shall be loaded into the bore via "pouring" with no additional packing pressure applied. This assembly method will achieve a "pour density" test configuration, which constitutes the lowest handling density of material and a worse-case scenario with regards to surface area available for deflagration. Pour density attained shall be reported as part of the test record and will be calculated from the mass of the material used and the nominal volume of the bore.
- The IHE candidate material is evaluated in two configurations:
    1. In one configuration, the explosive self-ignites from heating, similar to a cookoff test. (Although the igniter system is not required for this test configuration, any through holes in the non-vented cap end of the tube shall be plugged.). This configuration is used to establish a "critical temperature", T_c.
    2. In a second configuration, after reaching a set elevated temperature, which is slightly below the established critical temperature, deflagration is ignited by a donor pyrotechnic.
- Diagnostics:
    - External tube temperatures (e.g. thermocouples).
    - Post-reaction examination of the confinement tube, particularly fragment size distribution.
    - Velocimetry (e.g. PDV) on the tube wall close to the vented end to quantify the presence (or lack of) detonation at the end of the tube. PDV diagnostics may be optional if the occurrence of DDT can be successfully ascertained by comparison with deliberately-detonated tubes (e.g. postmortem analysis of fragments).

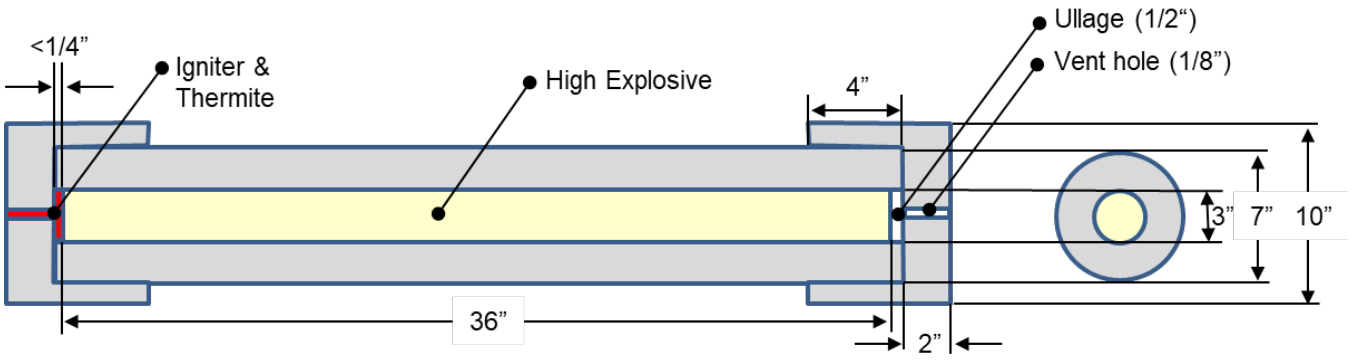

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Figure 1: Conceptual configuration of IHE Deflagration-to-Detonation Transition (DDT) IHE experiment.

1.1.3.1 Test Conditions

First test series (slow cook-off ensures ignition at the center of the charge):

- Production density explosive is heated ~20˚C/hr until self-ignition occurs. Intent of heating rate is to achieve no more than 10˚C radial temperature difference.
- The control location for temperature shall be a measurement of the external surface of the central tube, at the midpoint of the long dimension of the tube. The temperature measurement will not be in contact with a heating element, shall be adequately insulated from ambient air conditions, and adhered to the metal to ensure that the measurement accurately represents the surface temperature of the tube.
- The temperature of this control thermocouple when explosion occurs will be designated Tc (critical temperature) for the purpose of this experiment. It is understood that this critical temperature is not directly indicative of the explosive temperature necessary to induce self-ignition, but rather as a fiducial reference for conducting subsequent experiments. Designating a critical temperature using exterior thermocouples provides a test method that avoids the challenge of diagnosing internal temperatures without compromising the confinement of the assembly.
- This test configuration is identically repeated twice more for a total of three tests. The lowest Tc obtained of the three tests is used as the Tc for subsequent testing.
- External temperature difference is measured along the length of the central tube and shall not exceed 10 ˚C during heating.

Second test series:

- Production density explosive is heated at the same ramp rate of ~20˚C/hr to 10˚C below Tc, then promptly ignited with a pyrotechnic composition.
- If the final recorded temperature is higher than 10˚C below Tc, the test remains valid; the final recorded temperature must be ≥ [Tc-10˚C].

Third test series:

- Pour density molding powder is tested identically (heated at ~20˚C/hr to 10˚C below Tc, then promptly ignited with a pyrotechnic composition).
- If the final recorded temperature is higher than 10˚C below Tc, the test remains valid; the final recorded temperature must be ≥ [Tc-10˚C].

1.1.3.2 Number of Tests

Three tests at each test series (9 total). As mentioned above, all three repeats of the first configuration are performed first in order to determine the lowest Tc; that Tc is used for the remaining two series. The purpose of the triplicate execution of the second and third configurations is to establish a measure of statistical repeatability. If substantive variations in test outcome are observed—even if no test exhibits DDT—the validity of the test series must be reviewed by the DOE/NNSA IHE Qualification Update Group.

1.1.3.3 Quantity of Explosive Required

- ~8 kg per production density explosive test.
- ~5 kg per molding powder explosive test.
- ~63 kg for nine tests.

1.1.3.4 Criteria for Qualifying as IHE

No development of a detonation wave within the tube length in any test as confirmed by post-test examination of the tube and/or by fielding velocimetry.

- If velocimetry diagnostics are not fielded, two additional deliberate detonation tests must be performed to provide a baseline against which to compare the qualification test results. One tube is deliberately detonated with production-density explosive, the other with the pour density molding powder. For both tests, a section of central tube ≥ 1 ft long (otherwise with the same bore diameter and wall thickness) will be filled at one end with 6 inches of explosive material. A detonator and booster will be placed in contact with the inside surface of the explosive fill and deliberately detonated. No end caps are required. The failure morphology of the tube obtained from these deliberate detonation baseline tests can be used in comparison with the qualification testing to establish whether detonation occurred.

OR

- Absence of DDT may be diagnosed with velocimetry data.

2.2 Shock-to-Detonation Experiment

1.2.1 Introduction

The purpose of the shock-to-detonation experiment is to demonstrate that the IHE will not undergo shock-to-detonation transition (SDT) under a defined shock stimulus at ambient temperature, which differentiates the SDT behavior of IHEs from the SDT behavior of Conventional High Explosives (CHEs). Note that any explosive, IHE or CHE, must undergo SDT at some shock stimulus for a nuclear weapon to function as designed.

In addition to the defined ambient-temperature shock stimulus, an additional SDT experiment is required at high temperature, to show that the explosive is not excessively sensitized by exposure to high-temperature conditions.

The ambient-temperature threshold shock stimulus was developed based on consideration of the shock sensitivity of a set of CHEs and currently recognized IHEs (Gresshoff, 2018). Figure 2 shows the shock sensitivity of CHEs and IHEs represented as a threshold SDT pressure as a function of shock duration.

Figure 2 is based on run-to-detonation, or Pop-Plot, data for TATB-based (LX-17, PBX 9502, and UF-TATB) and HMX-based (LX-04, PBX 9501, LX-07-2, and LX-10) high explosives scaled to the shock initiation threshold based on short-pulse initiation data for LX-17 and LX-04 (Gresshoff, 2018). There is some uncertainty in this scaling; however, the shock duration for the SDT threshold was chosen with this in mind and was necessary as the run-to-detonation distance is unknown for a future candidate IHE. As pressure is decreased, the shock duration required for SDT increases until a pressure is reached where there is no SDT regardless of the shock duration. HMX and TATB cut-offs are estimated at ~1.5 and ~7.5 GPa respectively for the HEs evaluated in this study and published in the literature. It is expected that SDT does not occur below these pressures, even for very long shocks. The figure indicates the SDT criterion for a sustained shockwave (3 μs duration) is 3.5 GPa.

Previous work on IHE Qualification of TATB (PBX 9502, LX-17, and UF-TATB) show data from Pantex Plant (Slape, 1984) which suggest that IHE qualification with the No. 8 Blasting Cap detonator was performed on both molding powder and “compacted” parts at nominal density. Although it was never written in DOE-STD-1212 (which prescribes TB 700-2 protocol for transportation and storage with molding powder), this history suggests a precedence for short-duration, high pressure, Taylor wave-type, loading of pressed parts as a component of the material definition. Hydrocode calculations of the Pantex Modified NOL Card Gap test showed that the upper limit of output for a Taylor wave into Explosive D is approximately 5.3 GPa. The lower limit of duration available for a gas gun flyer plate design is approximately 0.5 μs duration (cap duration is expected to be longer, but a Taylor wave). Therefore, the criterion for short pulse shockwave is prescribed to be 5.3 GPa at 0.5 μs and noted on Figure 2.

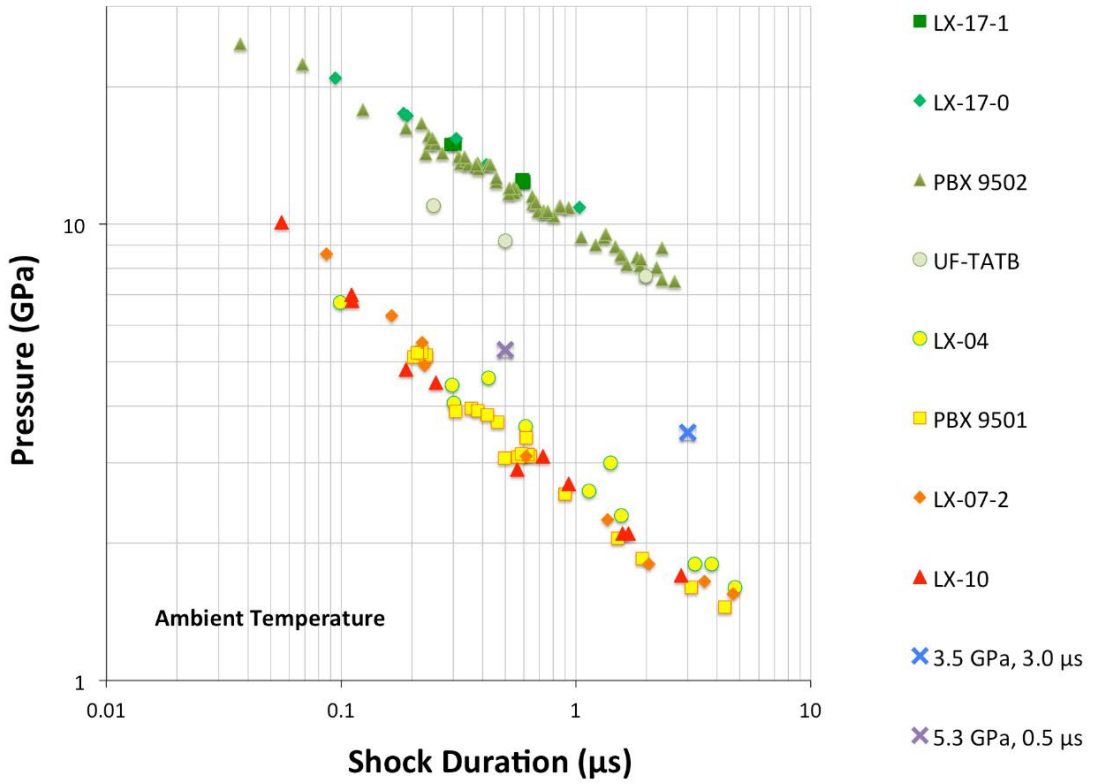


Figure 2. Shock sensitivity of several DOE explosives scaled from Pop-Plot data, showing the separation in behavior between IHEs and CHEs. The TATB-based IHEs (LX-17, PBX 9502, and UF-TATB) form a family with significantly lower shock sensitivity than the HMX-based CHEs (LX-04, PBX 9501, LX-07, and LX-10). The SDT criterion for IHEs is no evidence of detonation for a log-pulse (3 µs duration) of 3.5 GPa and a short-pulse (0.5 µs duration) of 5.3 GPa.

A second experimental series is required to evaluate SDT at high temperature. Virtually all known explosives are sensitized to SDT at high temperatures. It is important that the degree of sensitization to shock not be so high that the heated explosive represents a severe SDT hazard. The hazard is likely worse at the highest temperature where the explosive will survive, and the risk is that the explosive is extremely shock sensitive (e.g. an explosive that passes that SDT criteria at ambient, but recovers primary-like shock sensitivity at high temperatures is undesirable). The shock criterion for a heated test is substantially lower than criterion for the ambient temperature test. High-temperature shock sensitivity data for some IHEs and CHEs are shown in Figure 3 (Gresshoff, 2018). Because short-pulse data is not widely known for HEs at temperature, the data in the graph is still in the standard “Pop-Plot” format revealing pressure and run distance to detonation.

Also shown in Figure 3 is the new IHE criterion for high-temperature shock sensitivity – absence of shock-to-detonation transition with a 1.5 GPa shock sustained for at least 3 µs. The high-temperature testing must be done at a temperature that involves the effect of phase changes or other physical changes. For this reason, the test temperature is defined as the temperature 10°C below that which the explosive is expected to thermally explode, which will be a worst-case test for thermal sensitization.

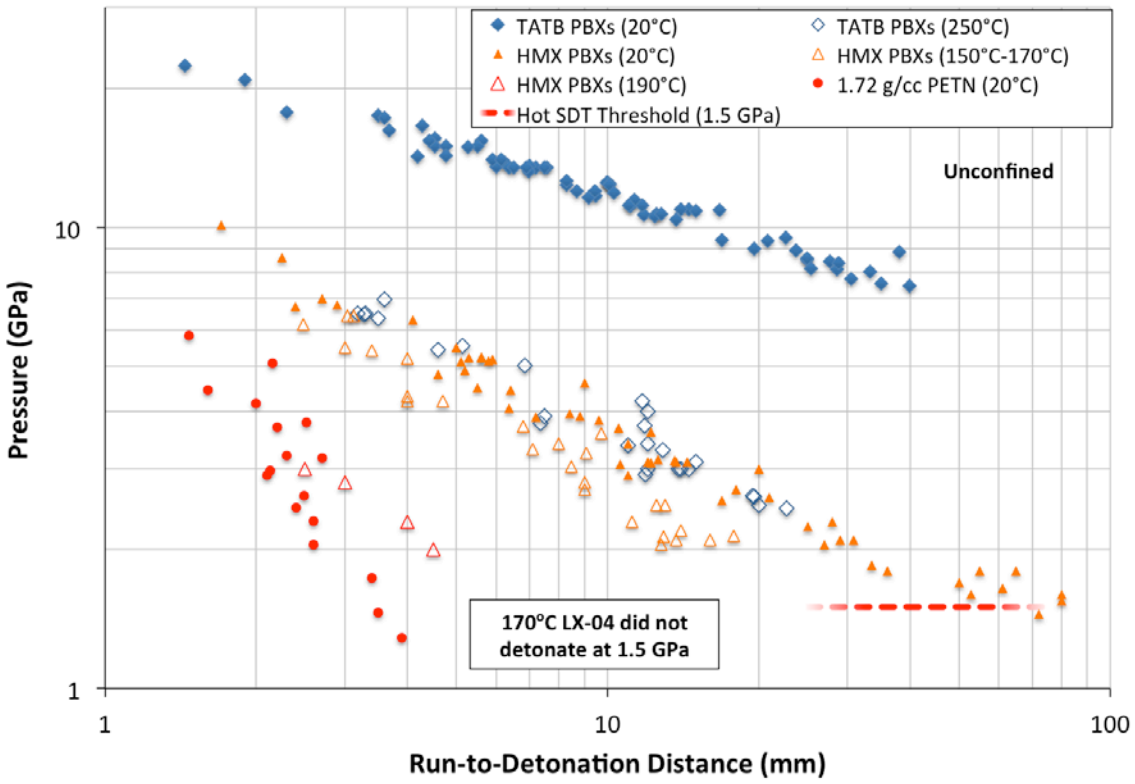


Figure 3. Shock sensitivity of several DOE explosives at high temperatures. The elevated-temperature SDT criterion of 1.5 GPa is shown as a dotted line as run-to-detonation distance is unknown in future candidate IHEs.

1.2.2 Underlying Physics

In the accepted understanding of shock-to-detonation transition (SDT) in composite solid explosives, interaction of the shock front with voids, interfaces, or other irregularities in the solid results in development of localized hot spots. If the shock is sufficiently strong and long-lasting, these hot spots react, coalesce, and release chemical energy fast enough to accelerate the shock wave until it forms a detonation. If the shock is too low in magnitude or duration, the hot spots may not react, or may quench before coalescing, and transition to detonation does not occur.

In addition to shock magnitude and duration, other factors are very important in SDT. The shock duration determines the time until a rarefaction from the rear of the sample reduces the shock pressure and may quench the reaction. Rarefaction waves from the side of explosive samples will have a similar effect, with the rarefaction penetrating farther from the edge as the shock travels from the impact surface. Shocks driven by small-diameter impactors similarly have rarefaction waves from the side that will quench the reaction. Therefore, size of explosive sample and diameter of the impactor driving the shock wave are important. If the shock is not planar or is not parallel to the explosive surface, these interactions are even more complex. If the shock wave at a surface is reflected back into the sample by a higher-impedance material, this also may have a strong effect on the SDT response.

To make the IHE test for SDT as unambiguous and reproducible as possible, it is specified as a 1-dimensional planar shock input with long duration. The explosive sample diameter and length are specified to avoid the effect of rarefactions from the side, while also allowing enough distance for the shock to run before side rarefactions come into play.

The propagation rate of the shock or reaction front provides a clear delineation between an unreacted shock and a detonation wave. Diagnostics are embedded in the explosive sample to measure either pressure or particle velocity, *in situ*, and measure if the shock wave is building to a detonation or is failing. The use of such diagnostics is an important element of these tests, as a reacting shock wave that may not have reached detonation conditions is a quite different response than an unreacted, or failing, shock front.

Sensitization of explosives at high temperature is driven by physical transformations in the explosive. For TATB plastic-bonded explosives, the shock sensitivity at 250°C is caused by the irreversible ratchet growth with formation of additional voids that sensitize the explosive to shock; when TATB explosives are physically confined, the shock sensitivity is significantly reduced. For HMX plastic-bonded explosives, the shock sensitivity is only slightly increased by heating to 150°C; the large increase in sensitivity at 190°C is caused by the beta-to-delta phase transition in HMX with the resultant formation of additional voids. To evaluate a candidate IHE, testing must be done at a sufficiently high temperature to include the effect of phase changes or other physical changes. The worst-case conditions are those in which the explosive is heated just below the temperature at which it will thermally decompose. This temperature is dependent on the thermal stability of the explosive, and on the configuration (e.g., size) of the explosive sample, and therefore the test temperature cannot be defined *a priori*. Instead, it is defined as the temperature 10°C below that at which the explosive will thermally explode in a relevant configuration.

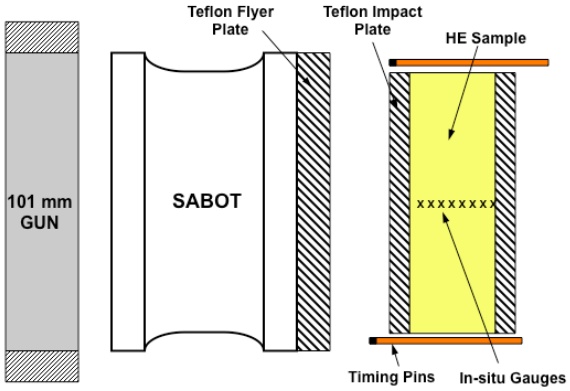
1.2.3 SDT Test Configuration and Diagnostics

- Use gun to achieve reproducible 1-D planar shock into sample.
- Ambient temperature test:
    - 3.5 GPa, >3.0 μs
    - 5.3 GPa, >0.5 μs
- High temperature test:
    - Explosive is heated at a ramp rate of ~20˚C/hr to a set point of [Tc-10 ˚C], where Tc is the temperature determined in the DDT cook-off test as measured on the boundary of the sample.
    - 1.5 GPa, >3.0 μs
- Explosive sample diameter and length sufficient to ensure 1-D shock:
    - diameter: ~60-90 mm (~2.5-4 inches).
    - length: ~30-45 mm (~1-1.5 inches).
- Explosive density: within the production range for the application.

- Diagnostics:
  - Embedded gauges (pressure or particle velocity) at several distances from the shock front.
  - Other standard diagnostics to measure impact velocity.
- To achieve shock pressures and durations for the 1D collision of a teflon impactor (2.15 g/cc, C_o=2.08 mm/μs, S_1=1.62) on an LX-17 IHE sample (1.9 g/cc, C_o=2.5 mm/μs, S_1=2.1) at room temperature (configuration shown in Figure 4):
  - 3.5 GPa for 3 μs:

    6 mm thick flyer at 1 km/s
  - 5.3 GPa for 0.5 μs:

    1 mm thick flyer at 1.5 km/s



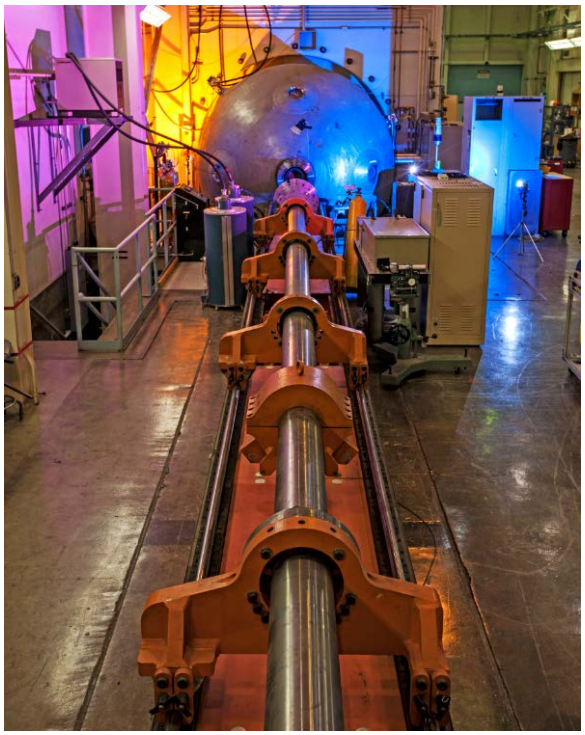


Figure 4. Example of SDT test configuration in the 100 mm gun at LLNL's High Explosive Application Facility (HEAF). Other similar configurations will give the same type of data and are equally acceptable. Elevated-temperature shock tests require heaters and thermocouples integrated into the target assembly.

1.2.3.1 Test Conditions

- Temperature
  - Ambient temperature: ~ 25°C.

    - High temperature: 10°C below the thermal explosion temperature for the explosive from the DDT cook-off experiment.
- Shock input to explosive with symmetric flyer/impact surface.
- Embedded diagnostics.

1.2.3.2 Number of Tests

- Three replicate tests at each temperature.

1.2.3.3 Quantity of Explosive Required

- ~600 g per test.
- ~1,800 g for three tests at each temperature.
- ~3.6 kg total.

1.2.3.4 Criteria for Qualifying as IHE

- No development of detonation wave in the explosive as shock progresses through the sample.
- Reaction wave, if any, is failing as the end of the sample is approached, as shown by the pressure or particle velocity gauges.

2.3 Skid Test

1.3.1 Introduction

The purpose of the skid test is to show that bare billets of explosive will not react with significant violence when subjected to a very severe drop environment, far worse than is anticipated in any actual handling accident.

For this test, which is a worker safety test, the acceptance criteria are based on worker safety concerns rather than detonation. As described below, the worst-case response for an explosive that has passed the skid test is non-violent explosive reaction.

The pendulum apparatus used in this skid test was first developed by Los Alamos National Laboratory in 2013 (Parker et al., 2020) and was conceived and designed to capture the underlying physics of reaction which had only previously been observed in "outlier data" as reported from the standard skid tests (Slape, 1984; Garrow, 2015). The new pendulum configuration allows exquisite control of the strike surface location, angle, and drop height such that potential reaction can be imaged to quantify the hazard and the experiment is highly repeatable. The apparatus has been designed to provide equivalent loading to the previously used vertical free-fall apparatus, with improved diagnostics.

1.3.2 Underlying Physics

The physical mechanisms governing explosive response in the skid test are very complex. Impacts such as those encountered from any conceivable drop height are incapable of driving a shock-to-detonation response. Ignition and deflagration is the worst possible outcome. The initial impact of an explosive causes compression and/or fracture with simultaneous conversion of mechanical energy to heat by frictional heating, which is generally grit-mediated. If the thermal energy is sufficient to ignite the explosive, and depending on the surface area that is produced by the fracture that may then become incorporated into the reaction, the ensuing response may range from a few points of light, to a rapid deflagration, to a detonation. If the DDT test described previously has been successfully completed before the skid test is executed, then the most violent response of a detonation is not possible, and the worst case is a rapid deflagration.

1.3.3 Skid Test Configuration and Diagnostics

- Pendulum skid impact test based on the new LANL Skid Test apparatus (Parker et al., 2020) shown in Figure 5
- Hemispherical sample, 28 cm diameter, of production density explosive
- Target surface will be gritty glass or steel.
    - Grit particles must be loose or weakly bonded such that they break free during impact.
    - Level of grit (silica sand, mean diameter ~600 μm) should be sufficient to cover the strike surface, while still providing space between grit (typical coverage: areal density ~$2x10^5$ particles/m^2) (Heatwole et al, 2015)
- Diagnostics: High-speed video side-on to impact plane and through target plate if transparent

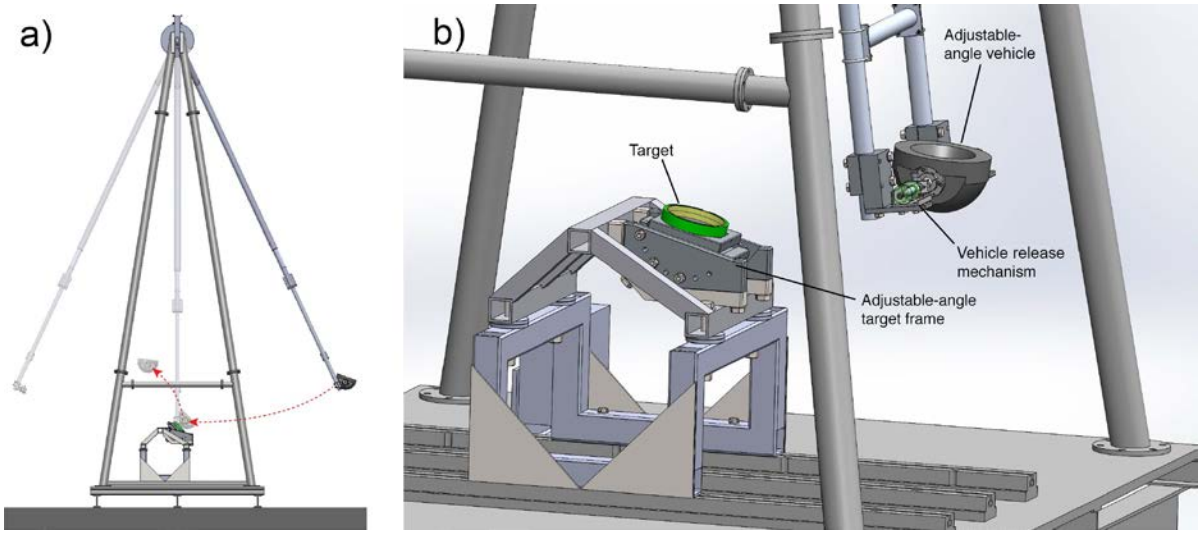


Figure 5. Pendulum skid impact test based on the new LANL Skid Test apparatus. (a) arm length = 15 ft (b) hemispherical charge rests in cradle, free to escape (bounce) upon contact with target.

1.3.3.1 Test Conditions

- Initial test configuration: Production machined hemisphere at ambient temperature
- Impact angle of 45˚
- Initial equivalent drop height of 12 ft. "Equivalent drop height" is the height at which the pendulum must be released in order to achieve an impact velocity that is equal to the impact velocity attained during vertical free-fall, i.e. $v = \sqrt{(2gh)}$. A 12 ft drop is a representative yet conservative worse-case height for handling accident scenarios involving workers manipulating a bare charge.

1.3.3.2 Number of Tests

- Three at 12 foot-equivalent drop height.

1.3.3.3 Quantity of Explosive Required

- ~10 kg per hemispherical charge.
- ~30 kg for three tests.

1.3.3.4 Criteria for Qualifying as IHE in the Skid Test

Reaction criteria (Note: These levels have been modified from levels in the original skid test which ranged from "0" for “no reaction” to "6" for “full detonation” (Garrow, 2015)). Image panels of the various reactions are shown in Figure 10 from Parker, et al. (2020):

- Reaction 0 is acceptable:
  - No visible smoke. No scorching of explosive surface. Video may show glowing abrasive particles from target surface.
- Reaction 1 is acceptable:
  - Visible smoke. Non-propagating, luminous ignition sites may be visible. Scorching of the explosive surface. No luminous flames are visible in high-speed videography from a side view.
- Reaction 2 is not acceptable:
  - Propagating, luminous flames are visible from high-speed videography. Postmortem examination reveals partial or complete disintegration of the explosive contact surface due to cracking induced by explosive reaction.

- The above criteria apply regardless of fracture of the explosive test object.
  - Occurrence of Reaction 2, or reaction violence exceeding Reaction 2, in any of the tests performed in the series, including tests where the charge fractured, disqualify the material as an IHE.

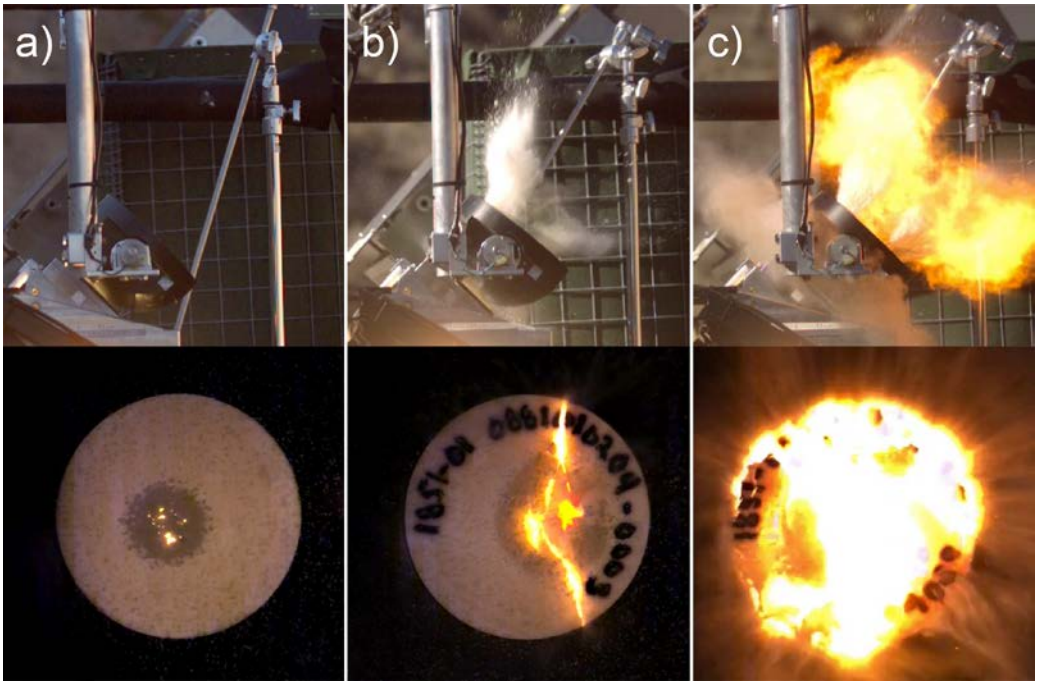


Figure 6. Examples of skid test reaction levels with a smaller, scaled, explosive charge. Three image pairs showing synchronous views from the side and through transparent impact surfaces: (a) Reaction 1, non-propagating luminous ignition sites, (b) Reaction 2, flame propagation into cracks, no fireball, and (c) Reaction 2, flame propagation and fireball.

2.4 Bullet Test

1.4.1 Introduction

The purpose of the bullet test is to show that an IHE does not react violently when impacted by a bullet under the conditions described below. This is a demonstration that the IHE is relatively unreactive to this type of stimulus and is not intended to prove that the IHE will not react to any sort of bullet or related stimulus. The ammunition selected is representative of threats to which the IHE will be exposed during its lifecycle but does not represent the worst possible case. The configuration represents the likely worst-case path of least resistance. Figure 10 shows an example of the response from this test for both HMX-based and TATB-based explosives.

1.4.2 Underlying Physics

Explosive response to the impact from a bullet is very complex. Typically, the bullet does not impart a shock to the explosive in such a way to cause shock-to-detonation transition, but instead provides input of mechanical and thermal energy to the explosive. The mechanical energy of the bullet impacting and tearing through the explosive is converted to thermal energy by the thermomechanical response of the explosive, and thermal energy from the hot bullet is deposited as the bullet travels through. This thermal energy may cause the explosive to ignite, and then may eventually lead to an explosion.

The mechanical response of the explosive is dependent on its configuration and confinement. The experimental configuration shown in Figure 7 offers a geometry somewhat representative of IHEs in their intended applications.

1.4.3 Bullet Test Configuration and Diagnostics

The test configuration is shown in Figure 7.

- Explosive sample is contained in a steel fixture with steel front and back plates.
- Bullets are shown in Figure 8 and Figure 9, and are 50 caliber, armor piercing, and military ball rounds.
- Bullet enters the sample through the front plate and exits through a plate-foam-plate stack-up.
- Diagnostics:
    - Include a method to measure the bullet velocity.
    - High-speed imaging to observe the target response for at least 10 seconds.

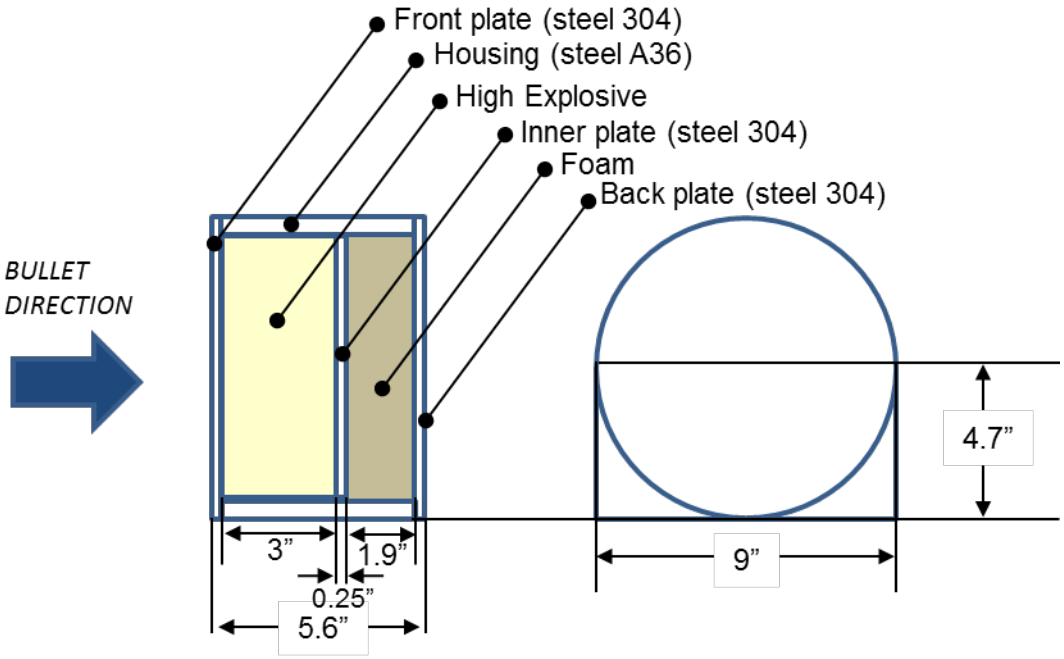
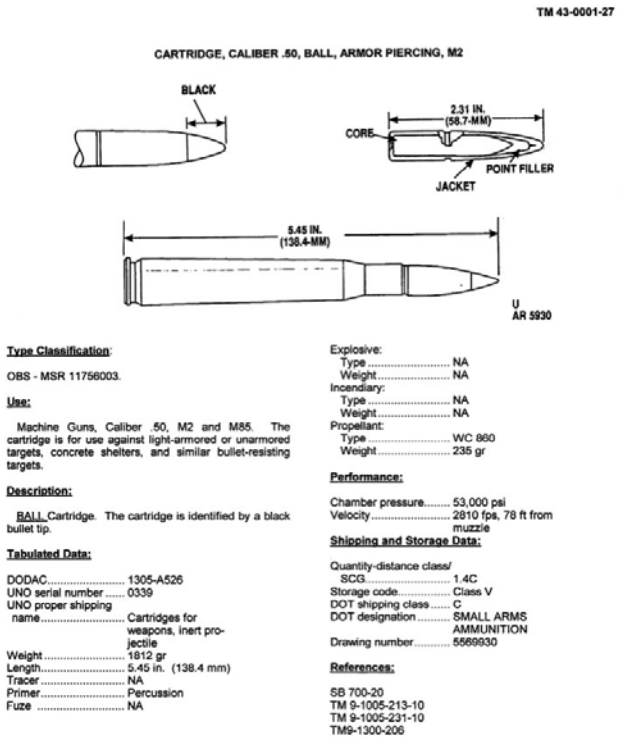


Figure 7. Conceptual configuration of IHE Qualification Bullet Test



TM 43-0001-27

CARTRIDGE, CALIBER .50, BALL, ARMOR PIERCING, M2

Type Classification:

OBS - MSR 11756003.

Use:

Machine Guns, Caliber .50, M2 and M85. The cartridge is for use against light-armored or unarmored targets, concrete shelters, and similar bullet-resisting targets.

Description:

BALL Cartridge. The cartridge is identified by a black bullet tip.

Tabulated Data:

DODAC	1305-A526
UNO serial number	0339
UNO proper shipping name	Cartridges for weapons, inert projectile
Weight	1812 gr
Length	5.45 in. (138.4 mm)
Tracer	NA
Primer	Percussion
Fuze	NA
Explosive:	
Type	NA
Weight	NA
Incendiary:	
Type	NA
Weight	NA
Propellant:	
Type	WC 860
Weight	235 gr

Performance:

Chamber pressure	53,000 psi
Velocity	2810 fps, 78 ft from muzzle

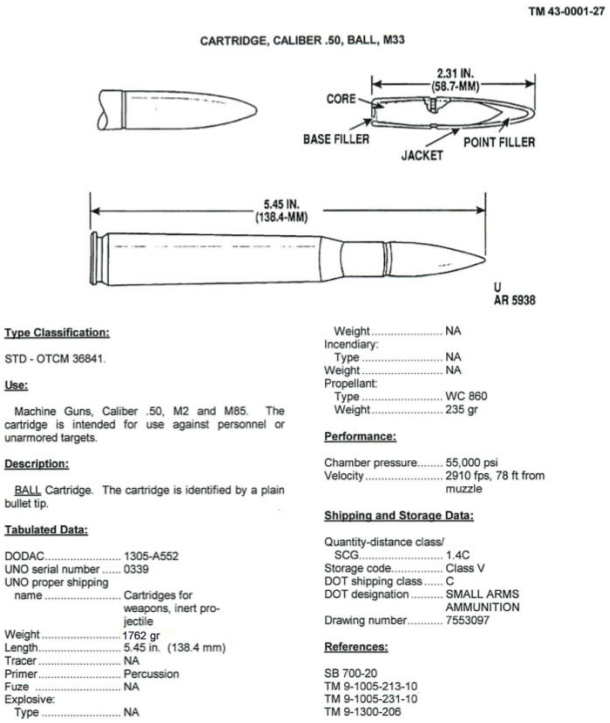
Shipping and Storage Data:

Quantity-distance class/ SCG	1.4C
Storage code	Class V
DOT shipping class	C
DOT designation	SMALL ARMS AMMUNITION
Drawing number	5569930

References:

SB 700-20
TM 9-1005-213-10
TM 9-1005-231-10
TM9-1300-206

Figure 8. 50-caliber armor piercing round.



TM 43-0001-27

CARTRIDGE, CALIBER .50, BALL, M33

Type Classification:

STD - OTCM 36841.

Use:

Machine Guns, Caliber .50, M2 and M85. The cartridge is intended for use against personnel or unarmored targets.

Description:

BALL Cartridge. The cartridge is identified by a plain bullet tip.

Tabulated Data:

DODAC	1305-A552
UNO serial number	0339
UNO proper shipping name	Cartridges for weapons, inert projectile
Weight	1762 gr
Length	5.45 in. (138.4 mm)
Tracer	NA
Primer	Percussion
Fuze	NA
Explosive:	
Type	NA
Weight	NA
Incendiary:	
Type	NA
Weight	NA
Propellant:	
Type	WC 860
Weight	235 gr

Performance:

Chamber pressure	55,000 psi
Velocity	2910 fps, 78 ft from muzzle

Shipping and Storage Data:

Quantity-distance class/ SCG	1.4C
Storage code	Class V
DOT shipping class	C
DOT designation	SMALL ARMS AMMUNITION
Drawing number	7553097

References:

SB 700-20
TM 9-1005-213-10
TM 9-1005-231-10
TM 9-1300-206

Figure 9. 50-caliber ball round.

1.4.3.1 Test Conditions

- Ammunition: 50 caliber armor piercing and 50 caliber military ball round.
- Muzzle velocity: standard for each type.
- One bullet per test.
- Explosive sample:
    - Diameter: ~8 inches (200 mm).
    - Thickness: ~ 3inches (75 mm).
    - Density: within the specified range for the application.
        - Main charges are generally 96-98% TMD.
        - Boosters are generally 92-95% TMD.

1.4.3.2 Number of Tests

- Three replicates with each bullet type (six tests total).

1.4.3.3 Quantity of Explosive Required

- ~ 4500 g per test.
- ~ 27 kg total.

1.4.3.4 Criteria for Qualifying as IHE

- Burn: smoke and/ or visible light is acceptable, burning reaction can completely consume material. Assembly may be distorted, and surfaces blackened. Any level of damage beyond that is a failure. If the assembly is fragmented, that is a failure.
- Panels of pass and fail are in Figure 10.

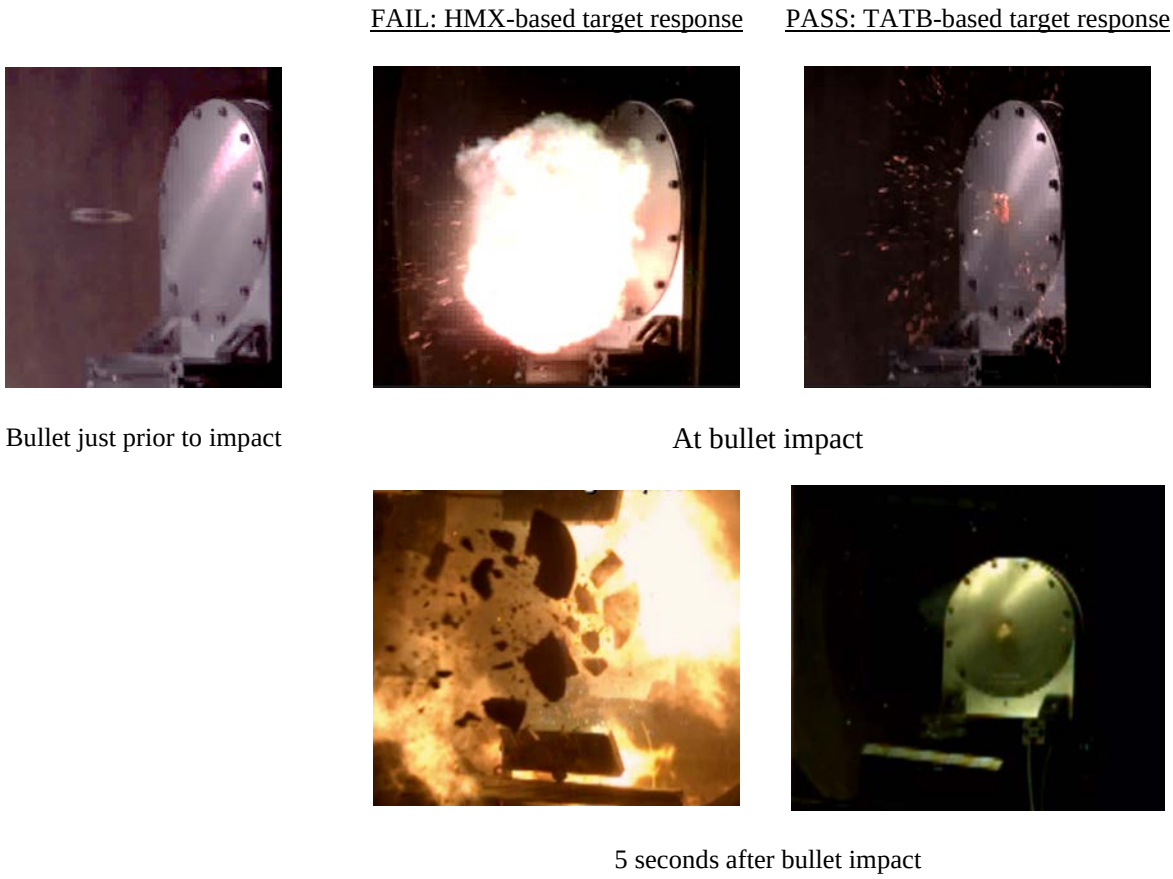


Figure 10. The bullet impact test distinguishes between the reaction violence of an HMX-based explosive and TATB-based explosive to the impact with a 50 caliber armor-piercing round. In this case, the HMX-based explosive fails to meet the IHE criteria. The visible light/reaction at impact is acceptable, however the violent disassembly of the undetonated HE constitutes a failure.

Section 2

IHE Subassembly Qualification Test Series

This section outlines a general plan to qualify IHE subassemblies that contain explosives that are not qualified as IHE materials. In general, this will occur when it is desired to have an IHE subassembly that consists of a main charge of IHE qualified materials with CHE boosters and/or detonators. However, it is also possible that the main charge be a material that has not passed the IHE material qualification tests outlined in Section 1, provided it qualifies to the same criteria at a system-relevant scale (as described herein), and it passes the SDT criterion for an IHE material at both ambient and heated conditions.

While this document provides an outline of the expectations for IHE subassembly qualification, this is an outline to aid in the development of a test plan for approval by the DOE/NNSA Explosives Safety Committee in consultation with the DOE/NNSA IHE Qualification Update Group. DOE-STD-1212, Chapter 16, Section 16.6 “IHE Subassembly Qualification Process” outlines the procedure for submitting a test plan, committee review procedures, and submission requirements. The test plan must consider worst-case configurations for testing.

2.1 Deflagration-to-Detonation Transition Experiment

For cases where the main charge is composed of IHE qualified materials, using booster, detonator, or other materials that are not IHE, it is a requirement to demonstrate that the materials that are not IHE cannot undergo DDT on a scale that is conservative to its relevant application in the subassembly.

For cases where it is desired to use a main charge that is not an IHE qualified material, but is smaller than was imagined in the material definition from the previous section, the main charge material must also be subjected to and pass a DDT test at the scale of use plus a conservative margin of scale and confinement consistent with the IHE materials test scale outlined in Section 1.1.

Each non-IHE material to be used shall be qualified by testing it in a scaled version of the DDT test. Each material will be tested in this configuration in a scale that is the actual scale of use plus a conservative margin in dimensions and confinement. All materials in the subassembly must pass this test individually for the subassembly to qualify as an IHE subassembly. No evidence of DDT may be observed in any test. Three replications of each test are required.

2.2 Shock-to-Detonation Transition Experiment – Main charge only

In order for the subassembly to qualify as an IHE subassembly, the main charge material must pass the identical SDT test as described in Section 1.2, for both ambient and heated configurations, with the same criteria for a passing result. Booster and detonator materials are not subjected to the SDT criteria to be consistent with previous test requirements.

2.3 Skid Test

Skid testing will be performed as above in Section 2.3, except that the assembly will be dropped for impact in the worst possible configuration - on the booster surrounded by main charge material consistent with the actual weapon configuration, with or without detonators. Three tests are required with drops at 45 degrees from 12 ft, with no observation of violent reaction (based on criteria described in Section1.3.3).

2.4 Multiple Bullet Impact Test

Bullet testing will be performed on the assembly, and in this case, the configuration of the target material will be designed to present a worst-case, path of attack, for the weapon subassembly. The test specimen geometry may or may not be the same as described in Section 2.4. If the path of attack includes a booster, then that booster must be included in the test. Threat is a three-round burst of NATO-7.62 mm (0.3 inches) ammunition. The passing criterion is to exhibit no violent reaction (based on criteria described in Section 1.4.3.4) when subjected to the threat. Three replicate tests are required.

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Environmental Report:

Fresquez, P.R., May 2011. *Chemical Concentrations In Field Mice Collected From Open-Detonation Firing Sites TA-36 Minie and TA-39 Point 6 At Los Alamos National Laboratory*. LA-UR-11-10614.

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CHEMICAL CONCENTRATIONS IN FIELD MICE COLLECTED FROM OPEN-DETONATION FIRING SITES TA-36 MINIE AND TA-39 POINT 6 AT LOS ALAMOS NATIONAL LABORATORY

P.R. Fresquez

ABSTRACT

Field mice (mostly *Peromyscus* spp.) were collected at two open-detonation (high explosive) firing sites—Minie at Technical Area (TA) 36 and Point 6 at TA-39—at Los Alamos National Laboratory in August of 2010 and in February of 2011 for chemical analysis. Samples of whole body field mice from both sites were analyzed for target analyte list elements (mostly metals), dioxin/furans, polychlorinated biphenyl congeners, high explosives, and perchlorate. In addition, uranium isotopes were analyzed in a composite sample collected from TA-36 Minie. In general, all constituents, with the exception of lead at TA-39 Point 6, in whole body field mice samples collected from these two open-detonation firing sites were either not detected or they were detected below regional statistical reference levels (99% confidence level), biota dose screening levels, and/or soil ecological chemical screening levels. The amount of lead in field mice tissue collected from TA-39 Point 6 was higher than regional background, and some lead levels in the soil were higher than the ecological screening level for the field mouse; however, these levels are not expected to affect the viability of the populations over the site as a whole.

INTRODUCTION

Small mammal mark-recapture studies were conducted at Los Alamos National Laboratory (LANL) at two open-detonation high explosive research and development firing sites—Minie at Technical Area (TA) 36 and Point 6 at TA-39—during August of 2010 (Bennett and Robinson 2011). The purpose of the mark-recapture studies was to evaluate the small mammal (field mice) species occurrence and population abundance at the open-detonation firing sites when compared to an undeveloped (control) site. Based on population abundance, species diversity and composition, sex ratios, and weights, the open-detonation firing sites do not appear to be adversely affecting small mammal population dynamics when compared to the undeveloped background site.

On the final day of trapping for the population study at the two detonation sites in 2010, all animals were euthanized and submitted for chemical analysis to investigate the

concentrations of various chemicals, particularly dioxin and furans, associated with open-detonation activities at LANL. Additional samples for chemical analyses were collected at both firing sites in February 2011. This chemical uptake analysis was conducted to gather information on the potential impact that the open-detonation operations conducted at TA-36 Minie and TA-39 Point 6 may have historically had on the sites. Field mice are effective indicators of contaminant presence due to their feeding and activity habits (i.e., burrowing) (Arthur et al. 1987), and at LANL they are used as the biota (radionuclide) dose (McNaughton 2006) and (chemical) uptake (Fresquez et al. 2010) models for terrestrial mammals because they have the smallest home range (~100 m^2).

METHODOLOGY

Site Descriptions

LANL is situated in northern New Mexico on the Pajarito Plateau (Figure 1), a series of finger-like mesas speared by east-to-west-oriented canyons. The mesa tops slope eastward from approximately 2377 m (7800 ft) to 1890 m (6200 ft). The surrounding land is largely undeveloped, including large tracts held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, and San Ildefonso Pueblo.

The firing sites are in remote locations and specialize in experimental studies of the dynamic properties of high explosive materials under high-pressure and temperature conditions. The facilities that make up the explosives testing operations are used primarily for research, development, test operations, and detonator development and testing related to the US Department of Energy Stockpile Stewardship Program (DOE 2008).

TA-36 Minie (Solid Waste Management Unit [SWMU] 36-004[c]) is located near the head of Fence Canyon (Figure 2). TA-39 Point 6 (SWMU 39-004[c]) is located in the bottom of Ancho Canyon (Figure 3). Both of the firing sites involved within this study have been in use since the 1950s. The vegetation consists of piñon (*Pinus edulis* Engelm.)

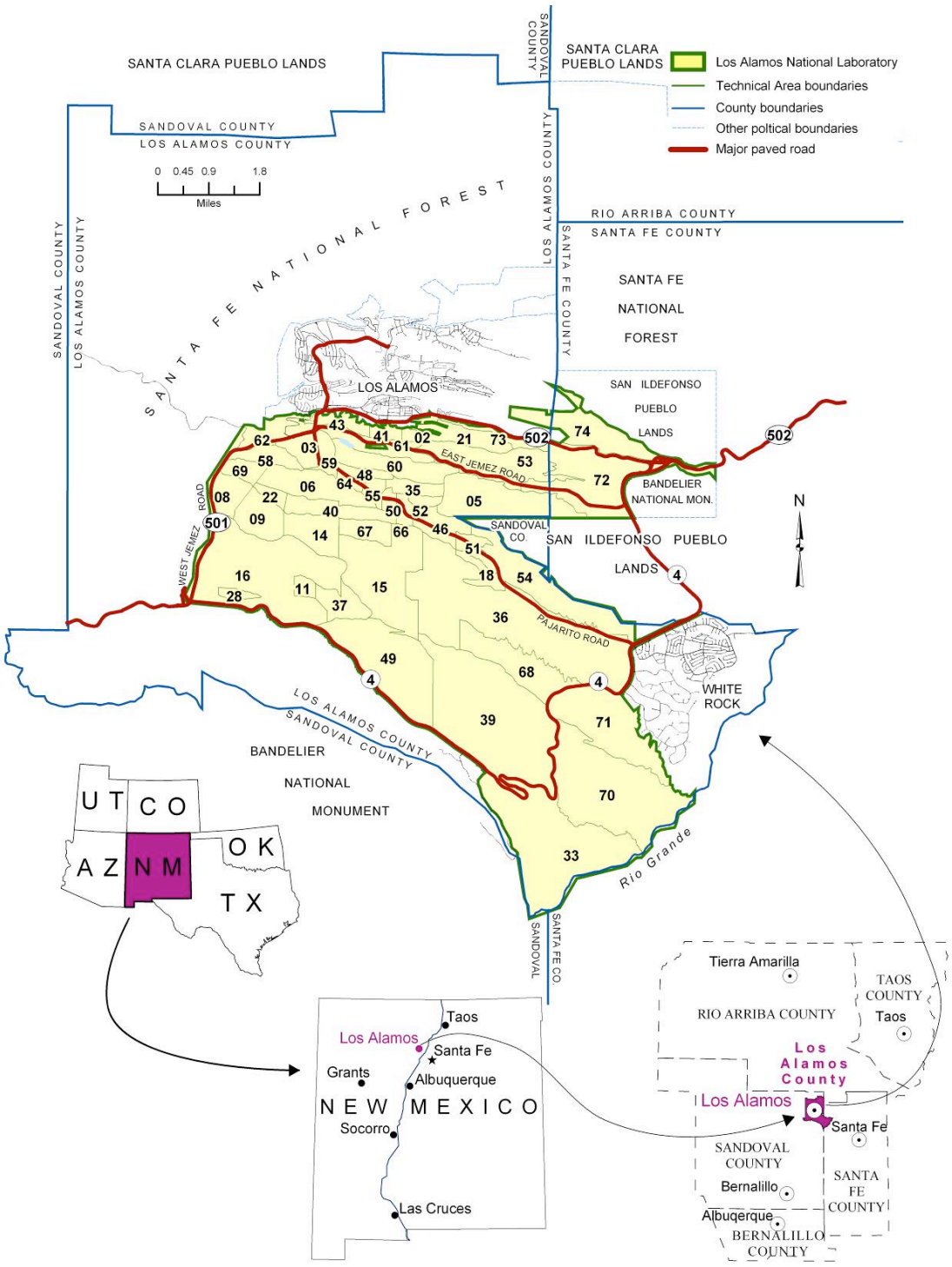

Figure 1. Location of Los Alamos National Laboratory (from Bennett and Robinson 2011)

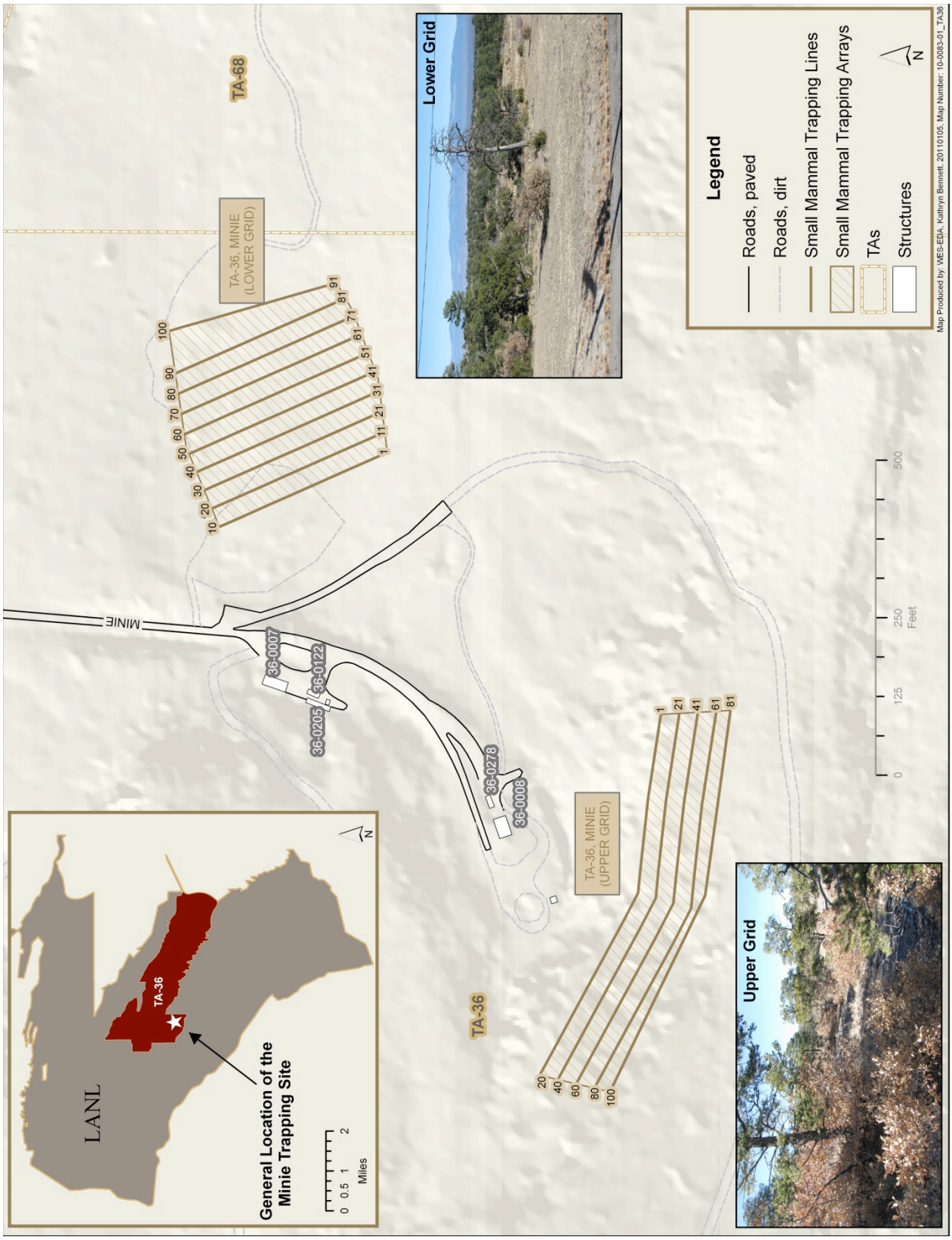

Figure 2. TA-36 Minie trapping location (from Bennett and Robinson 2011)

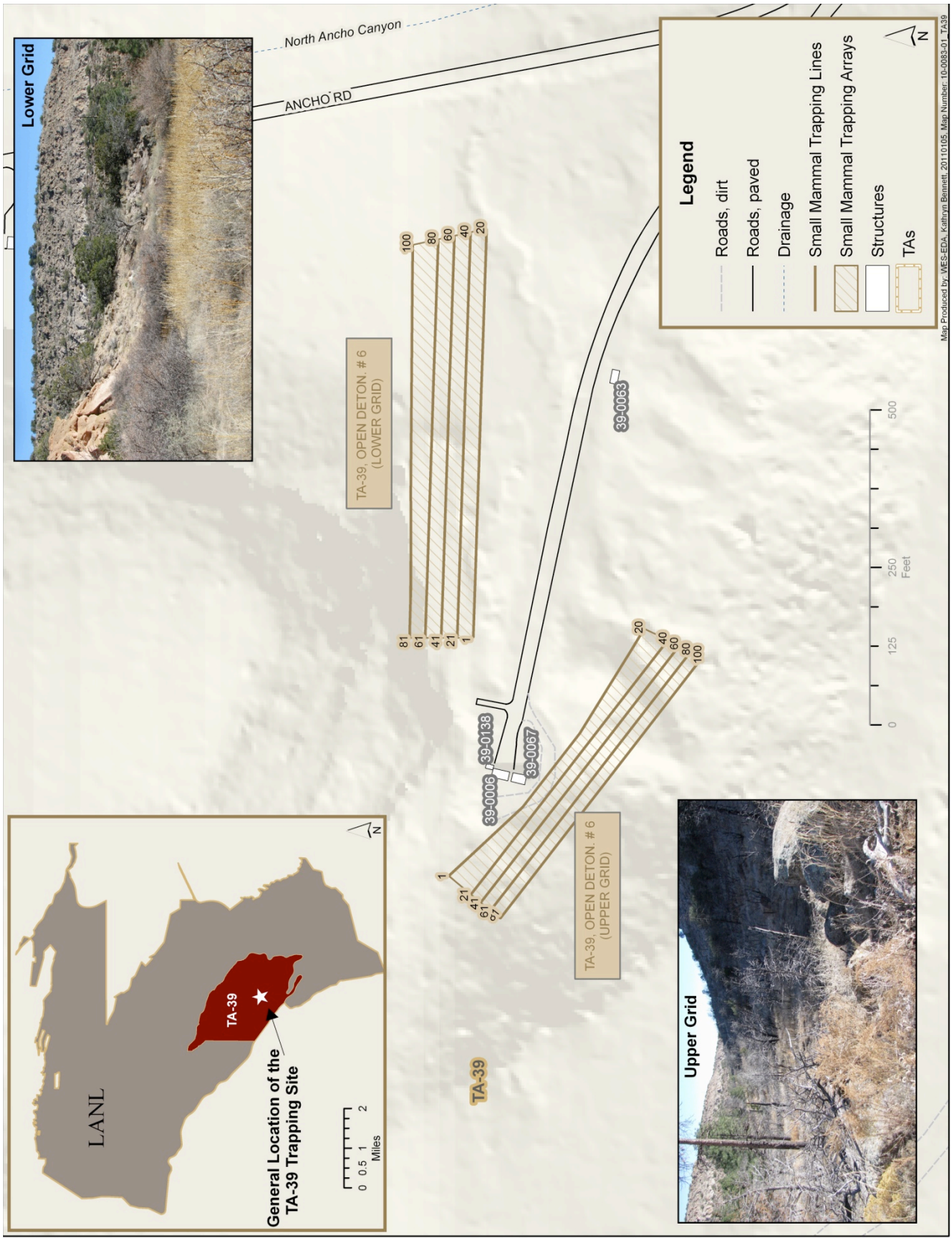

Figure 3. TA-39 Point 6 trapping location (from Bennett and Robinson 2011)

-(*Juniperus monosperma* [Englem.] Sarg.) with interspersed ponderosa pine (*Pinus ponderosa* C. Lawson) and gambel oak (*Quercus gambelii* Nutt.).

Small Mammal Trapping

Trapping grids, for the population study, were set up at TA-36 Minie and TA-39 Point 6 (see Figures 2 and 3). Each firing site was assigned two grids—lower and upper—with grid configuration based on topography of each site. The lower grids consisted of 10 lines of 10 traps with spacing of 10 m per trap and 10 m between each line, and these grids were situated downgradient of the firing site. The upper grids consisted of five lines of 20 traps with spacing of 10 m per trap and 10 m between each line, and these grids were situated adjacent and upgradient to the firing site. Each grid had 100 traps.

Trapping at each location took place over four consecutive nights. Traps were baited in the late afternoon with a molasses-coated horse feed and checked early each morning. Animals were collected and taken to a central location for processing. At the processing location, field mice were identified to species, weighed, sexed, and measured (total body, tail, hind foot, and ear). These data can be found in Bennett and Robinson (2011). Each animal was ear tagged and released. On the final day of trapping in 2010, all animals were euthanized, placed in double zip lock bags, and stored in a freezer at 4 degrees C. Additional samples for chemical analysis were collected in February 2011. All sample information can be found in the Appendix; the most common sample consisted of deer mice (*Peromyscus maniculatus*).

Captured mouse being weighed.

ALS (formally Paragon Analytics) Group analyzed the field mice (whole body) samples collected from TA-36 (Minie) for uranium-234, uranium-235, and uranium-238; and for target analyte list (TAL) elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury) from both sites. Polychlorinated biphenyls (PCBs) (congeners, homologs, and totals) and dioxin/furans in whole body field mice from both sites were analyzed by Cape Fear Analytical Laboratory, Inc., and General Engineering Laboratories analyzed the samples for high explosives and perchlorate.

Biota Comparison Levels

Radionuclides and chemical concentrations in biota from Laboratory areas are first compared to regional statistical reference levels (RSRLs). RSRLs, which represent natural and fallout levels, are the upper-level background concentrations (mean plus three standard deviations = 99% confidence level) for radionuclides and chemicals calculated from biota that was collected from regional locations away from the influence of the Laboratory (over nine miles away) (DOE 1991). For radionuclides, TAL elements, high explosives, dioxin/furans, perchlorate, and PCBs in whole body field mice, RSRLs can be found in Fresquez (2009, 2011).

If the levels of radionuclides in field mice collected from potentially impacted areas are higher than the RSRLs, the concentrations are compared to (tissue) screening levels (SLs) and then to standards. Biota SLs were set at 10% (0.01-rad/day) of the standard for terrestrial animals (0.1-rad/day) (DOE 2002) by the dose assessment team at the Laboratory to identify the potential contaminants of concern (McNaughton 2006).

There are no regulatory SLs for chemicals in tissues of biota; so if chemicals in biota are higher than the RSRLs then the chemical concentration in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2010). ESLs are LANL derived and are designed to reflect the concentration of a chemical in the soil that is not expected to produce any adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on soil (i.e., they are the

concentrations that are protective of ecological receptors under chronic exposure conditions).

RESULTS

TA-36 Minie

a. Uranium Isotopes. The concentration of uranium-238 in a composite whole body field mouse sample (n = 5 subsamples) was the only uranium isotope out of the three that was detected in higher amounts than the RSRL (Table 1). The amount of uranium-238, however, was two orders of magnitude below the biota dose screening level. Based on the isotopic distribution of uranum-234 and uranium-238, the source of uranium was depleted uranium.

Table 1. Uranium isotopes (pCi/g ash) in a composite whole body field mouse sample (n = 5) collected from TA-36 Minie in 2010. (Bold values are higher than 3TPU and the RSRL.)

Radionuclide[a]	Sample #3214	3TPU[b]	RSRL[c]	SL[d]
Uranium-234	0.066	0.025	0.11	46
Uranium-235/236	0.0055	0.0069	0.0092	46
Uranium-238	**0.261** DU[e]	0.072	0.098	46

[a]Method was by alpha spectrometry.
[b]Values are the total propagated uncertainty at the 99% confidence level.
[c]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2009).
[d]Screening Level is based on 0.01 rad/day.
[e]DU = depleted uranium based on the distribution of U-234 to U238.
Sample #SFB-10-11-3214 contained five mice—three from the upper grid and two from the lower grid.

b. TAL Elements. Most TAL elements in field mice (n = 3) collected from TA-36 Minie were below RSRLs (Table 2). The only two elements that were higher than the RSRLs were barium in two out of the three samples and lead in three out of the three samples. However, based on the highest concentration of barium in the soil at TA-36 Minie (204 mg/kg) (Vigil-Holterman and Juarez 2011a), the level was below the ESL of 1800 mg/kg for the field mouse (LANL 2010). Similarly, the highest lead concentration detected in soil at TA-36 Minie was 44 mg/kg (Vigil-Holterman and Juarez 2011a) and is lower than the ESL for the field mouse of 120 mg/kg (LANL 2010).

Table 2. TAL elements (mg/kg wet) in whole body field mice collected from TA-36 Minie and TA-39 Point 6 in 2010. (Bold values are higher than the RSRL.)

	TA-36 OD Minie			TA-39 OD Point 6			
Element[a]	**3202/U[d]**	**3203/L**	**3204/U**	**3215/L**	**3216/U**	**3217/L**	**RSRL[b]**
Aluminum	6.0	13	8.9	11	17	13	73
Barium	**5.6**	3.6	**5.8**	**8.6**	**5.2**	2.0	5.1
Beryllium[c]	0.00065	0.0015	0.00095	0.00090	0.00085	0.00075	0.016
Calcium	6800	6000	7700	8000	8100	7000	12624
Chromium	0.21	0.23	0.32	0.23	0.37	0.26	0.40
Cobalt	0.021	0.023	0.016	0.018	0.025	0.015	0.072
Copper	2.6	1.9	1.8	2.6	2.0	1.5	6.2
Iron	40	52	57	53	59	53	140
Magnesium	200	270	230	270	220	160	544
Manganese	0.94	1.7	0.94	1.5	1.2	0.97	7.6
Nickel	0.042	0.083	0.035	0.046	0.057	0.074	0.11
Potassium	2600	2600	2900	2400	2900	1700	3677
Sodium	1300	1000	1300	1100	1200	860	1920
Vanadium	0.0076	0.024	0.0064	0.013	0.027	0.015	0.14
Zinc	35	77	100	35	36	83	119
Antimony	0.034	0.084	0.030	0.043	0.066	0.12	0.17
Arsenic	0.0076	0.014	0.011	0.0060	0.0093	0.010	0.089
Cadmium	0.035	0.0039	0.0071	0.0020	0.010	0.015	0.039
Lead	**0.50**	**0.66**	**0.99**	**3.0**	**1.0**	**0.82**	0.49
Selenium	0.32	0.27	0.28	0.27	0.34	**0.42**	0.40
Silver	0.00087	0.0014	0.0010	0.00081	0.00087	0.0012	0.020
Thallium	0.0012	0.0020	0.0018	0.0027	0.0023	0.0027	0.0055
Mercury	0.0047	0.0017	0.0037	0.0013	0.0042	0.0017	0.013

[a]Al to Zn by method SW6010B and analyzed by inductively coupled plasma; Sb to Tl by method SW6020B and analyzed by inductively coupled plasma mass spectroscopy; Hg by method SW7471 and analyzed by cold vapor atomic adsorption.
[b]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2009).
[c]All U flagged undetected (<minimum detection limit [MDL]) TAL elements were reported as one-half the MDL; all B flagged estimated values (>MDL but <RL) were reported.
[d]Sample number/grid location (U = upper, L = lower)

c. Dioxin and Furans. There were no dioxin or furan concentrations that were detected above the standard quantification limit (SQL) (i.e., reporting level) in any of the eight whole body field mouse samples (Table 3).

d. High Explosives and Perchlorate. There were no detections of high explosives above the SQL in any of the four whole body field mice samples at TA-36 Minie (Table 4). Similarly, all field mouse samples (n = 4) contained perchlorate concentrations below the RSRL.

e. Polychlorinated Biphenyls. Total PCBs in three of the five whole body field mice samples collected from TA-36 Minie were slightly higher than the RSRL calculated from non-urban sites (undisturbed grasslands) but quite lower than the RSRL estimated from field mice collected near an urban waste transfer station in Española, NM (Table 5). Nevertheless, the highest PCB amounts detected in soil at TA-36 Minie (Aroclor 1248 = 0.0054 mg/kg, Aroclor 1254 = 0.0036 mg/kg, and Aroclor 1260 = 0.021 mg/kg) (Vigil-Holterman and Juarez 2011a) were all below the ESLs for the deer mouse (Aroclor 1248 = 0.014 mg/kg, Aroclor 1254 = 0.88 mg/kg, and Aroclor 1260 = 20 mg/kg) (LANL 2010).

TA-39 Point 6

a. TAL Elements. Most TAL elements in whole body field mice from TA-39 Point 6 (n = 3) were below or similar to the RSRLs (see Table 2). As in field mice from TA-36 Minie, the only two TAL elements that were found to be higher than the RSRLs were barium in two of the three samples and lead in all three samples. Based on the highest barium concentration in soil at TA-39 Point 6 measured in 1995 (302 mg/kg) (LANL PRS Database) and in 2010 (99 mg/kg) (Vigil-Holterman and Juarez 2011b), the levels are well below the ESL of 1800 mg/kg for field mice (LANL 2010). Conversely, the highest lead concentrations detected in soil at TA-39 Point 6 in 1995 (978 mg/kg) (LANL PRS Database) and in 2010 (375 mg/kg) (Vigil-Holterman and Juarez 2011b) were higher than the ESL of 120 mg/kg (LANL 2010). Undoubtedly, the highest lead concentrations in soil at TA-39 Point 6 were probably associated with samples collected on or near the firing pad; however, based on the average soil lead concentration from two sampling

Table 3. Dioxin and furan concentrations (pg/g wet) in whole body field mice samples collected from TA-36 Minie in 2010/11.

	Aug-10										Feb-11					
Dioxin/Furan[a]	3205/L[bc]	Lab Q	3206/L	Lab Q	3207/U	Lab Q	3208/U	Lab Q	3209/U	Lab Q	5081/L	Lab Q	5083/L	Lab Q	5085/L	Lab Q
Dioxins																
Tetrachlorodibenzodioxin[2,3,7,8-]	0.175	U	0.501	U	0.173	U	0.482	U	0.535	U	0.084	U	0.0668	U	0.0734	U
Tetrachlorodibenzodioxins (Total)	0.175	U	0.501	U	0.173	U	0.482	U	0.535	U	0.084	U	0.0668	U	0.0734	U
Pentachlorodibenzodioxin[1,2,3,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Pentachlorodibenzodioxins (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzodioxins (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	1.04	J	0.474	U	0.478	U	0.726	U	0.622	J	0.42	U	0.334	U	0.367	U
Heptachlorodibenzodioxins (Total)	4.6	J	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.412	J
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.59	J	1.67	J	0.956	U	1.45	U	1.61	J	0.896	J	0.668	U	1.25	J
Furans																
Tetrachlorodibenzofuran[2,3,7,8-]	0.165	J	0.258	J	0.222	J	0.311	J	0.359	J	0.257	J	0.156	J	0.211	J
Tetrachlorodibenzofurans (Totals)	0.379	J	0.493	J	0.468	J	0.311	J	0.698	J	0.464	J	0.289	J	0.188	J
Pentachlorodibenzofuran[1,2,3,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Pentachlorodibenzofuran[2,3,4,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Pentachlorodibenzofurans (Totals)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofuran[1,2,3,7,8,9-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U

Table 3 (cont.)

	Aug-10										Feb-11					
Furans (cont.)	**3205/L[bc]**	**Lab Q**	**3206/L**	**Lab Q**	**3207/U**	**Lab Q**	**3208/U**	**Lab Q**	**3209/U**	**Lab Q**	**5081/L**	**Lab Q**	**5083/L**	**Lab Q**	**5085/L**	**Lab Q**
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Hexachlorodibenzofurans (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Heptachlorodibenzofurans (Total)	0.496	U	0.474	U	0.478	U	0.726	U	0.557	U	0.42	U	0.334	U	0.367	U
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.992	U	0.949	U	0.956	U	1.45	U	1.11	U	0.84	U	0.668	U	0.734	U

[a]Method blank corrected data.
[b]Sample number/grid location (U = upper, L = lower).
[c]Results as related to the Laboratory Qualifier: Result followed by a blank space is a Detected value = result was above the reporting limit (RL); Result followed by a U is an Undetected value = result was below the minimum detectable level (MDL) (Shown); Result followed by a J is an Estimated value = result was above the MDL but below the RL.

Table 4. High explosives (µg/kg wet) and perchlorate (mg/kg wet) in whole body field mice collected from TA-36 Minie and TA-39 Point 6 in 2010. (Bold values are higher than the RSRL.)

		TA-36 OD Minie				TA-39 OD Site 6		
High Explosives/Perchlorate	**RL[a]**	**3210/U[b]**	**3211/L**	**3212/L**	**3213/U**	**3221/L**	**3222/U**	**RSRL[c]**
2,4-Diamino-6-nitrotoluene	2000	U[d]	U	U	U	U	U	
2,6-Diamino-4-nitrotoluene	2000	U	U	U	U	U	U	
3,5-Dinitroaniline	1000	U	U	U	U	U	U	
Amino-2,6-dinitrotoluene[4-]	500	U	U	U	U	U	U	
Amino-4,6-dinitrotoluene[2-]	500	U	U	U	U	U	U	
Dinitrobenzene[1,3-]	500	U	U	U	U	U	U	
Dinitrotoluene[2,4-]	500	U	U	U	U	U	U	
Dinitrotoluene[2,6-]	500	U	U	U	U	U	U	
HMX	500	U	U	U	U	U	U	
Nitrobenzene	500	U	U	U	U	U	U	
Nitrotoluene[2-]	500	U	U	U	U	U	U	
Nitrotoluene[3-]	500	U	U	U	U	U	U	
Nitrotoluene[4-]	500	U	U	U	U	U	U	
PETN	1000	U	U	U	U	U	U	
RDX	500	U	U	U	U	U	U	
TATB	1000	U	U	U	U	U	U	
Tetryl	500	U	U	U	U	U	U	
Trinitrobenzene[1,3,5-]	500	U	U	U	U	U	U	
Trinitrotoluene[2,4,6-]	500	U	U	U	U	U	U	
Tris (o-cresyl) phosphate	1000	U	U	U	U	U	U	
Perchlorate	0.0040	0.028	0.012	0.012	0.096	0.12	0.088	0.19

[a]Reporting level (standard quantification limit).
[b]Sample number/grid location (U = upper, L = lower).
[c]Regional Statistical Reference Level; this is the upper-level background concentration (mean + 3 SD) based on data from Fresquez (2011).
[d]Laboratory Qualifier. (Detected) = result was above the reporting limit (RL); U (Undetected) = result was below the minimum detectable level (MDL); J (Estimated) = result was above the MDL but below the RL.

Table 5. Polychlorinated biphenyl (PCB) homologs and totals (pg/g wet) in whole body field mice collected from TA-36 Minie in 2010/2011. (Total PCBs highlighted in bold are higher than the RSRL.)

	Aug-10				Feb-11						RSRL[c]	
PCB Homolog/Total	3205/L[ab]	Lab Q	3206/L	Lab Q	5080/L	Lab Q	5084/L	Lab Q	5082/L	Lab Q	Non-Urban	Urban
Total monoCB	5.62	U	5.69	U	6.76	U	5.36	U	5.1	U		
Total diCB	5.62	U	5.69	U	6.76	U	5.36	U	5.1	U		
Total triCB	26.3		5.69	U	6.76	U	5.36	U	5.1	U		
Total tetraCB	5.62	U	5.69	U	6.76	U	5.36	U	5.1	U		
Total pentaCB	73.8		93.2		19.7		36.8		15.2			
Total hexaCB	1140		1860		147		443		82.1			
Total heptaCB	1500		4120		163		428		88.4			
Total octaCB	540		1850		48.2		164		11.4			
Total nonaCB	130		146		6.76	U	12		5.1	U		
Total decaCB	66.2		30.1		6.76	U	5.36	U	5.1	U		
Total PCB	3470		8100		378		1080		197		885	28000

[a]Sample number/grid location (U = upper, L = lower).
[b]Result as related to Laboratory Qualifiers: Result followed by a blank space is a Detected value = result was above the standard quantification limit (SQL); Result followed by a U is an Undetected value = result was below the minimum detectable level (MDL) (shown); Result followed by a J is an Estimated value = result was above the MDL but below the SQL.
[c]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2011).

periods over the entire site, the amount (82 mg/kg; n = 57) (LANL PRS Database, Vigil-Holterman and Juarez 2011b) was lower than the ESL for field mice.

b. Dioxin and Furans. Out of the six field mice samples collected in August of 2010 and February of 2011, only one sample and for only one compound, pentachlorodibenzofuran [2,3,4,7,8-], was detected above the SQL (Table 6). The amount (5.26 pg/g wet weight), however, was just above the reporting limit of 4.8 pg/g wet weight, and there were no detections of this compound above the reporting limit in soil samples collected from the site (Vigil-Holterman and Juarez 2011b); thus, these data in the tissue of one field mouse sample out of six may be a false positive.

c. High Explosives and Perchlorate. There were no detections of high explosives above the SQLs in any of the field mice samples (n = 2) collected at TA-39 Point 6 (see Table 4). Similarly, the amounts of perchlorate (n = 2) were below the RSRL.

d. Polychlorinated Biphenyls. Two out of five whole body field mouse samples collected from TA-39 Point 6 were higher in total PCBs than either of the RSRLs (Table 7). These two samples were collected from the upper grid, which is closer to the firing site, as compared to the other three samples being collected at the lower grid, which is further away. Nevertheless, the highest PCB amounts detected in soil at TA-39 Point 6 (Aroclor 1254 = 0.042 mg/kg and Aroclor 1260 = 0.018 mg/kg) (Vigil-Holterman and Juarez 2011b) were still below the ESLs for the deer mouse (Aroclor 1254 = 0.88 mg/kg and Aroclor 1260 = 20 mg/kg) (LANL 2010).

CONCLUSIONS

The tissues of the biota collected from TA-36 Minie indicated that analyzed concentrations were below the RSRLs or applicable SLs or soil comparisons. Similarly, at TA-39 Point 6, with the exception of lead, there were no detections of inorganic and organic chemicals in whole body tissues of field mice above RSRLs or applicable SLs or soil comparisons. Additionally, average lead concentrations over the TA-39 Point 6 site indicate that the site as a whole is not above ESLs for the field mouse. In conclusion, none of whole body tissue concentrations within the samples collected from TA-36 Minie or from TA-39 Point 6 appear to significantly impact the field mice population. In fact,

Table 6. Dioxin and furan concentrations (pg/g wet) in whole body field mice samples collected from TA-39 Point 6 in 2010/2011.

	Aug-10						Feb-11					
Dioxin/Furan[a]	**3218/L[b,c]**	**Lab Q**	**3219/U**	**Lab Q**	**3220/U**	**Lab Q**	**5548/L**	**Lab Q**	**5550/L**	**Lab Q**	**5552/L**	**Lab Q**
Dioxins												
Tetrachlorodibenzodioxin[2,3,7,8-]	0.442	U	0.287	U	0.245	U	0.081	U	0.0845	U	0.0692	U
Tetrachlorodibenzodioxins (Total)	0.442	U	0.287	U	0.245	U	0.081	U	0.0845	U	0.0692	U
Pentachlorodibenzodioxin[1,2,3,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Pentachlorodibenzodioxins (Total)	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzodioxins (Total)	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.487	U	1.1	J	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzodioxins (Total)	0.487	U	1.1	J	0.495	U	0.405	U	0.402	U	0.346	U
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.07	J	2.06	J	1.03	J	0.81	U	0.803	U	0.728	J
Furans												
Tetrachlorodibenzofuran[2,3,7,8-]	0.345	J	0.323	J	0.655	J	0.177	J	0.169	J	0.208	J
Tetrachlorodibenzofurans (Totals)	0.633	J	0.434	J	0.655	J	0.499	J	0.492	J	0.421	J
Pentachlorodibenzofuran[1,2,3,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Pentachlorodibenzofuran[2,3,4,7,8-]	0.489	J	**5.26**		0.773	J	0.405	U	0.402	U	0.346	U
Pentachlorodibenzofurans (Totals)	0.489	J	**5.26**		0.773	J	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofuran[1,2,3,7,8,9-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U

Table 6 (cont.)

	Aug-10						Feb-11					
Furans (cont.)	**3218/L[b,c]**	**Lab Q**	**3219/U**	**Lab Q**	**3220/U**	**Lab Q**	**5548/L**	**Lab Q**	**5550/L**	**Lab Q**	**5552/L**	**Lab Q**
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.487	U	0.571	J	0.495	U	0.405	U	0.402	U	0.346	U
Hexachlorodibenzofurans (Total)	0.487	U	0.571	J	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Heptachlorodibenzofurans (Total)	0.487	U	0.484	U	0.495	U	0.405	U	0.402	U	0.346	U
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.974	U	0.968	U	0.989	U	0.81	U	0.803	U	0.692	U

[a]Method blank corrected data.
[b]Sample number/grid location (U = upper, L = lower).
[c]Results as related to the Laboratory Qualifier: Result followed by a blank space (Detected) = result was above the reporting limit (RL); Result followed by a U (Undetected) = result was below the minimum detectable level (MDL) (Shown); Result followed by an J (Estimated) = result was above the MDL but below the RL.

Table 7. Polychlorinated biphenyl (PCB) homologs and totals (pg/g wet) in whole body field mice collected from TA-39 Point 6 in 2010/2011. (Total PCBs highlighted in bold are higher than the RSRL.)

	Aug-10				Feb-11						RSRL[c]	
PCB Homolog/Total	3219/U[ab]	Lab Q	3220/U	Lab Q	5549/L	Lab Q	5551/L	Lab Q	5553/L	Lab Q	Non-Urban	Urban
Total monoCB	4.77	U	3.42	U	5.99	U	5.97	U	5.6	U		
Total diCB	4.77	U	3.42	U	5.99		5.97	U	5.6			
Total triCB	5.06	B	49.8		5.99		5.97		5.6			
Total tetraCB	9.72	B	41.5	B	5.99		5.97		5.6			
Total pentaCB	3370		12100		65.1		34		5.6			
Total hexaCB	44900		16400		471		189		65.9			
Total heptaCB	9820		4070		313		71.7		39.2			
Total octaCB	1020		802		130		33.2		10.7			
Total nonaCB	86.2		90.1		19.3		5.97	U	5.6	U		
Total decaCB	8.58		3.42	U	5.99	U	5.97	U	5.6	U		
Total PCB	**59300**		**33600**		998		328		116		857	28000

[a]Sample number/grid location (U = upper, L = lower).
[b]Result as related to Laboratory Qualifiers: Result followed by a blank space is a Detected value = result was above the standard quantification limit (SQL); Result followed by a U is an Undetected value = result was below the minimum detectable level (MDL) (shown); Result followed by a J is an Estimated value = result was above the MDL but below the SQL.
[c]Regional Statistical Reference Level; this is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez (2011).
B = blank corrected.

Bennett and Robinson (2011) reported that the populations from these two detonation sites were similar to an undisturbed background location.

We acknowledge that the sample numbers for chemical analysis in some cases may be small and recommend more sampling over time.

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APPENDIX

Information on field mice collected at open-detonation firing sites TA-36 Minie and TA-39 Point 6

							Constituents Analyzed			
TA	**Species Name**	**Ear Tag #**	**Date Collected**	**Weight (g)**	**Sample #**	**Grid Location**	**Uranium Isotopes**	**Dioxin/ Furans**	**PCB Congeners**	**HE/ Perchlorate**	**TAL Elements**
					SFB10-11-						
36	REME	4033	8/13/10	20	3202	Upper					X
36	PEMA	4040	8/13/10	10.5	3203	Lower					X
36	PEMA	2	8/13/10	17	3204	Upper					X
36	PEMA	4029	8/10/10	17	3205	Lower		X	X		
36	PEMA	4028	8/13/10	17.5	3206	Lower		X	X		
36	REME	4036	8/13/10	11	3207	Upper		X			
36	REME	3	8/13/10	7	3208	Upper		X			
36	REME	4034	8/13/10	8.5	3209	Upper		X			
36	REME		8/10/10	14.5	3210	Upper				X	
36	PETR	1	8/13/10	25	3211	Lower				X	
36	PETR	4027	8/13/10	34	3212	Lower				X	
36	PEMA	4037	8/13/10	19	3213	Upper				X	
36	4 PEMA 1 NEME	4043, 4032, 4030, 4035, 4048	8/13/10	Composite	3214	3U, 2L	X				
					MICE36-11-						
36	PETR		2/17/11	10	5080	Lower			X		
36	PEMA		2/15/11	15	5084	Lower			X		
36	PEBO		2/15/11	19	5085	Lower		X			
36	REME		2/17/11	11.5	5081	Lower		X			
36	PEMA		2/17/11	17	5082	Lower			X		
36	PEMA		2/17/11	15.5	5083	Lower		X			

39	PEMA	4098	8/26/10	16.5	3215	Lower					X
39	PEBO	2602	8/26/10	19.5	3216	Upper					X
39	PEMA	4085	8/26/10	27	3217	Lower					X
39	PEMA	2603	8/26/10	10.5	3218	Lower	X				
39	PEMA	4080	8/23/10	17	3219	Upper	X	X			
39	PEMA	4083	8/26/10	25	3220	Upper	X	X			
39	PEMA	4090	8/26/10	15.5	3221	Lower			X		
39	PEMA	4082	8/26/10	12.5	3222	Upper			X		
39	PEMA		2/24/11	12.5	MICE39-11-5550	Lower	X				
39	PEMA		3/1/11	19	5553	Lower		X			
39	PEMA		2/23/11	17	5549	Lower		X			
39	PEMA		2/23/11	12	5548	Lower	X				
39	PEMA		2/24/11	16	5551	Lower		X			
39	PEMA		2/24/11	13.5	5552	Lower	X				

PEMA = deer mouse (*Peromyscus maniculatus*)
PETR = pinyon mouse (*Peromyscus truei*)
REME = western harvest mouse (*Reithrodontomys megalotis*)
PEBO = brush mouse (*Peromyscus boylii*)
NEME = Mexican wood rat (*Neotoma mexicana*)
Sample Coordinates:

TA-36, upper grid (X = 1631558 and Y = 1756103) and lower grid (X = 1632355 and Y = 1756697)
TA-39, upper grid (X = 1636020 and Y = 1746329) and lower grid (X = 1636562 and Y = 1746542)

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 4 – Fresquez *et al.* 2013

Environmental Report:

Fresquez, P.R., L. Hansen, and C. Hathcock, 2013. *Chemical Concentrations in Field Mice/Voles Collected from an Open-Burn Site at Technical Area 16 at Los Alamos National Laboratory, Revision 1*, Los Alamos National Laboratory. LA-UR-13-200040.

Title:	**CHEMICAL CONCENTRATIONS IN FIELD MICE/VOLES COLLECTED FROM AN OPEN-BURN SITE AT TECHNICAL AREA 16 AT LOS ALAMOS NATIONAL LABORATORY: REVISION 1**
Author(s):	P.R. Fresquez, L. Hansen, and C. Hathcock
Intended for:	Report

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PREFACE

The purpose of this revision was to increase the data base for small mammal collections at the TA-16 burning grounds. In addition to inorganic elements and dioxin/furan concentrations in field mice/voles collected in 2011, the population parameters of field mice around the TA-16 burn ground site were estimated and samples were analyzed for polychlorinated biphenyls, high explosives, and perchlorate.

CHEMICAL CONCENTRATIONS IN FIELD MICE/VOLES COLLECTED FROM AN OPEN-BURN SITE AT TECHNICAL AREA 16 AT LOS ALAMOS NATIONAL LABORATORY: REVISION 1

P.R. Fresquez, L. Hansen, and C. Hathcock

ABSTRACT

Field mice and voles were collected around an open-burn (high-explosive waste) site, TA-16-388 (flash pad), at Technical Area 16 at Los Alamos National Laboratory in March of 2011 for the analysis of 23 target analyte list (TAL) elements (mostly metals) and 17 dioxin/furan chemicals. In July of 2012, small mammal community and population parameters were estimated across the site, and samples were analyzed for polychlorinated biphenyl's (PCBs), high explosives (HEs), and perchlorate. All TAL elements in whole-body field mouse samples (n=3) were either similar to regional statistical reference levels (RSRLs) or below ecological screening levels. Dioxins and furans (n=6) and HEs (n=2) were not detected in any of the whole-body field mouse/vole samples. Perchlorate concentrations (n=2) were below the RSRL. One out of the two small mammal samples contained PCB Arochlor-1260 above non-urban RSRLs; the amount, however, was similar to the urban RSRL. There was no adverse effect of burning ground operations on local small mammal populations.

INTRODUCTION

Two open-burn treatment units (burn units), the TA-16-388 Flash Pad and the TA-16-399 Burn Tray, located at Technical Area 16 (TA-16) at Los Alamos National Laboratory (LANL or the Laboratory), are used for the destruction of high explosives (HE), HE machining wastes, and wastes contaminated with HE (LANL 2003) **(Figures 1 and 2)**. The burn units have been in operation since the late 1950s and have been authorized to operate under an interim basis by the State of New Mexico since 1980. Currently, the Laboratory is in the process of applying for a hazardous waste permit for the open-burning treatment of HE wastes at TA-16. The public has voiced concern about potential effects from releases of chemicals, particularly dioxins and furans on the surrounding environment (New Mexico Environment Department [NMED] 2010).

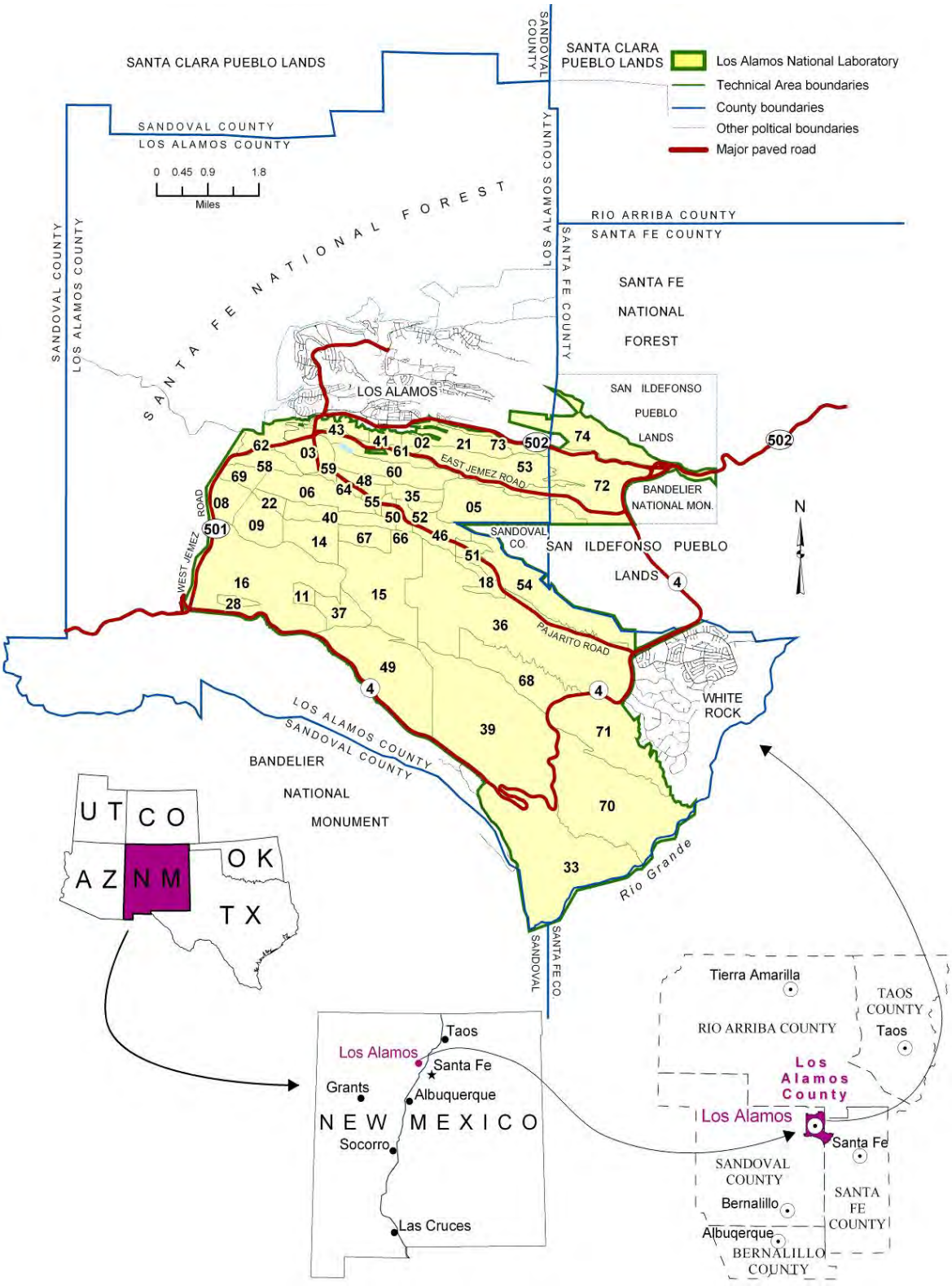

Figure 1. Location of Los Alamos National Laboratory**.**

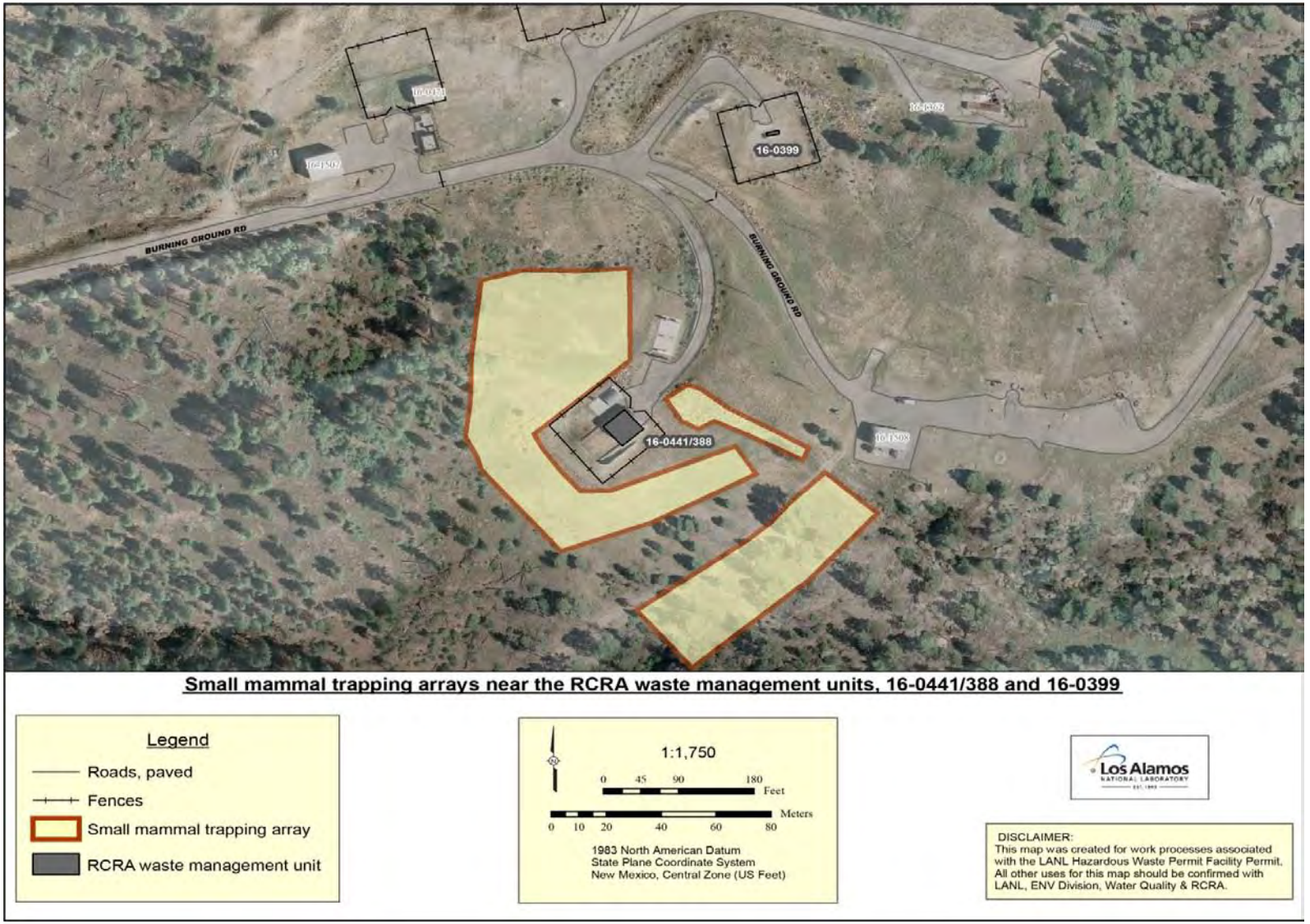

Figure 2. Location of burn units (referred to as the RCRA waste management units) and sampling arrays at TA-16 in 2011.

An analysis of Resource Conservation and Recovery Act (RCRA) metals and dioxin/furan chemicals in soil samples (n=37) collected in proximity to the two burn units at TA-16 showed that some elements like barium, cadmium, and silver were detected above background and each sample contained from 3 to 17 dioxin/furan chemicals. The human health and ecological risk analyses concluded that no risks to human or ecological receptors above acceptance thresholds are present at the site (LANL 2010a).

The purpose of the present study was to gain more information on any food-chain transfer of the chemicals of potential ecological concern at the burn units to a low-trophic-level animal receptor (e.g., field mice) to verify the results of the ecological risk analysis. In general, field mice are effective biomonitors because of their ease of collection, feeding habits (e.g., omnivore), limited home range, and association with the soil (e.g., burrowing) (Arthur et al. 1987, Talmage and Walton 1991, Smith et al., 2002). At LANL, field mice are used as the biota (radionuclide) dose (McNaughton 2006) and chemical (Fresquez et al. 2010) uptake models for terrestrial mammals because they have the smallest home range (0.089 to 1.5 acres) (Wood et al. 2010).

METHODOLOGY

Site Description

The Laboratory is situated in northern New Mexico on the Pajarito Plateau, a series of fingerlike mesas separated by east-to-west-oriented canyons. The mesa tops slope eastward from approximately 2377 m (7800 ft) to 1890 m (6200 ft). The surrounding land is largely undeveloped, including large tracts held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, and San Ildefonso Pueblo. The open-burn sites are located in a remote location at TA-16 and vegetation consist of mostly ponderosa pine (*Pinus ponderosa* C. Lawson), gambel oak (*Quercus gambelii* Nutt) and open field grasses.

Small Mammal Trapping

2011 Study. Large snap traps were set in three arrays (north/west/south, east, and southeast) around the most often used burn unit, TA-16-388 (Flash Pad), in March-April 2011 **(Figure 2)**. Traps were baited in the late afternoon with molasses-coated oat bait and checked early each morning. A total of nine field mice/voles were collected over the sampling period; three samples were used for target analyte list (TAL) analysis, and six samples were used for dioxin/furan

analysis. The samples for TAL analysis were each placed in double ziplock bags, whereas the dioxin/furan samples were each placed into 250-mL amber glass jars. All samples were secured with chain-of-custody tape, transported in an ice cooler, and stored in a freezer until they were submitted to the Laboratory's Sample Management Office. Samples consisted of deer mice (*Peromyscus maniculatus*) (PEMA), brush mice (*Peromyscus boylii*) (PEBO), and long-tailed voles (*Microtus longicaudus*) (MILO) (Appendix A).

ALS Group (formerly Paragon Analytics) analyzed the whole-body (carcass plus pelt) field mouse samples for TAL elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury). Seventeen dioxin/furan congeners in whole-body field mice/voles were analyzed by Cape Fear Analytical, LLC.

2012 Study. Small mammal trapping was conducted near TA-16-399 (Flash Pad) on July 2-3, using Sherman live traps. The objective of the sampling was to evaluate the status of the small mammal community and to collect samples for the analysis of polychlorinated biphenyls (PCBs), high explosives (HEs), and perchlorate. A trap web was set up with 12 spokes and 10 traps per spoke (Parmenter et al. 2003) **(Figure 3)**. Traps were baited on July 2nd, and checked on July 3rd. Six samples were collected, processed, and submitted similar to the 2011 study, but for organic chemical analyses.

Measures of abundance (captures per 100 trap nights), species richness, and species diversity for all captured animals; and average weight, male:female sex ratios; and indicators of reproductive activity (presence of pregnant females or juveniles) for the two most commonly trapped species, PEBO and PEMA, were determined. A comparison of these metrics to results from 21 other locations sampled between 2001 and 2010 on or near LANL using Sherman live traps during summer time periods (July through September) was conducted. Comparison trapping locations ranged from mesa tops to canyon bottoms and from pinyon-juniper to riparian, ponderosa pine, and mixed conifer habitats. Box and whisker plots were plotted for the number of captures per 100 trap nights, the species' sex ratios, the species' average nonpregnant adult weights, and community diversity, as indexed by Shannon' H metric (Shannon 1948). Sex ratios were not

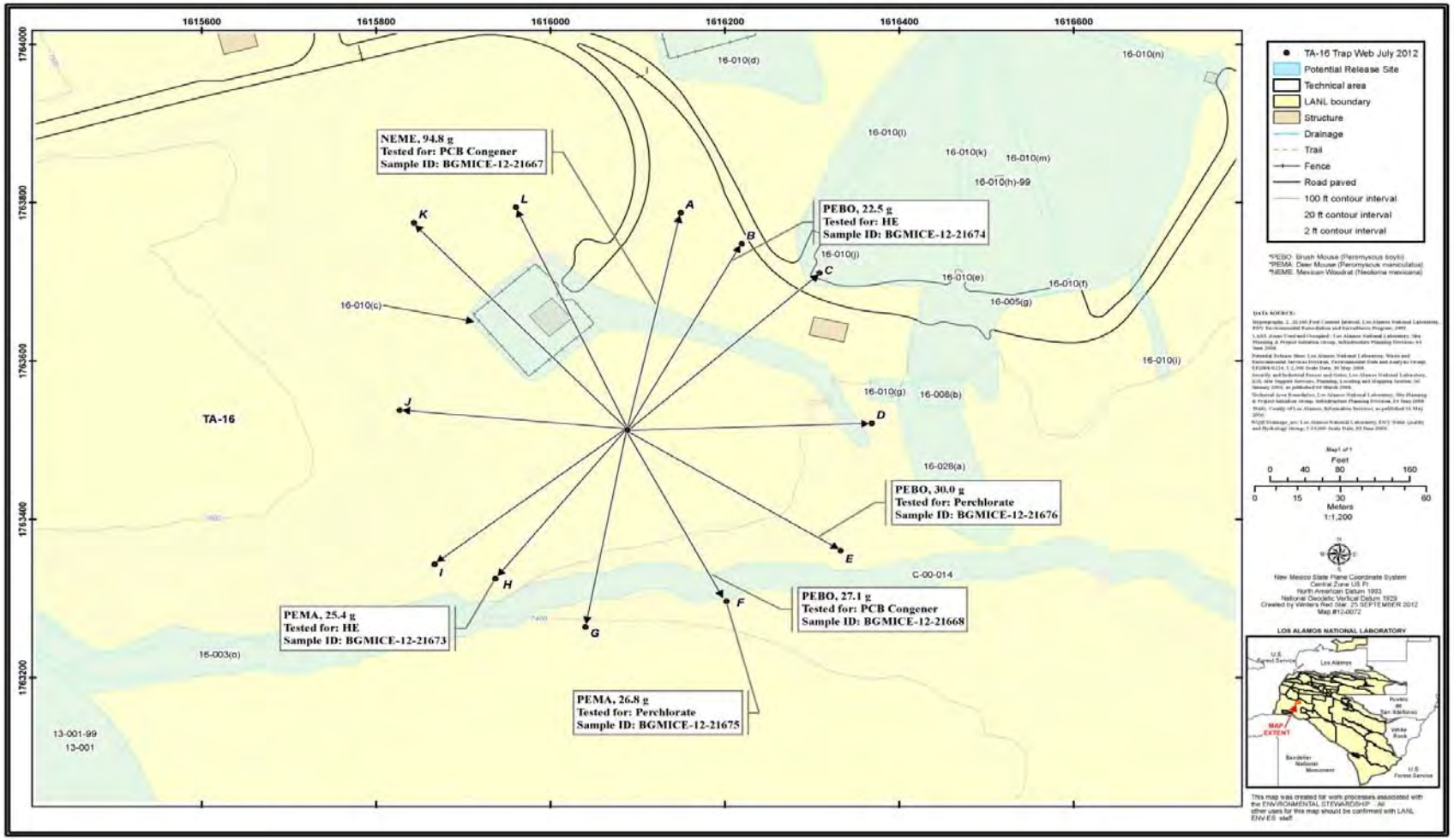

Figure 3. Map of the trapping web used to sample small mammals at the TA-16 burning grounds during July 2012. NEME = *Neotoma Mexicana*; PEBO = *Peromyscus boylii*; PEMA = *Peromyscus maniculatus*; PCB = polychlorinated biphenyl; HE = high explosives.

calculated if only one gender was captured in the trapping effort. The box and whisker plots represent the minimum value, the 25th percentile, the median, the 75th percentile, and the maximum value.

Biota Comparison Levels

Chemical concentrations in field mice/voles from Laboratory areas are first compared with regional statistical reference levels (RSRLs). RSRLs, which represent natural and fallout levels of chemicals, are the upper-level bounds of background concentrations (mean plus three standard deviations = 99% confidence level) calculated from field mice that were collected from regional locations away from the influence of the Laboratory (over 9 miles away) (U. S. Department of Energy [DOE] 1991). For TAL elements, dioxins/furans, PCBs, and perchlorate in whole-body field mice, RSRLs can be found in Fresquez (2009, 2011a). HEs are not naturally produced or commonly released, so the small mammals collected from regional locations should not contain these chemicals.

There are no regulatory screening levels for chemicals in tissues of field mice, so if chemicals in field mice are higher than the RSRLs, then the average chemical concentration in the soil at the place of collection is compared with ecological screening levels (ESLs) (LANL 2010b). ESLs are derived by the Laboratory from the literature and are designed to reflect the concentration of a chemical in the soil that is not expected to produce any adverse effects on selected biota receptors that commonly come into contact with soil or ingest biota that live in or on soil (i.e., they are the concentrations that are protective of ecological receptors under chronic exposure conditions).

RESULTS

2011 Study: Of the 23 TAL elements, barium, nickel, and cadmium were the only chemicals in whole-body field mice collected from around a burn unit at TA-16 (TA-16-388) that were detected in higher concentrations than the RSRLs in two or more samples **(Table 1)**. (Note that barium and cadmium were also detected above background concentrations in soil samples.) Nickel and cadmium in whole-body field mice were just above the RSRLs, whereas barium was substantially higher (15 to 27 mg/kg) than the field mouse RSRL (5.1 mg/kg). Nevertheless, the average concentration of barium in soil (519 mg/kg) from across the site (n=32) (LANL 2010a) was still below the ESL of 1800 mg/kg for the field mouse (LANL 2010b). Dioxins and furans

Table 1. TAL Elements (mg/kg wet) in Whole-Body Field Mice Collected from Burn Site at TA-16 in 2011.

Element[a]	9125[b] (brush mouse)	9131 (deer mouse)	9132 (deer mouse)	RSRL[c]
Aluminum	11	21	14	73
Barium	**15**	**27**	**22**	5.1
Beryllium[d]	0.0022	0.0019	0.0023	0.016
Calcium	11000	10000	11000	12624
Chromium	0.22	0.23	0.23	0.40
Cobalt	0.035	0.049	0.048	0.072
Copper	2.8	3.4	3.8	6.2
Iron	61	84	79	140
Magnesium	280	300	360	544
Manganese	3.1	2.6	2.4	7.6
Nickel	**0.14**	**0.12**	**0.18**	0.11
Potassium	2800	2700	2700	3677
Sodium	1300	1200	1200	1920
Vanadium	0.029	0.052	0.036	0.14
Zinc	23	23	25	119
Antimony	0.032	0.041	0.057	0.17
Arsenic	0.026	0.028	0.022	0.089
Cadmium	**0.048**	**0.040**	0.035	0.039
Lead	**0.59**	0.49	0.19	0.49
Selenium	0.29	0.39	0.39	0.40
Silver	0.0085	0.0068	0.0076	0.020
Thallium	0.0018	0.0017	0.0018	0.0055
Mercury	0.012	0.0081	0.0023	0.013

Note: Bold values are higher than the RSRL.
[a]Al to Zn by method SW6010B and analyzed by the inductively coupled plasma (ICP) technique; Sb to Tl by method SW6020B and analyzed by ICP/mass spectrometry; Hg by method SW7471 and analyzed by cold vapor atomic absorption.
[b]Sample number.
[c]The RSRL is the upper-limit regional background concentration (mean + 3 std dev) based on Fresquez 2009.
[d]All U flagged undetected (<method detection limit [MDL]) TAL elements were reported as one-half the MDL; all B flagged estimated values (>MDL but <reporting limit) were reported.

Table 2. Dioxin and Furan Concentrations (pg/g wet) in Whole-Body Field Mouse/Vole Samples Collected from Open-Burn Site TA-16 in 2011.

Dioxins/Furans[a]	9126[b] (MILO)	RQ[c]	9127 (MILO)	RQ	9128 (MILO)	RQ	9129 (MILO)	RQ	9130 (PEMA)	RQ	9133 (PEMA)	RQ
Dioxins												
Tetrachlorodibenzodioxin[2,3,7,8-]	0.0847	U	0.0843	U	0.084	U	0.0831	U	0.134	J	0.0837	U
Tetrachlorodibenzodioxins (Total)	0.0847	U	0.0843	U	0.084	U	0.0831	U	0.134	J	0.0837	U
Pentachlorodibenzodioxin[1,2,3,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.791	J	0.418	U
Pentachlorodibenzodioxins (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.791	J	0.418	U
Hexachlorodibenzodioxin[1,2,3,4,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.46	J	0.418	U
Hexachlorodibenzodioxin[1,2,3,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.734	J	0.418	U
Hexachlorodibenzodioxin[1,2,3,7,8,9-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzodioxins (Total)	0.423	U	0.422	U	0.42	U	0.416	U	1.19	J	0.418	U
Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	1.97	J	0.418	U
Heptachlorodibenzodioxins (Total)	0.423	U	0.422	U	0.42	U	0.416	U	2.87	J	0.418	U
Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	0.847	U	0.843	U	1.7	J	0.831	U	7.73	J	0.837	U

Table 2. Continued.

Dioxins/Furans[a]	9126[b]	RQ[c]	9127	RQ	9128	RQ	9129	RQ	9130	RQ	9133	RQ
Furans												
Tetrachlorodibenzofuran[2,3,7,8-]	0.246	U	0.268	U	0.282	U	0.299	U	0.197	U	0.244	U
Tetrachlorodibenzofurans (Total)	0.442	J	0.449	J	0.282	U	0.519	J	0.197	U	0.395	J
Pentachlorodibenzofuran[1,2,3,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Pentachlorodibenzofuran[2,3,4,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Pentachlorodibenzofurans (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[1,2,3,4,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[1,2,3,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[1,2,3,7,8,9-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Hexachlorodibenzofuran[2,3,4,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.776	J	0.418	U
Hexachlorodibenzofurans (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.776	J	0.418	U
Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	0.423	U	0.422	U	0.42	U	0.416	U	0.753	J	0.418	U
Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	0.423	U	0.422	U	0.42	U	0.416	U	0.418	U	0.418	U
Heptachlorodibenzofurans (Total)	0.423	U	0.422	U	0.42	U	0.416	U	0.753	J	0.418	U
Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	0.847	U	0.843	U	0.84	U	0.831	U	0.836	U	0.837	U

[a]Method was by 8290; blank corrected data.
[b]Sample number.
[c]Results as related to the reporting qualifier (RQ). Result followed by a blank space is a detected value = result was above the standard quantification limit (SQL); result followed by a U is an undetected value = result was below the method detection limit (MDL) (shown); result followed by a J is an estimated value = result was above the MDL but below the SQL.

were not detected above the analytical limit of quantification (detection limit) in any of the whole-body field mice/voles collected around the burn site, TA-16-388, at TA-16 **(Table 2)**. These data are similar to other dioxin/furan field-mouse uptake studies at the local (Fresquez 2011b) and national (Krouskop et al., 1991) levels and suggest that dioxins and furans, at least in the parts per trillion range (pg/g) in soil under natural field conditions, are not significantly assimilated, either by ingestion and/or by surface contact modes, to field mice/voles; possibly because of the adsorption of the chemical to soil surfaces or because of oxidation/reduction changes.

2012 Study: Trapped animals included one Mexican woodrat (*Neotoma mexicana*) (NEMA), three brush mice (PEBO) and two deer mice (PEMA). This resulted in a species richness of three, a capture rate of 4.2 animals per 100 trap nights, and a species diversity of 1.01. Species richness was within the range of normally observed results for LANL trapping efforts **(Figure 4)**. Captures per 100 trap nights and species diversity values were in the middle 50 percent of the data values for all trapping locations **(Figures 5 and 6)**.

Only two adult male PEMA were captured, so no pregnant females or juveniles were recorded for that species. There was evidence of reproduction in the captured PEBO **(Figure 7)**. Male:female sex ratios for PEBO at TA-16 were in the middle 50 percent of the data values for all trapping locations **(Figure 4)**. Average nonpregnant adult weights at the TA-16 burning grounds were above the 75th percentile for all species/gender combinations captured, and for PEBO and PEMA males, they were the highest values recorded at any of the LANL trapping locations **(Figure 8)**.

There were no HEs detected in any of the field mice collected around the burn unit and the perchlorate concentrations were similar to the RSRL **(Table 3).** One out of the two small mammals (brush mouse>wood rat) collected was higher in PCBs than the RSRL for undisturbed (non-urban) sites **(Table 4)**. PCB concentrations differ between small mammal species and may be attributed to differences in habitat use and foraging strategies (Johnson et al., 1996, Smith et al., 2006). Nevertheless, the highest PCB amount recorded (26,500 pg/g) was still similar to PCBs in field mice collected from around the perimeter of a public waste (garbage) transfer station (28,000 pg/g) (Fresquez 2011) and was far below the average (whole-body) amount (2.3E06 pg/g) that resulted in population alterations by decreasing reproductive capability and changes in liver, spleen, and adrenal function in field mice (Battey et al., 1990).

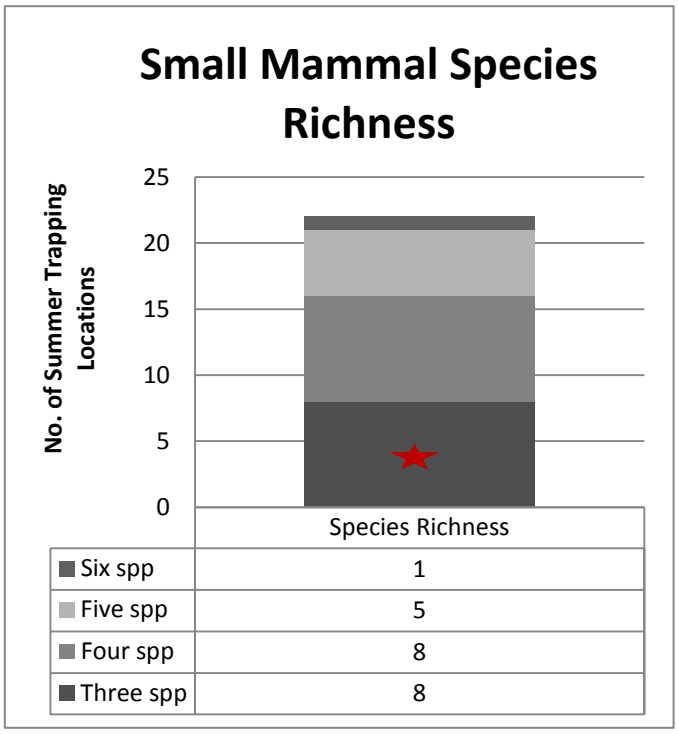

Figure 4. Species richness of small mammal communities sampled at LANL during summer between 2001 and 2012. The red star indicates the sampled species richness of three at the TA-16 burning grounds.

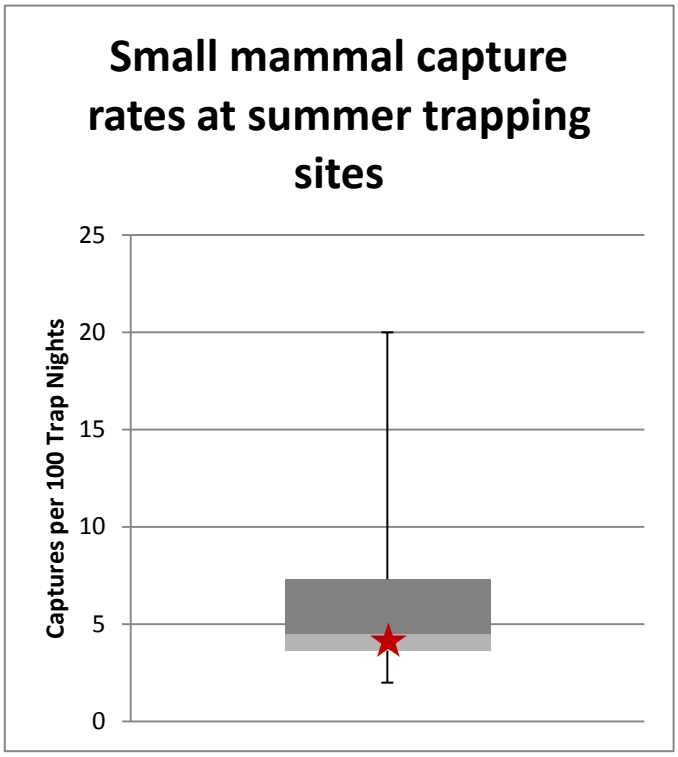

Figure 5. Capture rates of small mammal communities sampled at LANL during summer between 2001 and 2012. The red star indicates the sampled capture rate of 4.2 captures per 100 trap nights at the TA-16 burning grounds.

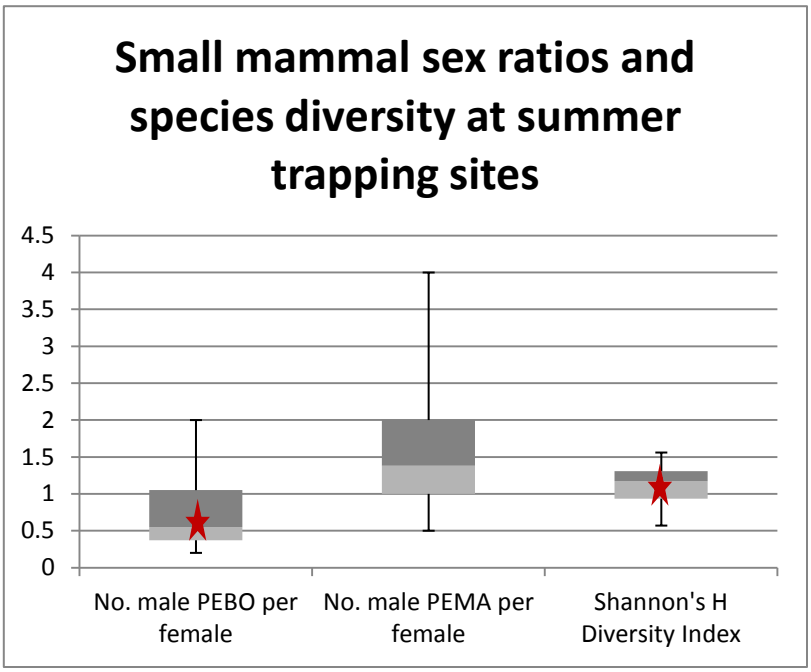

Figure 6. Sex ratios (males per female) and species diversity (Shannon's H index) for small mammals sampled at LANL during summer between 2001 and 2012. The red star indicates the sampled values at the TA-16 burning grounds of 0.5 male PEBO (*P. boylii*) per female, and a Shannon's H value of 1.01. No female PEMA (*P. maniculatus*) were captured, so no sex ratio was calculated for that species during this trapping effort.

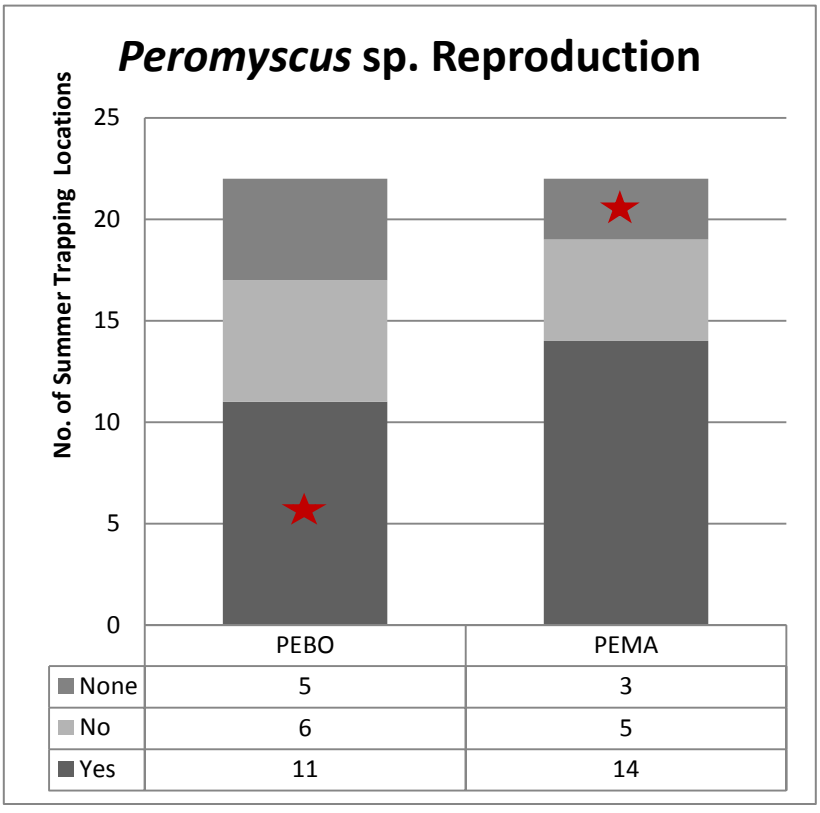

Figure 7. Evidence of reproduction (pregnant females or juveniles) in PEBO (*P. boylii*) and PEMA (*P. maniculatus*) populations sampled at LANL during summer between 2001 and 2012. Yes indicates the presence of either pregnant females or juveniles; No indicates only nonpregnant adult females present; and, None means that no adult females or juveniles of that species were captured. The red star indicates the sampling results at the TA-16 burning grounds of "Yes" for PEBO and "None" for PEMA.

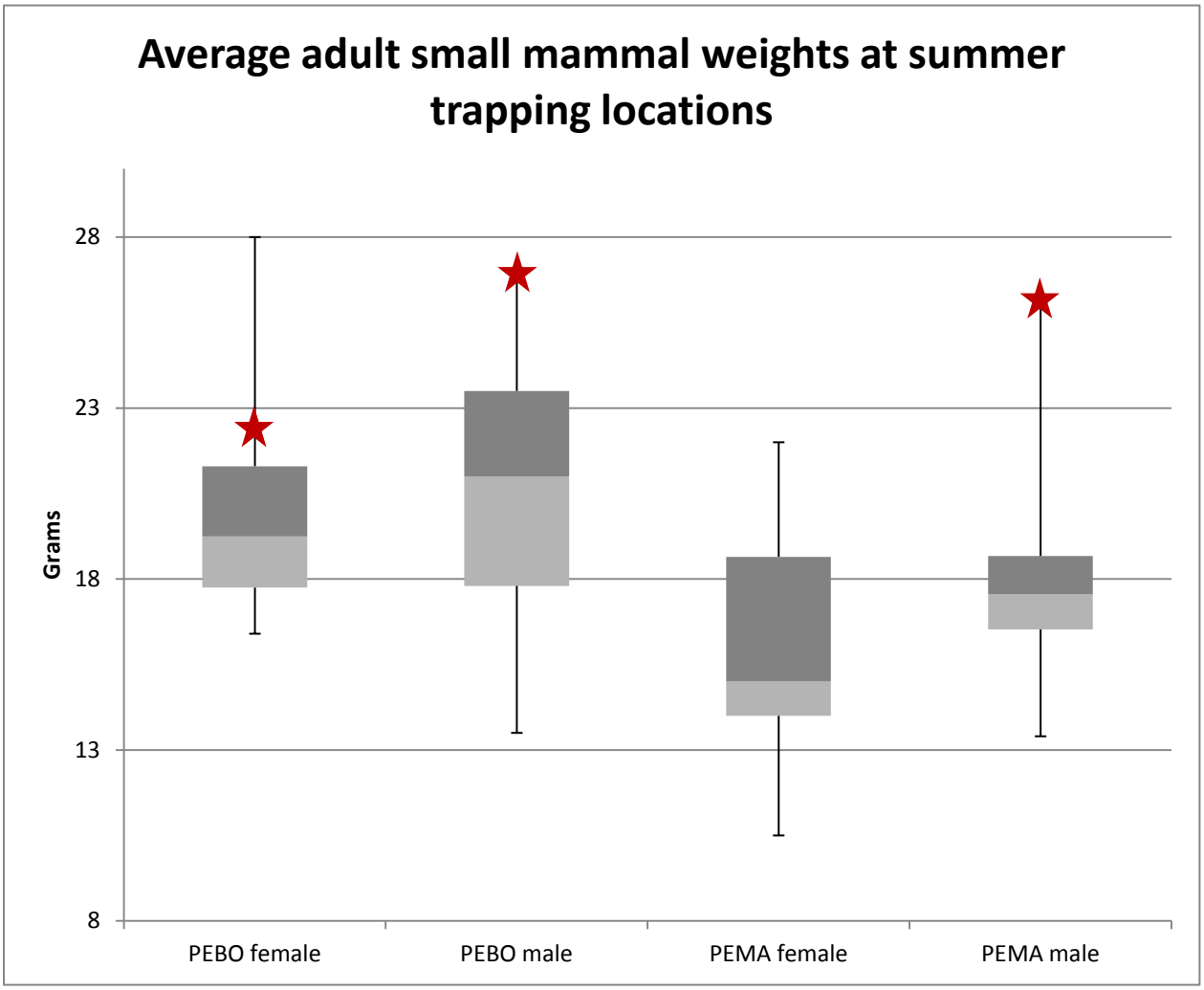

Figure 8. Average weight of adult nonpregnant female and of male PEBO (*P. boylii)* and PEMA (*P. maniculatus)* sampled at LANL during summer between 2001 and 2012. The red star indicates the sampling results at the TA-16 burning grounds of 22.5 g for female PEBO, 27.1 g for male PEBO, and 26.1 g for male PEMA. No female PEMA were captured during this trapping effort.

Table 3. High explosive concentrations (µg/kg wet) and perchlorate (mg/kg wet) in whole body field mice samples collected from TA-16 in 2012.

High Explosive/Perchlorate	12-21673[a] (deer mouse)	12-21674[a] (brush mouse)	
Trinitrotoluene[2,4,6-]	U	U	
Dinitrotoluene[2,4-]	U	U	
RDX	U	U	
Amino-2,6-dinitrotoluene[4-]	U	U	
HMX	U	U	
TATB	U	U	
Amino-4,6-dinitrotoluene[2-]	U	U	
Tetryl	U	U	
2,6-Diamino-4-nitrotoluene	U	U	
Dinitrotoluene[2,6-]	U	U	
3,5-Dinitroaniline	U	U	
2,4-Diamino-6-nitrotoluene	U	U	
PETN	U	U	
Tris (o-cresyl) phosphate	U	U	
Nitrotoluene[2-]	U	U	
Nitrobenzene	U	U	
Nitrotoluene[3-]	U	U	
Trinitrobenzene[1,3,5-]	U	U	
Dinitrobenzene[1,3-]	U	U	
Nitrotoluene[4-]	U	U	
	12-21675[a] (deer mouse)	**12-21676[a] (brush mouse)**	**RSRL[b]**
Perchlorate	0.0216	0.0032	0.19

[a]Sample number.
[b]Regional Statistical Reference Level; this is the upper-level background concentration (mean + 3 SD) based on data from Fresquez 2011a.

U (Undetected)=result was below the minimum detectable level.

Table 4. Polychlorinated biphenyl (PCB) homologs and totals (pg/g wet) in whole body field rat/mice collected from TA-16 in 2012.

PCB Homolog/Total[a]	12-21667[b] (wood rat)	12-21668[b] (brush mouse)	RSRL[c] Non-Urban	RSRL[c] Urban
Mono PCBs	0	0		
Di PCBs	0	0		
Tri PCBs	0	0		
Tetra PCBs	0	0		
Penta PCBs	23	1600		
Hexa PCBs	263	11100		
Hepta PCBs	146	10400		
Octa PCBs	91	2760		
Nona PCBs	7.5	511		
Deca PCB	0	49		
Total PCBs	531	26500	885	28000

[a]Method was by 1668A; blank corrected data.

[b]Sample number

[c]Regional Statistical Reference Level is the mean plus three standard deviations (99% confidence level) from Fresquez 2011a.

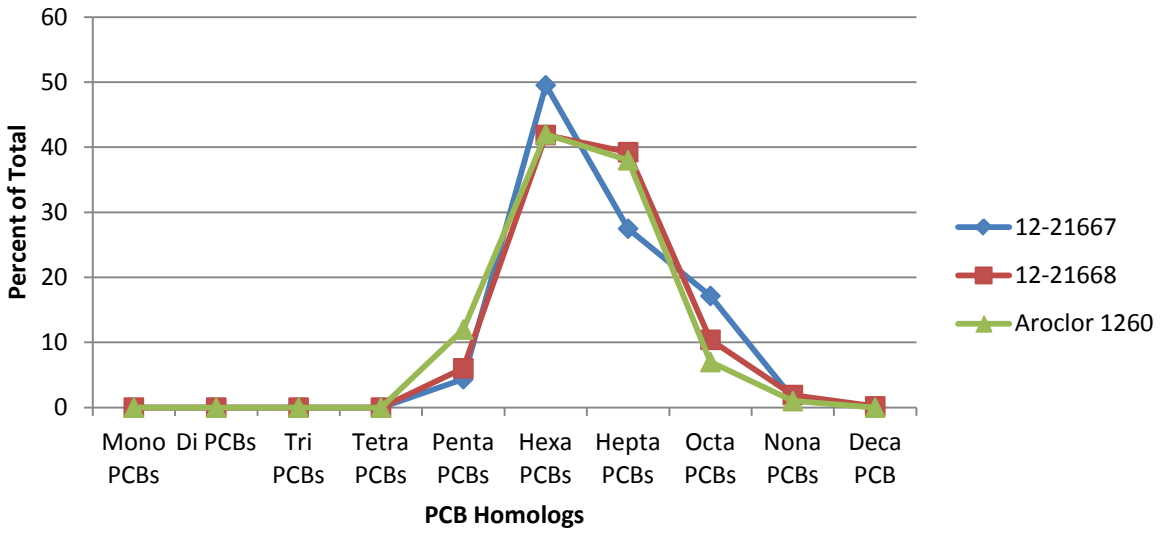

Figure 9. PCB homolog distribution of whole-body field wood rat (#21667)/brush mouse (#21668) samples collected from the TA-16 burning grounds in 2012 compared with Arochlor-1260.

The PCB homolog distribution of the field (brush) mouse collected near the TA-16 burn unit overlaps the distribution pattern of Archlor-1260 almost perfectly **(Figure 9)**.

Overall, both inorganic and organic data from whole-body field mice/voles collected at the burn unit site at TA-16 support the results of the ecological risk assessment conducted for this site. These data support the conclusion that there is no adverse effect of burn unit operations on local small mammal populations.

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APPENDIX A: Sample Information

Species	Array Location	Sample Number	Date Collected	Weight (grams)	TAL	Dioxins/ Furans	PCBs	HE	Perchlorate
PEMA[a]	N/W/S	MICEBURN-11-9133	3/17/11	21		X[b]			
PEMA	N/W/S	9132	3/17/11	13.5	X				
PEMA	SE	9131	3/18/11	16.5	X				
PEMA	N/W/S	9130	3/22/11	19.5		X			
MILO	N/W/S	9129	3/22/11	24		X			
MILO	N/W/S	9128	3/23/11	21.5		X			
MILO	N/W/S	9127	3/24/11	20.5		X			
MILO	N/W/S	9126	3/24/11	21		X			
PEBO	SE	9125	4/1/11	15	X				
NEME	A	BG-MICE-12-21667	7/3/12	94.8			X		
PEBO	B	21674	7/3/12	23.5				X	
PEBO	E	21676	7/3/12	30					X
PEBO	F	21668	7/3/12	27.1			X		
PEMA	F	21675	7/3/12	26.8					X
PEMA	H	21673	7/3/12	25.4				X	

Note: Coordinates are as follows: X = 1615893.65 and Y = 1763660.03.
[a]PEMA = Deer mouse (*Peromyscus maniculatus*), MILO = Long-tailed vole (*Microtus longicaudus*), PEBO = Brush mouse (*Peromyscus boylii*), NEME=Mexican wood rat.
[b]X = Analyzed.

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 5 – Hathcock & Fair 2013

Environmental Report:

Hathcock, C.D. and J.M. Fair, 2013. *Avian Monitoring at the TA 36 Minie Site, TA-39 Point 6 Site, and TA 16 Burn Ground*. LA-UR-13-27825.

Title:	**Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Grounds**
Author(s):	Charles D. Hathcock and Jeanne M. Fair Environmental Protection Division
Intended for:	RCRA Permitting Team and External

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year monitoring program for migratory birds in Fiscal Year (FY) 2013 to monitor avifauna at two open detonation sites and one open burn site at LANL. The objectives of this on-going study are to monitor patterns and trends of bird abundance and diversity over time at these sites. LANS biologists completed the first year of this effort in 2013.

Three surveys were completed at each of the study sites at the Technical Area (TA)-36 Minie Site, the TA-39 Point 6, and the TA-16 Burn Grounds between May and July 2013. A total of 590 birds representing 55 species were recorded. Of the 55 species detected at the three study sites, 54 are protected under the Migratory Bird Treaty Act (MBTA).

Results indicate that the avian abundance and diversity at the three study sites were comparable to or greater than that of the control sites. Continued monitoring will produce trends over time in avian abundance and diversity that can be compared to local, regional, and national data.

Introduction

As part of the Resource Conservation and Recovery Act (RCRA) permitting process for two open detonation sites, the TA-36 Minie Site and TA-39 Point 6, and one open burn site, the TA-16 Burn Grounds, at LANL, an avian monitoring program was started in 2013. The goal was to monitor avian use of the habitat surrounding the open detonation and open burning sites and compare their use to other locations at LANL in the same habitat type. Comparisons were made to control sites which have been surveyed since 2011 (Hathcock et al. 2011; Hathcock and Keller 2012).

LANS biologists used standard point count methodology to record avian density and diversity along transects in the three study sites during the summer of 2013. Summer surveys provide information about what migratory birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years, as they provide trend data, which can be compared with regional and national changes in bird populations, changes in the natural environment at LANL, and LANL operations.

Methods

Field Methods

Point count surveys along a transect were chosen as the most rigorous method to monitor patterns of bird abundance and richness, and population trends, in habitats found at two open detonation sites and one open burning site at LANL. This method is already used around LANL at other locations for long-term monitoring. The surveys were conducted along transects in the forested, undeveloped land surrounding the study sites (Figures 1 – 3). The habitat types around the sites are pinyon-juniper woodland (PJ) for the sites at TA-36 and -39 and mixed conifer forest (MC) for the site at TA-16. These habitat descriptions are based on the 1/4 hectare physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study

sites were compared to control sites at LANL. The control sites (Figure 4) are monitored annually in ongoing surveys conducted at LANL since 2011 as described in Hathcock and Keller (2012). The PJ study sites at TA-36 and -39 are similar to the PJ control sites at TA-70 and -71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at the TA-16 Burn Grounds is similar in elevation, and overstory vegetation, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present in the control sites.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1st – August 15. Ideally the breeding bird surveys should take place in the 2nd week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys.

- Each survey consists of nine points along the transect, ~ 250 m apart
- At each point of the survey the surveyor will look and listen for 5 minutes, noting any birds encountered. The distance for observations is considered as an "unlimited-distance circular plot"; however, noting the distance to each bird out to 100 meters should be done. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
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- Any bird(s) encountered will be recorded on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- The "NOTES" section should be used for indicating any potentially important aspects of the survey that may affect the data. Examples include: excess noise from nearby equipment and vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

Statistical Methods

Summary statistics are compiled to look at trends in avian abundance and diversity between the three study sites and the control sites. To compare relative abundances between years and with control sites, the "birds per hour" was calculated for each site. This was calculated by taking the total number of birds per habitat type and dividing by the total number of minutes surveyed. Then this number is multiplied by 60 to get the number of birds per hour.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine species diversity by location and habitat type. This diversity index is a popular measure in ecology that is used to describe the species richness in a community. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1\ (p_i\ (\ln\ (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

Another useful measure is the Shannon's equitability estimate (E_H) (Shannon 1948) which is a measure of evenness in the population. This measures the evenness with which individuals are divided among the taxa present. This measure ranges from 0 to 1 where one represents a completely even community in which all species' abundances are equal. The Shannon's E_H is calculated using the following formula:

$E_H = H/\ln S$

Where S is species count, ln is the natural log, and *H* is the Shannon's diversity index.

To compare indices, a bootstrapping technique is used where two samples, A and B, are pooled. Then 1,000 random pairs of samples (Ai and Bi) are taken from this pool, with the same numbers of individuals as in the original two samples. For each replicate pair, the diversity indices div(Ai) and div(Bi) are computed. The number of times |div(Ai)-div(Bi)| exceeds or equals |div(A)-div(B)| indicates the probability that the observed difference could have occurred by random sampling from one parent population as estimated by the pooled sample. A small probability value less than 0.05 indicates a significant difference in the diversity index between the two samples. The diversity indices and the bootstrap comparisons between indices were completed using the PAST statistical software (Hammer et al. 2001).

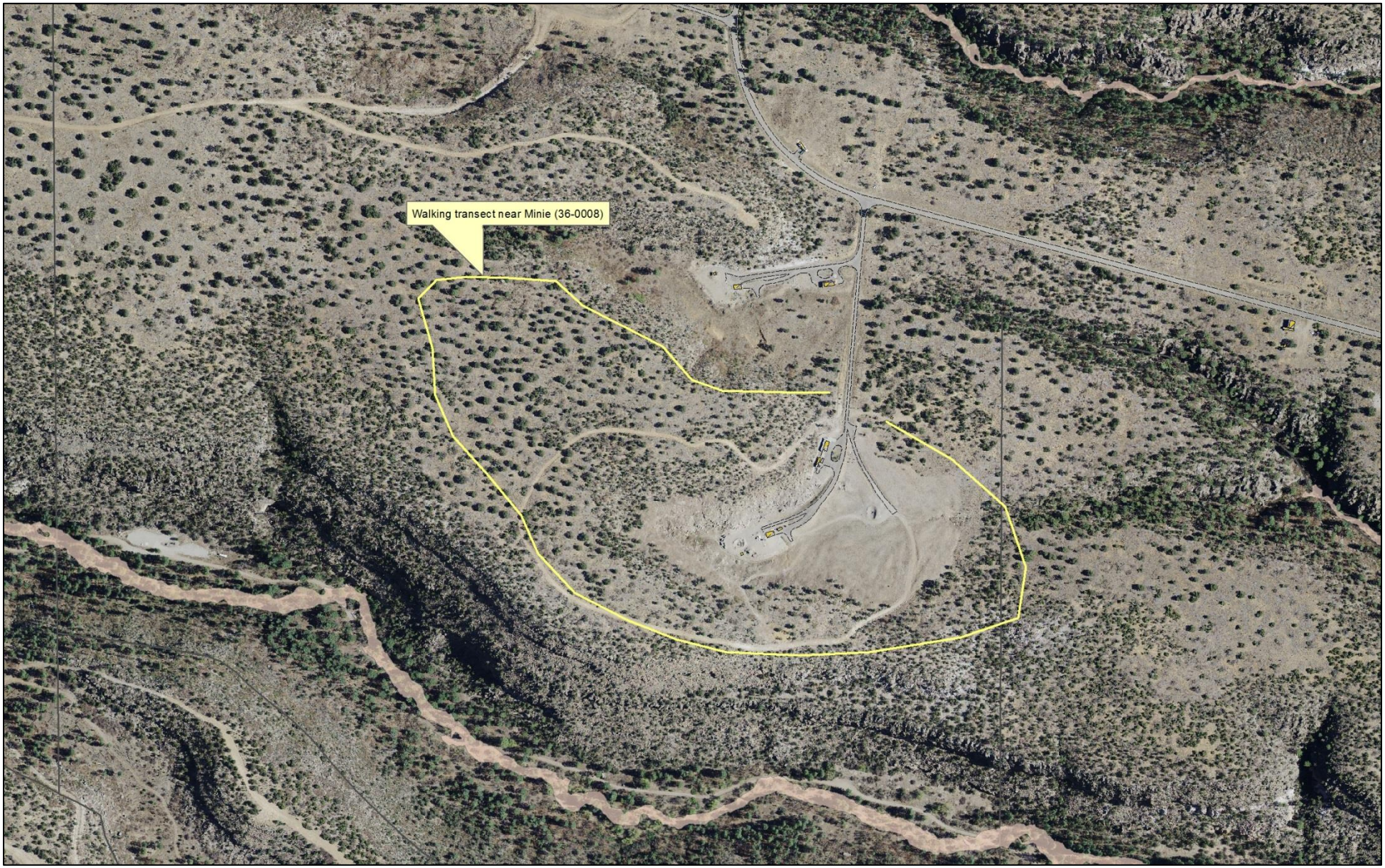

Figure 1. Field Working Map for the Transect Around the TA-36 Minie Site.

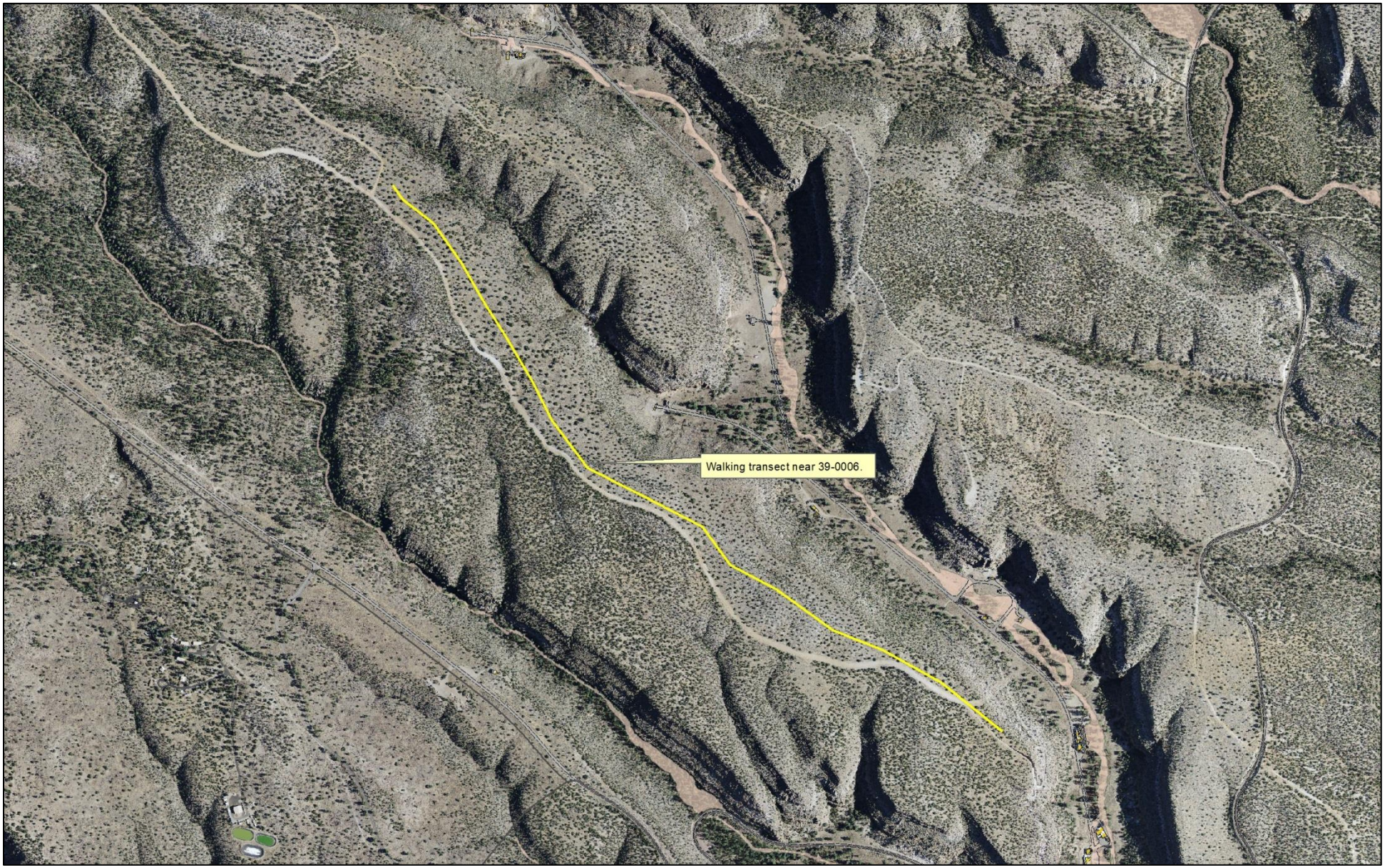

Figure 2. Field Working Map for the Transect Around the TA-39 Point 6.

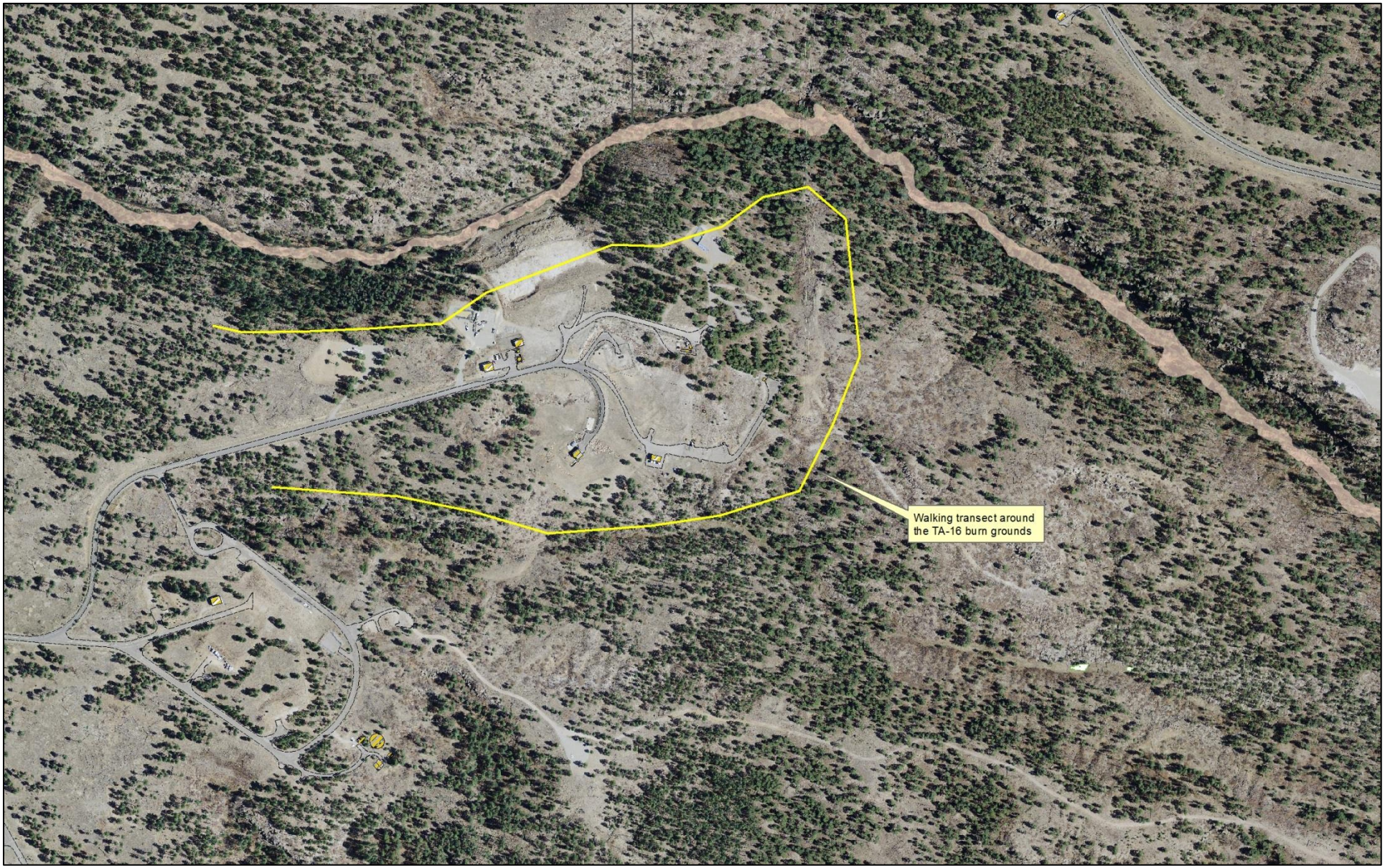

Figure3. Field Working Map for the Transect Around the TA-16 Burn Grounds.

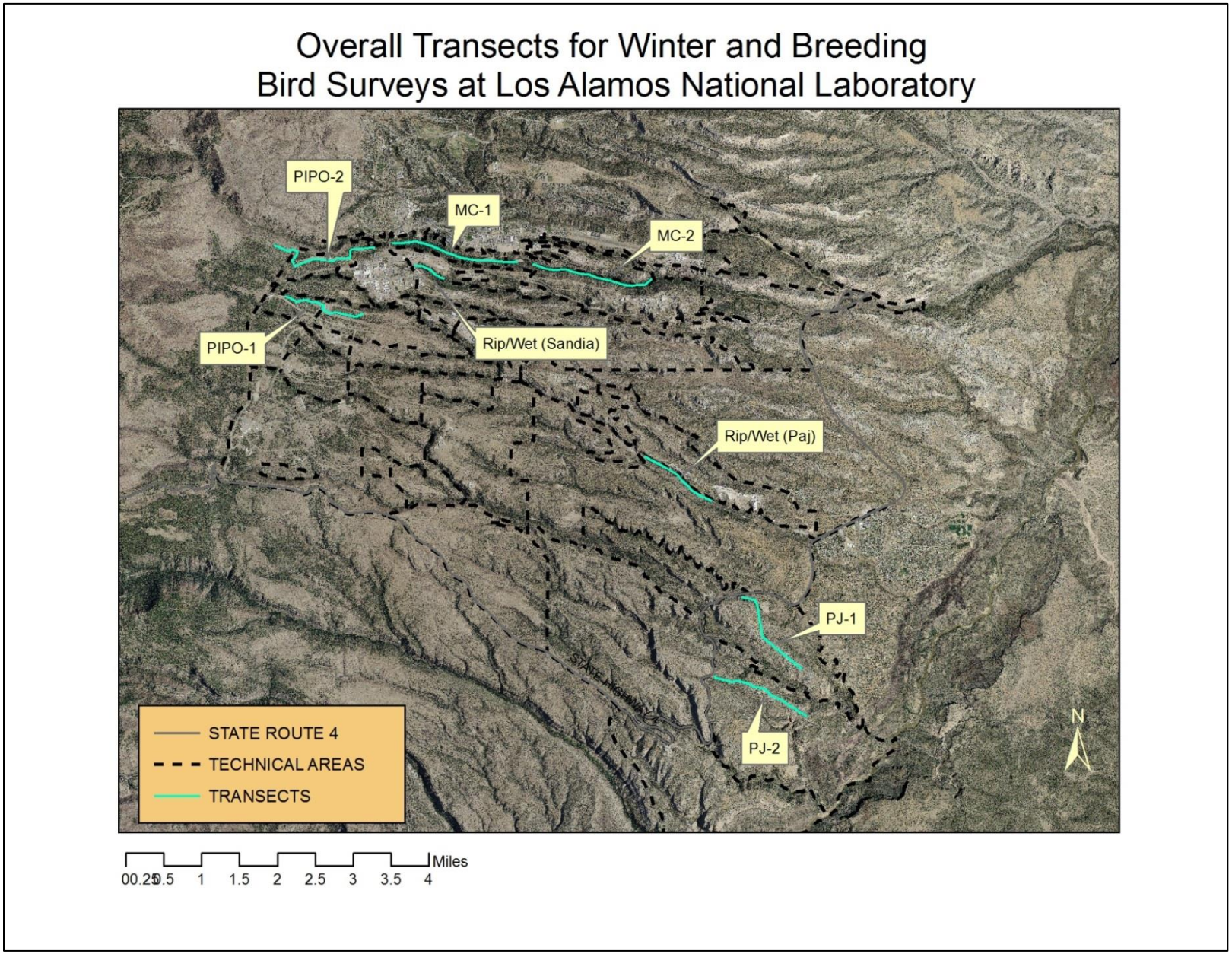

Figure 4. Control Transects from Ongoing Avian Monitoring Around LANL (Hathcock and Keller 2012). MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland, Rip/Wet: Riparian / Wetland.

Results and Discussion

Three surveys were completed at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Grounds between May and July 2013. A total of 590 birds representing 55 species were recorded. The ten most common species at these three sites were the House Finch, Spotted Towhee, Western Bluebird, Mourning Dove, Ash-throated Flycatcher, Pine Siskin, Western Wood-Pewee, Juniper Titmouse, Gray Flycatcher, and Plumbeous Vireo. A full account of the 2013 data is detailed in Table 1.

Table 1. Birds Recorded at the Three Study Sites in 2013.

Species Name	TA-36 Minie Site (PJ Habitat)	TA-16 Burn Grounds (MC Habitat)	TA-39 Point 6 (PJ Habitat)
Acorn Woodpecker		5	
American Kestrel			1
American Robin	1	7	1
Ash-throated Flycatcher	11	3	19
Audubon's Warbler		6	
Bewick's Wren	4		3
Black-chinned Hummingbird		1	3
Black-headed Grosbeak	1		
Black-throated Gray Warbler			5
Blue-gray Gnatcatcher	3		2
Broad-tailed Hummingbird	2	5	3
Brown Creeper		1	
Brown-headed Cowbird	1	4	
Bushtit			2
Canyon Towhee	2	1	1
Chipping Sparrow	3	1	6
Common Nighthawk	6		5
Common Raven	2	5	1
Cooper's Hawk		1	
Cordilleran Flycatcher		5	
Dark-eyed Junco		6	
Eurasian Collared-Dove	3		
Evening Grosbeak	3	5	
Grace's Warbler		6	
Gray Flycatcher	12		10
Great Horned Owl			1
Green-tailed Towhee	3		1
Hairy Woodpecker		1	

Hammond's Flycatcher		8	
House Finch	16	16	21
House Wren		1	
Juniper Titmouse	12		11
Lesser Goldfinch	2	3	4
Mountain Chickadee	5	5	
Mourning Dove	17	4	13
Pine Siskin	10	12	6
Plumbeous Vireo	10	11	1
Pygmy Nuthatch		11	
Red-shafted Flicker	3	3	3
Rock Wren	3	1	7
Say's Phoebe	2	1	2
Spotted Towhee	17	11	12
Steller's Jay		3	
Townsend's Solitaire	1		
Turkey Vulture		1	
Violet-green Swallow			6
Virginia's Warbler		17	
Warbling Vireo		2	
Western Bluebird	15	20	5
Western Kingbird	6		7
Western Scrub-Jay	5	1	8
Western Tanager		2	
Western Wood-Pewee	10	15	
White-breasted Nuthatch	1	9	
White-winged Dove	1		7
Grand Total	**193**	**220**	**177**

The bird surveys were analyzed to determine the "birds per hour", which is a measure of relative abundance, for each of the three study sites as well as the control sites of the comparable habitat type (Figure 5). The birds per hour were similar between the three study sites and the associated control sites. The TA-16 Burn Grounds site was slightly lower in bird per hour than the MC control sites, but not significantly lower ($t_{3,1}$=3.506, p = 0.07). Error bars were calculated for the control sites since multiple years of data were available. The birds per hour for the TA-16 Burn Grounds was within 2 standard deviations of the mean of the MC control sites (Figure 5). The TA-36 Minie Site and TA-39 Point 6 were very similar to the PJ control sites ($t_{3,1}$=0.717, p = 0.54 and $t_{3,1}$=1.274, p = 0.33).

As described in the next section, the diversity and evenness of the avian community at the TA-16 Burn Grounds were not significantly different than the MC control sites. One possible reason for the lower birds per hour measurement, albeit not significantly lower, at the TA-16 Burn Grounds

was related to the control sites that were used. Selecting a control site is one of the fundamental issues when designing an ecological study. In this study the control sites are based on previous and ongoing work at LANL, and the two control sites for the MC habitat are located along the bottom of Los Alamos Canyon. The birds per hour can be slightly different when MC on a mesa-top, such as the TA-16 Burn Grounds, is compared with similar habitat in the bottom of a canyon. There are also species of birds, such as the Common Raven, that are seen in high numbers in Los Alamos Canyon due to close proximity to the townsite.

The 2013 results indicate that the relative abundance of the bird communities at the three study sites were not significantly different than the control sites.

The Shannon's diversity indices are detailed in Table 2. The TA-16 Burn Grounds showed the largest diversity of bird species, which was expected since it is primarily MC habitat. A bootstrapping technique using 1,000 permutations was used to compare the diversity indices.

Compared to the control sites, the diversity and evenness of the TA-16 Burn Grounds were not significantly different than both the 2013 data ($p=0.53$ and 0.57) and the pooled data from 2011-2013 ($p=0.11$ and 0.17).

Compared to the control sites, the diversity of the TA-36 Minie Site was not significantly different than the 2013 data ($p=0.38$) and the pooled data ($p=0.66$). However, the evenness of the TA-36 Minie Site was significantly larger than the control sites for both the 2013 data as well as the pooled data ($p=0.001$ and 0.003).

Compared to the control sites, the diversity at TA-39 Point 6 was significantly larger than the 2013 data ($p=0.03$) and larger than the pooled data, but not significantly ($p=0.13$). The evenness of the TA-39 Point 6 was significantly larger than the control sites for both the 2013 data as well as the pooled data ($p=0.003$ and 0.017).

These results indicate that the bird diversity and evenness of the avian communities at the study sites are comparable to or greater than the control sites, with some being significantly greater. This indicates a healthy avian population at the study sites.

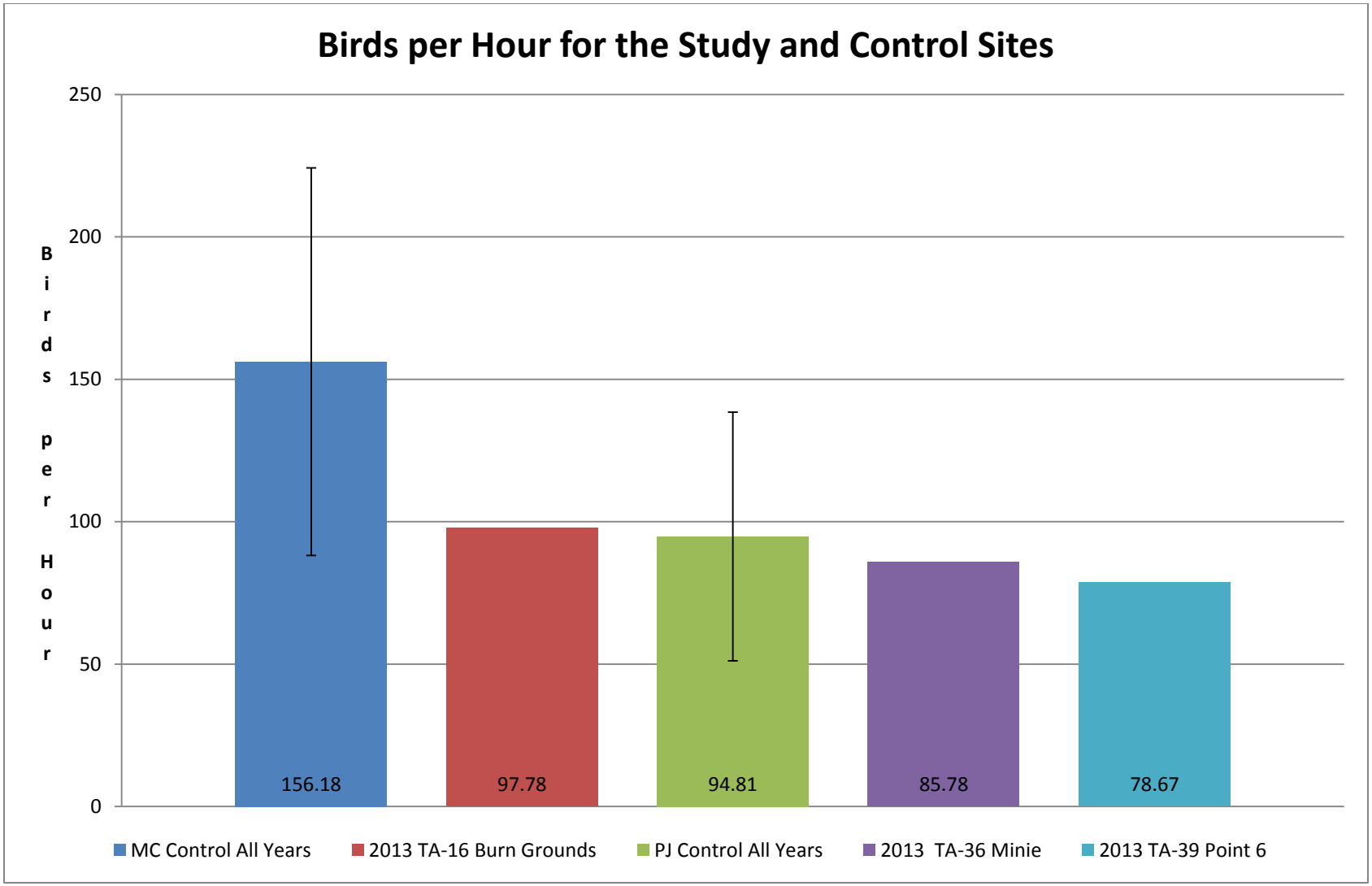

Figure 5. Birds per Hour for the Study and Control Sites. Error Bars are +/- 2 Standard Deviations. MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

Table 2. Shannon Values for the Study Sites and Control Sites; Statistically Significant Results are Bolded. MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

Transect Name	Diversity Index (H)	2013 PJ Control Sites Diversity Index (H)	All Years PJ Control Sites Diversity Index (H)	2013 MC Control Sites Diversity Index (H)	All Years MC Control Sites Diversity Index (H)
TA-36 Minie Site (PJ)	2.942	2.832	2.878		
TA-39 Point 6 (PJ)	3.09	**2.832 (p=0.03)**	2.878		
TA-16 Burn Grounds (MC)	3.304			3.383	3.501
Transect Name	Equitability Index (EH)	2013 PJ Control Sites Equitability Index (EH)	All Years PJ Control Sites Equitability Index (EH)	2013 MC Control Sites Equitability Index (EH)	All Years MC Control Sites Equitability Index (EH)
TA-36 Minie Site (PJ)	0.729	**0.5143 (p=0.001)**	**0.4805 (p=0.003)**		
TA-39 Point 6 (PJ)	0.709	**0.5143 (p=0.003)**	**0.4805 (p=0.017)**		
TA-16 Burn Grounds (MC)	0.6983			0.6269	0.6269

In addition to supporting federally protected species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for understanding migratory bird conservation. Of the 55 species detected at the three study sites, 54 are protected under the MBTA. Additionally, two of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980. Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three study sites are on the top 100 list. These two species are the Virginia's Warbler and Grace's Warbler.

Avian Nestbox Network

In 1997, an avian nestbox monitoring network was established on LANL, Los Alamos County land, and U.S. Forest Service land to investigate the health and condition of cavity-nesting bird populations on the Pajarito Plateau. The purpose of this study was to evaluate the magnitude and sources of ecological risks from contaminants and other environmental stressors for cavity-nesting birds at LANL. The main objective was to evaluate the ecological and physiological costs of exposure to various contaminants at LANL and their potential impact on population processes. In 2011, nestboxes were added to the TA-36 Minie Site and TA-39 Point 6 to investigate any potential impacts to cavity-nesting birds (Figures 6 and 7).

On Sept 17th 2012, the Environmental Protection Division received notification from the Waste Facilities Operations Facility Operations Director of potential fire suppression/tree removal activities near archaeological sites near the TA-36 Minie firing site. Nestboxes were removed from trees as part of the fuels mitigation activities. These nestboxes were replaced for the 2013 breeding season and monitoring resumed at TA-36 Minie Site for the summer breeding season. However, the habitat was significantly impacted in the area around TA-36 Minie Site by the removal of trees.

Due to the drought and the lower elevation of the nestboxes at TA-39 Point 6, no birds nested in the nestboxes in 2013. However, TA-36 Minie Site had two nests in the nestboxes in 2013. There was one Mountain Bluebird nest that hatched four eggs and one Western Bluebird nest that presumably hatched and fledged nestlings. Due to the extreme drought conditions in 2013, field work was under fire restrictions and nestboxes were not checked until July 1st, thus all baseline monitoring measurements were not collected. Due to the small sample size, no statistical comparisons can be made at this time to the over 500 nestboxes located throughout LANL and the Pajarito Plateau. However, due to the dry summer of 2013, most locations in the avian nestbox network had a decrease in hatching and fledgling success. For example, the percent of eggs hatched in 2013 was 68.12% compared to all previous years hatching success of 77-95%. Fledgling success was 67.55%, which in our study is highly dependent on elevation of the location. However, there are not noticeable differences in the four nests total that have hatched in the last two years at the TA-36 Minie Site, with a 100% hatch and fledge rate.

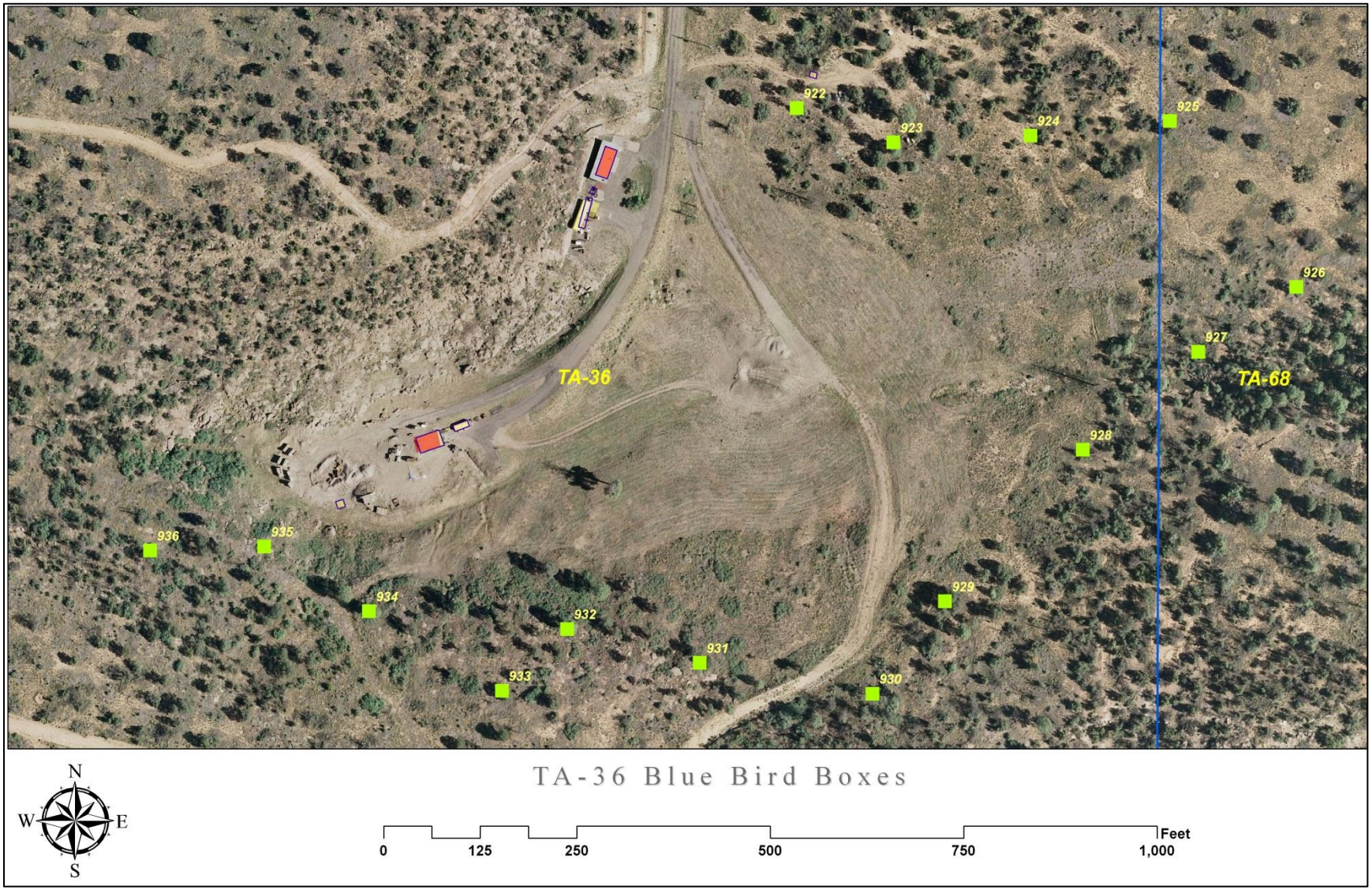

Figure 6. Avian Nestboxes Located at TA-36 Minie Site.

Figure 7. Avian Nestboxes Located at TA-39 Point 6.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the MBTA, and allow LANL to contribute to national goals in avian conservation monitoring and research.

Acknowledgments

We'd like to thank Leslie Hansen, David Keller, Hallie Mahowald, and Luciana Vigil-Holterman for comments on earlier versions of this report and Anne Jacobs, Maria Musgrave, Audrey Smith, and Kari Schoenberg for field help during this project.

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Revised Supplement 4-1
Alt Tech Evaluation
Attachment 6 – Hathcock 2014

Environmental Report:

Hathcock, C.D., October 2014. *Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory*. LA-UR-14-28161.

October 2014

Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory

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Results from 2014 indicate that the avian abundance and diversity at the three study sites were comparable to or significantly greater than that of the control sites. Continued monitoring will produce trends over time in avian abundance and diversity that can be compared to local, regional, and national data.

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LANS biologists used standard point count methodology to record avian density and diversity along transects in the three study sites and associated control sites during the summer of 2014. Summer surveys provide information about what migratory birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with regional and national trends in bird populations. They also can be correlated to changes in the natural environment at LANL.

Methods

Field Methods

Point count surveys along a transect were chosen as the most rigorous method to monitor patterns of bird abundance and richness in habitats found at two open detonation sites and one

open burning site at LANL. This method is already used at other LANL locations for long-term monitoring. The surveys were conducted along transects in the forested, undeveloped land surrounding the study sites (Figures 1–3). The habitat types around the sites are pinyon-juniper woodland (PJ) for the sites at TA-36 and TA-39 and mixed conifer forest (MC) for the site at TA-16. These habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study sites were compared to control sites at LANL. The control sites (Figure 4) are monitored annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock and Keller (2012). The PJ study sites at TA-36 and TA-39 are similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at the TA-16 Burn Ground is similar in elevation and overstory vegetation to the MC control sites, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon in TA-43, TA-2, and TA-21. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present at the control sites.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1st through August 15. Ideally the breeding bird surveys should take place the second week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

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The data were summarized to look at trends in avian abundance and diversity for the three study sites and the control sites. To compare relative abundances between years and sites, the "birds per hour" was calculated for each site. This was calculated by taking the total number of birds detected per survey and dividing by the total number of minutes surveyed. The result is multiplied by 60 to get the number of birds per hour.

The means of the study sites and control sites were compared using the Mann-Whitney U non-parametric two sample test. The data were not normally distributed thus the non-parametric test was used. Probability levels at 0.05 or less were considered significant.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine avian community diversity by location and habitat type. This diversity index is a popular measure in ecology. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1\ (p_i\ (\ln\ (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

Another useful measure is the Shannon's equitability estimate (E_H) (Shannon 1948) which is a measure of evenness in the population. This measures the evenness with which individuals are divided among the taxa present. This measure ranges from 0 to 1 where one represents a completely even community in which all species' abundances are equal. The Shannon's E_H is calculated using the following formula:

$E_H = H/\ln S$

Where S is species count, ln is the natural log, and *H* is the Shannon's diversity index.

To compare indices, a bootstrapping technique was used and probability levels at 0.05 or less were considered significant. A general description of the technique is where two samples, A and B, are pooled. Then 1,000 random pairs of samples (Ai and Bi) are taken from this pool, with the same numbers of individuals as in the original two samples. For each replicate pair, the diversity indices div(Ai) and div(Bi) are computed. The number of times |div(Ai)-div(Bi)| exceeds or equals |div(A)-div(B)| indicates the probability that the observed difference could have occurred by random sampling from one parent population as estimated by the pooled sample. A small probability value less than 0.05 indicates a significant difference in the diversity index between the two samples. The diversity indices and the bootstrap comparisons between indices were computed using the PAST statistical software (Hammer et al. 2001).

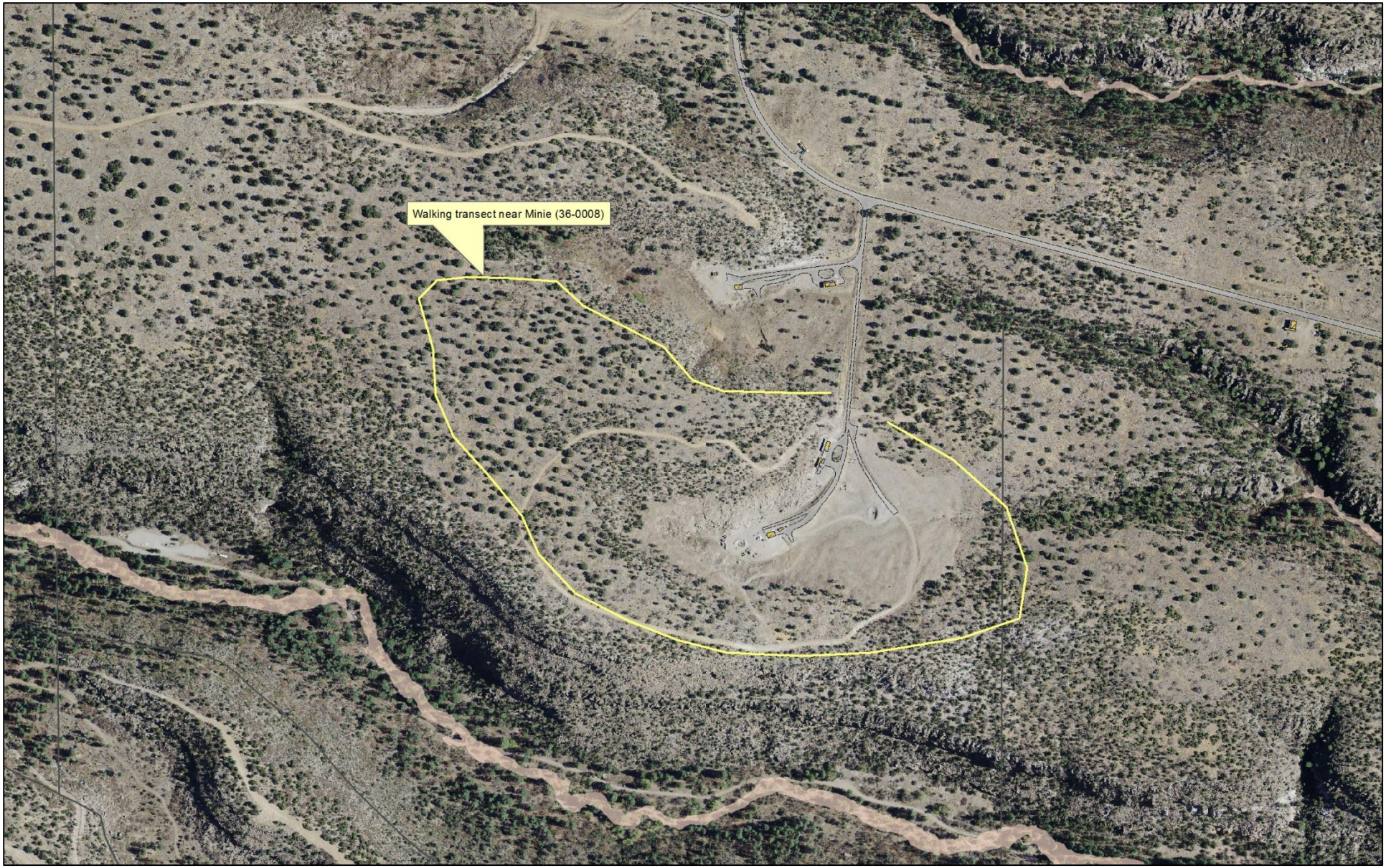

Figure 1. Field working map for the transect around the TA-36 Minie Site.

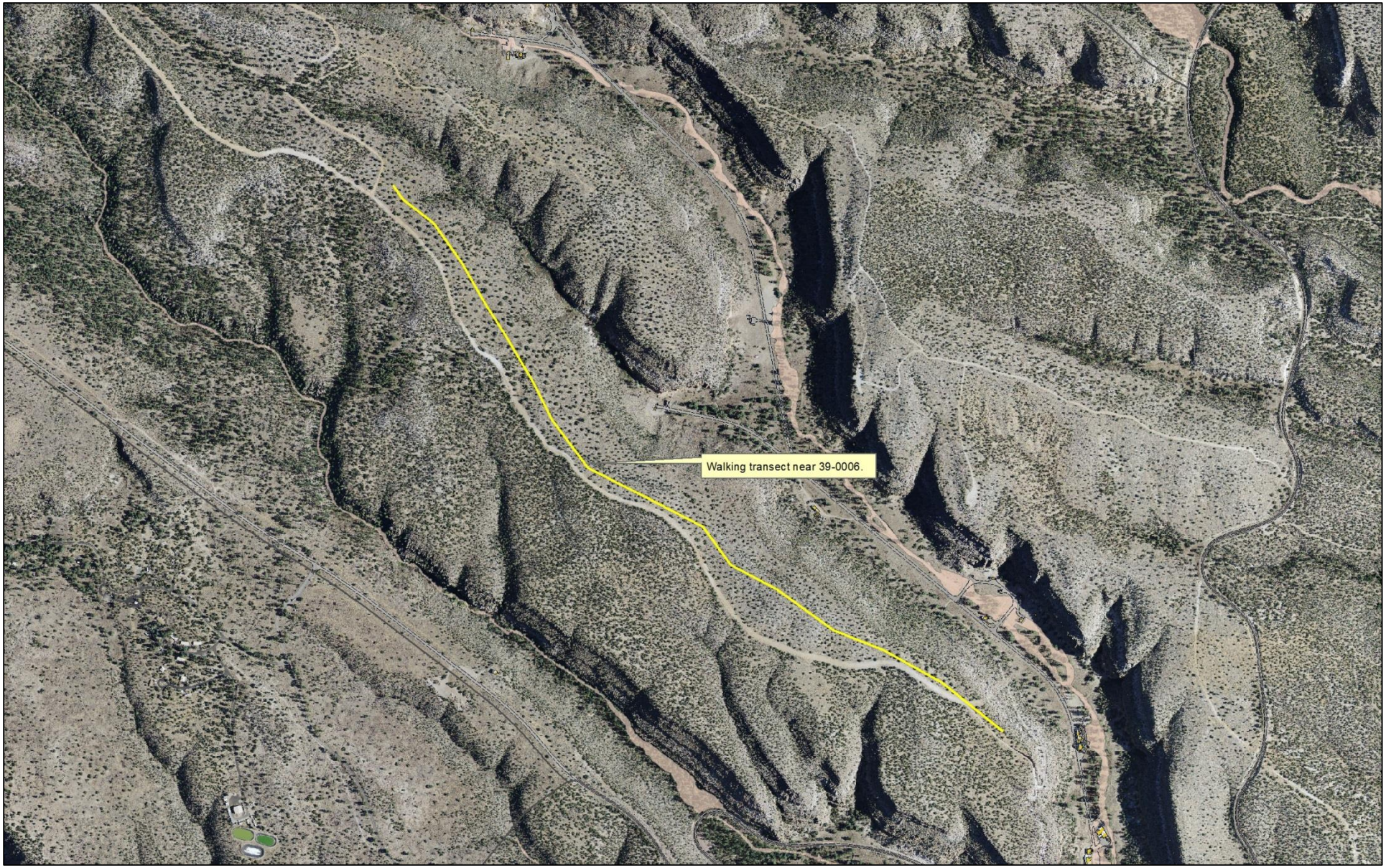

Figure 2. Field working map for the transect around the TA-39 Point 6.

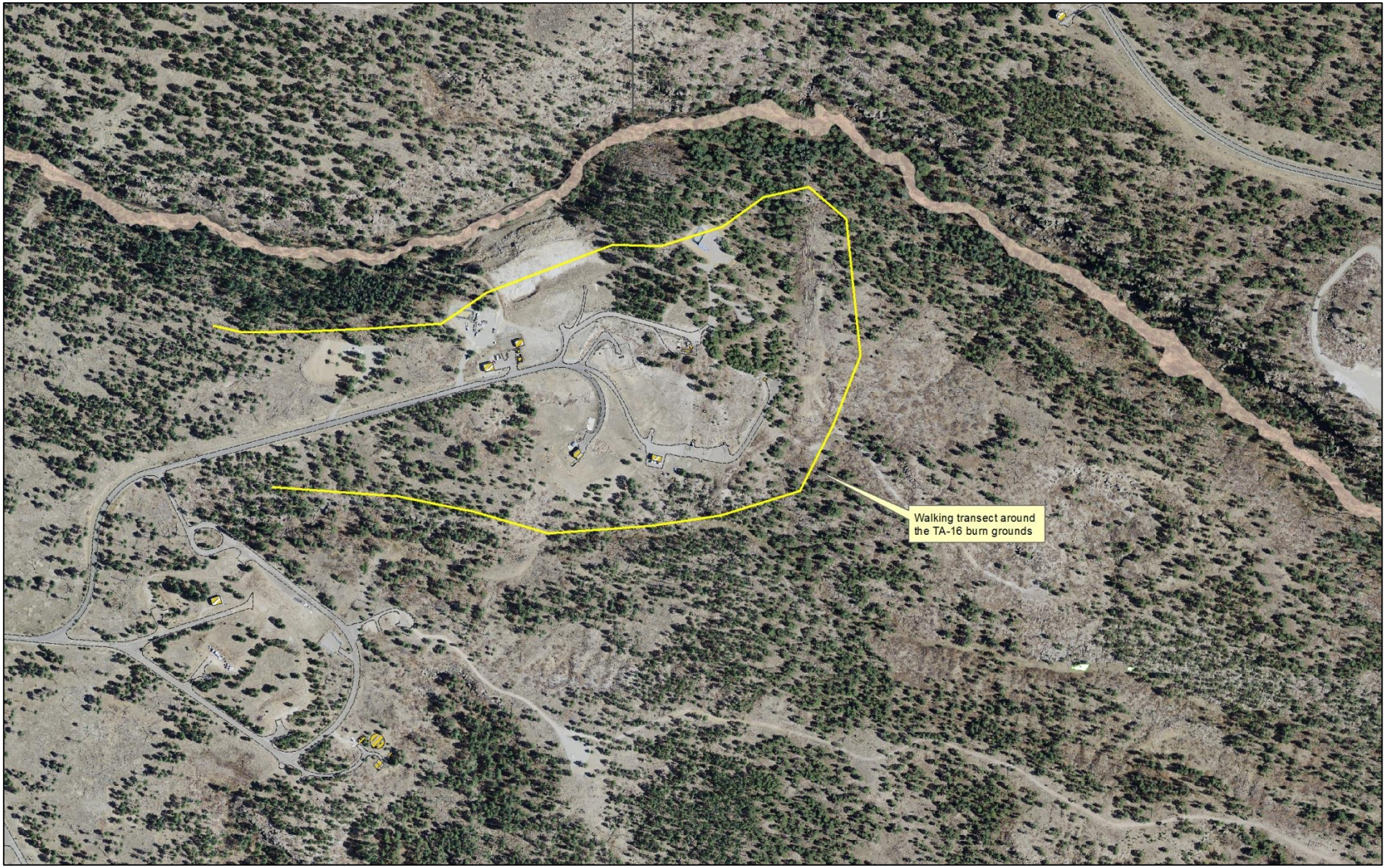

Figure3. Field working map for the transect around the TA-16 Burn Ground.

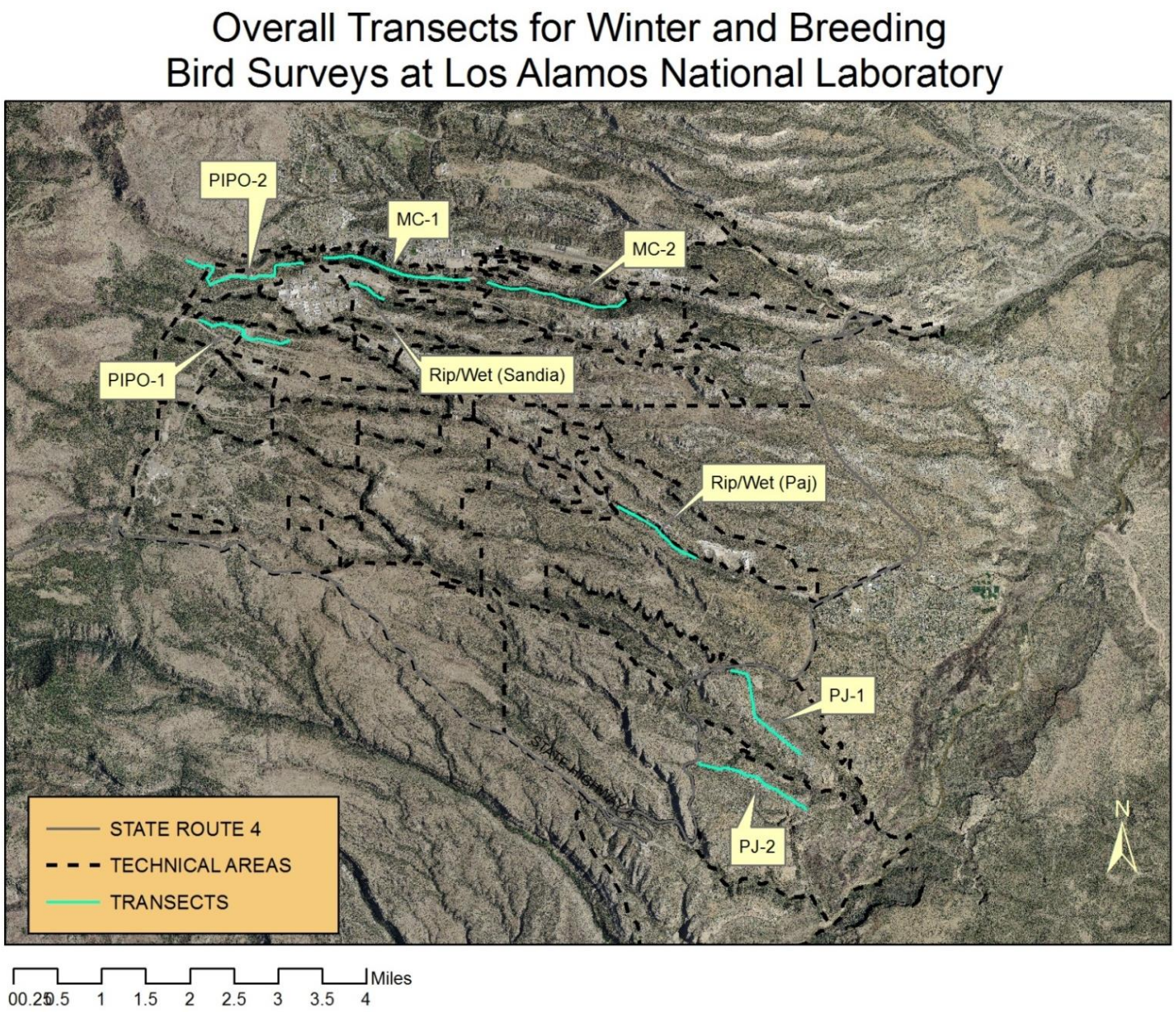

Figure 4. Control transects from ongoing avian monitoring around LANL (Hathcock and Keller 2012).
MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland, Rip/Wet: Riparian / Wetland.

Results and Discussion

Three surveys were completed at each of the three study sites and the associated control sites between May and July 2014. A total of 588 birds representing 54 species were recorded at the three study sites. A full account of the 2013–2014 data is detailed in Table 1.

The bird surveys were analyzed to determine the birds per hour, which is a measure of relative abundance, for each of the three study sites as well as the control sites of the comparable habitat type (Figure 5). The mean birds per hour at the TA-16 Burn Ground site was slightly lower than the MC control sites, but not significantly lower (Mann-Whitney U: Z = -1.0371, p = 0.30). The TA-36 Minie Site and TA-39 Point 6 birds per hour means were slightly higher that the PJ control sites, but not significantly higher (Mann-Whitney U: Z = 0.7913, p = 0.43 and Z = 1.0787, p = 0.28). The mean values with error bars corresponding to +/- 1 standard deviation for both years are represented in Figure 5. The 2014 results indicate that the relative abundance of the bird communities at the three study sites was not significantly different than the control sites.

In the first year of the study, the mean birds per hour at the TA-16 Burn Ground was significantly lower than the MC Control sites (Mann-Whitney U: Z = -2.2132, p = .026), but the difference lessened and was no longer significant in 2014. The mean birds per hour at the TA-16 Burn Ground were similar between years, but the control site numbers dropped in 2014.

The Shannon's diversity indices are detailed in Table 2. The TA-16 Burn Ground showed the largest diversity of bird species, which was expected since it is primarily MC habitat, which is known to be more diverse than PJ from past studies (Hathcock and Keller 2012).

Compared to the MC control sites, the diversity and evenness of the TA-16 Burn Ground were not significantly different (p=0.24 and 0.26).

Compared to the PJ control sites, the diversity of the TA-36 Minie Site was not significantly different (p=0.15); however, the evenness of the TA-36 Minie Site was significantly larger than the PJ control sites (p=0.024).

Compared to the PJ control sites, the diversity at TA-39 Point 6 was not significantly different (p=0.38); however, the evenness of the TA-39 Point 6 was significantly larger than the PJ control sites (p=0.12).

These results indicate that the bird diversity and evenness of the avian communities at the study sites are comparable to or greater than the control sites, with some being significantly greater. This suggests a healthy avian population at the study sites.

Table 1. Birds Recorded at the Three Study Sites in 2013–2014

Species	2013	2014	2013	2014	2013	2014
	TA-36	TA-36	TA-39	TA-39	TA-16	TA-16
	Pinyon-Juniper Woodland		Pinyon-Juniper Woodland		Mixed Conifer Forest	
Acorn Woodpecker					5	
American Kestrel			1			
American Robin	1	1	1	1	7	
Ash-throated Flycatcher	11	5	19	11	3	5
Audubon's Warbler		2			6	5
Bewick's Wren	4	8	3	10		
Black-chinned Hummingbird		1	3	2	1	
Black-headed Grosbeak	1	3		2		
Black-throated Gray Warbler			5	6		
Blue-gray Gnatcatcher	3	14	2			6
Broad-tailed Hummingbird	2	1	3	1	5	11
Brown Creeper					1	
Brown-headed Cowbird	1				4	1
Bushtit		2	2	14		
Canyon Towhee	2		1	1	1	
Chipping Sparrow	3	16	6	6	1	5
Clark's Nutcracker						4
Common Nighthawk	6		5	1		
Common Raven	2	5	1		5	6
Cooper's Hawk					1	
Cordilleran Flycatcher					5	10
Dark-eyed Junco					6	2
Downy Woodpecker						1
Eurasian Collared-Dove	3					
Evening Grosbeak	3				5	
Grace's Warbler					6	4
Great Horned Owl		3	1			
Green-tailed Towhee	3	1	1			
Hairy Woodpecker					1	1
Hammond's Flycatcher					8	9
Hermit Thrush						4
House Finch	16	17	21	4	16	2

Species	2013 TA-36 Pinyon-Juniper Woodland	2014 TA-36 Pinyon-Juniper Woodland	2013 TA-39 Pinyon-Juniper Woodland	2014 TA-39 Pinyon-Juniper Woodland	2013 TA-16 Mixed Conifer Forest	2014 TA-16 Mixed Conifer Forest
House Wren					1	1
Juniper Titmouse	12		11	13		
Lesser Goldfinch	2	6	4	12	3	
Mountain Bluebird		2		4		
Mountain Chickadee	5	2			5	8
Mourning Dove	17	17	13	22	4	
Northern Mockingbird				1		
Pine Siskin	10	2	6		12	4
Plumbeous Vireo	10	10	1		11	16
Pygmy Nuthatch					11	13
Red Crossbill				2		2
Red-shafted Flicker	3	1	3	2	3	4
Rock Wren	3	3	7	10	1	2
Say's Phoebe	2	1	2	1	1	
Spotted Towhee	17	8	12	6	11	18
Steller's Jay					3	2
Townsend's Solitaire	1					
Turkey Vulture					1	
Violet-green Swallow		5	6	4		2
Virginia's Warbler					17	11
Warbling Vireo					2	9
Western Bluebird	15	11	5	19	20	20
Western Kingbird	6	13	7	6		
Western Scrub-Jay	5	1	8	10	1	
Western Tanager		2		2	2	3
Western Wood-Pewee	10	8		4	15	10
White-breasted Nuthatch	1	4			9	8
White-throated Swift				1		
White-winged Dove	1	5	7	5		
Grand Total	193	186	177	193	220	209

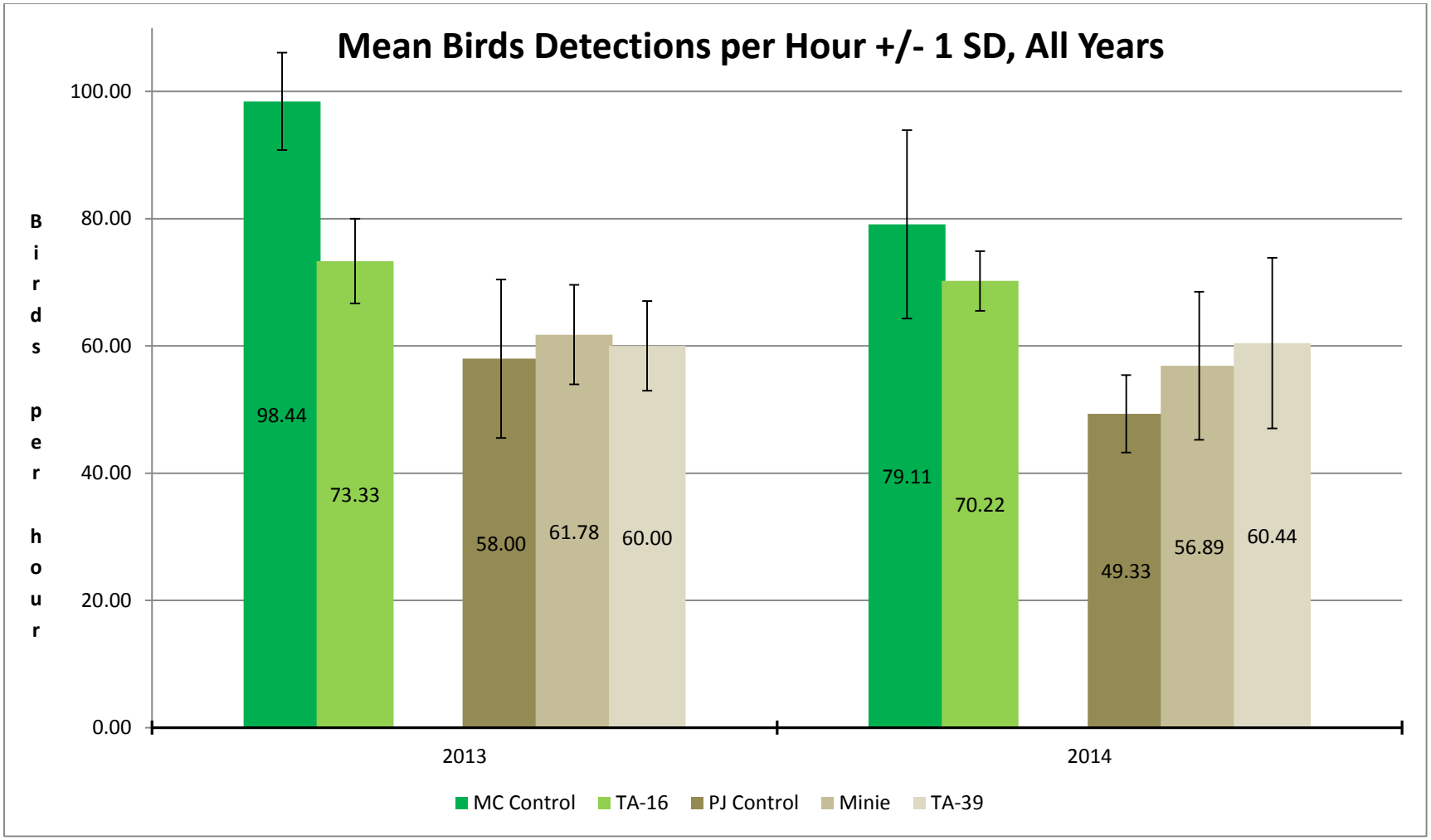

Figure 5. Birds per hour for the study and control sites. Error bars are +/- 1 standard deviation.
MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

Table 2. Shannon Values for the Study Sites and Control Sites; Statistically Significant Results are Bolded.

Transect Name	Diversity Index (H)	2014 PJ Control Sites Diversity Index (H)	2014 MC Control Sites Diversity Index (H)
TA-36 Minie Site (PJ)	3.141	2.99	
TA-39 Point 6 (PJ)	3.073	2.99	
TA-16 Burn Ground (MC)	3.207		3.327
Transect Name	Equitability Index (EH)	2014 PJ Control Sites Equitability Index (EH)	2014 MC Control Sites Equitability Index (EH)
TA-36 Minie Site (PJ)	**0.7009 (p=0.024)**	0.5525	
TA-39 Point 6 (PJ)	**0.6967 (p=0.012)**	0.5525	
TA-16 Burn Ground (MC)	0.679		0.7487

MC: Mixed Conifer Forest, PJ: Pinyon-Juniper Woodland.

In addition to supporting federally protected species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 54 species detected at the three study sites, all but one are protected under the MBTA. Additionally, three of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those three species are the Pinyon Jay, Juniper Titmouse, and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980. Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Three species detected at the three study sites are on the top 100 list. These three species are the Pinyon Jay, Virginia's Warbler, and Grace's Warbler.

Avian Nestbox Network

In 1997, an avian nestbox monitoring network was established on LANL, County of Los Alamos land, and U.S. Forest Service land to investigate the health and condition of cavity-nesting bird populations on the Pajarito Plateau. The purpose of this study was to evaluate the magnitude and sources of ecological risks from past LANL releases and other environmental stressors for cavity-nesting birds. The main objective was to evaluate the ecological and physiological costs of exposure to various constituents at LANL and their potential impact on population processes. In 2011, nestboxes were added to the TA-36 Minie Site and TA-39 Point 6 to investigate any potential impacts to cavity-nesting birds (Figures 6 and 7). Only data from the target species are reported herein, Western and Mountain Bluebirds and the Ash-throated Flycatcher.

During the 2014 nesting season, 15 nestboxes at TA-36 and 12 nestboxes at TA-39 were actively monitored. At TA-36, 10 nests were found and 4 of the nests fledged young successfully. This was an occupancy rate of 66% with a 40% success rate. Two of the nests were inhabited by Mountain Bluebirds and the other eight nests were inhabited by Western Bluebirds.

At TA-39, two nests were found and one of the nests fledged young successfully. This was an occupancy rate of 16%. One nest was inhabited by a Western Bluebird and the other was inhabited by an Ash-throated Flycatcher. Nearby nestboxes in lower Ancho Canyon also had low occupancy rates.

The overall avian nestbox network had 627 nestboxes in 2014 that were actively monitored. There were 126 active nests found and 87 of those nests fledged young successfully. This was an overall occupancy rate of 20% with a 69% success rate.

The occupancy and success rates at TA-36 were similar to the results in the overall network. More years of data are needed to begin to look at the results in a more robust manner.

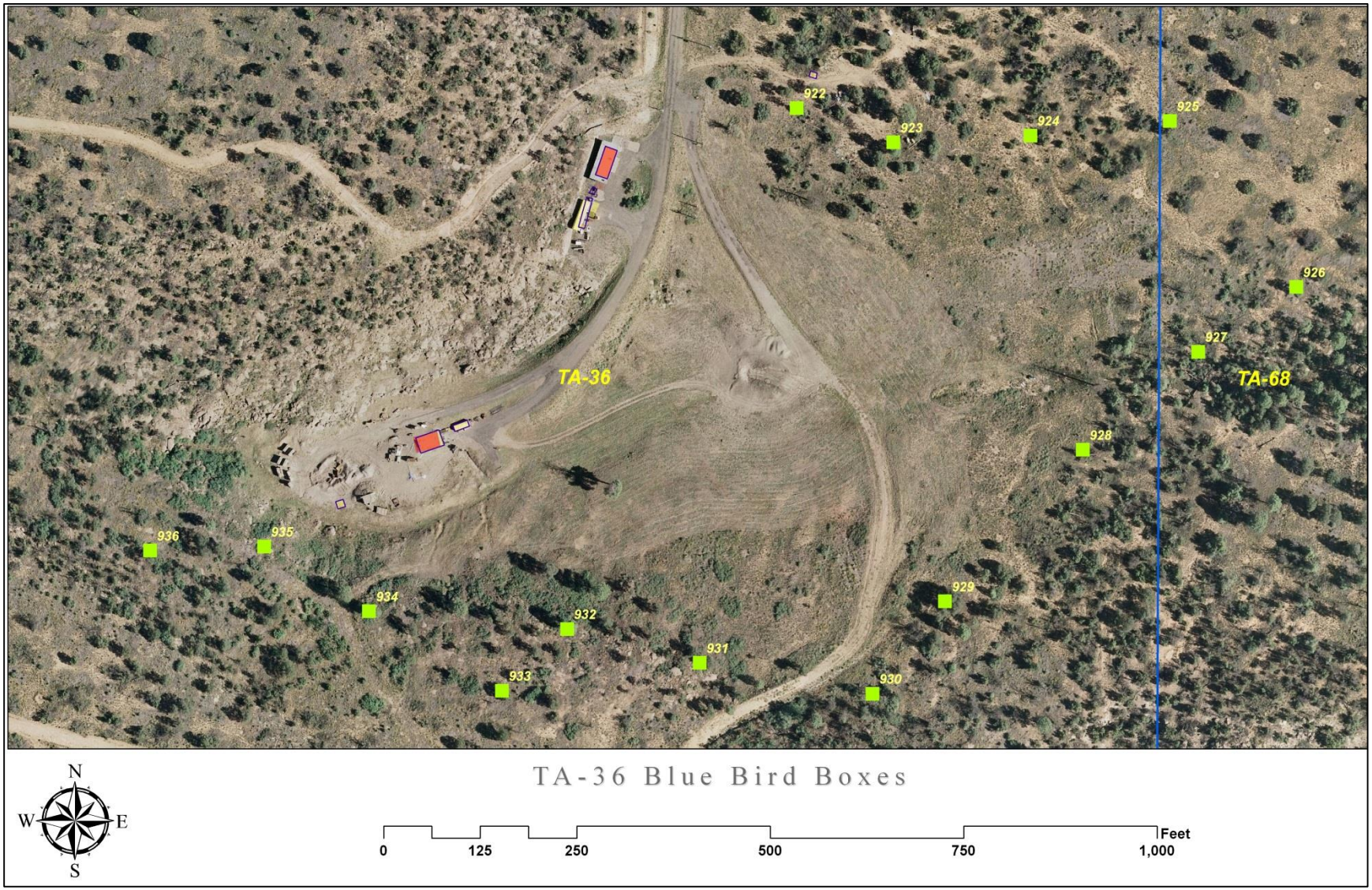

Figure 6. Avian nestboxes located at TA-36 Minie Site.

Figure 7. Avian nestboxes located at TA-39 Point 6.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the MBTA, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Attachment 7 – Hathcock 2015

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October 2015

Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY
EST. 1943

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Prepared for: U.S. Department of Energy, National Nuclear Security Administration,
Los Alamos Field Office

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna at two open detonation sites and one open burn site at LANL. Results from these efforts are compared among years and to avifauna monitoring conducted at other areas across LANL. The objectives of this study are to determine whether LANL firing site operations impact bird abundance or diversity. LANS biologists completed the third year of this effort in 2015.

Three avian point count surveys were completed at each of the study sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2015. A total of 881 birds representing 55 species were recorded at the study sites. All of the 55 species detected at the three study sites are protected under the Migratory Bird Treaty Act (MBTA). Three avian point count surveys were also completed at each of the control sites between May and July 2015.

The data were analyzed to determine abundance using an estimate of birds detected per hour, and to calculate the species diversity. The number of birds detected in three different feeding guilds were compared to examine functional community differences among areas.

Results from 2015 monitoring indicate a general increase in bird abundance across LANL. This is likely indicative of effects from greater precipitation in the winter of 2014 into the spring and early summer of 2015. Precipitation drives habitat suitability which can potentially drive animal populations using the addition resources. The link between moisture and habitat quality for a migratory bird indicates that the availability of high-quality habitats is dynamic due to variation in precipitation among seasons and years (Smith et al. 2010). There were no significant differences in bird abundance when comparing the three study sites to their respective controls. The species diversity indices at Minie site and TA-39 were not significantly different than their controls in 2015. The TA-16 burn ground bird diversity was significantly lower ($p < 0.01$) than its mixed conifer (MC) control, with 12 fewer species present. Also, there were no significant differences in the mean number of birds per feeding guild when comparing the three study sites to their respective controls in 2015.

In addition to avian point counts, nestboxes were monitored around all three study sites. These data are compared to the avian nestbox monitoring network, which was established in 1997 to investigate the occupancy rates and reproductive success of cavity-nesting bird populations. In 2015 there was an overall occupancy rate of 40% with a 66% success rate for the avian nestbox network at LANL. The percent occupancy and nest success were higher at both Minie site and TA-16, suggesting that the firing site operations are not negatively affecting nest success. Further study is needed at TA-39 because only one of 12 nestboxes at TA-39 was occupied. There may be an issue with nestbox placement at TA-39 and this issue will be investigated further in 2016. Continued monitoring will produce data that can be compared to local, regional, and national trends over time.

Introduction

As part of the Resource Conservation and Recovery Act permitting process at LANL for two open detonation sites (TA-36 Minie site and TA-39 point 6), and one open burn site, (TA-16 burn ground), an avian monitoring program was started at these locations in 2013 (Hathcock and Fair 2013). The goal is to compare avian abundance, diversity, and productivity at these sites to other locations at LANL of the same habitat type. Comparisons are made to control sites that have been surveyed since 2011 (Hathcock et al. 2011).

LANS biologists used standard point count methodology to record avian abundance and diversity along transects at the three study sites and associated control sites during the summer of 2015. Summer surveys provide information about what birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with regional and national trends in bird populations. They also can be correlated to changes in the natural environment at LANL.

In addition to avian point counts, nestboxes are monitored around all three study sites to investigate any potential impacts to occupancy rates and productivity of cavity-nesting birds. These data are compared to the LANL avian nestbox monitoring network, which was established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the study sites (Figures 1–3). The habitat types around the sites are pinyon-juniper (PJ) for the sites at TA-36 and TA-39 and MC at TA-16. These habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study sites were compared to control sites at LANL of the same habitat type. The control sites (Figure 4) are monitored annually in ongoing surveys that have been conducted at LANL since 2010 as described in Hathcock et al. (2011). Each habitat type control contains two replicate transects that are monitored in the same way as the study sites with the same number of points and during the same time periods. In each survey month, all study site and control site transects are randomized and surveyed following the random order.

The PJ study sites at TA-36 and TA-39 are similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at the TA-16 burn ground is similar in elevation and overstory vegetation to the MC control sites, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon in TA-43, TA-2, and TA-21. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present at the control sites.

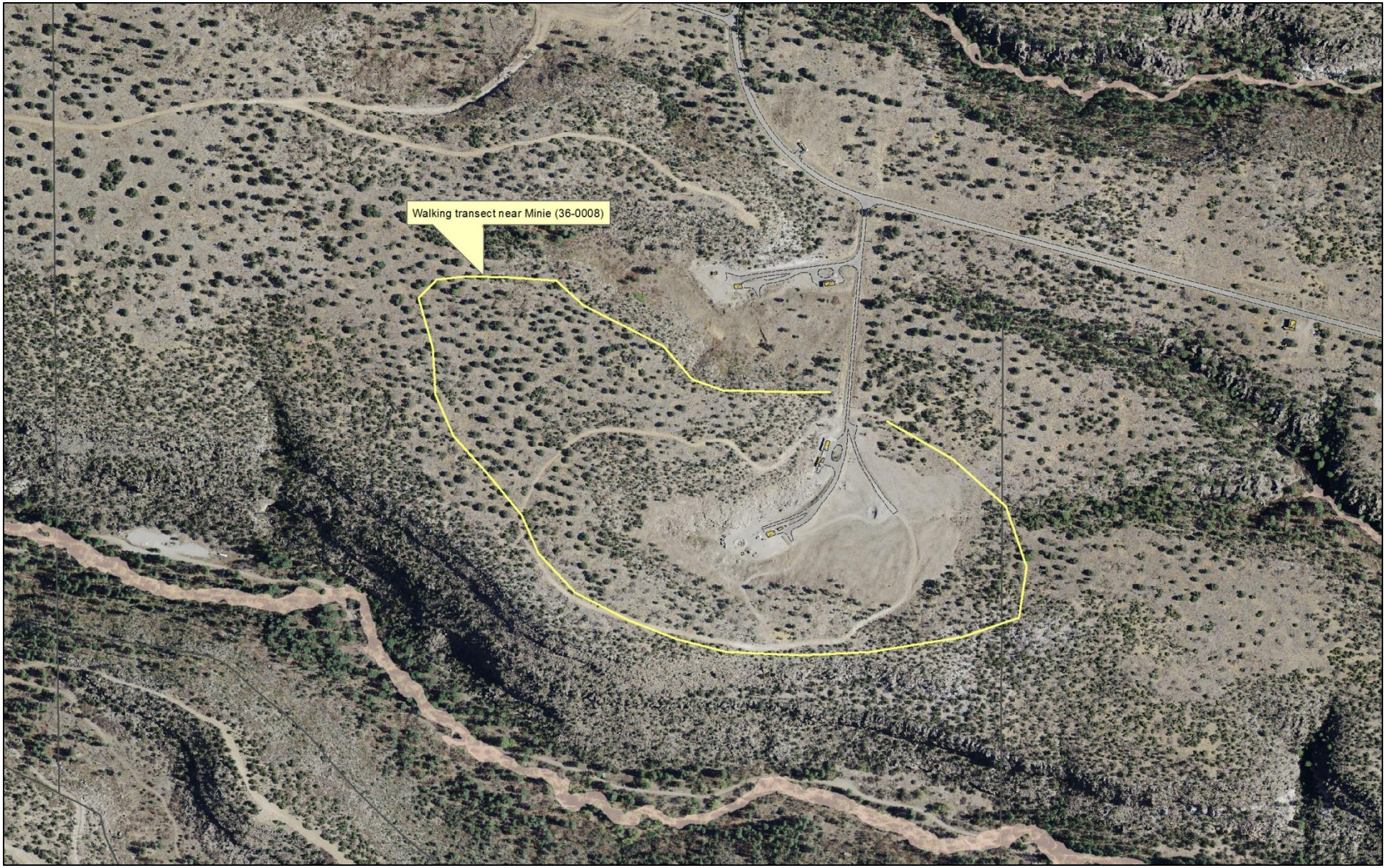

Figure 1. Field working map for the breeding bird survey transect around the TA-36 Minie site.

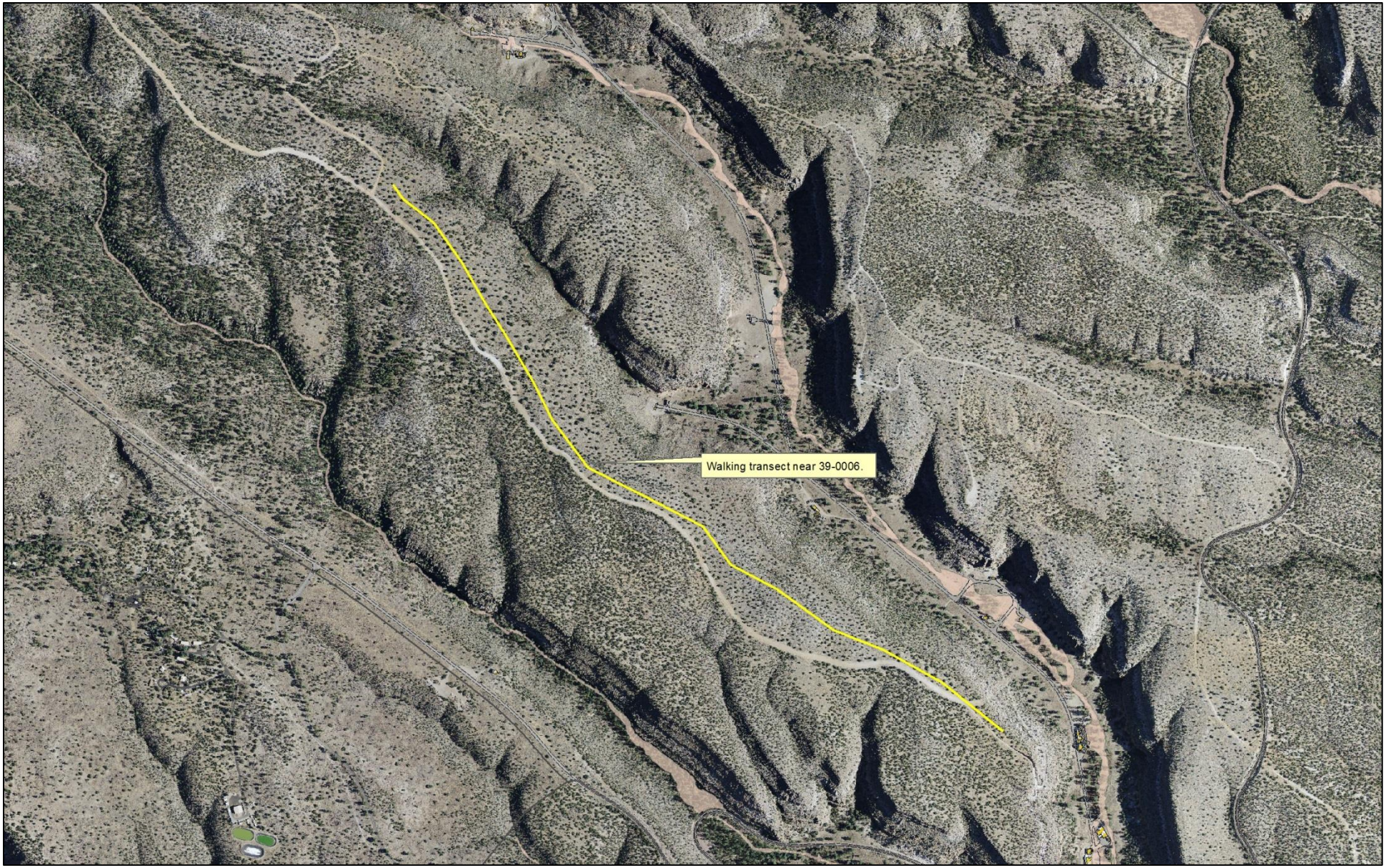

Figure 2. Field working map for the breeding bird survey transect around the TA-39 point 6.

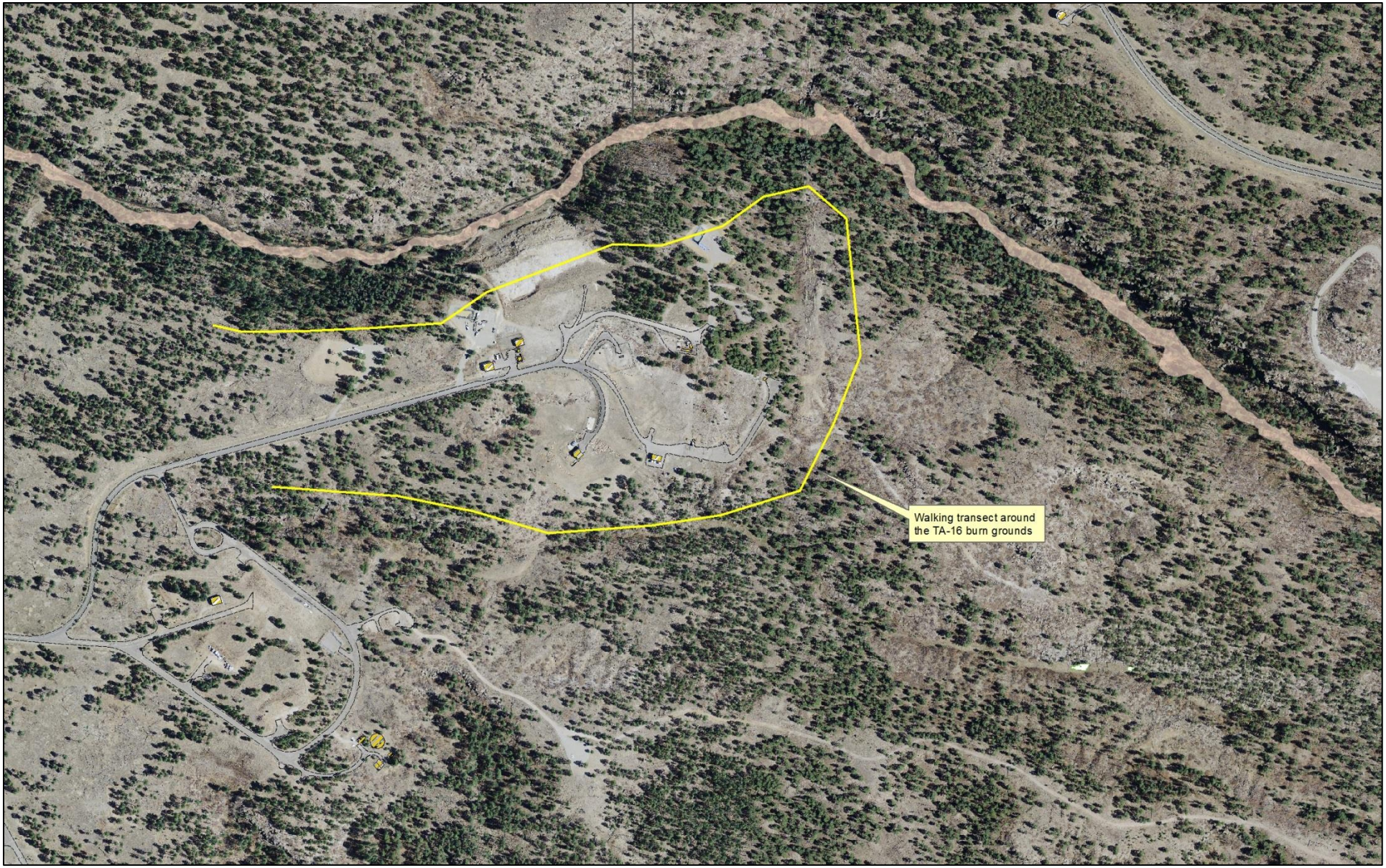

Figure 3. Field working map for the breeding bird survey transect around the TA-16 burn ground.

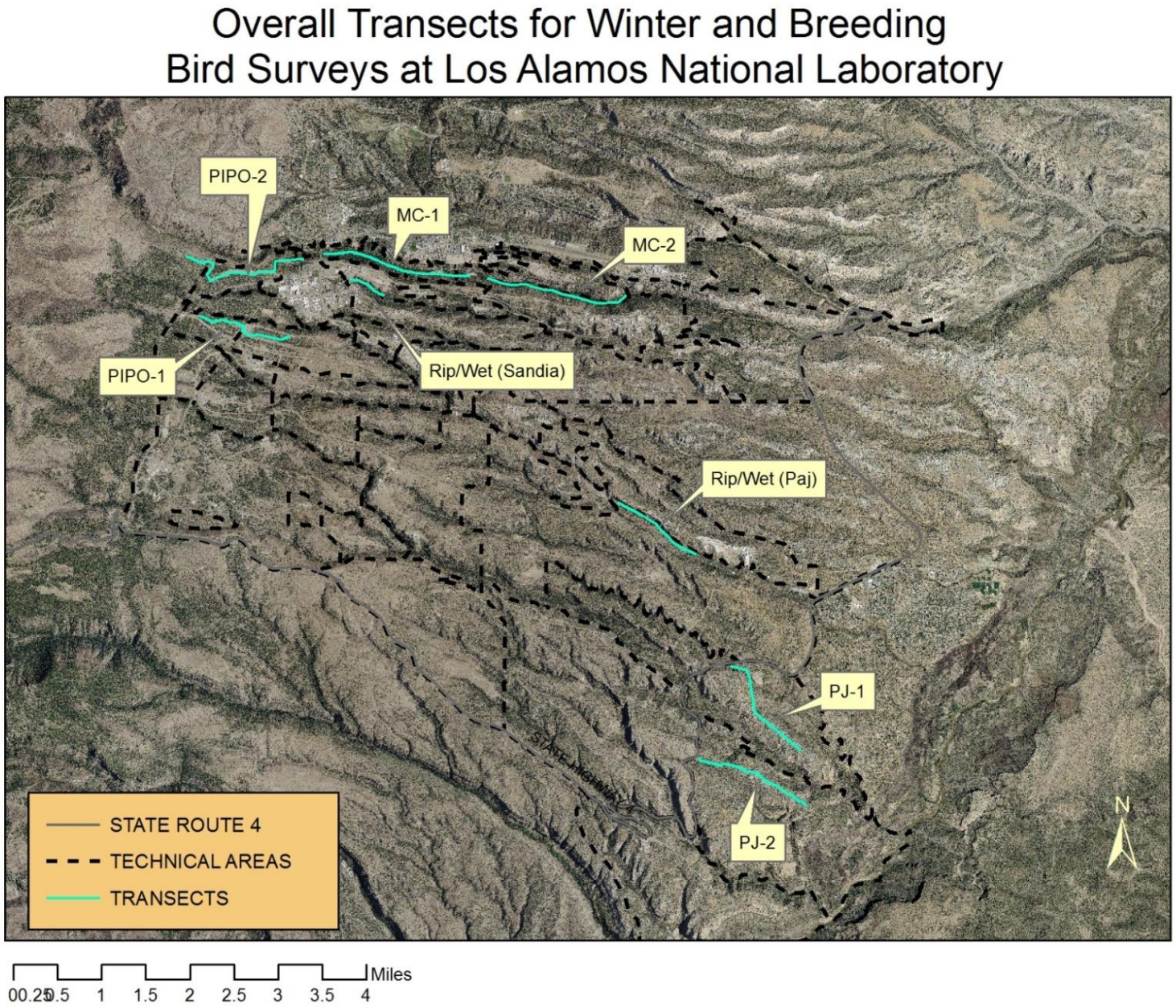

Figure 4. Control transects from ongoing avian monitoring around LANL.

MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland, Rip/Wet: Riparian / Wetland.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1 through August 15. Ideally the breeding bird surveys should take place the second week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along the transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an "unlimited-distance circular plot"; however, the distance to each bird out to 100 m should be noted. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, any birds encountered that have not otherwise been counted from a previous point or future point should also be noted. The surveyor's main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Surveys should not be conducted during rain events or wind greater than 15 mph.
- All birds encountered will be recorded on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- The "NOTES" section should be used for indicating any potentially important aspects of the survey that may affect the data. Examples include: excess noise from nearby equipment and vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to the TA-36 Minie site and TA-39 point 6 (Figures 5 and 6) and in 2015 nestboxes were added to the TA-16 burn ground (Figure 7). Data from the three study sites are compared to the overall avian nestbox network at LANL that was established in 1997.

Nestboxes are monitored every 1 to 2 weeks for active nests. When an active nest is found it is monitored more closely to determine whether the nest fails or successfully fledges young.

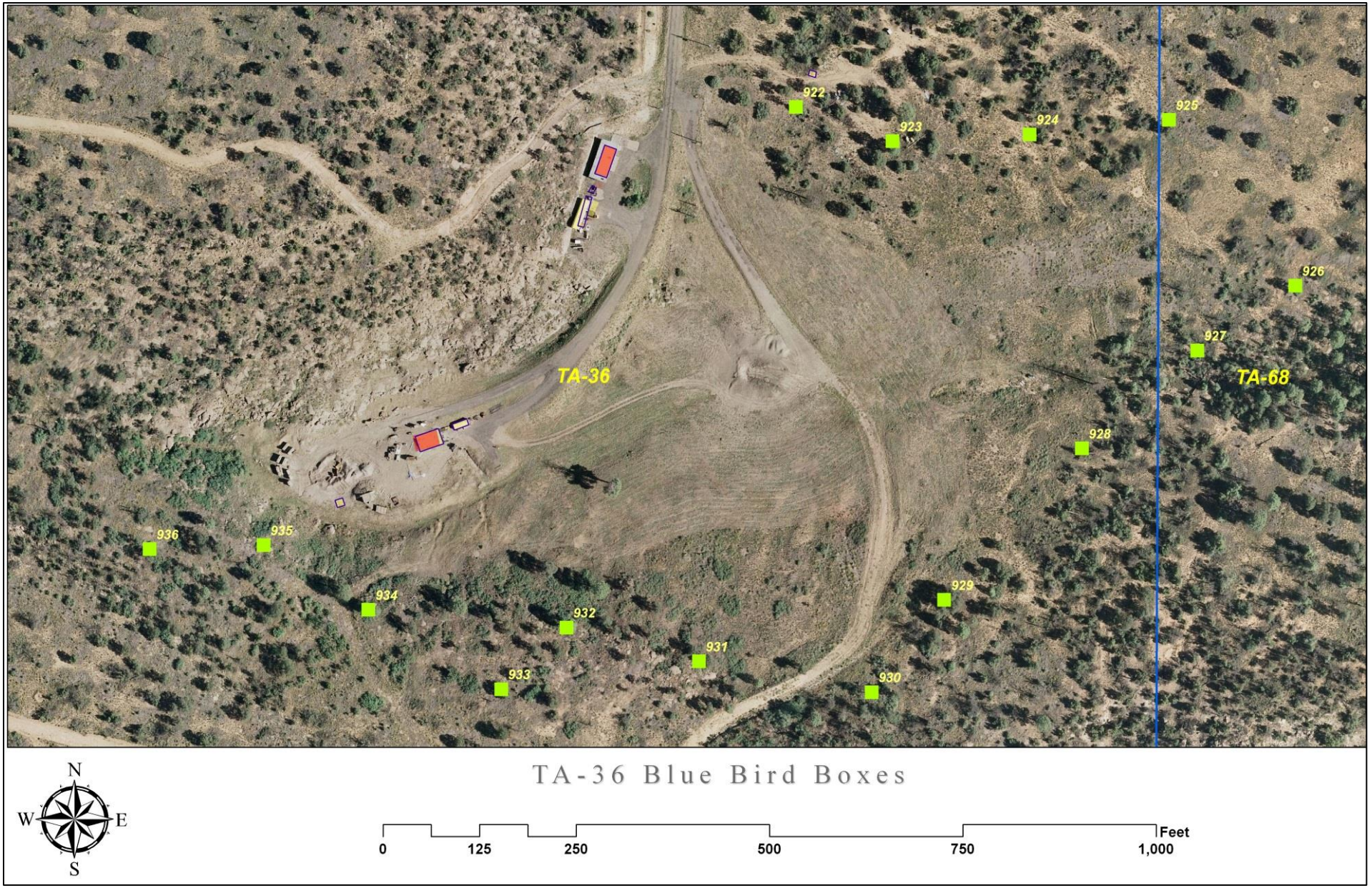

Figure 5. Avian nestboxes located at TA-36 Minie site.

Figure 6. Avian nestboxes located at TA-39 point 6.

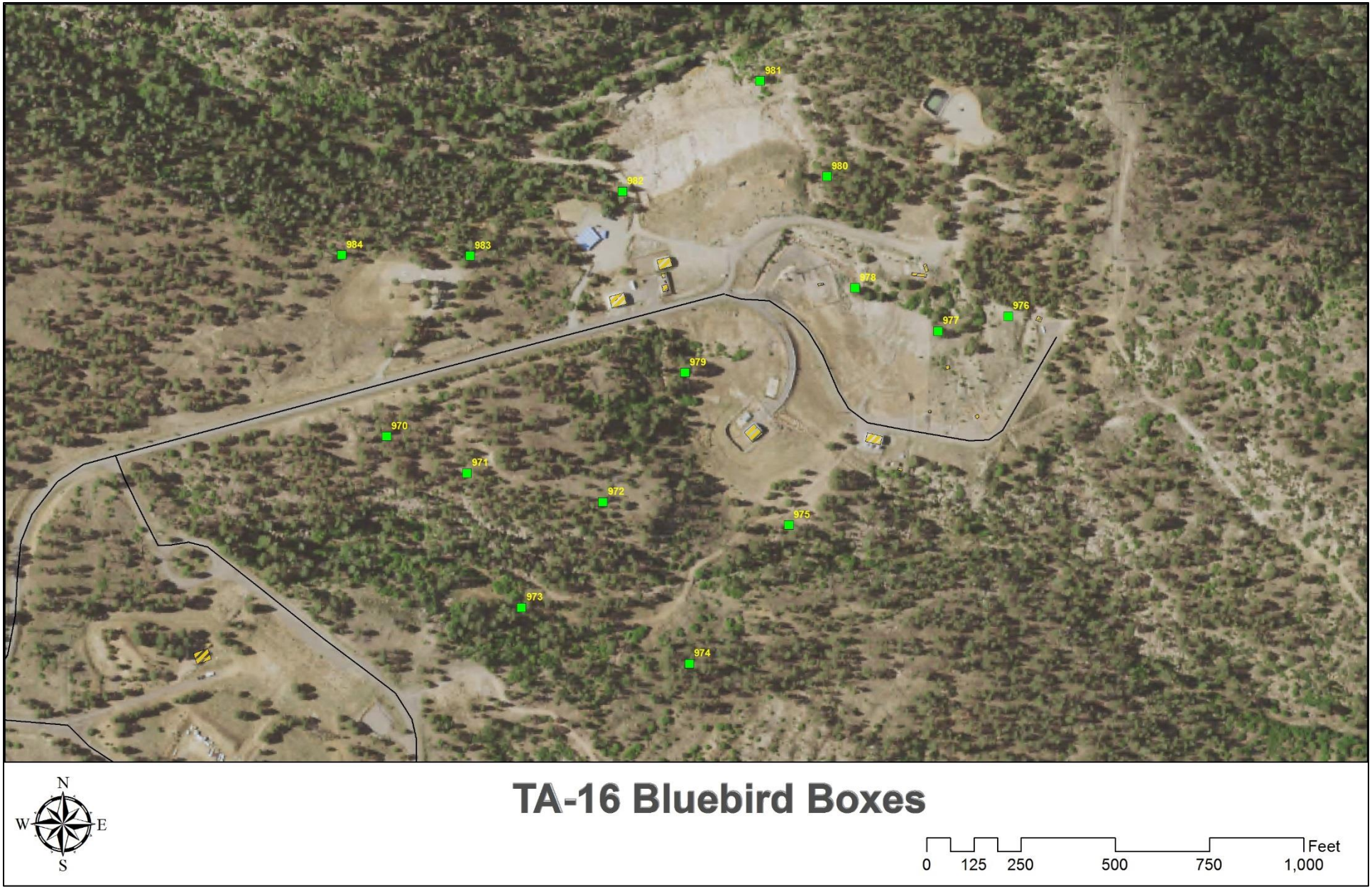

Figure 7. Avian nestboxes located at the TA-16 burn ground.

Statistical Methods

The data were summarized to look at trends in avian abundance and diversity for the three study sites and the control sites. To compare relative abundances between years and sites, the birds per hour (BPH) was calculated for each site by taking the total number of birds detected per survey and dividing by the total number of minutes surveyed. The result is multiplied by 60 to get the BPH. The BPH of the study sites and control sites were compared using the Mann-Whitney U non-parametric two sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine avian diversity for the study and control sites. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1 (p_i (\ln (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

To compare indices, a Shannon *t* test was used. As described in Magurran (1988), the variance of *H* is determined, which then allows the determination of the *t* value and degrees of freedom. Probability values of 0.05 or less indicated a significant difference in *H* between the two samples. The diversity indices and Shannon's *t* test were computed using PAST version 3.08 statistical software (Hammer et al. 2001).

Birds were categorized into feeding guilds based on the work of De Graaf et al. (1985). For food type, they did not necessarily include all foods taken by each species, only the major food items (20% of diet during a given period).

- Carnivore: vertebrates
- Crustaceovore: crustaceans
- Frugivore: fruits
- Granivore: nuts
- Herbivore: plants (leaves, stems, roots)
- Insectivore: insects
- Moltuscovore: mollusks
- Omnivore: a variety of foods including both animal and plant foods (the less common food group makes up 10% of diet)
- Piscivore: fish
- Vermivore: sandworms, earthworms, etc.

The guilds were customized to account for some bird species being split since the publication. Other changes were made to make it more suited to this study. All woodpeckers were changed from frugivores to omnivores; vermivores (American Robins in this study) were changed to omnivores; hummingbirds were changed from omnivores to nectarivores; Cassin's and House finches were changed from frugivores to granivores. Nectarivores and carnivores were dropped from the analysis due to low samples sizes, leaving granivores, insectivores, and omnivores for this report. The mean number of birds and standard deviation were calculated for each feeding guild. The means of the study sites and control sites were compared using the Mann-Whitney U non-parametric two sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant. All significant values in tables are bolded and shaded gray.

The control sites have been operated since 2011. The full datatset for the control sites was summarized for the point count surveys (2011–2015) and the Shannon's diversity index (Appendix 2).

Occupancy rate and nest success rate of the nestboxes at the three study sites and in the overall network were calculated. For any single site or overall, the number of active nestboxes divided by the total number of nestboxes is the occupancy rate. Similarly, the number of nestboxes that successfully fledged young divided by the number of active nestboxes is the nest success rate.

Results and Discussion

Three surveys were completed at each of the three study sites and the associated control sites between May and July 2015. A total of 881 birds representing 55 species were recorded at the three study sites. A full account of the 2013–2014 data is detailed in Appendix 1.

The mean BPH abundance values with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figure 8. The BPH was compared between study sites and their control site for each year using the Mann-Whitney U non-parametric two sample test (Table 1). These results indicate that in 2014 and 2015 the relative abundance of the bird communities at each of the study sites was similar to its respective control site. There was one significant difference in 2013 between the MC control site and the TA-16 burn ground ($p = 0.02$). This has been explained in earlier reports as being related to access restrictions in the first year of the study for this site.

Table 1. Comparisons of BPH between study sites and control sites among years.

Years	MC Control to TA-16	PJ Control to TA-39	PJ Control to Minie Site
2013	**Z = -2.2039 (p = 0.02)**	Z = -0.1313 (p = 0.89)	Z = 0.3889 (p = 0.69)
2014	Z = -1.6852 (p = 0.09)	Z = -0.3889 (p = 0.69)	Z = 1.1818 (p = 0.23)
2015	Z = 0.1291 (p = 0.89)	Z = -0.1296 (p = 0.89)	Z = 0.3939 (p = 0.69)

Note: statistically significant results are shaded.

Additionally, the mean BPH was compared between years for each site using the Mann-Whitney U non-parametric two sample test (Table 2). These results suggest that the relative abundance of bird communities at all three study sites remained similar over the years. The PJ control site does indicate that 2015 was significantly greater that the first two years of this study ($p = 0.008$ and $p = 0.004$). However, as noted in Figure 8, all sites had higher BPH values in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in BPH are attributed to the increased precipitation. Links between moisture and habitat quality for a migratory bird have been documented (Smith et al. 2010) and may be a causal factor. The data suggest that LANL operations are not negatively affecting the bird abundances at the three study sites.

Table 2. Comparisons of mean BPH between years and among sites.

Sites	2013 to 2014	2013 to 2015	2014 to 2015
MC Control	Z = 1.3659 (p = 0.17)	Z = -0.4010 (p = 0.68)	Z = -1.2855 (p = 0.19)
TA-16	Z = 0.8729 (p = 0.38)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)
PJ Control	Z = 0.6439 (p = 0.51)	**Z = -2.6514 (p = 0.008)**	**Z = -2.8121 (p = 0.004)**
TA-39	Z = 0.4364 (p = 0.66)	Z = -1.7457 (p = 0.08)	Z = -0.4364 (p = 0.66)
Minie Site	Z = 0.2214 (p = 1.0)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)

Note: statistically significant results are shaded.

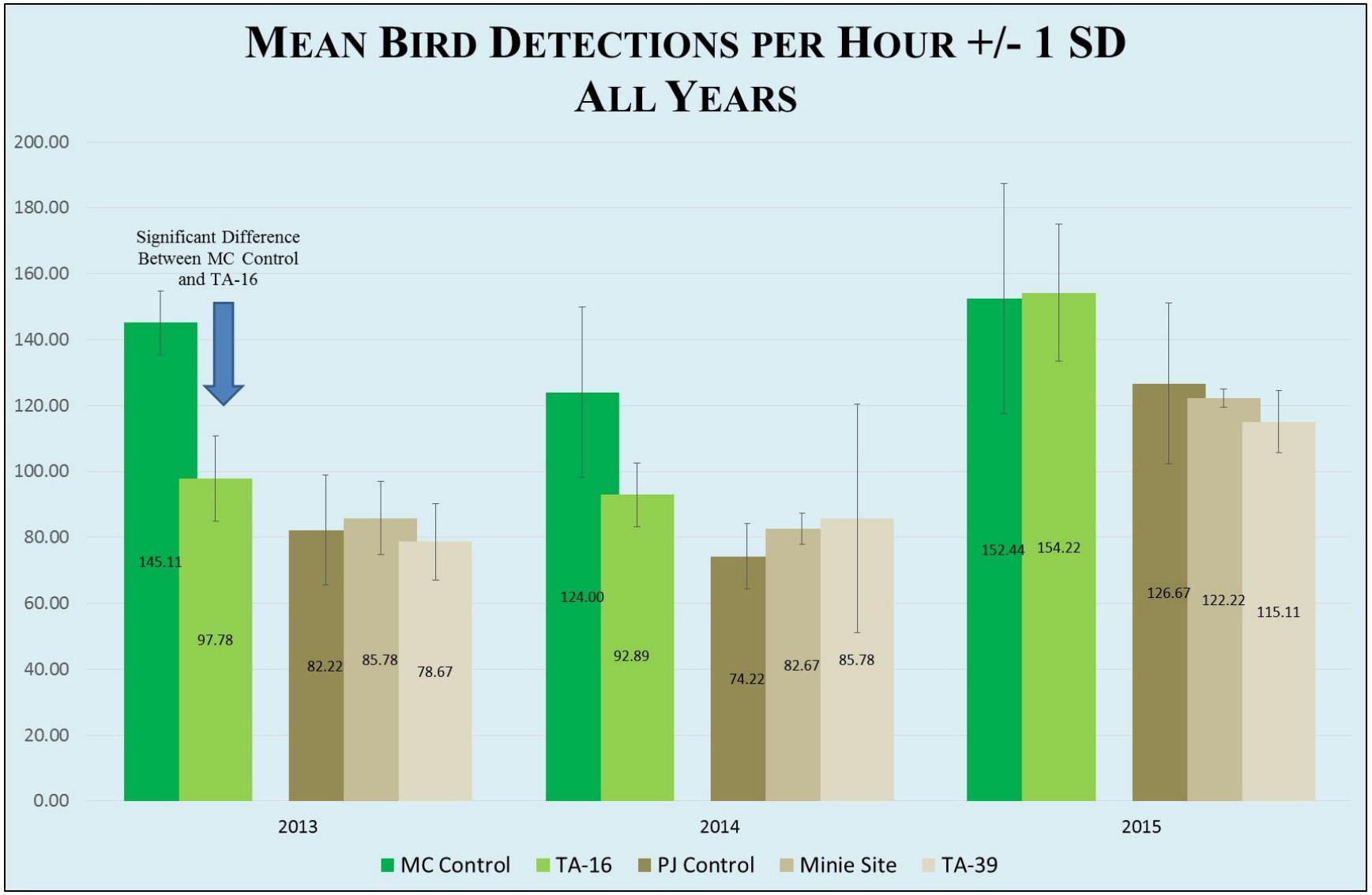

Figure 8. Birds per hour for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

The species diversity was determined using the Shannon's diversity index for each of the three study sites as well as the control sites of the comparable habitat type. The Shannon's diversity values for each site by year are represented in Figure 9. The bird diversity was compared between study sites and their control site for each year using the Shannon *t* test (Table 3).

Table 3. Shannon values for the study sites and control sites.

Years	MC Control to TA-16	PJ Control to Minie Site	PJ Control to TA-39
2013	t = 1.4194, df = 376 (p = 0.15)	**t = 2.9717, df = 510 (p < 0.01)**	**t = -2.3053, df 466 (p = 0.02)**
2014	t = 1.9235, df 412 (p = 0.06)	t = 1.8716, df = 455 (p = 0.06)	t = -1.0396, df = 477 (p = 0.29)
2015	**t = 4.4626, df = 653 (p < 0.01)**	t = 0.52699, df = 663 (p = 0.59)	t = 0.21662, df = 482 (p = 0.82)

Note: statistically significant results are shaded.

These results indicate that in 2013 the bird diversities in the PJ control sites were significantly less than Minie site ($p < 0.01$) and TA-39 ($p = 0.02$) trending toward similarity in following years. The results also indicate that in 2015 the bird diversity at the TA-16 burn ground was significantly lower ($p < 0.01$) than the MC control. This is contrary to the previously reported BPH data for the TA-16 burn grounds (Figure 5). The lower diversity value is due to 12 fewer species being present at the TA-16 burn grounds compared to the MC controls. Hathcock and Fair (2013) discussed this issue and attributed it to the fact that the MC control sites were in a canyon bottom closer to the townsite compared to the TA-16 burn grounds being on a mesa top.

This lower diversity value warranted further analysis. The Shannon's diversity values were determined for the ponderosa pine control sites. These control sites have not been used in this study because when this study began in 2013, the TA-16 burn ground was considered to be a MC habitat. This habitat does contain some components of a ponderosa pine forest. The Shannon's diversity value in 2015 for the ponderosa pine control was 3.161 which is a better fit to the data than the MC control. The Shannon t test was used to compare the 2015 diversity values from the TA-16 burn ground and the ponderosa pine control. These two sites were not significantly different ($t = 1.2603$, $df = 689$, $p = 0.20$). This is more speculative at this point and will be examined more extensively in the future. A significant difference in one year is not a trend. The data suggest that LANL operations are not negatively affecting bird diversity at the Minie site and TA-39, and more study is needed at the TA-16 burn ground.

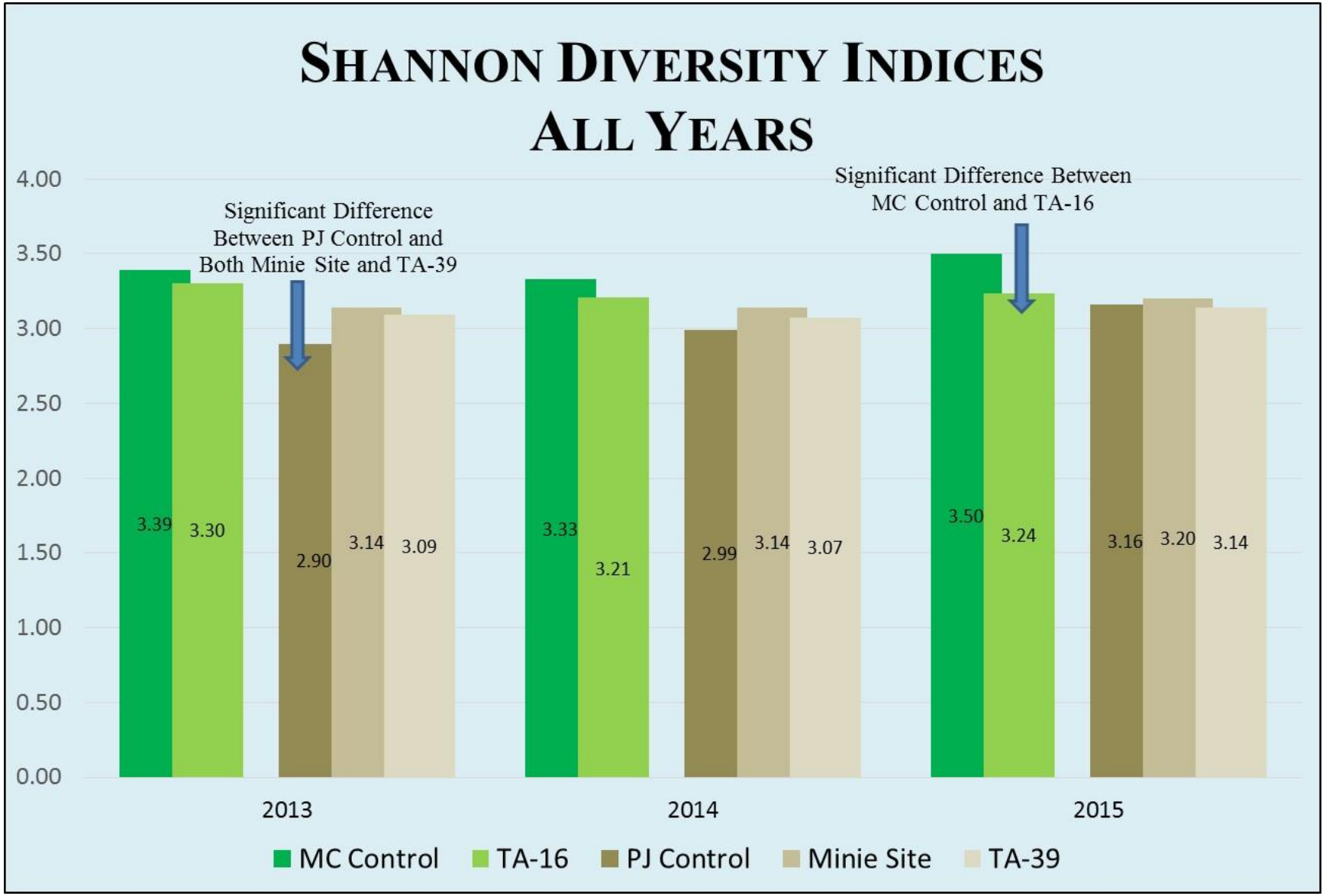

Figure 9. Shannon's diversity indices for the study and control sites.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat.

A new analysis was conducted in 2015 for this study. Bird species were categorized into feeding guilds based on the work of De Graaf et al. (1985). Only granivores, insectivores, and omnivores are presented in this report. The mean number of birds for these three feeding guilds with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figures 10–12. Insectivores have consistently been the largest feeding guild, followed by the omnivores and the granivores.

The mean number of birds were compared between years and among feeding guilds by study site using the Mann-Whitney U non-parametric two sample test (Table 4). These results indicate that there were no significant differences in feeding guilds between years for all three study sites. The control sites were analyzed similarly (Table 5) and trends very generally indicate that the mean numbers dropped slightly from 2013 to 2014 and then were highest in 2015. This fits well with the precipitation discussion earlier with the BPH differences.

A final analysis was performed to test for significant differences between study sites and their control site by feeding guild for each year using the Mann-Whitney U non-parametric two sample test (Table 6). There was one significant difference between the MC control site and the TA-16 burn ground ($p = 0.01$) with regard to omnivores. As discussed earlier, access limitations in 2013 may have affected the number of birds recorded. The significant differences disappeared in subsequent years. There were also significantly greater numbers of insectivores at Minie site compared to its control in 2013 and 2014.

Feeding guilds are also useful to monitor for habitat changes. From Figure 10 it is apparent that granivores are more prevalent in PJ habitats compared to MC. The opposite is seen in Figure 11 as insectivores are much higher in MC habitat than PJ. The omnivores are more evenly distributed among both habitats (Figure 12) which is indicative of their generalist nature, although the MC habitat does still have higher numbers of these birds.

During the 2015 nesting season, 15 nestboxes each at Minie site and TA-16, and 12 nestboxes at TA-39 were actively monitored. The overall avian nestbox network without the three study sites contained 653 nestboxes in 2015. Of those, 263 contained active nests and 174 of those nests fledged young successfully. This was an overall occupancy rate of 40% with a 66% success rate.

At Minie site, 14 nests were found and 9 of the nests fledged young successfully. Only 10 nestboxes were used, but 4 of those nestboxes had a second clutch. This was an occupancy rate of 66% with a 64% success rate.

At TA-39, only one nest was found and it successfully fledged young. This was an occupancy rate of 8%. These nestboxes at TA-39 will be relocated in 2016. The firing site at TA-39 is in a small narrow canyon and the nestboxes will be moved a little further out to a more open area to increase nesting attractiveness. The number of nestboxes in 2016 will also increase to 15 to be consistent.

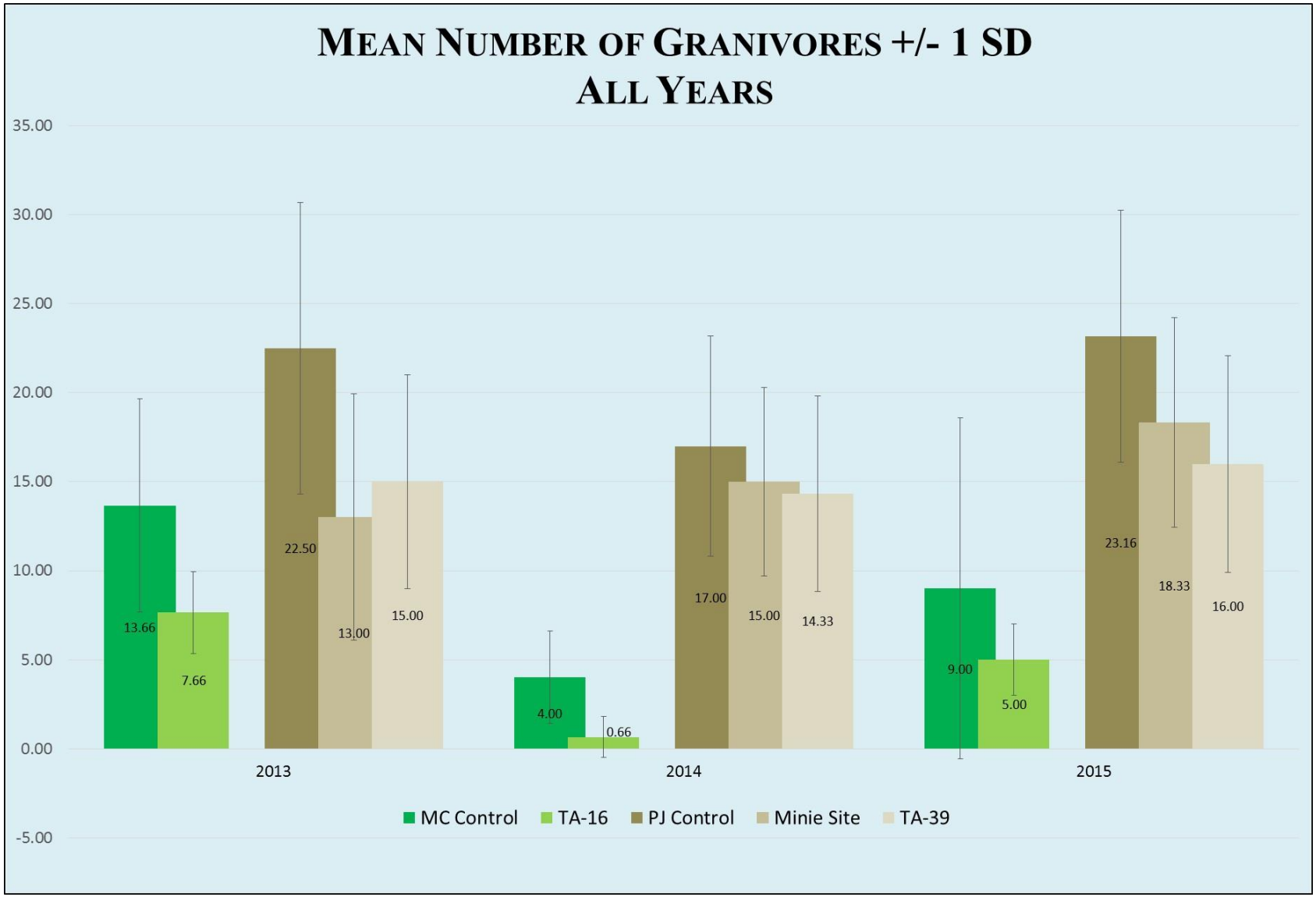

Figure 10. Mean number of granivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

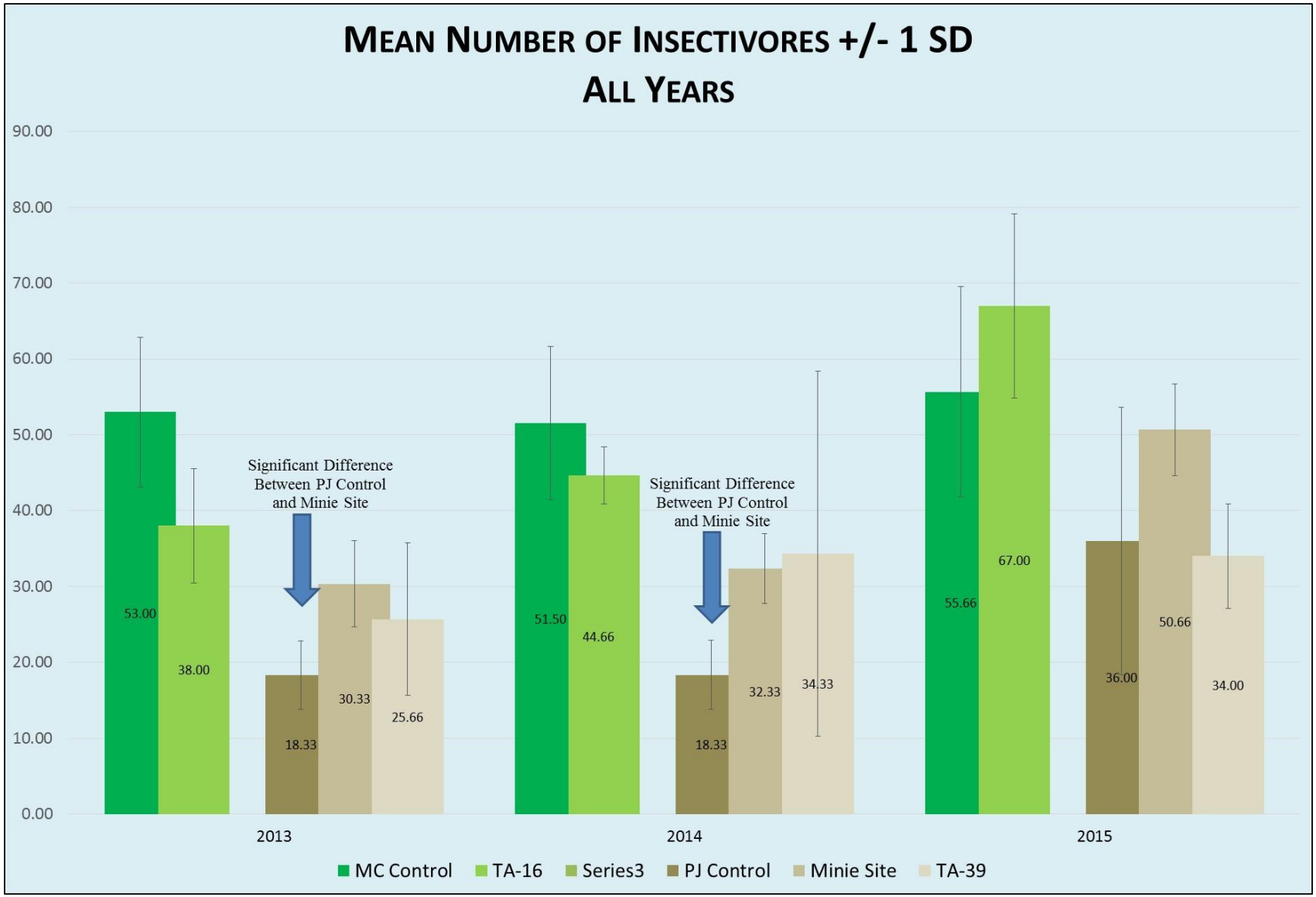

Figure 11. Mean number of insectivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

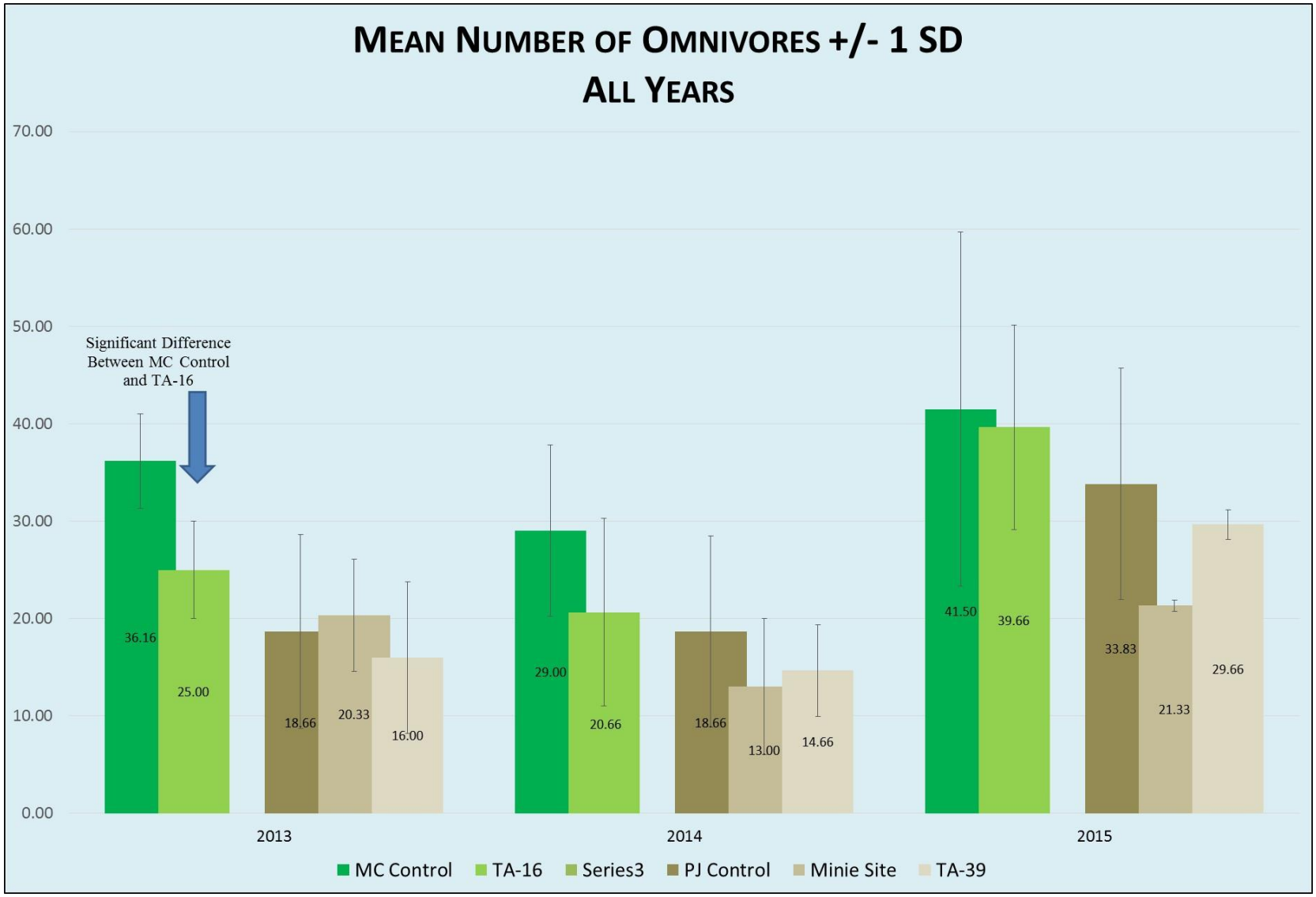

Figure 12. Mean number of omnivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

Table 4. Comparing the mean number of birds between years among feeding guilds for each study site.

	TA-16			TA-39			Minie Site		
Feeding Guild	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**
Granivore	Z = 1.7979 (p = 0.07)	Z = 1.1237 (p = 0.26)	Z = -1.7712 (p = 0.07)	Z = 0.0000 (p = 1.0)	Z = 0.2214 (p = 1.0)	Z = -0.8729 (p = 0.38)	Z = -0.4637 (p = 0.64)	Z = 0.0000 (p = 1.0)	Z = 0.0000 (p = 1.0)
Insectivore	Z = -0.8729 (p = 0.38)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)	Z = 0.0000 (p = 1.0)	Z = -0.8856 (p = 0.37)	Z = -0.4428 (p = 0.65)	Z = -0.4637 (p = 0.64)	Z = -1.7457 (p = 0.08)	Z = -1.7712 (p = 0.07)
Omnivore	Z = 0.4364 (p = 0.66)	Z = -1.3093 (p = 0.19)	Z = -1.3093 (p = 0.19)	Z = 0.2214 (p = 1.0)	Z = -1.7457 (p = 0.08)	Z = -1.7457 (p = 0.08)	Z = 0.8856 (p = 0.37)	Z = -0.4495 (p = 0.65)	Z = -1.7712 (p = 0.07)

Table 5. Comparing the mean number of birds between years among feeding guilds for each control site.

	MC Control			PJ Control		
Feeding Guild	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**	**2013 to 2014**	**2013 to 2015**	**2014 to 2015**
Granivore	**Z = 2.3550 (p = 0.01)**	Z = 0.8901 (p == 0.37)	Z = -0.8077 (p = 0.41)	Z = 0.8854 (p = 0.37)	Z = -0.1607 (p = 0.87)	Z = -1.3659 (p = 0.17)
Insectivore	Z = 0.2410 (p = 0.80)	Z = -0.5624 (p = 0.57)	Z = -1.4812 (p = 0.63)	Z = 0.1633 (p = 0.87)	**Z = -2.6608 (p < 0.01)**	**Z = -2.5711 (p = 0.01)**
Omnivore	Z = 1.4462 (p = 0.14)	Z = 0.0000 (p = 1.0)	Z = -1.2010 (p = 0.22)	Z = -1.1610 (p = 0.87)	**Z = -2.0051 (p = 0.04)**	**Z = -2.0890 (p = 0.03)**

Note: statistically significant results are shaded.

Table 6. Comparing the mean number of birds between study sites and their control by feeding guilds for each year.

	2013			2014			2015		
Site Comparisons	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**
MC Control and TA-16	Z = -1.1921 (p = 0.23)	Z = -1.6783 (p = 0.09)	**Z = -2.2039 (p = 0.02)**	Z = -1.8226 (p = 0.06)	Z = -0.9113 (p = 0.36)	Z = -0.9037 (p = 0.36)	Z = -0.5208 (p = 0.60)	Z = 0.7778 (p = 0.43)	Z = 0.1291 (p = 0.89)
PJ Control and Minie Site	Z = -1.1717 (p = 0.24)	**Z = 1.9696 (p = 0.04)**	Z = 0.3956 (p = 0.69)	Z = -0.2593 (p = 0.79)	**Z = 2.2132 (p = 0.02)**	Z = -0.7811 (p = 0.43)	Z = -1.0371 (p = 0.29)	Z = 1.4201 (p = 0.15)	Z = -1.4260 (p = 0.15)
PJ Control and TA-39	Z = -1.1668 (p = 0.24)	Z = 0.9191 (p = 0.35)	Z = -0.3939 (p = 0.69)	Z = -0.5186 (p = 0.60)	Z = 1.0415 (p = 0.29)	Z = -0.6482 (p = 0.51)	Z = -1.1619 (p = 0.24)	Z = 0.0000 (p = 1.0)	Z = -0.5186 (p = 0.60)

Note: statistically significant results are shaded.

At TA-16, 11 nests were found and 10 of the nests fledged young successfully. This was an occupancy rate of 73% with a 90% success rate.

The occupancy and success rates at Minie site and TA-16 were greater than the results in the overall network. The nestboxes at TA-39 have a placement problem that will be addressed in 2016. More years of data are needed to begin to look at the results in a more robust manner.

The nestbox data suggest that LANL operations at these sites are not negatively affecting nest success at two of the study sites, and more work is needed for TA-39.

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 55 species detected at the three study sites, all are protected under the MBTA. Additionally, three of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those three species are the Peregrine Falcon, Juniper Titmouse, and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three study sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the MBTA and associated memorandums of understanding, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three study sites from 2013–2015.

Species	2013	2014	2015	2013	2014	2015	2013	2014	2015
	TA-36			TA-39			TA-16		
	Pinyon-Juniper Woodland			Pinyon-Juniper Woodland			Mixed Conifer Forest		
Acorn Woodpecker							5		3
American Kestrel				1					
American Robin	1	1	2	1	1		7		9
Ash-throated Flycatcher	11	5	14	19	11	29	3	5	6
Audubon's Warbler		2					6	5	1
Bewick's Wren	4	8	9	3	10	15			
Black-chinned Hummingbird		1	1	3	2		1		1
Black-headed Grosbeak	1	3			2	4			1
Black-throated Gray Warbler			1	5	6	4			
Blue-gray Gnatcatcher	3	14	16	2		7		6	2
Broad-tailed Hummingbird	2	1	3	3	1	2	5	11	11
Brown Creeper							1		
Brown-headed Cowbird	1					2	4	1	
Bushtit		2		2	14				
Canada Goose						16			
Canyon Towhee	2		5	1	1	2	1		
Canyon Wren						2			2
Cassin's Kingbird	6	13	13	7	6	2			
Chipping Sparrow	3	16	17	6	6	5	1	5	3
Clark's Nutcracker								4	
Common Nighthawk	6		5	5	1	3			1

Species	2013	2014	2015	2013	2014	2015	2013	2014	2015
	TA-36			TA-39			TA-16		
	Pinyon-Juniper Woodland			Pinyon-Juniper Woodland			Mixed Conifer Forest		
Common Raven	2	5	1	1		2	5	6	2
Cooper's Hawk							1		
Cordilleran Flycatcher							5	10	6
Dark-eyed Junco							6	2	4
Downy Woodpecker								1	
Dusky Flycatcher						1			
Eurasian Collared-Dove	3								
Evening Grosbeak	3		4			8	5		29
Grace's Warbler							6	4	4
Gray Flycatcher	12	6	5	10	10	11			
Great-horned Owl		3		1					
Green-tailed Towhee	3	1		1					
Hairy Woodpecker			2			5	1	1	
Hammond's Flycatcher							8	9	12
Hepatic Tanager						1			
Hermit Thrush								4	6
House Finch	16	17	26	21	4	23	16	2	5
House Wren							1	1	
Juniper Titmouse	12		7	11	13	18			
Lesser Goldfinch	2	6	7	4	12	9	3		8
Mountain Bluebird		2	20		4				4
Mountain Chickadee	5	2	1				5	8	9
Mourning Dove	17	17	13	13	22	10	4		1
Northern Mockingbird					1				
Peregrine Falcon						1			

Species	2013	2014	2015	2013	2014	2015	2013	2014	2015
	TA-36			TA-39			TA-16		
	Pinyon-Juniper Woodland			Pinyon-Juniper Woodland			Mixed Conifer Forest		
Pine Siskin	10	2		6		3	12	4	5
Plumbeous Vireo	10	10	7	1		1	11	16	15
Pygmy Nuthatch						2	11	13	26
Red Crossbill					2			2	9
Red-shafted Flicker	3	1	3	3	2	4	3	4	11
Red-tailed Hawk						1			
Rock Wren	3	3	4	7	10	4	1	2	2
Say's Phoebe	2	1	2	2	1		1		1
Scaled Quail			1						
Spotted Towhee	17	8	19	12	6	33	11	18	16
Steller's Jay							3	2	5
Townsend's Solitaire	1								
Turkey Vulture							1		
Violet-green Swallow		5	7	6	4	1		2	19
Virginia's Warbler						1	17	11	21
Warbling Vireo							2	9	7
Western Bluebird	15	11	18	5	19	12	20	20	49
Western Scrub-Jay	5	1	3	8	10	4	1		
Western Tanager		2	3		2	1	2	3	7
Western Wood-Pewee	10	8	18		4	2	15	10	16
White-breasted Nuthatch	1	4	9			2	9	8	7
White-throated Swift					1				
White-winged Dove	1	5	9	7	5	6			1
Grand Total	**193**	**186**	**275**	**177**	**193**	**259**	**220**	**209**	**347**

Appendix 2. The full datatset for the control sites for point count surveys (2011–2015) including the Shannon's diversity index.

Breeding bird survey results from 2011 to 2015 for all control sites. Replicate control sites were not added until 2012.

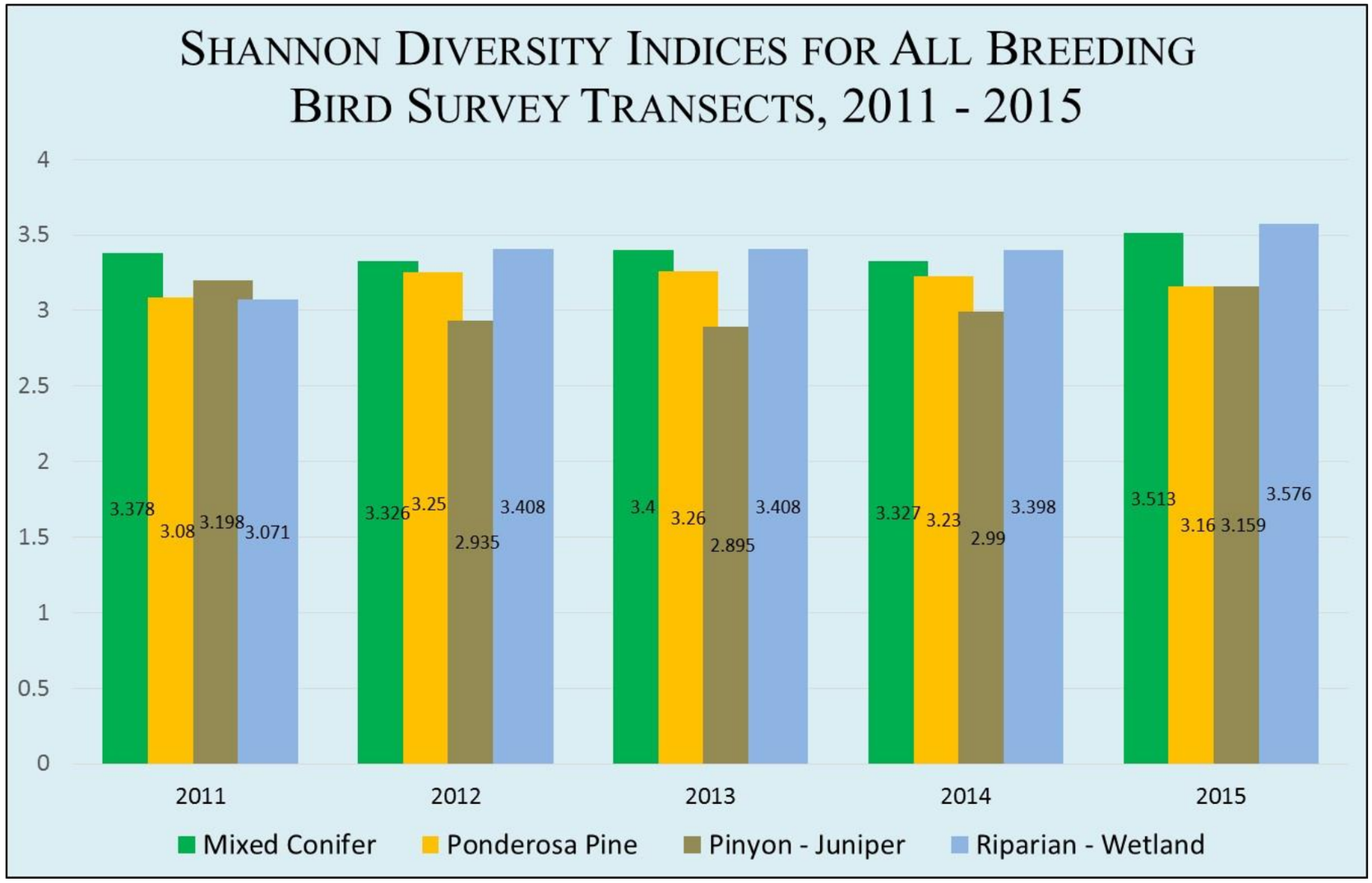
	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
Species	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Acorn Woodpecker	10				11	2		5	7	3		7	9			2	13	1		2
American Crow	3		1																	
American Kestrel		1						1										1	1	
American Robin	18	3	6	22	20	10	15	29	21	4	5	23	11	7	3	22	29	13	3	34
Ash-throated Flycatcher	5	7	29	9	18	8	52	8	13	1	33	10	17	6	30	10	10	1	50	4
Audubon's Warbler	1	5			7	26	1	2		6			4	21	1		6	47		2
Bewick's Wren	1		2				12	4			19	1			18	1	1		35	4
Black-chinned Hummingbird	1	1	2	3	1		1		3	5	4	9	4		2	10	2	3	5	3
Black-headed Grosbeak	7	2		4	1		1		9	2	6		4	1			9	2	5	3
Black-throated Gray Warbler															1				5	
Blue Grosbeak				4				1								1				1
Blue-gray Gnatcatcher			4	2			6	2	2		6	5			6	3		1	12	1
Broad-tailed Hummingbird	16	13	9	1	14	15	2	11	25	27	5	26	25	22	6	8	37	38	2	19
Brown Creeper					3	1							3			1	6			
Brown-headed Cowbird	5	1	9	4	10	5	3	7	12	7	2	9	3	2		4	5	3		24
Bullock's Oriole				1								2				2			2	1

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Bushtit	1	3	1	20			2		10			2			6	2			18	11
Canada Goose								6												16
Canyon Towhee	2		4	2	1		4	3	2		9				8	4		1	10	4
Canyon Wren	8				12				12				6		2	2	23		4	4
Cassin's Finch								1		2										
Cassin's Kingbird		3	4			5				13	3			3	8	8		2	24	6
Cedar Waxwing																	5			
Chipping Sparrow	4	11	14	3	7	17	8	6	1	20	1	3	1	15	5	7	18	52	30	15
Clark's Nutcracker						1														
Common Nighthawk			1								11	1			5			5	6	1
Common Raven	16	8	7	1	28	15	4	6	24	13	4	6	20	23	4	17	29	21	12	24
Cooper's Hawk						1				1			1	1			1			
Cordilleran Flycatcher	3				9				7	1		3	9	4		3	6	2		
Dark-eyed Junco	6	8	1		3	13		2	2	7		5		1		1	4	13	1	2
Downy Woodpecker	3			2																
Dusky Flycatcher	1																2	4		1
Eurasian Collared-Dove						2		3		3		3		3		1		2		3
European Starling								18												
Evening Grosbeak	47	81	10	43	4	3		6	8	28	4	21		10		2	2	26	49	7
Flammulated Owl						2	1	1												
Grace's Warbler						3		1	12	11		1	9	8		2	5	10		

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Gray Flycatcher		1	17			1	6	1			14				7				8	1
Great-tailed Grackle			19																	
Green-tailed Towhee	2		7	1		3	7	1			5	4		2						
Hairy Woodpecker	3	3	1	2	5	2	4	6	2				5	3	3	1	2	2	2	2
Hammond's Flycatcher	3	2			21	6			19	9			15	2			16	4		1
Hepatic Tanager				1					1											
Hermit Thrush		1			5	2		1		3			3	5			9	7		
House Finch	3	21	25	13	30	38	43	33	12	39	89	34	2	37	47	28	2	35	59	25
House Wren		2		1	1	3		11	1			20	2			12	3	3		10
Indigo Bunting								1												
Juniper Titmouse			13	8			21	5			20	1			12		1		16	
Lazuli Bunting								2												
Lesser Goldfinch	16	5	13	28	19	22	11	31	35	14	19	28	7	9	14	16	21	17	42	25
Lincoln's Sparrow					1											1				1
MacGillivray's Warbler	2	4		1	1							2	2						1	1
Marsh Wren																				1
Mountain Bluebird															3				1	
Mountain Chickadee	11	3		2	20	7		1	31	10		6	21	4		6	11	5		7
Mourning Dove	3	4	16	6	28	7	38	30	35	4	25	10	15	3	36	16	27	4	30	12
Northern Mockingbird			1				1				1	2			1					
Northern Saw-whet Owl	1																			

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Orange-crowned Warbler									1									3		3
Pine Siskin	13	7		5	1	5			12	27	8	5	15	28		11	40	47	6	6
Pinyon Jay							1								41					
Plumbeous Vireo	9	21	2	3	31	27	1	6	38	23		9	17	22	1	8	18	25	3	10
Pygmy Nuthatch	4	10			57	70		9	47	33		15	59	54		26	26	105		21
Red Crossbill		7				15	2			5				8			3	21		
Red-breasted Nuthatch	2	1				2														
Red-shafted Flicker	2	12	1	4	7	10	4	4	12	1	2	9	9	3	1	9	9	15	3	14
Red-tailed Hawk					1			7	2		2	5	4			2	1		1	3
Red-winged Blackbird								13				29				49				57
Rock Wren		2		1		3	5	3	1		6	3	8	1	8	9	4		5	9
Ruby-crowned Kinglet	4	2		1													4			
Rufous Hummingbird								2												
Say's Phoebe		1	3	1		1		7	2		1	3		2	1	4	3			
Song Sparrow	1				1			17	1			16				11				15
Sora																				6
Spotted Towhee	20	4	13	33	39	23	42	27	44	20	29	31	36	16	23	27	50	29	46	33
Steller's Jay	1	3			7	3		1	9	6		3	7	6		1	6	10		2
Summer Tanager			1																	
Townsend's Solitaire		1	1					1						2			2	1		1
Turkey Vulture					25	1	1		4	12		1	17	3	2		8		4	1

Species	Summer 2011				Summer 2012				Summer 2013				Summer 2014				Summer 2015			
	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland	Mixed Conifer	Ponderosa Pine	Pinyon - Juniper	Riparian - Wetland
Unknown Hummingbird					11	6	1	8	2		2									
Violet-green Swallow	23	10	6	6	54	51	7	47	38	28	8	52	52	21		38	43	43	3	52
Virginia Rail								1				7								10
Virginia's Warbler	18	11		16	26	13	5	13	38	30	1	15	15	19	1	8	20	22	1	7
Warbling Vireo	16				15				18			2	28	5		5	28	3	1	2
Western Bluebird	6	26	11	2	3	35	17	8	1	44	3	2	11	43	9	11	5	91	26	11
Western Scrub-Jay	1	1	14	5		1	28	11	1		16	8			11	2			20	7
Western Tanager	7		1	1	2	3	1		15	9	2	1	4	3	1	2	10	3		5
Western Wood-Pewee	8	19	8	19	49	49	11	49	38	36	3	18	33	38	2	31	50	41	4	53
White-breasted Nuthatch	4	9		1	25	16		4	15	3		8	17	5		5	11	19	4	10
White-crowned Sparrow	1															1				
White-throated Swift					36	6			7	4			28	5			32		2	8
White-winged Dove			3	1			1	1			2	1		1	5	2	4		8	15
Williamson's Sapsucker		2						2												
Willow Flycatcher				1																
Wilson's Warbler	1																4			2
Yellow Warbler				1					1							1				1
Yellow-breasted Chat				1																1
Wilson's Warbler	1																4			2
Yellow Warbler				1					1							1				1
Yellow-breasted Chat				1																1



Shannon's diversity indices during the breeding season from 2011 to 2015 for all control sites. Replicate control sites were not added until 2012.

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 8 – Hathcock *et al.* 2017

Environmental Report:

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Minor Revision April 2017

2016 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts are compared among years and with avifauna monitoring conducted at other areas across LANL. The objectives of this study are to determine whether LANL firing site operations impact bird abundance or diversity. LANS biologists completed the fourth year of this effort in 2016. The overall results from 2016 continue to indicate that operations are not *negatively* affecting bird populations. Data suggest that community structure may be changing at some sites and this trend will continue to be monitored.

Three avian point count surveys were completed at each of the study sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground (hereafter referred to as Minie site, TA-39, and TA-16) between May and July 2016. A total of 730 birds representing 54 species were recorded at the study sites. Three avian point count surveys were also completed at each of the control sites between May and July 2016.

The data were analyzed to determine abundance using an estimate of birds detected per hour, and to calculate the species diversity. The number of birds detected in three different feeding guilds were compared to examine functional community differences among areas.

Results from 2016 monitoring indicate a slight decrease from 2015 in bird abundances in pinyon-juniper (PJ) habitat and a small increase in bird abundances in mixed conifer (MC) habitat across LANL. The decrease is likely indicative of effects from below-average precipitation in the winter of 2015 into the spring and early summer of 2016. Precipitation drives habitat suitability, which can potentially drive animal populations using the resources. The link between moisture and habitat quality for a migratory bird indicates that the availability of high-quality habitats is dynamic due to variation in precipitation among seasons and years (Smith et al. 2010). Mixed conifer habitat is wetter than PJ, which may account for the small increase in bird abundance in the MC habitat. This increase in bird abundance was significantly higher ($p = 0.03$) in the MC control habitat compared with TA-16. There were no significant differences in bird abundance for the other two sites when comparing their respective controls.

The species diversity indices at Minie site were significantly less ($p = 0.01$) than its PJ control, with fourteen fewer species present. The TA-16 bird diversity was also significantly less ($p < 0.01$) than its MC control, with seven fewer species present. The fluctuations in bird abundances are not alarming and the differences between the study sites and control sites are not biologically significant. The 2016 results at the three study sites are still higher than the first two years of the study. The significant drop in species diversity at Minie site may be indicative of a change in community structure. Due to increased fuels reduction, including more tree removals, the habitat availability is changing. The site is becoming more grassland-like than PJ. There are currently no control sites for grasslands at LANL and this may be needed in the future.

In addition to avian point counts, nestboxes were monitored around all three study sites. These data are compared with the overall avian nestbox monitoring network. This network was established in 1997 to investigate the occupancy rates and reproductive success of cavity-nesting bird populations at LANL. The total number of boxes in the network in 2016 was 416, with another 42 placed around the three study sites. In 2016 there was an overall occupancy rate of 47% with a 65% success rate for the avian nestbox network at LANL. The percent occupancy and nest success at both Minie site and TA-16 were similar to the overall rate, suggesting that the firing site operations are not negatively affecting nest success. Further study is needed at TA-39 to ascertain if the 2016 re-deployment of some nestboxes within the more open habitat east of point 6 continues to lead to increased occupancy. An additional three boxes are needed at TA-39 to maintain even numbers at all three sites.

Introduction

As part of the Resource Conservation and Recovery Act permitting process at LANL for two open detonation sites (TA-36 Minie site and TA-39 point 6), and one open burn site, (TA-16 burn ground), an avian monitoring program was started at these locations in 2013 (Hathcock and Fair 2013). The goal is to compare avian abundance, diversity, and productivity at these sites with other locations at LANL of the same habitat type. Comparisons are made with control sites that have been surveyed since 2011 (Hathcock et al. 2011).

LANS biologists used standard point count methodology to record avian abundance and diversity along transects at the three study sites and associated control sites during the summer of 2016. Summer surveys provide information about what birds are breeding at the sites. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. They also can be correlated to changes in the natural environment at LANL.

In addition to avian point counts, nestboxes are monitored around all three study sites to investigate any potential impacts to occupancy rates and productivity of cavity-nesting birds. These data are compared with the overall LANL avian nestbox monitoring network established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys are conducted along single transects in the forested, undeveloped land surrounding the study sites (Figures 1–3). The habitat types around the sites are PJ for the sites at TA-36 and TA-39 and MC at TA-16. These habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The three study sites were compared with control sites at LANL of the same habitat type. The control sites (Figure 4) are monitored annually in ongoing surveys that have been conducted at LANL since

2011 as described in Hathcock et al. (2011). Each habitat type control contains two replicate transects that are monitored in the same way as the study sites with the same number of points and during the same time periods. In each survey month, all study site and control site transects are randomized and surveyed following the random order.

The PJ study sites at Minie site and TA-39 are similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, proximity to developed areas, and in being situated on the mesa top. The MC study site at TA-16 is similar in elevation and overstory vegetation to the MC control sites, but is dissimilar in that the study site is located on a mesa top and the control sites are located in the bottom of a canyon in TA-43, TA-2, and TA-21. Being the bottom of a canyon, there are some differences in understory vegetation with a greater understory present at the control sites.

Transects are approximately 2.0 to 2.5 km in length and allow for nine survey points spaced approximately 250 m apart. These survey routes and points may change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol requires a total of three surveys per study site and surveys should be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along the transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an “unlimited-distance circular plot”; however, the distance to each bird out to 100 m should be noted. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, note any birds encountered that have not otherwise been counted from a previous point or future point. The surveyor’s main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Do not conduct surveys during rain events or winds greater than 15 mph.
- Record all birds encountered on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- Use the “NOTES” section to indicate any potentially important aspects of the survey that may affect the data. Examples include excess noise from nearby equipment and vehicles or aircraft that make it hard to hear the birds. Also, noting other wildlife or evidence of wildlife that could be used for further reference should be recorded.

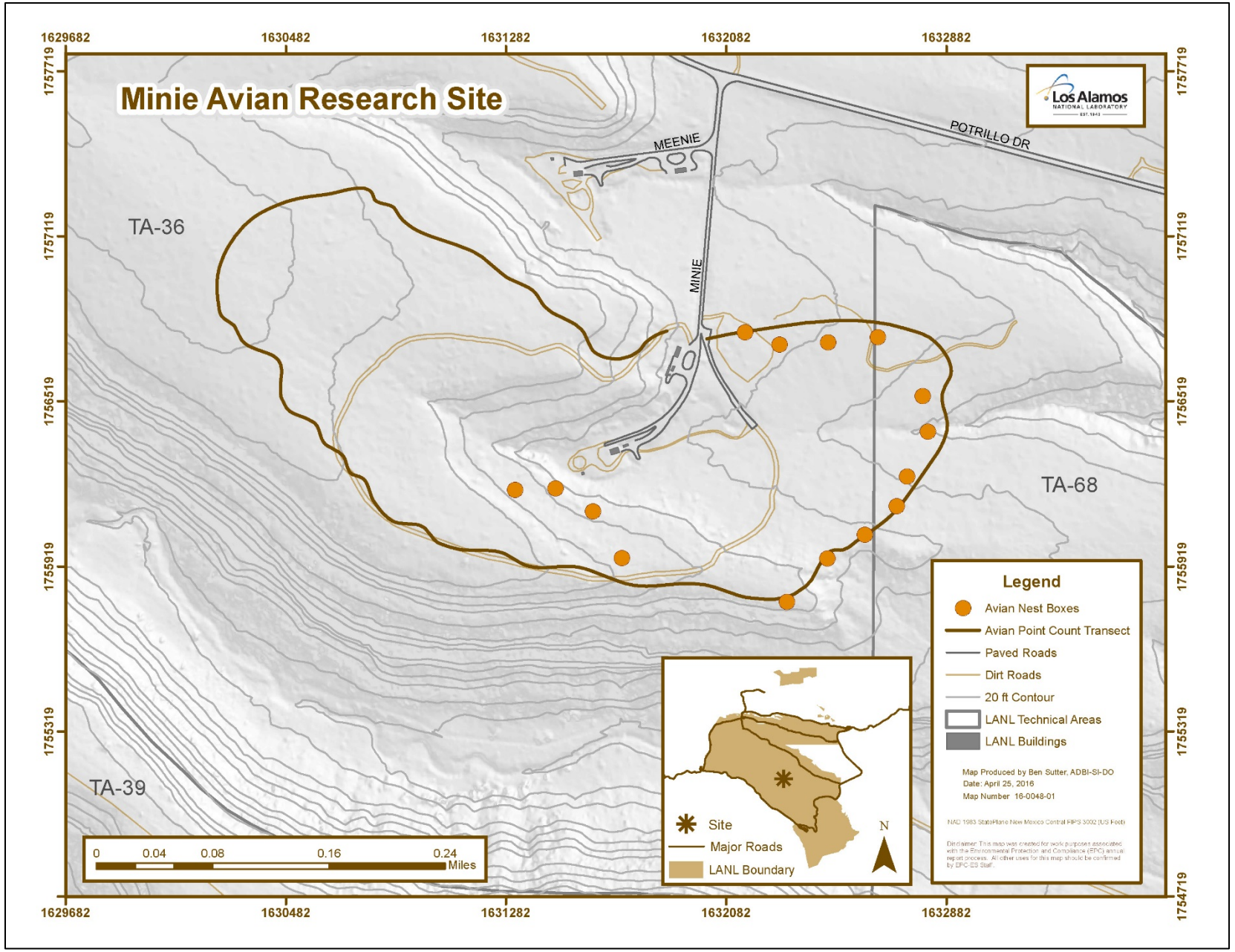

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site.

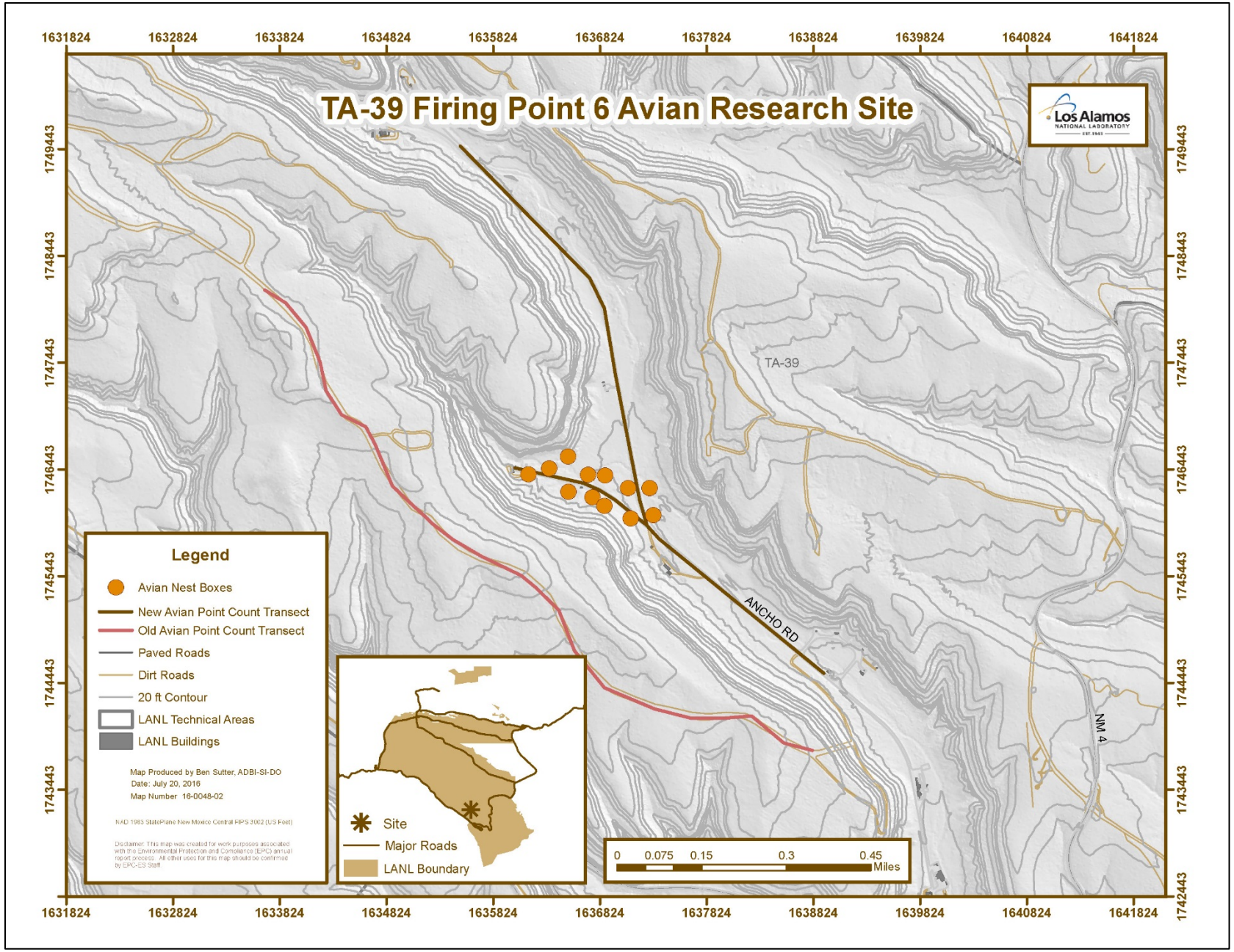

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6.

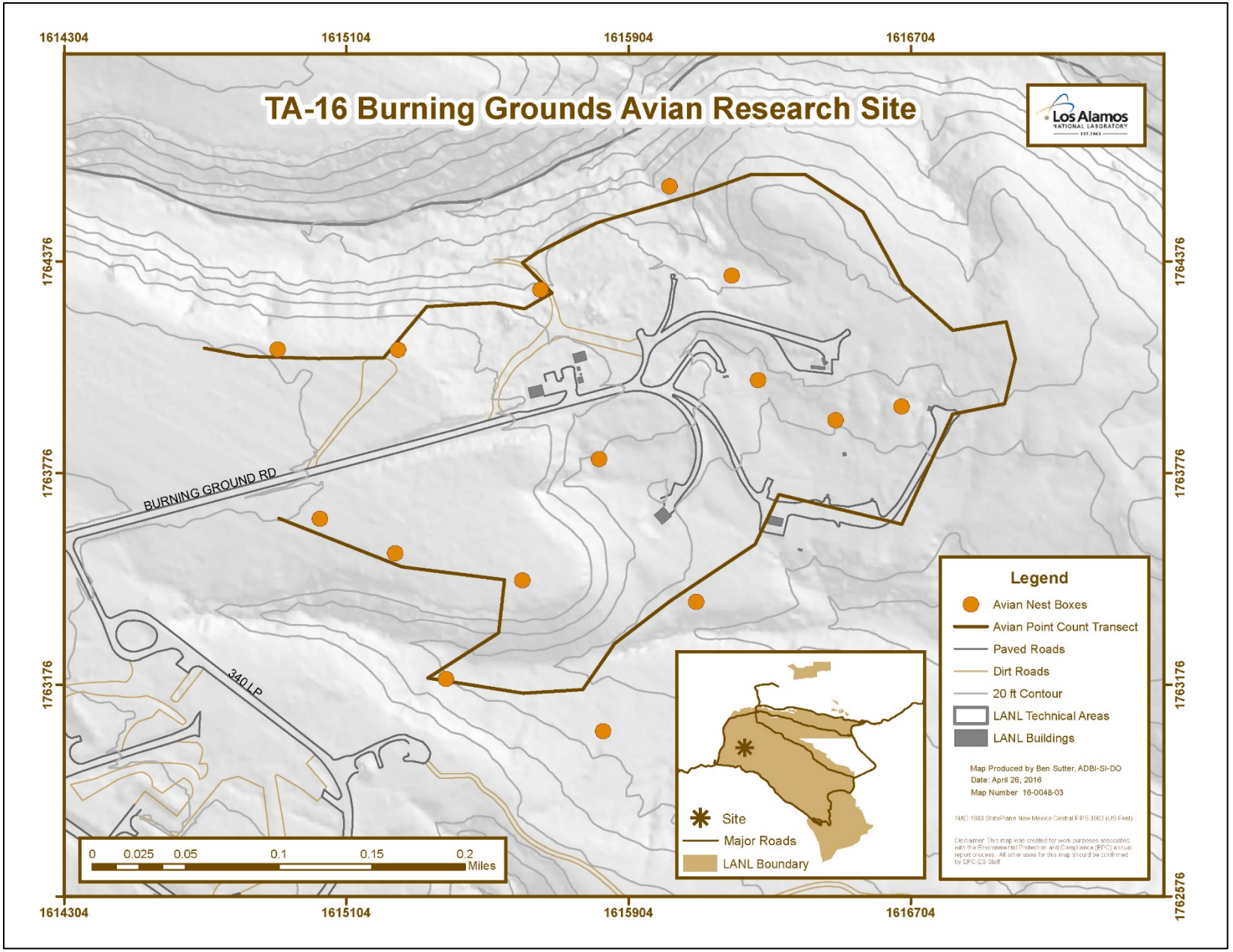

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground.

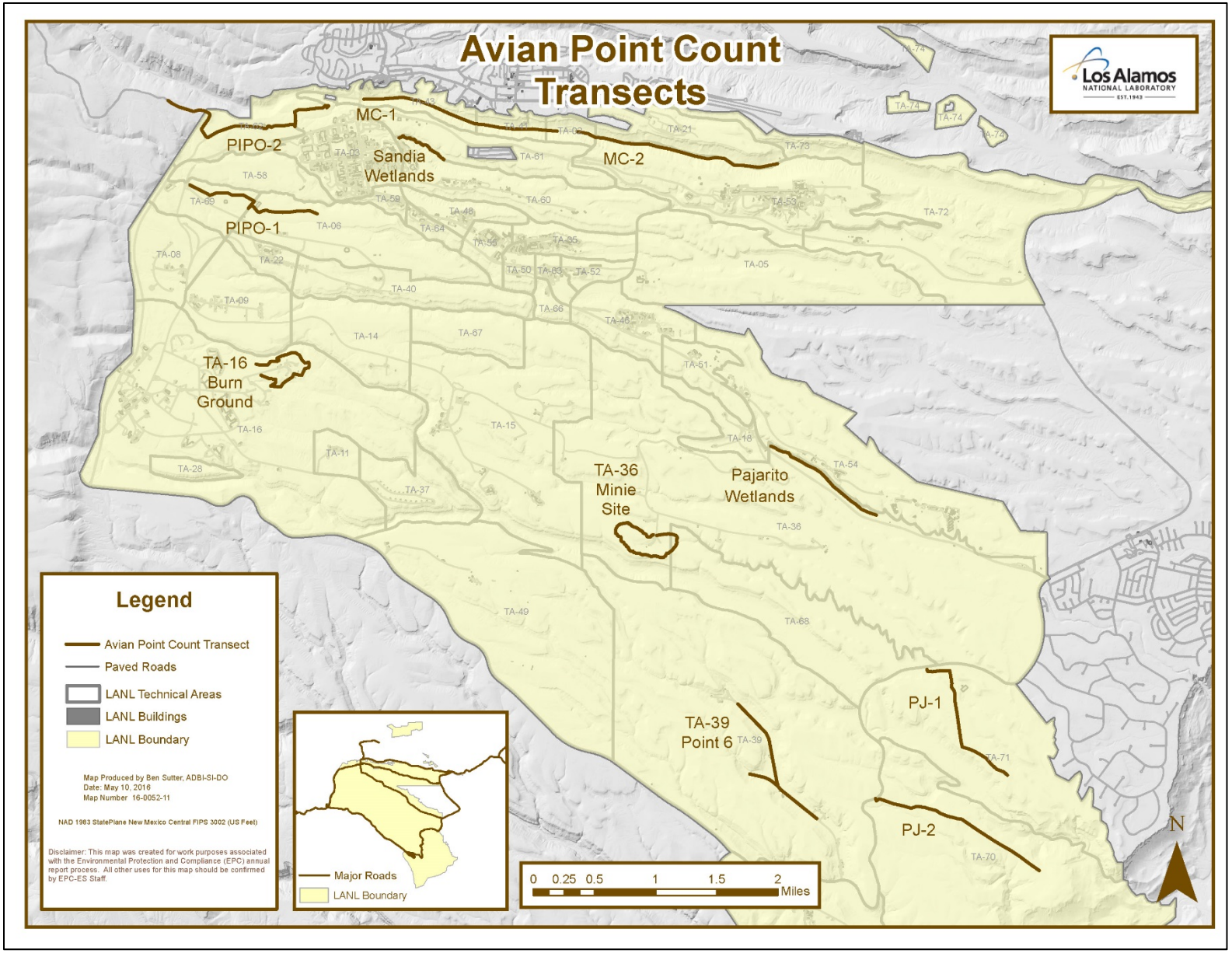

Figure 4. All avian point count transects around LANL.

MC: Mixed Conifer Forest, PIPO: Ponderosa Pine Forest, PJ: Pinyon-Juniper Woodland.

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie site and TA-39 (Figures 1 and 2) and in 2015 nestboxes were added to TA-16 (Figure 3). Data from the three study sites are compared with the overall avian nestbox network at LANL that was established in 1997.

Nestboxes are monitored every 1 to 2 weeks for active nests. When an active nest is found, it is monitored more closely to determine whether the nest fails or successfully fledges young.

Statistical Methods

The data were summarized to look at trends in avian abundance and diversity for the three study sites and the control sites. To compare relative abundances between years and sites, the birds per hour (BPH) was calculated for each site by taking the total number of birds detected per survey and dividing by the total number of minutes surveyed. The result is multiplied by 60 to get the BPH. The BPH of the study sites and control sites were compared using the Mann-Whitney U non-parametric two-sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine avian diversity for the study and control sites. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$H = -1 (p_i (\ln (p_i))$

Where p_i is a percentage value of a specific species in the total population and ln is the natural log.

To compare indices, a Shannon *t* test was used. As described in Magurran (1988), the variance of *H* is determined, which then allows the determination of the *t* value and degrees of freedom. Probability values of 0.05 or less indicated a significant difference in *H* between the two samples. The diversity indices and Shannon's *t* test were computed using PAST version 3.08 statistical software (Hammer et al. 2001).

Birds were categorized into feeding guilds based on the work of De Graaf et al. (1985). For food type, they did not necessarily include all foods taken by each species, only the major food items (20% of diet during a given period).

- Carnivore: vertebrates
- Crustaceovore: crustaceans
- Frugivore: fruits
- Granivore: nuts
- Herbivore: plants (leaves, stems, roots)

- Insectivore: insects
- Moltuscovore: mollusks
- Omnivore: a variety of foods including both animal and plant foods (the less common food group makes up 10% of diet)
- Piscivore: fish
- Vermivore: sandworms, earthworms, etc.

The guilds were customized to account for some bird species being split since the publication. Other changes were made to make it more suited to this study. All woodpeckers were changed from frugivores to omnivores; vermivores (American Robins in this study) were changed to omnivores; hummingbirds were changed from omnivores to nectarivores; Cassin's and House finches were changed from frugivores to granivores. Nectarivores and carnivores were dropped from the analysis due to low samples sizes, leaving granivores, insectivores, and omnivores for this report. The mean number of birds and standard deviation were calculated for each feeding guild. The means of the study sites and control sites were compared using the Mann-Whitney U non-parametric two-sample test because the data were not normally distributed. Probability values of 0.05 or less were considered significant. All significant values in tables are bolded and shaded gray.

Occupancy rate and nest success rate of the nestboxes at the three study sites and in the overall network were calculated. For any single site or overall, the number of active nestboxes divided by the total number of nestboxes is the occupancy rate. Similarly, the number of nestboxes that successfully fledged young divided by the number of active nestboxes is the nest success rate.

Results and Discussion

Three surveys were completed at each of the three study sites and the associated control sites between May and July 2016. A total of 730 birds representing 54 species were recorded at the three study sites. A full account of the 2013–2016 data is detailed in Appendix 1.

The mean BPH abundance values with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figure 5. The BPH was compared between study sites and their control site for each year using the Mann-Whitney U non-parametric two sample test (Table 1). These results indicate that in 2016 the relative abundance of the bird communities at Minie Site and TA-39 was similar to its respective control site. The MC control site was significantly ($p = 0.03$) higher than TA-16.

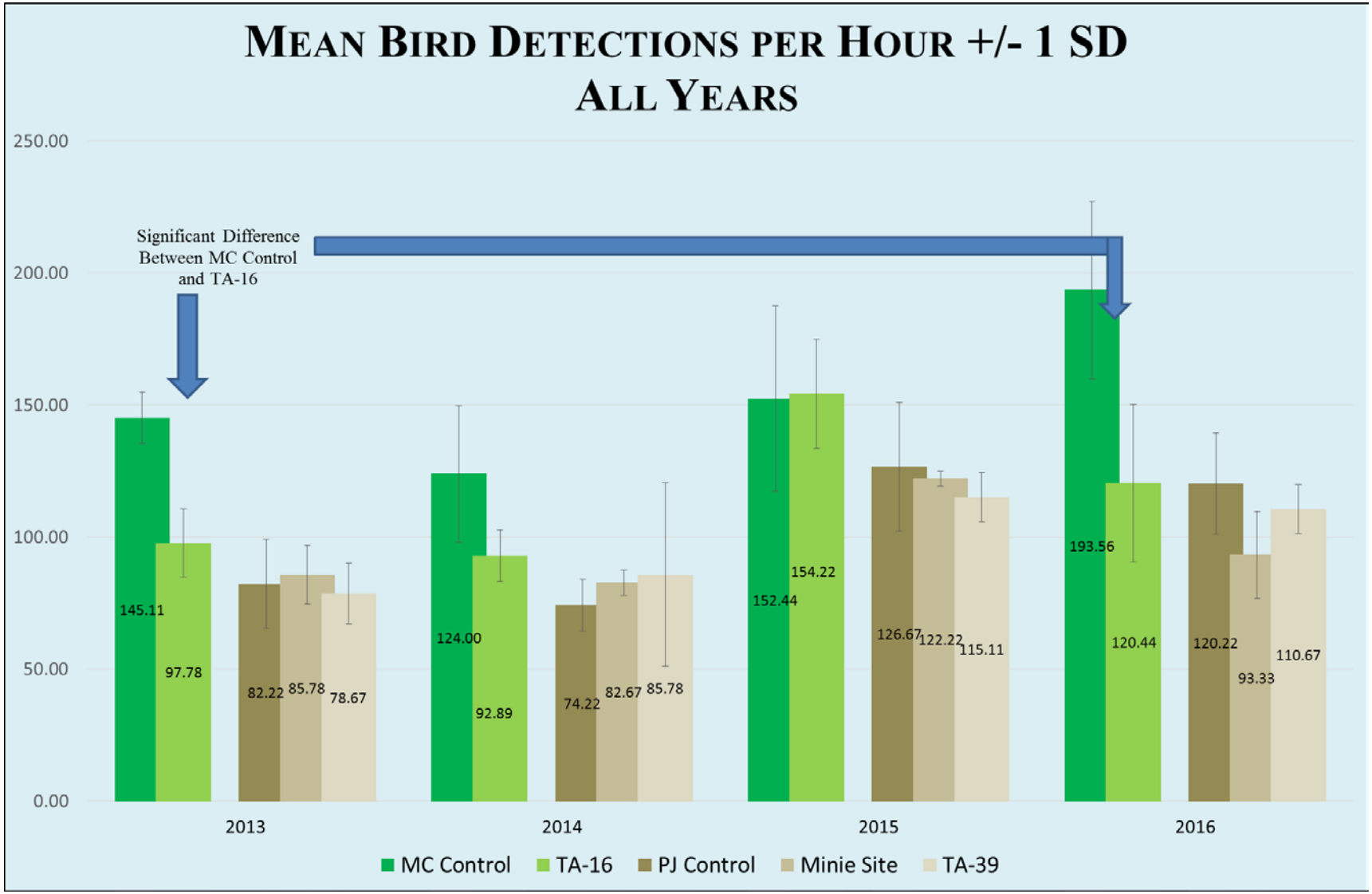

Figure 5. Birds per hour for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

Table 1. Comparisons of BPH between study sites and control sites among years.

Years	MC Control to TA-16	PJ Control to TA-39	PJ Control to Minie Site
2013	**Z = -2.203 (p = 0.03)**	Z = -0.1313 (p = 0.89)	Z = 0.3889 (p = 0.69)
2014	Z = -1.6853 (p = 0.09)	Z = -0.3889 (p = 0.69)	Z = 1.1818 (p = 0.23)
2015	Z = 0.1291 (p = 0.89)	Z = -0.1296 (p = 0.89)	Z = 0.3939 (p = 0.69)
2016	**Z = -2.194 (p = 0.03)**	Z = -0.6482 (p = 0.52)	Z = -1.1668 (p = 0.24)

Note: statistically significant results are shaded.

Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in BPH in 2015 were attributed to the increased precipitation. Links between moisture and habitat quality for a migratory bird have been documented (Smith et al. 2010) and may be a causal factor. The winter of 2015 and into early 2016 was drier. The fluctuations in bird abundances are not alarming and the differences between the study sites and control sites are not *biologically* significant. The 2016 results at the three study sites are still higher than the first two years of the study. The data suggest that LANL operations are not negatively affecting the bird abundances at the three study sites.

The species diversity was determined using the Shannon's diversity index for each of the three study sites as well as the comparable habitat type control sites. The Shannon's diversity values for each site by year are represented in Figure 6. The bird diversity was compared between study sites and their control site for each year using the *t* test (Table 2).

Table 2. Shannon values for the study sites and control sites.

Years	MC Control and TA-16	PJ Control and Minie Site	PJ Control and TA-39
2013	t = 1.4194, df = 376, p = 0.15	**t = 2.9717, df = 510, p < 0.01**	**t = 2.3053, df 466, p = 0.02**
2014	t = 1.9235, df 412, p = 0.06	t = 1.8716, df = 455, p = 0.06	t = 1.0396, df = 477, p = 0.29
2015	**t = 4.4626, df = 653, p < 0.01**	t = 0.52699, df = 663, p = 0.59	t = -0.2166, df = 482, p = 0.82
2016	**t = -2.6496, df 501, p < 0.01**	**t = 2.5304, df = 489, p = 0.01**	t = -1.587, df = 515, p = 0.11

Note: statistically significant results are shaded.

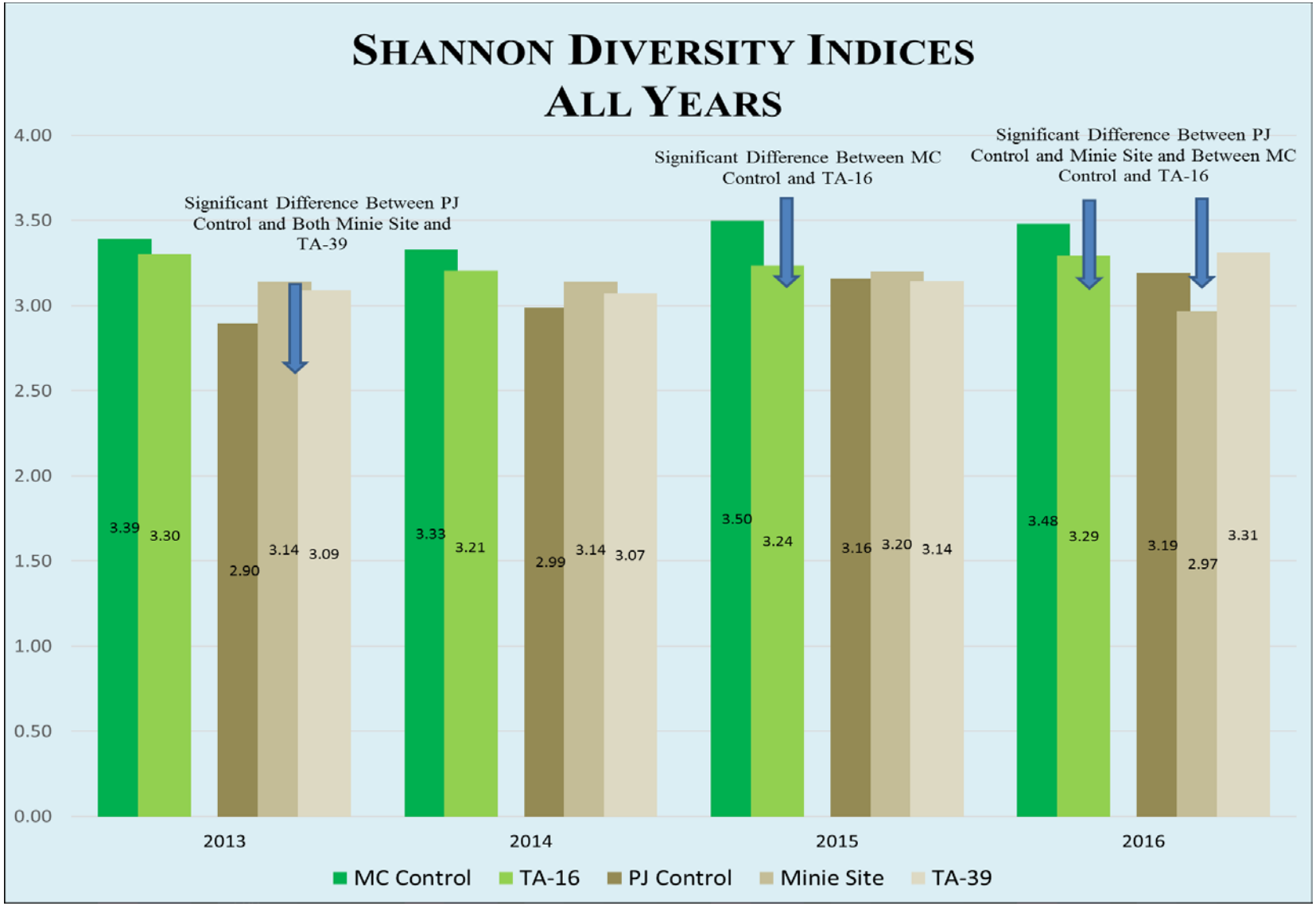

Figure 6. Shannon's diversity indices for the study and control sites.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat.

The 2013 results indicated that the bird diversities in the PJ control sites were significantly less than Minie site ($p < 0.01$) and TA-39 ($p = 0.02$) trending toward similarity in following years. The results also indicate that in 2015 the bird diversity at TA-16 was significantly lower ($p < 0.01$) than the MC control. Hathcock and Fair (2013) discussed this issue and attributed it to the circumstance that the MC control sites were located in a canyon bottom closer to the townsite compared with TA-16 located on a mesa top.

In 2016, the species diversity indices at Minie site were significantly less ($p = 0.01$) than its PJ control, with 14 fewer species present. The TA-16 bird diversity was also significantly less ($p < 0.01$) than its MC control, with seven fewer species present. The significant drop in species diversity at Minie site may be indicative of a change in community structure. Due to increased fuels reduction, including more tree removals, the habitat availability is changing. The site is becoming more grassland-like than PJ. There are currently no control sites for grasslands at LANL but additional control sites may be needed in the future. The 2016 data also show that species diversity was again significantly less at TA-16 than the MC control sites. This trend will continue to be monitored and new research may be warranted to investigate changes in habitat structure and quality.

A new analysis was started in 2015 for this study. Bird species were categorized into feeding guilds based on the work of De Graaf et al. (1985). Only granivores, insectivores, and omnivores are presented in this report. The mean number of birds for these three feeding guilds with error bars corresponding to +/- 1 standard deviation for each site by year are represented in Figures 7–9. Insectivores have consistently been the largest feeding guild, followed by the omnivores and the granivores.

The mean number of birds in 2016 were compared between years and among feeding guilds by study site using the Mann-Whitney U non-parametric two-sample test (Table 3). These results indicate that omnivores increased in the MC control and were significantly higher ($p = 0.03$) than at TA-16. Additionally, the overall number of granivores increased in the PJ control and were significantly higher ($p = 0.03$) than at Mine site. The control sites were analyzed similarly and trends very generally indicate that the mean numbers dropped slightly from 2013 to 2014, increased dramatically in 2015 and then decreased slightly in 2016. This fits well with the precipitation discussion earlier with the BPH differences.

Feeding guilds are also useful to monitor for habitat changes. From Figure 7 it is apparent that granivores are more prevalent in PJ habitats compared with MC. The opposite is seen in Figure 8 as insectivores are much higher in MC habitat than PJ. The omnivores are more evenly distributed among both habitats (Figure 9), which is indicative of their generalist nature, although the MC habitat does still have higher numbers of these birds.

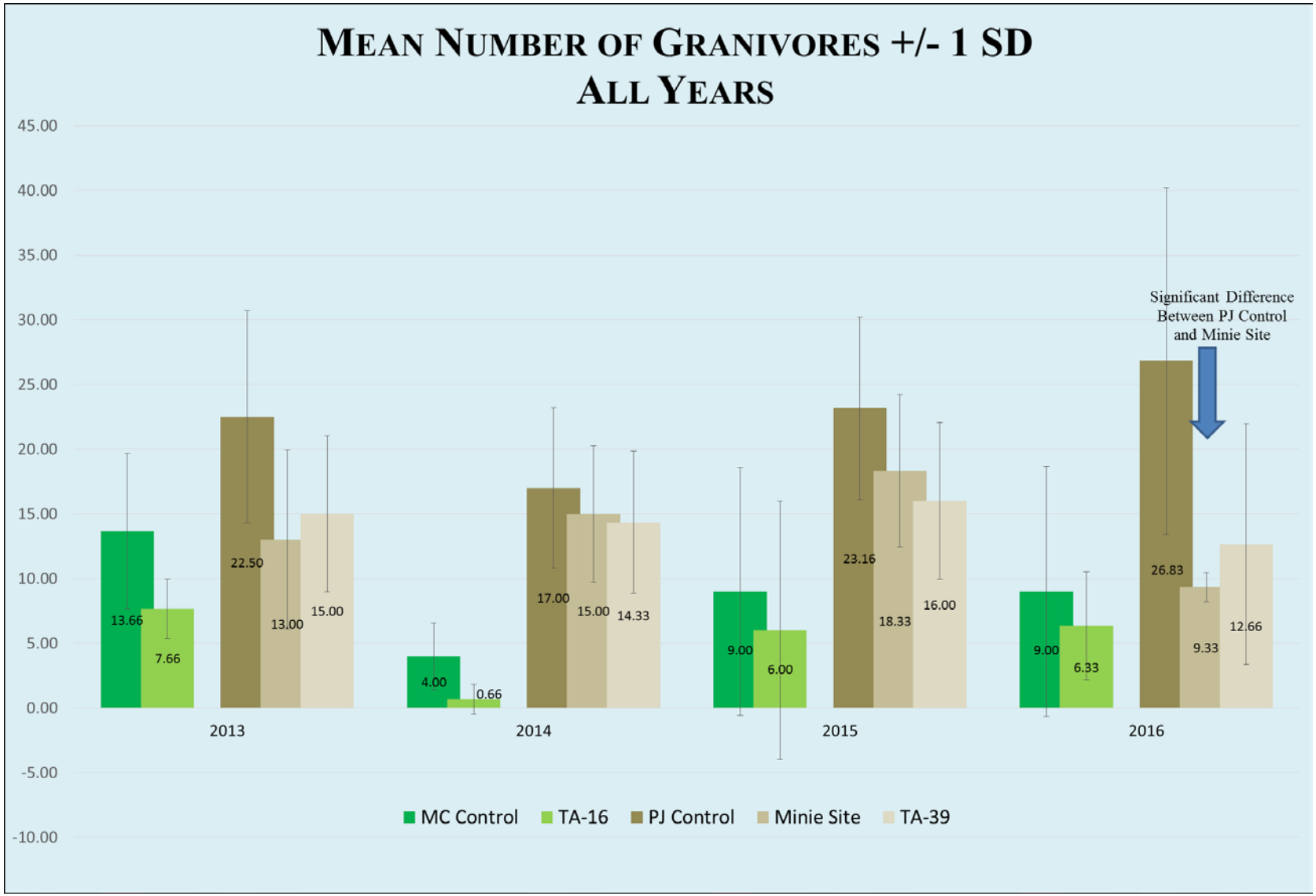

Figure 7. Mean number of granivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

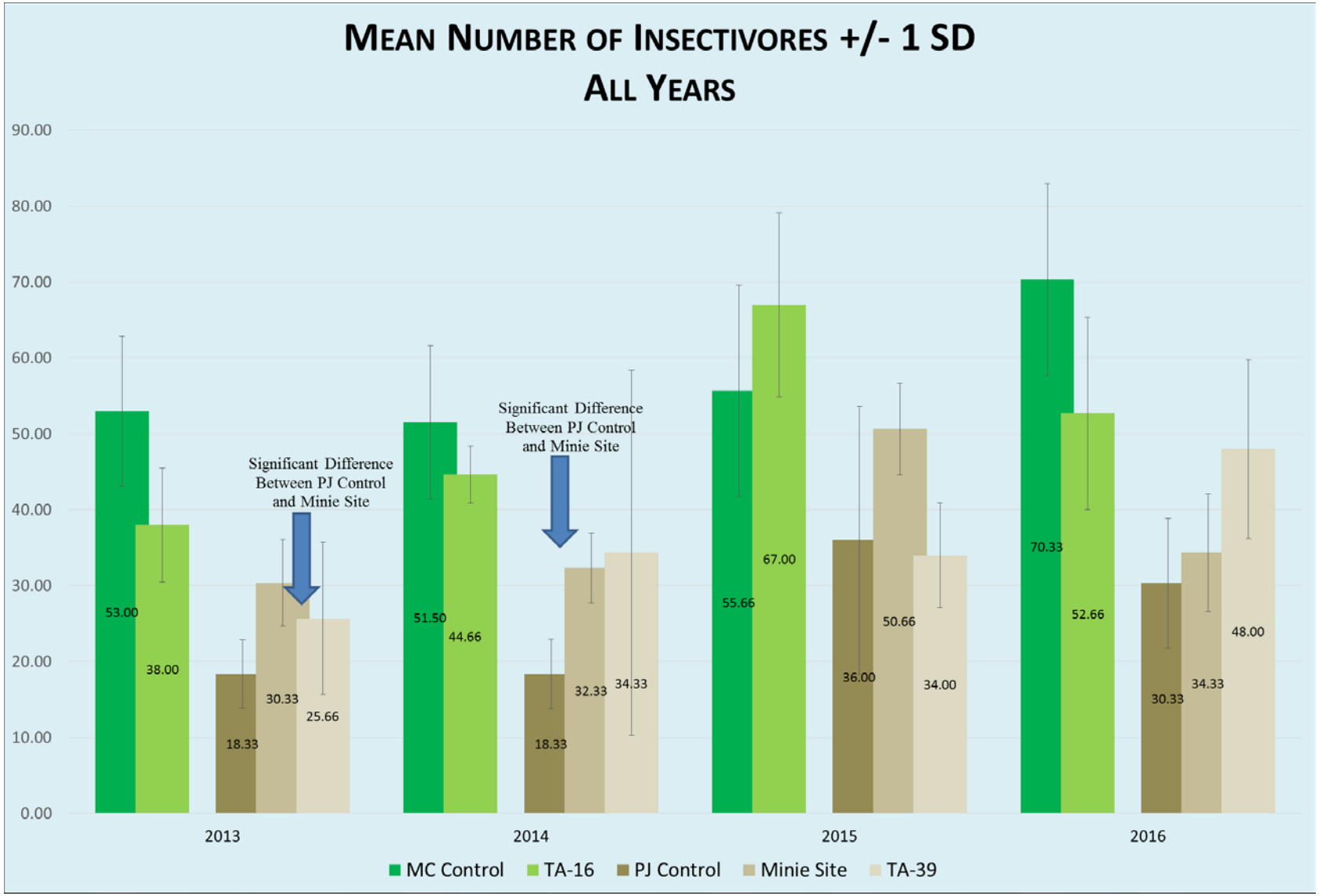

Figure 8. Mean number of insectivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

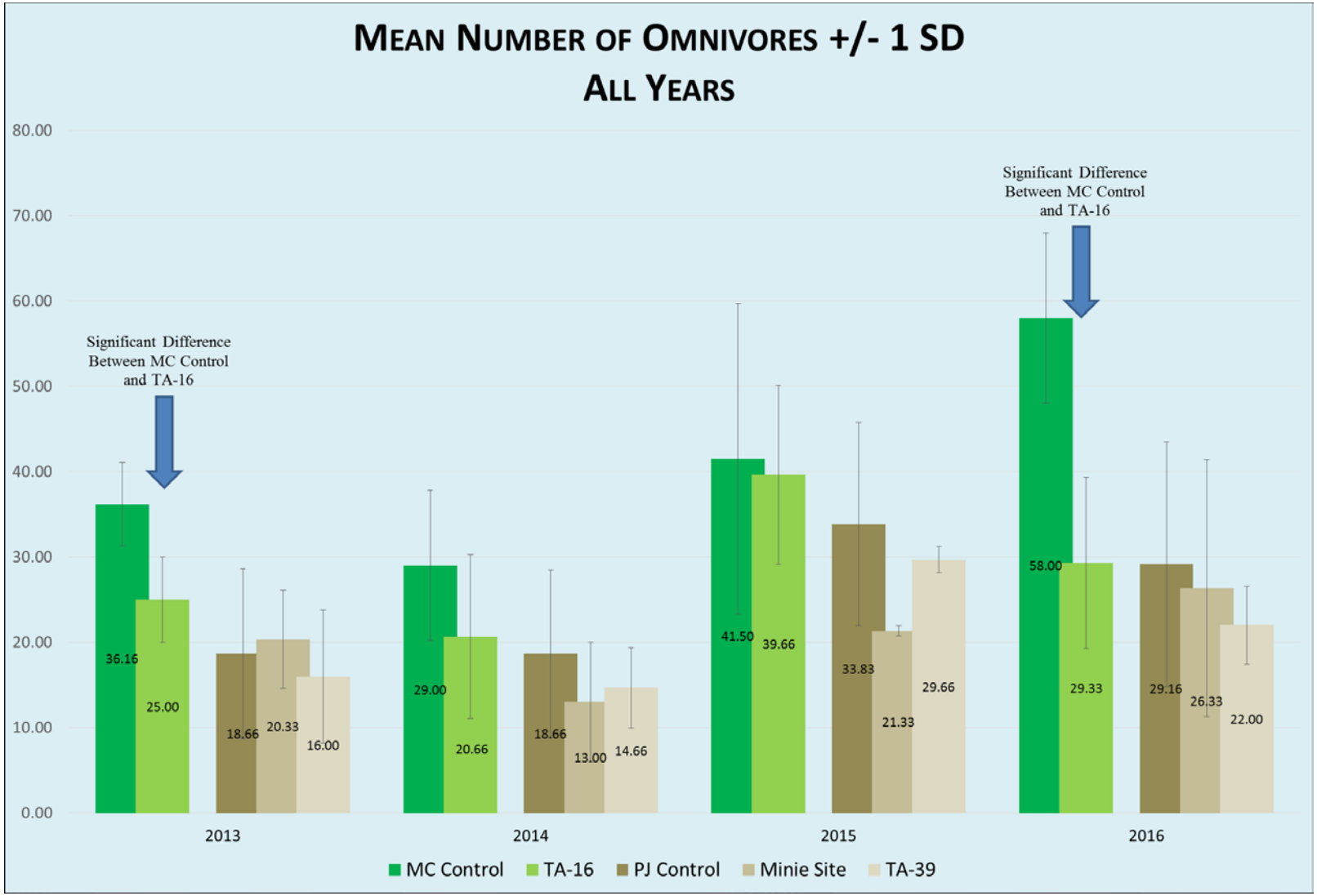

Figure 9. Mean number of omnivores for the study and control sites. Error bars are +/- 1 standard deviation.
MC Control: Mixed conifer habitat, PJ control: Pinyon-juniper habitat

Table 3. Comparing the mean number of birds between study sites and their control by feeding guilds for each year.

	2013			2014		
Site Comparisons	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**
MC Control and TA-16	Z = -1.1921 (p = 0.23)	Z = -1.6783 (p = 0.09)	**Z = -2.2039 (p = 0.03)**	Z = -1.8226 (p = 0.07)	Z = -0.9113 (p = 0.36)	Z = -0.9037 (p = 0.36)
PJ Control and Minie Site	Z = -1.1717 (p = 0.24)	**Z = 1.9696 (p = 0.05)**	Z = 0.3956 (p = 0.69)	Z = -0.2593 (p = 0.79)	**Z = 2.2132 (p = 0.03)**	Z = -0.7811 (p = 0.43)
PJ Control and TA-39	Z = -1.1668 (p = 0.24)	Z = 0.9191 (p = 0.35)	Z = -0.3939 (p = 0.69)	Z = -0.5186 (p = 0.60)	Z = 1.0415 (p = 0.29)	Z = -0.6482 (p = 0.51)

Note: statistically significant results are shaded.

(Continued)

	2015			2016		
Site Comparisons	**Granivore**	**Insectivore**	**Omnivore**	**Granivore**	**Insectivore**	**Omnivore**
MC Control and TA-16	Z = -0.5208 (p = 0.60)	Z = 0.7778 (p = 0.43)	Z = 0.1291 (p = 0.89)	Z = 0.0000 (p = 1.00)	Z = -1.6783 (p = 0.09)	**Z = -2.1947 (p = 0.03)**
PJ Control and Minie Site	Z = -1.0371 (p = 0.29)	Z = 1.4201 (p = 0.15)	Z = -1.4260 (p = 0.15)	**Z = -2.2039 (p = 0.03)**	Z = 0.3873 (p = 0.69)	Z = -0.2593 (p = 0.79)
PJ Control and TA-39	Z = -1.1619 (p = 0.24)	Z = 0.0000 (p = 1.0)	Z = -0.5186 (p = 0.60)	Z = -1.2964 (p = 0.19)	Z = 1.6783 (p = 0.09)	Z = -0.2593 (p = 0.79)

Note: statistically significant results are shaded.

During the 2016 nesting season, fifteen nestboxes each at Minie site and TA-16 and twelve nestboxes at TA-39 were actively monitored. The overall avian nestbox network without the three study sites contained 416 nestboxes in 2016. Of those, 188 contained active nests and 130 of those nests fledged young successfully. This was an overall occupancy rate of 45% with a 69% success rate.

At Minie site, thirteen nests were found and three of the nests fledged young successfully. Only eleven nestboxes were occupied, but two of those nestboxes had a second clutch. This was an occupancy rate of 73% with a 23% success rate.

At TA-39, seven nests were found. This was an occupancy rate of 58% with a 57% success rate. These nestboxes at TA-39 were relocated in 2016, and their occupancy increased seven-fold. The

firing site at TA-39 is in a small narrow canyon and the nestboxes were moved a little further out to a more open area to increase nesting attractiveness. The number of nestboxes in 2016 will also increase to 15 to be consistent.

At TA-16, eleven nests were found and seven of the nests fledged young successfully. This was an occupancy rate of 73% with a 63% success rate.

The occupancy rates at Minie site and TA-16 were greater than the results in the overall network. Yet, the nest success rates of these sites dropped well below the average of the rest of the network. This was largely due to an increase in predation. The redeployment of nestboxes within TA-39 also led to higher occupancy and nest success over previous years' placement. However, more years of data are needed to begin to look at the results in a more robust manner.

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 54 species detected at the three study sites, all are protected under the Migratory Bird Treaty Act. Additionally, two of the species detected at the three study sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three study sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Management Recommendations

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three study sites, contribute to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three study sites from 2013–2016.

Species	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
	TA-36				TA-39				TA-16			
	Pinyon-Juniper Woodland				Pinyon-Juniper Woodland				Mixed Conifer Forest			
Acorn Woodpecker									5		3	2
American Kestrel				1	1			2				
American Robin	1	1	2		1	1		2	7		9	4
Ash-throated Flycatcher	11	5	14	13	19	11	29	12	3	5	6	2
Audubon's Warbler		2						2	6	5	1	6
Bewick's Wren	4	8	9	9	3	10	15	9				
Black-chinned Hummingbird		1	1		3	2			1		1	
Black-headed Grosbeak	1	3				2	4	1			1	2
Black-throated Gray Warbler			1		5	6	4					
Blue-gray Gnatcatcher	3	14	16	8	2		7	5		6	2	1
Broad-tailed Hummingbird	2	1	3		3	1	2		5	11	11	5
Brown Creeper									1			
Brown-headed Cowbird	1						2		4	1		
Bushtit		2		2	2	14						
Canada Goose							16					
Canyon Towhee	2		5	3	1	1	2	10	1			1
Canyon Wren							2	3			2	
Cassin's Kingbird	6	13	13	5	7	6	2	21				1
Chipping Sparrow	3	16	17	29	6	6	5	8	1	5	3	10
Clark's Nutcracker										4		1
Common Nighthawk	6		5	2	5	1	3	2			1	2
Common Raven	2	5	1		1		2	1	5	6	2	2
Cooper's Hawk									1			1

	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Species	TA-36				TA-39				TA-16			
	Pinyon-Juniper Woodland				Pinyon-Juniper Woodland				Mixed Conifer Forest			
Cordilleran Flycatcher									5	10	6	3
Dark-eyed Junco									6	2	4	
Downy Woodpecker				1				1		1		1
Dusky Flycatcher				1			1					
Eurasian Collared-Dove	3											
Evening Grosbeak	3		4				8		5		29	
Grace's Warbler									6	4	4	8
Gray Flycatcher	12	6	5	7	10	10	11	10				
Great Horned Owl		3			1							
Green-tailed Towhee	3	1			1							
Hairy Woodpecker			2	1			5	3	1	1		1
Hammond's Flycatcher									8	9	12	5
Hepatic Tanager							1	2				1
Hermit Thrush										4	6	1
House Finch	16	17	26	17	21	4	23	9	16	2	5	5
House Wren									1	1		2
Juniper Titmouse	12		7	6	11	13	18	6				
Lesser Goldfinch	2	6	7	4	4	12	9	10	3		8	9
MacGillivray's Warbler												1
Mountain Bluebird		2	20	10		4					4	4
Mountain Chickadee	5	2	1	2				1	5	8	9	6
Mourning Dove	17	17	13	5	13	22	10	3	4		1	3
Northern Flicker								3				
Northern Mockingbird						1						
Peregrine Falcon							1					

	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Species	TA-36				TA-39				TA-16			
	Pinyon-Juniper Woodland				Pinyon-Juniper Woodland				Mixed Conifer Forest			
Pine Siskin	10	2		5	6		3	3	12	4	5	
Plumbeous Vireo	10	10	7	3	1		1	6	11	16	15	14
Pygmy Nuthatch				2			2	4	11	13	26	29
Red Crossbill						2				2	9	13
Red-shafted Flicker	3	1	3	2	3	2	4	5	3	4	11	11
Red-tailed Hawk							1	1				
Rock Wren	3	3	4		7	10	4	12	1	2	2	6
Say's Phoebe	2	1	2		2	1		5	1		1	3
Scaled Quail			1									
Spotted Towhee	17	8	19	27	12	6	33	16	11	18	16	14
Steller's Jay									3	2	5	6
Townsend's Solitaire	1											
Turkey Vulture									1			
Violet-green Swallow		5	7	1	6	4	1	9		2	19	2
Virginia's Warbler							1	2	17	11	21	13
Warbling Vireo									2	9	7	6
Western Bluebird	15	11	18	17	5	19	12	21	20	20	49	37
Western Scrub-Jay	5	1	3	4	8	10	4	8	1			
Western Tanager		2	3			2	1	1	2	3	7	2
Western Wood-Pewee	10	8	18	11		4	2	10	15	10	16	14
White-breasted Nuthatch	1	4	9	10			2	4	9	8	7	9
White-throated Swift						1						
White-winged Dove	1	5	9	2	7	5	6	16			1	2
Grand Total	**193**	**186**	**275**	**210**	**177**	**193**	**259**	**249**	**220**	**209**	**347**	**271**

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 9 – Hathcock *et al.* 2018

Environmental Report:

Hathcock, C.D., A.W. Bartlow, and B.E. Thompson. March 2018. *2017 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory*. LA-UR-18-22897.

March 2018

2017 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

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Executive Summary

Los Alamos National Security, LLC (LANS) biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts were compared among years to monitor trends. The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Additionally, nesting success of secondary-cavity nesting birds was examined using nestboxes. LANS biologists completed the fifth year of this effort in 2017. The overall results from 2017 continue to indicate that operations are not negatively affecting bird populations; however, we are seeing some species turnover through time and that will continue to be monitored.

Three bird point count surveys were completed at each of the treatment sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2017. A total of 785 birds representing 59 species were recorded at the treatment sites. Three bird point count surveys were also completed at each of the control sites between May and July 2017. Occupancy and nest success data from nestboxes at treatment sites were compared with the overall avian nestbox monitoring network.

Species richness and diversity at the treatment sites were not statistically different than their associated controls. Avian abundance showed more variability but treatment and controls were trending together year to year. Species composition seems to indicate some species turnover in the habitat types but very little difference between treatment and control sites.

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Introduction

An annual avian monitoring program was started in 2013 as part of the Resource Conservation and Recovery Act permitting process at Los Alamos National Laboratory (LANL) for two open detonation sites, Technical Area (TA) 36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017). The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Comparisons were made with control sites of similar habitat that have been surveyed since 2011 (Hathcock et al. 2011).

Los Alamos National Security, LLC (LANS) biologists used standard point count methodology to record avian abundance and diversity along transects at the three treatment sites and associated control sites during the summer of 2017. Summer surveys provide information about what birds were breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental change at LANL.

In addition to avian point counts, nestboxes were monitored around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success data were compared with the overall avian nestbox monitoring network, which was established in 1997.

Changes to the analysis methodologies were implemented this year. TA-16 is now being compared with a different set of controls, switching from a mixed conifer control to a ponderosa control. This change is retroactive for this report and all previous years were reanalyzed. The larger analysis of feeding guilds was dropped because of low sample sizes and difficulty in assigning guilds, they are still mentioned in a more general sense. Also, more robust statistics are used to analyze the datasets. In this report, the year 2017 is first analyzed separately, and then all years are analyzed to examine trends over time.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon-juniper woodland (PJ) for Minie and TA-39 and a ponderosa pine forest (PIPO) at TA-16. These habitat descriptions were based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) were monitored

annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock et al. (2011). Each habitat type control contained two replicate transects that were monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects were randomized and surveyed according to the random order.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was more natural.

Transects were approximately 2.0 to 2.5 km in length and allowed for nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site and surveys must be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an “unlimited-distance circular plot”; however, the distance to each bird out to 100 m should be noted. Care is needed to ensure that individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, note any species encountered that have not otherwise been counted from a previous point or future point. The surveyor’s main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Record all birds encountered on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- Use the “NOTES” section to indicate any potentially important aspects of the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Other wildlife or evidence of wildlife that could be used for other projects should be recorded.

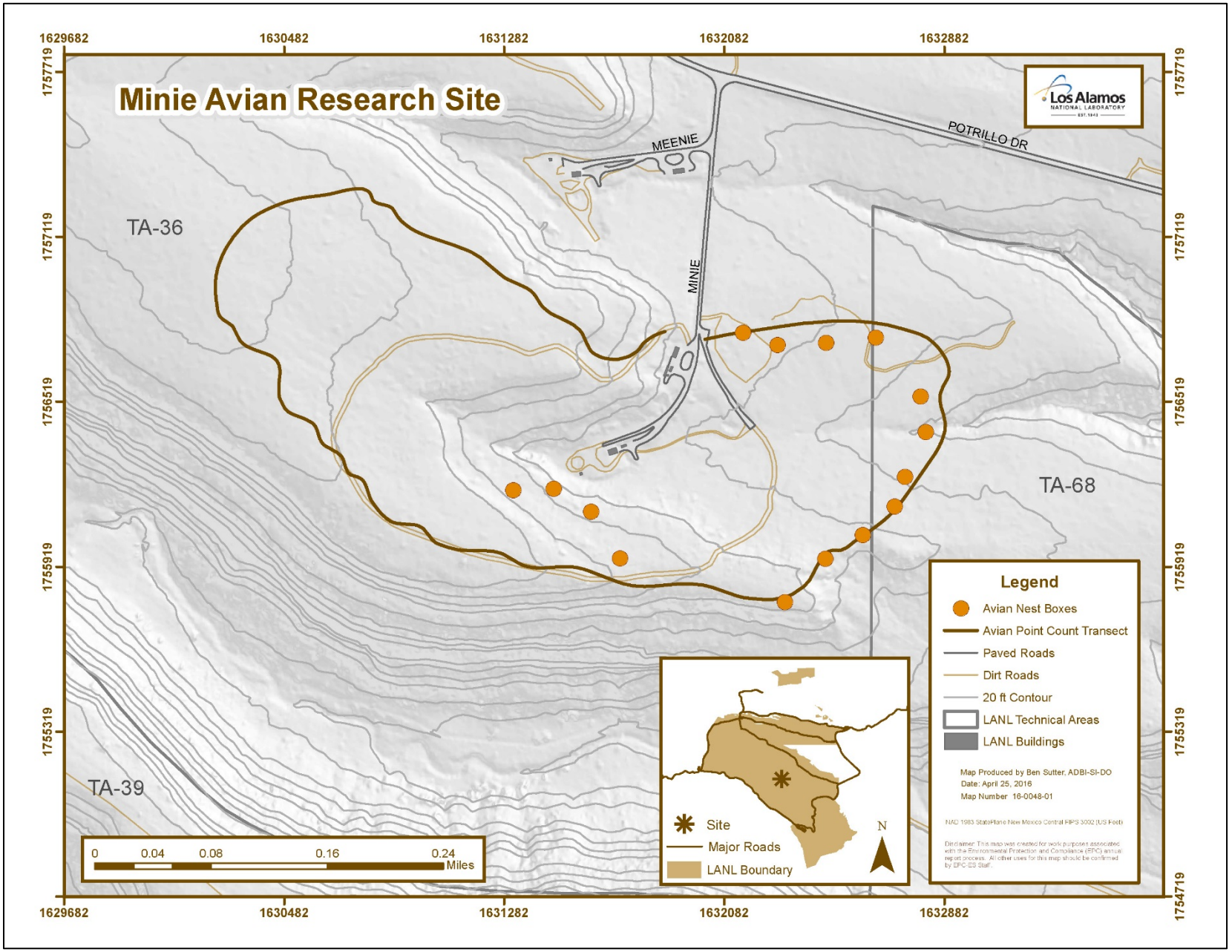


Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site

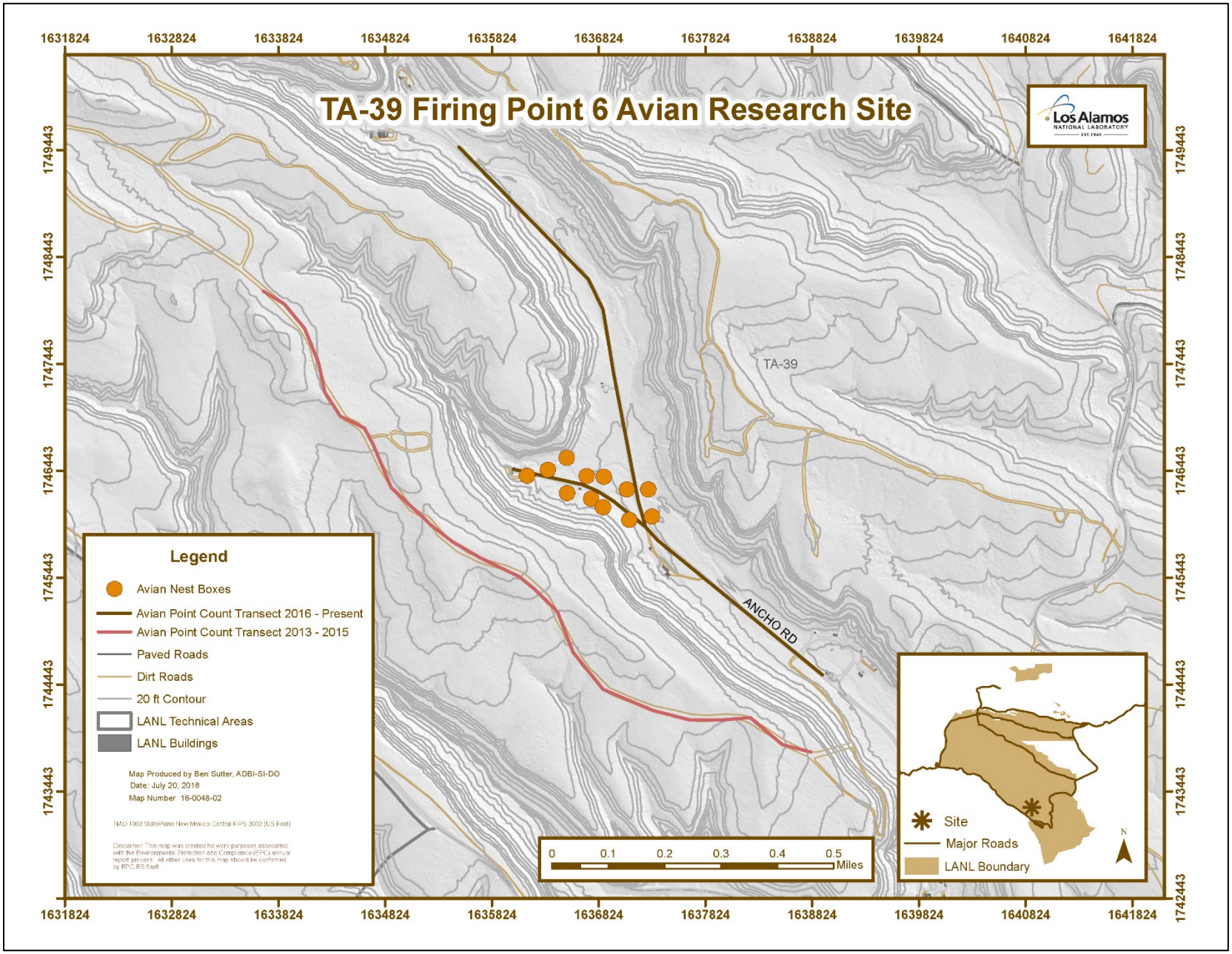


Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6

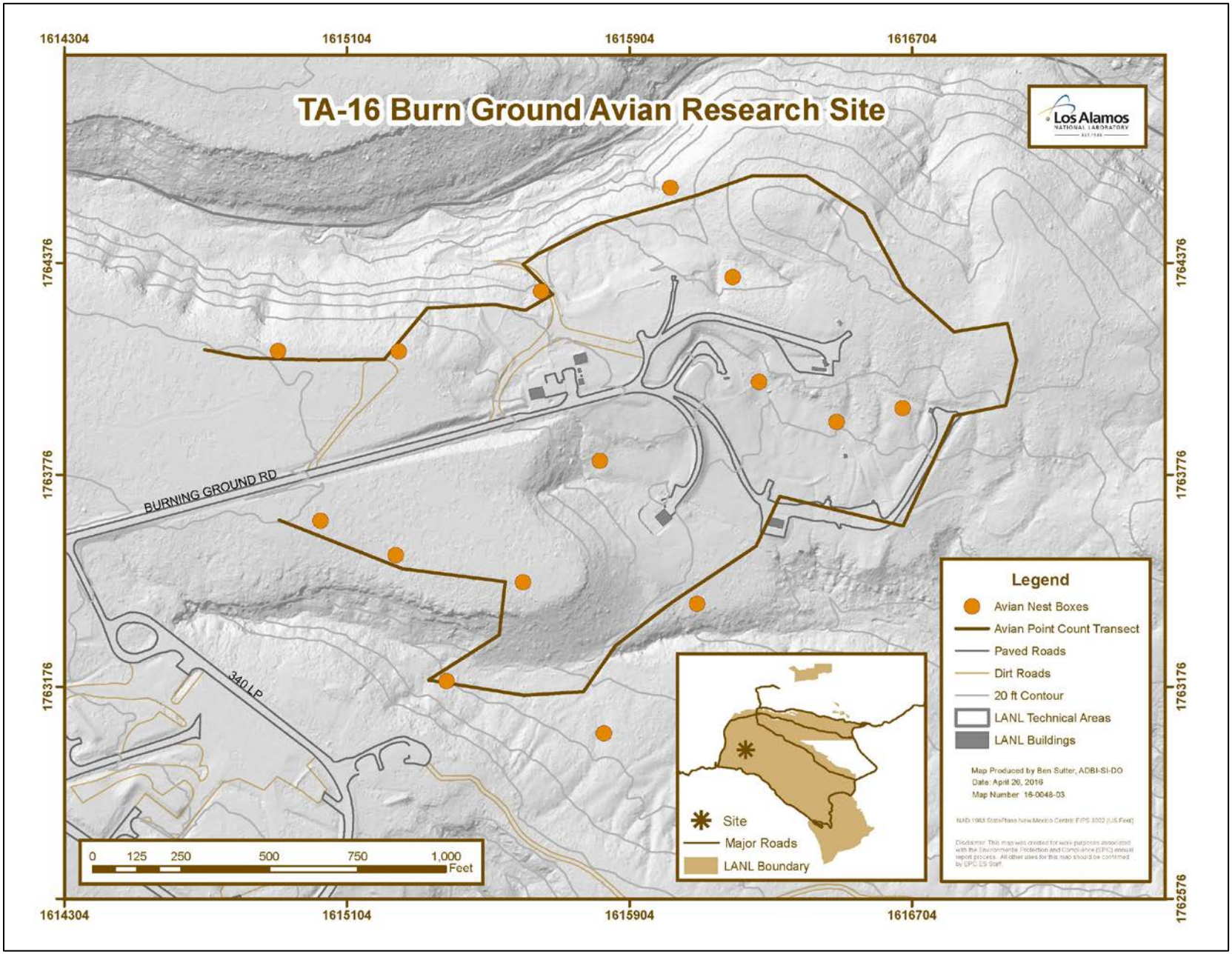


Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground

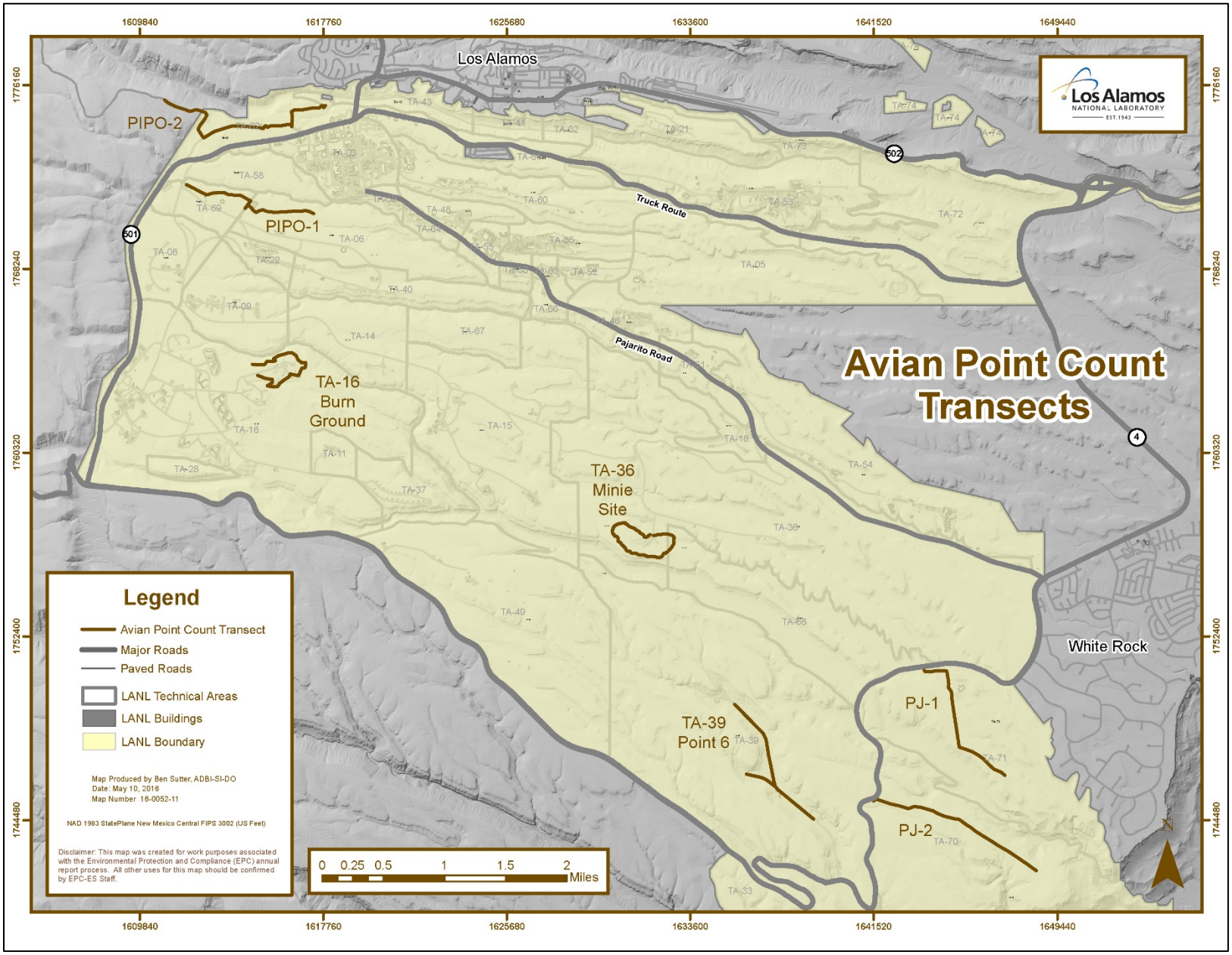


Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie and TA-39 (Figures 1 and 2). In 2015, nestboxes were added to TA-16 (Figure 3). Nestboxes were monitored every 1 to 2 weeks for active nests. When an active nest was found, it was monitored more frequently to determine whether the nest failed or successfully fledged young. Nestlings were also banded and the sex determined after the age of 10 days.

Statistical Methods for Point Counts

The data were summarized to compare species richness, diversity, abundance, and composition between sites and among years using the statistical software R (version 3.4.1; R Core Team 2017). Species richness and diversity were computed using the R-package 'iNEXT' (Hsieh et al. 2016; Chao et al. 2014) and plotted with bootstrap confidence intervals around the mean for rarefied/extrapolated samples, facilitating the comparisons of richness and diversity. The estimated asymptote along with a confidence interval was also provided. The Simpson's diversity index was calculated using the following formula: $D = 1 - (\sum n(n-1) / N(N-1))$, where n = the total number of organisms of a particular species and N = the total number of organisms of all species. The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0 represents no diversity. Species diversity was also computed using the statistical software PAST (Hammer et al. 2001) and a t-test was used to test for differences between treatment and control sites each year. Comparisons of Simpson diversity in two samples is described by Hutcheson (1970) and is an alternative to the permutation test. To examine species abundance, we used the number of individual birds among sites and across years and looked for trends. To examine species composition, non-metric multidimensional scaling (NMDS) was used to determine dissimilarity among sites. To compare species composition between treatments and years, an analysis of similarity (ANOSIM) was conducted using 1000 permutations. These analyses were completed using the community ecology package 'vegan' (Oksanen et al. 2017) in R.

Statistical Methods for Nestboxes

Occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network were calculated. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. Annually, data from the three treatment sites were compared with the overall avian nestbox network at LANL that was established in 1997.

Results and Discussion

Year 2017

Three surveys were completed at each of the three treatment sites and the associated control sites between May and July 2017. A total of 785 birds representing 59 species were recorded at the three treatment sites. A full account of the 2013–2017 data is detailed in Appendix 1.

Species richness is the number of different species represented in an ecological community and is simply a count of species. In this case, each treatment site and control are individual communities. Species diversity is a measure that takes into account the species richness and the overall abundance to compare evenness across a community. Here we used the Simpson's diversity index which measures the probability that two individuals randomly selected from a sample will belong to different species. The abundance is the total number recorded of a given species. Table 1 details the species richness, diversity, and abundance for 2017 for each site and its associated controls.

Table 1. The species richness, diversity, and abundance recorded at each site in 2017

2017	*Minie Site*	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	35	34	37	39	41	46	44
Diversity	0.9429	0.9486	0.9211	0.9462	0.9429	0.931	0.9462
Abundance	222	261	240	300	302	447	449

Species rarefaction and extrapolation from 2017 show no differences between treatment and control sites for species richness. There were overlapping 95% confidence intervals for species richness (Figures 5A–7A) for all three treatments and their controls. Simpson's diversity (Figures 5B–7B) was not as clear with 95% confidence intervals being further apart. To further analyze species diversity, we compared treatments to control sites using t-tests and confirmed that there was not a significant difference (Minie/Control t-test: $t = 0.1504$, $p = 0.88$; TA-39/Control t-test: $t = 1.2234$, $p = 0.22$; TA-16/Control t-test: $t = -0.6903$, $p = 0.49$) when comparing treatment to combined control sites. The two control transects for PJ were not as similar in diversity as expected ($t = -2.5322$, $p = 0.01$). For the PJ habitat type, control 1 is a walking transect and control 2 is a driving transect and the act of driving between points may be causing more species to be seen.

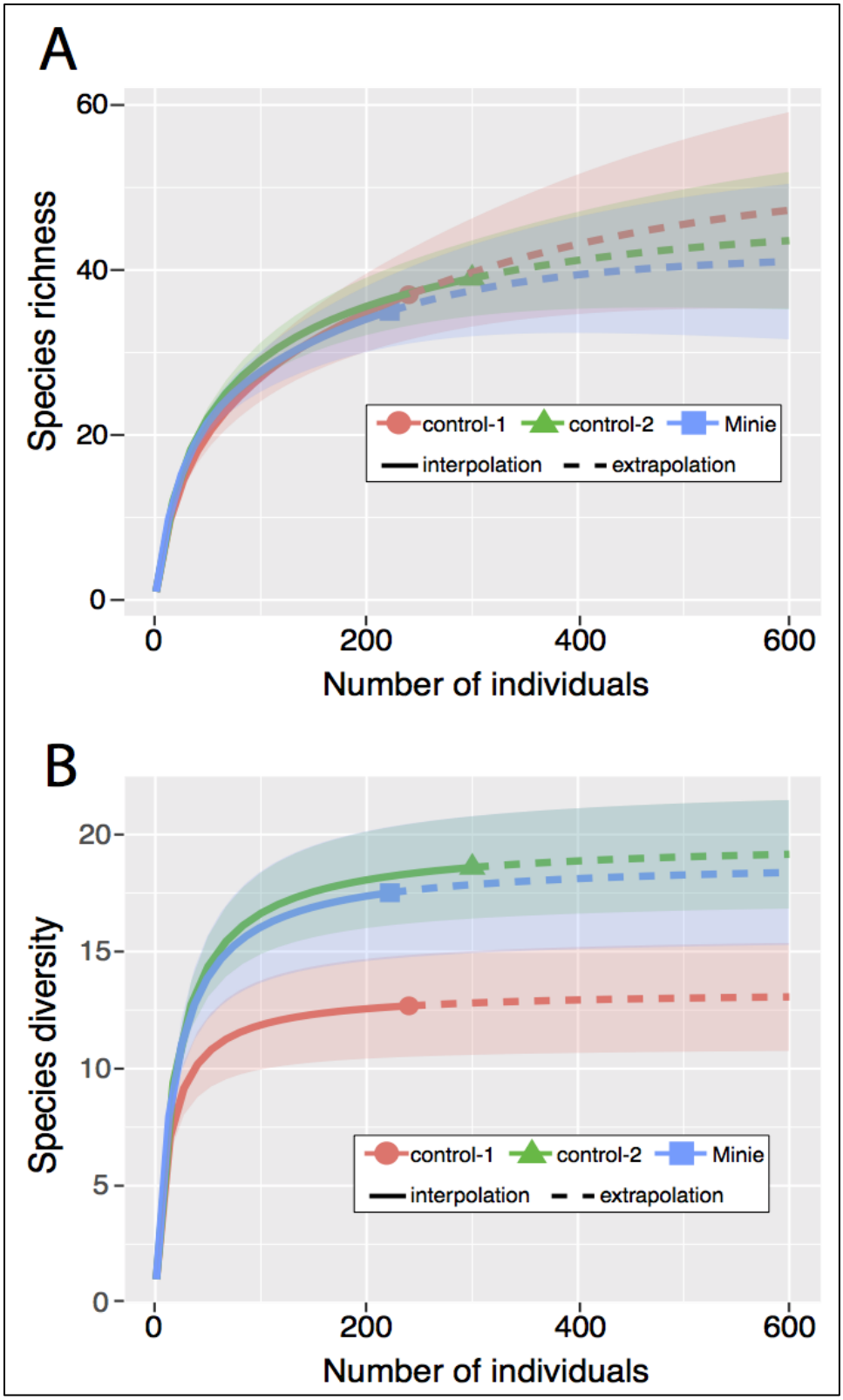


Figure 5. **Species rarefaction and extrapolation for species richness and diversity comparing Minie with the PJ controls**

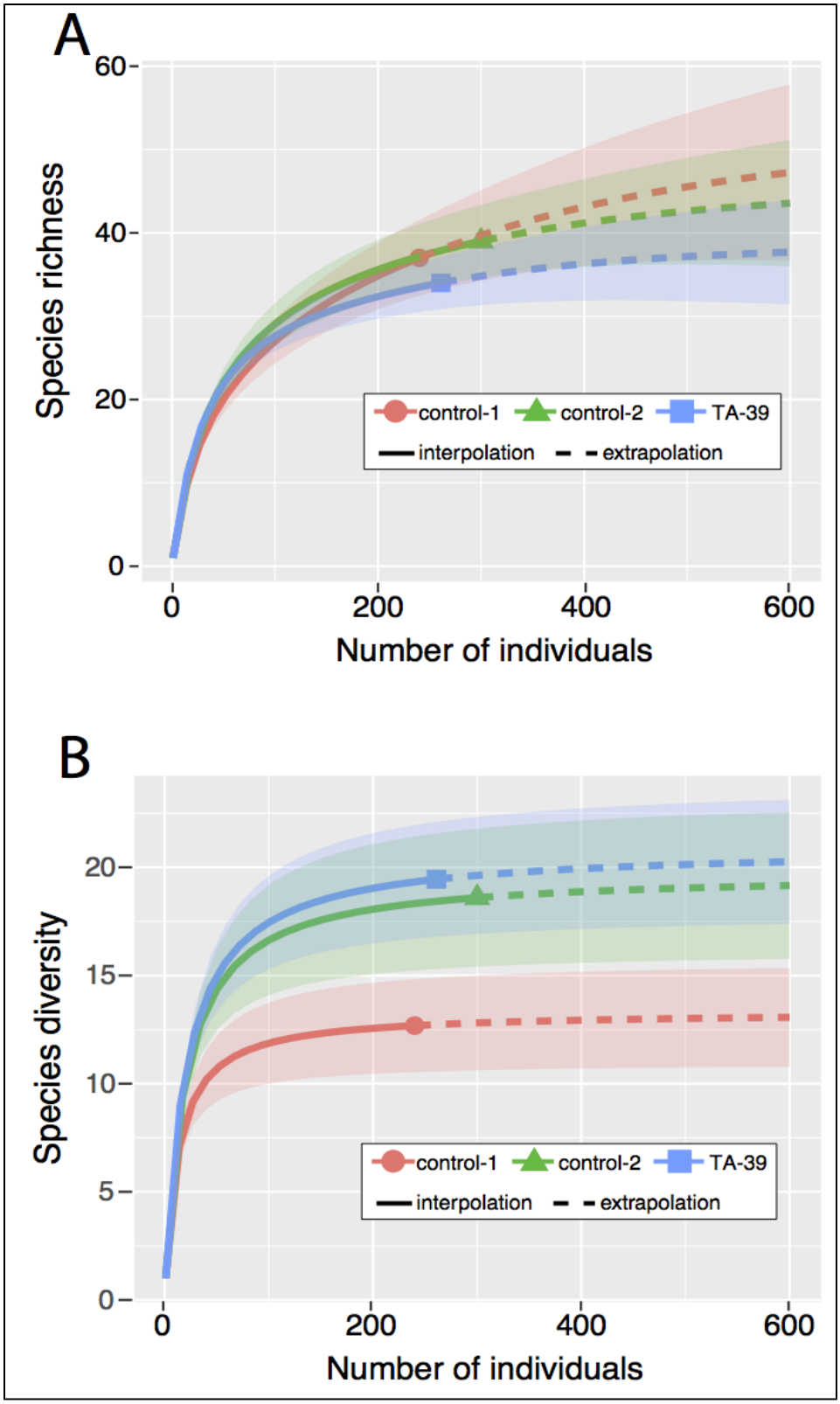


Figure 6. **Species rarefaction and extrapolation for species richness and diversity comparing TA-39 with the PJ controls**

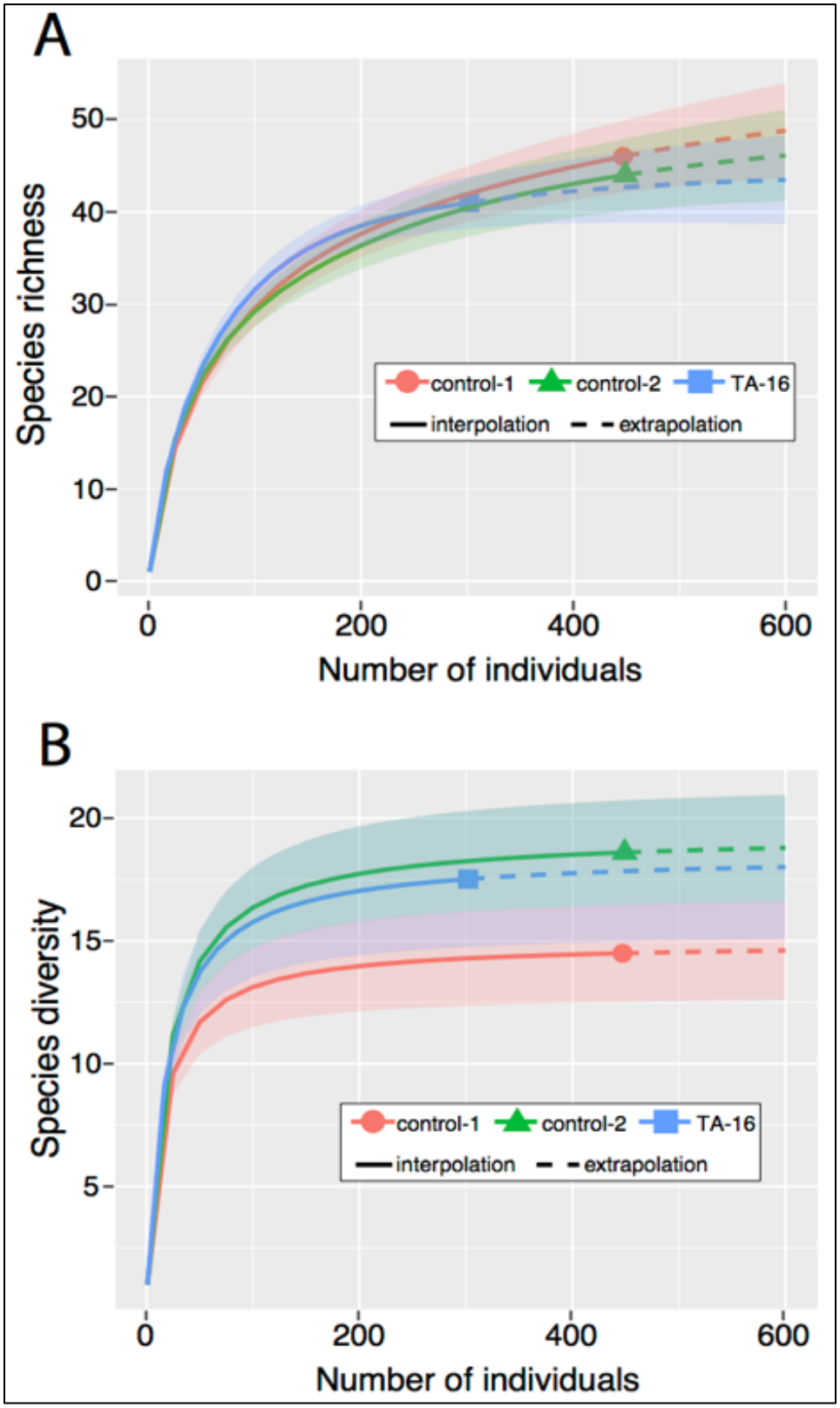


Figure 7. Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls

Multivariate analysis with ordination was used to explore the data further to look for patterns that may be explained by a multitude of other environmental factors not assessed directly. We used NMDS with three dimensions (Gardener 2014) in which a measure of 'stress' (mismatch between the rank order of distances in the data, and the rank order of distances in the ordination) was calculated. The samples were moved slightly in a direction that decreases the stress until stress appeared to reach a minimum. The final configuration of points is represented in Figure 8. Here, the species surrounding each site means that these species were important in separating the sites. The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated habitat types. This graphically shows how the data for the PJ control sites were not as similar as the PIPO control sites in terms of species composition, which were on either side of the y-axis. This also shows what species were driving the patterns. The transect in TA-39 was in a canyon bottom whereas the PJ control transects were on mesa tops. The species driving the location of TA-39 was the White-winged Dove (WWDO), which is not as prevalent at both of the PJ control transects. Additionally, the Pinyon Jay (PIJA) and the Black-throated Gray Warbler (BTYW) were found mostly in PJ sites, while the Acorn Woodpecker (ACWO) and Hammond's Flycatcher (HAFL) were mainly found in ponderosa habitats. Based on their known habitat preferences, these data were consistent. The treatment sites were not significantly different from control sites (ANOSIM: R = 0.0, P = 0.4).

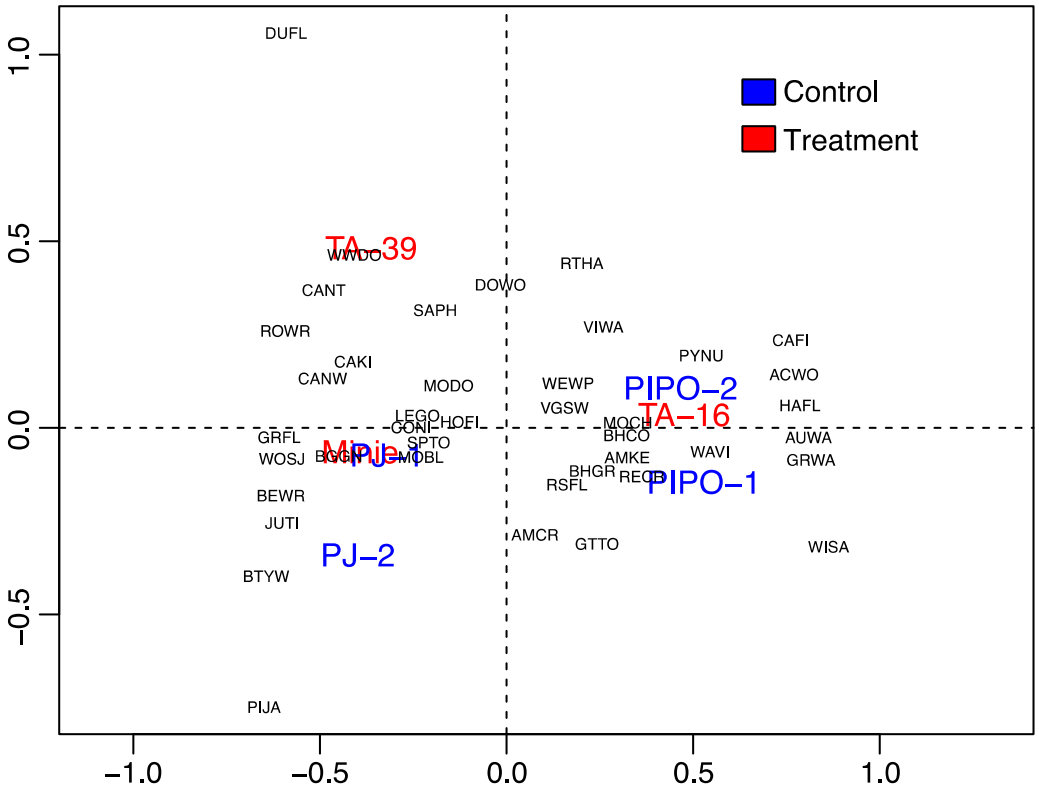


Figure 8. Non-metric multidimensional scaling of bird species and sites in 2017

Trends Over Time

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for a migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The fluctuations in bird abundances are not alarming, and the differences between the treatment sites and control sites are not biologically significant.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*
Minie	33	33	34	30	35
TA-39	31	31	39	38	34
PJ Control 1	29	30	33	36	37
PJ Control 2	30	29	37	33	39
TA-16	33	33	40	44	41
PIPO Control 1	34	34	30	41	41
PIPO Control 2	33	36	43	43	44

Tables 3–5 compare the species diversity over time between the treatment site and the combined control. The two control sites were combined to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of the study. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Figures 9 and 10 graphically represent the data fluctuations over time. Even though we see significant differences, the bird diversity at all sites is greater than 0.90, which compared with other systems, is very high.

Figures 11 and 12 graphically represent bird abundances over time. The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower, but the percent abundance is similar year to year when compared with the control sites.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls*

	2013	*2014*	*2015*	*2016*	*2017*
Minie	0.9464	0.9463	0.9502	0.9315	0.9429
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419
t-test	t = 3.9572 df = 501.3 p = <0.01	t = 2.5469 df = 510.42 p = 0.01	t = 1.5902 df = 644.91 p = 0.11	t = 0.4385 df = 499.33 p = 0.66	t = 0.1504 df = 448.66 p = 0.88

* Darker shading indicates a significant difference.

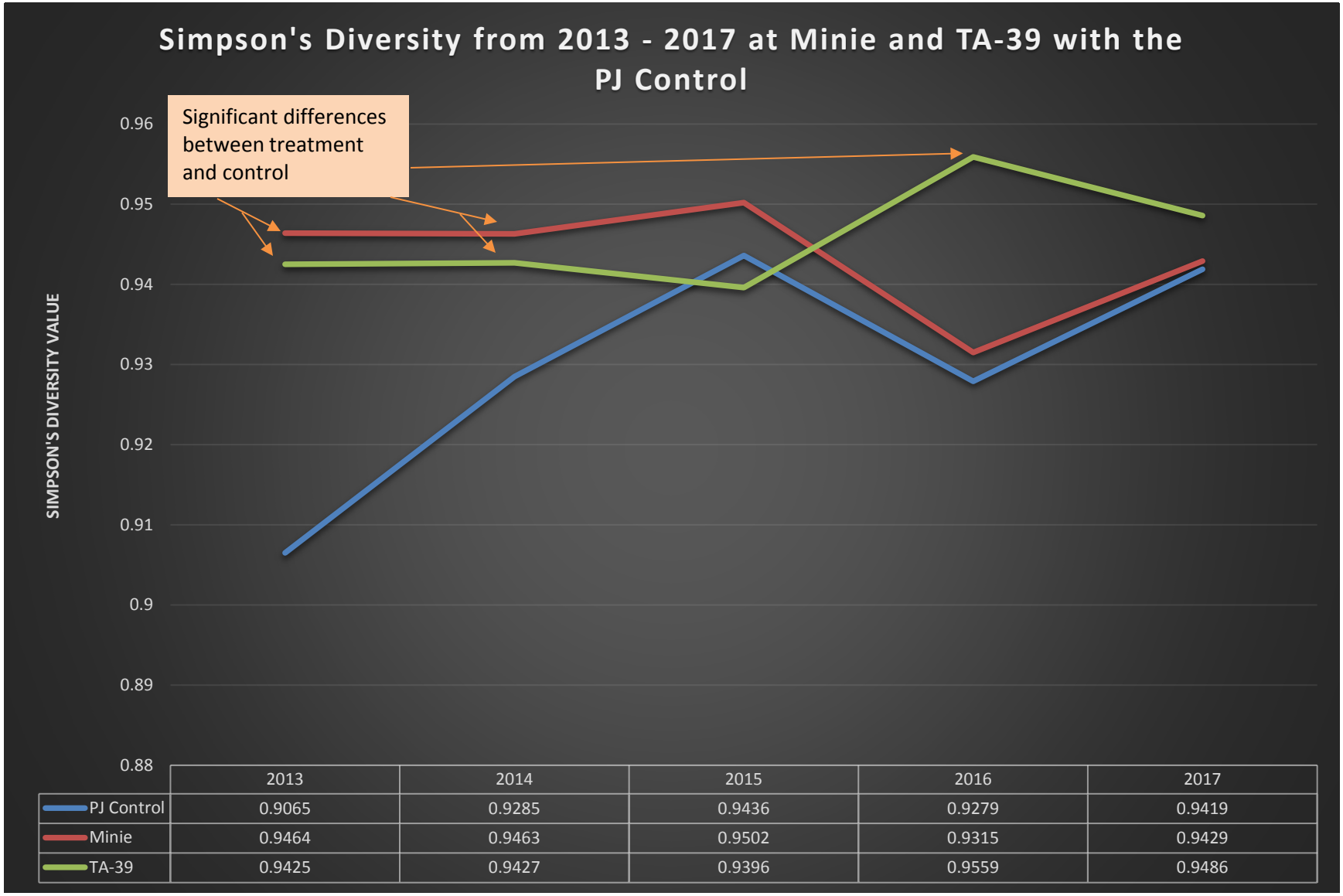
Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls*

	2013	*2014*	*2015*	*2016*	*2017*
TA-39	0.9425	0.9427	0.9396	0.9559	0.9486
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419
t-test	t = 3.3636 df = 538 p <0.01	t = 1.9703 df = 509.25 p = 0.05	t = -0.6751 df = 401.58 p = 0.50	t = 4.5611 df = 783.86 p <0.01	t = 1.2234 df = 705.5 p = 0.22

* Darker shading indicates a significant difference.

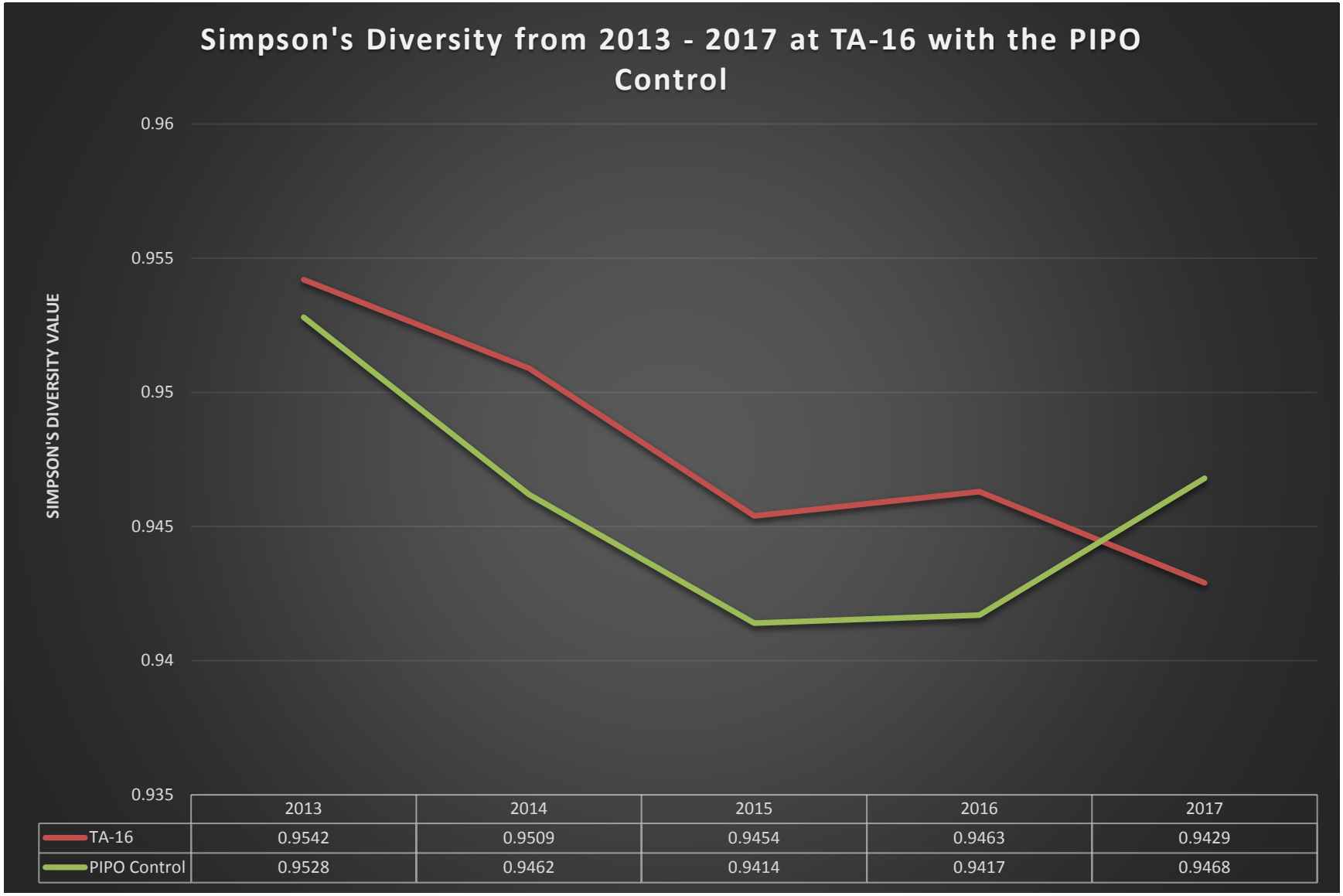
Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*
TA-16	0.9542	0.9509	0.9454	0.9463	0.9429
PIPO Control	0.9528	0.9462	0.9414	0.9417	0.9468
t-test	t = 0.3323 df = 378.91 p = 0.73	t = 0.9236 df = 472.24 p = 0.35	t = 0.748 df = 633.26 p = 0.45	t = 0.7438 df = 475.6 p = 0.45	t = -0.6903 df = 444.95 p = 0.49



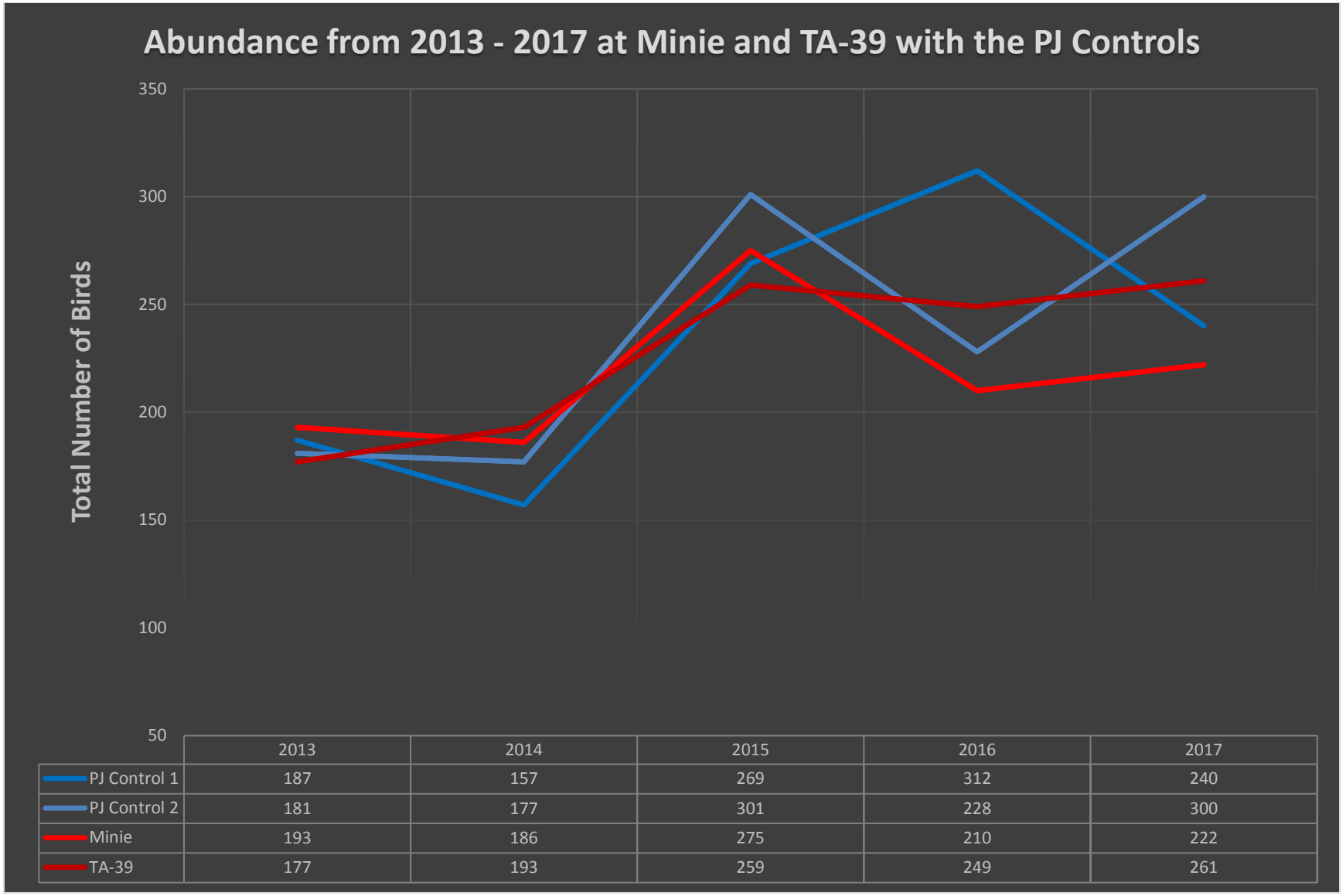
	2013	2014	2015	2016	2017
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419
Minie	0.9464	0.9463	0.9502	0.9315	0.9429
TA-39	0.9425	0.9427	0.9396	0.9559	0.9486

Figure 9. Changes in species diversity over time comparing Minie and TA-39 with the PJ controls



	2013	2014	2015	2016	2017
TA-16	0.9542	0.9509	0.9454	0.9463	0.9429
PIPO Control	0.9528	0.9462	0.9414	0.9417	0.9468

Figure 10. Changes in species diversity over time comparing TA-16 with the PIPO controls



	2013	2014	2015	2016	2017
PJ Control 1	187	157	269	312	240
PJ Control 2	181	177	301	228	300
Minie	193	186	275	210	222
TA-39	177	193	259	249	261

Figure 11. Changes in abundance over time comparing Minie and TA-39 with the PJ controls

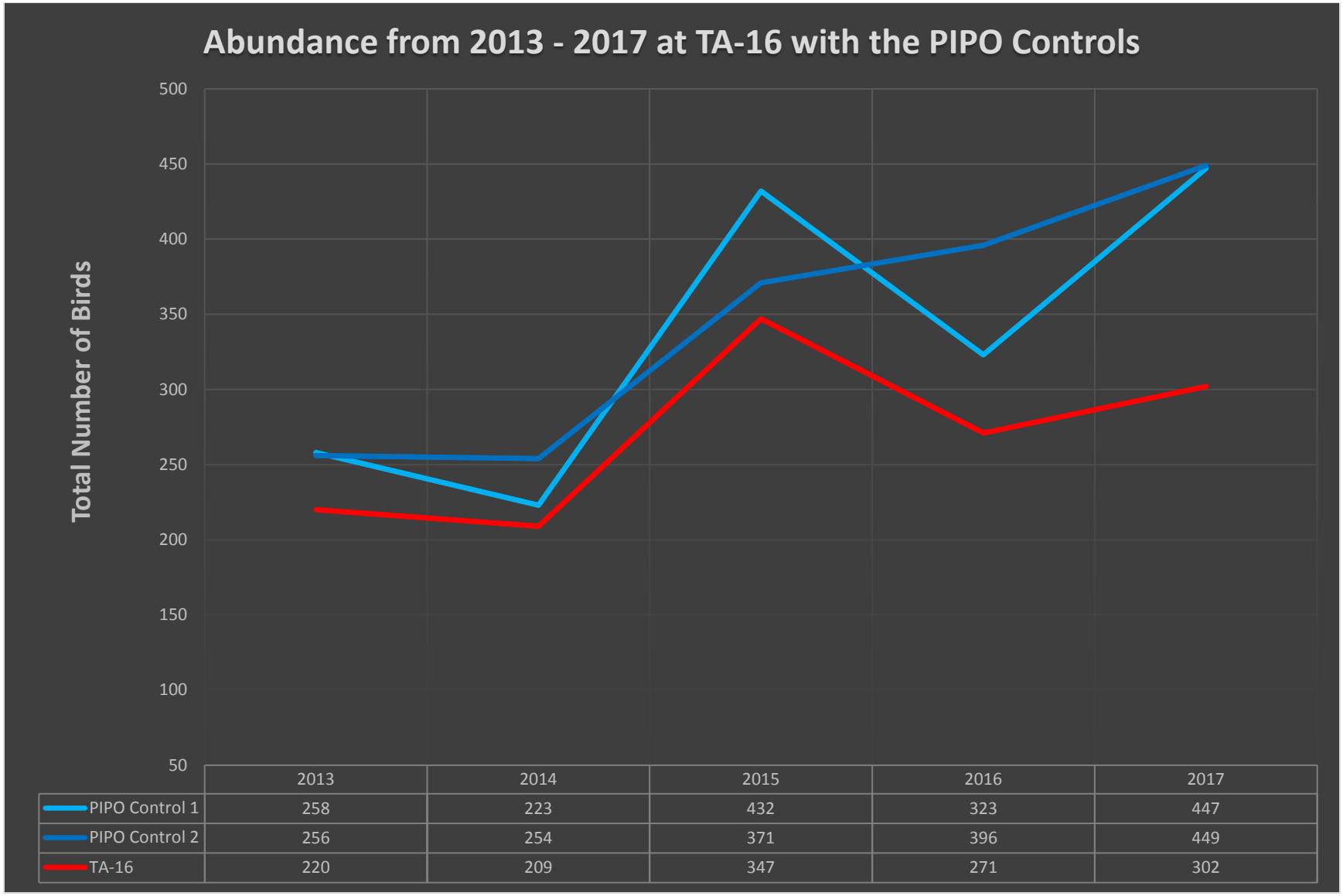


Figure 12. Changes in abundance over time comparing TA-16 with the PIPO controls

Species composition was analyzed over time according to whether sites were controls or treatments for PJ sites and ponderosa sites separately (Figures 13 and 14). Figure 13 shows the species composition for PJ sites for each year. The difference in species composition was significant between treatment sites and control sites for PJ habitats (ANOSIM: R = 0.35, P = 0.05; Figure 13). The species closest to each site were the species most important in separating those sites from the rest.

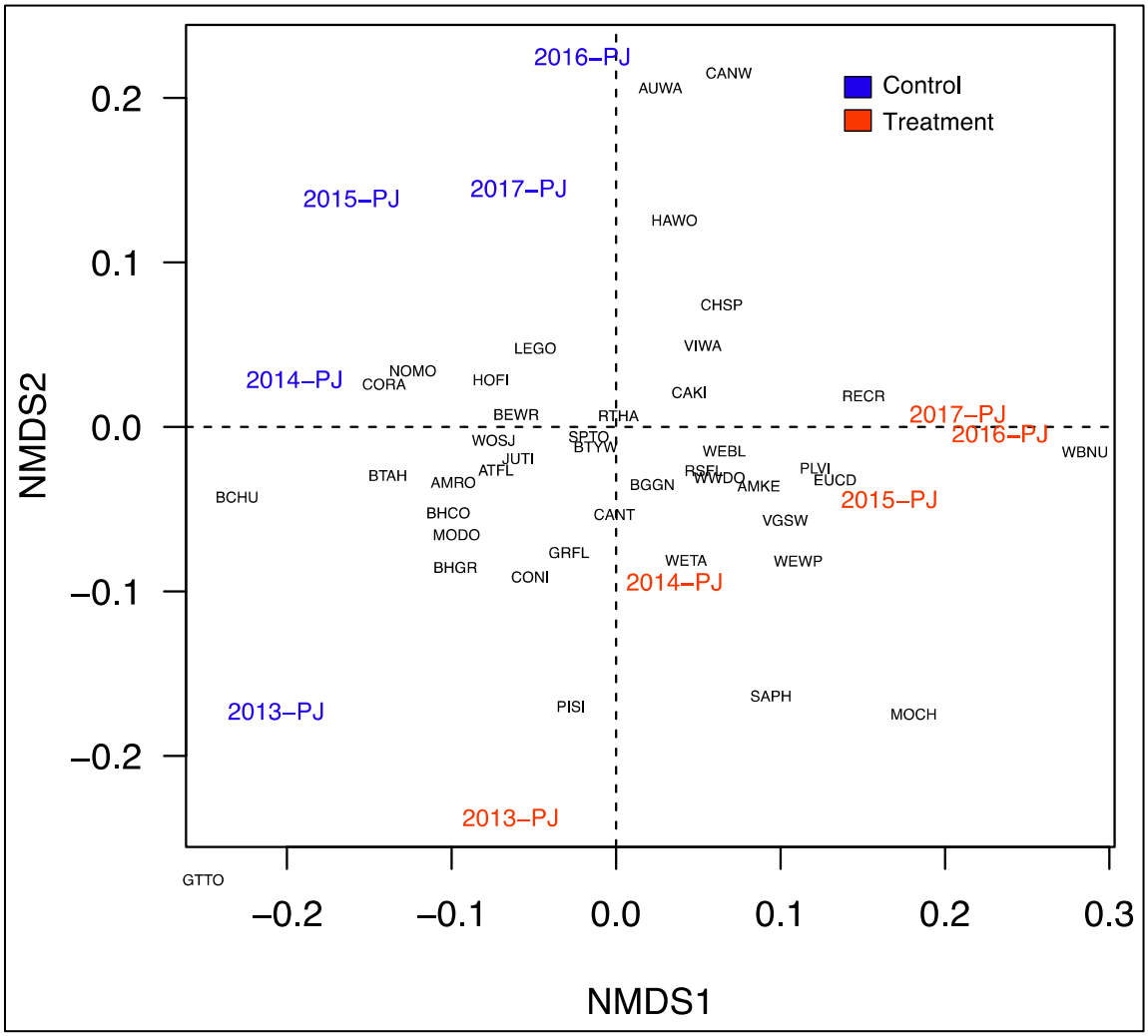


Figure 13. Non-metric multidimensional scaling of bird species from 2013 to 2017 by treatment for PJ sites

Species composition over time for ponderosa sites is shown in Figure 14. The difference in species composition was significant between treatment sites and control sites for ponderosa habitats (ANOSIM: R = 0.85, P = 0.007; Figure 14). Collectively, Figures 13 and 14 suggest that the control sites have different species composition than treatment sites over the course of the study.

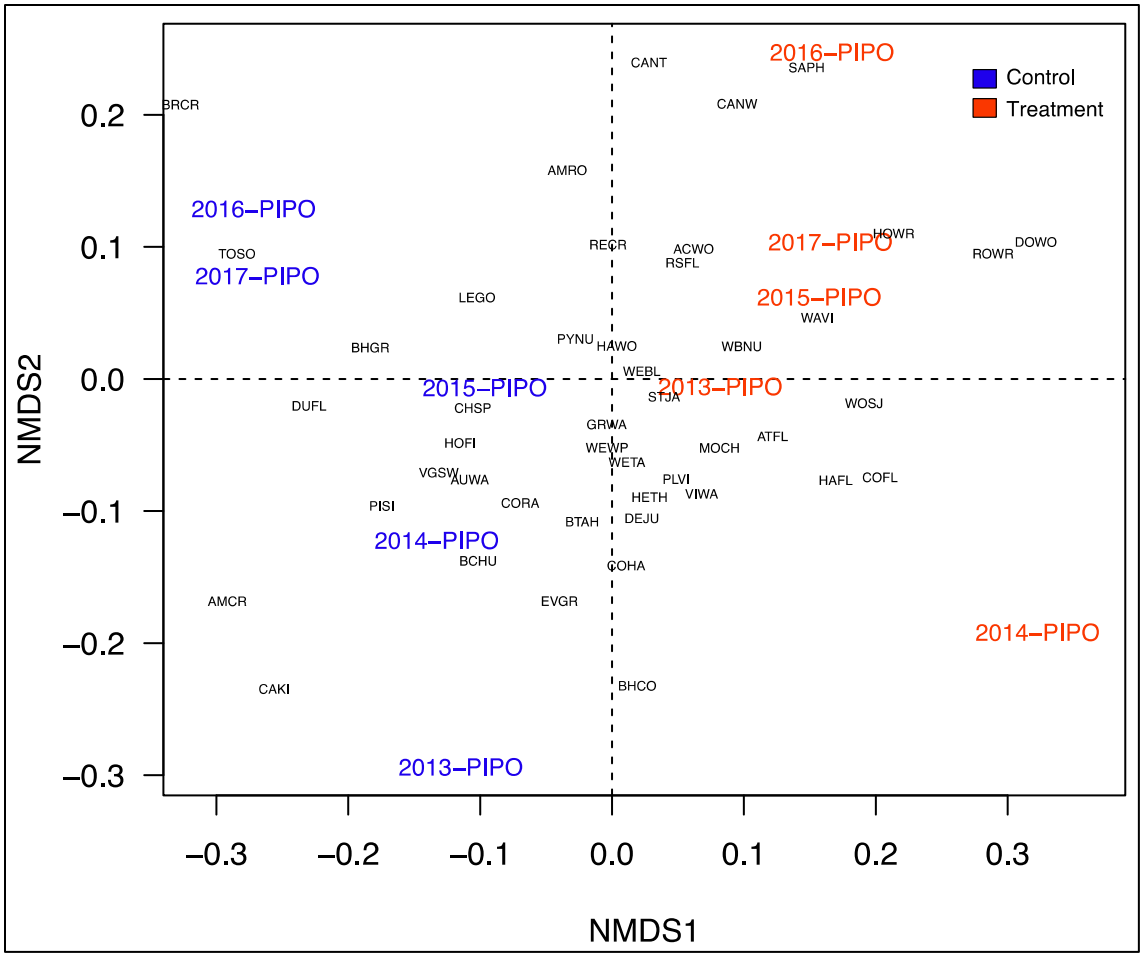


Figure 14. Non-metric multidimensional scaling of bird species from 2013 to 2017 by treatment for ponderosa sites

Figures 13 and 14 also show patterns over the five years. To examine these patterns further, we compared early years (2013 and 2014) and later years (2016 and 2017), excluding 2015. We tested for differences in similarity between the two time points for each of the habitat types, disregarding treatment for these tests. Species composition significantly differed between time points for PJ habitats (ANOSIM: R = 0.73, P = 0.029). This significance indicates that species composition has changed over the last five years. Species composition was similar between both time points for ponderosa sites (ANOSIM: R = 0.0, P = 0.44).

Rather than plot these results, we determined the top ten most abundant species for each habitat type for the early and late years (Tables 6 and 7). In PJ habitat, two of the top ten from early years, Mourning Dove and Gray Flycatcher, are absent in the late years. They were replaced by the Chipping Sparrow and Cassin's Kingbird. Additionally, bird abundances went up in later years. Although species turnover is happening, the top ten for both early and late years are equally represented by granivores and insectivores and the replacements were of the same feeding guild. In ponderosa habitat, only one of the top ten from early years, the Virginia's

Warbler, is absent in late years. It was replaced by the Chipping Sparrow. Again, the granivores and insectivores are well represented in the top ten list for early and late years.

Table 6. The top ten bird species in abundance in PJ habitat for early (2013 and 2014) and late (2016 and 2017) years

PJ Habitat Early		PJ Habitat Late	
Species	Number seen	**Species**	Number seen
House Finch	194	House Finch	247
Mourning Dove	130	Spotted Towhee	175
Ash-throated Flycatcher	109	Chipping Sparrow	143
Spotted Towhee	95	Ash-throated Flycatcher	107
Juniper Titmouse	68	Lesser Goldfinch	102
Western Bluebird	62	Juniper Titmouse	93
Bewick's Wren	62	Western Bluebird	93
Gray Flycatcher	59	Bewick's Wren	89
Lesser Goldfinch	57	Cassin's Kingbird	78
Woodhouse's Scrub-Jay	51	Woodhouse's Scrub-Jay	76

Table 7. The top ten bird species in abundance in ponderosa habitat for early (2013 and 2014) and late (2016 and 2017) years

Ponderosa Habitat Early		Ponderosa Habitat Late	
Species	Number seen	**Species**	Number seen
Western Bluebird	127	Pygmy Nuthatch	269
Pygmy Nuthatch	111	Western Bluebird	234
Western Wood-Pewee	99	House Finch	157
House Finch	94	Pine Siskin	145
Virginia's Warbler	77	Western Wood-Pewee	132
Plumbeous Vireo	72	Chipping Sparrow	128
Pine Siskin	71	Spotted Towhee	115
Spotted Towhee	65	Violet-green Swallow	91
Broad-tailed Hummingbird	65	Plumbeous Vireo	86
Violet-green Swallow	51	Broad-tailed Hummingbird	77

Species in a community align themselves in ways similar to those described by MacArthur and Wilson (1967) in *The Theory of Island Biogeography*. It hypothesized how distance and area could combine to regulate the balance between immigration and extinction in an island population. Immigration is the appearance of a new species in a community, while extinction is the disappearance of a species from a community. This relationship is known as species turnover. This concept of species turnover is what is driving the changes in composition over time. More study is needed to better understand these patterns and to determine the mechanism for species

turnover in these areas. For example, are the changes in species composition normal fluctuations that occur every few years or are we actually seeing permanent loss and gain of species? This and similar questions can be answered by continuing to monitor these sites and to analyze bird community data in other areas on the Pajarito Plateau.

Nestboxes

During the 2017 nesting season, 15 nestboxes at each of the treatment sites were actively monitored. The overall avian nestbox network without the three treatment sites contained 475 nestboxes in 2017. Of those, 226 contained active nests and 129 of those nests fledged young successfully. This was an overall occupancy rate of 48% with a 57% success rate.

At Minie, seven nests were found and two of the nests fledged young successfully. This was an occupancy rate of 46% with a 29% success rate.

At TA-39, three nests were found and none were successful. This was an occupancy rate of 20% with a 0% success rate. These are lower than the overall avian nestbox network; however, when compared with nestboxes within the greater Ancho Canyon area, the numbers are similar.

At TA-16, 17 nests were found and 13 of the nests fledged young successfully. Some of the nestboxes had double clutches, which is why the number of nests is higher than the number of nestboxes. This was an occupancy rate of 100% with a 76% success rate.

The occupancy rates at Minie and TA-16 were similar and greater than the results in the overall network. Yet, the nest success rates at Minie dropped well below the average of the rest of the network. This was largely due to an increase in predation of nests in this area.

In 2017, nonviable eggs and tissue samples from nestlings that died before fledging were submitted to an analytical lab for chemical analysis. Gaukler (2017) explained that eggs collected from all locations contained significantly higher concentrations of copper when compared with background concentrations from samples on nearby public lands. Macronutrients magnesium, potassium, and sodium were also higher compared with background eggs. Eggs collected from TA-16 also contained significantly higher concentrations of barium, mercury, and selenium. Nestlings collected from Minie, TA-39, and TA-16 contained detectable concentrations of some dioxin and furan congeners and also exceeded regional statistical reference levels (RSRLs). Polychlorinated biphenyls were detected in nestlings, although all concentrations were below RSRLs. Lastly, 2,3,7,8-tetrachlorodibenzodioxin toxic equivalents were calculated. Although there were significant differences, most chemical concentrations were below RSRLs, lowest observable adverse effect levels, and biota dose screening levels and were therefore not of ecological concern. As these data were preliminary, more samples are needed to make a robust assessment, including additional background samples.

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 59 species detected at the three treatment sites, all are protected under the Migratory Bird Treaty Act. Additionally, two of the species detected at the three treatment sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three treatment sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three treatment sites, contribute to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and allow LANS to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2017

Species	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
	TA-36 Minie Site					TA-39 Point 6					TA-16 Burn Grounds				
	Pinyon-Juniper Woodland					Pinyon-Juniper Woodland					Ponderosa Pine Forest				
Acorn Woodpecker											5		3	2	3
American Crow															1
American Kestrel				1		1			2						
American Robin	1	1	2		2	1	1		2		7		9	4	4
Ash-throated Flycatcher	11	5	14	13	13	19	11	29	12	8	3	5	6	2	3
Audubon's Warbler		2							2		6	5	1	6	
Bewick's Wren	4	8	9	9	14	3	10	15	9	2					
Black-chinned Hummingbird		1	1			3	2				1		1		1
Black-headed Grosbeak	1	3					2	4	1				1	2	
Black-throated Gray Warbler			1		2	5	6	4							
Blue-gray Gnatcatcher	3	14	16	8	10	2		7	5	4		6	2	1	3
Broad-tailed Hummingbird	2	1	3		1	3	1	2		3	5	11	11	5	7
Brown Creeper											1				
Brown-headed Cowbird	1							2			4	1			4
Bushtit		2		2		2	14			1					
Canada Goose								16							
Canyon Towhee	2		5	3	6	1	1	2	10	13	1			1	
Canyon Wren					1			2	3	8			2		
Cassin's Kingbird	6	13	13	5	2	7	6	2	21	21				1	
Chipping Sparrow	3	16	17	29	6	6	6	5	8	15	1	5	3	10	5
Clark's Nutcracker												4		1	

Species	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
	TA-36 Minie Site					TA-39 Point 6					TA-16 Burn Grounds				
	Pinyon-Juniper Woodland					Pinyon-Juniper Woodland					Ponderosa Pine Forest				
Common Nighthawk	6		5	2	4	5	1	3	2	7			1	2	2
Common Raven	2	5	1		1	1		2	1		5	6	2	2	5
Cooper's Hawk					1						1			1	
Cordilleran Flycatcher											5	10	6	3	3
Dark-eyed Junco											6	2	4		5
Downy Woodpecker				1					1	2		1		1	1
Dusky Flycatcher				1				1		1					
Eurasian Collared-Dove	3									4					
Evening Grosbeak	3		4					8			5		29		
Grace's Warbler											6	4	4	8	5
Gray Flycatcher	12	6	5	7	3	10	10	11	10	5					
Great Horned Owl		3				1									
Green-tailed Towhee	3	1				1									
Hairy Woodpecker			2	1				5	3		1	1		1	1
Hammond's Flycatcher											8	9	12	5	7
Hepatic Tanager								1	2	1				1	
Hermit Thrush												4	6	1	2
House Finch	16	17	26	17	12	21	4	23	9	30	16	2	5	5	12
House Wren											1	1		2	2
Juniper Titmouse	12		7	6	9	11	13	18	6	1					
Lesser Goldfinch	2	6	7	4	9	4	12	9	10	14	3		8	9	4
MacGillivray's Warbler														1	3
Mountain Bluebird		2	20	10	11		4						4	4	4
Mountain Chickadee	5	2	1	2					1	1	5	8	9	6	8
Mourning Dove	17	17	13	5	8	13	22	10	3	15	4		1	3	17

Species	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017	2013	2014	2015	2016	2017
	TA-36 Minie Site					TA-39 Point 6					TA-16 Burn Grounds				
	Pinyon-Juniper Woodland					Pinyon-Juniper Woodland					Ponderosa Pine Forest				
Northern Mockingbird					2		1								
Peregrine Falcon								1							
Pine Siskin	10	2		5	1	6		3	3		12	4	5		4
Plumbeous Vireo	10	10	7	3	9	1		1	6	6	11	16	15	14	11
Pygmy Nuthatch				2				2	4	12	11	13	26	29	41
Red Crossbill					1		2					2	9	13	9
Red-shafted Flicker	3	1	3	2	5	3	2	4	8		3	4	11	11	5
Red-tailed Hawk								1	1	1					
Rock Wren	3	3	4		2	7	10	4	12	14	1	2	2	6	
Say's Phoebe	2	1	2		2	2	1		5	2	1		1	3	3
Scaled Quail			1												
Spotted Towhee	17	8	19	27	32	12	6	33	16	12	11	18	16	14	21
Steller's Jay											3	2	5	6	3
Townsend's Solitaire	1														1
Turkey Vulture					1						1				
Violet-green Swallow		5	7	1	3	6	4	1	9	6		2	19	2	2
Virginia's Warbler					1			1	2	4	17	11	21	13	7
Warbling Vireo											2	9	7	6	5
Western Bluebird	15	11	18	17	16	5	19	12	21	13	20	20	49	37	32
Western Tanager		2	3		1		2	1	1	2	2	3	7	2	4
Western Wood-Pewee	10	8	18	11	10		4	2	10	8	15	10	16	14	22
White-breasted Nuthatch	1	4	9	10	13			2	4	4	9	8	7	9	20
White-throated Swift							1								
White-winged Dove	1	5	9	2		7	5	6	16	15			1	2	
Woodhouse's Scrub-Jay	5	1	3	4	8	8	10	4	8	6	1				

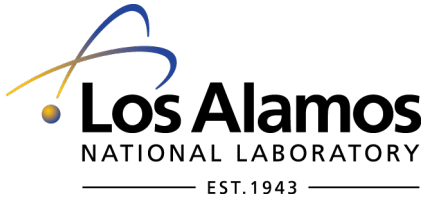
Revised Supplement 4-1
Alt Tech Evaluation
Attachment 10 – Hathcock *et al.* 2019

Environmental Report:

Hathcock, C.D., *et al.* May 2019. *2018 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory*. LA-UR-19-24156.

May 2019

2018 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory



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Executive Summary

Los Alamos National Laboratory biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts were compared among years to monitor trends. The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Additionally, nesting success of secondary-cavity nesting birds was examined using nestboxes. LANL biologists completed the sixth year of this effort in 2018. The overall results from 2018 continue to indicate that operations are not negatively affecting bird populations; however, we are seeing some species turnover through time and that will continue to be monitored.

Three bird point count surveys were completed at each of the treatment sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2018. A total of 842 birds representing 58 species were recorded at the three treatment sites. Three bird point count surveys were also completed at each of the control sites between May and July 2018. Occupancy and nest success data from nestboxes at treatment sites were compared with the overall avian nestbox monitoring network.

Species richness at the treatment sites was not statistically different from their associated controls; however, species diversity was. In all three cases, the diversity was higher at the treatment sites than at the control sites. Avian abundance showed more variability but treatment and controls were trending together year to year. Species composition seems to indicate some species turnover in the habitat types but very little difference between treatment and control sites.

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Introduction

An annual avian monitoring program was started in 2013 as part of the Resource Conservation and Recovery Act permitting process at Los Alamos National Laboratory (LANL) for two open detonation sites, Technical Area (TA) 36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014 & 2015; Hathcock et al. 2017 & 2018). The objectives of this study were to determine whether LANL operations impact bird species richness, diversity, abundance, or composition. Comparisons were made with control sites of similar habitat that have been surveyed since 2011 (Hathcock et al. 2011).

Biologists at LANL used standard point count methodology to record avian abundance and diversity along transects at the three treatment sites and associated control sites during the summer of 2018. Summer surveys provide information about what birds were breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental change at LANL.

In addition to avian point counts, nestboxes were monitored around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success data were compared with the overall avian nestbox monitoring network, which was established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon-juniper woodland (PJ) for Minie and TA-39 and a ponderosa pine forest (PIPO) at TA-16. These habitat descriptions were based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) were monitored annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock et al. (2011). Each habitat type control contained two replicate transects that were monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects were randomized and surveyed according to the random order.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar

in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was more natural.

Transects were approximately 2.0 to 2.5 km in length and allowed for nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site and surveys must be conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor will look and listen for 5 minutes, noting any birds encountered at each point. The distance for observations is considered as an "unlimited-distance circular plot"; however, the distance to each bird out to 100 m should be noted. Ensure individual birds are not re-counted from point to point. Use a range finder when possible for measuring the distance.
- While walking between points, note any species encountered that have not otherwise been counted from a previous point or future point. The surveyor's main focus is counting birds from each point and not spending unnecessary time looking for additional birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Record all birds encountered on the data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point.
- Use the "NOTES" section to indicate any potentially important aspects of the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Other wildlife or evidence of wildlife that could be used for other projects should be recorded.

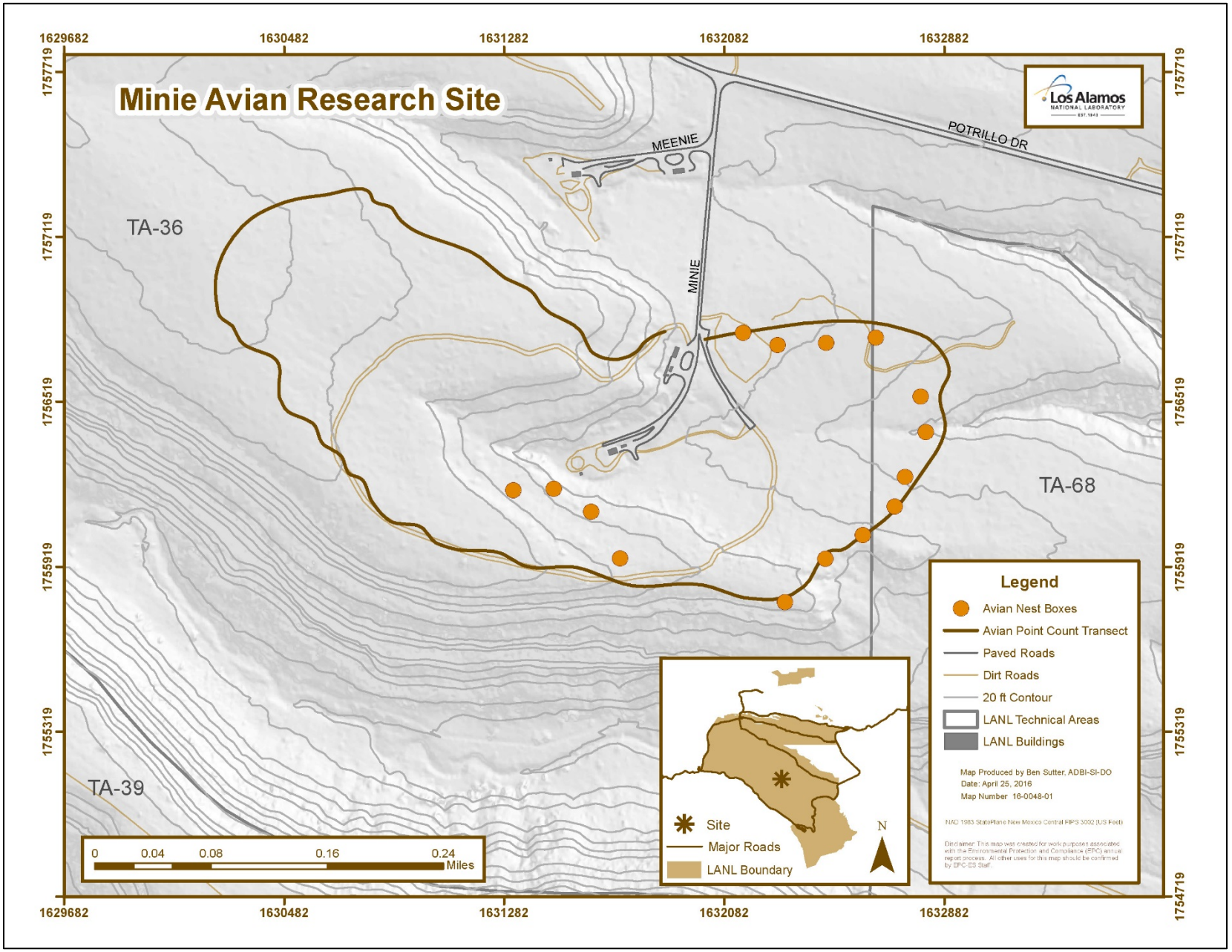

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site

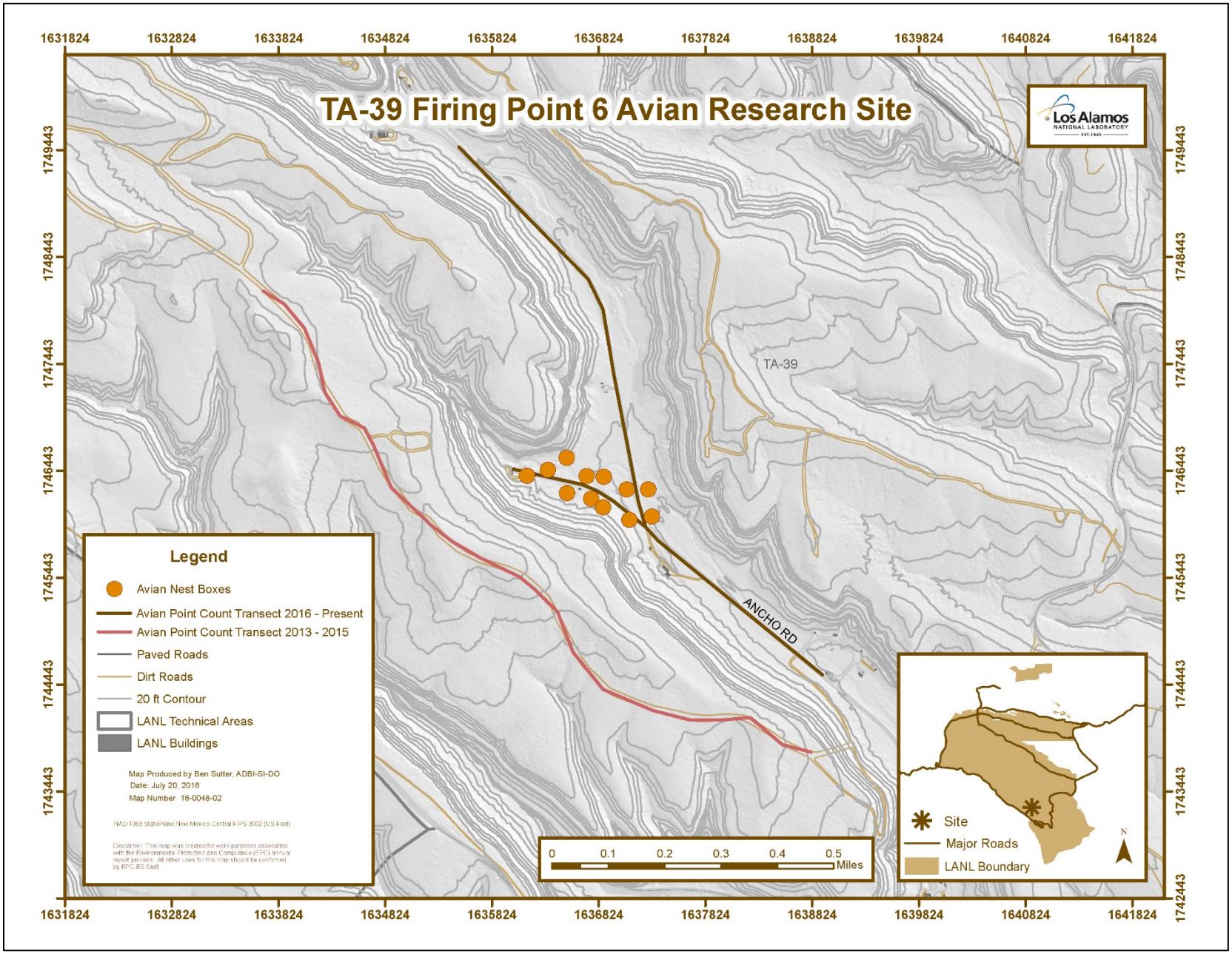

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6

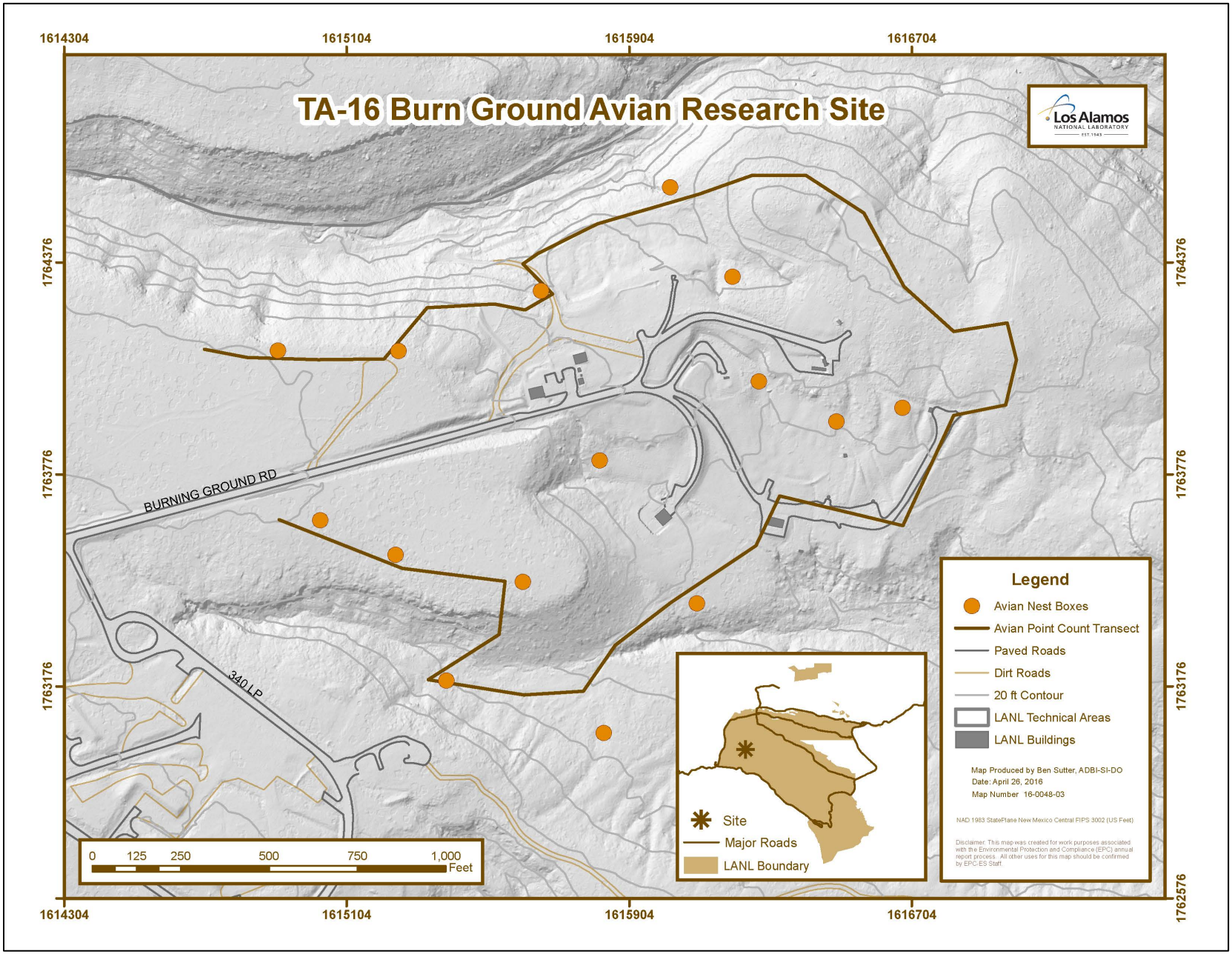

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground

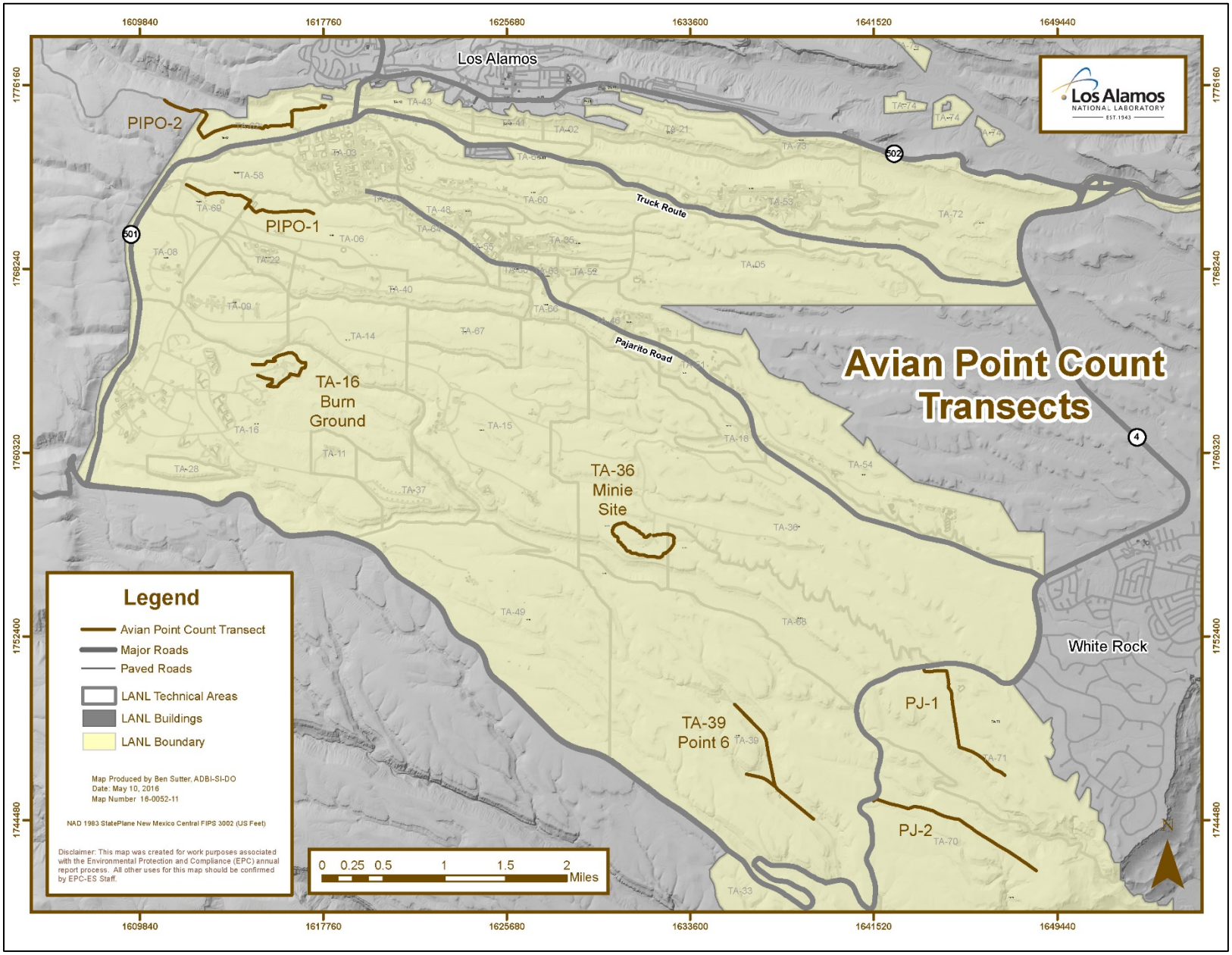

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie and TA-39 (Figures 1 and 2). In 2015, nestboxes were added to TA-16 (Figure 3). Nestboxes were monitored every 1 to 2 weeks for active nests. When an active nest was found, it was monitored more frequently to determine whether the nest failed or successfully fledged young. Nestlings were also banded and the sex determined after the age of 10 days.

Statistical Methods for Point Counts

The data were summarized to compare species richness, diversity, abundance, and composition between sites and among years using the statistical software R (version 3.4.1; R Core Team 2017). Species richness and diversity were computed using the R-package 'iNEXT' (Hsieh et al. 2016; Chao et al. 2014) and plotted with bootstrap confidence intervals around the mean for rarefied/extrapolated samples, facilitating the comparisons of richness and diversity. The estimated asymptote along with a confidence interval were also provided. The Simpson's diversity index was calculated using the following formula: $D = 1 - (\sum n(n-1) / N(N-1))$, where n = the total number of organisms of a particular species and N = the total number of organisms of all species. The value of D ranges between 0 and 1. With this index, 1 represents infinite diversity and 0 represents no diversity. Species diversity was also computed using the statistical software PAST (Hammer et al. 2001) and a t-test was used to test for differences between treatment and control sites each year. Comparisons of Simpson diversity in two samples are described by Hutcheson (1970) and is an alternative to the permutation test. To examine species composition, non-metric multidimensional scaling (NMDS) was used to determine dissimilarity among sites. To compare species composition between treatments and years, an analysis of similarity (ANOSIM) was conducted using 1000 permutations. These analyses were completed using the community ecology R-package 'vegan' (Oksanen et al. 2017).

Statistical Methods for Nestboxes

Occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network were calculated. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. Annually, data from the three treatment sites were compared with the overall avian nestbox network at LANL that was established in 1997.

In 2019 a nest survival model (Dinsmore et al. 2002) in Program MARK was generated to estimate nest survival (S) for Western Bluebirds during a 22-year period (1997-2018). The nesting period spanned 21 April to 16 August (118 days) across all years of the study. Data for each nest were subdivided into the incubation and nestling periods and formatted as groups for analyses in Program MARK (Dinsmore and Dinsmore 2007). There was also an interest in survival estimates for the three treatment sites. Because there were not enough data to fit models

specific to each site, a simple constant survival model was used, by nest stage. These estimates are presented for planning purposes only and are not meant to be directly comparable to estimates generated from the entire dataset (Unpublished data 2019).

Results and Discussion

Year 2018

Three surveys were completed at each of the three treatment sites and the associated control sites between May and July 2018. A total of 842 birds representing 58 species were recorded at the three treatment sites. A full account of the 2013–2018 data is detailed in Appendix 1.

Species richness is the number of different species represented in an ecological community and is simply a count of species. In this case, each treatment site and control are individual communities. Species diversity is a measure that takes into account the species richness and the overall abundance to compare evenness across a community. Here we used the Simpson's diversity index, which measures the probability that two individuals randomly selected from a sample will belong to different species. The abundance is the total number recorded of a given species. Table 1 details the species richness, diversity, and abundance for 2018 for each treatment site.

Table 1. The species richness, diversity, and abundance recorded at each site in 2018

2018	*Minie Site*	*TA-39*	*TA-16*
Richness	35	39	43
Diversity	0.9494	0.9405	0.9541
Abundance	242	315	285

To further analyze species richness and diversity, species rarefaction and extrapolation plots were developed with the control sites being combined. Species rarefaction and extrapolation from 2018 show no differences between treatment and control sites for species richness. There were overlapping 95% confidence intervals for species richness (Figures 5A–6A) for all three treatments and their controls. Simpson's diversity (Figures 5B–6B) was significantly different since the 95% confidence intervals did not overlap. In these cases, the treatment sites were higher in diversity than the controls.

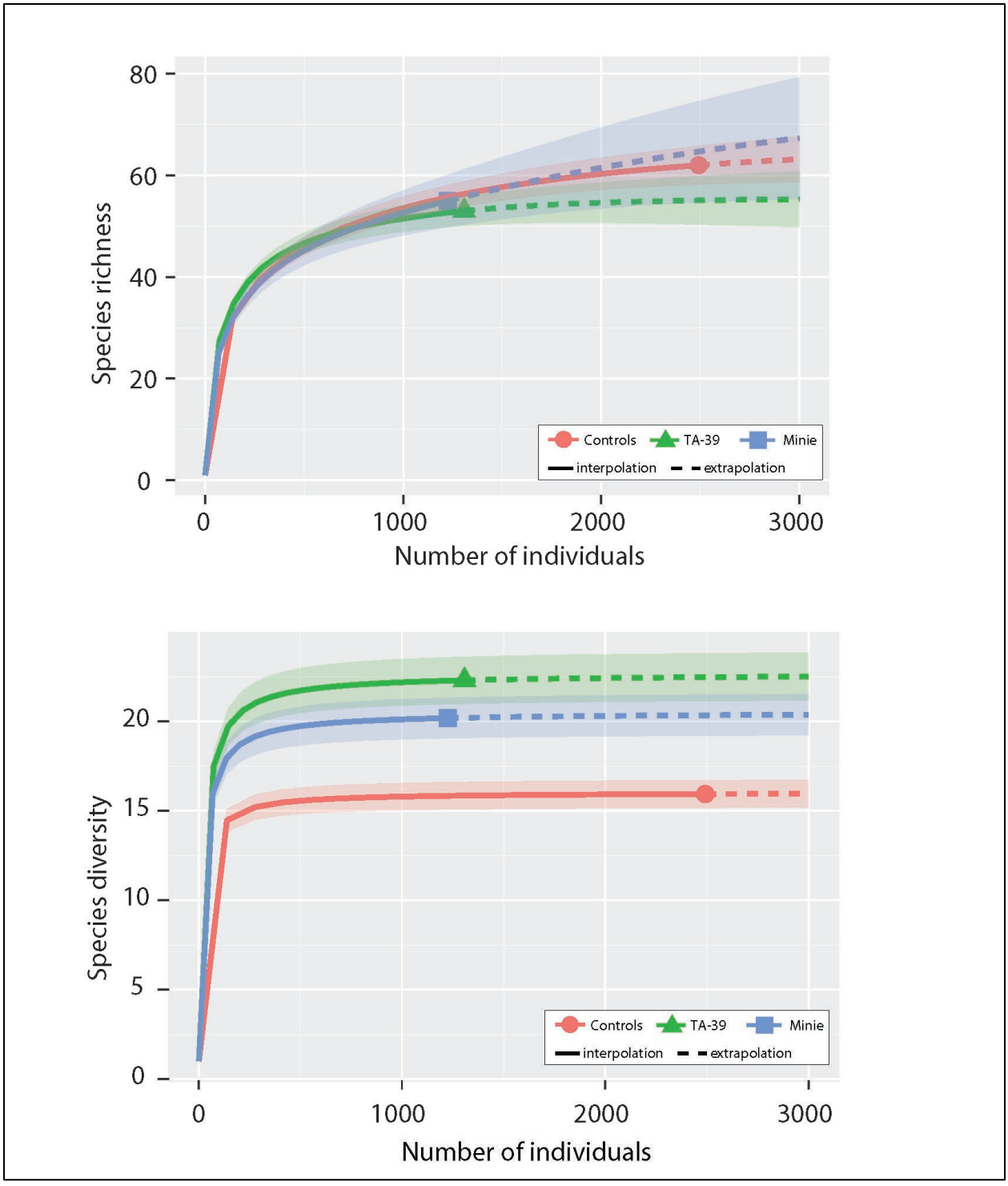

Figure 5. Species rarefaction and extrapolation for species richness and diversity comparing Minie and TA-39 with the PJ controls

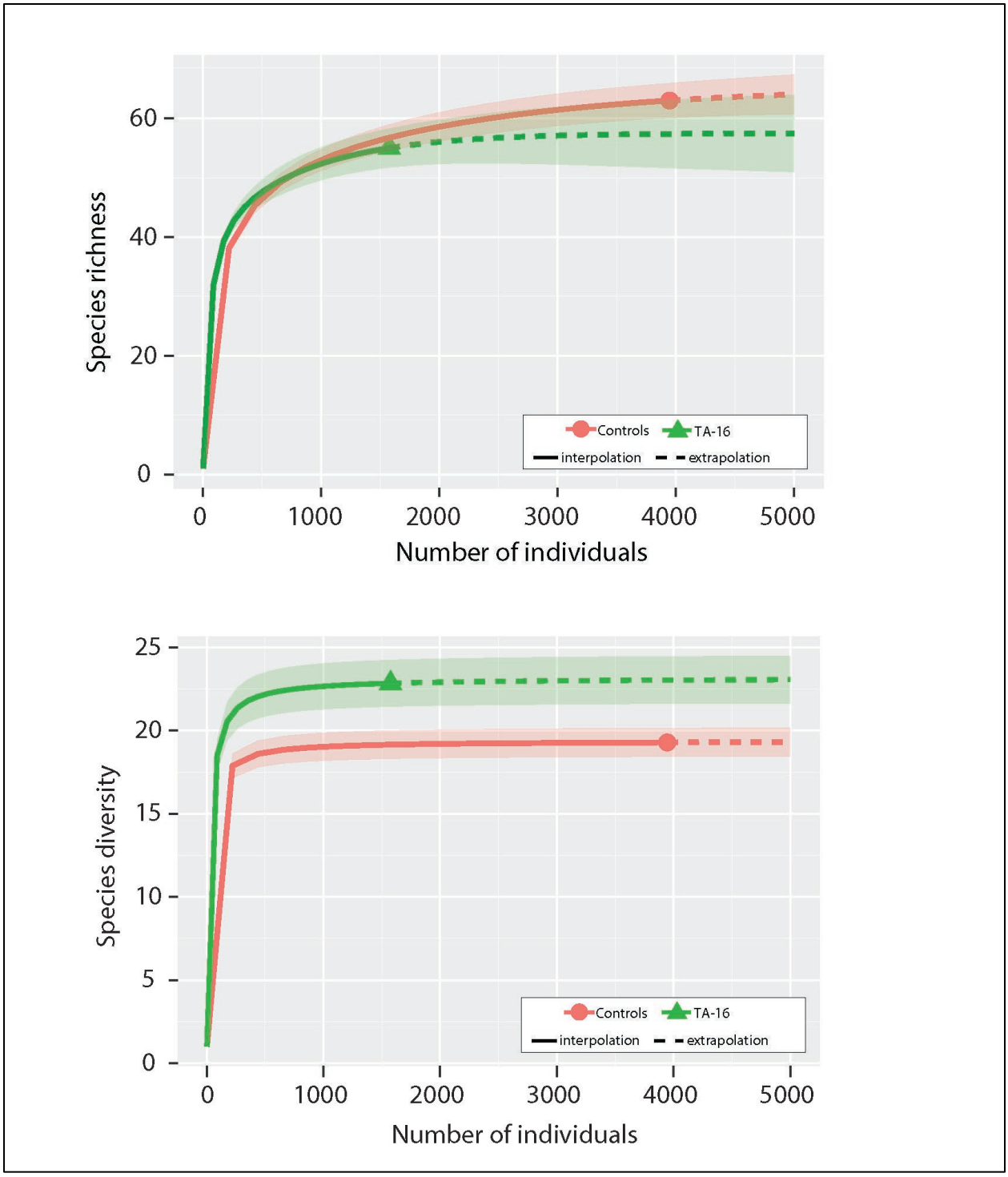

Figure 6. Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls

Multivariate analysis with ordination was used to explore the data further to look for patterns that may be explained by a multitude of other environmental factors not assessed directly. We used non-metric multidimensional scaling (NMDS) (Gardener 2014). NMDS is a method used to

collapse data from multiple dimensions–such as several communities in different sites–into just a few dimensions. A measure of 'stress' (mismatch between the rank order of distances in the actual data, and the rank order of distances in the ordination) is calculated according to the number of dimensions (k). Lower stress values (typically < 0.1) mean greater conformity of the ordinated distances to the actual multivariate distances. Using this method, the samples are moved slightly in a direction that decreases the stress until stress reaches a minimum. More dimensions can be added when high stress is produced from too few dimensions. The final configuration of points for 2018 is represented in Figure 7 where the treatments and controls are plotted (k = 3, stress = 0.002). The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated habitat types. Here, the PJ sites are grouped on the left and PIPO sites on the right. In the plot it is clear that the PJ-2 control transect is slightly different that the other control and the two treatments. The species that seem to be driving the PJ-2 control are the Black-throated Gray Warbler, American Kestrel, Black-chinned Hummingbird, and Juniper Titmouse. There must be some subtle habitat differences between the two controls for PJ. The PIPO controls and treatment site are more closely aligned with one another. In 2018, even with some variation, the treatments were not statistically different than the controls overall (ANOSIM: R = -0.15, P = 0.67) and the two habitat types were different as one would expect (ANOSIM: R = 0.96, P = 0.037).

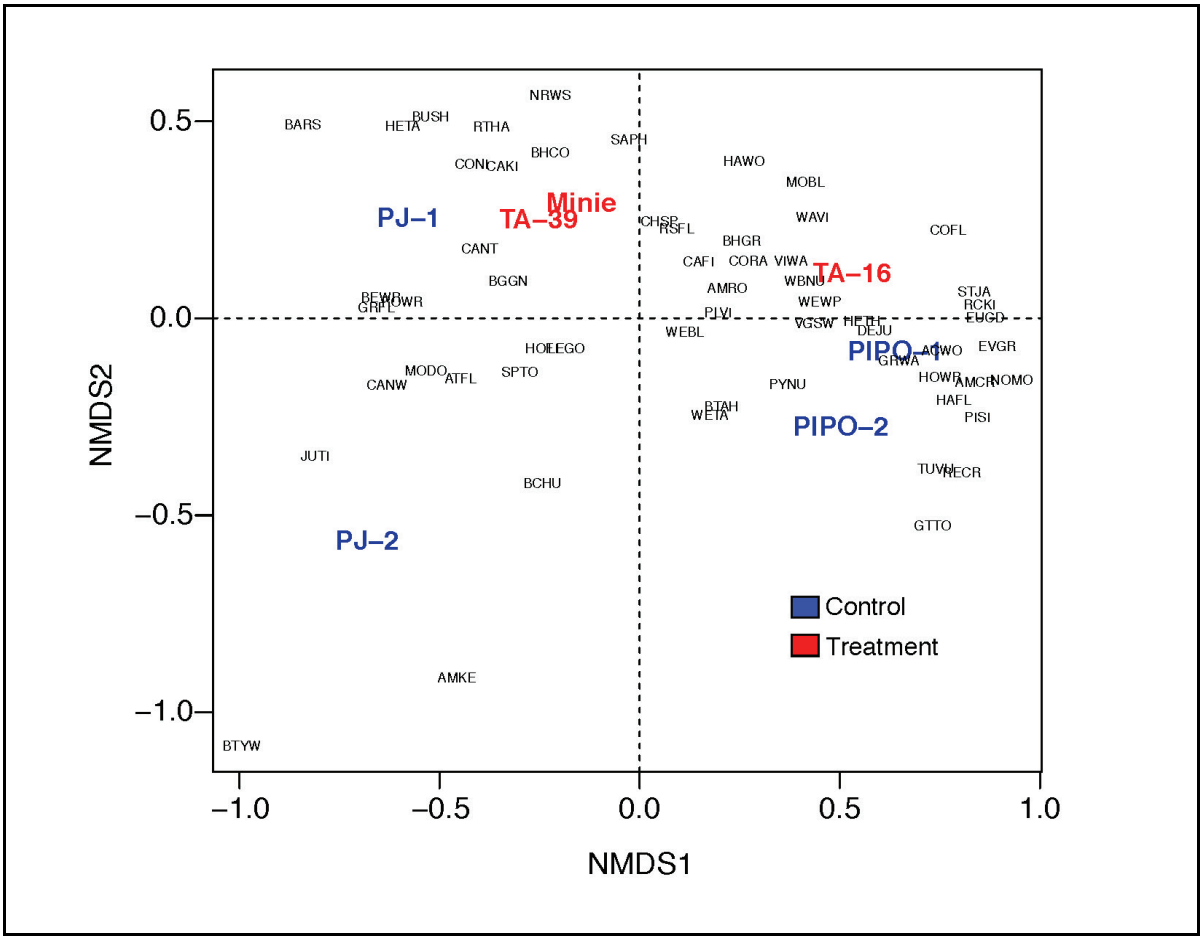

Figure 7. Non-metric multidimensional scaling of bird species and sites in 2018

Trends Over Time

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for a migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The fluctuations in bird abundances are not alarming, and the differences between the treatment sites and control sites are not biologically significant. The winter moisture for the winter of 2018-2019 was at or slightly above normal (personal communication B. Parmenter) so it will be interesting to see what the effects will be to bird numbers in 2019.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
Minie	33	33	34	30	35	35
TA-39	31	31	39	38	34	39
PJ Control 1	29	30	33	36	37	30
PJ Control 2	30	29	37	33	39	23
TA-16	33	33	40	44	41	43
PIPO Control 1	34	34	30	41	41	37
PIPO Control 2	33	36	43	43	44	40

Tables 3–5 compare the species diversity over time between the treatment site and the combined control. The two control sites were combined to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of the study. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is greater than 0.90, which compared with ecological systems in general, is very high.

The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower, but the percent abundance is similar year to year when compared with the control sites. Darker shading indicates a significant difference.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
Minie	0.9464	0.9463	0.9502	0.9315	0.9429	0.9494
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419	0.9255
t-test	t = 3.9572 df = 501.3 p = <0.01	t = 2.5469 df = 510.42 p = 0.01	t = 1.5902 df = 644.91 p = 0.11	t = 0.4385 df = 499.33 p = 0.66	t = 0.1504 df = 448.66 p = 0.88	t = 3.577 df = 644.09 p < 0.01

Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
TA-39	0.9425	0.9427	0.9396	0.9559	0.9486	0.9405
PJ Control	0.9065	0.9285	0.9436	0.9279	0.9419	0.9255
t-test	t = 3.3636 df = 538 p <0.01	t = 1.9703 df = 509.25 p = 0.05	t = -0.6751 df = 401.58 p = 0.50	t = 4.5611 df = 783.86 p <0.01	t = 1.2234 df = 705.5 p = 0.22	t = 2.085 df = 717.79 p = 0.03

Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*
TA-16	0.9542	0.9509	0.9454	0.9463	0.9429	0.9541
PIPO Control	0.9528	0.9462	0.9414	0.9417	0.9468	0.9431
t-test	t = 0.3323 df = 378.91 p = 0.73	t = 0.9236 df = 472.24 p = 0.35	t = 0.748 df = 633.26 p = 0.45	t = 0.7438 df = 475.6 p = 0.45	t = -0.6903 df = 444.95 p = 0.49	t = 2.52 df = 570.39 p = 0.01

Species composition was analyzed over time according to whether sites were controls or treatments for PJ sites and ponderosa sites separately (Figures 8 and 9 respectively). Figure 8 shows the species composition for PJ sites for each year (k = 4, stress = 0.09). Four dimensions were used to decrease the stress and get a better representation of the data. As expected, the difference in species composition was significant between treatment sites and control sites for PJ habitats (ANOSIM: R = 0.64, P = 0.001). In the figure, the species closest to each site were the species most important in separating those sites from the rest. An early versus late analysis was done where the years 2013 – 2015 were compared to 2016 – 2018. The differences in species composition was not significantly different (ANOSIM: R = 0.108, P = 0.11).

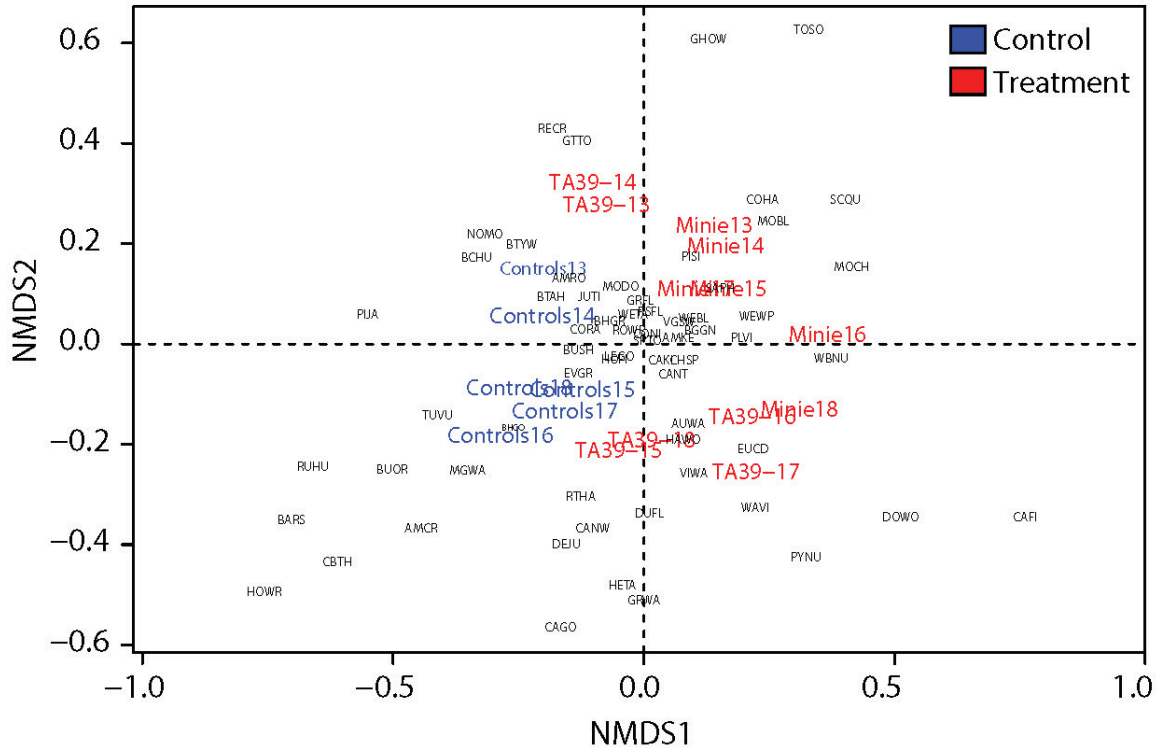

Figure 8. Non-metric multidimensional scaling of bird species from 2013 to 2018 by treatment for PJ sites

Species composition over time for ponderosa sites are shown in Figure 9 (k = 3, stress = 0.06). As expected, the difference in species composition was significant between treatment sites and control sites for ponderosa habitats (ANOSIM: R = 0.88, P = 0.003). The species closest to each site were the species most important in separating those sites from the rest. An early versus late analysis was done where the years 2013 – 2015 were compared to 2016 – 2018. The differences in species composition was not significantly different (ANOSIM: R = -0.026, P = 0.46).

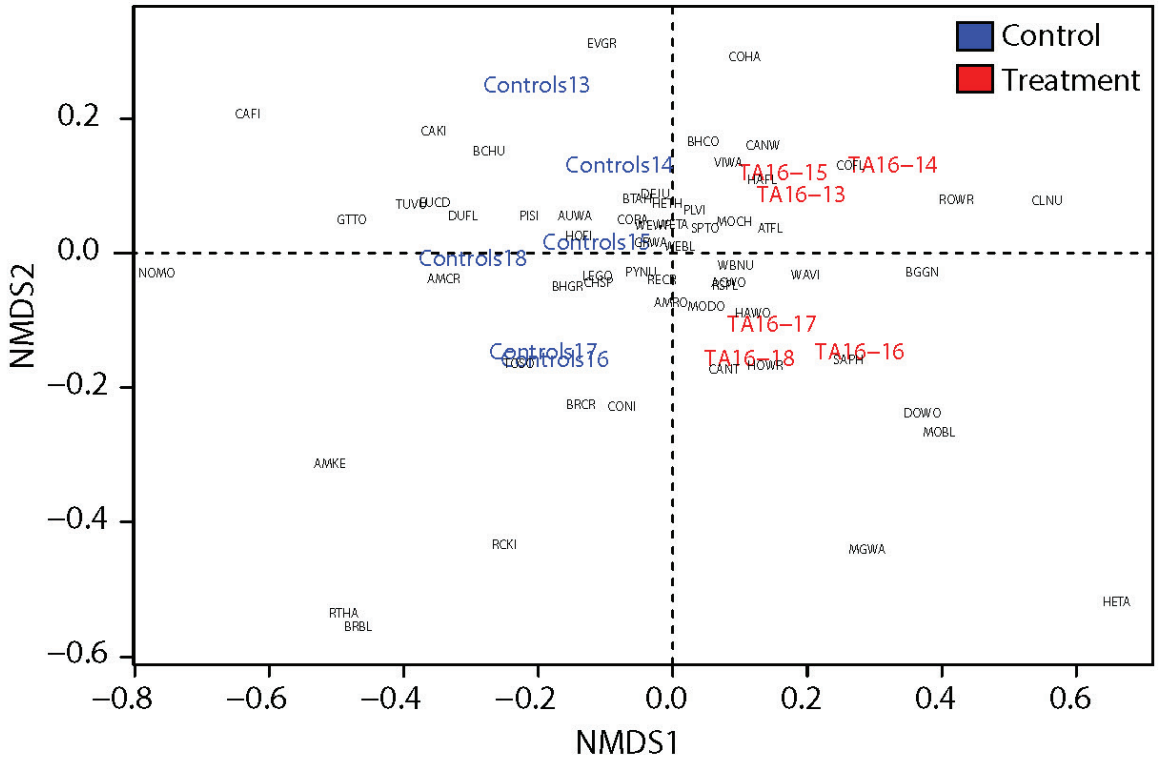

Figure 9. Non-metric multidimensional scaling of bird species from 2013 to 2018 by treatment for ponderosa sites

Collectively, Figures 8 and 9 suggest that the control sites have slightly different species composition than treatment sites over the course of the study.

Species in a community align themselves in ways similar to those described by MacArthur and Wilson (1967) in *The Theory of Island Biogeography*, which hypothesized how distance and area could combine to regulate the balance between immigration and extinction in an island population. Immigration is the appearance of a new species in a community, while extinction is the disappearance of a species from a community. This relationship is known as species turnover. The concept of species turnover is what drives the changes in composition over time.

More study is needed to better understand these patterns and to determine the mechanism for species turnover in these areas. The subtle changes in composition over time may be normal fluctuations, but if the gap widens then it may be indicative of a larger process at work. This and similar questions can be answered by continuing to monitor these sites and to analyze bird community data in other areas on the Pajarito Plateau.

Nestboxes

During the 2018 season, the overall avian nestbox network was managed at lower levels than previously. The treatment sites were maintained at previous years' effort, but site-specific constraints from increased fire restrictions in 2018 limited the overall network management.

During the 2018 nesting season, 15 nestboxes each at Minie, Burn Grounds, and TA-39 were actively monitored. The overall avian nestbox network, without the three treatment sites, only contained 177 nestboxes in 2018. Of those, 94 contained active nests and 46 of those nests fledged young successfully. This was an overall occupancy rate of 53% with a 49% success rate.

Tables 6 and 7 compare the occupancy and success rates for each treatment site and the overall nestbox network since 2015.

Table 6. Comparison of occupancy for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*
Overall Network	40%	45%	48%	53%
Minie	66%	73%	46%	20%
TA-39	8%	58%	20%	33%
TA-16	-	73%	100%	53%

Table 7. Comparison of success for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*
Overall Network	66%	69%	57%	49%
Minie	64%	23%	29%	33%
TA-39	100%	57%	0%	40%
TA-16	-	63%	76%	63%

In 2018 there were three successful nests that fledged young at Minie, five at TA-39, and eight at TA-16. The occupancy rate at Minie is lower and stands out in comparison to previous years.

Precipitation was low, possibly contributing to reduced nesting attempts and lower box occupancy rates. Success rates at the three treatment sites were not very different in comparison to the overall network and did not display decrease over time.

In 2018, nonviable eggs collected from nestboxes at Minie, TA-16, and TA-39 were submitted to an analytical lab for chemical analyses. Eggs collected from two of the firing sites (Minie and TA-39) contained higher concentrations of copper when compared with background concentrations from samples on nearby public lands. The source of elevated copper found in two western bluebird egg samples collected near the firing sites could be from some high-explosives testing; copper has historically been detected above soil screening levels at Technical Area 39 (Juarez and Vigil-holterman 2011). Yet, copper soil levels at Minie, near the firing site were below the regional statistical reference level (RSRL) in 2018. However, it has been suggested that birds are relatively resistant to copper toxicity when compared with other taxa (Eisler 1998). Although magnesium, potassium, and sodium concentrations were higher compared with background egg concentrations, these elements are macronutrients which are required by living organisms in large quantities. Eggs collected from TA-16 contained higher concentrations of antimony, mercury, and selenium and exceeded regional RSRLs, but were all below the known lowest observable adverse effects levels (LOAELs). Eggs collected from TA-39 contained higher concentrations of mercury and selenium compared to the RSRLs, but were below the LOAEL. Most chemical concentrations that were detected at all of the sites were below RSRLs and all were below the LOAELs. These data suggest that egg element concentrations observed here are not of ecological concern. As these data are preliminary, more samples are needed to make a robust assessment, including additional background samples.

Nest survival estimates for the three treatment sites for the incubation and nestling periods of the Western Bluebird are in figures 10 and 11. Nest survival is comprised of two phases for this analysis, the incubation phase and the nestling phase. Due to low sample sizes for this type of analysis, confidence intervals are large and these results should be considered only for possible pattern analyses. During incubation, survival at Burn Grounds and TA-39 Point 6 did not differ from all other sites while survival at Minie Site was lower than that at all other sites pooled (Figure 10). During the nestling period survival at the three sites did not differ from that at all other sites pooled together (Figure 11).

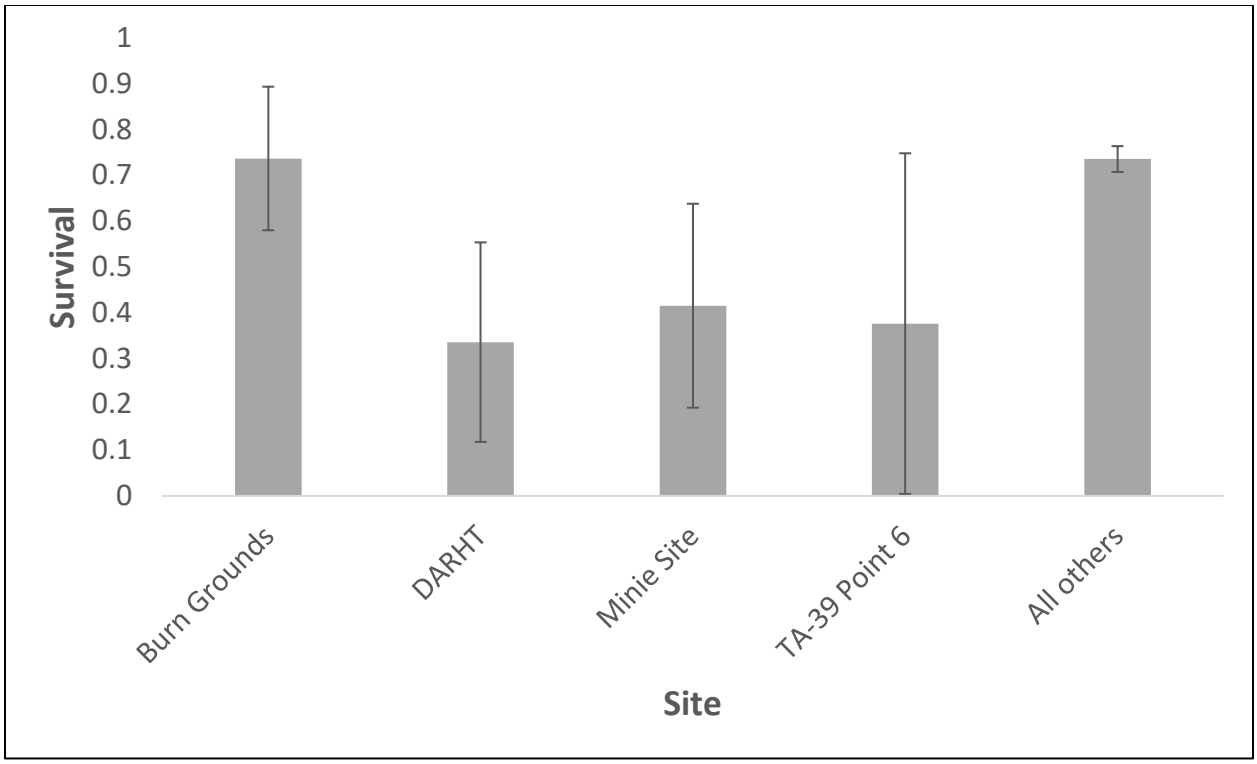

Figure 10. Estimated probability of surviving the 14-day incubation period for Western Bluebird nests at selected sites. Estimates (±95% CI) were generated using a constant survival model with no covariates.

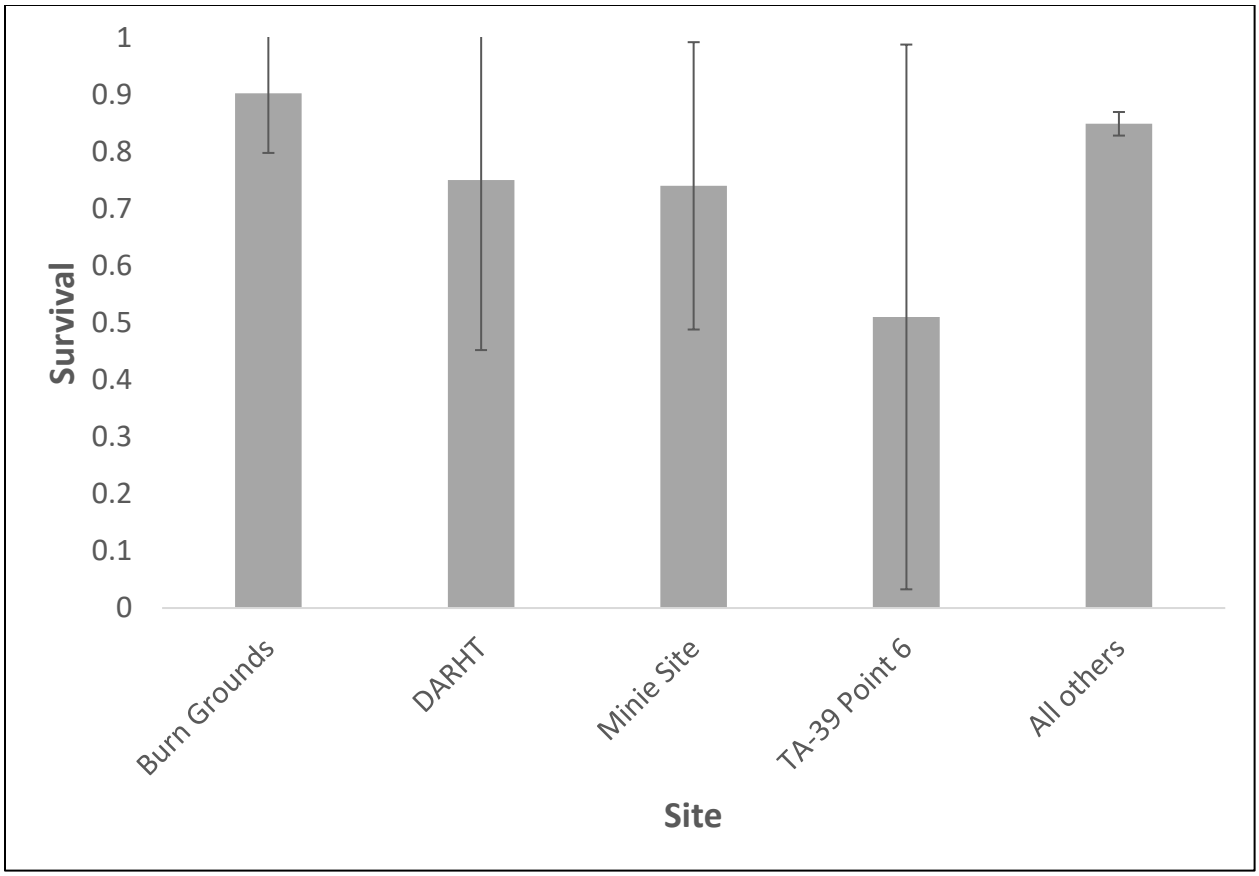

Figure 11. Estimated probability of surviving the 18-day nestling period for Western Bluebird nests at selected sites. Estimates (±95% CI) were generated using a constant survival model with no covariates.

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 59 species detected at the three treatment sites, all are protected under the Migratory Bird Treaty Act. Additionally, two of the species detected at the three treatment sites are on the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008). Those two species are the Juniper Titmouse and Grace's Warbler. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901). Another conservation tool used in migratory bird management is the Birder's Conservation Handbook (Wells 2007), which lists the top 100 birds most at risk in North America. Two species detected at the three treatment sites are on the top 100 list. They are the Virginia's Warbler and Grace's Warbler.

Continuing the research reported herein will provide a long-term dataset on the ecological health of LANL's avifauna at the three treatment sites, contribute to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and allow LANL to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2018

Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Acorn Woodpecker													5		3	2	3	5
American Crow																	1	1
American Kestrel				1			1			2								
American Robin	1	1	2		2		1	1		2		4	7		9	4	4	6
Ash-throated Flycatcher	11	5	14	13	13	10	19	11	29	12	8	8	3	5	6	2	3	8
Audubon's Warbler		2				5				2			6	5	1	6		1
Bewick's Wren	4	8	9	9	14	14	3	10	15	9	2	8						
Black-chinned Hummingbird		1	1				3	2				1	1		1		1	
Black-headed Grosbeak	1	3				1		2	4	1		3			1	2		2
Black-throated Gray Warbler			1		2		5	6	4									
Blue-gray Gnatcatcher	3	14	16	8	10	9	2		7	5	4	2		6	2	1	3	6
Broad-tailed Hummingbird	2	1	3		1		3	1	2		3	1	5	11	11	5	7	10
Brown Creeper													1					
Brown-headed Cowbird	1								2			3	4	1			4	2
Bushtit		2		2		11	2	14			1	12						
Canada Goose									16									
Canyon Towhee	2		5	3	6	2	1	1	2	10	13	19	1			1		1
Canyon Wren					1				2	3	8	6			2			
Cassin's Finch						4												
Cassin's Kingbird	6	13	13	5	2	5	7	6	2	21	21	32				1		

	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
Chipping Sparrow	3	16	17	29	6	22	6	6	5	8	15	25	1	5	3	10	5	21
Clark's Nutcracker														4		1		
Common Nighthawk	6		5	2	4	4	5	1	3	2	7	5			1	2	2	
Common Raven	2	5	1		1	2	1		2	1		1	5	6	2	2	5	5
Cooper's Hawk					1								1			1		
Cordilleran Flycatcher													5	10	6	3	3	1
Dark-eyed Junco												1	6	2	4		5	2
Downy Woodpecker				1						1	2			1		1	1	1
Dusky Flycatcher				1					1		1							
Eurasian Collared-Dove	3										4							1
Evening Grosbeak	3		4						8				5		29			1
Grace's Warbler												2	6	4	4	8	5	8
Gray Flycatcher	12	6	5	7	3	6	10	10	11	10	5	8						
Great Horned Owl		3					1											
Green-tailed Towhee	3	1					1											
Hairy Woodpecker			2	1		1			5	3			1	1		1	1	2
Hammond's Flycatcher													8	9	12	5	7	5
Hepatic Tanager									1	2	1	2				1		
Hermit Thrush						1								4	6	1	2	2
House Finch	16	17	26	17	12	18	21	4	23	9	30	44	16	2	5	5	12	7
House Wren													1	1		2	2	6
Juniper Titmouse	12		7	6	9	3	11	13	18	6	1							
Lesser Goldfinch	2	6	7	4	9	12	4	12	9	10	14	19	3		8	9	4	8
MacGillivray's Warbler																1	3	

	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
Mountain Bluebird		2	20	10	11	1		4							4	4	4	7
Mountain Chickadee	5	2	1	2						1	1		5	8	9	6	8	9
Mourning Dove	17	17	13	5	8	8	13	22	10	3	15	11	4		1	3	17	3
Northern Mockingbird					2			1										
Peregrine Falcon									1									
Pine Siskin	10	2		5	1		6		3	3			12	4	5		4	2
Plumbeous Vireo	10	10	7	3	9	9	1		1	6	6	5	11	16	15	14	11	18
Pygmy Nuthatch				2		2			2	4	12	9	11	13	26	29	41	20
Red Crossbill					1			2						2	9	13	9	
Red-shafted Flicker	3	1	3	2	5	2	3	2	4	8		3	3	4	11	11	5	5
Red-tailed Hawk									1	1	1	1						
Rock Wren	3	3	4		2	10	7	10	4	12	14	14	1	2	2	6		
Ruby-crowned Kinglet																		2
Say's Phoebe	2	1	2		2	5	2	1		5	2	4	1		1	3	3	4
Scaled Quail			1															
Spotted Towhee	17	8	19	27	32	24	12	6	33	16	12	16	11	18	16	14	21	22
Steller's Jay													3	2	5	6	3	4
Townsend's Solitaire	1																1	
Turkey Vulture					1								1					1
Violet-green Swallow		5	7	1	3	2	6	4	1	9	6	6		2	19	2	2	4
Virginia's Warbler					1	3			1	2	4		17	11	21	13	7	5
Warbling Vireo						2							2	9	7	6	5	4
Western Bluebird	15	11	18	17	16	19	5	19	12	21	13	6	20	20	49	37	32	27
Western Tanager		2	3		1			2	1	1	2	2	2	3	7	2	4	6

	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Species	TA-36 Minie Site						TA-39 Point 6						TA-16 Burn Grounds					
	Pinyon-Juniper Woodland						Pinyon-Juniper Woodland						Ponderosa Pine Forest					
Western Wood-Pewee	10	8	18	11	10	7		4	2	10	8	11	15	10	16	14	22	20
White-breasted Nuthatch	1	4	9	10	13	5			2	4	4	2	9	8	7	9	20	10
White-throated Swift								1										
White-winged Dove	1	5	9	2		3	7	5	6	16	15	15			1	2		
Woodhouse's Scrub-Jay	5	1	3	4	8	7	8	10	4	8	6	4	1					
Northern Rough-winged Swallow						3												

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 11 – Sanchez *et al.* 2020

Environmental Report:

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January 2020

2019 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

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Environmental Protection and Compliance Division

Environmental Stewardship Group

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Executive Summary

Los Alamos National Laboratory biologists in the Environmental Compliance and Protection Division at Los Alamos National Laboratory (LANL) initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. Monitoring results from these efforts were compared among years to monitor trends. The objectives of this study were to 1) determine whether LANL operations impact bird species richness, diversity, or abundance 2) evaluate trends in species abundance by feeding guild, and 3) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. LANL biologists completed the seventh year of this effort in 2019.

Three bird point count surveys were completed at each of the treatment sites at the Technical Area (TA) 36 Minie site, the TA-39 point 6, and the TA-16 burn ground between May and July 2019. A total of 853 birds representing 53 species were recorded at the three treatment sites and compared to their associated controls. Occupancy and nest success data from nestboxes at treatment sites were compared with the overall avian nestbox monitoring network.

In 2019 the species richness and diversity at the treatment sites were not statistically different from their associated controls. Rarefaction and extrapolation plots for all years through 2018 suggest that over time the species diversity was statistically different between treatments and controls, although the diversity was higher at the treatment sites than the control sites. Avian abundance showed more variability but treatment and controls were trending together year to year. The mean number of granivores, insectivores, and omnivores varies from year to year, but there is not a significant trend at any of the treatment sites. The dominant feeding guild at the treatment sites continues to be insectivores.

The overall results from 2019 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations. This long-term monitoring will continue to monitor for any changes over time.

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Introduction

As part of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) started an annual avian monitoring program in 2013. The permit was for two open detonation sites, Technical Area (TA)-36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018). This program supported a study with the objectives to (1) determine whether LANL operations impact bird species richness, diversity, or abundance (2) evaluate species abundance by feeding guilds over time and (3) examine nest success of secondary-cavity nesting birds using nestboxes. Comparisons were made with control sites of similar habitat that have been surveyed since 2011 (Hathcock et al. 2011).

Biologists at LANL used standard point count methodology to record avian richness, diversity, and abundance along transects at the three treatment sites and associated control sites during the summer of 2019. Summer surveys provide information about what birds are breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental changes at LANL.

In addition to avian point counts, nestboxes were monitored around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success data were compared with the overall avian nestbox monitoring network, which was established in 1997.

Methods

Field Methods for Point Count Surveys

The point count surveys were conducted along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon (*Pinus edulis*) –juniper (*Juniperus monosperma*) woodland (PJ) for Minie (Figure 1) and TA-39 (Figure 2) and a ponderosa pine (*Pinus ponderosa*) forest (PIPO) at TA-16 (Figure 3). These habitat descriptions were based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) were monitored annually in ongoing surveys that have been conducted at LANL since 2011 as described in Hathcock et al. (2011). Each habitat type control contained two replicate transects that were monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects were randomized and surveyed according to the random order.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was in an undeveloped area.

Transects were approximately 2.0 to 2.5 km in length with nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site conducted between 0.5 hours before sunrise and 4 hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor looks and listens for 5 minutes, recording all birds encountered at each point on a data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point. The observation distance is considered as an “unlimited-distance circular plot”; however, the distance to each bird out to 100 m should be recorded. A range finder should be used if available. Avoid re-counting individuals between points.
- While walking between points, any obvious species not recorded at the previous point that also wouldn’t be counted at the next point should be recorded. The surveyor should not spend excess time looking for birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Use the “NOTES” section to indicate any additional information about the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Other wildlife or unusual sightings that could be used for other projects should be recorded.

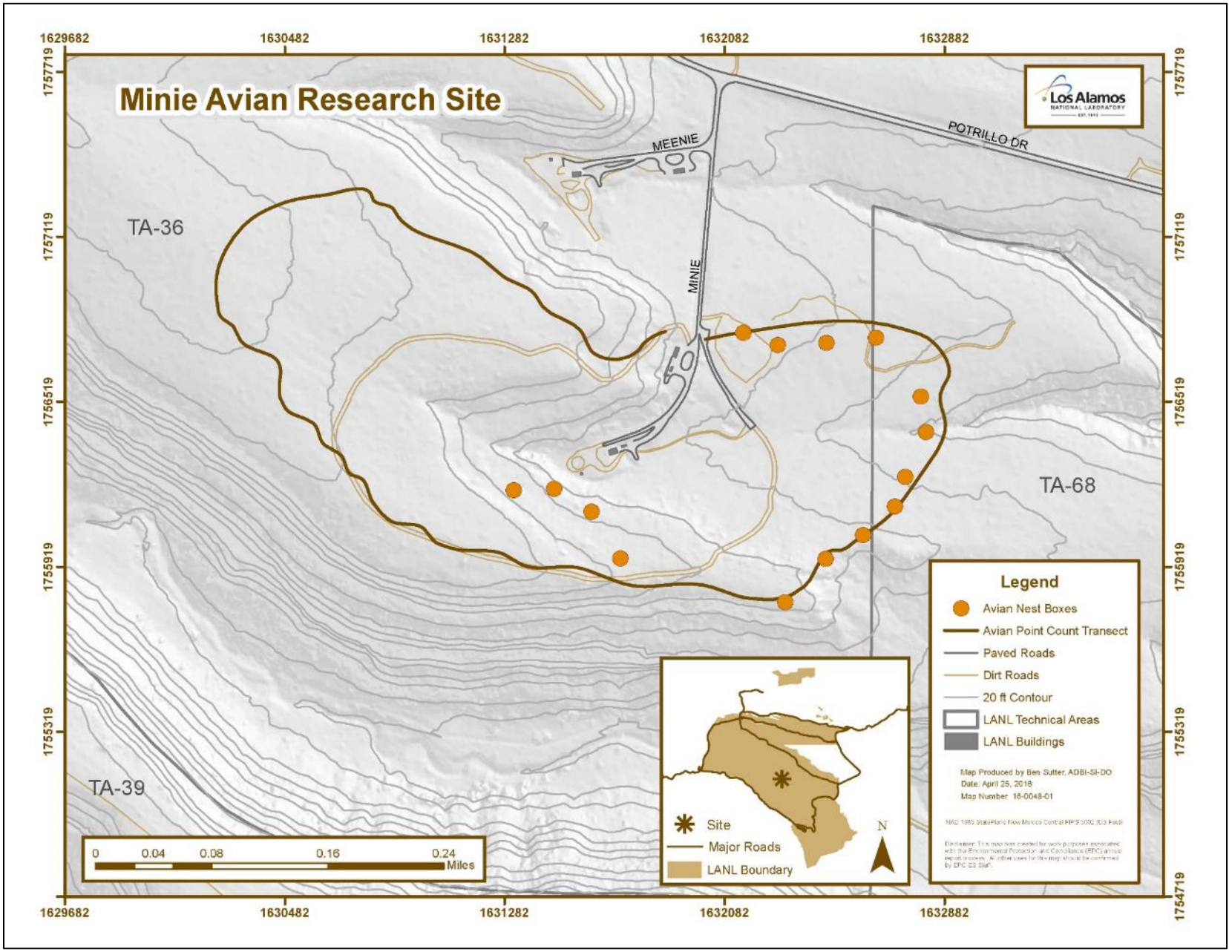

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie site

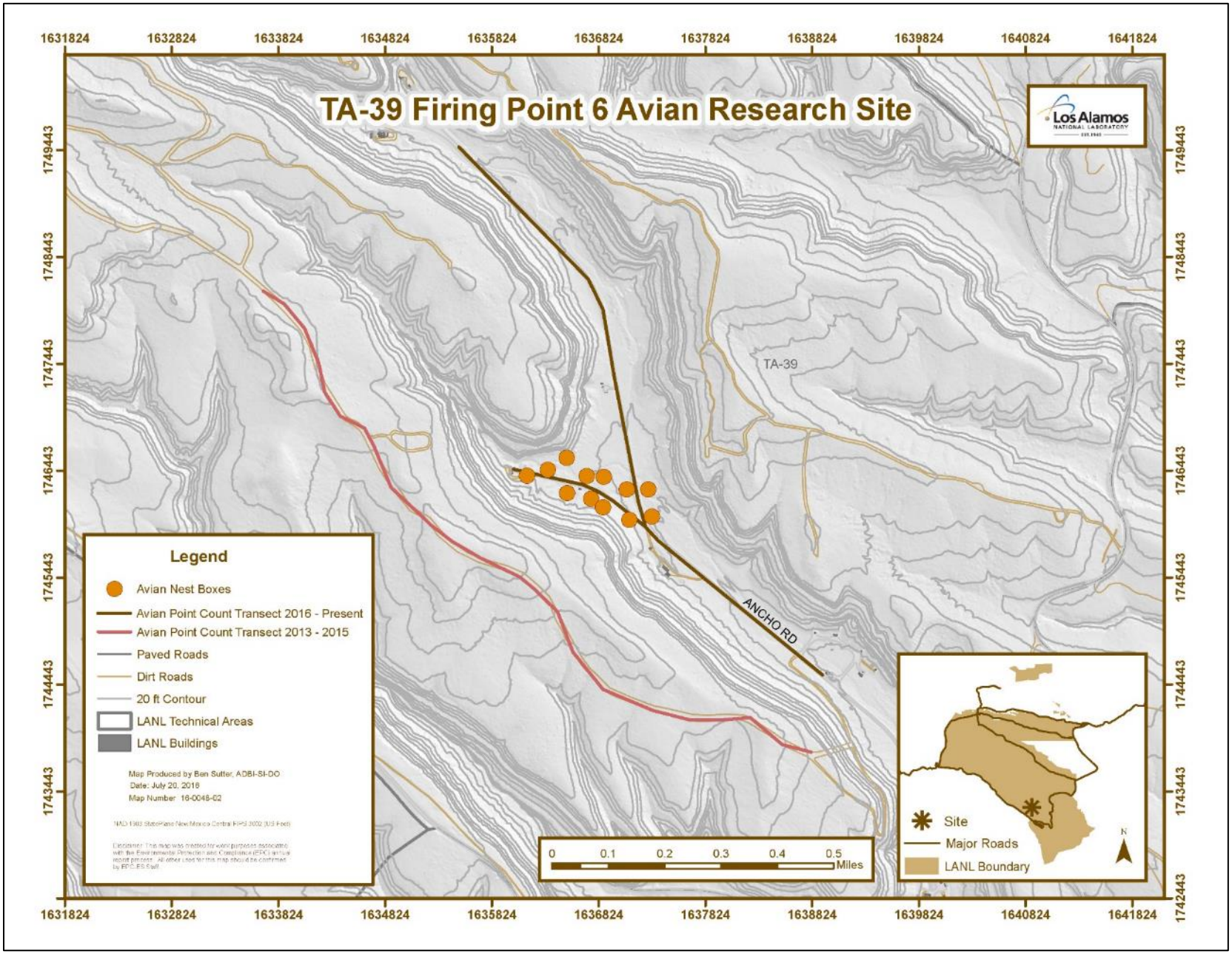

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 point 6

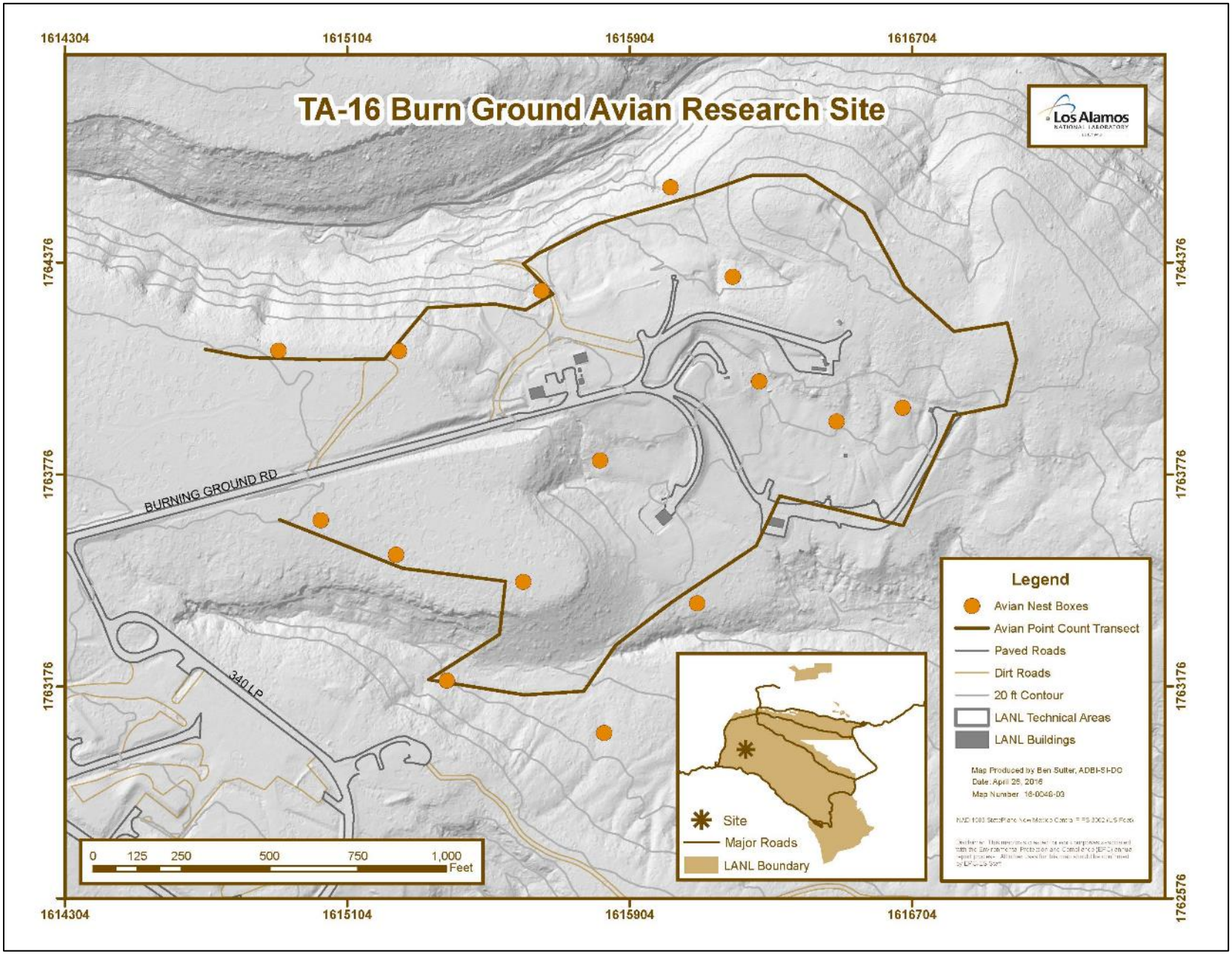

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 burn ground

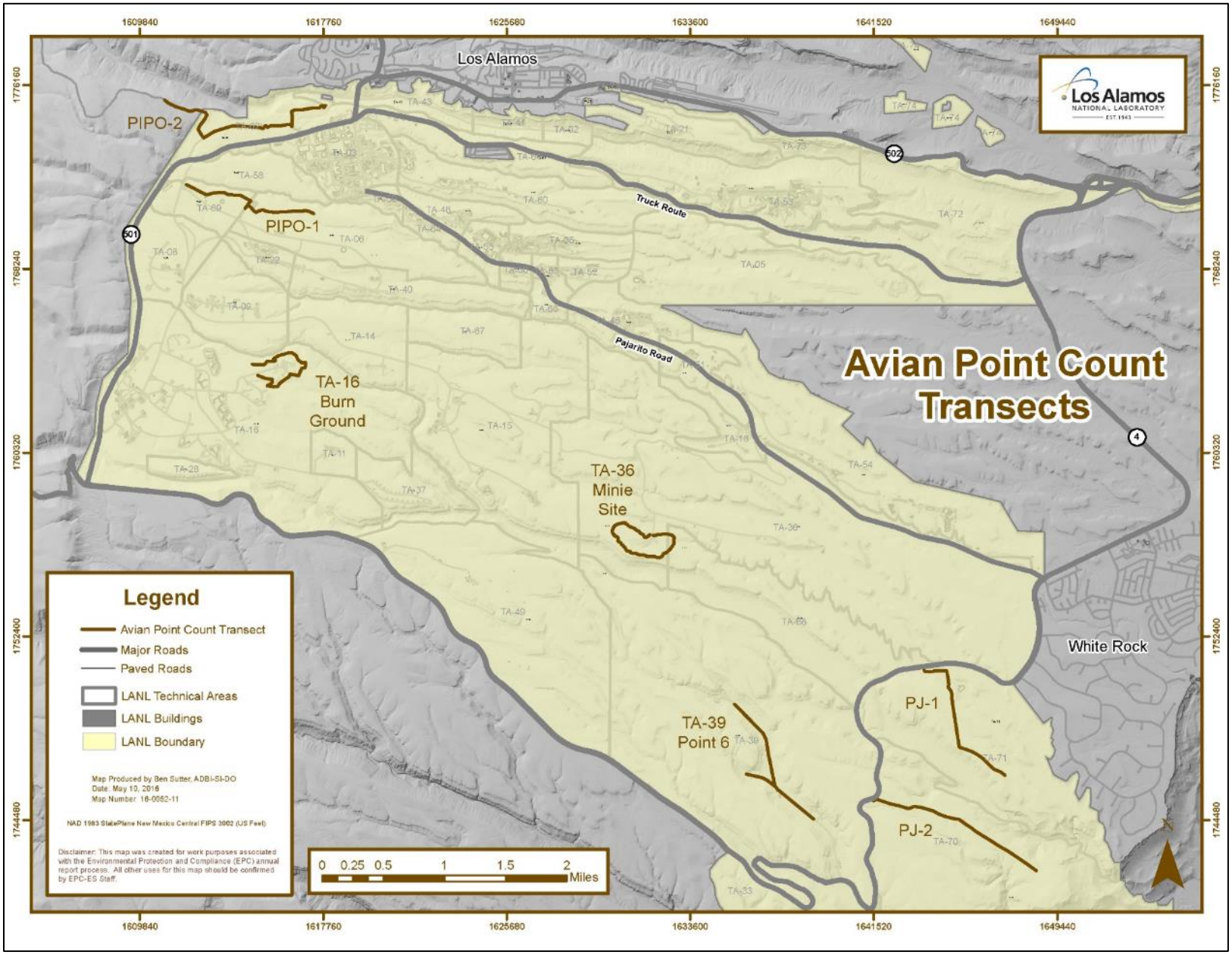

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Statistical Methods for Point Counts

These data were summarized to compare species richness, diversity, and abundance between treatment and control sites and over time. Species richness and abundance were calculated in Microsoft Excel©, and species diversity was computed using the statistical software PAST (Hammer et al. 2001). The Shannon's diversity index (Shannon and Weaver 1949) was used to compare diversity between habitats (Clarke et al. 2014). Shannon's diversity ranges for most ecological systems are between 1.5 and 3.5, and are rarely greater than 4.5, where high values indicate high diversity. A t-test was used to test for differences between treatment and control site diversity each year.

In addition, these data were summarized to compare species of three feeding guilds at each transect over time. The three feeding guilds included granivores, insectivores, and omnivores. Since there are three surveys completed at each transect per year, these data at each transect were averaged and compared over time.

Field Methods for Nestbox Monitoring

In 2011, nestboxes were added to Minie and TA-39 (Figures 1 and 2). In 2015, nestboxes were added to TA-16 (Figure 3). Nestboxes were monitored every one to two weeks for active nests. When an active nest was found, it was monitored more frequently to determine whether the nest failed or successfully fledged young. Nestlings were also banded and the sex was determined after the age of 10 days.

Statistical Methods for Nestboxes

Occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network were calculated. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. Annually, data from the three treatment sites were compared with the overall avian nestbox network at LANL which was established in 1997.

Results and Discussion

Point Count Surveys-Year 2019

Three surveys were completed at each of the three treatment sites and the associated control sites between May and July 2019. A total of 853 birds representing 53 species were recorded at the three treatment sites. A full account of the 2013–2019 data is detailed in Appendix 1.

Species richness is the number of different species represented in an ecological community and is simply a count of species. In this case, each treatment site and control are individual communities. Species diversity is a measure that takes into account the species richness and the

overall abundance to compare evenness across a community. Here we used the Shannon's diversity index, which measures the probability that two individuals randomly selected from a sample will belong to different species. The abundance is the total number recorded of a given species. Tables 1 and 2 detail the species richness, diversity, and abundance for 2019 for each treatment and control site.

Table 1. The species richness, diversity, and abundance recorded at all treatment and control sites in 2019

	Minie	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	34	38	30	33	39	41	41
Diversity	3.063	3.083	2.755	2.901	3.291	3.127	3.292
Abundance	245	298	226	187	310	364	394

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The moisture for the winter of 2018–2019 was at or slightly above normal, but the species richness at all sites was similar to the previous year.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Minie	33	33	34	30	35	35	34
TA-39	31	31	39	38	34	39	38
PJ Control 1	29	30	33	36	37	30	30
PJ Control 2	30	29	37	33	39	23	33
TA-16	33	33	40	44	41	43	39

PIPO Control 1	34	34	30	41	41	37	41
PIPO Control 2	33	36	43	43	44	40	41

Tables 3–5 compare the species diversity over time between the treatment site and the combined control. The two control sites were combined to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of this study. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is around 3, which compared with ecological systems in general is very high.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Minie	3.141	3.141	3.161	2.968	3.134	3.220	3.060
PJ Control	2.895	2.990	3.159	3.075	3.241	2.940	2.970
t-test	**t = -3.2012**	t = -1.8716	t = -0.5269	t = 1.291	t =1.4637	**t =-3.907**	t =-1.2465
	df = 508	df = 455	df = 663	df = 460	df = 498	**df = 588**	df = 626
	p = 0.001	p = 0.06	p = 0.60	p = 0.20	p = 0.14	**p < 0.01**	p = 0.21

Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
TA-39	3.090	3.073	3.143	3.318	3.178	3.130	3.080
PJ Control	2.895	2.990	3.159	3.075	3.241	2.940	2.970
t-test	**t = -2.527**	t = -1.0396	t = 0.2166	**t = -3.7477**	t = 0.95934	**t = -2.7474**	t = -1.4205
	df = 464	df = 477	df = 483	**df =664**	df = 675	**df = 699**	df = 670
	p = 0.012	p = 0.30	p = 0.83	**p <0.01**	p = 0.34	**p = 0.006**	p = 0.16

Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
TA-16	3.304	3.207	3.236	3.293	3.238	3.360	3.290
PIPO Control	3.261	3.225	3.161	3.216	3.296	3.170	3.320
t-test	t = -0.66864	t = 0.26454	t = -1.2603	t = -1.1396	t = 0.88237	**t = -2.9553**	t = 0.51719
	df = 404	df = 495	df = 689	df = 511	df = 539	**df = 578**	df =648
	p = 0.50	p = 0.79	p = 0.21	p = 0.25	p = 0.38	**p = 0.003**	p = 0.61

To further analyze richness and Simpson's diversity (Simpson 1949) over time, species rarefaction and extrapolation plots (Hsieh et al. 2016, Chao et al. 2014) were developed in 2018 that included all years of data with the control sites combined. Species rarefaction and extrapolation show no differences between treatment and control sites for species richness. There were overlapping 95% confidence intervals for species richness (Figures 5A–6A) for all three treatments and their controls. Simpson's diversity is normally a measure between 0 and 1, but when analyzed using Hill numbers (Hsieh et al. 2016) it effectively reports the number of dominant species. The rarefaction and extrapolation plots for species diversity (Figures 5B–6B) were significantly different since the 95% confidence intervals did not overlap. In these cases, the treatment sites were higher in diversity than the controls with a higher number of dominant species. Tables 3-5 show there were no significant differences of diversity between treatment and control sites in 2019. Since the extrapolation curves are not expected to change much between years, these will be reanalyzed every five years.

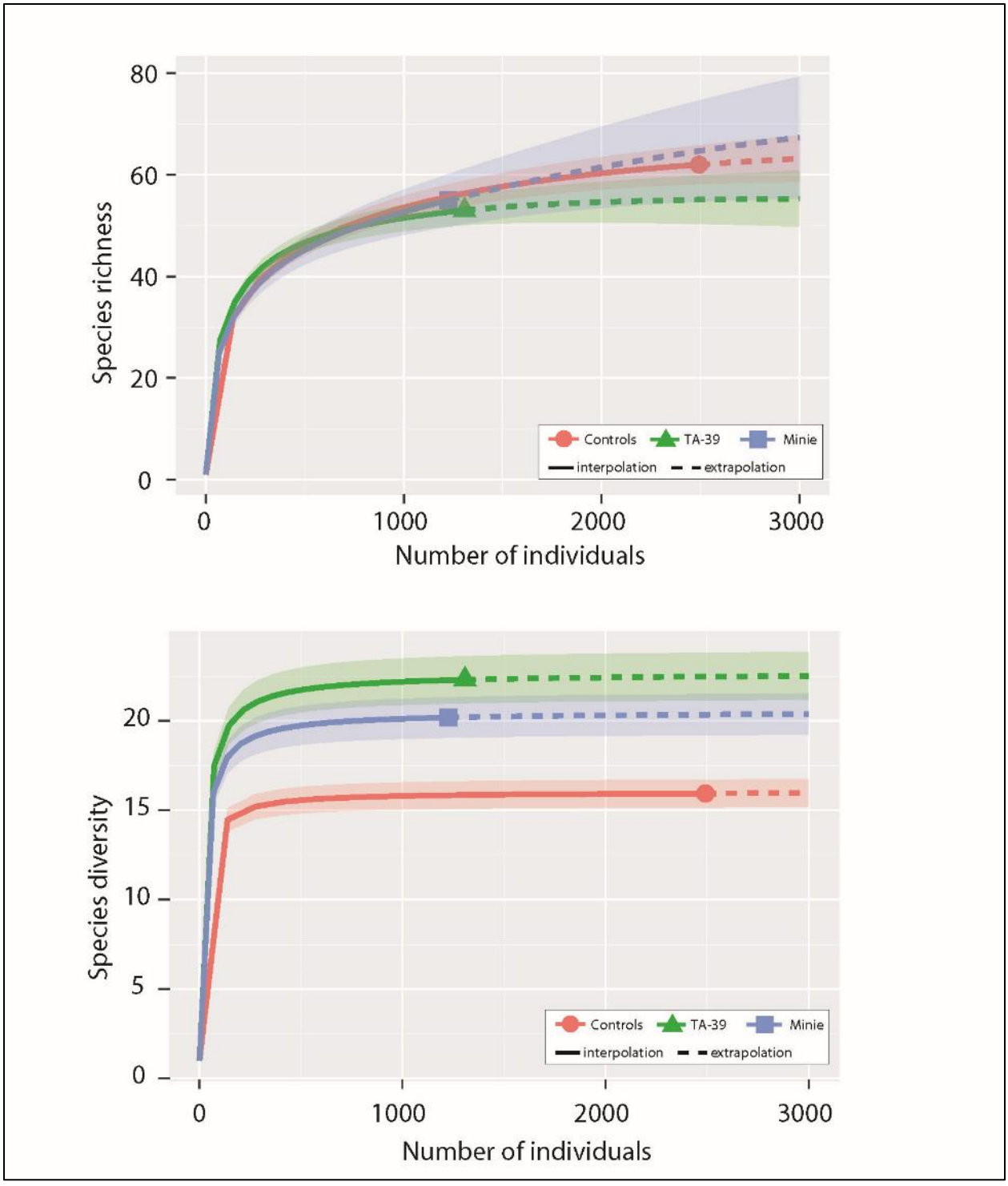

Figure 5. 2013 – 2018 Species rarefaction and extrapolation for species richness and diversity comparing Minie and TA-39 with the PJ controls

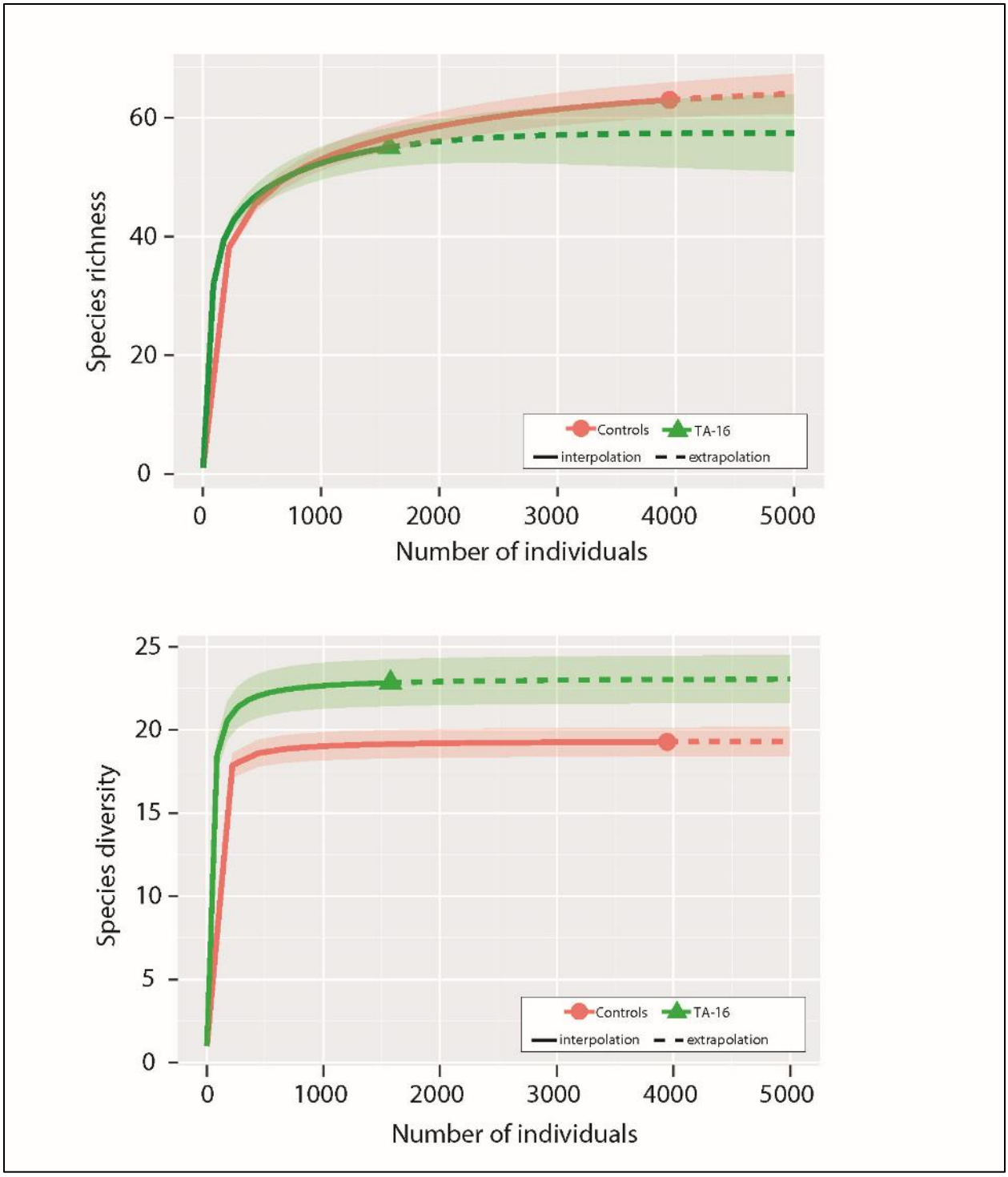

Figure 6. 2013 – 2018 Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls

The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower, but the percent abundance is similar year to year when compared with the control sites. Table 6 compares the abundance between the treatment and control sites over time. Similar to the species richness trends, there was an increase in abundance in 2015. The fluctuations in bird abundances were not alarming, and the differences between the treatment sites and control sites were not biologically significant. The moisture for the winter of 2018–2019 was at or slightly above normal, but the species abundance at all sites were similar to previous years.

Table 6. Changes in species abundance over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Minie	193	186	275	210	222	242	245
TA-39	177	193	259	249	261	315	298
PJ Control 1	187	157	269	312	240	235	226
PJ Control 2	181	177	301	228	300	168	187
TA-16	220	209	347	271	302	285	310
PIPO Control 1	258	223	432	323	447	374	364
PIPO Control 2	256	254	371	396	449	366	394

Figures 7-9 summarize the feeding guild trends over time at the treatment sites and the combined control sites. Overall, there are fewer granivores at all transect locations. Most of the species documented are insectivores and omnivores. Tracking bird abundance by feeding guild is important, because recent studies have shown changes in food sources, specifically for insectivores, have cascading effects on bird populations (Hallmann et al. 2017). Although there are periods of significant differences between years, they tend to follow the fluctuations in abundance and species richness.

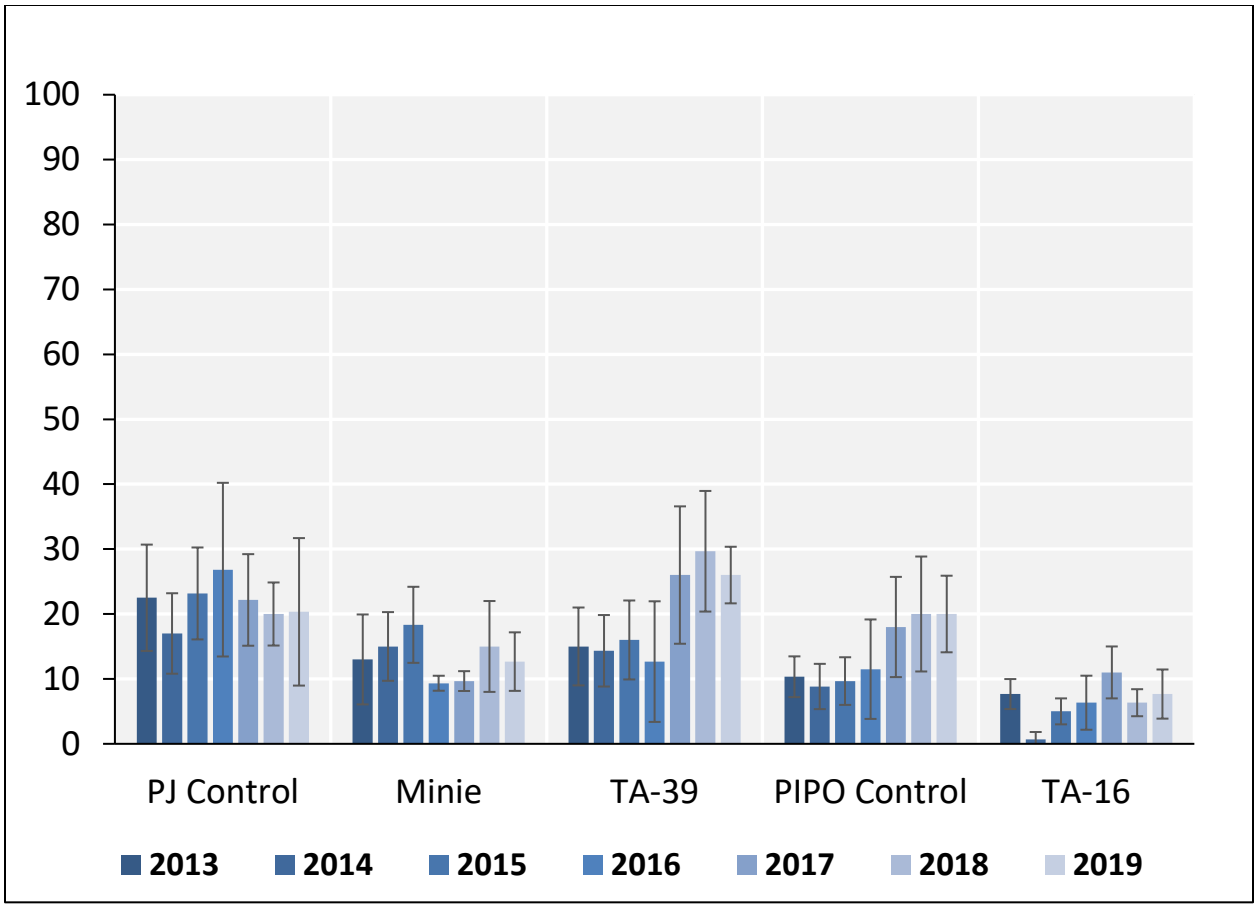

Figure 7. Average number of granivores +/- 1 standard deviation during breeding bird surveys at treatment sites and combined control sites over time.

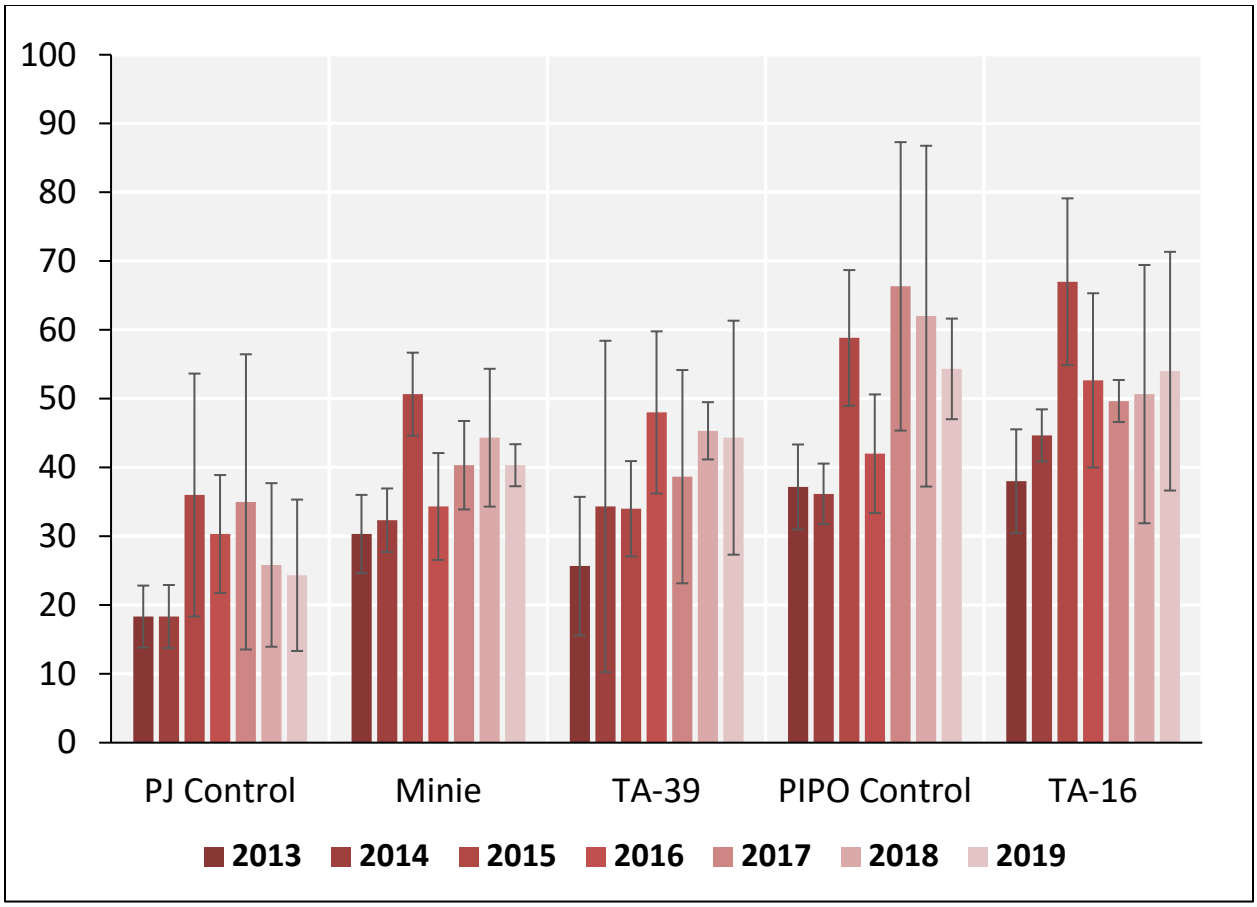

Figure 8. Average number of insectivores +/- 1 standard deviation during breeding bird surveys at treatment sites and combined control sites over time.

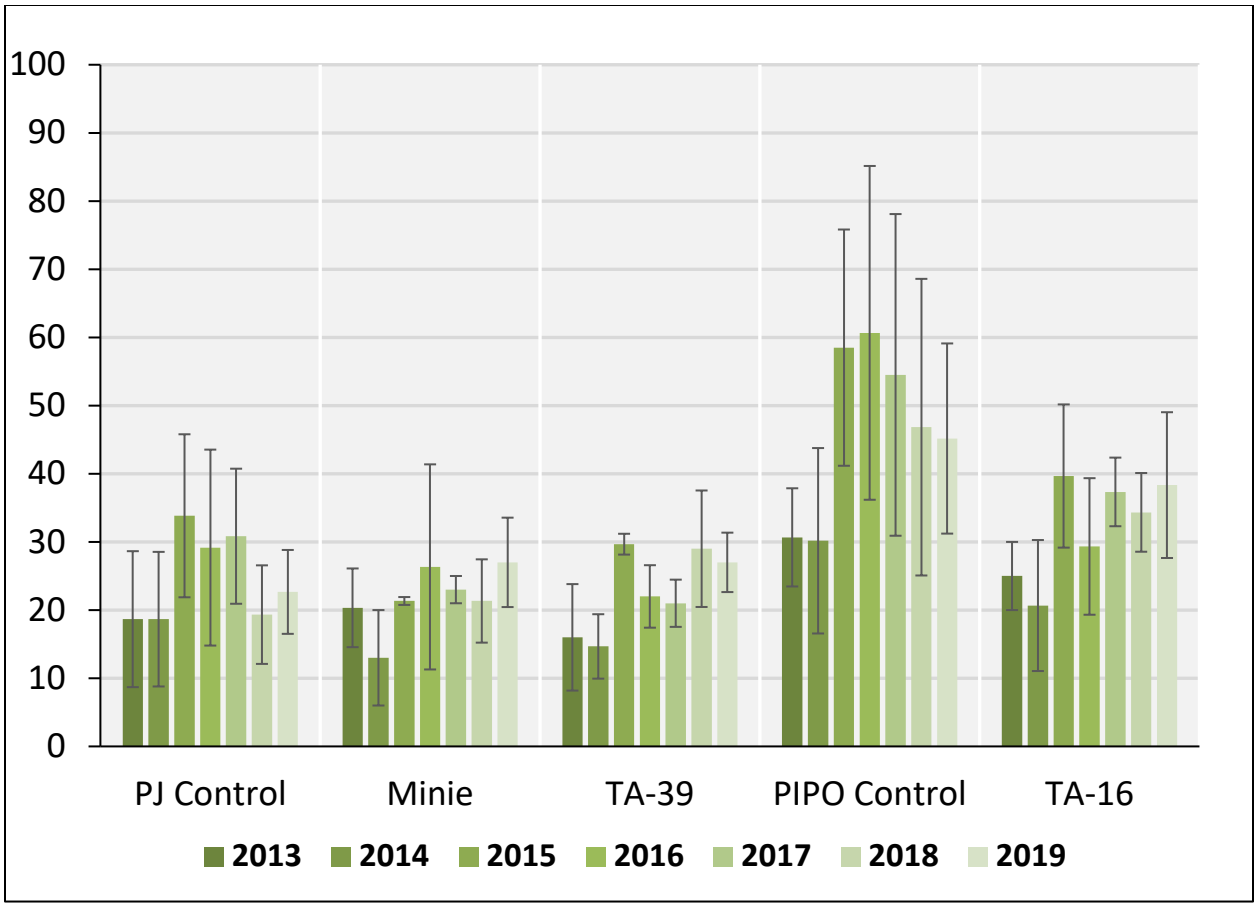

Figure 9. Average number of omnivores +/- 1 standard deviation during breeding bird surveys at treatment sites and combined control sites over time.

The number of granivores at TA-16 in comparison with the PIPO controls is lower overall. TA-16 is located on a mesa top surrounded by canyons with rocky cliff faces. Perhaps there is less understory vegetation on the cliff faces surrounding TA-16, resulting in less food for granivores. More study on habitat components between TA-16 and the PIPO control is needed to determine potential causes of the granivore variation.

Nestboxes

During the 2018 season, the overall avian nestbox network was managed at lower levels. Treatment sites were maintained at previous years' effort, but site-specific constraints from increased fire restrictions in 2018 limited the overall network management. In 2019, there were no restrictions and the nestbox network was managed throughout the breeding season with no limitations.

During the 2019 nesting season, 15 nestboxes at each treatment site were actively monitored. The overall avian nestbox network, without the three treatment sites, contained 378 nestboxes in

2019. Of those, 167 contained active nests and 85 of those nests fledged young successfully. This was an overall occupancy rate of 44% with a 51% success rate.

Tables 7 and 8 compare the occupancy and success rates for each treatment site and the overall nestbox network since 2015.

Table 7. Comparison of occupancy for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*	*2019*
Overall Network	40%	45%	48%	53%	44%
Minie	66%	73%	46%	20%	60%
TA-39	8%	58%	20%	33%	13%
TA-16	-	73%	100%	53%	87%

Table 8. Comparison of success for the treatment sites and the overall nestbox network over time.

	2015	*2016*	*2017*	*2018*	*2019*
Overall Network	66%	69%	57%	49%	51%
Minie	64%	23%	29%	33%	44%
TA-39	100%	57%	0%	40%	0%
TA-16	-	63%	76%	63%	54%

In 2019, there were four successful nests that fledged young at Minie, zero at TA-39, and seven at TA-16. Both occupancy and success rates at TA-39 were low in comparison to the other treatment sites and the overall network. TA-39 is the lowest elevation treatment site and occupancy has been decreasing over time at this site and surrounding areas of the avian nestbox network. Wysner et al. (2019) found that Western Bluebirds, one of the target species of the network, have increased their nesting elevation over time in the study area. Western Bluebirds have the highest occupancy rates throughout the nestbox network, and the shift in nesting elevation could be driving the lower occupancy rates at TA-39. Occupancy and success rates at

the other two treatment sites seem to be fluctuating naturally in comparison to the overall network and have not displayed a decreasing trend over time.

In 2019, nonviable eggs collected from nestboxes at the treatment sites and the rest of the nestbox network were submitted to an analytical lab for chemical analyses. These data will be reported in a separate report.

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 53 species detected at the three treatment sites, all are protected under the Migratory Bird Treaty Act. In addition, sensitive species from the Birds of Conservation Concern Region 16 list, the Southern Rockies/Colorado Plateau region (USFWS 2008), the New Mexico Avian Conservation Partners Species Conservation Level One List (NMACP 2019), and the Birder's Conservation Handbook (Wells 2007) have been documented at the treatment sites. Those species are the Juniper Titmouse, Grace's Warbler, Virginia's Warbler, and the Woodhouse's Scrub Jay. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901).

Continuing the research reported herein will provide a long-term dataset for the ecological health of avifauna at the three treatment sites at LANL. In addition, this research contributes to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and it allows LANL to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2019

Species	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
Acorn Woodpecker															5		3	2	3	5	3
American Crow																			1	1	
American Kestrel				1				1			2										
American Robin	1	1	2		2			1	1		2		4	2	7		9	4	4	6	12
Ash-throated Flycatcher	11	5	14	13	13	10	17	19	11	29	12	8	8	6	3	5	6	2	3	8	4
Audubon's Warbler		2				5					2				6	5	1	6		1	11
Bewick's Wren	4	8	9	9	14	14	5	3	10	15	9	2	8	1							
Black-chinned Hummingbird		1	1				1	3	2				1	2	1		1		1		1
Black-headed Grosbeak	1	3				1	1		2	4	1		3	2			1	2		2	
Black-throated Gray Warbler			1		2			5	6	4											
Blue-gray Gnatcatcher	3	14	16	8	10	9	8	2		7	5	4	2	13		6	2	1	3	6	4
Broad-tailed Hummingbird	2	1	3		1		3	3	1	2		3	1	2	5	11	11	5	7	10	8
Brown Creeper															1						
Brown-headed Cowbird	1									2			3	2	4	1			4	2	8
Bushtit		2		2		11		2	14			1	12								
Canada Goose										16				2							
Canyon Towhee	2		5	3	6	2	3	1	1	2	10	13	19	6	1			1		1	
Canyon Wren					1					2	3	8	6	2			2				
Cassin's Finch						4															
Cassin's Kingbird	6	13	13	5	2	5	6	7	6	2	21	21	32	37				1			
Chipping Sparrow	3	16	17	29	6	22	10	6	6	5	8	15	25	27	1	5	3	10	5	21	8

Species	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
Clark's Nutcracker																4		1			
Common Nighthawk	6		5	2	4	4	1	5	1	3	2	7	5	7			1	2	2		
Common Raven	2	5	1		1	2	3	1		2	1		1	2	5	6	2	2	5	5	7
Cooper's Hawk					1										1			1			1
Cordilleran Flycatcher															5	10	6	3	3	1	2
Dark-eyed Junco													1	1	6	2	4		5	2	
Downy Woodpecker				1							1	2		1		1		1	1	1	
Dusky Flycatcher				1						1		1									
Eurasian Collared-Dove	3											4								1	
Evening Grosbeak	3		4							8					5		29			1	
Grace's Warbler							1						2	4	6	4	4	8	5	8	22
Gray Flycatcher	12	6	5	7	3	6	3	10	10	11	10	5	8	3							
Great Horned Owl		3						1													
Green-tailed Towhee	3	1						1													
Hairy Woodpecker			2	1		1				5	3			1	1	1		1	1	2	1
Hammond's Flycatcher															8	9	12	5	7	5	10
Hepatic Tanager										1	2	1	2					1			
Hermit Thrush						1										4	6	1	2	2	5
House Finch	16	17	26	17	12	18	17	21	4	23	9	30	44	50	16	2	5	5	12	7	12
House Wren														1	1	1		2	2	6	8
Juniper Titmouse	12		7	6	9	3	26	11	13	18	6	1									
Lesser Goldfinch	2	6	7	4	9	12	8	4	12	9	10	14	19	15	3		8	9	4	8	5
MacGillivray's Warbler																		1	3		
Mountain Bluebird		2	20	10	11	1	9		4								4	4	4	7	4
Mountain Chickadee	5	2	1	2							1	1		1	5	8	9	6	8	9	1

Species	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
Mourning Dove	17	17	13	5	8	8	11	13	22	10	3	15	11	8	4		1	3	17	3	5
Northern Mockingbird					2		1		1												
Northern Rough-winged Swallow						3															
Peregrine Falcon										1											
Pine Siskin	10	2		5	1			6		3	3				12	4	5		4	2	
Plumbeous Vireo	10	10	7	3	9	9	15	1		1	6	6	5	5	11	16	15	14	11	18	16
Pygmy Nuthatch				2		2	3			2	4	12	9	11	11	13	26	29	41	20	16
Red Crossbill					1				2							2	9	13	9		6
Red-shafted Flicker	3	1	3	2	5	2	1	3	2	4	8		3	2	3	4	11	11	5	5	2
Red-tailed Hawk							1			1	1	1	1								
Rock Wren	3	3	4		2	10	11	7	10	4	12	14	14	12	1	2	2	6			4
Ruby-crowned Kinglet																				2	
Say's Phoebe	2	1	2		2	5	1	2	1		5	2	4		1		1	3	3	4	1
Scaled Quail			1																		
Spotted Towhee	17	8	19	27	32	24	19	12	6	33	16	12	16	15	11	18	16	14	21	22	34
Steller's Jay							1								3	2	5	6	3	4	4
Townsend's Solitaire	1																		1		
Turkey Vulture					1										1					1	
Vesper Sparrow																					1
Violet-green Swallow		5	7	1	3	2	1	6	4	1	9	6	6	9		2	19	2	2	4	2
Virginia's Warbler					1	3	1			1	2	4		5	17	11	21	13	7	5	5
Warbling Vireo						2									2	9	7	6	5	4	6
Western Bluebird	15	11	18	17	16	19	21	5	19	12	21	13	6	7	20	20	49	37	32	27	20
Western Tanager		2	3		1				2	1	1	2	2	6	2	3	7	2	4	6	16
Western Wood-Pewee	10	8	18	11	10	7	18		4	2	10	8	11	12	15	10	16	14	22	20	24

Species	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
	TA-36 Minie Site							TA-39 Point 6							TA-16 Burn Grounds						
	Pinyon-Juniper Woodland							Pinyon-Juniper Woodland							Ponderosa Pine Forest						
White-breasted Nuthatch	1	4	9	10	13	5	2			2	4	4	2	6	9	8	7	9	20	10	10
White-throated Swift									1												
White-winged Dove	1	5	9	2		3	2	7	5	6	16	15	15	5			1	2			1
Woodhouse's Scrub-Jay	5	1	3	4	8	7	14	8	10	4	8	6	4	5	1						

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 12 – Rodriguez & Abeyta 2021

Environmental Report:

Rodriguez, J.M. and E.J. Abeyta. *2020 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory*. LA-UR-21-22304-Rev.01.

March 2021

2020 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY

Prepared by: **Jadzia Rodriguez and Elisa Abeyta, Environmental Protection and Compliance Division, Environmental Stewardship Group, Los Alamos National Laboratory**

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EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL) biologists in the Environmental Protection and Compliance Division initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. In this annual report we compare monitoring results from these efforts among years to monitor trends. The objectives of this study are to 1) determine whether LANL operations impact bird species richness, diversity, or abundance and 2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. LANL biologists completed the eighth year of this effort in 2020.

Between May and July 2020, we completed three avian point count surveys at each of the treatment sites which are the Technical Area (TA)-36 Minie site, the TA-39 point 6, and the TA-16 burn ground. We recorded a total of 1,005 birds representing 63 species at the three treatment sites and compared these results to data from their associated control sites. We also compared occupancy and nest success data from nestboxes at treatment sites with the overall avian nestbox monitoring network.

In 2020, species richness and avian abundance showed variability, but treatment and controls were trending together year to year. The species diversity at the TA-36 Minie site and TA-16 burn ground were statistically different from their associated controls. To examine this further, we prepared rarefaction and extrapolation plots for all years and over time. The species diversity at all three treatment sites has been diverging from the controls over the last few years. We determined that the diversity was higher at the treatment sites than the controls which is not alarming. Nestbox results suggest natural fluctuations year to year.

The overall results from 2020 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations. This long-term project will continue to monitor for any changes over time.

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INTRODUCTION

As part of the Resource Conservation and Recovery Act permit process, Los Alamos National Laboratory (LANL) started an annual avian monitoring program in 2013. The permit was for two open detonation sites, Technical Area (TA)-36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018; Sanchez et al. 2020). The objectives of this long-term monitoring program are to (1) determine whether LANL operations impact bird species richness, diversity, or abundance and (2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. This involves making comparisons with control sites of similar habitat that LANL biologists have surveyed since 2011 (Hathcock et al. 2011).

LANL biologists used standard point count methodology to record avian richness, diversity, and abundance along transects at the three treatment sites and their associated control sites during the summer of 2020. Summer surveys provide information about what birds are breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental changes at LANL.

In addition to avian point counts, LANL biologists monitored nestboxes around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success were compared to the overall avian nestbox monitoring network, which was established in 1997.

METHODS

Field Methods for Point Count Surveys

LANL biologists conducted the point count surveys along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon (*Pinus edulis*) – juniper (*Juniperus monosperma*) woodland (PJ) for Minie (Figure 1) and TA-39 (Figure 2) and a ponderosa pine (*Pinus ponderosa*) forest (PIPO) at TA-16 (Figure 3). The habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) are monitored annually. The control sites were originally established in 2011 (Hathcock et al. 2011). Each habitat type control contained two replicate transects that LANL biologists monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects are monitored randomly.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in

the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was in an undeveloped area.

Transects were approximately 2.0 to 2.5 km in length with nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys was May 1 through August 15. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site conducted between 0.5 hours before sunrise and four hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor looks and listens for five minutes, recording all birds encountered at each point on a data sheet. For each observation, the minimum data collected should be point number, time, species, number of individuals, and distance from the point. The observation distance is considered as an "unlimited-distance circular plot"; however, surveyors should be recording the distance to each bird out to 100 m. A range finder should be used if available. Avoid re-counting individuals between points.
- While walking between points, surveyors should be recording any obvious species not recorded at the previous point that also wouldn't be counted at the next point. The surveyor should not spend excess time looking for birds between points.
- Do not conduct surveys during rain events or winds greater than 24 kph.
- Use the "NOTES" section to indicate any additional information about the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Surveyors should be recording other wildlife or unusual sightings that could be used for other projects.

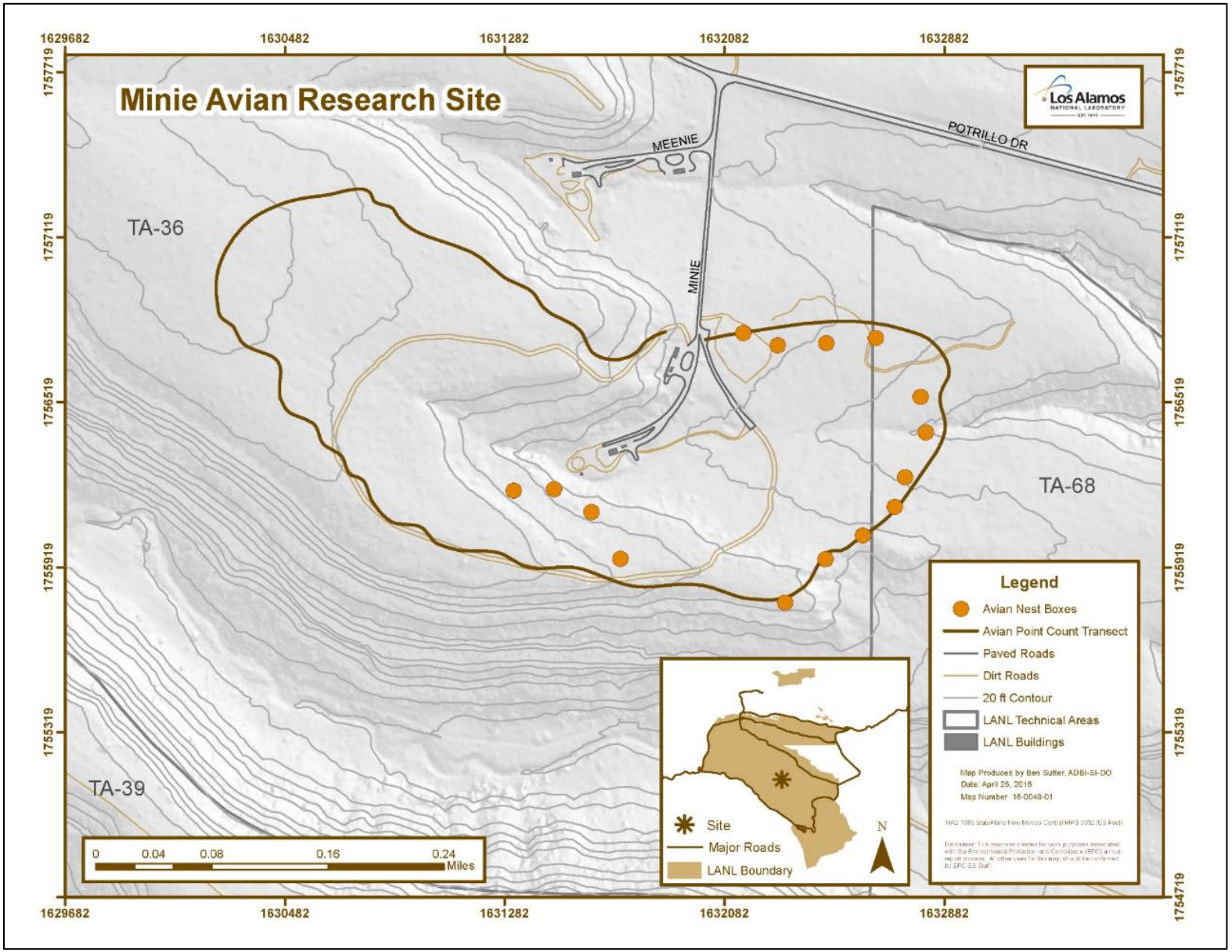

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie Site

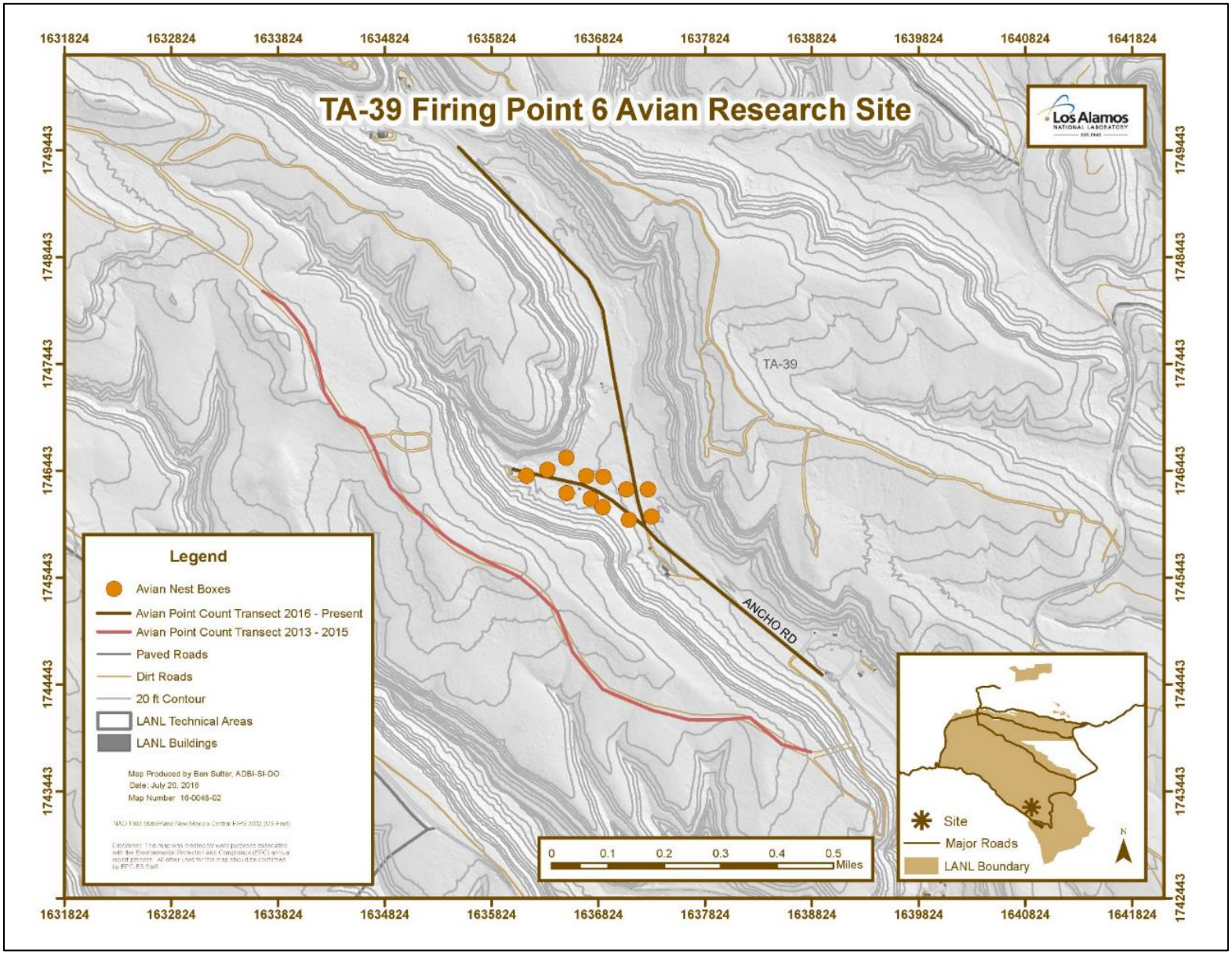

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 Point 6

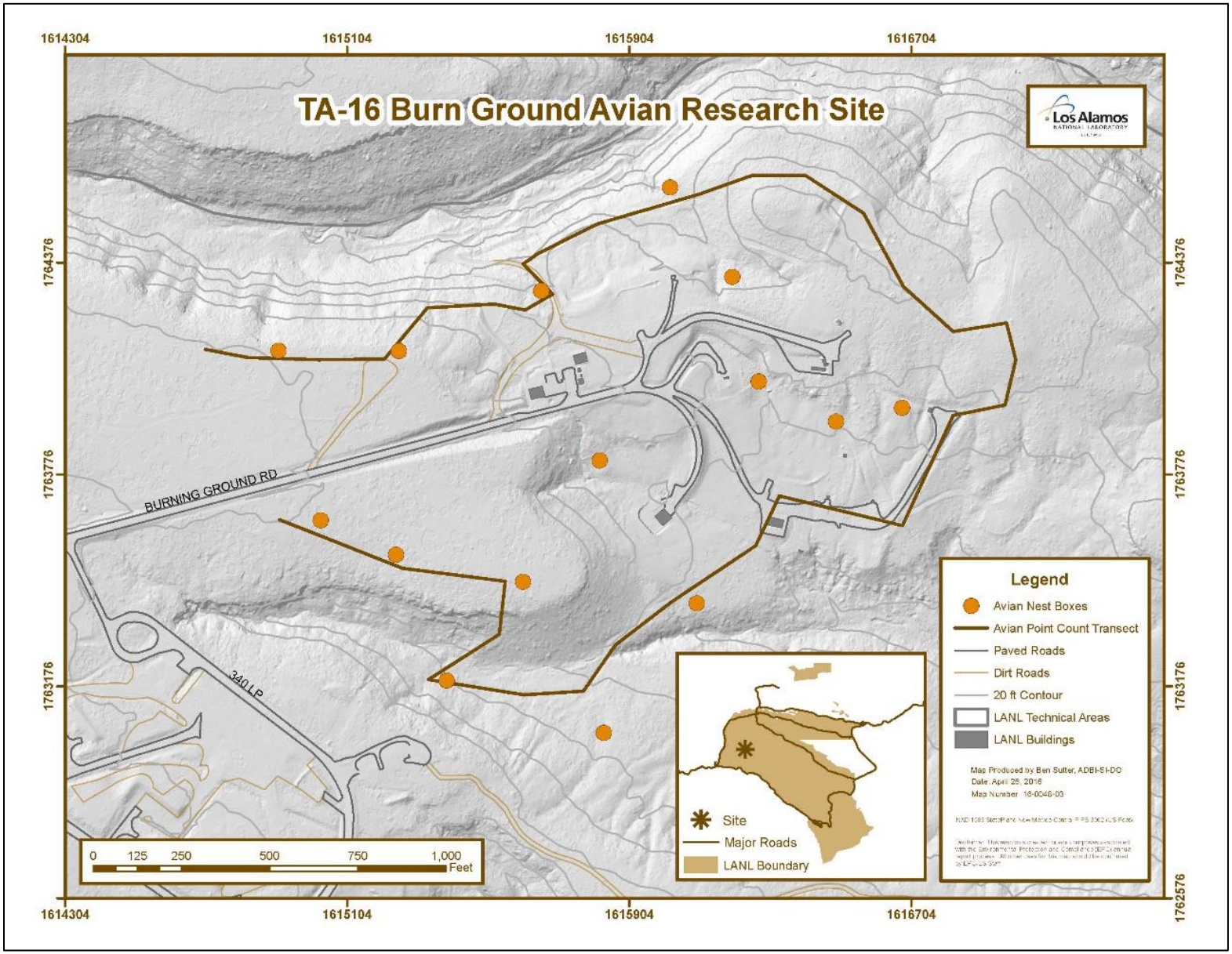

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 Burn Ground

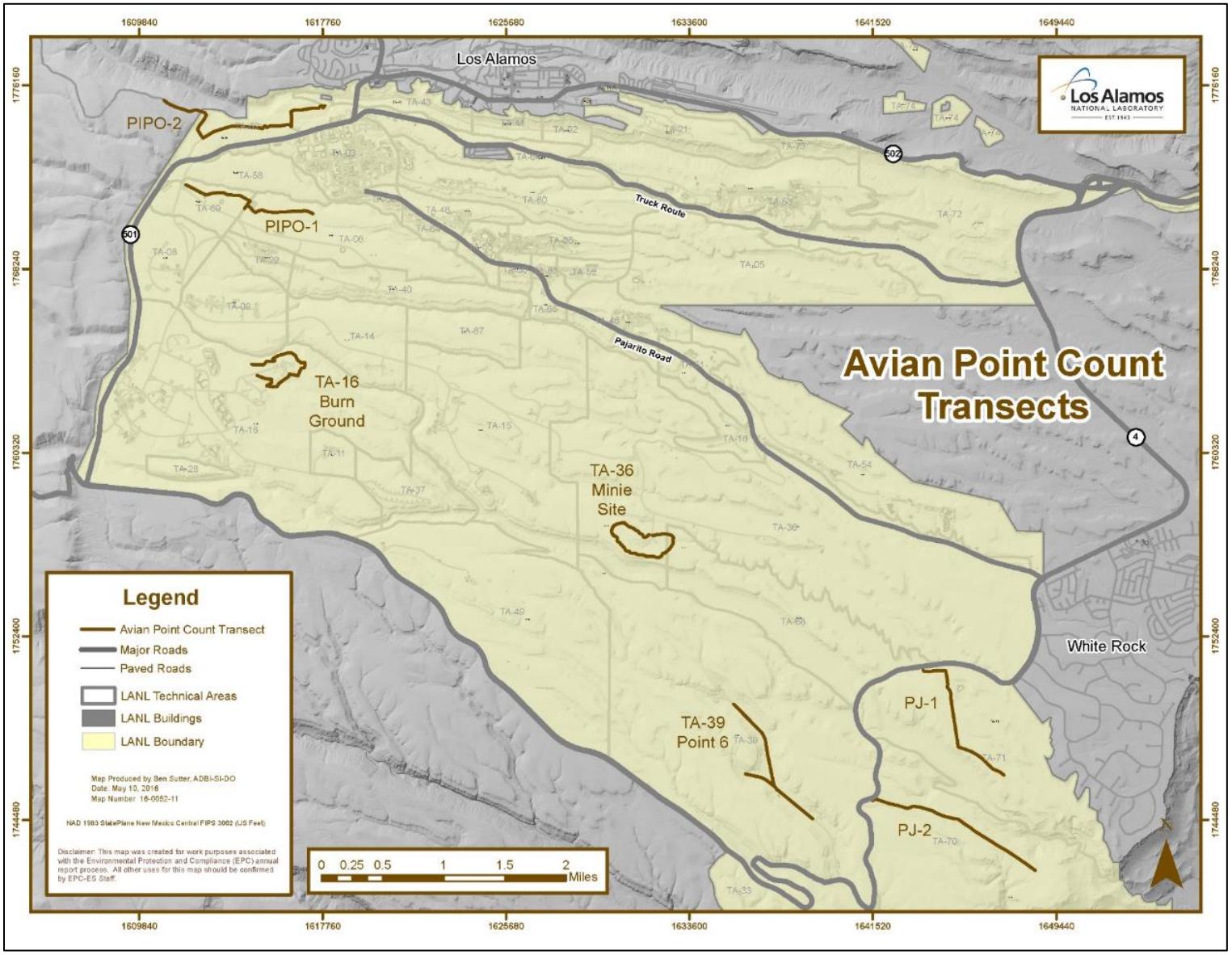

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Statistical Methods for Point Counts

We summarized these data to compare species richness, diversity, and abundance between treatment and control sites and over time. We considered each treatment site and control to be individual communities. Species richness is the number of different species represented in an ecological community and is simply a count of species (Boulinier et al. 1998). Species diversity is a measure that takes into account the species richness and the overall abundance to compare evenness across a community (Tramer 1969). Shannon's diversity index measures the probability that two individuals randomly selected from a sample will belong to different species (Shannon and Weaver 1949). The abundance is the total number recorded of a given species (Gotelli and Colwell 2011).

We calculated species richness and abundance using the statistical software R (version 3.6.1; R Core Team 2019) and computed species diversity using the statistical software PAST (Hammer et al. 2001). We used the Shannon's diversity index to compare diversity between habitats (Clarke et al. 2014). Shannon's diversity ranges for most ecological systems are between 1.5 and 3.5, and are rarely greater than 4.5, where high values indicate high diversity. We used a diversity t-test in the PAST software to test for differences between treatment and combined control site diversity each year.

We also used the R-package 'iNEXT' to compute species rarefaction and extrapolation plots (Hsieh et al. 2016, Chao et al. 2014) that analyzed species richness and Simpson's diversity over time (Simpson 1949), which included all years of data with the control sites combined. We used the Simpson's diversity index for the interpolation and extrapolation plots of species diversity. The Simpson's diversity index differs from Shannon's diversity index because it is influenced by the dominant species in a community based on abundance (Fontana et al. 2011). Simpson's diversity is normally a measure between zero and one, with zero representing no diversity and one representing infinite diversity. This index resists drastic changes to diversity by placing more importance on species evenness. We analyzed species diversity using Hill numbers (Hsieh et al. 2016) in order to effectively report the number of dominant species in the plots.

We examined species composition at TA-39 using non-metric multidimensional scaling (NMDS) to determine dissimilarity among the years when surveys were conducted. This was done to try to explain how changing the transect location from the canyon rim to the canyon bottom affected the data over time at TA-39. We conducted an analysis of similarity (ANOSIM) using 1000 permutations to compare the species composition at TA-39 between survey years. We used the community ecology R-package 'vegan' (Dixon 2003) to complete the NMDS and ANOSIM analyses. NMDS is an ordination technique that condenses highly-dimensional multivariate datasets into a smaller number of dimensions (Dexter et al. 2018). An NMDS plot is usually reduced to two or three dimensions to observe patterns in community data between species composition and other environmental variables. The number of dimensions is used to calculate a measure of 'stress', which is the discrepancy between the rank order of distances in the actual

data and the rank order of distances in the ordination. A high stress value (>0.2) indicates that the data is misleading while a low stress value (<0.1) indicates that the ordination is a good representation of the rank order of distances in the multivariate dataset (Dexter et al. 2018). Stress is reduced in an ordination by maintaining the rank order of distances while rearranging the sample points in slightly different positions (Dexter et al. 2018, De Fraga et al. 2014). A lower stress value can be attained by adding more dimensions, but too many dimensions could lead to misinterpretation of the data. We selected an NMDS plot with a low stress value and the minimum number of dimensions to minimize the distortion to the actual dataset. The R-package 'vegan' generated a Shepard diagram to display the stress in the NMDS plot. A Shepard diagram is a type of scatter plot with a fitted regression line that compares the distance between sample points in the actual data and in the ordination (Khan et al. 2020, Clarke 1993).

Field Methods for Nestbox Monitoring

In 2011, LANL biologists added nestboxes to Minie and TA-39 (Figures 1 and 2). In 2015, biologists added nestboxes to TA-16 (Figure 3). We monitored nestboxes every one to two weeks for active nests. When an active nest was found, we monitored it more frequently to determine whether the nest failed or successfully fledged young. We also banded nestlings and determined the sex after the age of 10 days. We compared the data from the nestboxes at the treatment sites to the data from the overall nestbox network at LANL. This year, due to the coronavirus pandemic (SARS-CoV-2) (Zhou et al. 2020) and its impact on personnel working together, we only managed a subset of the overall nestbox network.

Statistical Methods for Nestboxes

We calculated occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network. For any single site or overall, the occupancy rate was the number of active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. We compared the 2020 data from the three treatment sites with the overall avian nestbox network at LANL which was established in 1997 (Fair and Myers 2002).

RESULTS AND DISCUSSION

Point Count Surveys-Year 2020

LANL biologists completed three surveys at each of the three treatment sites and the associated control sites between May and July 2020. A total of 1,005 birds representing 63 species were recorded at the three treatment sites. A full account of the 2013 – 2020 data is detailed in Appendix 1.

Table 1 details the species richness, diversity, and abundance for 2020 for each treatment and control site.

Table 1. The species richness, diversity, and abundance recorded at all treatment and control sites in 2020

	Minie	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	33	40	37	32	46	33	40
Diversity	3.134	3.076	2.874	2.862	3.367	2.900	3.176
Abundance	203	413	292	269	389	373	429

Table 2 outlines the species richness over time at the treatment and individual control sites. The three treatment sites were maintaining a steady species richness over time with almost all indicating a slight increase in the number of species in 2015. Precipitation at LANL from January through July 2015 was the most precipitation since 1949 (Weather Machine 2015). The increases in richness, diversity, and abundance in 2015 were most likely attributed to the increased precipitation. Links between moisture and habitat quality for migratory birds have been documented (Smith et al. 2010) and may be a causal factor. In addition, the winter of 2015 and into early 2016 was drier. The moisture for the winter of 2018 – 2019 was at or slightly above normal, but the species richness at all sites was similar to the previous year. Temperatures were above average during the summer of 2020 while the winter moisture of 2019 – 2020 was below average (Weather Machine 2020). Species richness at all sites varied during 2020, which may have been influenced by the above average total precipitation Los Alamos received in the middle of March. We predict that the species richness in 2021 will be lower at several sites due to an unusually early and cold storm system that occurred in September 2020. The cold front contributed to a mass mortality event of migratory songbirds across New Mexico (NMDGF 2020), which may influence the data collected for next year's surveys.

Table 2. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Minie	33	33	34	30	35	35	34	33
TA-39	31	31	39	38	34	36	38	40
PJ Control 1	29	30	33	36	37	30	30	37
PJ Control 2	30	29	37	33	39	23	33	32

TA-16	39	33	40	44	41	43	39	46
PIPO Control 1	34	34	30	40	46	40	41	33
PIPO Control 2	33	36	43	43	44	39	40	40

Tables 3 – 5 compare the species diversity over time between the treatment site and the combined controls. We combined the two control sites to analyze diversity because we were interested in the relative abundances among species and not the actual numbers. There have been some significant differences at times over the course of this study which are indicated in bold font with a darker shading. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is around 3, which compared with ecological systems in general is very high.

Table 3. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Minie	3.141	3.141	3.191	2.968	3.134	3.215	3.063	3.134
PJ Control	2.877	2.990	3.159	3.067	3.241	2.938	2.967	2.975
t-test	**t = -3.2012 df = 508 p = 0.001**	t = -1.8716 df = 455 p = 0.062	t = -0.52699 df = 663 p = 0.60	t = 1.291 df = 460 p = 0.20	t =1.4637 df = 498 p = 0.14	**t =-3.907 df = 588 p < 0.01**	t =-1.2465 df = 626 p = 0.21	**t = -2.139 df = 502 p = 0.033**

Table 4. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
TA-39	3.090	3.073	3.140	3.318	3.178	3.131	3.083	3.076
PJ Control	2.877	2.990	3.159	3.067	3.241	2.938	2.967	2.975

t-test	**t = -2.527 df = 464 p = 0.012**	t = -1.0396 df = 477 p = 0.30	t = 0.26785 df = 484 p = 0.79	**t = -3.7477 df =664 p <0.01**	t = 0.95934 df = 675 p = 0.34	**t = -2.7474 df = 699 p = 0.006**	t = -1.4205 df = 670 p = 0.16	t = -1.4646 df = 942 p = 0.14

Table 5. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
TA-16	3.304	3.207	3.236	3.293	3.238	3.357	3.291	3.367
PIPO Control	3.261	3.225	3.161	3.213	3.296	3.171	3.316	3.184
t-test	t = -0.66864 df = 404 p = 0.50	t = 0.26454 df = 494 p = 0.79	t = -1.2603 df = 689 p = 0.21	t = -1.1396 df = 511 p = 0.25	t = 0.88237 df = 539 p = 0.38	**t = -2.9553 df = 578 p = 0.003**	t = 0.44118 df =640 p = 0.66	**t = -3.3172 df = 824 p = 0.001**

We analyzed species richness and Simpson's diversity data between 2013 – 2020 using extrapolation curves (Figures 5A – 6B). Species rarefaction and extrapolation show a significant difference between treatment and control sites for species richness (Figure 5A). Figure 5A displays 95% confidence intervals where the TA-39 treatment site and the PJ Controls do not overlap. However, the species rarefaction and extrapolation for the PJ treatment and control sites between 2013 – 2018 did not show any significant differences for species richness (Hathcock et al. 2018). The Minie and TA-16 treatment sites and their associated controls had overlapping 95% confidence intervals for species richness (Figures 5A and 6A). The cause of the difference in species richness may be attributed to a change of transect locations at the TA-39 treatment site in 2016 (Figure 2). The original transect was located on the mesa above the treatment site and was more of a pinyon-juniper woodland while the replacement transect sited in 2016 was along the canyon bottom around the treatment site and contained more ponderosa pine trees. Slight differences in habitat structure have been shown to impact species composition (Seymour and Dean 2010). We looked at these data using an NMDS plot. Figure 7 represents the final configuration of survey years as points in the NMDS plot for TA-39 (dimensions = 2, stress = 0.0225). The Shepard diagram (Figure 8) shows minimal scatter around the regression line between the observed dissimilarity and ordination distance, which indicates that the NMDS plot

has low stress (non-metric fit $R^2 = 0.999$, linear fit $R^2 = 0.997$). NMDS ordinations use the rank order of distances to show the dissimilarity between samples (Faith et al. 1987), which means samples in close proximity to one another are similar while samples that are distant from each other are not alike. Figure 7 shows how the species composition at TA-39 was more similar between years that are clustered together on the NMDS plot (Debinski et al. 2006). We separated the years when surveys occurred into early year (2013 – 2015) and later year (2016 – 2020) categories to reflect the change in habitat corresponding to the selection of a new transect location. The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated categories of survey years. The NMDS plot grouped early years on the left and later years on the right (Figure 7). Our NMDS plot only displayed 16 species to improve clarity (Figure 7). These 16 species represent the top ten most commonly observed species for early years and later years (Table 6). Species that appeared in the list for both categories of survey years are in bold. The species that seem to be driving the difference between early and later years are the Juniper Titmouse, Cassin's Kingbird, and the Western Wood-Pewee. Even though the polygons for the early and later years are not closely aligned with one another and do not overlap, the categories of survey years were not statistically different from each other (ANOSIM: $R = 0.05917$, $P = 0.08$).

The rarefaction and extrapolation plots for species diversity (Figures 5B and 6B) were significantly different since the 95% confidence intervals did not overlap. In these cases, the treatment sites were higher in diversity than the controls with a higher number of dominant species. These results are similar to the 2013 – 2018 species rarefaction and extrapolation results presented in a previous report (Hathcock et al. 2018). Tables 3 – 5 show there were significant differences of diversity between the Minie and TA-16 treatment sites and their associated control sites in 2020. Since the extrapolation curves are not expected to change much between years, these will be reanalyzed every five years after this report.

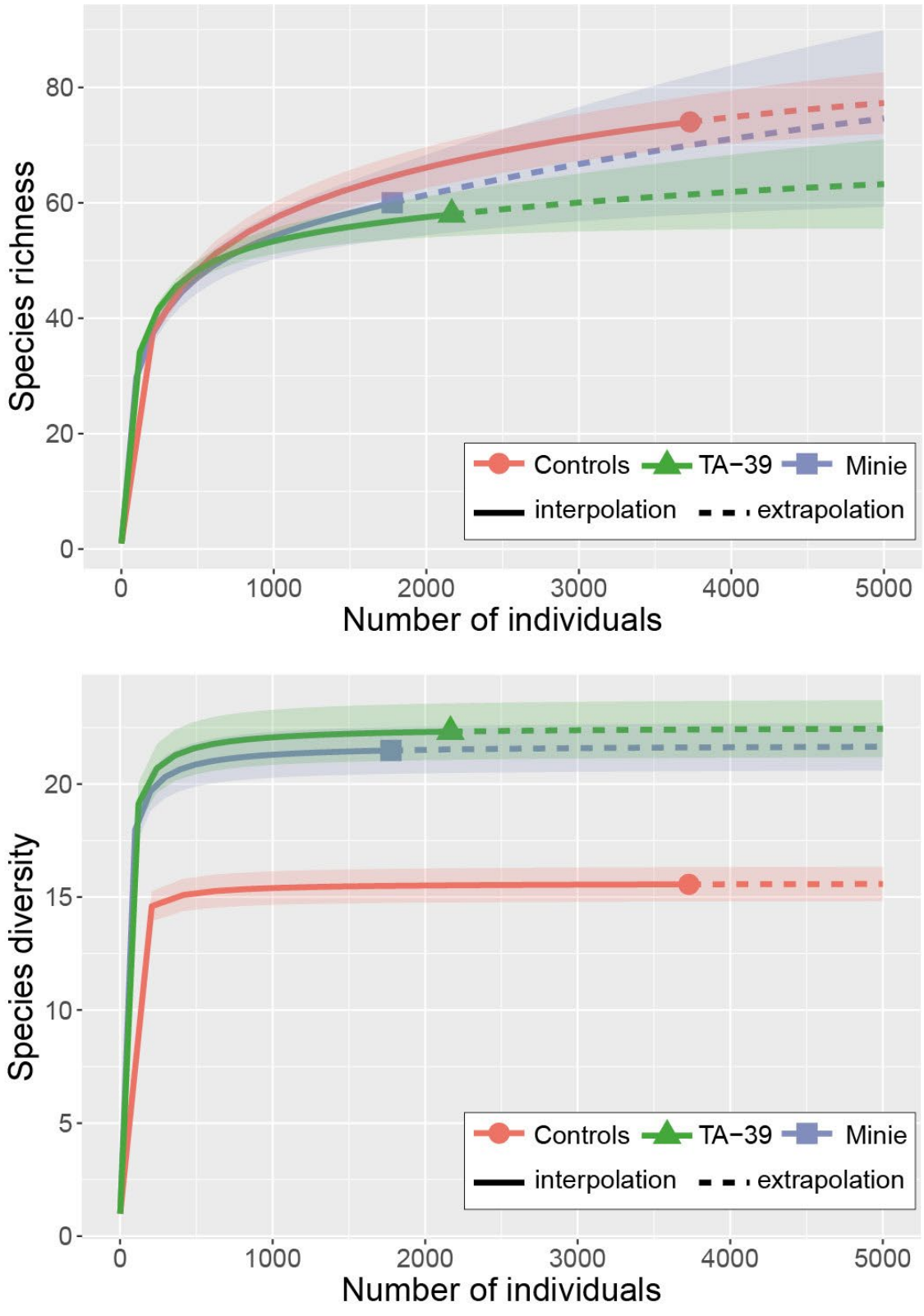

Figure 5. 2013 – 2020 Species rarefaction and extrapolation for species richness and diversity comparing Minie and TA-39 with the PJ controls. Top is "A" and bottom is "B".

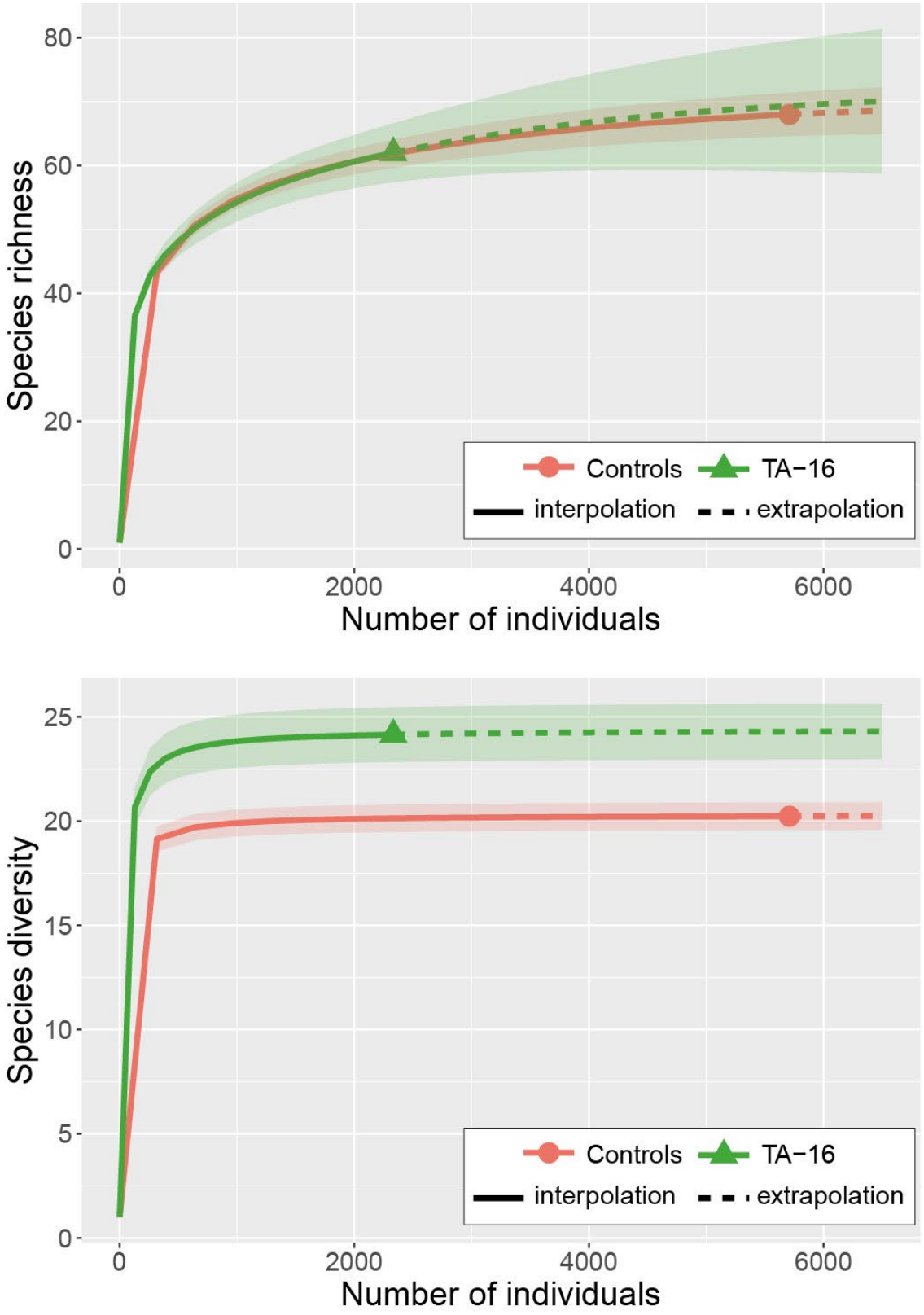

Figure 6. 2013 – 2020 Species rarefaction and extrapolation for species richness and diversity comparing TA-16 with the PIPO controls. Top is "A" and bottom is "B".

Table 6. Top 10 most common species of birds observed at TA-39 during Early Years (2013 – 2015) and Later Years (2016 – 2020)

Early Years		*Later Years*	
Species	*Abundance*	*Species*	*Abundance*
Ash-throated Flycatcher	60	**House Finch**	186
Spotted Towhee	51	Cassin's Kingbird	160
House Finch	48	Chipping Sparrow	99
Mourning Dove	45	**Lesser Goldfinch**	85
Juniper Titmouse	42	**Spotted Towhee**	79
Western Bluebird	36	Violet-green Swallow	77
Gray Flycatcher	31	Rock Wren	72
Bewick's Wren	28	**Western Bluebird**	64
Lesser Goldfinch	25	Western Wood-Pewee	59
Woodhouse's Scrub-Jay	22	White-winged Dove	53

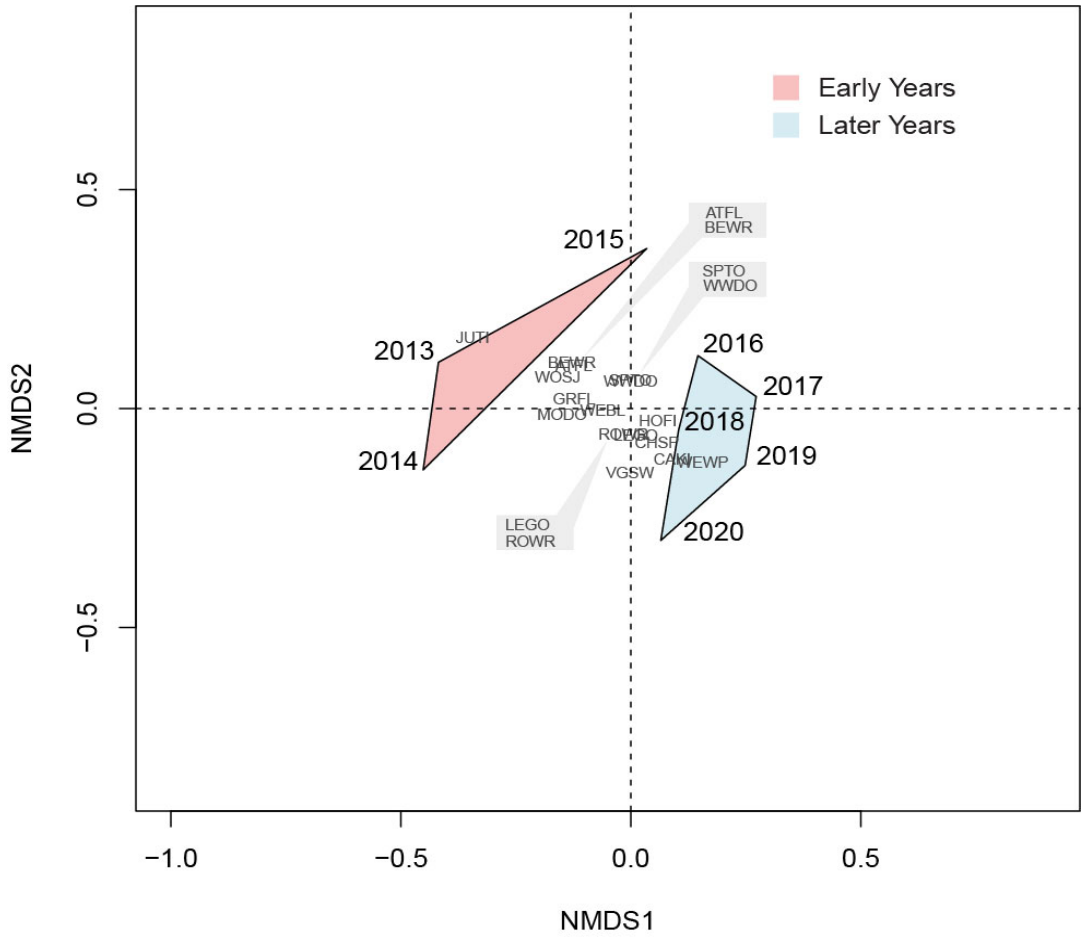

Figure 7. Non-metric multidimensional scaling (NMDS) of bird species and years at the TA-39 treatment site

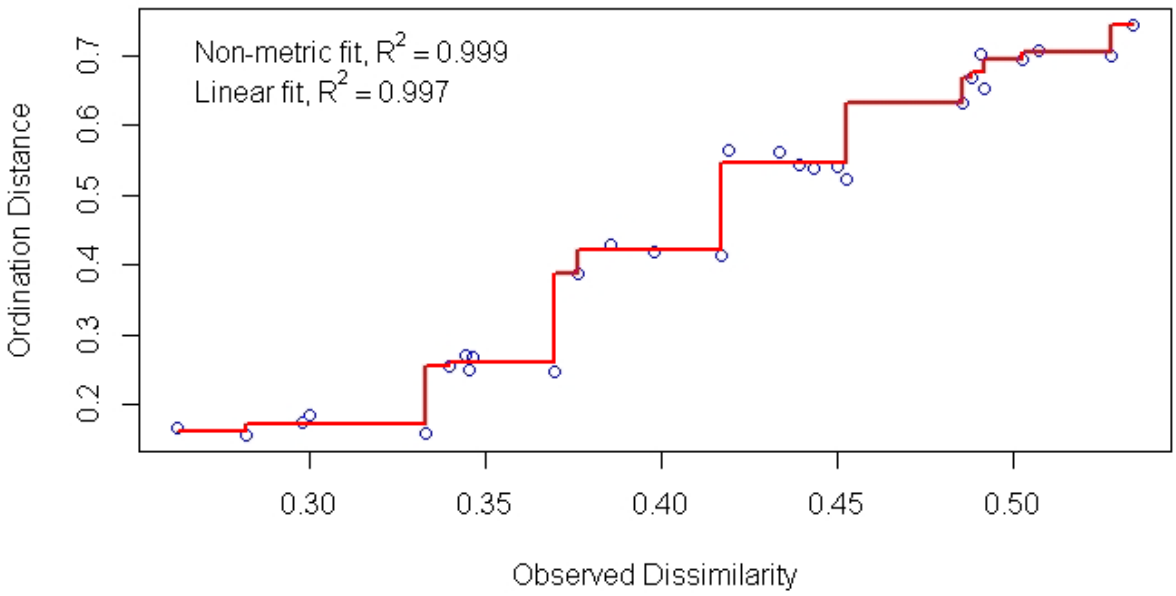

Figure 8. Shepard diagram of NMDS ordination for the TA-39 treatment site

The overall abundance of birds is trending the same for all treatment sites compared with the controls. At TA-16, the overall abundance is lower when compared with the PIPO 1 and PIPO 2 control sites. Table 7 compares the abundance between the treatment and control sites over time. Similar to the species richness trends, there was an increase in abundance in 2015. The fluctuations in bird abundances were not alarming, and the differences between the treatment sites and control sites were not biologically significant. The moisture for the winter of 2018 – 2019 was at or slightly above normal, but the species abundance at all sites were similar to previous years. The abundance increased in 2020, except at Minie, despite below average moisture for the winter of 2019 – 2020.

Table 7. Changes in species abundance over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Minie	193	186	275	210	222	242	245	203
TA-39	177	193	260	249	261	315	298	413
PJ Control 1	187	157	269	312	240	235	226	292
PJ Control 2	181	177	301	228	300	168	187	269
TA-16	220	209	347	271	302	285	310	389

PIPO Control 1	258	223	432	323	447	374	364	373
PIPO Control 2	256	254	371	396	449	366	394	429

Nestboxes

During the 2020 nesting season, LANL biologists actively monitored 15 nestboxes at each treatment site. We monitored 157 nestboxes throughout the overall avian nestbox network, without the three treatment sites. Of those, 117 contained active nests and 69 of those nests fledged young successfully. This was an overall occupancy rate of 58% with a 59% success rate.

Tables 7 and 8 compare the occupancy and nest success rates for each treatment site and the overall nestbox network since 2015.

Table 8. Comparison of occupancy for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
Overall Network	40%	45%	48%	53%	44%	58%
Minie	66%	73%	46%	20%	60%	47%
TA-39	8%	58%	20%	33%	13%	27%
TA-16	-	73%	100%	53%	87%	87%

Table 9. Comparison of nest success for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*
Overall Network	66%	69%	57%	49%	51%	59%
Minie	64%	23%	29%	33%	44%	86%
TA-39	100%	57%	0%	40%	0%	75%
TA-16	-	63%	76%	63%	54%	54%

In 2020, there were six successful nests that fledged young at Minie, three at TA-39, and seven at TA-16. Occupancy at TA-39 was low in comparison to the other treatment sites and the overall network. The nest success rate at TA-39 seemed to fluctuate in 2020 since the occupied nestboxes had a higher success rate compared to previous years. TA-39 is the lowest elevation treatment site and occupancy has been decreasing over time at this site and surrounding areas of the avian nestbox network. Wysner et al. (2019) found that Western Bluebirds, one of the target species of the network, have increased their nesting elevation over time in the study area. Western Bluebirds have the highest occupancy rates throughout the nestbox network, and the shift in nesting elevation could be driving the lower occupancy rates at TA-39. Occupancy and success rates at the other two treatment sites seem to be fluctuating naturally in comparison to the overall network and have not displayed a decreasing trend over time.

In 2020, LANL biologists submitted nonviable eggs collected from nestboxes at the treatment sites and the rest of the nestbox network to an analytical lab for chemical analyses. These data will be presented in a separate report.

MANAGEMENT RECOMMENDATIONS

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Of the 63 species detected at the three treatment sites, the Migratory Bird Treaty Act protects all but one species. The Eurasian Collared-Dove is not native and therefore not protected under the Migratory Bird Treaty Act. In addition, LANL biologists have documented sensitive species from the Sensitive Species Best Management Practices Source Document (Berryhill et al. 2020) and the Birds of Management Concern and Focal Species list (USFWS 2011) at the treatment sites. Those species are the Juniper Titmouse, Grace's Warbler, Virginia's Warbler, Black-throated Gray Warbler, and the Mourning Dove. Sensitive species documented at the control sites are the Cassin's Finch and the Gray Vireo. The primary statutory authority for Birds of Conservation Concern is the Fish and Wildlife Conservation Act of 1980 (16 United States Code § 2901).

Continuing the research reported herein will provide a long-term dataset for the ecological health of avifauna at the three treatment sites at LANL. In addition, this research contributes to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and it allows LANL to contribute to national goals in avian conservation monitoring and research.

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APPENDIX 1. ALL BIRDS RECORDED AT THE THREE TREATMENT SITES FROM 2013–2020

Species	TA-36 Minie Site – Pinyon-Juniper Woodland								TA-39 Point 6 – Pinyon-Juniper Woodland								TA-16 Burn Grounds – Ponderosa Pine Forest							
	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
Acorn Woodpecker																	5		3	2	3	5	3	5
American Crow																					1	1		1
American Kestrel				1				1	1			2												
American Robin	1	1	2		2				1	1		2		4	2		7		9	4	4	6	12	6
Ash-throated Flycatcher	11	5	14	13	13	10	17	12	19	11	30	12	8	8	6	11	3	5	6	2	3	8	4	6
Audubon's Warbler		2				5						2				5	6	5	1	6		1	11	14
Bewick's Wren	4	8	9	9	14	14	5	10	3	10	15	9	2	8	1	2								
Black-chinned Hummingbird		1	1				1	2	3	2				1	2	3	1		1		1		1	12
Black-headed Grosbeak	1	3				1	1	2		2	4	1		3	2	1			1	2		2		1
Black-throated Gray Warbler			1		2			2	5	6	4													
Blue-gray Gnatcatcher	3	14	16	8	10	9	8	11	2		7	5	4	2	13	5		6	2	1	3	6	4	9
Broad-tailed Hummingbird	2	1	3		1		3	2	3	1	2		3	1	2	9	5	11	11	5	7	10	8	
Brown Creeper																	1							
Brown-headed Cowbird	1										2			3	2	10	4	1			4	2	8	4
Bushtit		2		2		11			2	14			1	12		2								
Canada Goose											16				2									
Canyon Towhee	2		5	3	6	2	3	5	1	1	2	10	13	19	6	3	1			1		1		
Canyon Wren					1						2	3	8	6	2	4			2					
Cassin's Finch						4																		
Cassin's Kingbird	6	13	13	5	2	5	6	5	7	6	2	21	21	32	37	49				1				2
Chipping Sparrow	3	16	17	29	6	22	10	10	6	6	5	8	15	25	27	24	1	5	3	10	5	21	8	32
Clark's Nutcracker																		4		1				
Common Nighthawk	6		5	2	4	4	1	5	5	1	3	2	7	5	7	3			1	2	2			1
Common Raven	2	5	1		1	2	3		1		2	1		1	2	5	5	6	2	2	5	5	7	4
Cooper's Hawk					1												1			1			1	
Cordilleran Flycatcher																	5	10	6	3	3	1	2	4
Dark-eyed Junco														1	1		6	2	4		5	2		2
Downy Woodpecker				1								1	2		1	2		1		1	1	1		
Dusky Flycatcher				1							1		1											2
Eurasian Collared-Dove	3												4			2						1		
Evening Grosbeak	3		4								8						5		29			1		
Grace's Warbler							1							2	4	1	6	4	4	8	5	8	22	12

Species	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
	TA-36 Minie Site								TA-39 Point 6								TA-16 Burn Grounds							
	Pinyon-Juniper Woodland								Pinyon-Juniper Woodland								Ponderosa Pine Forest							
Gray Flycatcher	12	6	5	7	3	6	3	2	10	10	11	10	5	8	3	14								
Great Horned Owl		3							1															
Green-tailed Towhee	3	1							1															1
Hairy Woodpecker			2	1		1		1			5	3			1	1	1	1		1	1	2	1	1
Hammond's Flycatcher																	8	9	12	5	7	5	10	5
Hepatic Tanager											1	2	1	2						1				
Hermit Thrush						1												4	6	1	2	2	5	5
House Finch	16	17	26	17	12	18	17	11	21	4	23	9	30	44	50	53	16	2	5	5	12	7	12	18
House Wren															1		1	1		2	2	6	8	2
Juniper Titmouse	12		7	6	9	3	26	8	11	13	18	6	1			3								
Lesser Goldfinch	2	6	7	4	9	12	8	4	4	12	9	10	14	19	15	27	3		8	9	4	8	5	6
MacGillivray's Warbler																				1	3			1
Mountain Bluebird		2	20	10	11	1	9	3		4						2			4	4	4	7	4	5
Mountain Chickadee	5	2	1	2								1	1		1		5	8	9	6	8	9	1	4
Mourning Dove	17	17	13	5	8	8	11	9	13	22	10	3	15	11	8	10	4		1	3	17	3	5	17
Northern Mockingbird					2		1	4		1														
Northern Rough-winged Swallow						3																		
Orange-crowned Warbler																								1
Peregrine Falcon											1													
Pine Siskin	10	2		5	1			1	6		3	3					12	4	5		4	2		6
Plumbeous Vireo	10	10	7	3	9	9	15	3	1		1	6	6	5	5	12	11	16	15	14	11	18	16	24
Pygmy Nuthatch				2		2	3				2	4	12	9	11	10	11	13	26	29	41	20	16	23
Red Crossbill					1					2						1		2	9	13	9		6	26
Red-shafted Flicker	3	1	3	2	5	2	1		3	2	4	8		3	2	2	3	4	11	11	5	5	2	7
Red-tailed Hawk							1	2			1	1	1	1										
Rock Wren	3	3	4		2	10	11	10	7	10	4	12	14	14	12	20	1	2	2	6			4	1
Ruby-crowned Kinglet																						2		
Savannah Sparrow																								1
Say's Phoebe	2	1	2		2	5	1	1	2	1		5	2	4		6	1		1	3	3	4	1	1
Scaled Quail			1																					
Spotted Towhee	17	8	19	27	32	24	19	20	12	6	33	16	12	16	15	20	11	18	16	14	21	22	34	24
Steller's Jay							1										3	2	5	6	3	4	4	2
Townsend's Solitaire	1																				1			
Turkey Vulture					1			2								1	1					1		
Vesper Sparrow																							1	
Violet-green Swallow		5	7	1	3	2	1	6	6	4	1	9	6	6	9	47		2	19	2	2	4	2	7

Species	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020	2013	2014	2015	2016	2017	2018	2019	2020
	TA-36 Minie Site								TA-39 Point 6								TA-16 Burn Grounds							
	Pinyon-Juniper Woodland								Pinyon-Juniper Woodland								Ponderosa Pine Forest							
Virginia's Warbler					1	3	1				1	2	4		5		17	11	21	13	7	5	5	8
Warbling Vireo						2											2	9	7	6	5	4	6	3
Western Bluebird	15	11	18	17	16	19	21	23	5	19	12	21	13	6	7	17	20	20	49	37	32	27	20	27
Western Tanager		2	3		1					2	1	1	2	2	6	1	2	3	7	2	4	6	16	10
Western Wood-Pewee	10	8	18	11	10	7	18	14		4	2	10	8	11	12	18	15	10	16	14	22	20	24	28
White-breasted Nuthatch	1	4	9	10	13	5	2	1			2	4	4	2	6	3	9	8	7	9	20	10	10	8
White-throated Swift										1						2								
White-winged Dove	1	5	9	2		3	2	1	7	5	6	16	15	15	5	2			1	2			1	
Woodhouse's Scrub-Jay	5	1	3	4	8	7	14	10	8	10	4	8	6	4	5		1							

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 13 – Gadek & Velardi 2021

Environmental Report:

Gadek, C.R. and M. S. Velardi, October 2021. *2021 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory*. LA-UR-21-30407.

October 2021

2021 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory

Los Alamos NATIONAL LABORATORY

Prepared by: **Chauncey Gadek and Milu Velardi, Environmental Protection and Compliance Division, Environmental Stewardship Group, Los Alamos National Laboratory**

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Executive Summary

Los Alamos National Laboratory (LANL) biologists in the Environmental Protection and Compliance Division initiated a multi-year program in 2013 to monitor avifauna (birds) at two open detonation sites and one open burn site on LANL property. In this annual report we compare monitoring results from these efforts among years to assess trends in local migratory bird communities. The objectives of this study are to 1) determine whether LANL operations impact bird abundance, species richness, or diversity, and 2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. LANL biologists completed the ninth year of this effort in 2021.

Between May and July 2021, we completed three avian point count surveys at each of the treatment sites which are the Technical Area (TA)-36 Minie site, the TA-39 point 6, and the TA-16 burn ground. We recorded a total of 778 birds representing 58 species at the three treatment sites and compared these results to data from their associated control sites. We also compared occupancy and nest success data from nestboxes at treatment sites with the overall avian nestbox monitoring network.

In 2021, abundance and species richness at treatment and control sites continued to trend similarly from year to year with minor random deviations. Though richness remained stable across all sites, three new bird species were observed at the treatment sites: Blue Grosbeak, White-crowned Sparrow, and Willow Flycatcher indicative of a healthy avian community. The species diversity at the TA-36 Minie site and TA-39 were statistically higher than their associated controls. The species diversity at all three treatment sites has been consistently lower at control relative to treatment sites, likely due to subtle habitat differences. The slightly elevated diversity at treatment sites in 2021 is not unexpected and shows no clear pattern of diverging with diversity at treatment sites. Overall diversity remains high across all sites relative to similar habitats.

Nestbox occupancy and success continue to fluctuate annually, though all three treatment sites experienced decreases in nest success between 2020 and 2021, likely driven by extremely low precipitation levels during winter of 2020.

The overall results from 2021 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations. This long-term project will continue to monitor for any changes over time.

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Introduction

As part of the Resource Conservation and Recovery Act permit process, Los Alamos National Laboratory (LANL) started an annual avian monitoring program in 2013. The permit was for two open detonation sites, Technical Area (TA)-36 Minie site and TA-39 point 6, and one open burn site, TA-16 burn ground (hereafter referred to as Minie, TA-39, and TA-16, or together as treatment sites) (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018, 2019; Sanchez et al. 2020; Rodriguez and Abeyta 2021). The objectives of this long-term monitoring program are to (1) determine whether LANL operations impact bird abundance, species richness, or diversity, and (2) examine occupancy and nest success of secondary-cavity nesting birds using nestboxes. This involves comparing community and nestbox metrics at treatment sites with control sites of similar habitat that LANL biologists have surveyed since 2011 (Hathcock et al. 2011).

LANL biologists used standard point count methodology to record avian abundance, richness, and diversity along transects at the three treatment sites and their associated control sites during the summer of 2021. Summer surveys provide information about which bird species are breeding at each site. These surveys are most valuable when they are conducted over multiple years since they provide long-term trend data that can be compared with local, regional, or national trends in bird populations. These data can also be used to test for correlations between bird communities and the natural environment, including environmental changes at LANL.

In addition to avian point counts, LANL biologists monitored nestboxes around all three treatment sites to investigate any potential impacts to occupancy rates and productivity of secondary cavity-nesting birds. Occupancy and nest success were compared to the overall avian nestbox monitoring network, which was established in 1997 (Fair and Myers 2002).

Methods

Field Methods for Point Count Surveys

LANL biologists conducted the point count surveys along single transects in the forested, undeveloped land surrounding the treatment sites (Figures 1–3). The habitat types around the sites are a pinyon (*Pinus edulis*) – juniper (*Juniperus monosperma*) woodland (PJ) for Minie (Figure 1) and TA-39 (Figure 2) and a ponderosa pine (*Pinus ponderosa*) forest (PIPO) at TA-16 (Figure 3). The habitat descriptions are based on the 1/4 ha physiognomic cover classes in the LANL land cover map (McKown et al. 2003). The treatment and control sites (Figure 4) are monitored annually. The control sites were originally established in 2011 (Hathcock et al. 2011). Each habitat type control contained two replicate transects that LANL biologists monitored in the same way as the treatment sites, with the same number of points and during the same time periods. In each survey month, all treatment and control site transects are monitored randomly.

The treatment sites at Minie and TA-39 were similar to the PJ control sites at TA-70 and TA-71 in elevation, vegetation, and proximity to developed areas; however, the transect at TA-39 was in the canyon bottom while the controls were on mesa tops. The treatment site at TA-16 was similar in elevation and overstory vegetation to the PIPO control sites and all were on mesa tops. One of the PIPO control transects was adjacent to development and the other transect was in an undeveloped area.

Transects were approximately 2.0 to 2.5 km in length with nine survey points spaced approximately 250 m apart. These survey routes and points can change slightly over time due to construction activities or access constraints. The time frame for breeding bird surveys is May 11 through July 9. Ideally, the breeding bird surveys should take place the second week of May, June, and July. This protocol required a total of three surveys per site conducted between 0.5 hours before sunrise and four hours after sunrise.

The following steps apply to breeding bird surveys:

- Each survey consists of nine points along a transect spaced approximately 250 m apart.
- The surveyor looks and listens for five minutes, recording all birds encountered at each point on a data sheet. For each observation, the minimum data collected is point number, time, species, number of individuals, and distance from the point. The observation distance is considered as an “unlimited-distance circular plot”; however, surveyors record the distance to each bird out to an estimated 100 m. A range finder should be used if available. Surveyors avoid re-counting individuals between points.
- While walking between points, surveyors record any obvious species not recorded at the previous point that also wouldn’t be counted at the next point. Surveyors do not spend excess time looking for birds between points.
- Surveys are not conducted during rain events or winds greater than 24 kph.
- Surveyors use the “NOTES” section to indicate any additional information about the survey that may affect the data. Examples include excess noise from nearby equipment, vehicles, or aircraft that make it hard to hear the birds. Surveyors record other wildlife or unusual sightings that could be used for other projects.

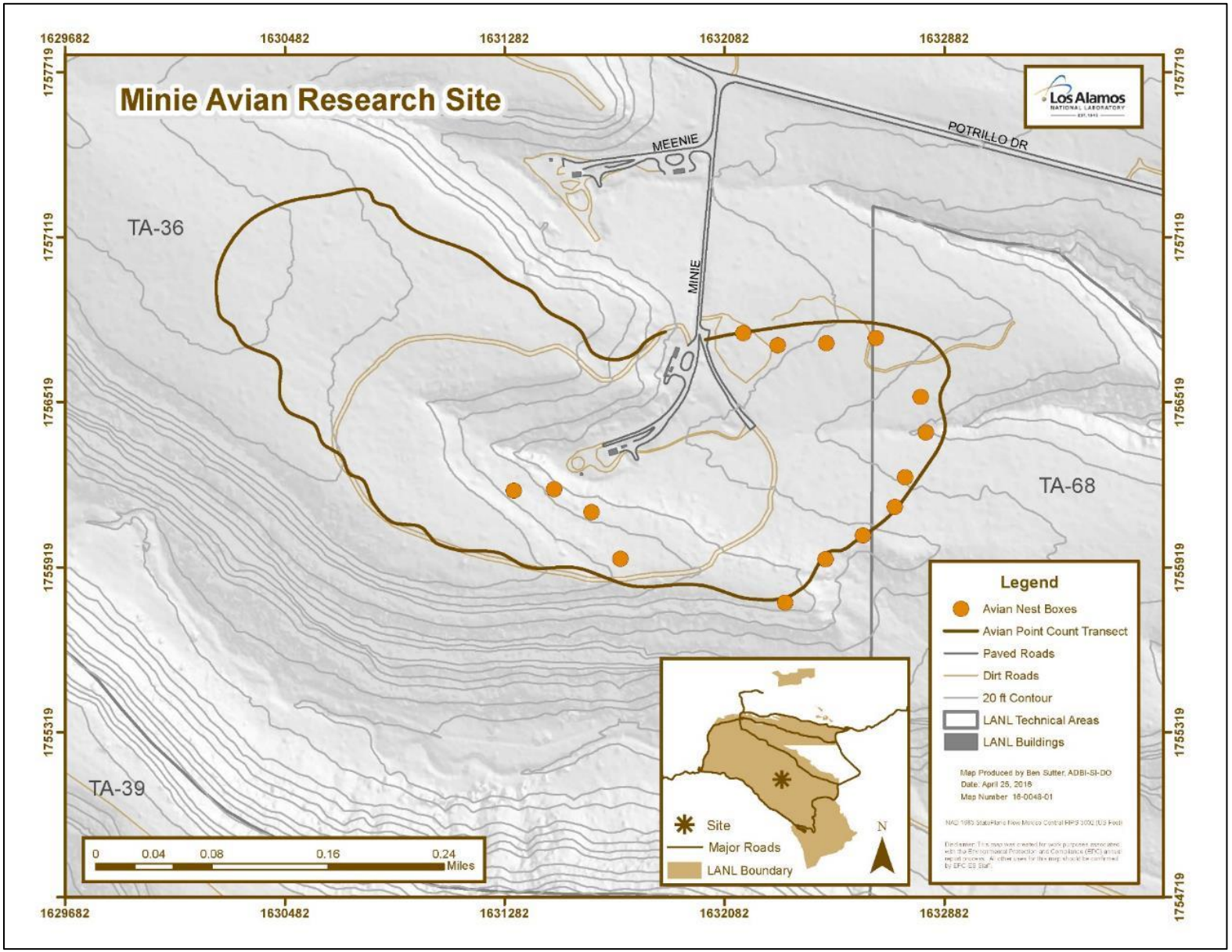

Figure 1. Breeding bird survey transect and nestbox locations around TA-36 Minie Site

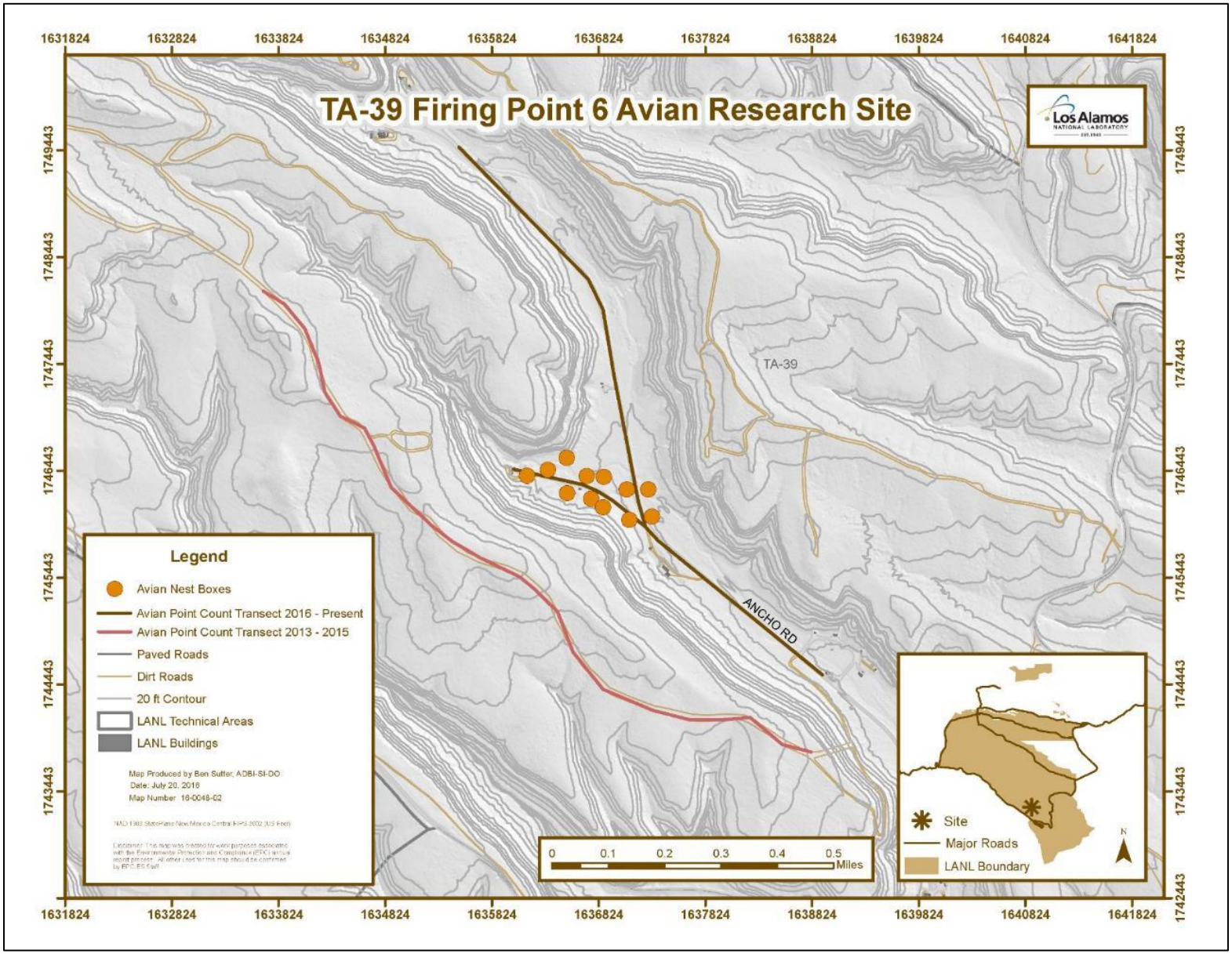

Figure 2. Breeding bird survey transect and nestbox locations around TA-39 Point 6

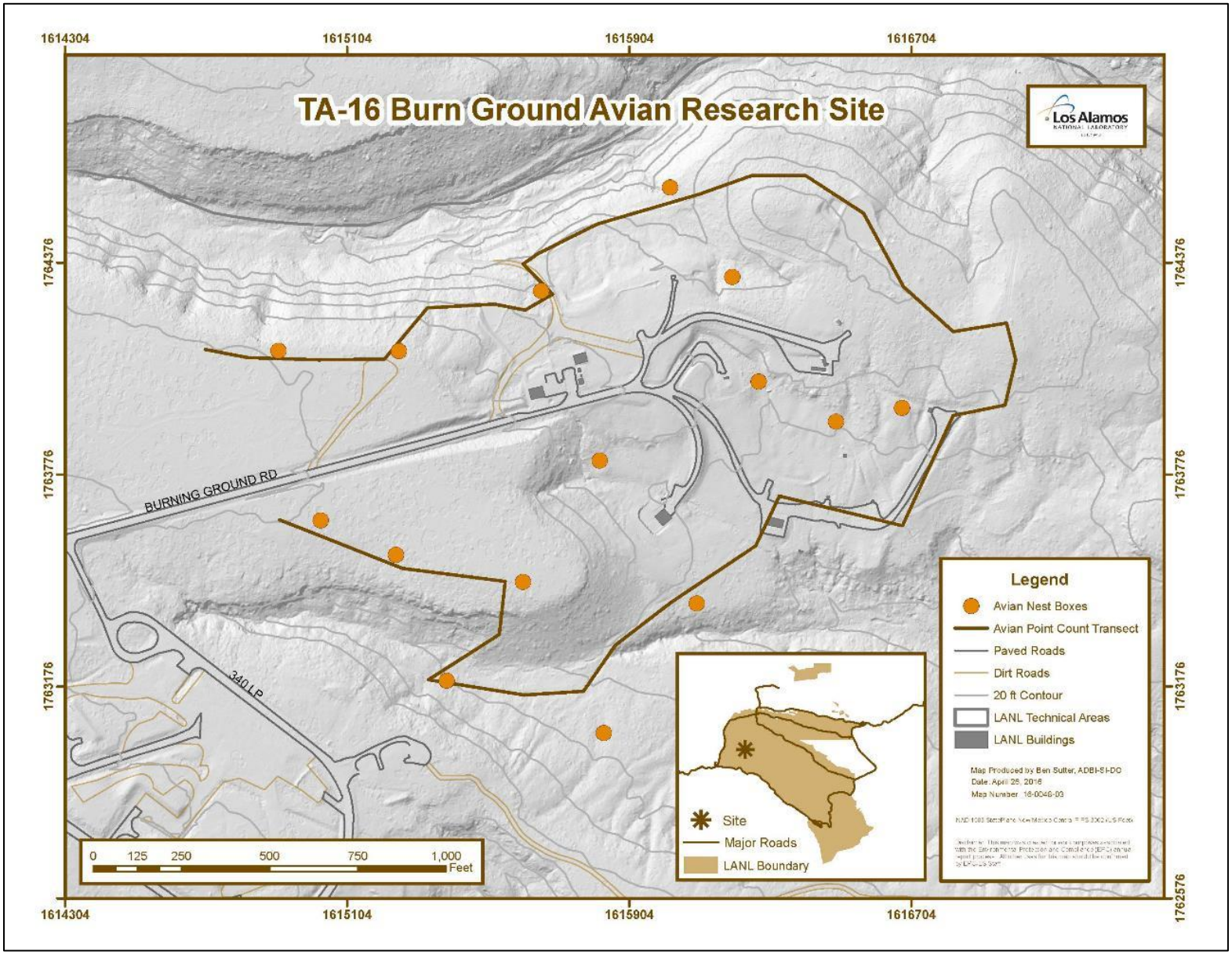

Figure 3. Breeding bird survey transect and nestbox locations around the TA-16 Burn Ground

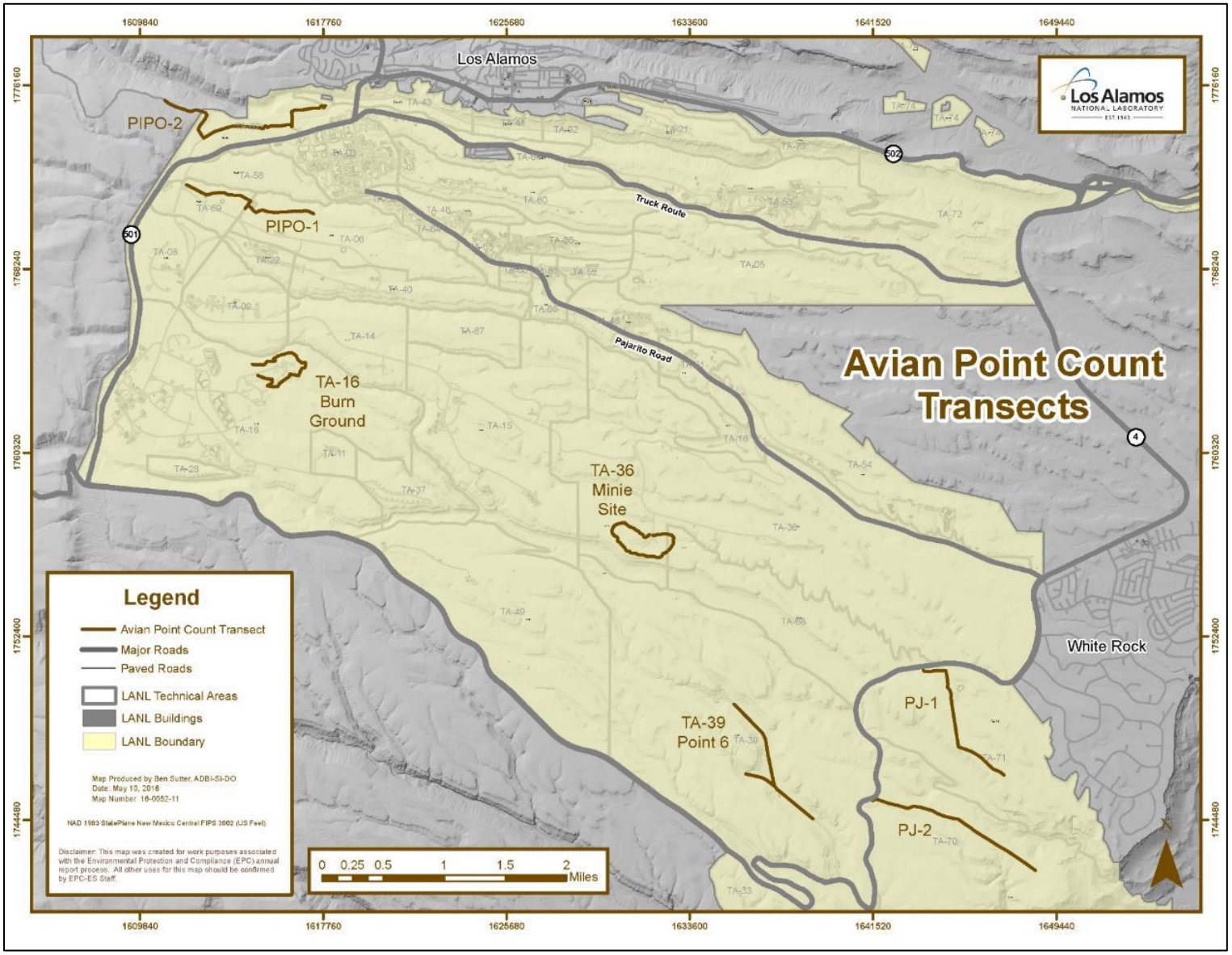

Figure 4. All avian point count transects around LANL

PIPO: ponderosa pine forest, PJ: pinyon-juniper woodland

Statistical Methods for Point Counts

We summarized these data to compare abundance, species richness, and diversity between treatment and control sites and over time. We considered each treatment site and control to be individual communities. Abundance is the total number of individuals recorded of a given species (Gotelli and Colwell 2011). Species richness is the number of different species represented in an ecological community and is simply a count of species (Boulinier et al. 1998). Species diversity is a measure that takes into account species richness and the overall abundance to compare evenness across a community (Tramer 1969). As a species diversity metric, we used Shannon's diversity index which measures the probability that two individuals randomly selected from a sample will belong to different species (Shannon and Weaver 1949).

We calculated species richness, diversity, and abundance using the statistical software R (version 4.1.0; R Core Team 2021) and the package *vegan* (Dixon 2003). We used the Shannon's diversity index to compare diversity between habitats (Clarke et al. 2014). Shannon's diversity ranges for most ecological systems are between 1.5 and 3.5, and are rarely greater than 4.5, where high values indicate high diversity. We used a Hutcheson's T-test in the R package *ecolTest* (Salinas and Ramirez-Delgado 2021) to test for differences between treatment and combined control site diversity each year.

In September of 2020, biologists and concerned citizens documented a large avian mortality event across New Mexico (NMDGF 2020). While researchers have yet to determine the causal factors of the die-off, an anomalous early cold front and record breaking wildfires along the Pacific coast coincided with the event. In 2021, LANL biologists predicted to see a decrease in species richness due to the mass mortality event in 2020. To test for a signal of the avian mortality event, we looked for differences in richness and abundance between 2020 and 2021 using a repeated measures ANOVA framework with transect as a repeated measurement in the R package *lme4* (Bates et al. 2015). Because bird species recovered from the 2020 mortality event tended to be insectivores (D'Ammassa 2020), we also binned all species in two major summer feeding guilds (insectivores and omnivores) in the ANOVAs.

Field Methods for Nestbox Monitoring

In 2011, LANL biologists added nestboxes to Minie and TA-39 (Figures 1 and 2). In 2015, biologists added nestboxes to TA-16 (Figure 3). We monitored nestboxes every one to two weeks for active nests. When an active nest was found, we monitored it more frequently to determine whether the nest failed or successfully fledged young. We also banded nestlings and determined the sex after the age of 10 days. We compared the data from the nestboxes at the treatment sites to the data from the overall nestbox network at LANL.

Statistical Methods for Nestboxes

We calculated occupancy and nest success rates of the nestboxes at the three treatment sites and in the overall network. For any single site or overall, the occupancy rate was the number of

active nestboxes divided by the total number of nestboxes. Similarly, the nest success rate was the number of nestboxes that successfully fledged young divided by the number of active nestboxes. We compared the 2021 data from the three treatment sites with the overall avian nestbox network at LANL which was established in 1997 (Fair and Myers 2002).

Results and Discussion

Point Count Surveys-Year 2021

LANL biologists completed three surveys at each of the three treatment sites and the associated control sites between May and July 2021. Table 1 summarizes the species richness, diversity, and abundance for 2021 for each treatment and control site. A total of 778 birds representing 58 species were recorded at the three treatment sites. A full account of the 2013 – 2021 data is detailed in Appendix 1.

Table 1. The species richness, diversity, and abundance recorded at all treatment and control sites in 2021

	Minie	*TA-39*	*PJ Control 1*	*PJ Control 2*	*TA-16*	*PIPO Control 1*	*PIPO Control 2*
Richness	33	38	33	25	37	36	44
Diversity	3.00	3.03	2.82	2.54	3.20	3.01	3.22
Abundance	209	286	225	159	283	349	448

Abundance

Overall bird abundance has trended similarly for both treatment and control sites (Figure 5 & Table 2). Overall abundance has tended to increase since 2013 with minor fluctuations. The fluctuations in bird abundances were not alarming, and abundances at treatment sites and control sites have continued to trend together (Figure 5). Bird abundances seems to partially track winter precipitation levels with 2015-2017 representing the wettest winters in our dataset (NOAA 2021). Abundance values marginally decreased in 2021, with the exception of Minie and PIPO-2 sites, potentially driven by extreme drought conditions during winter 2020 and spring 2021 (NOAA 2021).

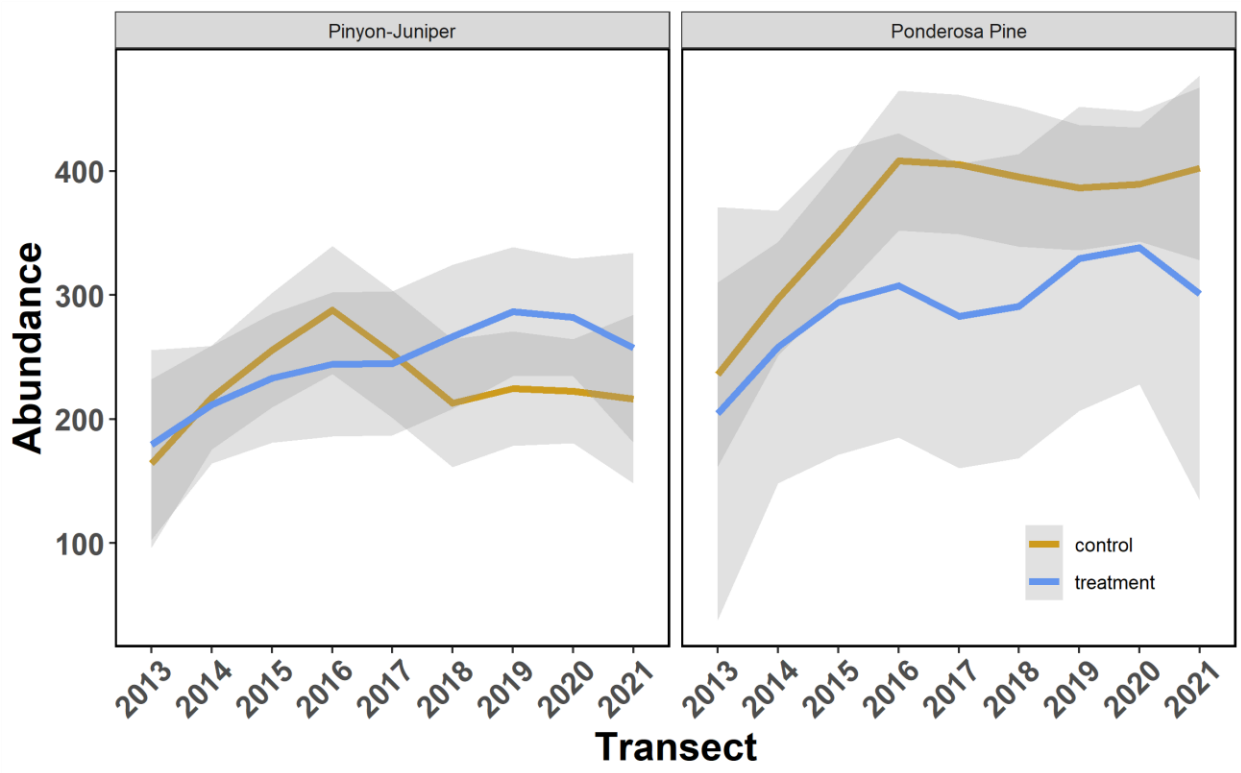

Figure 5. Abundance values by year averaged across treatment (blue line) and control sites (orange line). Shaded gray areas represent local smoothed 95% CI.

Table 2. Changes in species abundance over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Minie	193	186	275	210	222	242	245	203	209
TA-39	177	193	260	249	261	315	298	413	286
PJ Control 1	187	157	269	312	240	235	226	292	225
PJ Control 2	181	177	301	228	300	168	187	269	159
TA-16	220	209	347	271	302	285	310	389	283
PIPO Control 1	258	223	432	323	447	374	364	373	349
PIPO Control 2	256	254	371	396	449	366	394	429	448

Species Richness

Figure 6 & Table 3 illustrate changes in species richness over time at the treatment and individual control sites. Overall the mean richness at treatment sites has remained stable with small annual fluctuations since monitoring began (Figure 6 & Table 3). Species richness at both treatment and control sites have largely trended together with average richness at treatment sites slightly increasing in 2015- 2017, similar to abundance values, suggesting richness may also be influenced by winter precipitation.

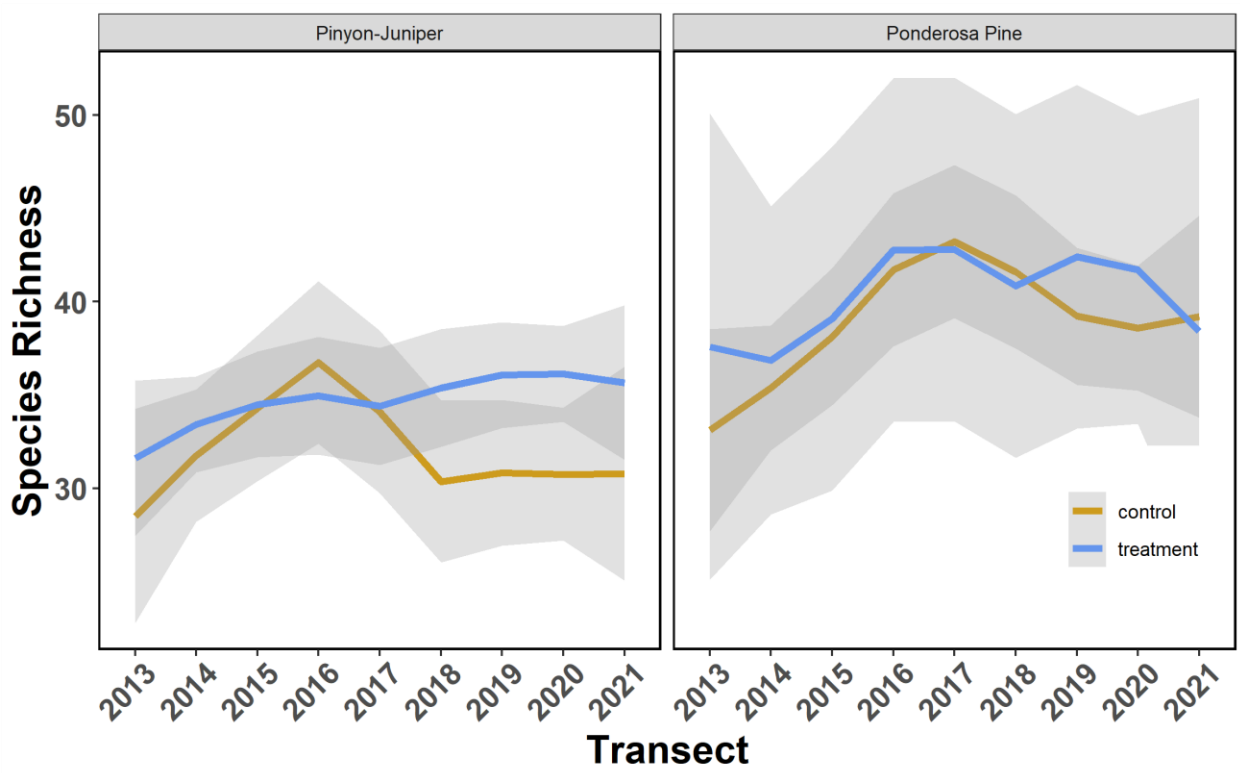

Figure 6. Species richness values by year averaged across treatment (blue line) and control sites (orange line). Shaded gray areas represent local smoothed 95% CI.

Table 3. Changes in species richness over time for all treatment and control sites

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Minie	33	33	34	30	35	35	34	33	33
TA-39	31	31	39	38	34	36	38	40	38
PJ Control 1	29	30	33	36	37	30	30	37	33
PJ Control 2	30	29	37	33	39	23	33	32	25
TA-16	39	33	40	44	41	43	39	46	37

PIPO Control 1	34	34	30	40	46	40	41	33	36
PIPO Control 2	33	36	43	43	44	39	40	40	44

Diversity

Figure 7 and Tables 4 – 6 compare the species diversity over time between the treatment site and the combined controls. We combined the two control sites to analyze diversity because we were interested in the relative abundances among species. Significant differences in diversity between sites by year are indicated in bold font with a darker shading. In these cases, the diversity was significantly higher at the treatment site than the combined controls. Even though we see significant differences, the bird diversity at all sites is around 3, which—compared with ecological systems in general—is very high.

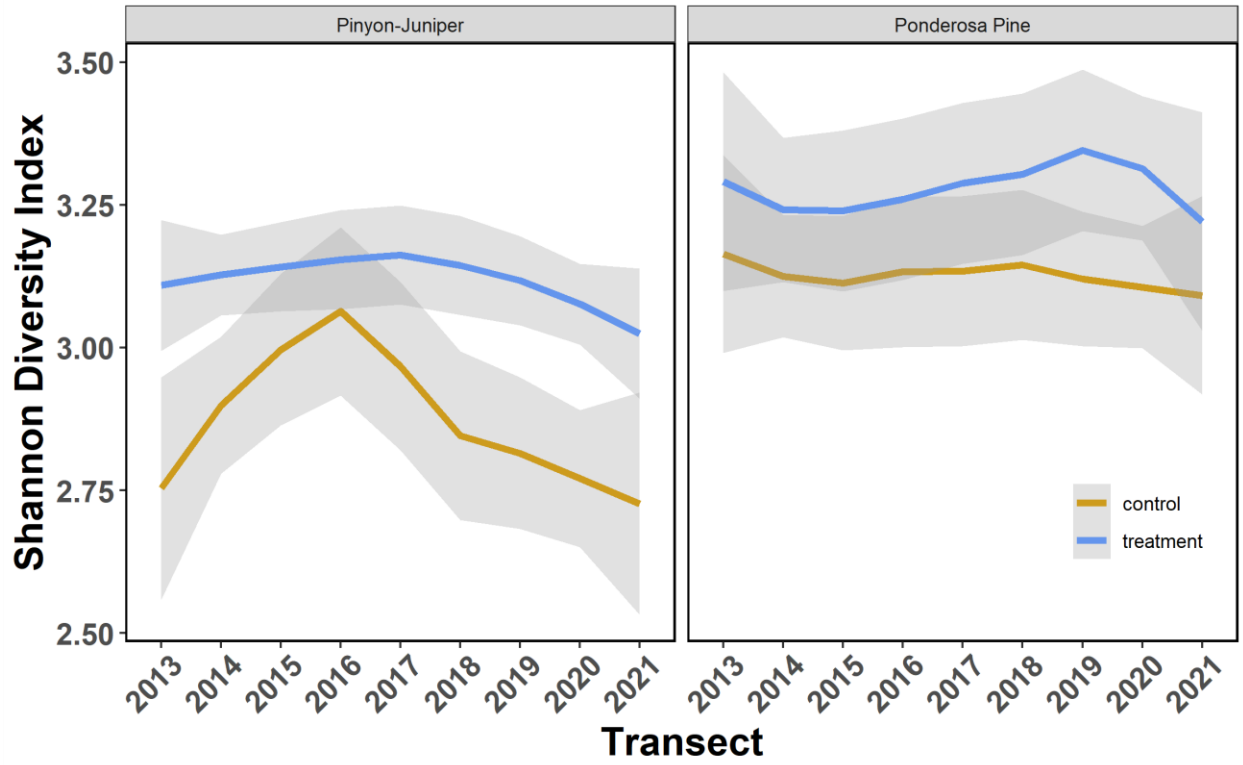

Figure 7. Shannon diversity index values by year averaged across treatment (blue line) and control sites (orange line). Shaded gray areas represent local smoothed 95% CI.

Table 4. Changes in species diversity over time comparing Minie Site with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Minie	3.14	3.14	3.19	2.97	3.13	3.21	3.06	3.13	3.00
PJ Control	2.88	2.99	3.16	3.07	3.24	2.94	2.97	2.98	2.80
Hutcheson's t-test	**t = 3.34 df = 523 p < 0.001**	t = 1.97 df = 468 p = 0.05	t = 0.55 df = 683 p = 0.58	t = -1.34 df = 473 p = 0.18	t = -1.53 df = 515 p = 0.13	**t = 4.07 df = 599 p < 0.0001**	t = 1.29 df = 634 p = 0.20	**t = 2.23 df = 528 p = 0.03**	**t = 2.41 df = 532 p = 0.02**

Table 5. Changes in species diversity over time comparing TA-39 with the PJ controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
TA-39	3.09	3.07	3.13	3.32	3.18	3.13	3.08	3.07	3.03
PJ Control	2.88	2.99	3.16	3.07	3.24	2.94	2.97	2.97	2.80
Hutcheson's t-test	**t = 2.64 df = 481 p < 0.01**	t = 1.08 df = 488 p = 0.28	t = -0.28 df = 492 p = 0.78	**t = 3.91 df = 690 p < 0.00001**	t = -1.00 df = 693 p = 0.32	**t = 2.83 df = 702 p < 0.01**	t = 1.46 df = 673 p = 0.15	t = 1.49 df = 945 p = 0.14	**t = 2.73 df = 644 p < 0.01**

Table 6. Changes in species diversity over time comparing TA-16 with the PIPO controls

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
TA-16	3.30	3.21	3.23	3.29	3.24	3.36	3.29	3.36	3.20
PIPO-Control	3.26	3.22	3.16	3.21	3.20	3.17	3.31	3.18	3.22
Hutcheson's t-test	t = 0.71 df = 419 p = 0.48	t = -0.28 df = 517 p = 0.78	t = 1.30 df = 702 p = 0.20	t = 1.18 df = 524 p = 0.24	t = -0.91 df = 549 p = 0.36	**t = 3.07 df = 598 p < 0.005**	t = -0.46 df = 659 p = 0.65	**t = 3.42 df = 842 p < 0.001**	t = -0.24 df = 583 p = 0.81

Detecting 2020 Mass Mortality Event

Though upwards of 100,000 birds are thought to have died in the mass mortality event last September (NMDGF 2020), repeated measures ANOVAs between years and foraging guilds, controlled for transect, showed no significant difference in abundance or richness between 2020 and 2021 (Figure 8). It is likely that most of the birds involved in the die-off, were migrants flying through New Mexico and therefore did not contribute to local breeding populations.

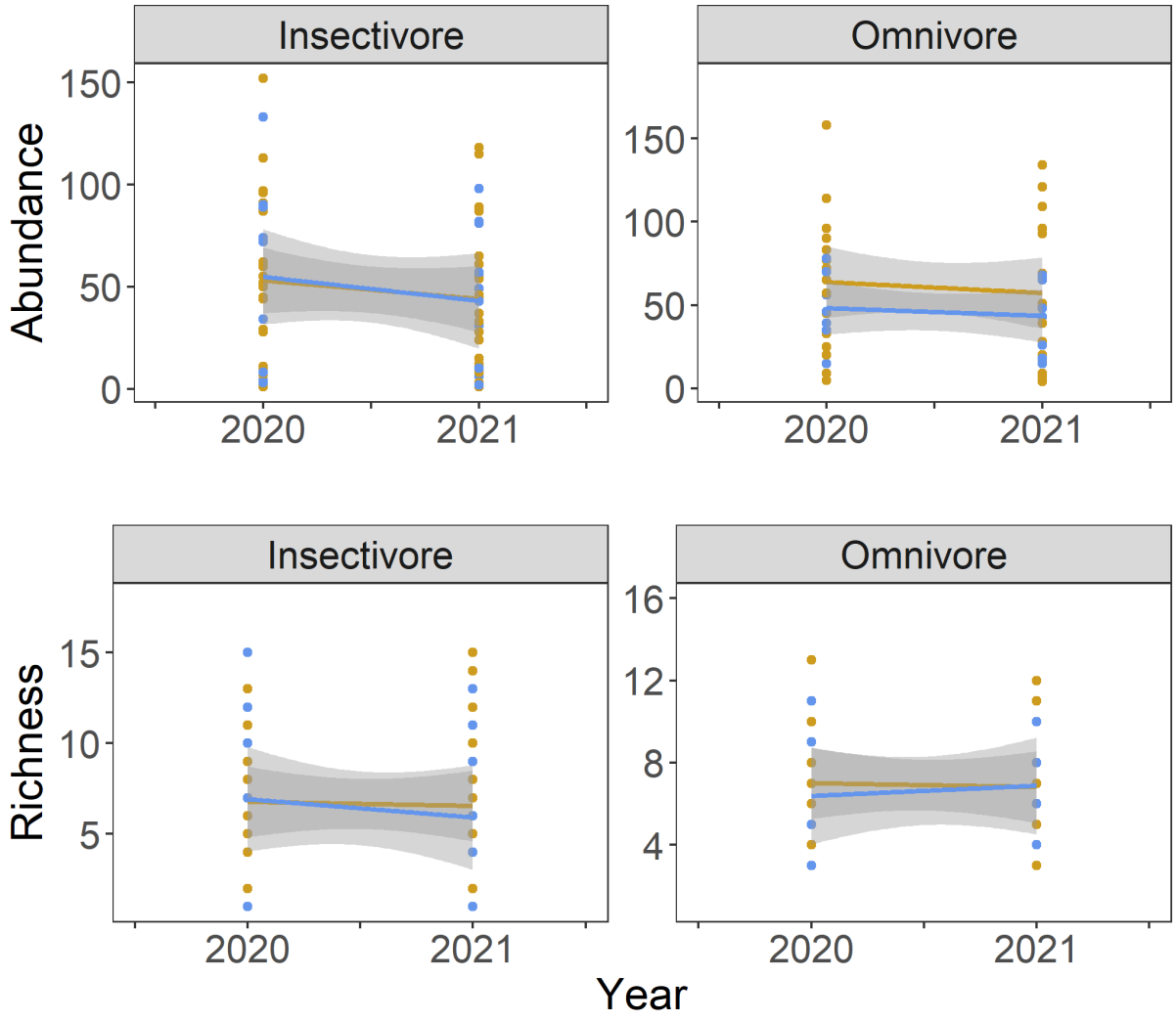

Figure 8. Richness compared between 2020 and 2021 for two major summer foraging guilds between control sites (orange) and treatment sites (blue).

Nestboxes

During the 2021 nesting season, LANL biologists actively monitored 15 nestboxes at each treatment site and a total of 365 nestboxes throughout the overall avian nestbox network. Of those, 110 contained active nests and 49 of those nests fledged young successfully for an overall

occupancy rate of 30% and a 45% success rate. Both the occupancy and success rates for 2021 were the lowest recorded since the start of the nestbox monitoring at firing sites in 2015 (Tables 7 & 8). Figure 9 and Tables 7 and 8 compare the occupancy and nest success rates for each treatment site and the overall nestbox network since 2015.

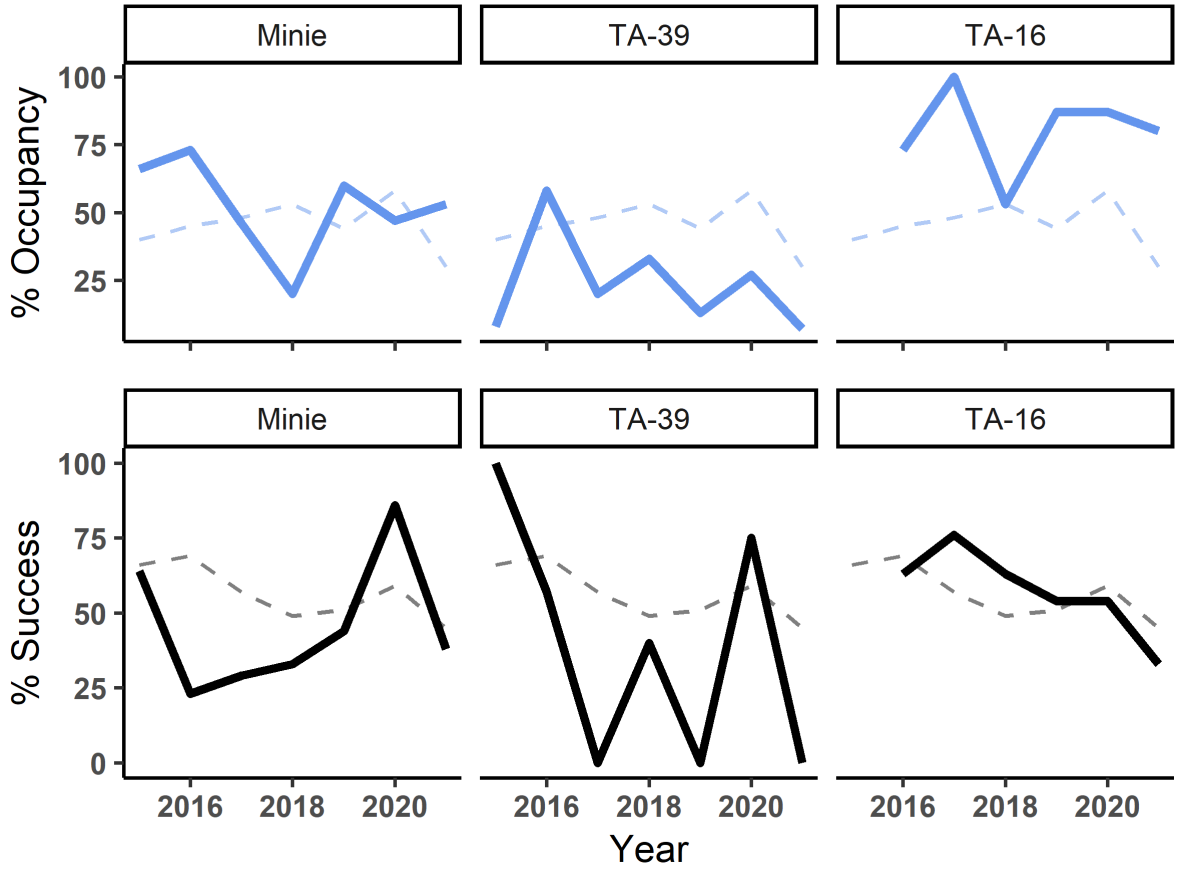

Figure 9. Nestbox occupancy (blue line; top) and success (black line; bottom) plotted by year for the three treatment sites. Dashed lines are global yearly mean for occupancy and success combined across all sites.

Table 7. Comparison of occupancy for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Overall Network	40%	45%	48%	53%	44%	58%	30%
Minie	66%	73%	46%	20%	60%	47%	53%
TA-39	8%	58%	20%	33%	13%	27%	7%

TA-16	-	73%	100%	53%	87%	87%	80%

Table 8. Comparison of nest success for the treatment sites and the overall nestbox network over time

	2015	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Overall Network	66%	69%	57%	49%	51%	59%	45%
Minie	64%	23%	29%	33%	44%	86%	38%
TA-39	100%	57%	0%	40%	0%	75%	0%
TA-16	-	63%	76%	63%	54%	54%	33%

In 2021, there were three successful nests that fledged young at Minie, four at TA-16, and zero at TA-39. Occupancy at TA-39 was also low relative to the other treatment sites and the overall network. The nest success rate at TA-39 has been highly variable since monitoring began in 2015 ranging between 0% and 75%. TA-39 is the lowest elevation treatment site and occupancy has been decreasing over time at this site and surrounding areas of the avian nestbox network (Figure 9 & Table 7). Wysner et al. (2019) found that Western Bluebirds, one of the target species of the network, have increased their nesting elevation over time in the study area. Western Bluebirds have the highest occupancy rates throughout the nestbox network, and shifts in nesting elevation could be driving the lower occupancy rates at TA-39. Occupancy and success rates at the Minie treatment site have fluctuated annually and have not displayed a decreasing trend over time, though the success rate dropped substantially between 2020 and 2021 (Figure 9 & Table 8). While occupancy has been relatively high and naturally fluctuating at TA-16, the success rate has been decreasing since 2017 with the largest decrease in success occurring in 2021.

Decreases in occupancy and nest success were pervasive across both control and treatment sites between 2020 and 2021 with 79% of all nestbox sites showing a decrease in occupancy and 86% showing a decrease in nesting success (Figure 10 & Table 9). These decreases are likely driven by extreme low precipitation values winter 2020 and spring 2021 (NOAA 2021). Decreases in precipitation have been linked to declines in body mass which may indirectly impact reproductive success (Smith et al. 2010).

In 2021, LANL biologists submitted nonviable eggs collected from nestboxes at the treatment sites and the rest of the nestbox network to an analytical lab for chemical analyses. These data will be presented in a separate report.

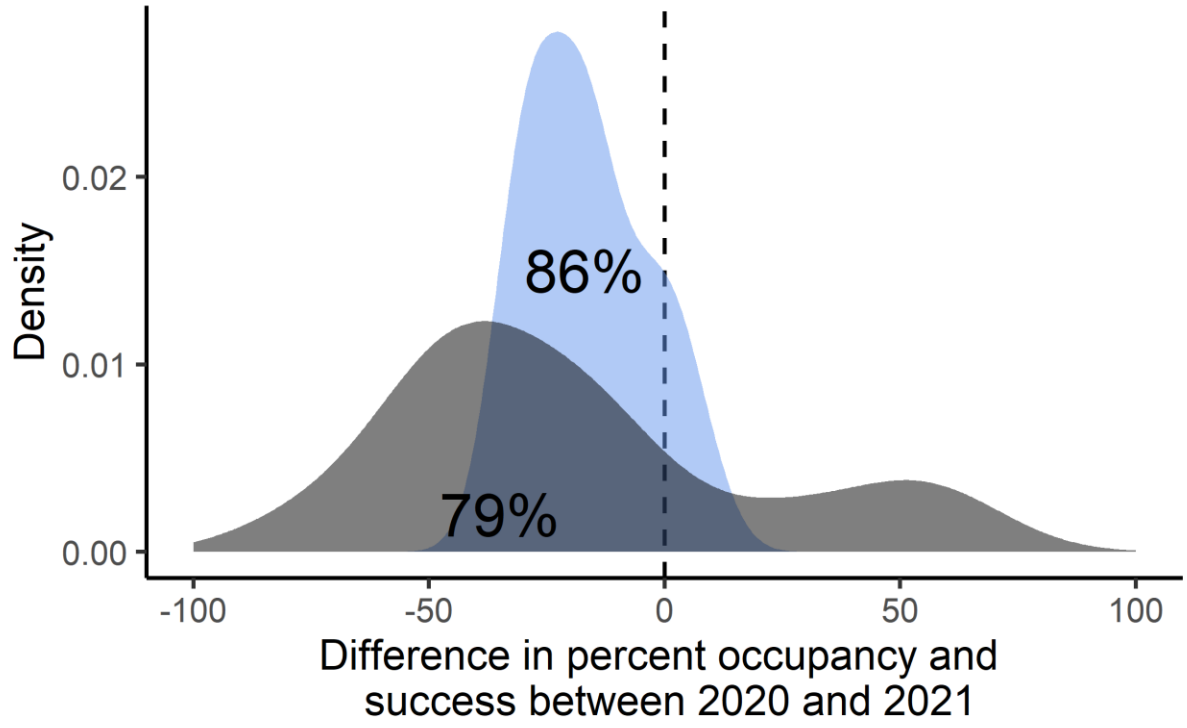

Figure 10. Distribution of between-year comparisons of percent occupancy (grey) and success (blue) between 2020 and 2021. Shaded area to left of dashed line illustrates number of sites that had a reduction in percent occupancy or success in 2021 compared to 2020. Percentages indicate number of comparisons falling below zero.

Table 9. Results from best fit repeated measures ANOVA for comparison between 2020 and 2021 abundance and richness binned by foraging guild and using transect as repeated measure.

Insectivore			
Abundance ~ Year + Site Cat	**df**	**t**	**P value**
Year	20	-1.320	0.20
Site Category (Treatment/Control)	12	0.823	0.43
Richness ~ Year + Site Cat	**df**	**t**	**P value**
Year	21	-0.728	0.48

Site Category (Treatment/Control)	13	0.780	0.45
Omnivore			
Abundance ~ Year + Site Cat	**df**	**t**	**P value**
Year	12	-1.532	0.15
Site Category (Treatment/Control)	12	0.036	0.97
Richness ~ Year + Site Cat	**df**	**t**	**P value**
Year	12	-0.628	0.54
Site Category (Treatment/Control)	12	0.674	0.51

Management Recommendations

In addition to supporting federally protected bird species such as the Mexican Spotted Owl and the Southwestern Willow Flycatcher, LANL lands are important for migratory bird conservation. Over the 9 year study period LANL biologists have documented sensitive species from the Sensitive Species Best Management Practices Source Document (Berryhill et al. 2020) and the Birds of Management Concern and Focal Species list (USFWS 2021) at the treatment sites. Those species are the Cassin's Finch, Juniper Titmouse, Grace's Warbler, Virginia's Warbler, Black-throated Gray Warbler, Evening Grosbeak, Peregrine Falcon, and the Mourning Dove. The Gray Vireo is the only sensitive species documented in only control sites. Of the 79 species detected at the three treatment sites, the Migratory Bird Treaty Act protects all but one species. The Eurasian Collared-Dove is not native and therefore not protected under the Migratory Bird Treaty Act.

Continuing to document migratory bird occurrences and nest success across treatment and control sites, provides a long-term dataset to assess the ecological health of avifauna at the three treatment sites at LANL. In addition, this research contributes to meeting the Department of Energy's commitments under the Migratory Bird Treaty Act and associated memorandum of understanding with the U.S. Fish and Wildlife Service, and it allows LANL to contribute to national goals in avian conservation monitoring and research.

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Appendix 1. All birds recorded at the three treatment sites from 2013–2021

Species	TA-36 Minie Site									TA-39 Point 6									TA-16 Burn Grounds								
	Pinyon-Juniper Woodland									Pinyon-Juniper Woodland									Ponderosa Pine Forest								
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
Acorn Woodpecker																			5		3	2	3	5	3	5	1
American Crow																							1	1		1	1
American Kestrel				1				1	1	1			2					2									
American Robin	1	1	2		2					1	1		2		4	2			7		9	4	4	6	12	6	14
Ash-throated Flycatcher	11	5	14	13	13	10	17	12	12	19	11	30	12	8	8	6	11	4	3	5	6	2	3	8	4	6	6
Audubon's Warbler		2				5							2				5		6	5	1	6		1	11	14	9
Bewick's Wren	4	8	9	9	14	14	5	10	4	3	10	15	9	2	8	1	2										
Black-chinned Hummingbird		1	1				1	2	1	3	2				1	2	3		1		1		1		1	12	1
Black-headed Grosbeak	1	3				1	1	2	1		2	4	1		3	2	1	1			1	2		2		1	1
Black-throated Gray Warbler			1		2			2		5	6	4															
Blue-gray Gnatcatcher	3	14	16	8	10	9	8	11	8	2		7	5	4	2	13	5	2		6	2	1	3	6	4	9	3
Blue Grosbeak																		1									
Broad-tailed Hummingbird	2	1	3		1		3	2		3	1	2		3	1	2	9	3	5	11	11	5	7	10	8		
Brown Creeper																			1								
Brown-headed Cowbird	1								1			2			3	2	10	3	4	1			4	2	8	4	4
Bushtit		2		2		11				2	14			1	12		2									
Canada Goose												16				2											
Canyon Towhee	2		5	3	6	2	3	5	3	1	1	2	10	13	19	6	3	9	1			1		1			
Canyon Wren					1							2	3	8	6	2	4				2						
Cassin's Finch						4																					1
Cassin's Kingbird	6	13	13	5	2	5	6	5	4	7	6	2	21	21	32	37	49	14				1				2	
Chipping Sparrow	3	16	17	29	6	22	10	10	10	6	6	5	8	15	25	27	24	16	1	5	3	10	5	21	8	32	6
Clark's Nutcracker																				4		1					
Common Nighthawk	6		5	2	4	4	1	5		5	1	3	2	7	5	7	3	1			1	2	2			1	
Common Raven	2	5	1		1	2	3			1		2	1		1	2	5		5	6	2	2	5	5	7	4	2
Cooper's Hawk					1														1			1			1		
Cordilleran Flycatcher																			5	10	6	3	3	1	2	4	
Dark-eyed Junco															1	1			6	2	4		5	2		2	3
Downy Woodpecker				1									1	2		1	2	1		1		1	1	1			
Dusky Flycatcher				1								1		1												2	1
Eurasian Collared-Dove	3													4			2							1			
Evening Grosbeak	3		4						1			8							5		29			1			
Grace's Warbler							1								2	4	1	6	6	4	4	8	5	8	22	12	17
Gray Flycatcher	12	6	5	7	3	6	3	2	4	10	10	11	10	5	8	3	14	5									

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
	TA-36 Minie Site									TA-39 Point 6									TA-16 Burn Grounds								
	Pinyon-Juniper Woodland									Pinyon-Juniper Woodland									Ponderosa Pine Forest								
Great Horned Owl		3								1																	
Green-tailed Towhee	3	1								1																1	
Hairy Woodpecker			2	1		1		1	1			5	3			1	1	4	1	1		1	1	2	1	1	
Hammond's Flycatcher																			8	9	12	5	7	5	10	5	7
Hepatic Tanager									2			1	2	1	2			1				1					
Hermit Thrush						1														4	6	1	2	2	5	5	2
House Finch	16	17	26	17	12	18	17	11	11	21	4	23	9	30	44	50	53	22	16	2	5	5	12	7	12	18	11
House Wren																1			1	1		2	2	6	8	2	1
Juniper Titmouse	12		7	6	9	3	26	8	20	11	13	18	6	1			3	2									
Lesser Goldfinch	2	6	7	4	9	12	8	4	4	4	12	9	10	14	19	15	27	8	3		8	9	4	8	5	6	2
MacGillivray's Warbler																						1	3			1	
Mountain Bluebird		2	20	10	11	1	9	3	2		4						2	1			4	4	4	7	4	5	
Mountain Chickadee	5	2	1	2									1	1		1			5	8	9	6	8	9	1	4	6
Mourning Dove	17	17	13	5	8	8	11	9	7	13	22	10	3	15	11	8	10	9	4		1	3	17	3	5	17	5
Northern Mockingbird					2		1	4			1							2									
Northern Rough-winged Swallow						3																					
Orange-crowned Warbler																										1	
Peregrine Falcon									1			1						1									
Pine Siskin	10	2		5	1			1		6		3	3						12	4	5		4	2		6	
Plumbeous Vireo	10	10	7	3	9	9	15	3	3	1		1	6	6	5	5	12	4	11	16	15	14	11	18	16	24	17
Pygmy Nuthatch				2		2	3		1			2	4	12	9	11	10	1	11	13	26	29	41	20	16	23	5
Red Crossbill					1						2						1			2	9	13	9		6	26	1
Red-shafted Flicker	3	1	3	2	5	2	1		1	3	2	4	8		3	2	2		3	4	11	11	5	5	2	7	5
Red-tailed Hawk							1	2	1			1	1	1	1												
Rock Wren	3	3	4		2	10	11	10	4	7	10	4	12	14	14	12	20	15	1	2	2	6			4	1	
Ruby-crowned Kinglet																								2			1
Savannah Sparrow																										1	
Say's Phoebe	2	1	2		2	5	1	1	2	2	1		5	2	4		6	5	1		1	3	3	4	1	1	4
Scaled Quail			1																								
Spotted Towhee	17	8	19	27	32	24	19	20	17	12	6	33	16	12	16	15	20	14	11	18	16	14	21	22	34	24	16
Steller's Jay							1												3	2	5	6	3	4	4	2	1
Townsend's Solitaire	1																						1				
Turkey Vulture					1			2									1		1					1			
Vesper Sparrow																									1		
Violet-green Swallow		5	7	1	3	2	1	6		6	4	1	9	6	6	9	47	5		2	19	2	2	4	2	7	6
Virginia's Warbler					1	3	1					1	2	4		5		2	17	11	21	13	7	5	5	8	3

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021	2013	2014	2015	2016	2017	2018	2019	2020	2021
	TA-36 Minie Site									TA-39 Point 6									TA-16 Burn Grounds								
	Pinyon-Juniper Woodland									Pinyon-Juniper Woodland									Ponderosa Pine Forest								
Warbling Vireo						2													2	9	7	6	5	4	6	3	7
Western Bluebird	15	11	18	17	16	19	21	23	8	5	19	12	21	13	6	7	17	3	20	20	49	37	32	27	20	27	8
Western Tanager		2	3		1						2	1	1	2	2	6	1	2	2	3	7	2	4	6	16	10	7
Western Wood-Pewee	10	8	18	11	10	7	18	14	10		4	2	10	8	11	12	18	12	15	10	16	14	22	20	24	28	25
White-breasted Nuthatch	1	4	9	10	13	5	2	1	2			2	4	4	2	6	3	2	9	8	7	9	20	10	10	8	10
White-crowned Sparrow																		1									
White-throated Swift											1						2										
White-winged Dove	1	5	9	2		3	2	1	1	7	5	6	16	15	15	5	2	5			1	2			1		
Willow Flycatcher																		1									
Woodhouse's Scrub-Jay	5	1	3	4	8	7	14	10	10	8	10	4	8	6	4	5		2	1								

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 14 – Gaulker & Stanek 2019

Environmental Report:

Gaukler, S.M. and J. Stanek, June 2019. *Inorganic Element Concentrations in Passerine Eggs Collected at Technical Areas 36, 39, and 16 at Los Alamos National Laboratory*. LA-UR-19-25647.

June 2019

Inorganic Element Concentrations in Passerine Eggs Collected at Technical Areas 36, 39, and 16 at Los Alamos National Laboratory

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ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LOAELs	lowest observable adverse effect levels
mg/kg	milligrams per kilogram
RSRLs	regional statistical reference levels
TA	Technical Area
TAL	total analyte list

SUMMARY

In 2018, nonviable avian eggs were opportunistically collected at Los Alamos National Laboratory near open detonation sites at Technical Area (TA) 36 and TA-39 and near the TA-16 burning grounds and were evaluated for inorganic elements (mostly metals). A total of eight western bluebird *Sialia mexicana*) and ash-throated flycatcher (*Myiarchus cinerascens*) egg samples were collected among the three locations of interest. Due to the small sample size, statistical comparisons could not be made. However, concentrations of inorganic elements observed in this study were compared with the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval; regional statistical reference level [RSRL]). Several inorganic elements were not detected in avian eggs and the majority of inorganic elements detected were below the RSRL. The few elements that exceeded the RSRL were below the lowest observable adverse effect level (LOAEL), when available. These data suggest that inorganic element concentrations in eggs observed here are not of ecological concern. As these data are preliminary, more data are needed to make a robust assessment, including additional background samples.

INTRODUCTION

Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of nonviable eggs and/or nestlings that die of natural causes is noninvasive and is nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Sources of inorganic elements include both anthropogenic and natural sources and birds can be exposed through a number of routes including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals) and dioxins and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

OBJECTIVES

The objective of this study is to document chemical concentrations in eggs and nestlings collected near TAs 36, 39, and 16 and to compare concentrations of inorganic elements observed in this study with the upper-level bounds of background concentrations.

METHODS

Sample Collection

Eggs were collected from nest boxes when they were determined to be nonviable due to documented timing of known incubation periods for the species. In 2018, two nonviable egg samples were collected from TA-36, two egg samples from TA-39, and four samples from TA-16. All egg samples were either western bluebirds (*Sialia mexicana*) or ash-throated flycatchers (*Myiarchus cinerascens*) and were collected in June and July of 2018. No nestling samples were obtained in 2018 because the nest boxes located in the areas of interest did not have nestlings that died of natural causes that could be collected opportunistically.

Chemical Analyses

Due to limited sample mass, nonviable eggs were analyzed for TAL only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. The two samples collected near TA-36 and submitted for analyses consisted of one individual western bluebird egg and one composite of six western bluebird eggs. The two samples collected near TA-39 and submitted for analyses consisted of one individual ash-throated flycatcher egg and one composite of three western bluebird eggs. The four samples collected near TA-16 and submitted for analyses consisted of two individual western bluebird eggs, one composite of four western bluebird eggs, and one composite of two ash-throated flycatcher eggs.

Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All metal results were reported on an mg/kg (milligram per kilogram) dry weight basis.

Analyses of Chemical Levels

The 2018 results could not be statistically compared with background data due to small sample sizes; more data are needed to enable a robust evaluation of open detonation sites and background locations. However, results from 2018 were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from nonviable eggs of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2016 and 2018 (n=8). Results were also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

PRELIMINARY RESULTS AND DISCUSSION

Many of the inorganic elements assessed in this study were not detected in passerine egg samples. Elements that are not (or very little is) maternally transferred into eggs or do not accumulate in eggs include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001).

Minie Firing Site (TA-36)

The two western bluebird egg samples collected from TA-36 did not have detectable levels of several elements including aluminum, antimony, arsenic, beryllium, cadmium, lead, nickel, silver, or vanadium. Detectable concentrations of barium, calcium, chromium, cobalt, iron, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were all below the RSRL and the LOAEL (when available). One egg sample contained copper concentrations of 4.1 mg/kg that was higher than the RSRL of 3.6 mg/kg (Table 1).

The elevated copper in western bluebird egg samples observed in 2018 at TA-36 and TA-39 (see below) are similar with previous observations (Gaukler, 2017) and could be from some high-explosives testing. Copper has historically been detected above soil screening levels at Technical Area 39 (Juarez and Vigil-holterman 2011). Contrarily, copper soil levels at Technical Area 36, near the firing site were below the RSRL in 2018. No reliable screening levels exists for egg tissues, although it has been suggested that birds are relatively resistant to copper toxicity when compared with other taxa (Eisler 1998).

TA-39

Two egg samples collected from nest boxes at TA-39 did not contain detectable concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of barium, cobalt, and zinc were all below the RSRL. One western bluebird egg sample contained higher concentrations of calcium, copper, iron, magnesium, manganese, mercury, potassium, selenium, and sodium compared with RSRLs (Table 2). Although calcium, magnesium, potassium, and sodium were higher in eggs collected at Technical Area 39 compared with the RSRL, these elements are macronutrients, which are required by living organisms in large quantities. Copper, iron, manganese and selenium are essential micronutrients to living organisms in small concentrations, but can become toxic at high enough levels. No reliable screening levels are available for copper, iron, and manganese; however, both mercury and selenium egg concentrations were below the LOAELs for these elements (Heinz et al 1996; Thompson et al 1996)

TA-16 Burn Grounds

Western bluebird and ash-throated flycatcher eggs collected from nest boxes at TA-16 did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, lead, nickel, thallium or vanadium. One sample out of the four collected contained higher concentrations of antimony (0.21 mg/kg) compared with the RSRL (0.11 mg/kg). Two samples out of four collected contained higher concentrations of mercury (0.23 and 0.25 mg/kg) compared with RSRLs (0.18 mg/kg; Table 3). However, both of the samples were below the LOAEL for mercury (1.67 mg/kg, converted from wet to dry weight), suggesting that adverse health effects are not expected at the observed concentrations (Thompson et al 1996). No reliable screening levels are available for antimony; therefore, it is unknown at what concentrations adverse effects could be expected.

CONCLUSIONS

The overall results indicate that the levels of inorganic elements in the eggs of western bluebirds and ash-throated flycatcher are not likely to cause adverse effects in breeding bird populations. Most constituents were not detected in the nonviable egg samples collected near firing sites at TA-36 and TA-39 and the burning grounds at TA-16. Most constituents that were detected were below RSRLs and all were below the LOAELs (when available). These data suggest that egg elements concentrations observed here are not of ecological concern. As these data are preliminary, more data from nonviable eggs and nestlings are needed to make a robust assessment, including additional

background samples. Evaluating avian nestling samples for high explosives is also of interest for future work as those data become available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near the Minie Firing Site (TA-36) compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

Element	Western bluebird (n=1) SFB-18-160523	Western bluebird (n=6) SFB-18-160524	RSRL
Barium	19	12	35
Calcium	3100	3200	4983
Chromium	ND	0.22	1.3
Cobalt	ND	0.03	0.6
Copper	2.8	**4.1**	3.6
Iron	160	130	250
Magnesium	390	350	447
Manganese	1.6	2.9	4.5
Mercury	0.04	0.08	0.18
Potassium	7500	7500	12040
Selenium	1.9	2.1	3.2
Sodium	7300	7600	10299
Thallium	ND	0.0019	0.0192
Zinc	46	51	78

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near TA-39 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

Element	Western bluebird (n=3) SFB-18-160525	Ash-throated flycatcher (n=1) SFB-18-160526	RSRL
Barium	11	7.9	35
Calcium	**8900**	2400	4983
Cobalt	0.15	0.06	0.6
Copper	**9.2**	2.4	3.6
Iron	**350**	86	250
Magnesium	**1100**	330	447
Manganese	**6.5**	0.78	4.5
Mercury	**0.62**	0.15	0.18
Potassium	**27000**	7600	12040
Selenium	**8.3**	2.6	3.2
Sodium	**24000**	9200	10299
Zinc	150	33	78

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

Table 3. Inorganic element concentrations (mg/kg dry weight) detected in eggs collected near TA-16 burning grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2018 (n=8).

Element	Western bluebird (n=1) SFB-18-160510	Ash-throated flycatcher (n=2) SFB-18-160520	Western bluebird (n=1) SFB-18-160521	Western bluebird (n=4) SFB-18-160522	RSRL
Antimony	**0.21**	ND	ND	ND	0.11
Barium	15	6.8	12	9.8	35
Calcium	600	3700	2900	2900	4983
Chromium	ND	ND	ND	0.28	1.3
Cobalt	ND	0.07	ND	0.04	0.6
Copper	3.2	3.1	2.2	2.5	3.6
Iron	38	150	87	190	250
Magnesium	420	320	290	320	447
Manganese	1.3	2.3	1.8	3.1	4.5
Mercury	**0.23**	**0.25**	0.16	0.13	0.18
Potassium	11000	8200	8400	8200	12040
Selenium	1.3	3.2	2.9	2.7	3.2
Silver	ND	0.026	ND	ND	0.04
Sodium	8700	7600	9100	6700	10299
Zinc	8.7	50	30	54	78

ND = nondetect

Bold values indicate a detectable concentration that is higher than the RSRL.

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March 2020

2019 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and a Nestling Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory

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Table 3. Inorganic element concentrations (mg/kg dry weight) detected in a western bluebird composite egg sample collected near TA-39 Point 6 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n=23). No values were above their respective RSRL. 16

ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LOAEL	slowest observable adverse effect levels
mg/kg	milligrams per kilogram
pg/g	picograms per gram
PCBs	polychlorinated biphenyls
RSRLs	regional statistical reference levels
TA	Technical Area
TCDD	tetrachlorodibenzodioxin-2,3,7,8
TEF	toxic equivalent factors
TEQ	toxic equivalents
WHO	World Health Organization

1.0 SUMMARY

In 2019, non-viable avian eggs and one nestling were opportunistically collected at Los Alamos National Laboratory (LANL) near open detonation sites located at Technical Area (TA) 16 burn grounds, TA-36 Minie, and TA-39 Point 6. These samples were evaluated for inorganic elements (mostly metals), polychlorinated biphenyls (PCBs), dioxins, and furans. A total of 26 western bluebird (*Sialia mexicana*) and five mountain bluebird (*Sialia currucoides*) egg samples and one non-viable ash-throated flycatcher (*Myiarchus cinerascens*) nestling were collected among the three locations of interest. Concentrations of inorganic elements observed in this study were compared with the regional statistical reference level (RSRL) which is the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Several inorganic elements were not detected in avian eggs and the majority of inorganic elements detected were below the RSRL. The few elements that exceeded the RSRL were below the lowest observable adverse effect level (LOAEL), when available. One nestling collected from TA-16 contained detectable concentrations of some dioxin and furan congeners. Octachlorodibenzodioxin-1,2,3,4,6,7,8,9 concentration exceeded the RSRL, but did not exceed the calculated tetrachlorodibenzodioxin-2,3,7,8 (TCDD) toxic equivalent LOAEL. PCBs were also detected in the nestling sample and were above the RSRL but below the LOAEL. These data suggest that inorganic and organic element concentrations in eggs and nestlings are not of ecological concern. More data are needed to make a robust assessment and to evaluate trends over time.

2.0 INTRODUCTION

In support of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) began annual avian monitoring in 2013 around TA-16 burn grounds and at two firing sites, TA-36 Minie and TA-39 Point 6. Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of non-viable eggs and/or nestlings that die of natural causes is noninvasive and is nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Several congeners of PCBs, dioxins, and furans elicit similar toxic effects (i.e., immunotoxicity, carcinogenicity, and endocrine disruption) as those caused by tetrachlorodibenzodioxin-2,3,7,8 (TCDD), the most potent in this class of chemicals (Van den Berg et al. 2006). These congeners, like TCDD, have a high binding affinity to the aryl hydrocarbon receptor (Van den Berg et al. 2006). The World Health Organization (WHO) developed toxic equivalency factors (TEFs) for TCDD-like compounds that can be used to determine the relative potency, or toxic equivalents (TEQs), of dioxin-like compounds for different classes of animals (i.e., fish, birds,

and mammals), as well as to facilitate risk assessment for TCDD-like exposure (Van den Berg et al. 2006).

Sources of inorganic elements include both anthropogenic and natural sources; birds can be exposed through a number of routes, including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals), dioxins, and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

3.0 OBJECTIVES

The objective of this study is to document chemical concentrations in eggs and nestlings collected near TA-16 burn grounds, TA-36 Minie, and TA-39 Point 6 and to compare concentrations of inorganic elements, polychlorinated biphenyls (PCBs), dioxins, and furans observed in this study with the upper-level bounds of background concentrations.

4.0 METHODS

4.1. Sample Collection

Eggs and nestlings were collected from nest boxes when they were determined to be non-viable, based on documented timing of known incubation periods for the species. In 2019, warm temperatures in the early spring and then a period of very cold temperatures led to higher than usual numbers of non-viable eggs. We collected a total of 31 non-viable eggs at LANL near the TA-16 burn grounds (Figure 1) and near open detonation sites TA-36 Minie (Figure 2) and TA-39 Point 6 (Figure 3). At TA-16, 22 non-viable western bluebird (*Sialia mexicana*) samples and one non-viable ash-throated flycatcher (*Myiarchus cinerascens*) nestling sample were collected and submitted as six composite samples and one individual sample, respectively. At TA-36, five non-viable mountain bluebird (*Sialia currucoides*) eggs were collected and submitted as one composite sample. At TA-39, four non-viable western bluebird eggs were collected and submitted as one composite sample. All samples were collected May through July of 2019. Concentrations of chemicals in eggs and nestlings have been monitored annually at these locations since 2014.

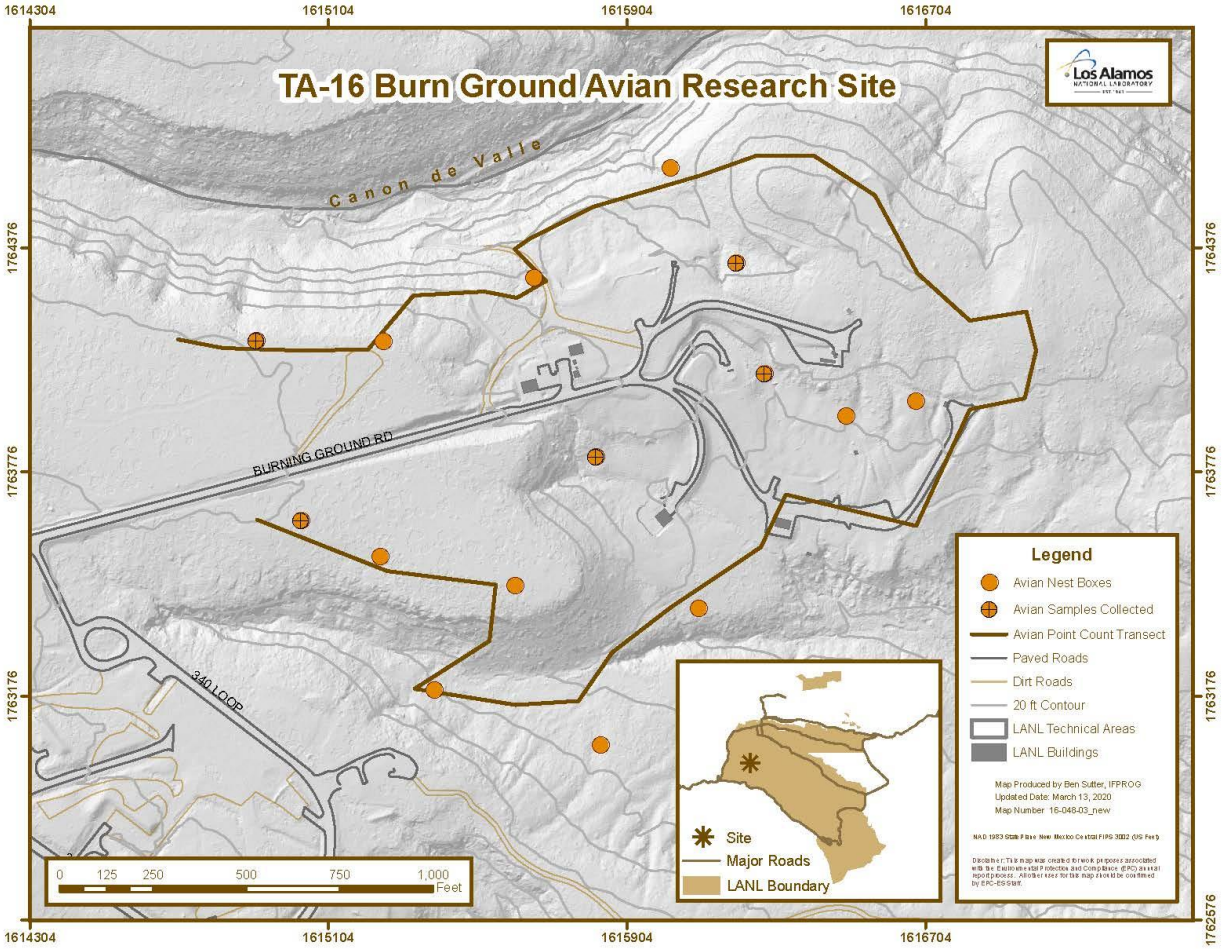

Figure 1. Avian nest box locations around TA-16 burn grounds.

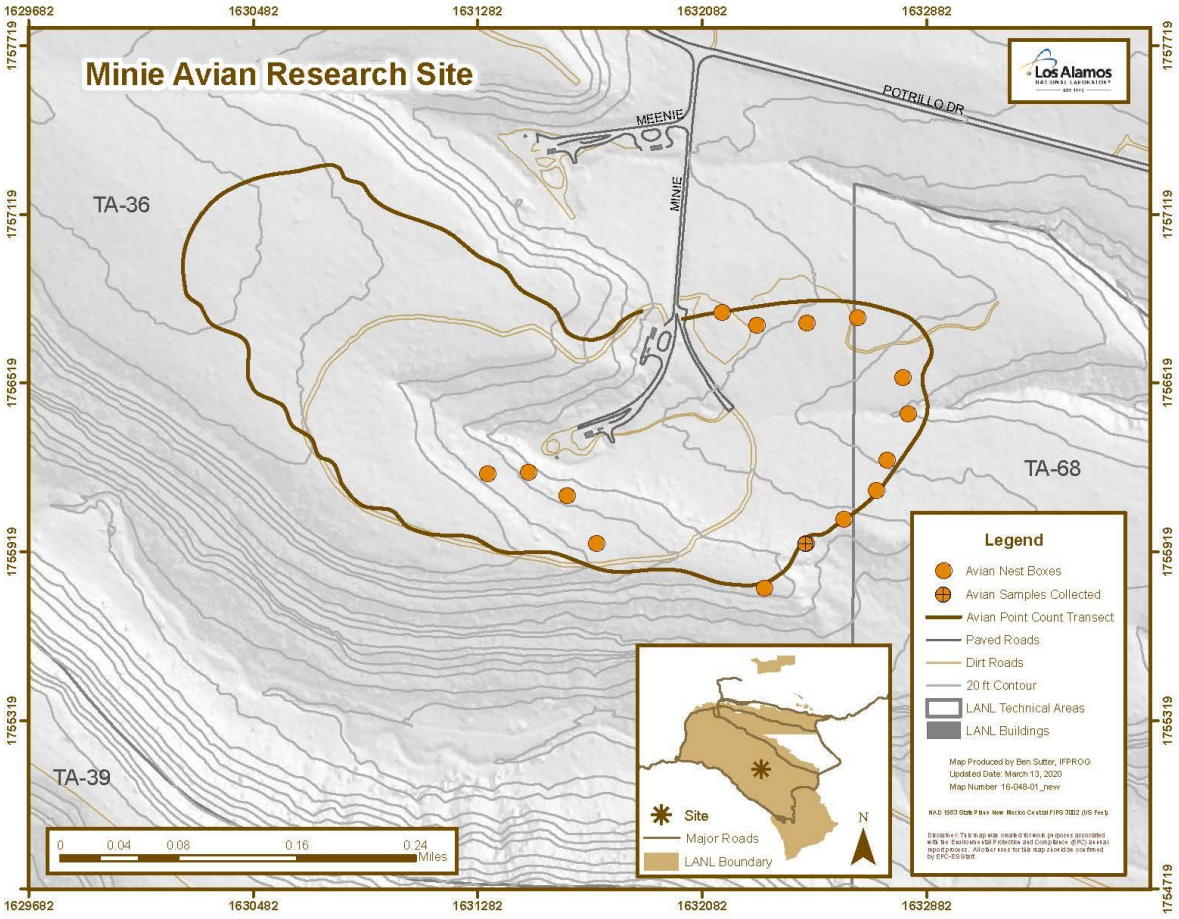

Figure 2. Avian nest box locations around TA-36 Minie.

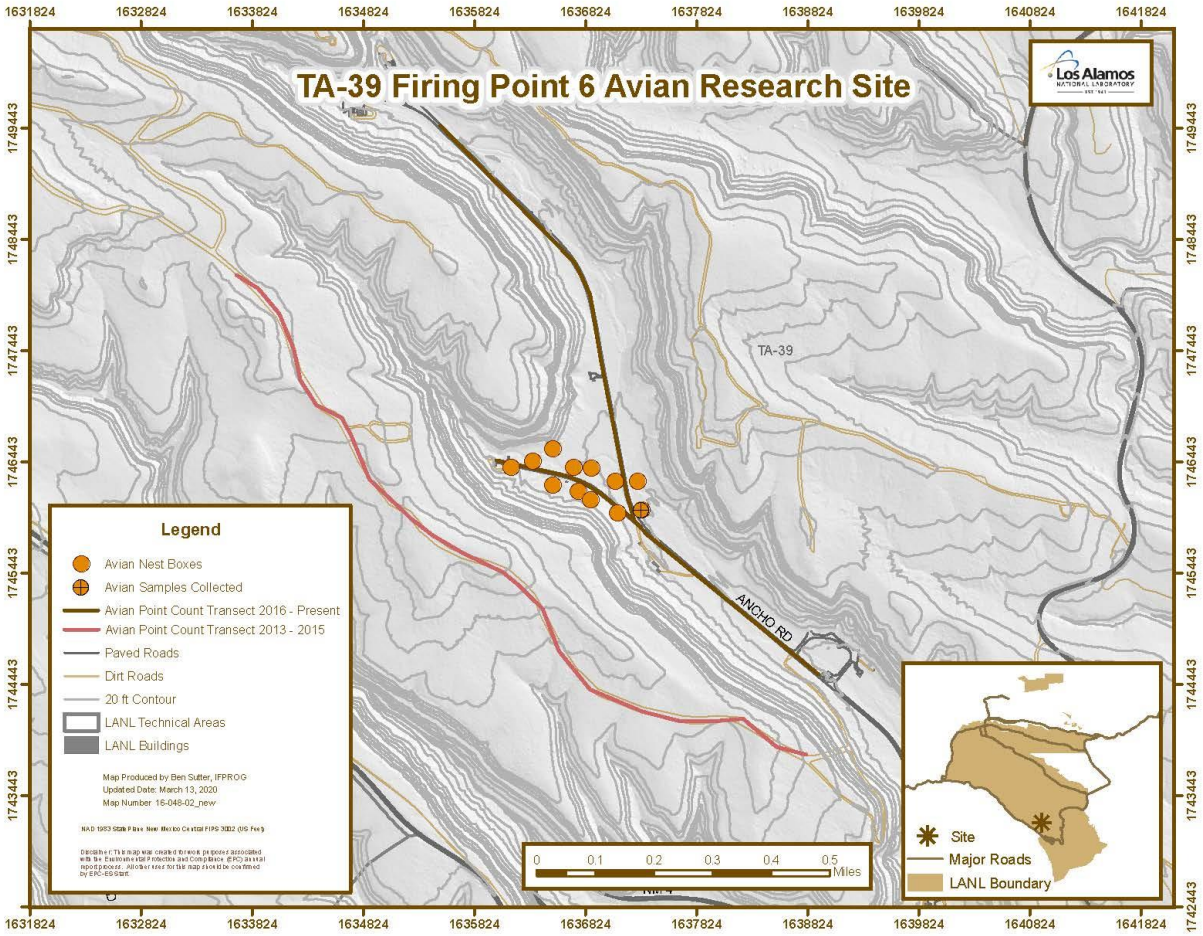

Figure 3. Avian nest box locations around TA-39 Point 6.

4.2. Chemical Analyses

Due to limited sample mass, non-viable eggs were analyzed for total analyte list (mostly inorganic metals) only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured in egg samples by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All inorganic element results were reported on an mg/kg (milligram per kilogram) dry weight basis.

The non-viable nestling sample collected near TA-16 was analyzed for PCB congeners by EPA Method 1668A and dioxin/furan congeners by EPA SW-846 Method 8290 at Cape Fear Analytical LLC, Wilmington, North Carolina. All organic chemical results are reported on a wet weight basis.

4.3. Statistical Methods

The 2019 results were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from non-viable eggs of western bluebirds and ash-throated flycatchers collected from Bandelier National Monument from 2016 through 2019 (n = 23). Non-viable egg results are also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

In the nestling, TCDD-like TEQs were calculated for all aryl hydrocarbon–binding PCB, dioxin, and furan congeners; these include:

- non-*ortho*-substituted PCB congeners 77, 81, 126, and 169
- mono-*ortho*-substituted PCB congeners 105, 114, 118, 123, 156, 157, 167, and 189
- tetrachlorodibenzodioxin-2,3,7,8
- pentachlorodibenzodioxin-1,2,3,7,8
- hexachlorodibenzodioxin-1,2,3,4,7,8
- hexachlorodibenzodioxin1,2,3,6,7,8
- hexachlorodibenzodioxin-1,2,3,7,8,9
- heptachlorodibenzodioxin-1,2,3,4,6,7,8
- octachlorodibenzodioxin-1,2,3,4,6,7,8,9
- tetrachlorodibenzofuran-2,3,7,8
- pentachlorodibenzofuran-1,2,3,7,8
- pentachlorodibenzofuran-2,3,4,7,8
- hexachlorodibenzofuran-1,2,3,4,7,8
- hexachlorodibenzofuran-1,2,3,6,7,8
- hexachlorodibenzofuran-1,2,3,7,8,9
- hexachlorodibenzofuran-2,3,4,6,7,8
- heptachlorodibenzofuran-1,2,3,4,6,7,8
- heptachlorodibenzofuran-1,2,3,4,7,8,9
- octachlorodibenzofuran-1,2,3,4,6,7,8,9

Each congener was multiplied by its respective avian-specific WHO TEF (Van den Berg et al. 2006), and added together for a total TEQ for the nestling sample. PCB congeners 156 and 157 co-eluted, and therefore were treated as one; the WHO TEFs were the same for both PCB congeners.

Nestling sample results of PCBs, dioxin, furans, and TEQs were compared with RSRLs and LOAELs, when available. The nestling RSRL was calculated from non-viable nestlings of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2018 and 2019 (n = 4 samples).

5.0 RESULTS AND DISCUSSION

Similar with previous years, many of the inorganic elements assessed in this study were not detected in passerine egg samples. Several elements are not (or very little is) maternally transferred into eggs or do not accumulate in eggs and include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001), which may explain why these elements were mostly not detected.

Similarly, most dioxins and furans were not detected in the nestling sample collected from TA-16 burn grounds. Most constituents that were detected in eggs and the nestling were below RSRLs, and all constituents were below the LOAELs, when available.

5.1. TA-16 Burn Grounds

Western bluebird eggs collected from nest boxes at TA-16 burn grounds did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, nickel, or vanadium. Of the elements containing detectable concentrations in eggs, only antimony, barium, and selenium were detected at concentrations above the RSRLs (Table 1). One sample out of the six collected contained slightly higher concentrations of antimony (0.27 mg/kg) compared with the RSRL (0.26 mg/kg). No reliable screening levels were available for antimony. One sample out of six collected contained higher concentrations of selenium (3.5 mg/kg) when compared with the RSRL (3.3 mg/kg dry weight). Selenium is an essential micronutrient and needed by living organisms. Additionally, the selenium concentration was far below the LOAEL of 10 mg/kg dry weight (Heinz et al. 1989).

Two samples out of six collected contained higher concentrations of barium (68 and 210 mg/kg) when compared with RSRL (31 mg/kg; Table 1). Legacy barium in the canyon sediment is known to occur in the area (Reid 2003) and has been detected in water samples near Cañon de Valle, which may suggest that birds may be exposed by direct drinking of water, and then the constituent is maternally transferred to their eggs. No reliable screening levels were available for barium; therefore, it is unknown at what concentrations adverse effects could be expected. However, of the non-viable egg samples collected at TA-16 burn grounds since 2016 ($n = 17$), only five of them contained barium concentrations above their respective RSRLs. Additionally, percentages of eggs hatched in nest boxes at TA-16 burn grounds ($n= 48$) compared with nest boxes at the background location ($n = 120$) were not statistically different (Mann-Whitney U test; $p > 0.05$). The hatching success in nest boxes at TA-16 burn grounds ($n = 48$) was 74.5% and was consistent with those reported previously for the area (Fair and Myers 2002). Barium did not have a negative impact on eggshell thickness when TA-16 burn grounds ($n = 40$) data was compared with background locations ($n = 54$; mixed-effects regression model; $p > 0.05$). These results suggest that adverse effects at the population level are unlikely to occur.

PCBs were detected in the nestling sample at 0.0126 mg/kg and were above the RSRL of 0.0045 mg/kg but well below the LOAEL in avian eggs of 3.0 mg/kg (Hoffman et al. 1996). Thus, even though the PCB concentrations were higher than the RSRL, these levels are not expected to negatively impact the bird population.

Most dioxins and furans were not detected in the nestling sample collected from TA-16 burn grounds. The nestling contained detectable concentrations of octachlorodibenzodioxin-1,2,3,4,6,7,8,9 of 7.65 mg/kg, which exceeds the RSRL of 2.42 mg/kg. Lowest observable adverse effect levels were not available for each dioxin and furan congener. However, the most potent dioxin congener, TCDD, is found to induce toxic effects in eastern bluebirds (*Sialia sialis*) when egg concentrations are between 0.001 and 0.01 mg/kg (Thiel et al. 1988). The TCDD toxic equivalency factor of octachlorodibenzodioxin-1,2,3,4,6,7,8,9 for avian species is 0.0001 (Van den Berg et al. 2006). Multiplying the detectable concentration of 7.65 mg/kg by the toxic equivalency factor yields a value of 0.000765 mg/kg, which was much less than the TCDD

LOAEL observed in eastern bluebird eggs. Total toxic equivalents (dioxin-like PCB, dioxin, and furan congeners) were 13.63 pg/g and were well below the RSRL of 23.51 pg/g.

5.2. TA-36 Minie

The one mountain bluebird egg sample, collected from TA-36 Minie, did not have detectable levels of several elements, including aluminum, antimony, arsenic, beryllium, cadmium, nickel, silver, or vanadium. Detectable concentrations of barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were all below the RSRL (Table 2). Mercury and selenium concentrations were well below LOAELs (Heinz et al. 1989, Thompson 1996); no other LOAELs were available.

5.3. TA-39 Point 6

One egg sample collected from a nest box at TA-39 Point 6 did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, chromium, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of antimony, barium, calcium, cobalt, copper, iron, magnesium, manganese, mercury, potassium, selenium, sodium, and zinc were all below the RSRLs (Table 3). Mercury and selenium concentrations were well below LOAELs (Heinz et al. 1989, Thompson 1996); no other LOAELs were available.

6.0 CONCLUSIONS

The overall results indicate that the levels of constituents detected in the eggs and nestlings are not likely to cause adverse effects in breeding bird populations. Several constituents were not detected in the non-viable egg and nestling samples collected near TA-16 burn grounds, TA-36 Minie, and TA-39. Most constituents that were detected were below RSRLs and all were below the LOAELs, when available. These results suggest that the detectable concentrations observed here were not of ecological concern. More data from non-viable eggs and nestlings are needed to make a robust assessment and to examine trends over time. Evaluating avian nestling samples for high explosives are also of interest for future work as those data becomes available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in single or composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n = 23).

Element	Western bluebird (n = 2) SFB-19-184785	Western bluebird (n = 5) SFB-19-184786	Western bluebird (n=1) SFB-19-184787	Western bluebird (n=4) SFB-19-184788	Western bluebird (n=4) SFB-19-184789	Western bluebird (n=4) SFB-19-184790	RSRL
Antimony	0.110	0.057	0.069	**0.270**	0.076	0.081	0.264
Barium	24	**68**	**210**	17	11	34	31
Calcium	2,700	2,500	3,800	3,800	2,900	2,600	5,637
Chromium	ND	0.20	ND	ND	ND	0.22	1.74
Cobalt	ND	0.089	0.077	0.046	0.041	0.063	0.354
Copper	3.10	2.30	2.80	3.90	3.30	2.80	4.85
Iron	180	170	100	130	120	150	274
Lead	ND	0.028	ND	ND	0.030	0.029	0.405
Magnesium	380	320	340	380	370	320	436
Manganese	2.80	2.70	2.00	1.20	2.40	3.40	4.47
Mercury	0.032	0.061	0.042	0.110	0.064	0.038	0.143
Potassium	7,400	6,700	6,800	8,200	7,000	6,200	11,035
Selenium	2.7	**3.5**	2.7	2.9	2.9	2.7	3.3
Silver	ND	ND	ND	ND	0.005	ND	0.040
Sodium	7,200	9,100	7,700	8,900	8,600	6,800	10,561
Thallium	ND	0.0076	0.0120	ND	0.0052	0.0090	0.0222
Zinc	65.0	65.0	43.0	62.0	51.0	52.0	95.8

ND = non-detect
Bold values indicate a detectable concentration that are higher than the RSRL.

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in a mountain bluebird composite egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n = 23). No values were above the RSRL.

Element	Mountain bluebird (n = 5) SFB-19-184791	RSRL
Barium	15	31
Calcium	3,100	5,637
Chromium	0.20	1.74
Cobalt	0.049	0.354
Copper	2.90	4.85
Iron	140	274
Lead	0.042	0.405
Magnesium	330	436
Manganese	3.40	4.47
Mercury	0.011	0.143
Potassium	7,200	11,035
Selenium	2.0	3.3
Sodium	9,000	10,561
Thallium	0.0082	0.0222
Zinc	54.0	95.8

Table 3. Inorganic element concentrations (mg/kg dry weight) detected in a western bluebird composite egg sample collected near TA-39 Point 6 compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2016-2019 (n=23). No values were above their respective RSRL.

Element	Western bluebird (n = 4) SFB-19-184792	RSRL
Antimony	0.130	0.264
Barium	10	31
Calcium	3,100	5,637
Cobalt	0.043	0.354
Copper	2.70	4.85
Iron	110	274
Magnesium	360	436
Manganese	2.20	4.47
Mercury	0.059	0.143
Potassium	6,900	11,035
Selenium	2.3	3.3
Sodium	7,200	10,561
Zinc	55.0	95.8

Revised Supplement 4-1
Alt Tech Evaluation
Attachment 16 – Gaulker & Stanek 2021

Environmental Report:

Gaukler, S.M. and J. Stanek, March 2021. *2020 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and a Nestling Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory*. LA-UR-21-22303.

22 February 2022

2020 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and Nestlings Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory: Revision 1

A note from the authors regarding the revision: In report number LA-UR-21-22303, inorganic element results were reported on a wet weight basis when after further review, we have concluded that the results are consistent with dry weight values. This change does not affect the observations, the comparisons, or conclusions of the study.

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Prepared for: U.S. Department of Energy, National Nuclear Security Administration, Los Alamos Field Office

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ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LOAEL	slowest observable adverse effect levels
mg/kg	milligrams per kilogram
pg/g	picograms per gram
PCBs	polychlorinated biphenyls
RSRLs	regional statistical reference levels
TA	Technical Area
TCDD	tetrachlorodibenzodioxin-2,3,7,8
TEF	toxic equivalent factors
TEQ	toxic equivalents
RCRA	Resource Conservation and Recovery Act
WHO	World Health Organization

1.0 SUMMARY

In 2020, non-viable avian eggs and two nestling were opportunistically collected at Los Alamos National Laboratory (LANL) near open detonation sites located at Technical Area (TA) 16 burn grounds, TA-36 Minie, and TA-39 Point 6. These samples were evaluated for inorganic elements (mostly metals), dioxins, and furans. A total of six eggs and two deceased western bluebird (*Sialia mexicana*) nestling samples were collected among the three locations of interest. Concentrations of inorganic elements observed in this study were compared with the regional statistical reference level (RSRL) which is the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Several inorganic elements were not detected in avian eggs and all inorganic elements detected were below the RSRL and the lowest observable adverse effect level (LOAEL), when available. One nestling collected from TA-39 contained detectable concentrations of two dioxin congeners. Heptachlorodibenzodioxin-1,2,3,4,6,7,8 and octachlorodibenzodioxin-1,2,3,4,6,7,8,9 concentration exceeded the RSRL, but did not exceed the calculated tetrachlorodibenzodioxin-2,3,7,8 (TCDD) toxic equivalent LOAEL. These data suggest that inorganic and organic element concentrations in eggs and nestlings are not of ecological concern. More data are needed to make a robust assessment and to evaluate trends over time.

2.0 INTRODUCTION

In support of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) began annual avian monitoring in 2013 around TA-16 burn grounds and at two firing sites, TA-36 Minie and TA-39 Point 6. Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of non-viable eggs and/or nestlings that die of natural causes is non-invasive and is non-destructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Several congeners of polychlorinated biphenyls (PCBs), dioxins, and furans elicit similar toxic effects (i.e., immunotoxicity, carcinogenicity, and endocrine disruption) as those caused by tetrachlorodibenzodioxin-2,3,7,8 (TCDD), the most potent in this class of chemicals (Van den Berg et al. 2006). These congeners, like TCDD, have a high binding affinity to the aryl hydrocarbon receptor (Van den Berg et al. 2006). The World Health Organization (WHO) developed toxic equivalency factors (TEFs) for TCDD-like compounds that can be used to determine the relative potency, or toxic equivalents (TEQs), of dioxin-like compounds for different classes of animals (i.e., fish, birds, and mammals), as well as to facilitate risk assessment for TCDD-like exposure (Van den Berg et al. 1998).

Sources of inorganic elements include both anthropogenic and natural sources; birds can be exposed through a number of routes, including diet, ingestion of soil, drinking water, and

inhalation. Inorganic elements (mostly metals), dioxins, and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

3.0 OBJECTIVES

The objective of this ongoing study is to document chemical concentrations in eggs and nestlings collected near TA-16 burn grounds, TA-36 Minie, and TA-39 Point 6 and to compare concentrations of inorganic elements, PCBs, dioxins, and furans observed in this study with the upper-level bounds of background concentrations.

4.0 METHODS

4.1. Sample Collection

Eggs and nestlings were collected from nest boxes when they were determined to be non-viable, based on documented timing of known incubation periods for the species. We collected a total of six non-viable eggs and two deceased nestlings at LANL near the TA-16 burn grounds (Figure 1) and near open detonation sites TA-36 Minie (Figure 2) and TA-39 Point 6 (Figure 3). At TA-16, five non-viable western bluebird (*Sialia mexicana*) eggs and one deceased nestling samples were collected and submitted as one composite sample and four individual samples. At TA-36, one non-viable western bluebird egg was collected and submitted and at TA-39, one deceased western bluebird nestling was collected and submitted. All samples were collected May through July of 2020. Concentrations of chemicals in eggs and nestlings have been monitored annually at these locations since 2014.

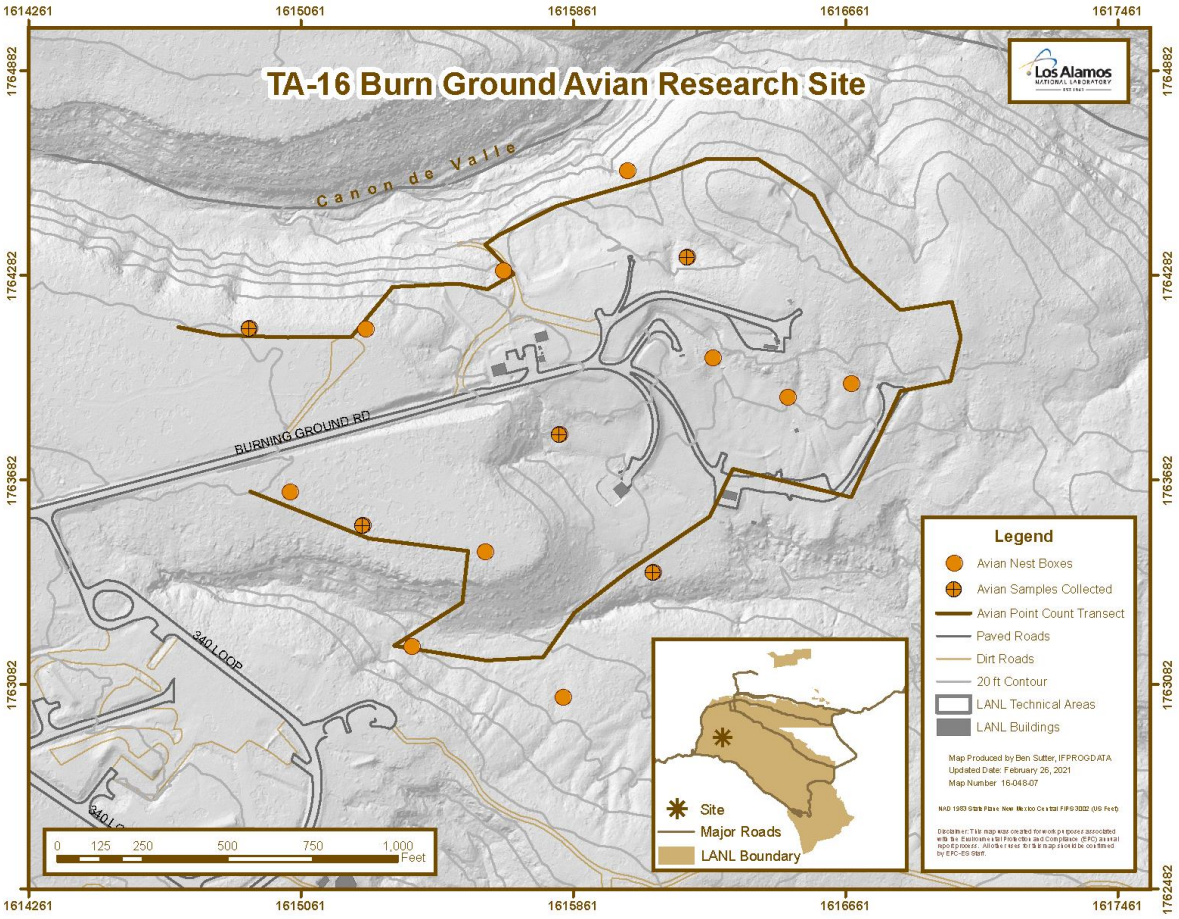

Figure 1. Avian nest box locations around TA-16 burn grounds.

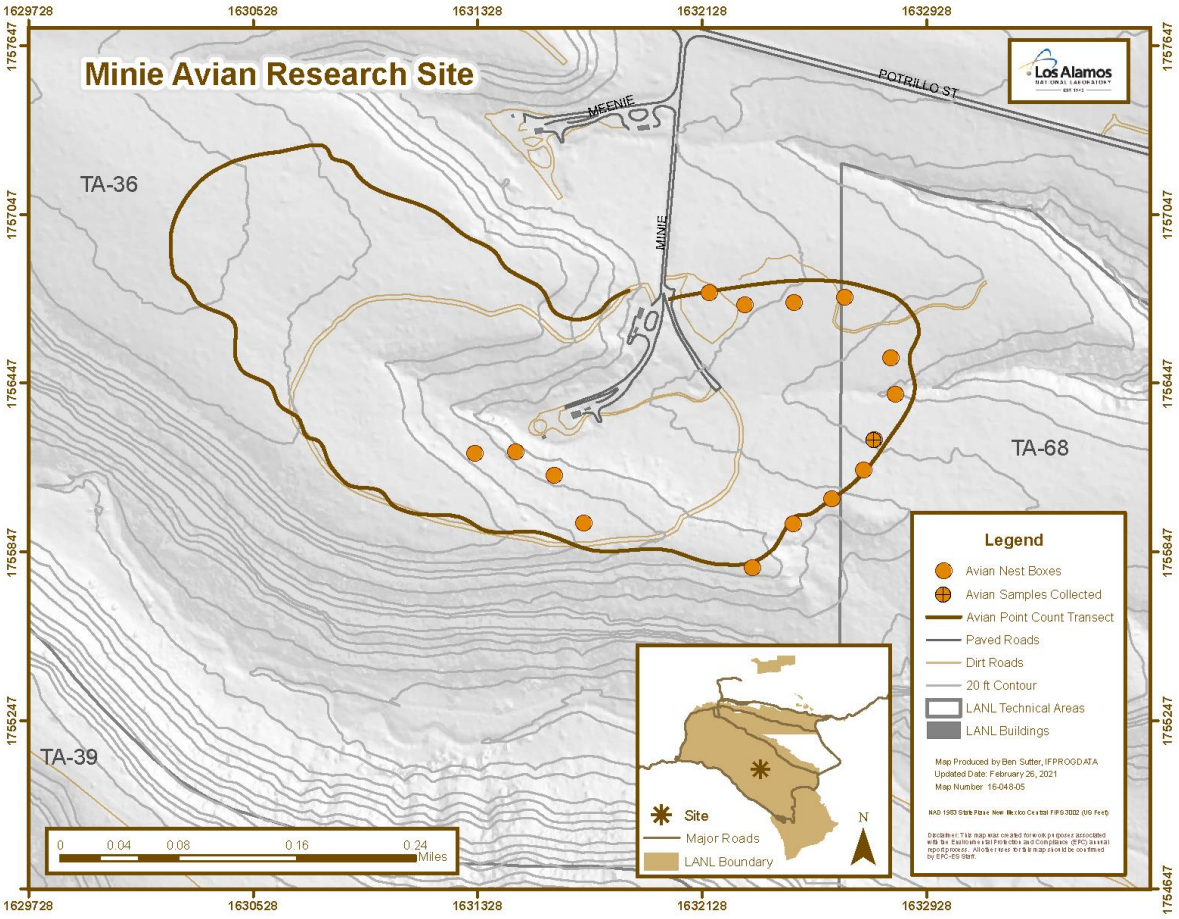

Figure 2. Avian nest box locations around TA-36 Minie.

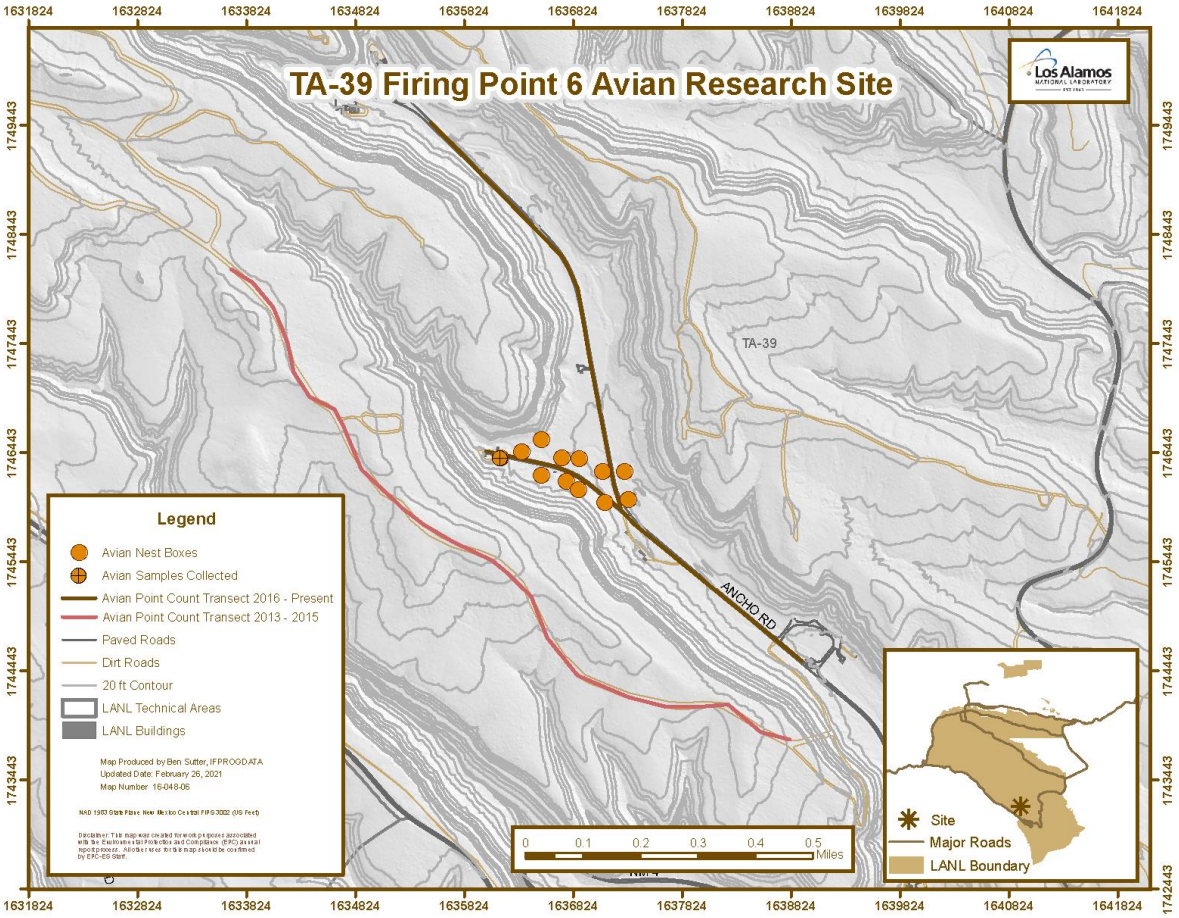

Figure 3. Avian nest box locations around TA-39 Point 6.

4.2. Chemical Analyses

Due to limited sample mass, non-viable eggs and one nestling sample were analyzed for total analyte list (mostly inorganic metals) only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured in egg samples by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020A), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All inorganic element results were reported on an mg/kg (milligram per kilogram) dry weight basis.

The non-viable nestling sample collected near TA-39 was analyzed for dioxin and furan congeners by EPA SW-846 Method 8290 at Cape Fear Analytical LLC, Wilmington, North Carolina. All organic chemical results are reported on a wet weight basis.

4.3. Statistical Methods

The 2020 results were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from non-viable eggs of western bluebirds and ash-throated flycatchers (*Myiarchus cinerascens*) collected from Bandelier National Monument in 2020 (n = 7 samples). Non-viable egg results are also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

Nestling sample results of dioxin and furans, were compared with RSRLs and LOAELs, when available. The nestling RSRL was calculated from non-viable nestlings of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2018 and 2019 (n = 5 samples). Nestling sample results of TAL were compared directly with one sample collected from background locations.

5.0 RESULTS AND DISCUSSION

Similar with previous years, many of the inorganic elements assessed in this study were not detected in passerine egg samples. Several elements are not (or very little is) maternally transferred into eggs or do not accumulate in eggs and include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001), which may explain why these elements were mostly not detected.

Similarly, most dioxins and furans were not detected in the nestling sample collected from TA-39 burn grounds. Overall, most constituents that were detected in egg and the nestling samples were below RSRLs, and all constituents were below the LOAELs, when available.

5.1. TA-16 Burn Grounds

Western bluebird eggs collected from nest boxes at TA-16 burn grounds did not contain detectable concentrations of aluminum, arsenic, beryllium, cadmium, chromium, cobalt, nickel, silver, or vanadium. Of the elements containing detectable concentrations in eggs, all concentrations were below the RSRLs (Table 1). Mercury and selenium concentrations were well below LOAELs (Ohlendorf and Heinz, 2011, Shore et al. 2011); no other LOAELs were available.

Many inorganic elements were not detected in the non-viable nestling sample from TA-16 burn grounds. Detections patterns and concentrations of inorganic elements between the nestling from TA-16 and the nestling sample from a background location are similar.

5.2. TA-36 Minie

The one western bluebird egg sample collected from TA-36 Minie, did not have detectable levels of several elements, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, thallium, or vanadium. Detectable concentrations of antimony, barium, calcium, copper, iron, magnesium, manganese, mercury, potassium, selenium, sodium, and

zinc were all below the RSRL (Table 2). Mercury and selenium concentrations were well below LOAELs (Ohlendorf and Heinz, 2011, Shore et al. 2011); no other LOAELs were available.

5.3. TA-39 Point 6

Most dioxins and furans were not detected in the nestling sample collected from TA-39. The sample contained detectable concentrations of 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at 4.51 pg/g (picograms per gram) and 1,2,3,4,6,7,8-heptachlorodibenzodioxin at 1.83 pg/g, which exceeds the RSRL of 2.36 pg/g and 1.43 pg/g, respectively. Lowest observable adverse effect levels are not available for each dioxin and furan congener. However, TCDD, the most potent dioxin congener, induces toxic effects in avian eggs at concentrations between 1,000 to 10,000 pg/g wet weight (Harris and Elliott 2011). Toxic equivalent factors can be used to calculate the toxic equivalent values of dioxin-like compounds. The toxic equivalent factor for 1,2,3,4,6,7,8,9-octachlorodibenzodioxin and 1,2,3,4,6,7,8-heptachlorodibenzodioxin for avian species is 0.0001 and 0.001, respectively (Van den Berg et al. 1998). Multiplying the detectable concentration by the toxic equivalent factors yield values that are orders of magnitude less than the lowest observable adverse effect level for TCDD observed in avian eggs (Harris and Elliott 2011).

6.0 CONCLUSIONS

The overall results indicate that the levels of constituents detected in the eggs and nestlings are not likely to cause adverse effects in breeding bird populations. Several constituents were not detected in the non-viable egg and nestling samples collected near TA-16 burn grounds, TA-36 Minie, and TA-39. Most constituents that were detected were below RSRLs and all were below the LOAELs, when available. These results suggest that the detectable concentrations observed here were not of ecological concern. More data from non-viable eggs and nestlings are needed to make a robust assessment and to examine trends over time. Evaluating avian nestling samples for high explosives are also of interest for future work as those data become available.

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Table 1. Inorganic element concentrations (mg/kg dry weight) detected in single or composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2020 (n = 7). No values were above the RSRL.

Element	Western bluebird (n = 1) SFB-20-206077	Western bluebird (n = 1) SFB-20-206078	Western bluebird (n=1) SFB-20-206079	Western bluebird (n=2) SFB-20-206080	RSRL
Antimony	0.140	0.140	0.130	0.087	0.228
Barium	95	55	8	85	124
Calcium	1,900	3,300	3,600	2,500	18,838
Copper	3.70	3.00	2.20	2.60	4.65
Iron	150	150	280	150	292
Lead	0.39	ND	ND	ND	0.43
Magnesium	300	270	360	380	620
Manganese	1.80	1.50	1.70	2.00	3.88
Mercury	0.072	0.057	0.060	0.180	0.192
Potassium	9,700	9,100	7,900	7,800	11,225
Selenium	2.6	2.6	3.2	2.6	4.0
Sodium	9,400	10,000	8,300	8,300	11,221
Thallium	ND	ND	ND	0.0076	0.0263
Zinc	44.0	39.0	42.0	51.0	61.9

ND = non-detect

Table 2. Inorganic element concentrations (mg/kg dry weight) detected in a western bluebird egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data from 2020 (n = 7). No values were above the RSRL.

Element	Western bluebird (n = 1) SFB-20-206081	RSRL
Antimony	0.19	0.228
Barium	17	124
Calcium	17,000	18,838
Copper	4.10	4.65
Iron	150	292
Magnesium	530	620
Manganese	2.80	3.88
Mercury	0.021	0.192
Potassium	10,000	11,225
Selenium	2.0	4.0
Sodium	9,700	11,221
Zinc	55.0	61.9

Revised Supplement 4-1
2024 Alt Tech Evaluation
Attachment 17 – Gaulker & Stanek 2022

Environmental Report:

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11 February 2022

2021 Results for Avian Monitoring of Inorganic and Organic Element Concentrations in Passerine Eggs and Nestlings Collected from Technical Area 16 Burn Grounds, Technical Area 36 Minie, and Technical Area 39 Point 6 at Los Alamos National Laboratory

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ACRONYMS AND TERMS

ALS	Australian Laboratory Services
EPA	Environmental Protection Agency
LANL	Los Alamos National Laboratory
LOAEL	lowest observable adverse effect levels
mg/kg	milligrams per kilogram
PCBs	polychlorinated biphenyls
RSRLs	regional statistical reference levels
TA	Technical Area
TCDD	tetrachlorodibenzodioxin-2,3,7,8
TEF	toxic equivalent factors
TEQ	toxic equivalents
RCRA	Resource Conservation and Recovery Act
WHO	World Health Organization

1.0 SUMMARY

In 2021, non-viable avian eggs and one nestling were opportunistically collected at Los Alamos National Laboratory (LANL) near open detonation sites located at Technical Area (TA) 16 burn grounds and TA-36 Minie. Similar to previous years, nestboxes were monitored at TA-39 Point 6, however, no avian samples were available for opportunistic collection. Samples were evaluated for inorganic elements (mostly metals), dioxins, and furans. One ash-throated flycatcher (*Myiarchus cinerascens*) egg sample was collected from TA-16 burn grounds. One ash-throated flycatcher and one mountain bluebird (*Sialia currucoides)* egg sample and one deceased western bluebird (*Sialia mexicana*) nestling sample were collected from TA-36 Minie. Concentrations of inorganic elements observed in this study were compared with the regional statistical reference level (RSRL) which is the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Several inorganic elements were not detected in avian eggs. Most inorganic elements detected were below the RSRL and all were the lowest observable adverse effect level (LOAEL), when available. The nestling collected from TA-36 did not contain detectable concentrations of dioxin or furan congeners. These data suggest that inorganic and organic element concentrations in eggs and nestlings are not of ecological concern. More data are needed to make a robust assessment and to evaluate trends over time.

2.0 INTRODUCTION

In support of the Resource Conservation and Recovery Act (RCRA) permit process, Los Alamos National Laboratory (LANL) began annual avian monitoring in 2013 around TA-16 burn grounds and at two firing sites, TA-36 Minie and TA-39 Point 6. Biomonitoring is an important tool for assessing environmental contamination by analyzing chemicals or their metabolites from biological tissues (Becker 2003). Avian eggs and nestlings are useful as bioindicators because different species occupy many trophic levels. Additionally, the collection of non-viable eggs and/or nestlings that die of natural causes is non-invasive and is non-destructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Levels of some constituents in biological tissues can also indicate whether adverse effects could be expected (Gochfeld and Burger 1998). Examining population parameters along with tissue concentrations provides a more comprehensive and robust assessment of potential impacts caused by environmental pollution.

Several congeners of polychlorinated biphenyls (PCBs), dioxins, and furans elicit similar toxic effects (i.e., immunotoxicity, carcinogenicity, and endocrine disruption) as those caused by tetrachlorodibenzodioxin-2,3,7,8 (TCDD), the most potent in this class of chemicals (Van den Berg et al. 2006). These congeners, like TCDD, have a high binding affinity to the aryl hydrocarbon receptor (Van den Berg et al. 2006). The World Health Organization (WHO) developed toxic equivalency factors (TEFs) for TCDD-like compounds that can be used to determine the relative potency, or toxic equivalents (TEQs), of dioxin-like compounds for different classes of animals (i.e., fish, birds, and mammals), as well as to facilitate risk assessment for TCDD-like exposure (Van den Berg et al. 1998).

Sources of inorganic elements include both anthropogenic and natural sources; birds can be exposed through a number of routes, including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals), dioxins, and furans are of interest at open-detonation firing sites (TA-36 and TA-39) and at the burn grounds at TA-16 (Fresquez 2011).

3.0 OBJECTIVES

The objective of this ongoing study is to document chemical concentrations in eggs and nestlings collected near TA-16 burn grounds, TA-36 Minie, and TA-39 Point 6 and to compare concentrations of inorganic elements, PCBs, dioxins, and furans observed in this study with the upper-level bounds of background concentrations.

4.0 METHODS

4.1. Sample Collection

Eggs and nestlings were collected from nest boxes when they were determined to be non-viable, based on documented timing of known incubation periods for the species. We collected a total of four non-viable eggs and one deceased nestling at LANL near the TA-16 burn grounds (Figure 1) and near open detonation site TA-36 Minie (Figure 2). At TA-16 burn grounds, two non-viable ash-throated flycatcher (*Myiarchus cinerascens*) egg samples were collected and submitted as one composite sample. At TA-36 Minie, one non-viable mountain bluebird egg (*Sialia currucoides)*, one non-viable ash-throated flycatcher egg, and one deceased western bluebird (*Sialia mexicana*) nestling were collected and submitted as individual samples. All samples were collected May through July of 2021. Concentrations of chemicals in eggs and nestlings have been monitored annually at these locations since 2014.

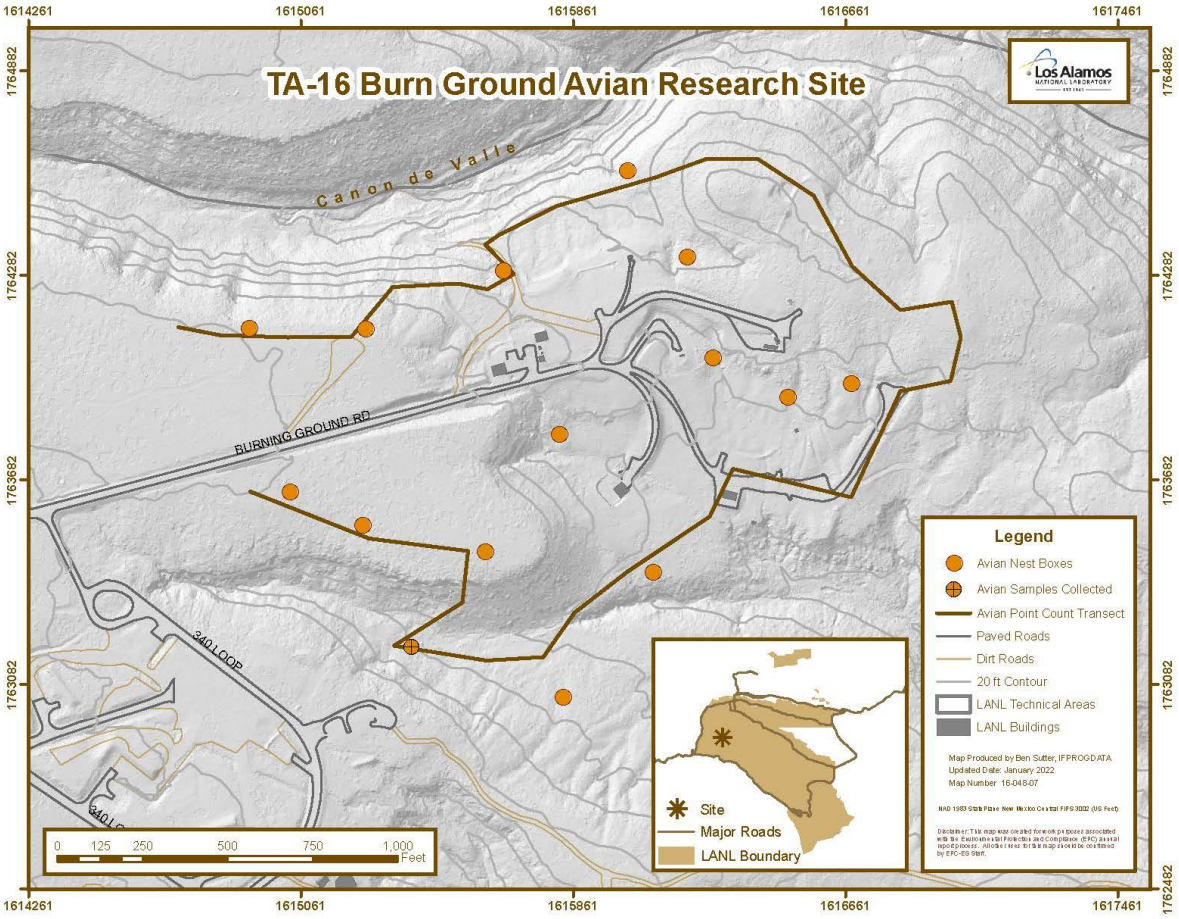

Figure 1. Avian nest box locations around TA-16 burn grounds.

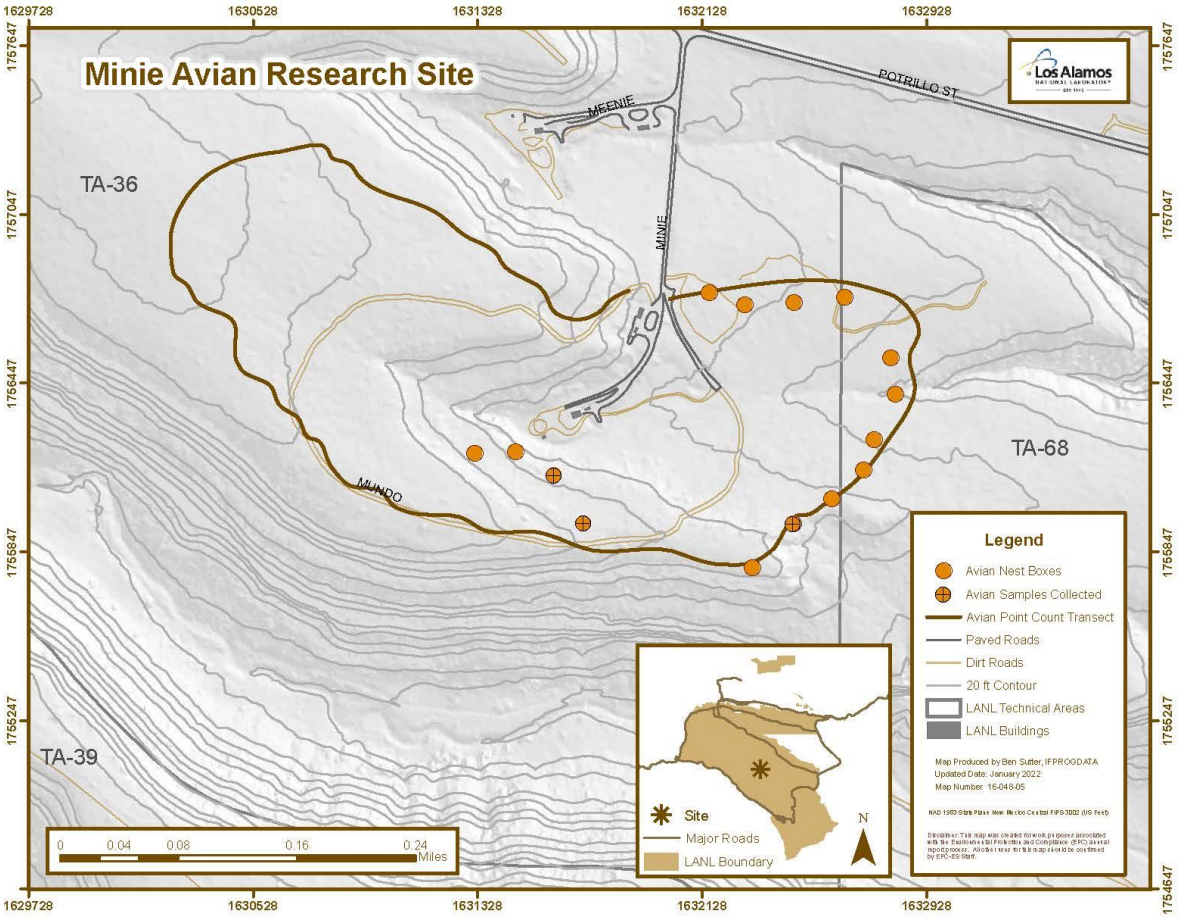

Figure 2. Avian nest box locations around TA-36 Minie.

4.2. Chemical Analyses

Due to limited sample mass, non-viable eggs were analyzed for total analyte list (mostly inorganic metals) only and were analyzed at ALS (Australian Laboratory Services, formerly Paragon Analytics, Inc.) in Fort Collins, Colorado. Antimony, arsenic, cadmium, lead, selenium, silver, and thallium concentrations were measured in egg samples by inductively coupled plasma mass spectrometry (Environmental Protection Agency [EPA] SW-846 Method 6020), and aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were measured by inductively coupled plasma atomic emission spectrometry (EPA SW-846 Method 6010B). Mercury was measured by cold-vapor atomic absorption procedure (EPA SW-846 Method 7471A). All inorganic element results were reported on an mg/kg (milligram per kilogram) wet weight basis.

The non-viable nestling sample collected near TA-36 Minie was analyzed for dioxin and furan congeners by EPA SW-846 Method 8290 at Cape Fear Analytical LLC, Wilmington, North Carolina. All organic chemical results are reported on a wet weight basis.

4.3. Statistical Methods

The 2021 results were compared with the regional statistical reference levels (RSRL), which represents natural and fallout levels of chemicals, and are the upper-level bounds of background concentrations (mean + three standard deviations = 99% confidence interval). Regional statistical reference levels were calculated from non-viable eggs of western bluebirds and ash-throated flycatchers collected from Bandelier National Monument from 2021 (n = 10 samples). Non-viable egg results are also compared with the lowest observable adverse effect levels (LOAEL) from peer reviewed literature, when available.

Detectable concentrations of dioxin and furans congeners are compared with RSRLs and LOAELs, when available. The nestling RSRL was calculated from non-viable nestlings of western bluebirds and ash-throated flycatchers at background locations from Bandelier National Monument in 2018 through 2020 (n = 8 samples).

5.0 RESULTS AND DISCUSSION

Similar with previous years, many of the inorganic elements assessed in this study were not detected in passerine egg samples. Several elements are not (or very little is) maternally transferred into eggs or do not accumulate in eggs and include cadmium (Leach et al. 1979; Stoewsand et al. 1986), lead (Pattee 1984), vanadium (White and Dieter 1978), and silver (Schwarzbach et al. 2006; Seiler and Skorupa 2001), which may explain why these elements were mostly not detected. Similarly, no dioxins and furans were detected in the nestling sample collected from TA-36 Minie.

5.1. TA-16 Burn Grounds

The composite ash-throated flycatcher egg sample collected from nest boxes at TA-16 burn grounds did not contain detectable concentrations of aluminum, antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, nickel, silver, thallium or vanadium. Mercury was detected at a concentration of 0.031 mg/kg and slightly exceeded the RSRL of 0.011 (Table 1), but was far below the LOAEL of 1.9 mg/kg (Shore et al. 2011). The remaining detectable elements were below the RSRLs (Table 1). Selenium concentrations were also below the LOAEL of 2.6 mg/kg (Ohlendorf and Heinz, 2011,); no other LOAELs were available.

5.2. TA-36 Minie

The one mountain bluebird and one ash-throated flycatcher egg sample collected from TA-36 Minie, did not have detectable levels of several elements, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, thallium, or vanadium. The mountain bluebird egg sample contained antimony concentrations of 0.024, which slightly exceeded the RSRL of 0.019 mg/kg (Table 2). The ash-throated flycatcher egg sample contained mercury concentrations of 0.019 mg/kg which slightly exceeded the RSRL of 0.011 (Table 2), but was far below the LOAEL of 1.9 mg/kg (Shore et al. 2011). The remaining detectable elements were below the RSRLs (Table 2). Selenium concentrations were also below the LOAEL of 2.6 mg/kg (Ohlendorf and Heinz, 2011,); no other LOAELs were available. No dioxin and furan congeners were detected in the western bluebird nestling sample collected from TA-36 Minie.

6.0 CONCLUSIONS

The overall results indicate that the levels of constituents detected in the eggs and nestlings are not likely to cause adverse effects in breeding bird populations. Several constituents were not detected in the non-viable egg and nestling samples collected near TA-16 burn grounds and TA-36 Minie. The majority of constituents that were detected were below RSRLs and all were below the LOAELs, when available. These results suggest that the detectable concentrations observed here are not of ecological concern. More data from non-viable eggs and nestlings are needed to make a robust assessment and to examine trends over time. Evaluating avian nestling samples for high explosives are also of interest for future work as those data become available.

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Table 1. Detectable inorganic element concentrations (mg/kg wet weight) detected in a composite egg samples collected near TA-16 burn grounds compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data in 2021 (n = 10).

Element	Ash-throated Flycatcher (n = 2) SFB-21-233901	RSRL
Barium	0.47	3.9
Calcium	550	6,588
Copper	0.53	1.71
Iron	23	70
Magnesium	62	130
Mercury	0.031	0.011
Potassium	1,900	3,227
Selenium	0.85	1.0
Sodium	2,400	3,506
Zinc	11	23.1

Table 2. Inorganic element concentrations (mg/kg wet weight) detected in a single egg sample collected near the TA-36 Minie compared with RSRL. The RSRL is the upper limit background concentrations (mean + three standard deviations) for passerine eggs based on data in 2021 (n = 10).

Element	Mountain bluebird (n = 1) SFB-21-233902	Ash-throated flycatcher (n = 1) SFB-21-233903	RSRL
Antimony	0.024	ND	0.019
Barium	1.9	ND	3.9
Calcium	690	640	6,588
Copper	0.45	0.54	1.71
Iron	17	23	70
Magnesium	81	72	130
Manganese	ND	0.36	1.04
Mercury	0.003	0.019	0.011
Potassium	2,000	1,400	3,227
Selenium	0.42	0.64	1.0
Sodium	2,300	1,900	3,506
Zinc	7.4	9.5	23.1

ND = Not detected

Supplement 4-2

Open Detonation Unit Groundwater Monitoring and Surface Drainage Information

Table 4.2-1. Pertinent Groundwater Data At or Above Regulatory Standards for Monitoring the TA-36-8 OD Unit, 2000 - 2019

Location	Analyte	# of Analyses	# of Detects	% Detects	Detects versus Nondetects	Minimum Report Result	Maximum Report Result	Action Limit	Units	Action Limit Type	# of Exceedances	First Sample Date	Last Sample Date	Date(s) of Exceedances
Alluvial														
WCO-1r	Iron	4	4	100.0	4/0	113	1560	1000	µg/L	NM GW STD	1	9/20/2010	8/16/2019	3/15/2019
Regional														
R-19 S3	Gross alpha	15	1	6.7	1/14	16.5	16.5	15	pCi/L	EPA MCL	1	9/26/2000	4/14/2015	4/14/2015
R-19 S3	Iron	45	6	13.3	6/39	32.3	1100	1000	µg/L	NM GW STD	1	9/26/2000	4/14/2015	9/26/2000
R-19 S3	Radium-226	7	3	42.9	3/4	0.462	10.4	5	pCi/L	NM GW STD	1	4/9/2001	9/14/2009	4/9/2001, 7/10/2001, 6/14/2004
R-20 S1	Nitrate-Nitrite as Nitrogen	30	16	53.3	16/14	0.0587	748	10	mg/L	EPA MCL	1	3/11/2004	10/23/2019	8/3/2010
R-20 S1	Radium-226	8	4	50.0	4/4	0.578	32.1	5	pCi/L	NM GW STD	3	3/15/2004	10/23/2019	3/15/2004, 5/11/2004, 9/20/2004
R-20 S2	Dioxane[1,4-]	35	1	2.9	1/34	61.4	61.4	4.59	µg/L	NMED A1 TAP SCRN LVL	1	7/19/2005	10/17/2019	9/18/2008
R-20 S2	Manganese	48	48	100.0	48/0	38.5	388	200	µg/L	NM GW STD	10	3/10/2004	10/17/2019	3/10/2004 (2), 5/5/2004 (2), 9/3/2004, 9/7/2004, 11/8/2004(2), 7/19/2005 (2)
R-20 S2	Perchlorate	32	21	65.6	21/11	0.0923	32.5	13.8	µg/L	NMED A1 TAP SCRN LVL	1	3/10/2004	10/17/2019	11/8/2004
R-20 S2	Radium-226	9	5	55.6	5/4	0.559	62.2	5	pCi/L	NM GW STD	3	3/10/2004	10/17/2019	3/10/2004, 5/5/2004, 11/8/2004
R-23	Acetone	54	8	14.8	8/46	1.35	21100	14100	µg/L	NMED A1 TAP SCRN LVL	2	9/24/2002	10/23/2019	9/24/2002 (2)
R-23	Benzo(a)anthracene	39	1	2.6	1/38	0.255	0.255	0.12	µg/L	NMED A1 TAP SCRN LVL	1	9/24/2002	10/23/2019	7/22/2011
R-23	Bis(2-ethylhexyl)phthalate	38	5	13.2	5/33	0.769	7.6	6	µg/L	EPA MCL	1	9/24/2002	10/23/2019	12/17/2003
R-23	Manganese	62	33	53.2	33/29	2.5	604	200	µg/L	NM GW STD	2	12/17/2003	10/23/2019	12/17/2003, 9/3/2009
R-23	Radium-226	14	5	35.7	5/9	0.524	13.9	5	pCi/L	NM GW STD	3	9/24/2002	10/23/2019	10/17/2002, 12/17/2003, 3/23/2004
R-27	Indeno(1,2,3-cd)pyrene	17	1	5.9	1/16	0.4	0.4	0.343	µg/L	NMED A1 TAP SCRN LVL	1	7/1/2006	2/8/2019	9/14/2010
R-31 S3	Iron	7	7	100.0	7/0	250	5190	1000	µg/L	NM GW STD	6	12/16/2000	5/21/2007	8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2)
R-31 S3	Manganese	7	7	100.0	7/0	257	3500	200	µg/L	NM GW STD	7	12/16/2000	5/21/2007	8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2), 12/16/2000
R-32 S1	Bis(2-ethylhexyl)phthalate	34	5	14.7	5/29	2.37	6	6	µg/L	EPA MCL	1	3/1/2004	10/15/2019	6/9/2008
R-32 S1	Radium-226	11	1	9.1	1/10	21.4	21.4	5	pCi/L	NM GW STD	1	3/1/2004	10/15/2019	3/1/2004
R-39	Bis(2-ethylhexyl)phthalate	21	4	19.0	4/17	7.04	9.8	6	µg/L	EPA MCL	4	2/19/2009	10/23/2019	10/26/2016, 10/25/2017, 10/24/2018, 10/23/2019
R-49 S1	Dibenz(a,h)anthracene	20	1	5.0	1/19	0.0515	0.0515	0.0343	µg/L	NMED A1 TAP SCRN LVL	1	6/23/2009	10/29/2019	10/22/2015
R-54 S1	Bis(2-ethylhexyl)phthalate	8	1	12.5	1/7	11.2	11.2	6	µg/L	EPA MCL	1	2/15/2010	11/2/2011	2/15/2010
R-54 S1	Iron	16	16	100.0	16/0	101	4600	1000	µg/L	NM GW STD	9	2/15/2010	11/2/2011	2/15/2010, 7/27/2010 (2), 10/13/2010 (2), 7/12/2011 (2), 1/14/2011 (2)
R-54 S1	Manganese	16	16	100.0	16/0	42.1	306	200	µg/L	NM GW STD	8	2/15/2010	11/2/2011	7/27/2010 (2), 10/13/2010 (2), 7/12/2011 (2), 1/14/2011 (2)

EPA TAP SCRN LVL = U.S. Environmental Protection Agency screening level for tap water.
NMED A1 TAP SCRN LVL = New Mexico Environment Department screening level for tap water.
NM GW STD = New Mexico groundwater standard.
(2) = number of samples

Table 4.2-2. Pertinent Groundwater Data At or Above Regulatory Standards for Monitoring the TA-39-6 OD Unit, 2000-2019

Location	Analyte	# of analyses	# of Detects	% Detects	Detects versus Nondetects	Minimum Report Result	Maximum Report Result	Action Limit	Units	Action Limit Type	# of Exceedances	First Sample Date	Last Sample Date	Date(s) of Exceedances
Regional														
R-31 S3	Iron	7	7	100.0	7/0	250	5190	1000	µg/L	NM GW STD	7	12/16/2000	5/21/2007	12/16/2000, 8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2)
R-31 S3	Manganese	7	7	100.0	7/0	257	3500	200	µg/L	NM GW STD	7	12/16/2000	5/21/2007	12/16/2000, 8/19/2005 (2), 11/30/2006 (2), 5/21/2007 (2)
Spring 8A	Dichlorobenzidine[3,3'-]	11	1	9.1	1/10	9.6	9.6	1.25	µg/L	NMED A1 TAP SCRN LVL	1	9/26/2000	10/12/2017	10/7/2003

EPA TAP SCRN LVL = U.S. Environmental Protection Agency screening level for tap water.
NMED A1 TAP SCRN LVL = New Mexico Environment Department screening level for tap water.
NM GW STD = New Mexico groundwater standard.
(2) = number of samples

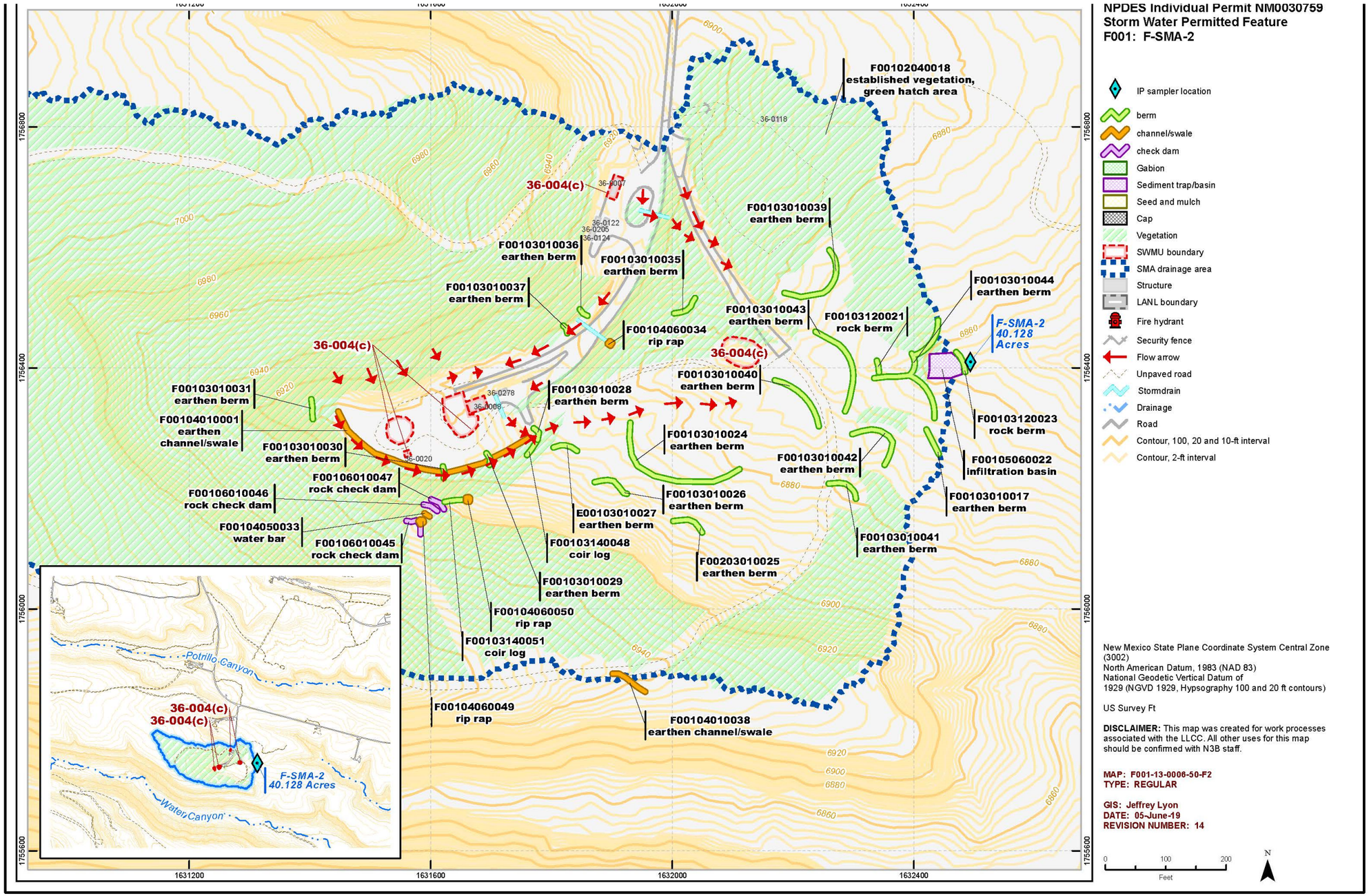


Figure 4.2-1. Drainage Control Features Near the TA-36-8 OD Unit.

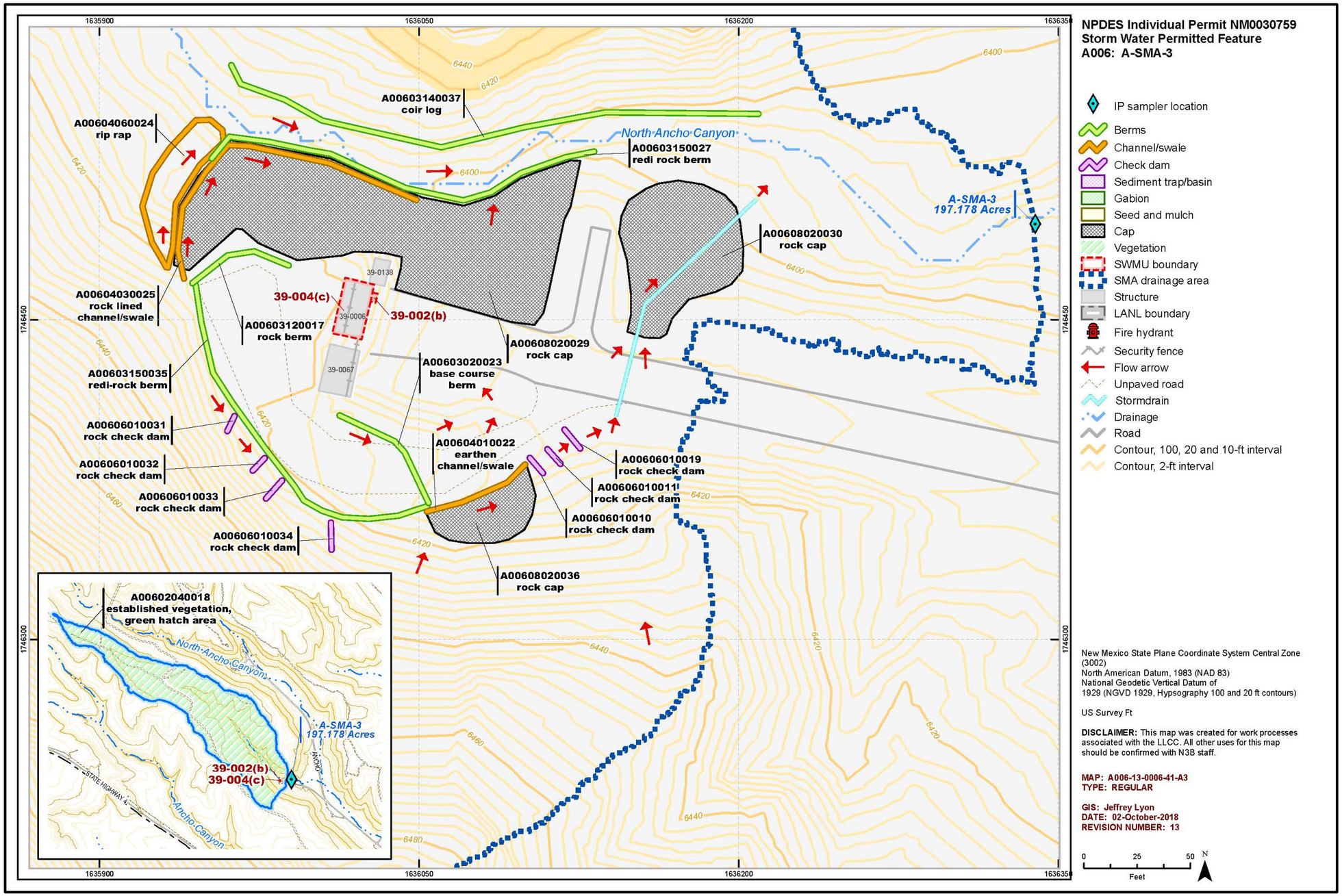


Figure 4.2-2. Drainage Control Features Near the TA-39-6 OD Unit.

Water Table Contours and Sampling Locations Downgradient of Unit at TA-36

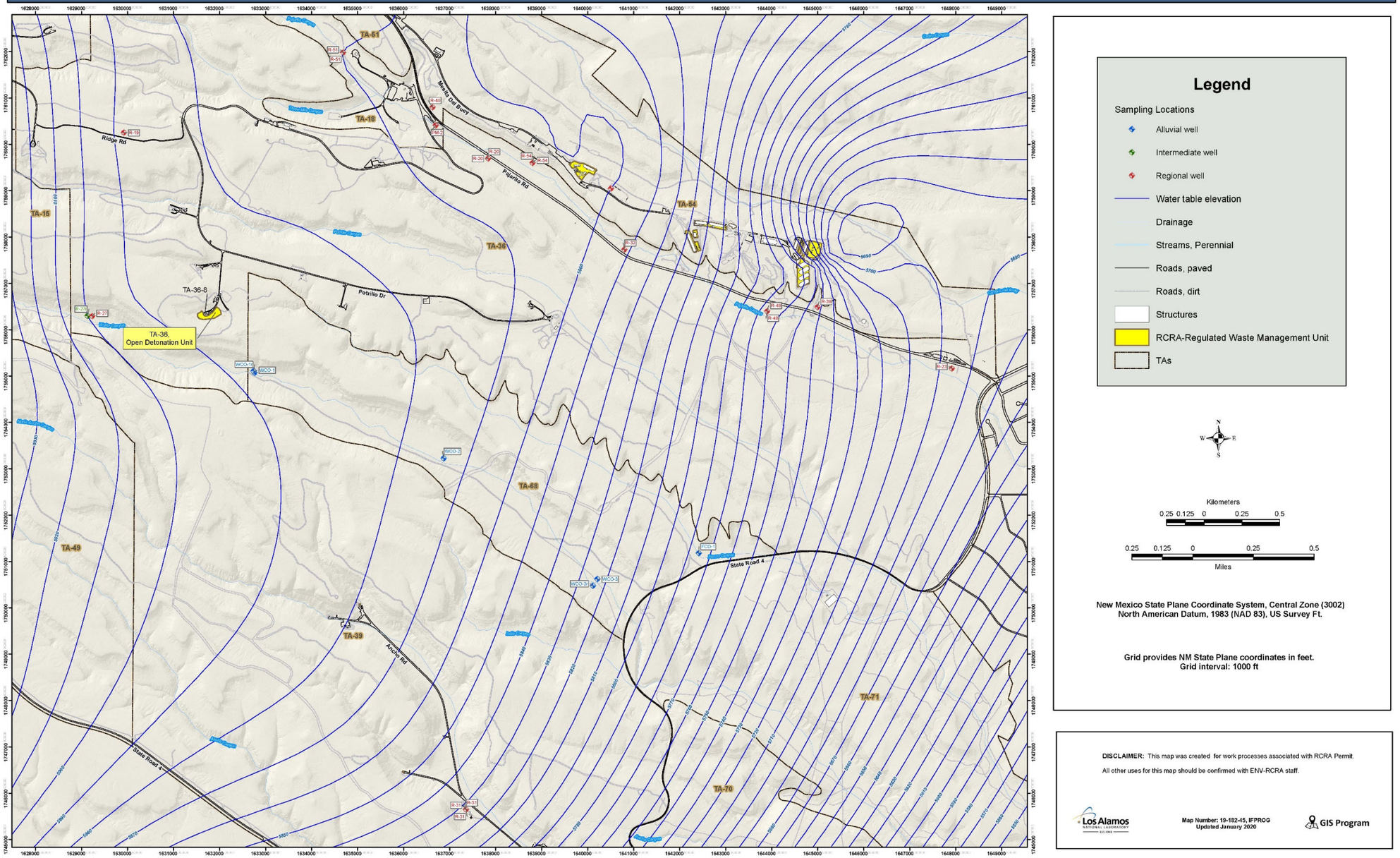
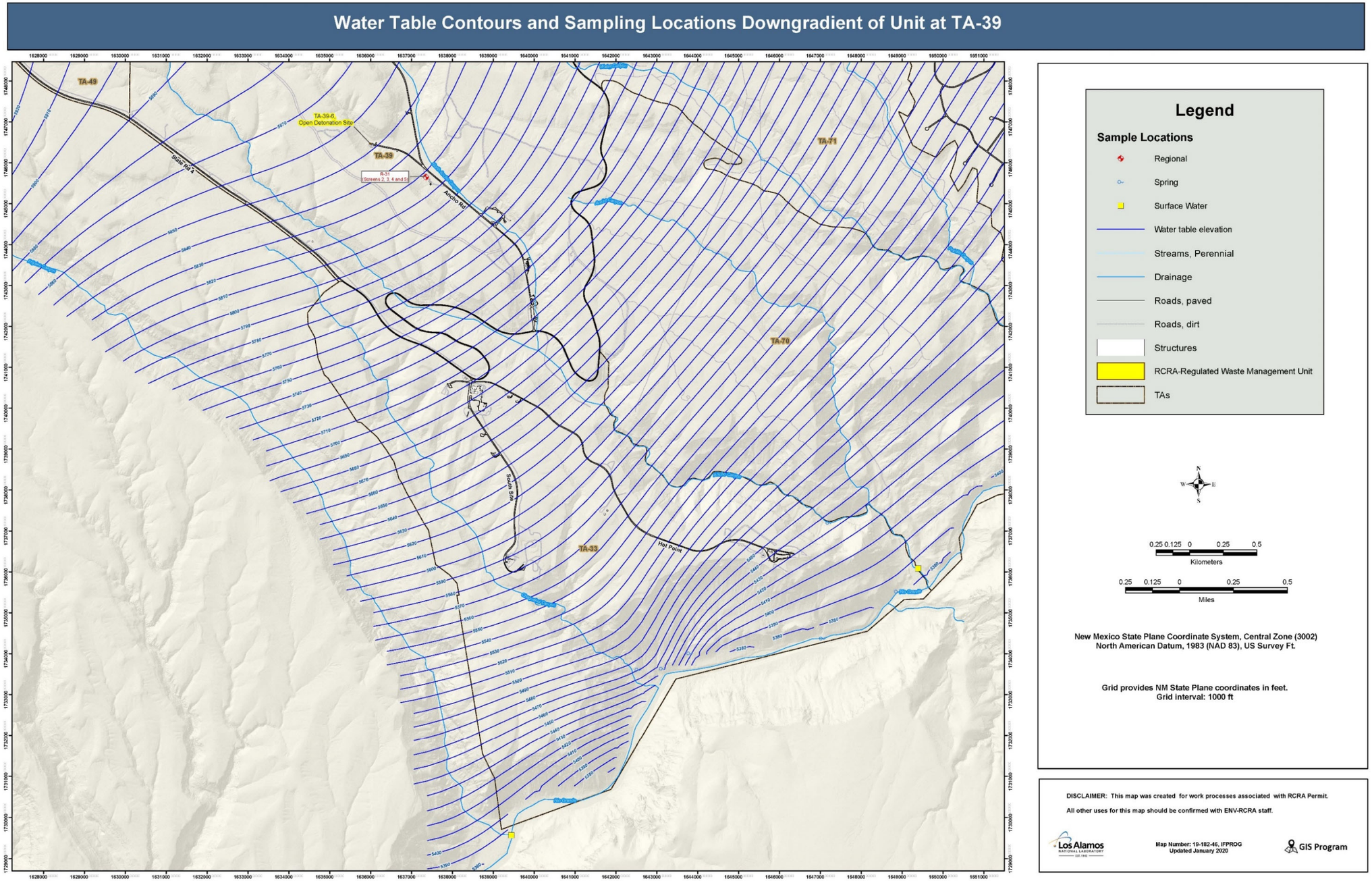


Figure 4.2-3. Water Table Contours and Sampling Locations Downgradient of Unit at Technical Area 36



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Supplement 4-3

Hybrid Air Modeling Analysis and Ecological and Health Risk Assessment for Open Burning and Open Detonation Operations at Los Alamos National Laboratory

March 2024

Hybrid Air Modeling Analysis and Ecological and Health Risk Assessment for Open Burning and Open Detonation Operations at Los Alamos National Laboratory

Los Alamos
NATIONAL LABORATORY

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1 Facility Description

This report describes the air modeling analysis associated with a risk evaluation for open burn (OB) and open detonation (OD) operations at Los Alamos National Laboratory (LANL). The OB operations are conducted at Technical Area (TA) 16, and the OD operations are conducted at TA-36 and TA-39. The purpose of the air modeling is to develop reasonable estimates of air quality impacts from OB and OD operations at these units for a subsequent ecological and health risk assessment.

LANL is located in Los Alamos County in north-central New Mexico. It is approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. It is located on 40 square miles of land that comprises multiple canyons and mesa tops with elevations that range from 5400 feet along the southwestern boundary to 8000 feet on the western boundary along the Jemez Mountains. The facilities and the associated residential and commercial areas of Los Alamos County are situated on the Pajarito Plateau. The facility is owned and co-operated by the U.S. Department of Energy (DOE)/National Nuclear Security Administration and Triad National Security, LLC.

2 Purpose of Hybrid Air Quality Dispersion Modeling

The purpose of the air dispersion modeling is to demonstrate that the OB and OD emissions comply with the national ambient air quality standards (NAAQS) and the New Mexico ambient air quality standards (NMAAQS). Dispersion modeling is also necessary to demonstrate that ambient concentrations and soil concentrations from the effects of deposition of toxic air pollutants and other pollutants of concern (POC) do not result in ecological or human health risks. The modeling proposed will follow the procedures in the current dispersion modeling guidelines published by the New Mexico Environment Department (NMED) Air Quality Bureau (AQB) on July 21, 2022 (NMEDa 2022), and the general guidelines provided by the U.S. Environmental Protection Agency (EPA) based on hybrid modeling performed at the Holston Army Ammunition Plant in EPA Region 4 (email dated August 17, 2022, from Sasha Gerhard, EPA Office of Resource Conservation & Recovery, Attachment 1). The air dispersion modeling protocol for OB and OD for the ATK Launch Systems, Inc., in Promontory, Utah, will also be referenced (ATK Addendum 2013).

3 Methodology for Hybrid Air Dispersion Modeling

The EPA currently recommends a hybrid approach to modeling dispersion from open burning and open detonation processes. Using two separate regulatory models—OBODM (Open Burn/Open Detonation Dispersion Model) and AERMOD (AMS/EPA Regulatory Model)—in the analysis allows facilities to draw on the strengths of both models while reducing the weaknesses of each model on the modeling results. For example, OBODM more closely models the source characteristics of open burning and open detonation operations compared with the volume source algorithm in AERMOD, whereas AERMOD features more-refined algorithms for handling meteorological data and predicting air concentrations and deposition fluxes. OBODM is an older method, but it performs well when applied to OB or OD. The EPA has not maintained the software to operate on current computer systems, but it is still available on the EPA SCRAM (Support Center for Regulatory Atmospheric Modeling) website. AERMOD has replaced OBODM as the standard model to use for open burn and open detonation hazardous waste management units (HWMUs; Attachment 1). LANL maintains a copy of OBODM on a stand-alone computer with a Microsoft XP operating system that allows the software to be used.

OBODM was used in 2013 to conduct the initial modeling that supports the risk assessment for the LANL Resource Conservation and Recovery Act (RCRA) Subpart X permit application. OBODM is intended for

use in evaluating the potential air quality impacts of the open burning and open detonation of obsolete munitions and solid propellants at U.S. Department of Defense and DOE installations (Bjorklund, et al., 1998a). The OB and OD treatment of waste propellants and propellant-contaminated material can be classified as instantaneous events for OD treatment and as quasi-continuous events for OB treatment; however, propellants are not treated by OB or OD at LANL.

OBODM predicts the downwind transport of pollutants using cloud rise and dispersion model algorithms from existing dispersion models. A complete description of the plume rise and dispersion algorithms used in OBODM is found in Volume II of the user's manual (Bjorklund, et al., 1998b). OBODM allows for a simplistic representation of local meteorology and includes a screening-level complex terrain algorithm. All OBODM source and receptor locations are defined relative to a rectangular or a polar coordinate system in which north (0 degrees) is the positive Y-axis and east (90 degrees) is the positive X-axis. All vertical (z) coordinates are heights above ground level except when the OBODM complex terrain screening mode is used, in which case the z coordinates are terrain heights above mean sea level. Overall, the designation of receptors for OBODM is based on the original modeling completed in 2013 for LANL OB and OD events. Concentrations for this limited number of receptors will be used for determining ambient concentrations for the updated risk assessment; however, they will be compared with AERMOD results for an expanded receptor grid to ensure that the most conservative ground level concentration (GLC) values are applied.

OBODM has two distinct parts. The first part simulates the OB and OD events and generates initial parameters of the emission cloud (emission rate, cloud height, cloud diameter). OB and OD result in combustion of the energetics and the rapid rise of the hot combustion products—due to buoyancy—until a final height is reached. At this point, the emission cloud has no upward momentum and begins to disperse downwind. This process can be estimated using the air dispersion model OBODM to predict the final cloud height of the OB or OD plumes.

OBODM calculates peak air concentrations, time-weighted air concentrations, and dosage (time-integrated concentration) for OB and OD releases. It can also consider the effects on concentration and dosage of the gravitational settling and deposition of particulates; however, OBODM has several limitations that constrain the modeling in this application. For example, a receptor grid for OBODM is limited with a maximum of 100 X coordinates and 100 Y coordinates that can be specified in either rectangular or polar coordinates. Also, a maximum of 100 discrete or unique points may be specified. Additionally, OBODM cannot predict deposition in complex terrain and uses older algorithms for downwind dispersion of emitted pollutants.

To overcome these limitations, the hybrid modeling approach will use results of the OBODM modeling as source input parameters for the AERMOD model, which is the EPA's preferred dispersion model for short-range transport (up to 50 kilometers). The OBODM final plume rise results will be evaluated to determine the most conservative parameters for input in AERMOD as a volume source to predict downwind dispersion and deposition.

The GLC results of the open burn/open detonation dispersion (OBOD) modeling (based on a limited receptor grid and public receptors) will be compared with the results from AERMOD to ensure that the most conservative estimates of ambient concentrations are applied to subsequent analyses.

4 OB and OD Operations Information, Source Parameters, and Methodology

4.1 Open Burning

4.1.1 *Description of Open Burning Unit*

The TA-16-388 Flash Pad is located at the TA-16 Burn Ground in the southwestern quadrant of LANL. The TA-16 Burn Ground is bounded on the northern side by Cañon de Valle and on the southern side by Water Canyon. The unit is used for the open burning treatment of detonable quantities of explosive waste and explosives-contaminated wastes. The location of the open burning unit at LANL that is addressed in this protocol is shown in Figure 4-1.

The unit consists of a 22-foot (ft) by 22 ft concrete pad that has 3 ft high concrete walls along the back and two sides. Each of the three walls has a 5 ft long, forced-air propane burner mounted on it. The propane burners provide the heat and fuel for waste treatment operations at the TA-16-388 Flash Pad. A picture of the unit is included as Figure 4-2. Treatment operations are most often conducted using the two side burners to treat waste placed in a steel tray. A retractable steel structure covers the concrete pad, burners, and trays when the unit is not in use. The location coordinates of the open burn unit in UTM[1] Zone 13, NAD 83[2] coordinates are as follows:

Unit	X-Coordinate	Y-Coordinate
TA-16-388 Flash Pad	379670.0m	3967821.0m

The unit is used only for treatment of explosive waste and explosives-contaminated waste. All treatment events use at least two propane burners, and an average treatment operation lasts up to 1 hour.

[1] Universal Transverse Mercator
[2] North American Datum of 1983

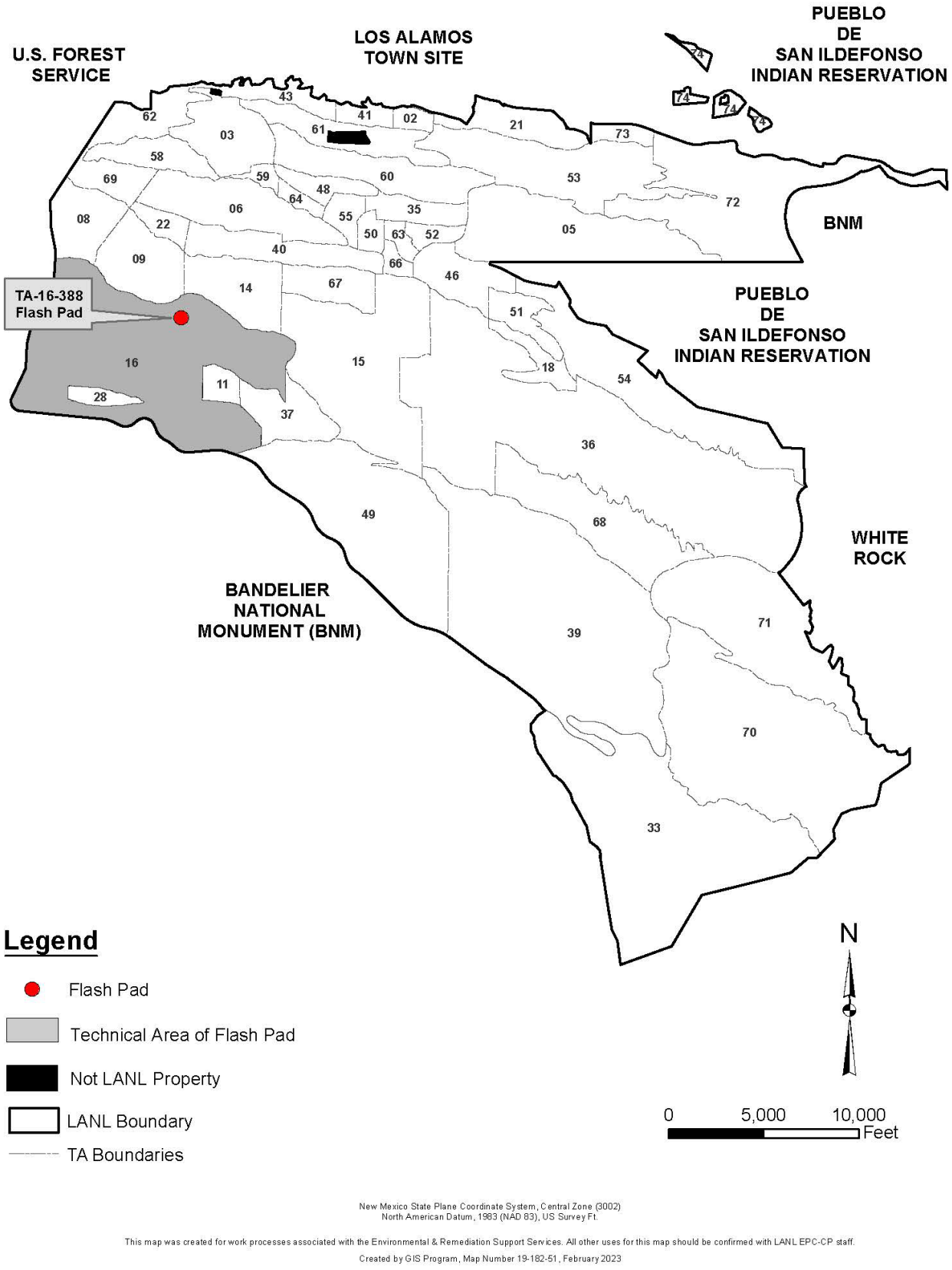

Figure 4-1. Location map of open burning unit at Los Alamos National Laboratory.

Figure 4-2. Photograph of Technical Area 16-388 Flash Pad.

4.1.2 *Source Characterization: Typical Open Burning Treatment Operations for the OBOD Modeling*

The maximum amount of explosive waste that can be treated at the TA-16-388 Flash Pad is 200 pounds (lb) at any one time. Although the explosive waste burn could include other noncombustible material, the 200 lb burn amount is assumed to be 100% combustible material. Other noncombustible material waste could be included, such as equipment or metal waste, but assuming the burn amount is all combustible material provides a conservative estimate. Additionally, the maximum annual amount of explosive waste that can be treated is 6000 lb. This approach allows for the calculation of annual air impacts for a potential maximum volume of waste per year and the calculation of the cumulative effects associated with that potential maximum.

The number of treatment operations and the amount of time it takes to complete treatment operations at the TA-16-388 Flash Pad were overestimated as part of this air impacts analysis. Modeling of air impacts will assume that the unit conducted treatment operations for a full hour and could have operated continuously from 8 a.m. to 5 p.m. over an entire year to ensure that the maximum hourly annual air concentration was captured. However, most treatment events are conducted in approximately 1 hour and in the morning when the wind is generally the lowest of the day; only one burn is conducted per day. The average number of actual treatment events per year is approximately 58 burns per year. If the unit

operated continuously from 8 a.m. to 5 p.m. every weekday, 58 burns that took 1 hour each would calculate to just over one week's worth of open burning.

The waste streams treated at the TA-16-388 Flash Pad are different from the waste streams on which the emissions factors used in this analysis are based; the actual waste streams treated are less hazardous to human health and the environment. No attempt was made to eliminate non-characteristic emissions from the analysis, which increases the conservative nature of the analysis. Waste stream emissions factors that have been chosen for this analysis estimate a higher air impact than would be released from day-to-day operations at the TA-16-388 Flash Pad.

4.1.3 *Source Parameter Input Values*

The input values used in the model runs are summarized in Table 4-1. The fuel heat content for waste burned is representative of the range of wastes treated; however, the heat content of propane used to assist each burn is much higher than waste heat content. The calculated propane heat content assumes that 1 gallon of propane is burned each minute during the 1-hour burn, with a weight of 4.24 lb/gallon (60 gallons/hr). This assumption yields 254.4 lb propane per burn. A representative propane heat content is 6030 kcal/liter or 11,893 cal/g (EPA 2008). The fuel quantities are maximum hourly and annual values. The fuel burn rates were calculated from the hourly fuel quantity divided by the fuel burn time. A release height of 0.5 meters was specified.

Table 4-1. Model Input Values

Parameter	Input Value
Fuel Heat Content, cal/g	12,893 (1000 waste; 11,893 propane)
Hourly Fuel Quantity, lb	454.4 (200 waste; 254.4 propane)
Annual Fuel Quantity, lb	13,632 (6000 waste; 7632 propane)
Fuel Burn Time, sec	2498
Fuel Burn Rate, lb/sec	0.18
Fuel Burn Rate, g/sec	82.5
Contaminant Emission Rate, g/sec	1

4.1.4 *OBODM Steps for Open Burning*

OBODM runs were conducted to determine the maximum GLC for various averaging periods. The methodology comprises the following steps:

1. A source strength model input file is prepared for determining short-term GLCs using the maximum quantity of hourly waste treated and propane used. The input file contains the maximum quantity for each hour from 8 a.m. to 5 p.m. for each day of the year.
2. Using a 1-year continuous, hourly, onsite, meteorological dataset, OBODM was run using the hourly source strength file for the short-term 1-, 3-, 8-, and 24-hour averaging periods.
3. The hourly model results were used to create a source strength input file for estimating annual or chronic GLCs. In a descending order, hourly fuel quantity from Table 4-1 is assigned to the hours of the year with the highest predicted GLC from the hourly model runs until the sum of the hourly values equals the maximum annual waste and propane use.
4. OBODM was run using the annual source strength file and the same 1-year onsite meteorological dataset for the annual averaging period.

5. In each model run, the contaminant emission rate was set at 1 gram per second (1 g/sec); thus, the maximum GLC predicted is for a contaminant emission rate of 1 g/sec.
6. For OBODM/AERMOD hybrid modeling, the OB results were analyzed to determine minimum and maximum plume rise at a given distance downwind of the open burn based on the days generating the highest 1-, 3-, 8-, and 24-h GLC recorded for the year. These results were used as input to AERMOD to determine the worst-case ambient impacts. Overall, it has been documented that a conservative impact assessment will result from the minimum plume rise (ATK Addendum 2013).

Each run was conducted using the appropriate source strength file as described above and the 1-year hourly meteorological dataset from the LANL TA-6 station. Table 4-2 summarizes the two scenarios modeled, and Table 4-3 describes the receptors.

Table 4-2. Open Burning Model Scenarios

Averaging Period	Waste Quantity (lb)
1, 3, 8, and 24 hours[1]	454.4 (200 waste; 254.4 propane)
Annual	13,632 (6000 waste; 7632 propane)

[1] The 1-, 3-, 8-, and 24-hour averaging periods are used to ensure that worst-case plume rise will be used as input to AERMOD.

4.1.5 *Meteorological Data*

LANL maintains a network of onsite meteorological stations that is adequate to predict maximum downwind concentrations from open burning operations when using a full year of meteorological data. The centrally located TA-6 station is the official meteorological station for LANL, and data from it are reported to the National Weather Service. The station consists of a 92-meter-high tower instrumented for wind and temperature at four levels. A 1-year continuous hourly record from this station was used in the model input. The dataset for 2021 was processed for both OBODM and AERMOD and was submitted to NMED for review and approval. The TA-16 Burn Ground site elevation is 7500 ft, and the elevation of the TA-6 Meteorological Station is 7424 ft. The TA-6 station is also the closest LANL meteorological station to the burn ground—about 1.5 miles away. The use of an official meteorological station consistently lessens uncertainty and increases the ability to compare current, previous, and future modeling.

4.1.6 *Receptors for OBODM*

Receptors are locations (onsite or offsite) where an individual may be exposed to contaminants due to a stationary source of contamination to the air. Receptors with terrain elevations are established to ensure the maximum downwind concentrations are captured in the model runs. For OBODM, a Cartesian receptor grid is set up with the burn ground being the center point of a 2000- by 2000-meter grid with 100-meter spacing between receptors. Public receptors include nearby roadways, recreation areas, schools, hospitals, and tribal land. A list of public receptors is shown in Table 4-3.

Table 4-3. Open Burning Public Receptors

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation (meters)
Bandelier Entrance at SR 4	384789.7	3962060.7	2031.2
Bandelier Visitor Center	385202.9	3960086.4	1845.1
San Ildefonso West of SR 4	388891.3	3967279.6	2006.7
White Rock Overlook Park	393146.0	3965274.7	1911.6

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation (meters)
Piñon Elementary School, White Rock	390207.5	3964769.6	1981.0
Elk Ridge Trailer Park	382432.8	3970723.1	2228.0
Los Alamos Medical Center	381001.8	3971679.6	2226.7
West Jemez Road	377585.0	3969284.5	2386.7
Ponderosa Campground	377386.1	3966238.8	2311.2
LANL SE Boundary	388723.0	3958724.3	1643.8
SR 4 SE	387161.9	3961999.5	1993.5
SR 4 SE	387131.3	3963223.8	1952.0
SR 4 SE	388019.0	3963805.4	1985.6
Pajarito Rd[2]	388416.9	3965488.9	2003.9
Pajarito Rd[2]	386702.8	3966284.8	2035.8
Pajarito Rd[2]	385417.2	3967692.8	2130.0
Pajarito Rd[2]	383764.3	3968549.8	2180.4
Pajarito Rd[2]	382142.0	3969498.7	2220.6
West Jemez Rd	377367.0	3967907.1	2364.6
West Jemez Rd	378132.2	3970600.7	2406.3
SR 4 SW	383427.6	3962917.7	2105.2
SR 4 SW	382264.4	3964080.9	2156.9
SR 4 SW	380948.2	3965427.7	2208.7
SR 4 SW	379142.3	3966223.5	2260.6

[1]All UTM coordinates are based on NAD 83.
[2]Public receptors used in OBODM and in past OBOD modeling reports but not used in AERMOD modeling because they are located on a private, restricted road. Key: SR = State Road; SE = Southeast; SW = Southwest

Figure 4-3 shows the LANL property boundary, roadways, and the location of the onsite and offsite receptors used in the analysis. LANL property is shaded darker than the surrounding land in the figure. The sites and associated receptor grid are indicated in the black grid squares. Public receptors are indicated in yellow.

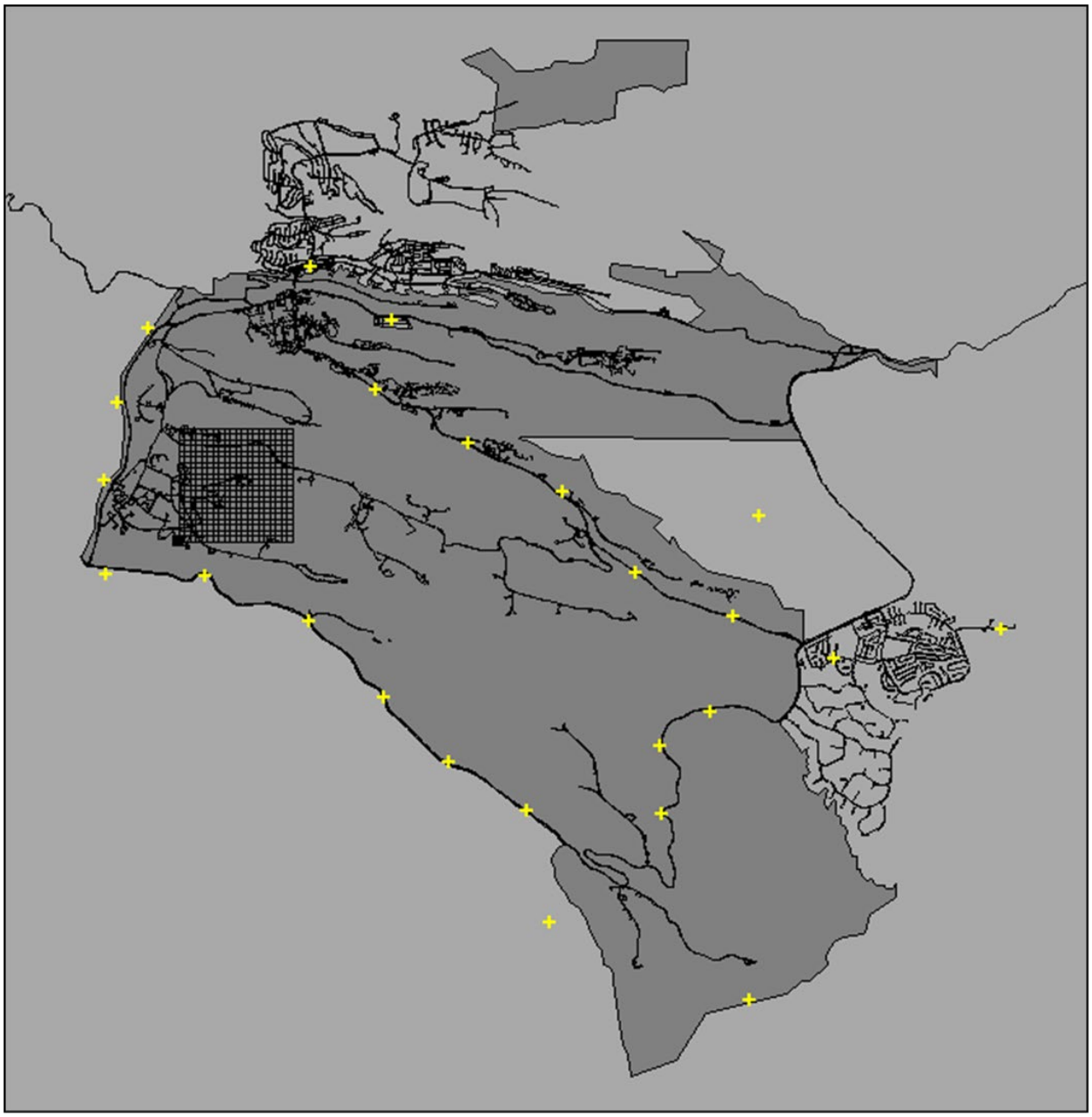

Figure 4-3. Location map of public receptors and receptor grid (Black grid squares are receptors at the site location; yellow plus signs are public receptors.)

4.2 Open Detonation

4.2.1 *Description of the Open Detonation Units and Operations*

OD operations are conducted at TA-36 and TA-39, as shown in Figure 4-4. TA-36 is located in the east-central portion of LANL and is spread over several mesa tops between a branch of Pajarito Canyon to the north and Water Canyon to the south. Mesa-top elevations at TA-36 range from approximately 6380 to 7120 feet above mean sea level. TA-36 contains an OD unit, several firing sites, and supporting offices where research is conducted with various types of explosives. The OD unit at TA-36 is located in

the southern portion of TA-36 near Building TA-36-8 and is shown in Figure 4-5. A picture of the detonation site is shown in Figure 4-6. The TA-36-8 OD unit consists of an irregularly shaped, sand- and grass-covered area that measures approximately 500 feet east to west and 300 feet north to south. The western portion is relatively flat; the eastern portion is concave to minimize fragment dispersion. The TA-36-8 OD unit may be used to treat solid and liquid hazardous explosive waste.

The TA-36-8 OD unit has a maximum treatment capacity of 2000 lb of explosive waste per detonation. Due to preparation time and monitoring requirements at this unit, only one detonation is performed per hour. The unit is used primarily for nontreatment-related experimental test detonations and occasionally for treatment of hazardous explosive waste. Following waste placement at the unit, detonation operations are conducted from Building TA-36-8, the control building.

TA-39 is located in the southern portion of LANL and includes much of the mesa between Water Canyon to the north and Ancho Canyon to the south. Mesa-top elevations at TA-39 range from approximately 6500 to 7000 feet above mean sea level. The area was established in 1959 for testing of explosive materials and has been used continuously for that purpose. The OD unit at TA-39 is located in a canyon bottom and consists of a relatively flat, sand-covered area that measures approximately 40 ft by 40 ft. Steep canyon walls rise to heights of 100 ft or more in the immediate vicinity of the OD unit, roughly forming a semicircle around the unit. The canyon walls serve to attenuate the force of the detonations. The OD unit at TA-39 is associated with Building TA-39-6, as shown in Figure 4-7. A picture of the detonation site is provided in Figure 4-8. Building TA-39-6 is a reinforced concrete structure that extends partially beneath the detonation area. The TA-39-6 OD unit may be used to treat solid and liquid hazardous explosive waste.

Table 4-4. Location map of open detonation units at Los Alamos National Laboratory

Unit	X-Coordinate	Y-Coordinate
TA-36-8	384428.8m	3965530m
TA-39-6	385714m	3962501m

The TA-39-6 OD unit has a maximum waste treatment capacity of 1000 lb of explosive waste per detonation per hour. The unit is used primarily for nontreatment-related experimental test detonations and occasionally for treatment of hazardous explosive waste. Following waste placement at the unit,

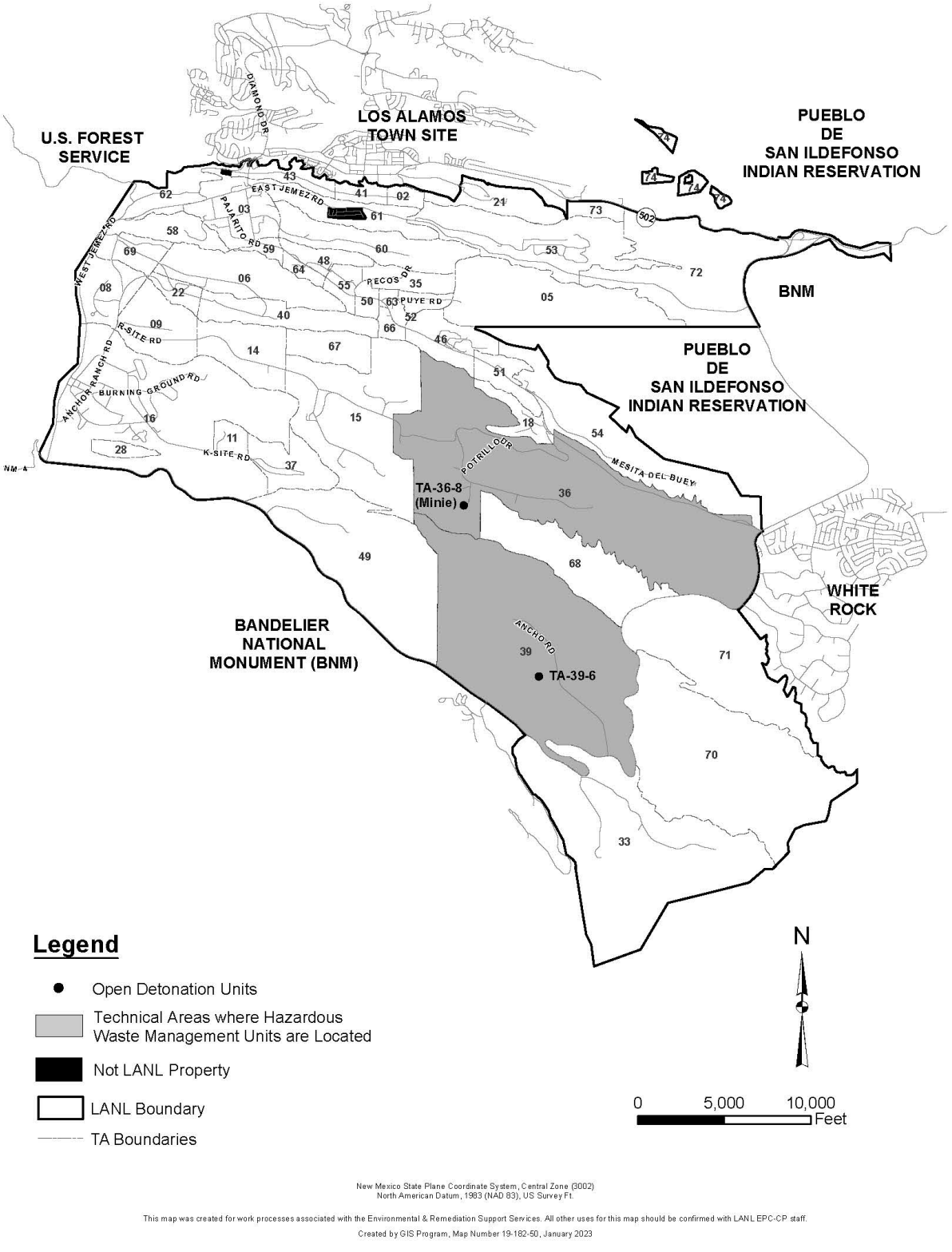

Figure 4-4. Location map of open detonation units at Los Alamos National Laboratory.

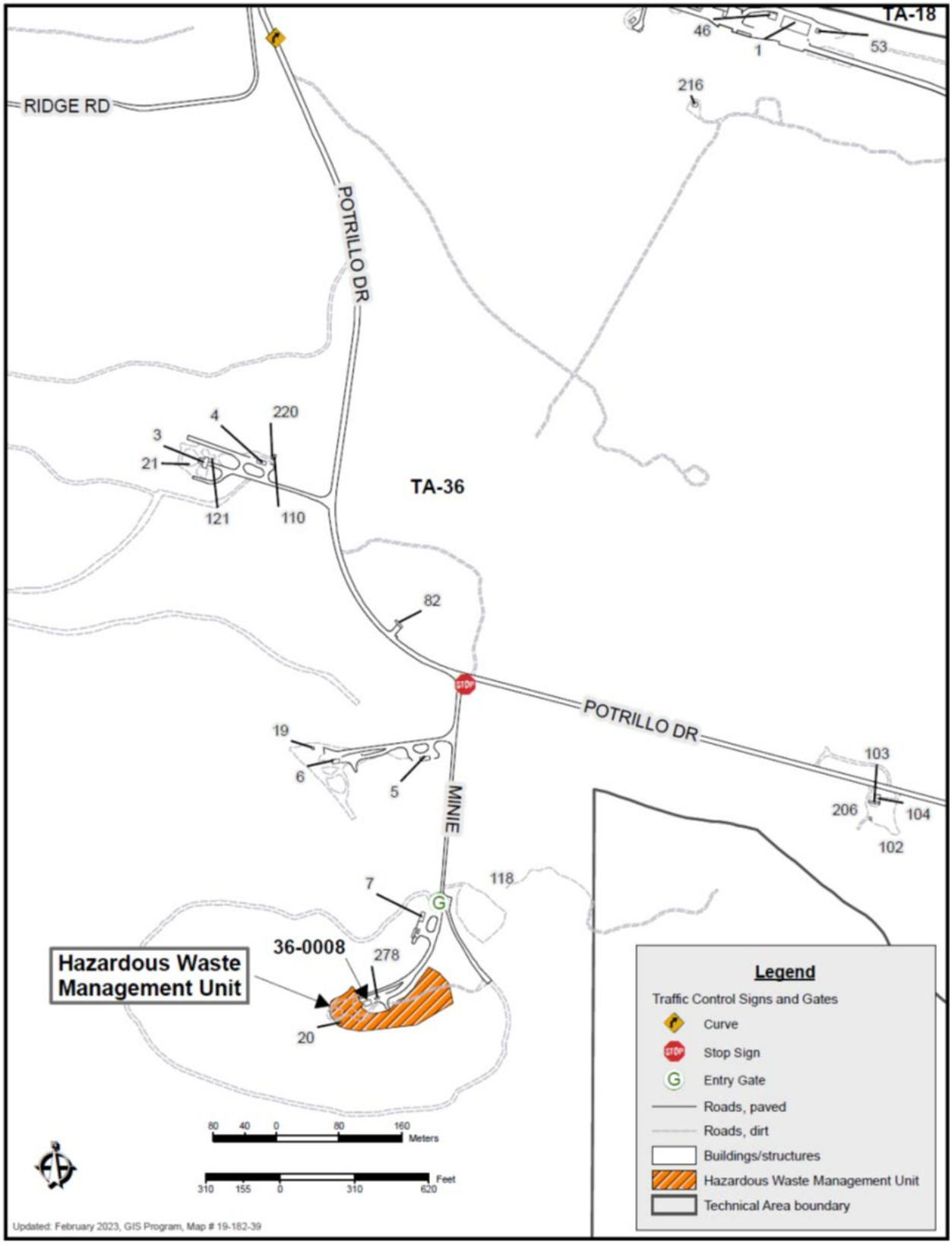

Figure 4-5. Map showing open detonation unit at Technical Area 36 Building 8.

Figure 4-6. Photograph of Technical Area 36-8 detonation pad.

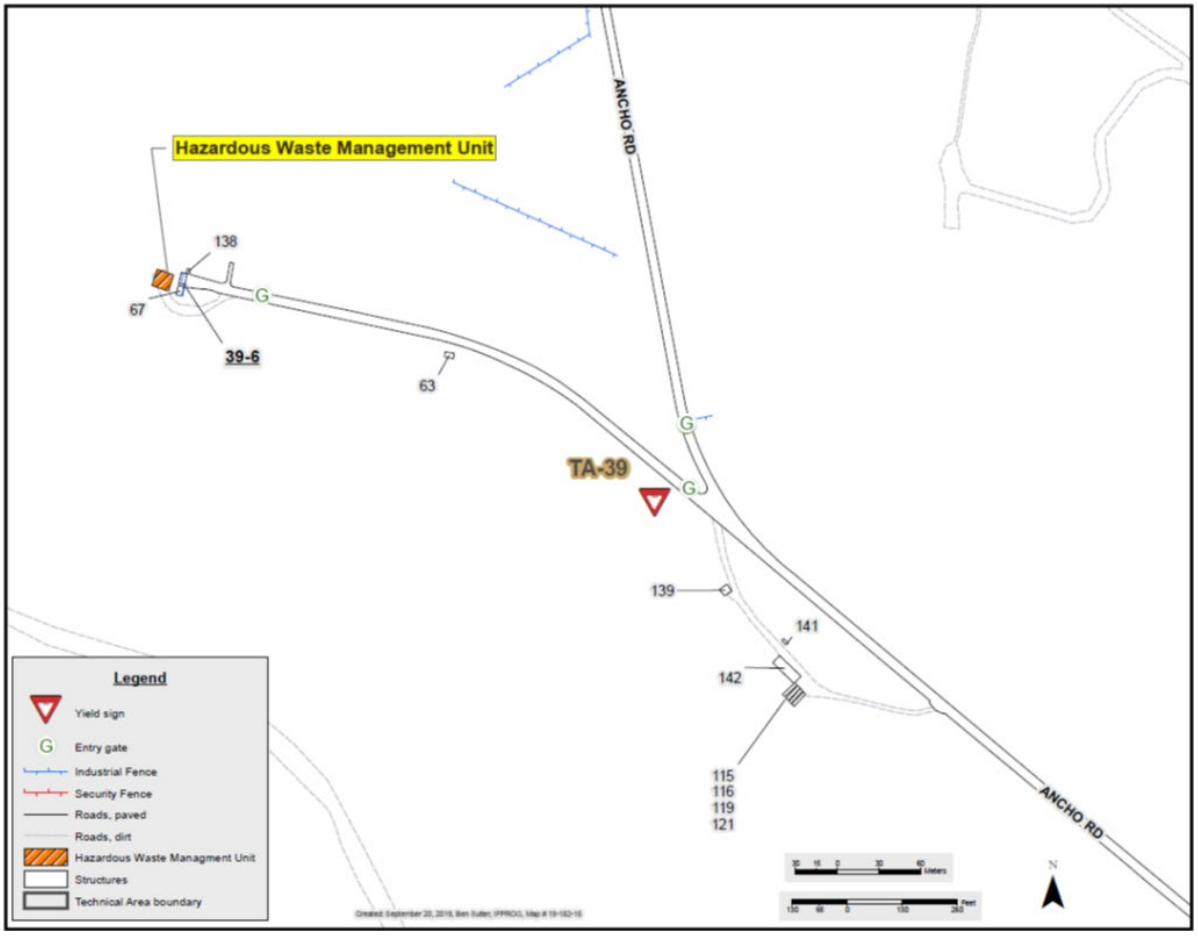

Figure 4-7. Map showing open detonation unit at Technical Area 39 Building 6.

Figure 4-8. Photograph of Technical Area 39-6 detonation pad.

4.2.2 *Source Characterization: Typical Open Detonation Treatment Operations*

OD operations are necessary for hazardous waste treatment to remove the characteristic of reactivity. Treatment by OD renders hazardous waste nonreactive and any infrequent residue amenable to handling and dispositioning. Nontreatment-related experimental test detonations (i.e., shots) are also currently performed at these locations.

Solid and liquid hazardous explosive waste may be treated (i.e., open detonated) at the unit. Waste streams treated through OD include

- excess explosives that vary from large pieces of explosives, small amounts of standard explosives, and developmental explosives;
- detonators, initiators, and mild detonating fuses that may be in metal or plastic casings and may contain lead-based primaries or be enclosed in a lead sheath;
- shaped charges and test assemblies with metal or plastic liners, sheaths, or holders;
- projectiles and munitions that may be larger than 50 caliber or smaller caliber ammunition that is damaged;
- pressing molds that are contaminated with explosives;
- explosives-contaminated waste generated in laboratories, make-up rooms, and at the firing site; and
- black powder or gun powder.

The previous list separates the two basic categories of explosives that may be managed at the OD treatment units. The first category consists of explosives-contaminated waste; the second category consists of explosive waste. Most of the waste treated at the OD units is explosive waste.

Explosives-contaminated waste includes make-up room (also called preparation room) wastes, laboratory wastes, contaminated molds, firing site debris, and decommissioning and demolition waste. Make-up room waste and laboratory waste consist of explosives-contaminated waste, such as paper towels, swabs, and similar materials that contain no tangible pieces of explosives but are used in the preparation of shots in the make-up building or as part of research and development processes. Firing site debris—wood scraps, cardboard, burlap, Plexiglas/Lexan, plastic, glass, Styrofoam, electrical cables, and metallic foils used for pin switches or metals such as target plates—is not generally explosives contaminated; however, firing site debris potentially contaminated with explosives can be generated occasionally. If the debris is explosives-contaminated and not rendered safe immediately, it is stored in the satellite accumulation area within the make-up building and treated as soon as possible.

Decommissioning and demolition waste can be generated when buildings are upgraded or removed from service. These wastes may be metal or glass piping that is not amenable to steam cleaning or open burning. Firing site debris could also include corrective action wastes or wastes generated as a result of investigation or remediation in the future. Other explosives-contaminated waste includes molds and other materials—used in the manufacturing of high-explosives parts—that may become contaminated and cannot be steam cleaned.

Explosive waste includes identifiable excess explosives that are safe to handle. It includes explosives assemblies and explosives, identifiable booster charge scrap, and any other process or cleanup wastes that are believed to be potentially reactive. Waste containers for explosives-contaminated waste and explosive waste generally consist of plastic bags or paper-lined cardboard boxes. These wastes make up most of the waste treated through OD at LANL. Up to 90 percent of the wastes treated within a year are excess explosives. Munitions, detonators, projectiles, and initiators make up an estimated annual quantity of approximately 2 percent of waste treated through OD.

4.2.3 *Source Parameter Input Values*

OD operations at TA-36 and TA-39 occur from 8 a.m. to 5 p.m. local time in the summer and from 9 a.m. to 4 p.m. in the winter. At TA-36-8, up to 2000 lb of high-explosives waste is treated in each open-air surface detonation, with a maximum of 15,000 lb of waste per year. Due to preparation and radiation-monitoring requirements, only one shot per hour is conducted for TA-36-8. At TA-39-6, up to 1000 lb of high-explosives waste is treated per open-air surface detonation per hour, with a maximum of 15,000 lb of waste per year.

Typically, only one detonation occurs daily; however, to ensure that the maximum hourly concentration is captured, all hours of the year from 8 a.m. to 5 p.m. were modeled using OBODM. The modeling is done by using as input a source strength file with the maximum hourly high-explosives waste quantity for each site of 2000 lb for TA-36 and 1000 lb for TA-39 for each hour. All other hours are specified as 0 lb of waste.

To ensure that the maximum annual air concentration is captured by the analysis, annual source strength files for each site were created based on the results of the hourly model run. Using an annual file with 8760 hours per year, hourly waste quantities are placed within the file for the hour of the year, which corresponds to the hours that show the highest concentrations in the hourly model runs. This process is done in a descending manner, starting with the hour that shows the highest concentration and moving down the hourly results until the annual waste quantities of 15,000 lb/year are reached.

The source parameter input values used in the OBODM model runs are summarized in Table 4-5. The fuel heat content specified is representative of the range of wastes treated. The fuel quantities are maximum hourly and annual values. Selection of the instantaneous emission type in model setup results in the model calculated fuel burn time of 2.5 seconds. The fuel burn rates are calculated from the hourly

fuel quantity divided by the fuel burn time. The model option for OBODM to calculate plume rise and present the results for each hour will be selected.

Table 4-5. Model Input Values

Parameter	TA-36-8	TA-39-6
Fuel Heat Content, cal/g	1000	1000
Hourly Fuel Quantity, lb	2000	1000
Annual Fuel Quantity, lb	15,000	15,000
Fuel Burn Time, sec	2.5	2.5
Fuel Burn Rate, lb/s	800	100
Fuel Burn Rate, g/sec	36,287.4	45,359
Contaminant Emission Rate, g/sec	1	1

4.2.4 *Methodology Steps for Open Detonation Modeling*

OBODM runs are conducted to determine the maximum GLC. The methodology comprises the following steps:

1. For each detonation site, a source strength model input file is prepared for short-term GLCs using the maximum hourly waste quantity for each site. The input file contains the maximum waste quantity for each hour from 8 a.m. to 5 p.m. for each day of the year.
2. Using a 1-year, continuous, hourly, onsite meteorological dataset, OBODM is run for each site using the hourly source strength file for the short-term 1-, 3-, 8-, and 24-hour averaging periods.
3. The hourly model results are used to create a source strength input file for estimating annual or chronic GLCs. In a descending order, the hourly fuel quantity is assigned to the hours of the year with the highest predicted GLC from the hourly model runs until the sum of the hourly values equaled the maximum annual waste quantity.
4. OBODM is run for each site using the annual source strength file and the same 1-year, onsite meteorological dataset for the annual averaging period.
5. In each model run, the contaminant emission rate is set at 1 g/sec; thus, the maximum GLC predicted was for a contaminant emission rate of 1 g/sec. The maximum GLC over the 1-g/sec emission rate, referenced as the X/Q value, has units of $\mu g/m^3$ per 1 g/sec.
6. Emission factors, together with maximum waste quantities, are used to calculate the emission rate in g/sec for each specific pollutant or contaminant projected to occur from a detonation.
7. For the hybrid modeling, the OD results for plume rise will be analyzed to determine minimum and maximum plume rise at a given distance downwind of the open detonation based on the days that generate the highest 1-, 3-, 8-, and 24-h GLC recorded for the year. Overall, it has been documented that a conservative impact assessment will result from the minimum plume rise (ATK Addendum 2013). The plume parameters will be used as inputs to AERMOD to determine the ambient impacts. OBODM ambient impacts will be compared to the AERMOD results to determine the worst-case ambient impacts for the health and ecological risk assessments and the air quality standards.

Each run will be conducted using the appropriate source strength file as previously described: the 1-year, hourly, meteorological dataset from the LANL TA-6 station. Table 4-6 summarizes the four scenarios modeled.

Table 4-6. Four Modeling Scenarios

OD Site	Averaging Period	Waste Quantity
TA-36-8	1, 3, 8, and 24 hours	2000 lb
TA-36-8	Annual[1]	15,000 lb
TA-39-6	1, 3, 8, and 24 hours	1000 lb
TA-39-6	Annual	15,000 lb

[1] The annual source strength file for this site used 8 hours with 2000 lb per hour rather than a single hour with 1000 lb of waste, to produce a 15,000-lb total; therefore, the maximum concentration is conservative.

4.2.5 *Meteorological Data*

See Section 4.1.5 for discussion of meteorological data for OBOD modeling.

4.2.6 *Receptors for OD Modeling*

Receptors with terrain elevations are established to ensure that the maximum downwind concentrations are captured in the model runs. A Cartesian receptor grid is set up for each detonation site, with the site being the center point of a 1000- by 1000-meter grid with 100-meter spacing between receptors. Public receptors include nearby roadways, recreation areas, schools, hospitals, and tribal land. A list of public receptors is shown in

Table 4-7.

Figure 4-9 shows the LANL property boundary, roadways, and the receptors used in the analysis. In the figure, LANL property is shaded darker than the surrounding land. The two sites and associated receptor grids are indicated in the black grid squares, with TA-36 north of the TA-39 site. Public receptors are indicated in yellow.

Table 4-7. Public Receptors

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation[2] (feet)
Bandelier Entrance at SR 4	384789.7	3962060.7	2031.2
Bandelier Visitor Center	385202.9	3960086.4	1845.1
Midpoint 2 OD Sites[2]	385071.3	3964015.1	2058.1
TA-36-8 Proximity[2]	384473.6	3965417.7	2117.9
San Ildefonso West of SR 4	388891.3	3967279.6	2006.7
White Rock Overlook Park	393146.0	3965274.7	1911.6
Piñon Elementary School, White Rock	390207.5	3964769.6	1981.0
Elk Ridge Trailer Park	382432.8	3970723.1	2228.0
Los Alamos Medical Center	381001.8	3971679.6	2226.7
West Jemez Road	377585.0	3969284.5	2386.7
Ponderosa Campground	377386.1	3966238.8	2311.2
TA-39 Entrance[2]	386855.8	3961142.4	1916.8
LANL SE Boundary	388723.0	3958724.3	1643.8
SR 4 SE	387161.9	3961999.5	1993.5
SR 4 SE	387131.3	3963223.8	1952.0

Receptor	X-Coordinate[1] (meters)	Y-Coordinate[1] (meters)	Elevation[2] (feet)
SR 4 SE	388019.0	3963805.4	1985.6
Pajarito Rd[2]	388416.9	3965488.9	2003.9
Pajarito Rd[2]	386702.8	3966284.8	2035.8
Pajarito Rd[2]	385417.2	3967692.8	2130.0
Pajarito Rd[2]	383764.3	3968549.8	2180.4
Pajarito Rd[2]	382142.0	3969498.7	2220.6
West Jemez Rd	377367.0	3967907.1	2364.6
West Jemez Rd	378132.2	3970600.7	2406.3
SR 4 SW	383427.6	3962917.7	2105.2
SR 4 SW	382264.4	3964080.9	2156.9
SR 4 SW	380948.2	3965427.7	2208.7
SR 4 SW	379142.3	3966223.5	2260.6

[1]All UTM coordinates are based on NAD 83.
[2]Public receptors used in OBODM and in past OBOD modeling reports but not used in AERMOD modeling because they are located on a private, restricted road.
Key: SR = State Road; SE = Southeast; SW = Southwest

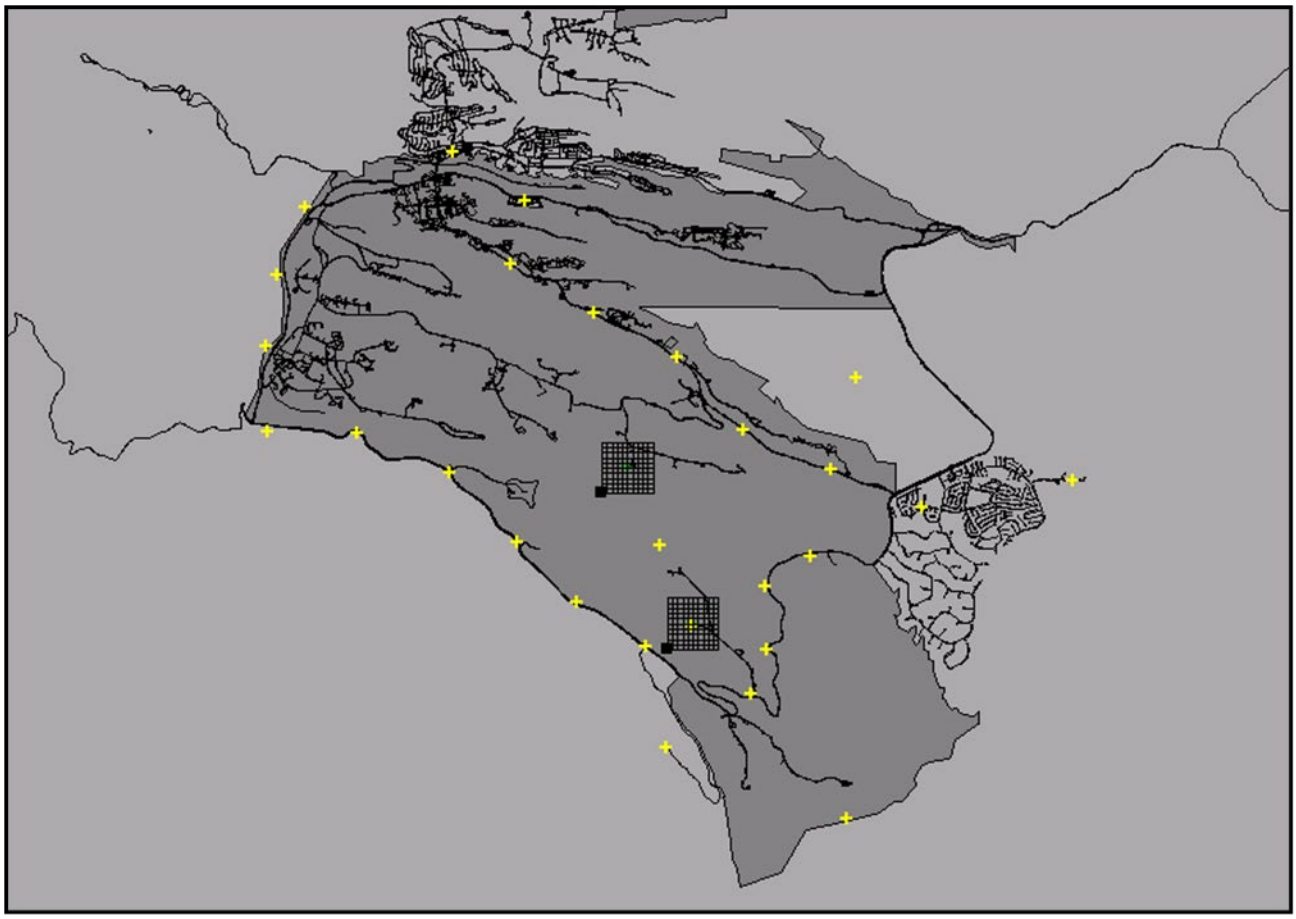

Figure 4-9. Location map of public receptors and receptor grids for OBODM OD modeling.

4.3 AERMOD

4.3.1 *Dispersion Model Input Options*

The dispersion modeling analysis used AERMOD, an EPA-preferred and NMED-recommended Gaussian plume model for use within 50 kilometers of emission sources. AERMOD is appropriate for determining compliance with the ambient air quality standards in the complex topography around LANL. LANL will use the current version of BEEST, a commercial graphical interface of AERMOD. The analysis will use all EPA default regulatory options specified in AERMOD.

4.3.2 *Source Characterization*

Methodology for Processing Plume Rise Results for Input in AERMOD

The plume rise determinations are based on Volume 1 and Volume 2 of the OBODM User's Guide. The AERMOD GLC results were used for the analysis of the NAAQS, NMAAQS, toxic air pollutants (TAP), hazardous air pollutants (HAP), and other POCs in the report for the RCRA Subpart X application.

For the purposes of this modeling approach, OBODM is applied to OB or OD events to determine the most conservative values for the plume rise at a given distance downwind. Open burning and open detonation results in combustion of the energetics and the rapid rise of the hot combustion products, due to buoyancy, until a final height is reached. At this point, the emission cloud has no upward momentum and begins to disperse downwind. This process can be estimated using OBODM to predict the final cloud height of the OB or OD plume. This height is then specified as the release height in the volume source algorithm in AERMOD.

The initial diameter of the cloud at final plume height for the open burn and open detonation events were determined using Equation 2-71 from Volume 2, Section 2.6.3, of the OBODM User's Guide for calculating the radius:

$$r(x) = [\gamma c][\Delta hc(x)] + rR$$

where:
$r(x)$ = radius of the cloud at final plume height
x = the distance at which final plume height is achieved
γc = 0.6 (OBODM default value)
$\Delta hc(x)$ = final plume height
rR = radius of a circle with same area as burn/detonation pans

Assuming that the vapor cloud is a sphere, the sigmas for the AERMOD volume source can be calculated from the results obtained from Equation 2-71. Thus, according to the AERMOD User's Guide, the initial vertical and horizontal sigmas for a volume source, such as the vapor cloud, can be calculated by dividing the calculated cloud diameter by 4.3.

Based on OB and OD modeling, the most conservative plume rise results will be applied to the AERMOD source parameters as a volume source. A unitized emission rate of 1.0 gram/second is used in each model run to preclude modeling each potentially emitted constituent separately. Unitized emissions rates will be adjusted for each POC's specific emission factor to calculate the ambient concentration and deposition rate for the risk assessment. Concentration and deposition are directly proportional to air modeling results based on the unit emission rate employed in the AERMOD modeling analysis.

Emission Factors for OB

This section describes the sources of emission factors and the emission factors applied to each waste stream treated by open burning. Waste streams treated by open burning are described in Section 4.1.2 of this document. An emission factor is a documented representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Based on the waste streams described, emission factors were chosen for pollutants that had air quality standards. Emission factors are not shown for pre-treatment and post-treatment emissions (such as fugitive dust) because no equipment operates off-road, earth-moving operations are not part of the open burning/open detonation activities, and ash generation is routinely negligible from open burning operations. Additionally, emission factors for the detonation of explosives—of which more recent research has been conducted and is available—were not considered for use because detonation has processes, such as fragment formation, that do not occur during open burning.

Materials burned at the TA-16-388 Flash Pad may vary in composition from mostly to all explosives and explosives pieces to small quantities of explosives on contaminated combustible solids or noncombustible solids. Most of the emissions products (more than 99 percent) associated with open burning are carbon, nitrogen, and oxygen. In fact, emission products from most energetic material treated by open burning can be adequately represented by the analytes carbon dioxide, carbon monoxide, nitrogen oxide, and nitrogen dioxide—with only trace quantities of total saturated hydrocarbons, acetylene, ethylene, propene, benzene, toluene, and particulates (EPA 1998).

To characterize the potential impact to the site from air dispersion and depositions, the minimal fractions of contaminants that may be produced during open burning treatment activities have been estimated using calculations and emission factors from documented sources. The maximum amount of burnable material that can be treated at the TA-16-388 Flash Pad is 200 lb per burn and 6000 lb per year. To reasonably but conservatively represent waste treatment activities at the TA-16-388 Flash Pad, a combined waste stream was developed that encompasses the most conservative emission factors from surrogates that represent the waste streams treated by open burning. This methodology sufficiently covers the worst-case scenario for emissions from the unit.

Surrogate waste streams described in the following sections and chosen to represent each waste stream detailed in Section 4.1.2 were chosen from one of the limited documented sources. The waste-stream-specific emission factors were combined to create a single surrogate waste stream that encompasses all waste streams that may be treated at the TA-16-388 Flash Pad. This waste stream is represented by the combined emission factors shown in Table 4-8. Emission factors for the propane that is used as fuel for open burning waste treatment are shown separately but are included with the waste stream surrogate as part of the air impact assessment.

Table 4-8. OB Emission Factors by Surrogate Waste Streams and Combined Waste Stream[1]

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
1,2,4-Trimethylbenzene			3.87E−07	4.25E−07	2.43E−04	2.43E−04	Diesel and Dunnage
1,2,4-Trimethylbenzene & sec-Butylbenzene		3.43E−07	4.53E−07	1.10E−06	5.09E−04	5.09E−04	Diesel and Dunnage
1,3,5-Trimethylbenzene		4.29E−08	9.07E−08	2.99E−07	5.57E−04	5.57E−04	Diesel and Dunnage
1,3-Butadiene			9.07E−08	4.98E−07	1.34E−06	1.34E−06	Diesel and Dunnage
1-Butene		2.29E−07	2.72E−07	5.97E−07	4.69E−06	4.69E−06	Diesel and Dunnage
1-Hexene		1.07E−07			2.19E−06	2.19E−06	Diesel and Dunnage
1-Pentene		3.55E−08	9.07E−08	9.95E−08	1.72E−06	1.72E−06	Diesel and Dunnage
2,2,4-Trimethylpentane		1.29E−07			6.97E−06	6.97E−06	Diesel and Dunnage
2,2-Dimethylbutane		4.29E−08				4.29E−08	M31A1E1
2,3,4-Trimethylpentane					1.38E−06	1.38E−06	Diesel and Dunnage
2,3-Dimethylbutane		3.55E-08			2.06E-06	2.06E-06	Diesel and Dunnage
2,3-Dimethylhexane					5.40E-06	5.40E-06	Diesel and Dunnage
2,3-Dimethylpentane					3.33E−06	3.33E−06	Diesel and Dunnage
2,4,4-Trimethyl-1-pentene		8.58E−08	9.07E−08	1.99E−07		1.99E−07	PBXN-110
2,4-Dimethylhexane				1.99E−07	6.42E−06	6.42E−06	Diesel and Dunnage
2,4-Dimethylpentane					2.16E−06	2.16E−06	Diesel and Dunnage
2,5-Dimethylhexane					1.11E−05	1.11E−05	Diesel and Dunnage
2-Methyl-1-butene			9.07E−08	1.99E−07	1.05E−06	1.05E−06	Diesel and Dunnage
2-Methyl-2-butene			9.07E−08			9.07E−08	M-43
2-Methylheptane		3.44E−08	9.07E−08		4.42E−05	4.42E−05	Diesel and Dunnage
2-Methylhexane		4.29E−08	1.81E−07		1.38E−05	1.38E−05	Diesel and Dunnage
2-Methylnaphthalene					2.18E−05	2.18E−05	Diesel and Dunnage
2-Methylpentane		6.89E−08			9.47E−06	9.47E06	Diesel and Dunnage
3-Ethylhexane, 3-Methylheptane		1.07E-07	9.07E-08		5.90E-05	5.90E−05	Diesel and Dunnage
3-Methyl-1-butene			9.07E−08	1.99E−07		1.99E−07	PBXN-110
3-Methylhexane					1.55E−05	1.55E−05	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
3-Methylpentane		3.77E−08			5.08E−06	5.08E−06	Diesel and Dunnage
Acenaphthylene					6.71E−06	6.71E−06	Diesel and Dunnage
Acetophenone					1.74E−07	1.74E−07	Diesel and Dunnage
Acetylene		1.02E−06	5.89E−06	3.09E−06	9.52E−05	9.52E−05	Diesel and Dunnage
Aluminum					7.13E−07	7.13E−07	Diesel and Dunnage
Anthracene					1.02E−07	1.02E−07	Diesel and Dunnage
Aromative (e.g., Styrene)		5.43E−05	2.81E−06	7.07E−06	2.29E−03	2.29E−03	Diesel and Dunnage
Barium		4.20E−07			1.61E−07	4.20E−07	M31A1E1
Benzene		9.98E−07	1.76E−06	4.88E−06	7.84E−05	7.84E−05	Diesel and Dunnage
Benzo(a)anthracene					9.81E−07	9.81E−07	Diesel and Dunnage
Benzo(a)pyrene					7.42E−07	7.42E−07	Diesel and Dunnage
Benzo(b)fluoranthene					7.84E−07	7.84E−07	Diesel and Dunnage
Benzo(ghi)perylene					3.45E−07	3.45E−07	Diesel and Dunnage
Benzo(k)fluoranthene					7.46E−07	7.46E−07	Diesel and Dunnage
Benzyl alcohol		1.91E−09			3.96E−05	3.96E−05	Diesel and Dunnage
Biphenyl					6.45E−06	6.45E−06	Diesel and Dunnage
Butylbenzyl phthalate (85-68-7)					1.22E−07	1.22E−07	Diesel and Dunnage
Carbon Tetrachloride		6.89E−08				6.89E−08	Diesel and Dunnage
Chromium		3.97E−07				3.97E−07	M31A1E1
Chrysene					9.33E−07	9.33E−07	Diesel and Dunnage
cis-2-Butene		1.29E−07	9.07E−08	1.99E−07		1.99E−07	PBXN-110
cis-2-Pentene			9.07E−08			9.07E−08	M-43
CO	2.80E−02	1.66E−04	1.40E−03	2.32E−02	2.98E−02	2.98E−02	Diesel and Dunnage
CO2		6.45E−01	7.73E−01	1.04E+00	1.63E+00	1.63E+00	Diesel and Dunnage
Copper		6.31E−06				6.31E−06	M31A1E1
Cyclohexane		3.55E−08	9.07E−08		2.67E−05	2.67E−05	Diesel and Dunnage
Cyclopentane		4.29E−08	9.07E−08	9.95E−08	1.53E−06	1.53E−06	Diesel and Dunnage
Dibenz (a, h) anthracene					2.00E−07	2.00E−07	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
Diethyl phthalate		6.58E−08			7.00E−08	7.00E−08	Diesel and Dunnage
Dimethyl phthalate					1.88E−07	1.88E−07	Diesel and Dunnage
Di-n-butyl phthalate		3.30E−07			1.46E−07	3.30E−07	M31A1E1
Di-n-octyl phthalate					9.19E−07	9.19E−07	Diesel and Dunnage
Ethane		6.38E−08	1.81E−07	9.95E−07	1.15E−05	1.15E−05	Diesel and Dunnage
Ethyl chloride		6.89E−08				6.89E−08	M31A1E1
Ethylbenzene		4.44E−07	3.42E−07	7.96E−07	5.49E−05	5.49E−05	Diesel and Dunnage
Ethylene		9.78E−07	4.81E−06	6.67E−06	7.43E−05	7.43E−05	Diesel and Dunnage
Fluoranthene					7.85E−07	7.85E−07	Diesel and Dunnage
HCL			9.97E−04	1.79E−04		9.97E−04	M-43
i-Butane		7.11E−08			1.24E−06	1.24E−06	Diesel and Dunnage
i-Butene		1.51E−07	5.44E−07	1.29E−06	2.26E−06	2.26E−06	Diesel and Dunnage
Indeno(1,2,3-cd) pyrene					2.83E−07	2.83E−07	Diesel and Dunnage
i-Pentane			9.07E−08		1.08E−05	1.08E−05	Diesel and Dunnage
i-Propylbenzene					1.03E−04	1.03E−04	Diesel and Dunnage
m- & p-Xylene		1.33E−06	6.83E−07	7.96E−07	4.52E−04	4.52E−04	Diesel and Dunnage
Methane					8.72E−05	8.72E−05	Diesel and Dunnage
Methyl chloroform		3.44E−08				3.44E−08	M31A1E1
Methylchloride		2.84E−07		1.81E−07		2.84E−07	M31A1E1
Methylcyclohexane		3.30E−07			1.56E−04	1.56E−04	Diesel and Dunnage
Methylcyclopentane					9.93E−06	9.93E−06	Diesel and Dunnage
Methylenechloride		7.46E−07				7.46E−07	M31A1E1
m-Ethyltoluene		8.58E−08		1.99E−07	1.28E−04	1.28E−04	Diesel and Dunnage
Naphthalene					8.38E−05	8.38E−05	Diesel and Dunnage
n-Butane		3.44E−07	9.07E−08	9.95E−08	4.60E−06	4.60E−06	Diesel and Dunnage
n-Decane		3.55E−08	8.16E−07	1.29E−06	1.97E−03	1.97E−03	Diesel and Dunnage
n-Heptane			9.07E−08		5.90E−05	5.90E−05	Diesel and Dunnage
n-Hexane			9.07E−08		1.60E−05	1.60E−05	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
Nitrogen dioxide (peroxide)		9.67E−05	4.69E−04	2.82E−04	5.07E−05	4.69E−04	M-43
Nitrogen Oxide		1.18E−03	6.28E−03	2.62E−03	7.99E−04	6.28E−03	M-43
Nitrogen Oxides	7.50E−02					7.50E−02	TNT
n-Nonane		4.29E−08		1.99E−07	1.03E−03	1.03E−03	Diesel and Dunnage
n-Octane		3.55E−08	9.07E−08		2.48E−04	2.48E−04	Diesel and Dunnage
Non-methane Organic Compound		1.03E−07	4.99E−05	1.07E−04	7.84E−03	7.84E−03	Diesel and Dunnage
n-Pentane					9.05E−06	9.05E−06	Diesel and Dunnage
n-Propylbenzene		1.72E−07		9.95E−08	8.16E−05	8.16E−05	Diesel and Dunnage
OCDD					1.03E−11	1.03E−11	Diesel and Dunnage
o-Ethyltoluene		3.90E−07		2.99E−07		3.90E−07	M31A1E1
o-Xylene		3.44E−07	9.07E−08	3.75E−07	1.25E−04	1.25E−04	Diesel and Dunnage
Particulates	9.00E−02					9.00E−02	TNT
Perylene					1.72E−07	1.72E−07	Diesel and Dunnage
p-Ethyltoluene		7.11E−08	1.81E−07	4.25E−07	1.53E−04	1.53E−04	Diesel and Dunnage
Phenanthrene					7.17E−06	7.17E−06	Diesel and Dunnage
Phenol					1.56E−05	1.56E−05	Diesel and Dunnage
PM10		9.10E−01	1.18E−03	4.87E−01	5.44E−03	9.10E−01	M31A1E1
Propane		3.08E−07		2.99E−07	2.22E−06	2.22E−06	Diesel and Dunnage
Propene			1.09E−06	2.99E−06	1.30E−05	1.30E−05	Diesel and Dunnage
Pyrene					7.06E−07	7.06E−07	Diesel and Dunnage
Styrene		2.57E−07			4.99E−05	4.99E−05	Diesel and Dunnage
Sulfur Dioxide		1.22E−03	1.18E−04	3.47E−04	1.88E−04	1.22E−03	M31A1E1
Toluene		2.84E−07	5.44E−07		1.22E−04	1.22E−04	Diesel and Dunnage
Total Alkanes (Paraffins)		2.33E−06	5.44E−07		3.50E−03	3.50E−03	Diesel and Dunnage
Total Alkenes (Olefins)		2.57E−06	1.33E−05	1.59E−05	1.93E−04	1.93E−04	Diesel and Dunnage
Total Non-methane Hydrocarbons/NMHC		9.88E−05	4.13E−05	5.11E−05	1.20E−02	1.20E−02	Diesel and Dunnage
Total Unidentified Hydrocarbons		1.92E−05	2.47E−05	4.41E−05	6.04E−03	6.04E−03	Diesel and Dunnage

Name of Pollutant	TNT Emission Factor	M31A1E1 Emission Factor	M-43 Emission Factor	PBXN-110 Emission Factor	Diesel and Dunnage Emission Factor	Combined Emission Factor[2]	Surrogate Name of Max Emission Factor
trans-2-Butene		5.19E−08	1.81E−07	3.98E−07	2.91E−06	2.91E−06	Diesel and Dunnage
trans-2-Pentene					1.08E−06	1.08E−06	Diesel and Dunnage
Vinyl Chloride				2.23E−07		2.23E−07	PBXN-110
Vinylidene Chloride		2.15E−07				2.15E−07	M31A1E1
Volatile Organic Compounds	5.50E−04					5.50E−04	TNT
Zinc		4.14E−07			6.26E−05	6.26E−05	Diesel and Dunnage

[1] Emission factors are displayed in units of grams of pollutant per grams of waste treated.
[2] The highest emission factor of all surrogate waste streams was included within the combined emission factor to provide the most conservative set of emission factors possible.

Emission Factors for Excess Explosives, Explosives Machining Waste, and Explosives-Contaminated Noncombustible Debris

Approximately 99 percent of the waste treated at the TA-16-388 Flash Pad is a combination of explosives machining waste, excess explosives waste, and explosives-contaminated noncombustible debris. The excess explosives waste stream consists of

- pure explosives that could be held within plastic bags, cardboard, or paper in some cases;
- the explosives-machining waste stream consists of pure explosives shavings or cuttings, water, and sometimes cloth filters; and
- the explosives-contaminated noncombustible debris consists primarily of metal piping, equipment, concrete, or soil generated during decommissioning and environmental restoration activities.

Because the non-combustible materials themselves do not burn, the only emissions result from the burning of the explosives.

The specific types of explosives treated by open burning vary depending primarily on research and development and stockpile stewardship activities. The primary types of explosives treated are 1,3,5-triamino-2,4,6-trinitrobenzene (TATB), cyclotetramethylenetetranitramine (HMX), trinitrotoluene (TNT), and cyclonite (RDX). Emission factors are not available for all the explosives treated.

TNT is the least oxygenated; therefore, it is an explosive that burns less completely ("dirtier") than others treated at the TA-16-388 Flash Pad. Emission factors for burning TNT are available in Chapter 6, Section 3, Table 6.3-1 of the EPA's Compilation of Air Pollutant Emission Factors (EPA 1983). There are no toxic air pollutant emission factors for TNT in AP-42; therefore, the emission factors available from the *Open Burn/Open Detonation Dispersion Model (OBODM) User's Guide* (Bjorklund, et al., 1998a.) for burning types of explosives like those burned at the TA-16-388 Flash Pad were reviewed. The types of materials in the OBODM User's Guide that are most like those treated at LANL are:

- M-43, which contains RDX;
- PBXN-110, which contains HMX; and
- M31A1E1, a mixture of explosives.

Although these waste stream surrogates contain some of the explosives treated by open burning at LANL, several contaminants are within the surrogates that would not be present in LANL explosives. No attempt has been made to eliminate from this analysis emissions that could be considered non-characteristic waste treated at LANL. Emission factors from each of the waste stream surrogates are used as published for this assessment to provide a conservative emissions estimate. The highest pollutant-specific emission factor for any of the three waste stream surrogates was chosen for inclusion in this air impact assessment. Columns 2 through 5 of Table 4-8 summarize the emission factors used to represent this waste stream in grams (g) of pollutant per g of waste (g/g) and identify the waste surrogate of origin.

Emission Factors for Combustible Solids

Emission factors from the diesel and dunnage surrogate waste in the OBODM User's Guide (Bjorklund, et al., 1998a) were used for this waste category. The diesel and dunnage waste consisted of scrap wood, dead branches from trees and shrubs, Styrofoam packing material, other combustibles, and diesel fuel. These emission factors, shown in Column 6 of Table 4-8, should be much higher than those produced from the typical treatment of explosives-contaminated combustible waste stream at LANL. In contrast with the diesel and dunnage surrogate waste, the explosives-contaminated combustible debris waste stream

at LANL is characterized by dry waste, no vegetation, no diesel, a high heating value from the explosives in the waste, and clean supplemental fuel (propane burners).

While reviewing available surrogate waste streams from the OBODM User's Guide, it was initially determined that the aluminized ammonium perchlorate (AP) propellant manufacturing waste category might be a better fit as a surrogate for the LANL explosives-contaminated, combustible-debris waste stream. The manufacturing surrogate waste was conceptually designed to simulate the mix of AP-contaminated plastic gloves, cotton rags, Kimwipes, wood towel rods, and similar materials that result from the clean-up of the vessels used to manufacture AP-based propellants (EPA 1998). As a general description, this surrogate gets far closer to the waste stream treated at LANL than the diesel and dunnage waste surrogate; however, there are two major reasons this surrogate was not ultimately selected to represent this LANL waste stream. The first reason is that LANL does not treat AP through open burning, so these emission factors are not accurately representative of the wastes treated at LANL. The second and more important reason for not choosing this waste surrogate is that the trial-run execution for the development of emission factors for the AP-manufacturing surrogate waste was flawed and therefore was not used to represent any waste stream that is treated by open burning at LANL.

Specifically, it was determined that the surrogate waste used for the trials was not representative of a true manufacturing waste because of the way the propellant was placed in contact with the combustible materials. One-inch cubes were placed randomly on top and in contact with the combustible materials rather than dispersed over the materials as a powder—the way in which the waste stream would be generated. Because of this cube-dispersion method, all of the trials resulted in holes in the stainless steel pan. The unique mix of emission products, the melted plastic, and the rate of conversion of N to NO_x observed for the surrogate AP-manufacturing waste demonstrated that this burn was very different from all other burns that involved energetic materials (EPA 1998).

An additional consideration during the development of an emission factor list for this waste stream is the potential for dioxin and furan formation. Dioxins and furans are formed from burning almost any kind of material, including forest fires, residential wood combustion, and residential oil heating (EPA 1997). The factors that affect dioxin formation include temperature, time and turbulence, oxygen, carbon, chlorine, bromine, catalysts, and humidity. Precursors to the formation of dioxins/furans within the lower range of temperatures (200–400° Celsius [C]) rely heavily on the presence of the products of incomplete combustion, including chlorine compounds, halogens, soot or fly ash, and metals (Zhang, et al., 2017). For the reasons described as follows, these compounds generally are not present in the waste treated by open burning, and the temperature at which treatment events occur is sustained well above this lower temperature range.

The temperature of the propane burners is more than 760° C. The temperature of the burn area stays consistently above 982° C. The types of explosives burned at the TA-16-388 Flash Pad most often range in burn temperature from approximately 1070° C to 2030° C and often make up a large percentage of the waste being treated. Temperatures that exceed 400° C are documented to provide destruction at a faster pace than formation (Zhang, et al., 2017). At higher temperatures (650–900 °C), there is a very close dependence of the formation of chlorinated and nonchlorinated aromatic compounds on a longer residence time in a combustion and afterburning chamber with the presence of the necessary parameters (Wielgosiński 2011).

This result is not the case for treatment events at the TA 16 388 Flash Pad. The formation of dioxins/furans requires incomplete combustion. The nature of propane burning ensures complete combustion of materials by providing an environment for the three Ts of combustion: temperature, time, and turbulence.

The documented temperature of treatment events is more than sufficient to ensure that the reactive characteristic (explosives content) within the waste is eliminated, and the creation of dioxin/furan compounds is avoided by ensuring that the combustion process is complete. The temperature of the burn is high enough that there is no smoldering, char, or soot formation within the process that would be necessary for dioxin formation and very little ash is generated by the treatment process overall. The TA 16 388 Flash Pad internal operating procedures require that, for all burn events, the waste must continue to be treated until the operator visually determines that the waste is fully treated. The system design and operations of the treatment process ensure that sufficient oxygen is available for complete combustion. The multidirectional propane burners ensure that high combustion turbulence is maintained throughout the treatment event. There is minimal residence time for gases and soot/carbon if present to be trapped with metal catalysts to form dioxins/furans. Additionally, the air turbulence of the operation of two propane burners in an open-air environment further decreases the residence time of gas and other material.

Materials are present in the waste that may contribute to the formation of dioxins/furans. Chlorine and halogens are generally not present in the waste treated by open burning. However, paper and small plastic bags (which make up less than 1 percent of waste material treated by open burning at LANL) are materials that may potentially produce chlorine compounds when burned. Metals are present within the waste streams treated by open burning; however, the intent of the waste treatment is to burn off explosives contamination on the metal, not to completely vaporize the metal. Carbon is present fundamentally as a part of an explosive waste stream; however, it is actively burned rather than allowed to smolder and generate char or soot. Lastly, though most of the waste treated by controlled open burning at the TA 16 388 Flash Pad is wetted waste, the water is evaporated off the waste explosive as the waste is burned and the moisture does not contribute to the formation of dioxins/furans.

The documented waste treatment at the open burn unit ensures that all waste is treated so that waste byproducts are not created and that the formation of dioxin/furans does not occur.

Emission Factors for Open Burning of Liquids

The explosives-contaminated solvent waste stream historically consisted of oils and solvents contaminated with explosives. Due to changes in processes and improved waste characterization, this waste stream has decreased considerably in recent history. No oils and most solvents will not be treated by open burning in the future. The only solvent that may be treated at the TA-16-388 Flash Pad is dimethyl sulfoxide (DMSO), which contains 25 percent or greater dissolved explosives.

No emission factors were identified for burning explosives-contaminated liquids. Also, DMSO is not a petroleum product; therefore, emission factors from burning of fuel oil used in past analyses are not applicable. This waste stream is treated infrequently, so no emission factors specific to DMSO have been incorporated into the assessment. The trace solvents discussed previously for the surrogate waste streams serve as solvent representation.

Emission Factors for Open Burning of Propane

Propane is burned to improve combustion efficiency of explosives and explosives-contaminated waste streams. A typical burn uses two burners at a time for approximately 60 minutes per burn. The two burners combined consume approximately 1 gallon of propane per minute, for a total of 60 gallons (254.4 lb) per burn. Emissions from burning the propane are additive to the emissions from burning the waste. The emission factors were obtained from Chapter 1.5, Table 1.5-1 of AP-42 (EPA 2008). The commercial boiler emission factors were used because the heat input capacities for commercial boilers are generally between 0.3 and 10 million British Thermal Units per hour. No toxic air pollutant emission factors were located. Propane is a very clean-burning fuel, and products of incomplete combustion should be minimal. Emission factors are shown in Table 4-9.

Table 4-9. Emission Factors for Propane

Contaminant	Emission Factor (lb/1000 gal)	Emission Factor (lb/lb)
Nitrogen Oxides	13	3.07E−03
Carbon Monoxide	7.5	1.77E−03
PM10	0.7	1.65E−04
PM2.5	0.7	1.65E−04
Sulfur Dioxide	9	2.12E−03
Nonmethane Hydrocarbons	1	2.36E−04

Emission Factors for OD

Waste streams treated through OD are described in Section 4.1.2 of this document. After review of the operating record, it was determined that wastes treated during calendar year 2006 were varied and represented a dataset that encompassed all waste streams and waste stream components expected to be treated at the units throughout the current and future waste treatment uses. For the treatment units, all emission factors (except PM2.5 and PM10) were chosen based on the components within the waste streams treated in 2006 using the draft Chapter 16 for AP-42 (AP-42 2009; Attachment 12). The emission factors provided in AP-42 draft Chapter 16 are a summary of the data publicly available through 1995, except PM emission factors are based on the study by Aurell, et al., 2014. Based on the draft Chapter 16, Section 16.2.1, the emission factors were obtained from a series of emission characterization studies conducted on an open test range and in a 32,900 ft^3, 50 ft diameter hemispherical detonation chamber. These studies were conducted at Dugway Proving Grounds, Utah (DPG), between 1989 and 1995.

As stated in draft Chapter 16, Section 16.1.1, in 1988, the U.S. Army conducted a highly successful study using a detonation chamber at Sandia National Laboratories (SNL) in Albuquerque, New Mexico. Based on the test results, the DoD concluded that the plumes released when energetic materials are destroyed by OB and OD processes do not contain sufficient quantities of toxic or hazardous pollutants to pose a danger to human health or the environment. The study also concluded that the emission factors for the predominant emission products produced in the emissions tests were statistically equivalent to those produced in the DPG open-range tests, i.e., the emission products did not change substantially even when the quantity of energetic material detonated increased by a factor of 32,000.

In this document, the primary reference for emission factors is Table 16.2-14, Summary Statistics for the Detonation Data Sets (AP-42 2009). In this table, many of the units of measure for the emission products are expressed in such forms as lb/lb NEW (net explosive weight), where NEW is the total weight of all explosive substances (i.e., high explosives weight, propellant weight, and pyrotechnic weight). Other listed emission factors are provided as lb/lb N (nitrogen), lb/lb C (carbon), or lb/lb S (sulfur), etc. These emission factors allow a more reasonable and less conservative estimate of emissions if applied. For most of the modeling assessments to determine the environmental impacts, the amounts of NEW, nitrogen, carbon, or sulfur were not assessed in the LANL waste materials; however, the lb metal/lb waste was assessed for this application based on the waste assessments for the materials treated at the OD sites. The fractions for barium, copper, and lead were calculated separately for each metal based on the information in the 2006 waste profile as presented in Attachment 4. The adjusted total amount of metals was assessed for computing the fraction of metal emissions for the remaining metal constituents. Otherwise, all other calculations were based on the total mass of explosive waste used in the detonation. Applying lb/lb explosive waste for the unit of measure in lieu of the specific emission factors where lb/lb NEW, lb/lb N or lb/lb C, etc. increases the conservativeness of the estimate of environmental impact for the risk assessment because the total mass of combined waste is greater than any one of the

constituents, such as NEW, carbon, or nitrogen, etc. LANL applied the mean emission factor values listed in Table 16.2-14. These emission factors are presented in Table 4-10.

Table 4-10. Emission Factors for OD Operations based on the Draft AP-42 Ch. 16, Table 16.2-14

Emission Products	CAS RN	Emission Factor[1] for OD	UOM as Listed in Draft AP-42 Ch. 16	UOM as Applied for Modeling
Carbon Monoxide	630-08-0	7.1E-02	lb/lb C	lb/lb waste[2]
Carbon Dioxide	124-38-9	3.5E+00	lb/lb C	lb/lb waste[2]
Nitrogen Oxides	N/A	5.3E-02	lb/lb N	lb/lb waste[2]
Sulfur Dioxide	7446-09-5	4.8E-04	lb/lb NEW	lb/lb waste[2]
Energetics	N/A	4.5E-07	lb/lb Energetic	lb/lb waste[2]
SVOCs in Energetics	N/A	1.00E-08	lb/lb SVOC	lb/lb waste[2]
SVOCs Not in Energetics	N/A	2.8E-07	lb/lb NEW	lb/lb waste[2]
Benzene	71-43-2	2.0E-04	lb/lb C	lb/lb waste[2]
TNMHC	N/A	7.7E-03	lb/lb C	lb/lb waste[2]
Acetylene	74-86-2	7.7E-04	lb/lb C	lb/lb waste[2]
Ethylene	74-85-1	7.1E-04	lb/lb C	lb/lb waste[2]
Methylene Chloride	75-09-2	6.2E-04	lb/lb C	lb/lb waste[2]
Propylene	115-07-1	1.3E-04	lb/lb C	lb/lb waste[2]
Toluene	108-88-3	6.7E-05	lb/lb C	lb/lb waste[2]
Naphthalene (as SVOC)	91-20-3	2.8E-07	lb/lb NEW	lb/lb waste[2]
Metals in Energetics as Particle (or Elemental)	N/A	9.8E-02	lb/lb metal	lb metal/lb waste[2,3]
Metals in Alloys	N/A	3.1E-02	lb/lb metal	lb metal/lb waste[2,3]
Metals in Energetics As Compound	N/A	2.6E-01	lb/lb metal	lb metal/lb waste[2,3]

[1] The mean emission factor as listed in AP-42 Ch. 16 draft is used in the calculation of the ground-level concentration.
[2] Application of the emission factor to the weight of waste processed in lieu of the initial draft Ch. 16 value is a conservative estimate of emissions.
[3] Based on the data for 2006 RCRA Waste Explosive Descriptions, EPA Waste Codes, and Explosives Detonated at TA-36 and TA-39 OD units. These data provided a lb/lb waste calculation that was adjusted for the amount of metal per lb of waste using a factor of 0.077 lb metal/lb waste for all metals except barium, copper and lead. See Attachment 4 for further details.
Key: SVOC = semi-volatile organic compound

Research on OD emissions at the Naval Air Warfare Center Weapons Division at China Lake, California, addressed the fate of metals from munitions during OD treatment operations (NAVAIR 2004). This research showed that metal components of waste (e.g., casings, projectiles, platings, paints, coatings) do not melt or vaporize during OD but rather fragment. During OD, explosives quickly transform from solid to high-temperature and high-pressure gases, which cause the metal components to fracture. The metal fragments are in contact with the hot gases but not long enough to cause the metal to melt or vaporize. The metal fragments are accelerated outside of the detonation zone by the initial blast and are not exposed to the afterburning (fireball) phase of the detonation. Most metal components end up as fragments, with a minor proportion becoming particulates. In this regard, the emission calculations for metals are an overestimate of particulate by allowing the assumption that the fragment portion is modeled as particulate.

Research conducted by the Navy at China Lake, California, addressed the formation of dioxins during OD treatment operations (NAVAIR 2005). This research pointed out significant differences between OD of wastes and incineration of wastes. During incineration, dioxins are formed through recombination of combustion gases (e.g., oxygen, chlorine). Very specific conditions are needed to form dioxins, including a temperature range of 250–450°C (482–842°F) and a residence time of seconds to minutes. These

conditions are common in incinerators but are not present during OD operations. OD occurs in microseconds, and the afterburning phase is complete in seconds. Temperatures during OD operations can range from about 2500–5600°C, and the temperatures associated with afterburning are on the order of 700°C to 1700°C (NAVAIR 2004). These higher temperatures cause the dioxin precursor molecules to fall apart. Also, OD operations occur at very high pressures—on the order of hundreds of kilo bars—whereas incinerators operate at ambient pressure.

As described in the draft AP-42 Chapter 16 (AP-42 2009), the intramolecular rearrangement for detonations is so fast that only a small percentage of the atoms in one molecule have time to react with atoms in adjacent energetic molecules that are decomposing at the exact same time. Because the detonation of explosives does not require air, it can occur in a vacuum, in an inert atmosphere, or even under water. The initial detonation products are free carbon (soot), carbon monoxide, hydrogen, methane, ethane, formaldehyde, nitrogen, carbon dioxide, water vapor, small hydrocarbons, and small CxHy fragments. The initial stage of the detonation process is over in less than 10 microseconds and is followed by a 2- to 10-second duration fireball (afterburn). In this second stage of the process, combustible detonation reaction products (e.g., carbon monoxide, methane, ethane, formaldehyde, hydrogen, and the CxHy fragments) are spontaneously oxidized (combusted) to CO_2 and H_2O. Fireball temperatures are on the order of 926.7–1704.4°C. As the plume expands, it entrains additional air, which allows further combustion reactions to take place until the plume temperature falls to approximately 815°C, where these reactions stop. This effect prevents dioxins from forming during OD operations; therefore, dioxins/furans are not considered emissions during OD operations at TA-36 or TA-39 and are not included in the modeling exercise.

For volatile organic compound (VOC) emissions, Section 2.1.4.3 of the background document for the draft Chapter 16 (Background Document AP-42 2009; Attachment C) states that the SNL and DPG test results demonstrated conclusively that the VOCs emitted were almost exclusively the first members of the alkane, alkene, and alkyne classes of hydrocarbons and the first members of the aromatic hydrocarbon class, of which benzene is the most toxic. A key point was that for every energetic material detonated in the SNL study and on the test range at DPG, benzene represented a substantial percentage of the total mass of the aromatic hydrocarbons found but was only 2.0 percent of the total mass for all the non-methane hydrocarbons (TNMHCs).

The emission products and related emission factors used in the modeling exercise for OD operations at TA-36 and TA-39 are shown in Table 4-10. These emission factors are based primarily on Table 16.2-14, Summary Statistics for the Detonation Data Sets from the draft AP-42 Chapter 16. A list of explosives detonated at the units was developed from the operating record for the RCRA waste explosives detonated. The chemicals were placed into categories, with a single emission factor for each category. Categories can generally be described to be components of the waste stream itself (e.g., energetics, metals, and fuel) or constituents produced as part of the treatment process (i.e., emission products). A list of emission products and emission factors was derived from a list of explosives and explosives-contaminated waste detonated at the OD units.

For this application submittal, the draft Chapter 16 for AP-42 represents the most current publicly available information as prepared for the U.S. Army Defense Ammunition Center, McAlester, Oklahoma, under Contract Number DACA87-02-D0028; however, subsequent work and OD plume studies have been conducted since 2010 as part of a program under the direction of Dr. Keith Clift, and program studies have been conducted by Dr. Brian Gullett. Dr. Clift was the Demilitarization Capabilities Division Chief for the Demilitarization Directorate at the Joint Munitions Command (JMC). Dr. Clift's program has continued OB/OD emissions testing with Dr. Gullet's team for a two-fold purpose: to continue to fill data gaps for OB/OD emissions factors (i.e., covered OD data gaps, etc.) and to increase both the quantity and representativeness of the data by collecting open-air/live-fire data from actual production OB/OD demilitarization operations. Some of the testing is being done because of the improved sampling methods

and/or analytical methods available, including the use of drones, which allows for much-improved latitude to sample emissions within the dynamic OB/OD plume. Interim data processing is currently being performed. The program is an ongoing effort to enhance and improve the data quality of existing OB/OD emission factors.

Dr. Gullett is the Senior Professional Research Engineer for the Air and Energy Management Division at the National Risk Management Research Laboratory at the Office of Research and Development for the EPA in the Research Triangle Park in North Carolina. Dr. Gullett is the lead researcher for the JMC demilitarization program for OB/OD studies. Since 2010, Dr. Gullett's team has compiled a database on OB/OD emission factors for the military's JMC. This database references data that have gone through the EPA's quality assurance review process and are published in public journals or DoD reports. The published journals and DoD reports currently available for public review have little or no additional information on (uncovered) open-range detonations such as those being conducted at LANL. Additional studies, including those for uncovered open-range detonations, were planned for 2020, but were not conducted until August and November 2021. Based on a communication with Dr. Gullett (email dated March 1, 2023), the EPA is preparing an updated emission factor database that should be available by mid-2024.

In Table 4-11, emission factors are shown with the emitted contaminants and are indicated in units emitted per unit of explosive material detonated. Emission products and related constituents were obtained from a third party based on waste treated at LANL (CCS 2011). The emission factors are applied as listed in Table 4-11. The emission factors are listed for the constituents that are identified as criteria pollutants or TAPs and those with known human health risk or ecological screening values.

Table 4-11. Emission Products and Emission Factors for Explosive Waste Detonated at OD Sites

Contaminant	Note	Emission Factor (lb/lb waste)
Carbon Monoxide	1	7.1E-02
PM10	2	2.9E-01
PM2.5	2	4.2E-01
Nitrogen Oxides	(as NO_2 only)	5.3E-02
Sulfur Dioxide	1	4.8E-04
Benzene	1	2.0E-04
TNMHC	1	7.7E-03
Acetylene	1	7.7E-04
Ethylene	1	7.1E-04
Propylene	1	1.3E-04
Toluene	1	6.7E-05
Naphthalene	3	2.8E-07
Methylene Chloride	1	6.2E-04
Aluminum Oxide	5	7.7E-02
Barium	5	4.2E-02
Cobalt Acetoacetonate	5	5.9E-04
Copper	5	5.9E-04
Lead	5	4.4E-03
Trioctyl phosphate	4	2.6E-01
Aluminum	5	9.8E-02

Contaminant	Note	Emission Factor (lb/lb waste)
Titanium	5	9.8E-02
Ammonium perchlorate	3	2.8E-07
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX)	3	2.8E-07
Nitrocellulose	3	2.8E-07
Nitroguanidine	3	2.8E-07
Nitromethane	3	2.8E-07
Pentaerythritol tetranitrate (PETN)	3	2.8E-07
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	3	2.8E-07
Tetryl	3	2.8E-07
2,4,6-trinitrotoluene (TNT)	3	2.8E-07
Acrylonitrile	6	1.00E−08
Bis(2-ethylhexyl) adipate	6	1.00E−08
tris-2-chloroethyl phosphate	6	1.00E−08
Dibutylphthalate	6	1.00E−08
Dinitrotoluene (2,4-)	6	1.00E−08
Dioctyladipate	6	1.00E−08
Dioctylphthalate	6	1.00E−08
Diphenylamine	6	1.00E−08

Notes:
[1] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42
[2] Emission factors for $PM_{2.5}$ and PM_{10} are based on the paper "Aerostat-based sampling of emissions from open burning and open detonation of military ordnance," J. Aurell, et al. *Journal of Hazardous Materials*, Oct. 2014.
[3] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42 for SVOCs Not in Energetics
[4] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42 for Metals in Energetics as Compounds
[5] Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is less than 7.7% for metals, except Lead, Barium, and Copper. See Attachment 4 for the calculation. The metal fractions of metal waste for Lead, Barium and Copper are calculated separately in Att. 4.
[6] Based on the Mean Emission Factors listed in Table 16.2-14 of the draft Ch. 16 of AP-42 for SVOCs in Energetics. Because no data are listed for this emission product, the value for below detection limits was assigned as explained in Section 2.1.4.4, Page 22, of the Ch. 16 Background Document.

4.3.3 *Receptor Grid Description*

The LANL site and outermost property boundary are extensive in size. In addition, some public roadways and houses are located within the outermost boundary. Receptor grid specifications consider these factors. In addition to the receptors listed for the OB and OD modeling using OBODM, the following receptor grids were used in the analysis:

- a fence line grid with 100-meter spacing along the outermost property boundary;
- a fine grid with 100-meter spacing that extends 1 km from the property boundary;
- a medium grid with 500-meter spacing that extends 5 km from the property boundary;
- a coarse grid with 1000-meter spacing that extends 10 km from the property boundary; and
- additional fine grids at the Elk Ridge trailer park on East Jemez Road (the truck route) and along public roadways that cross LANL (SR 4 from White Rock to TA-33, Main Hill Road up to and through Los Alamos, and West Jemez Road at TA-3 up to the intersection with SR 4).

Public entry is prohibited on Pajarito Road to provide additional security for key LANL operations along that corridor. No receptors were placed on Pajarito Road for AERMOD modeling.

Public receptors contained within the established grids total a large figure greater than 22,500 grid dimensions and are conservative because of the extensive property boundary, and public receptor grids extending beyond the required modeling distances. Evaluating impacts for receptors located in a grid at each OB/OD site also increases the grid size. The receptor grids established for this analysis ensure that the maximum impacts were captured for both public receptors and receptors located in grids surrounding the OB and OD sites.

LANL is located in a complex terrain. Ground elevations were obtained from https://apps.nationalmap.gov/downloader/#/. A national elevation dataset GeoTiff file for the modeling domain was downloaded. The dataset has a resolution of 1/3 arc-second (approximately 10 meters) and uses the NAD 83 UTM coordinate system.

4.3.4 *Meteorological Data*

The 2021 LANL TA-6 meteorological tower data was used in the dispersion modeling. The TA-6 tower is LANL's official weather station and is representative of the meteorological conditions at the facility. The TA-6 station consists of a 92-meter tower instrumented for wind and temperature at four levels and near-surface instrumentation for measuring temperature, moisture, pressure, precipitation, and surface energy balance terms. Surface data from all four levels of the tower for calendar year 2021 were used. For preparation of the dataset, Trinity Consultants used AERSURFACE to produce detailed land use inputs, including surface roughness that varies depending on the wind direction (and corresponding upwind land use) at each hour. Trinity also switched the NWS surface station for cloud cover data from Albuquerque to the Los Alamos Airport (KLAM) because of the good-quality cloud cover data for 2021, where the base elevation is 2263 meters. The 2021 1-year dataset containing the profile and surface files were submitted to NMED for review and approval.

4.3.5 *Ambient Air Quality Standards*

National and New Mexico Ambient Air Quality Standards

Ambient air quality standards are the maximum allowable concentrations designed to protect the most sensitive individuals from harm from airborne pollutants. Table 4-12 is from the "New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines" and lists the national and New Mexico ambient air quality standards and applicable significance levels. Air toxics as listed in 20.2.72 New Mexico Administrative Code are pollutants, and the emissions will be assessed. Modeling will be completed where required by the guidance.

Table 4-12. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Period	Significance Level ($\mu g/m^3$)	Class I Significance Level ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	NMAAQS ($\mu g/m^3$ unless noted)	PSD Increment Class I ($\mu g/m^3$)	PSD Increment Class II ($\mu g/m^3$)
CO	8-hour	500		10,303.6	9960.1		
	1-hour	2000		40,069.6	14,997.5		
H_2S	1-hour	1.0			13.9		
	1/2-hour	5.0			139.3		

Pollutant	Averaging Period	Significance Level (µg/m^3)	Class I Significance Level (µg/m^3)	NAAQS (µg/m^3)	NMAAQS (µg/m^3 unless noted)	PSD Increment Class I (µg/m^3)	PSD Increment Class II (µg/m^3)
	1/2-hour	5.0			41.8		
Pb	Quarterly	0.03		0.15			
NO_2	annual	1.0	0.1	99.66	94.02	2.5	25
	24-hour	5.0			188.03		
	1-hour	7.52		188.03			
O_3	8-hour	1.96		137.3			
PM2.5	annual	0.2	0.05	12		1	4
	24-hour	1.2	0.27	35		2	9
PM_{10}	annual	1.0	0.2			4	17
	24-hour	5.0	0.3	150		8	30
SO_2	annual	1.0	0.1		52.4	2	20
	24-hour	5.0	0.2		261.9	5	91
	3-hour	25.0	1.0	1309.3		25	512
	1-hour	7.8		196.4			
Reduced S	1/2-hour				3 ppb		
	1/2-hour				10 ppb		

Source: NMED 2022

Air dispersion modeling for this project does not include an assessment for Prevention of Significant Deterioration (PSD) increment consumption. LANL is located in Air Quality Control Region 157, where minor source baseline has not been triggered and PSD increment-consuming emission sources do not exist. Facility emissions that result in ambient impacts below significance levels are not considered to contribute to exceedance of air quality standards and were not analyzed further for cumulative impact.

4.3.6 *Cumulative Impact Analysis*

Cumulative impact analyses will be conducted for pollutants and averaging period for which a significance level is exceeded. A neighboring source emission inventory was obtained for each OB and OD site from the NMED AQB Modeling Group in May 2023 for a modeling analysis to determine the impact of nearby sources. For insignificant impacts, cumulative impact determination using the addition of background concentration or surrounding source analysis will not be conducted.

For CO, NO_2, and SO_2, the dispersion modeling guidelines allow two methods to determine cumulative impact. The measured background concentration from an ambient air quality monitor is added to the modeled facility's maximum impact. Alternatively, the dispersion modeler has the option to model all nearby sources instead of adding a background concentration if the facility is more than 10 km from the center of Albuquerque and El Paso. For this project, LANL is choosing to add background concentration from approved ambient monitors (see Table 4-13) to obtain conservative maximum cumulative impact. LANL is situated in a rural area with few offsite nearby emission sources and most nearby sources are other LANL operations. Adding background concentrations from ambient monitors located in areas with more population and higher industrial activity, such as Santa Fe, Bloomfield, and Albuquerque (see Table 4-13) will result in a conservatively high prediction of the maximum ambient impact.

For particulate emissions, in accordance with the AQB dispersion modeling guidelines, all permitted nearby emission sources within 10 km will be modeled, a secondary formation concentration will be calculated (for PM2.5), and a background concentration from appropriate ambient monitor will be combined to obtain the cumulative impact.

The dispersion modeling included analysis of groups of selected emission sources—called *source categories*—to determine their ambient contribution. At a minimum, the groups analyzed will include (1) the OB-OD emission sources alone, and (2) the nearby emission sources to determine the cumulative impact where applicable.

Cumulative impact analysis will include two methods:

- For gaseous pollutants such as CO, NO_2 and SO_2, facility-only impact will be added to the background concentrations for the selected averaging period from appropriate ambient monitors (Table 4-13) approved by the NMED AQB. Most of the monitors listed are from highly populated (Albuquerque) or highly industrialized (Bloomfield) areas and will result in higher backgrounds when compared with the LANL airshed and surrounding area.
- For particulate matter, facility and nearby sources will be modeled separately since facility emissions are based on unitized emission rates, and the background concentrations from appropriate ambient monitors will be added as specified in the modeling guidelines. For PM2.5, the concentration for secondary formation will be added to the cumulative impact.

Table 4-13. Methods Proposed for Cumulative Impact Analysis

Pollutant	Averaging Time	Cumulative Impact Method	Background Ambient Concentration µg/m^3	Ambient Monitor	NAAQS or NMAAQS µg/m^3
CO	8-hour	Maximum screening high 8- hour concentration plus background concentration	1265	Albuquerque del Norte High School	9960.1
CO	1-hour	Maximum screening high 1-hour concentration plus background concentration	2148	Albuquerque del Norte High School	14,997.5
NO_2	Annual	Maximum screening concentration plus background concentration	17.2	Albuquerque del Norte High School	94.02
NO_2	24-hour	Compliance with the NO_2 1-hour standard satisfies this requirement but modeling was completed for the 24-hour standard.	–	–	188.03
NO_2	1-hour	Maximum screening concentration plus 1-hour 98th%ile background concentration	81.2	Albuquerque del Norte High School	188.03
PM2.5	Annual	Maximum screening concentration plus annual background concentration	3.7	Santa Fe	12
PM2.5	24-hour	Maximum concentration plus nearby sources, plus secondary formation, plus 98th %ile background concentration	9.2	Santa Fe	35

Pollutant	Averaging Time	Cumulative Impact Method	Background Ambient Concentration µg/m^3	Ambient Monitor	NAAQS or NMAAQS µg/m^3
PM10	24-hour	Facility plus surrounding sources, plus nearby sources, plus 2nd high background concentration	19.0	Santa Fe	150
SO_2	Annual	Maximum screening concentration plus annual 99th%ile background concentration	1.3	Albuquerque del Norte High School	52.4
SO_2	24-hour	Per NMED AQB guidelines, SO_2 1-hour NAAQS is the surrogate that demonstrates compliance, but modeling was completed for the 24-hour standard.	–	Not applicable	261.9
SO_2	3-hour	Per NMED AQB guidelines, SO_2 1-hour NAAQS is the surrogate that demonstrates compliance, but modeling was completed for the 3-hour standard.	–	Not applicable	1309.3
SO_2	1-hour	Maximum screening concentration plus 1-hour 99th%ile background concentration	10.1	Albuquerque del Norte High School	196.4

4.3.7 *Summary of OBODM and AERMOD Unitized Emission Rate Modeling*

The following tables and figures focus on the results of using OBODM results for both maximum concentrations for the 1-hour, 3-hour, 8-hour, and 24-hour averaging periods and the associated analysis of the plume rise parameters. Overall, the worst-case plume rise (minimum plume rise as noted in ATK Addendum 2013) parameters are directly associated with the conditions that created the maximum concentration for the one-hour averaging period. The plume rise parameters associated with the maximum one-hour concentration for each of the three sites is presented in Table 4-14.

Results for the hybrid OBODM/AERMOD air dispersion modeling project demonstrated that the AERMOD modeling produced considerably higher results than the maximum OBODM results (see Figure 4-10). Table 4-16 through Table 4-18 demonstrate these findings. The AERMOD results of the listed averaging times and locations are presented in Figure 4-11 through Figure 4-13 for each site.

For the maximum 1-hour concentration for ODTA-39-6, operations were modeled based on the period of 8 a.m. to 5 p.m. The hours of operation for the AERMOD modeling were restricted to the period of 10 a.m. to 3 p.m. for 1000-pound-per-hour detonations because of the potential impact of PM2.5 at the public receptors. See Section 5.0 for further details and the analysis of PM2.5 cumulative impact.

In summary, the details provided in Table 4-16 through Table 4-18 demonstrate that the AERMOD results using the hybrid modeling methods are considerably higher than the OBODM results for all averaging times evaluated above; therefore, the hybrid modeling method provides much more conservative results than OBODM modeling alone.

Table 4-14. Date and time for maximum OBODM 1-hour concentration and calculation of volume source release height, and initial horizontal and vertical dimensions.

							AERMOD Release Hgt. or max.plume Rise	Release Hgt. (Center of Vol. above ground)	Radius (m) of cloud at	Diameter (m) of cloud at	Initial Horizontal	Initial Vertical	1-hr Max
				Minimum Plume Rise and Distance									
OB-OD Sites	MONTH	DAY	HOUR	Rise - m	Max Hgt.- m	Distance - m	meters	meters	final plume Ht.	final plume Ht.	Dim. (SYINIT)	Dim. (SZINIT)	ug/m3
ODTA-36-8	1	21	0900	145.9	159.2	107.6	159.2	79.60	96.48	192.96	44.87	37.02	0.252
ODTA-39-6	1	8	0800	123.6	134.2	250.6	134.2	67.10	81.48	162.96	37.90	31.21	4.157
OBTA-16-388	12	11	0900	89.8	90.3	94.8	90.3	45.2	55.14	110.28	25.65	21.00	17.15

Table 4-15. List of OBODM and AERMOD Modeling File Names

OB / OD site	Model Run	File Names
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr 1-3-8-24hr AllReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr 1-3-8-24hr PublicReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr Annual AllReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr Annual PublicReceptors CO2_2021_CO2
TA-36-8	AERMOD	ODTA36-8 1-21-2021 0900hr Monthly PublicReceptors CO2_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr 1-3-8-24hr AllRec 1000-lb 10am-3pmOps_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr 1-3-8-24hr PublicRec 1000-lb 10am-3pmOps_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr Annual AllRec 1000-lb 10am-3pm M-F_2021_CO2
TA-39-6	AERMOD	ODTA39-6 1-8-2021 0800hr Annual+Monthly PublicRec 1000-lb 10am-3pmOps_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr AllRecs_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr Public rec_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr Annual AllReceptors_2021_CO2
TA-16-388	AERMOD	OBTA16-388-2023 12-11-2021 0900hr Annual Public rec_2021_CO2
TA-39-6	OBODM	39H1TST.INP and 39H1TST.OUT
TA-16-388	OBODM	388H1Y23.INP and 388H1Y23.OUT
TA-36-8	OBODM	36H1Y23.INP and 36H1Y23.OUT

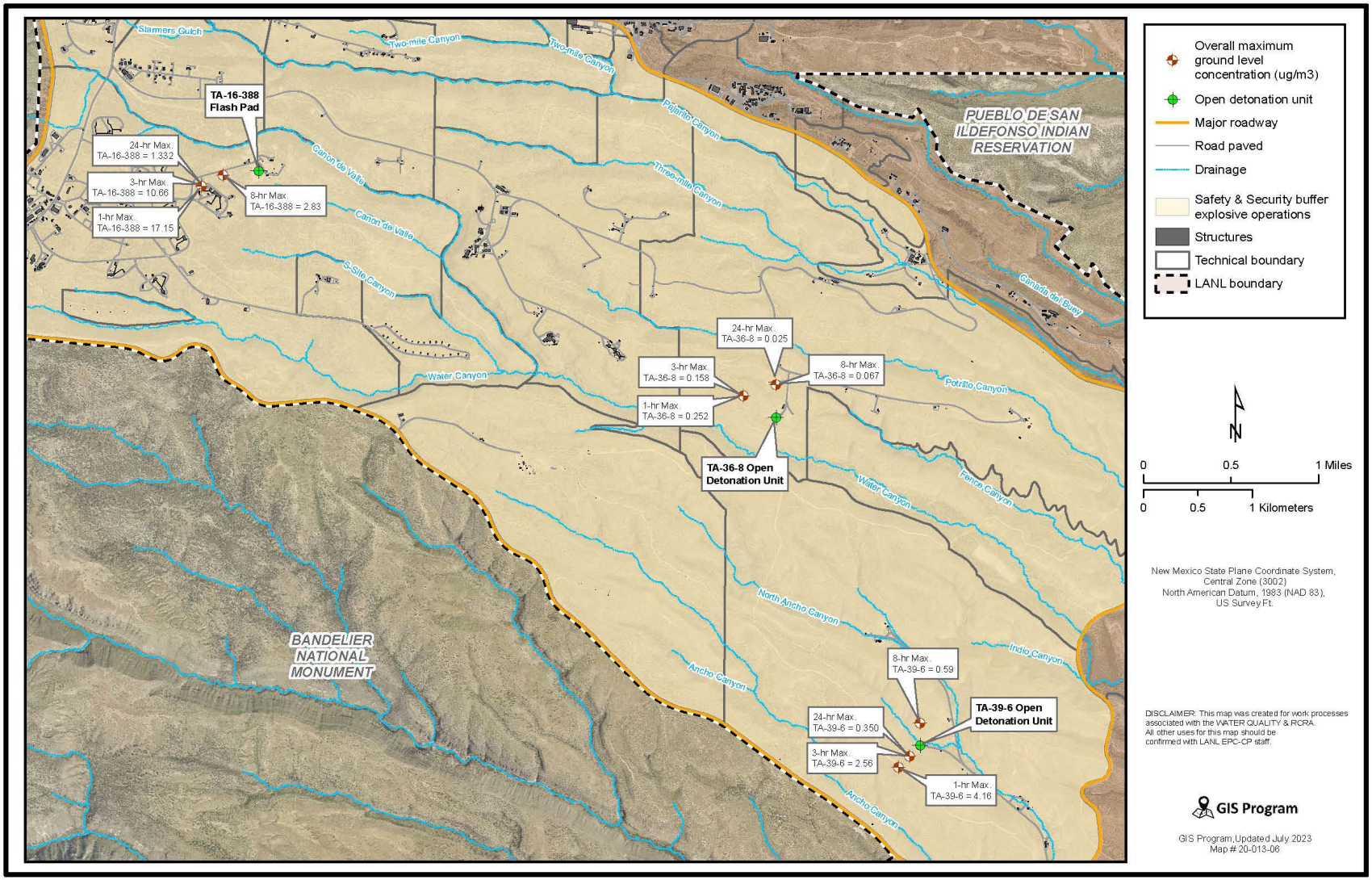

Figure 4-10. Maximum OBODM concentrations for a unitized emission rate and location of results.

Table 4-16. Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors, plus ratio of AERMOD results to OBODM results for All Receptors at ODTA-36-8.

											All Receptors
				AERMOD							AERMOD/
OD TA-36-8	OBODM			Concentration		AERMOD			AERMOD		OBODM
	All Receptors			for Same OBODM	AERMOD	All Receptors		AERMOD	Public Receptors Only		Conc. Ratio
Model	8am-5pm	X-Coordinate	Y-coordinate	Receptor	All Receptors	X-Coordinate	Y-coordinate	Public Receptors	X-Coordinate	Y-coordinate	Increase or
Averaging (t)	ug/m3	meters	meters	ug/m3	ug/m3	meters	meters	ug/m3	meters	meters	(-) Decrease
1-hr Max. (C)	0.252	384130.0	3965730.0	21.47	51.92	384230.0	3965530.0	6.18	383102.6	3963208.6	205.70
3-hr Max. (C)	0.158	384130.0	3965730.0	10.74	21.06	384330.0	3965530.0	2.07	383102.6	3963208.6	133.41
8-hr Max. (C)	0.067	384430.0	3965830.0	6.70	13.11	384330.0	3965630.0	1.44	382217.7	3964283.6	196.34
24-hr Max. (C)	0.025	384430.0	3965830.0	2.33	4.37	384330.0	3965630.0	0.48	382217.7	3964283.6	176.02
Annual Max. (C)	Not Available (NA) (1)				1.07	384430.0	3965630.0	0.029	382217.7	3964283.6	NA (1)
Notes											
(1) Desktop with Windows XP failed before annual concentrations were modeled using OBODM. However, the key plume rise parameters for calculating the volume source release parameters is based on the hourly results.											

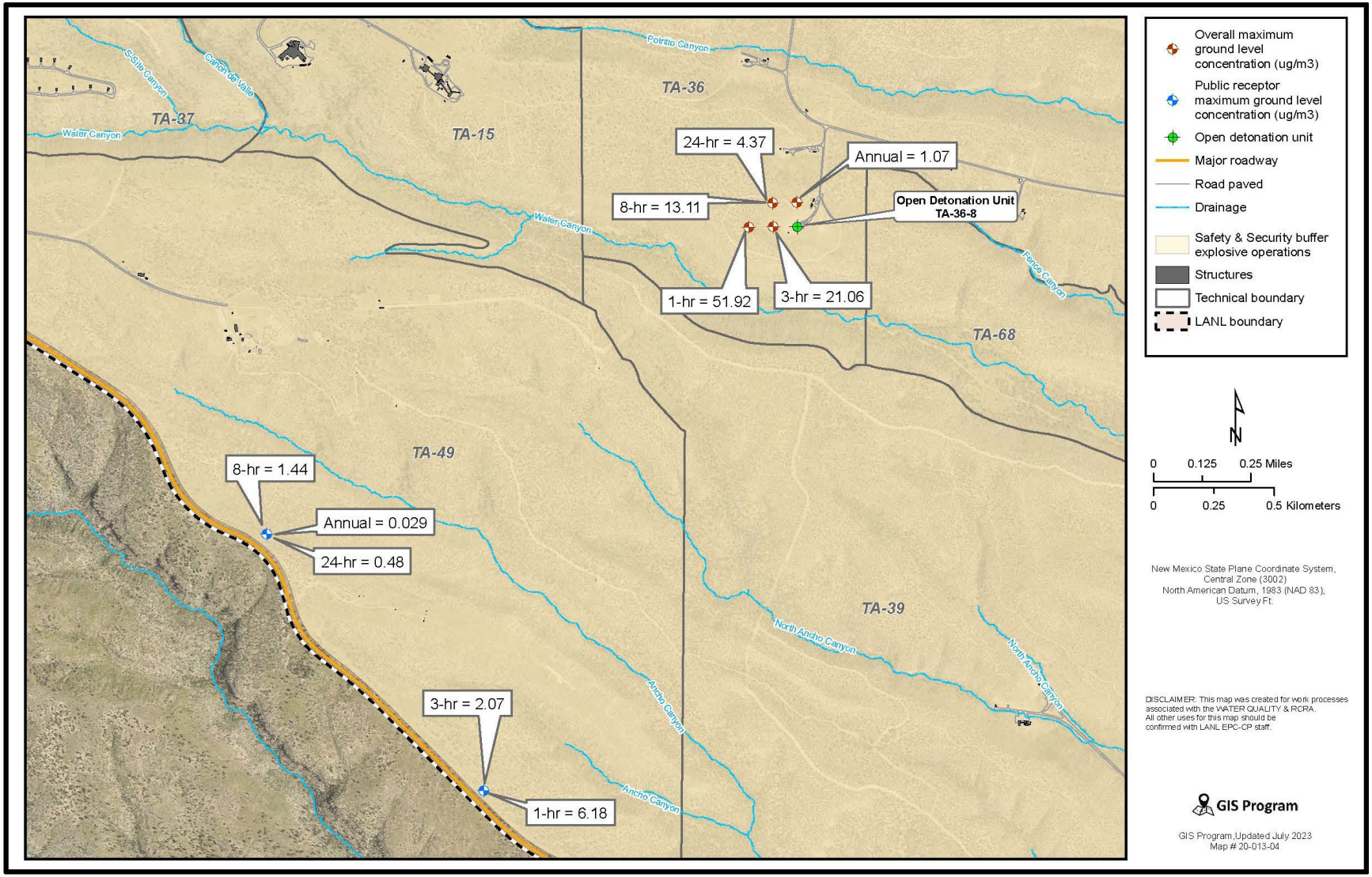

Figure 4-11. ODTA-36-8 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors.

Table 4-17. ODTA-39-6 Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

											All Receptors
				AERMOD		AERMOD		AERMOD			AERMOD/
OD TA-39-6	OBODM			Concentration	AERMOD	All Receptors		AERMOD	Public Receptors Only		OBODM
	All Receptors			for Same OBODM	10a-3pm	10a-3pm		10a-3pm	10a-3pm		Conc. Ratio
Model	8am-5pm	X-Coordinate	Y-coordinate	Receptor	All Receptors	X-Coordinate	Y-coordinate	Public Receptors	X-Coordinate	Y-coordinate	Increase or
Averaging (t)	ug/m3	meters	meters	ug/m3	ug/m3	meters	meters	ug/m3	meters	meters	(-) Decrease
1-hr Max. (C)	4.16	385514.0	3962301.0	19.38	38.34	385614.0	3962306.0	10.38	384957.8	3962054.5	9.22
3-hr Max. (C)	2.56	385614	3962401	21.71	21.71	385614.0	3962401.0	5.51	384943.4	3962068.0	8.48
8-hr Max. (C)	0.59	385714	3962701	3.66	11.90	385714.0	3962601.0	2.61	384943.4	3962068.0	20.07
24-hr Max. (C)	0.350	385614	3962401	3.49	3.97	385714.0	3962601.0	0.87	384943.4	3962068.0	11.33
Annual Max. (C)	Not Available (NA) (1)				0.79	385714.0	3962601.0	0.043	384957.8	3962054.5	NA (1)
Notes											
(1) Desktop with Windows XP failed before annual concentrations were modeled using OBODM. However, the key plume rise parameters for calculating the volume source release parameters is based on the hourly results.											

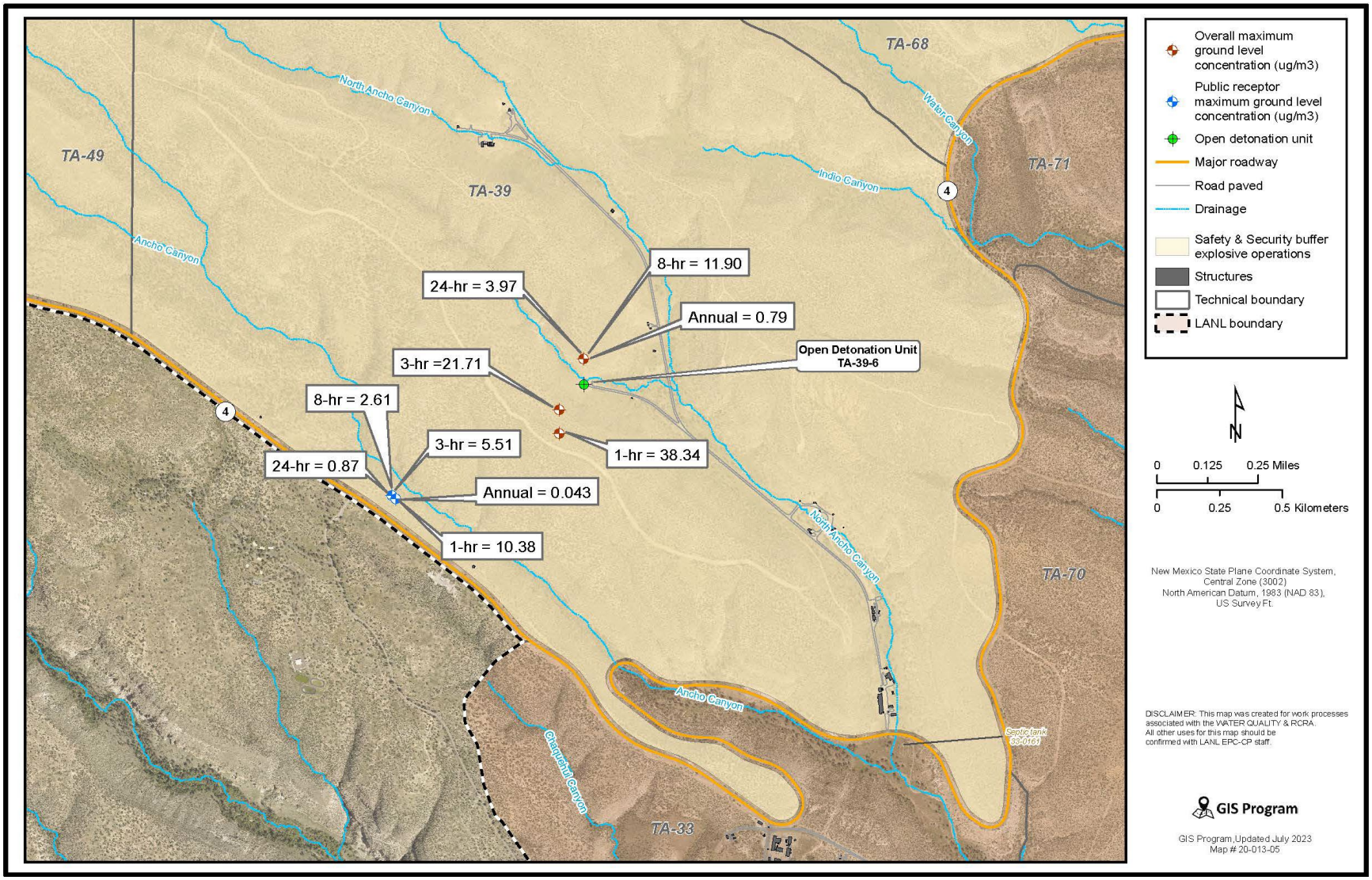

Figure 4-12. ODTA-39-6 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

Table 4-18. OBTA-16-388 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

											All Receptors
				AERMOD							AERMOD/
OB TA-16-388	OBODM			Concentration		AERMOD			AERMOD		OBODM
	All Receptors			for Same OBODM	AERMOD	All Receptors		AERMOD	Public Receptors Only		Conc. Ratio
Model	8am-5pm	X-Coordinate	Y-coordinate	Receptor	All Receptors	X-Coordinate	Y-coordinate	Public Receptors	X-Coordinate	Y-coordinate	Increase or
Averaging (t)	ug/m3	meters	meters	ug/m3	ug/m3	meters	meters	ug/m3	meters	meters	(-) Decrease
1-hr Max. (C)	17.15	379170.0	3967721.0		132.55	379570.0	3967821.0	16.05	377650.0	3962796.0	7.73
3-hr Max. (C)	10.66	379170.0	3967721.0		51.42	379570.0	3967821.0	5.47	379282.3	3966223.5	4.82
8-hr Max. (C)	2.83	379370.0	3967821.0		34.97	379570.0	3967821.0	2.06	377233.6	3966970.0	12.36
24-hr Max. (C)	1.332	379170.0	3967721.0		12.60	379570.0	3967821.0	0.76	379282.3	3966223.5	9.45
Annual Max. (C)	Not Available (NA) (1)				2.56	379570.0	3967821.0	0.054	379048.3	3966298.6	NA (1)
Notes											
(1) Desktop with Windows XP failed before annual concentrations were modeled using OBODM. However, the key plume rise parameters for calculating the volume source release parameters is based on the hourly results.											

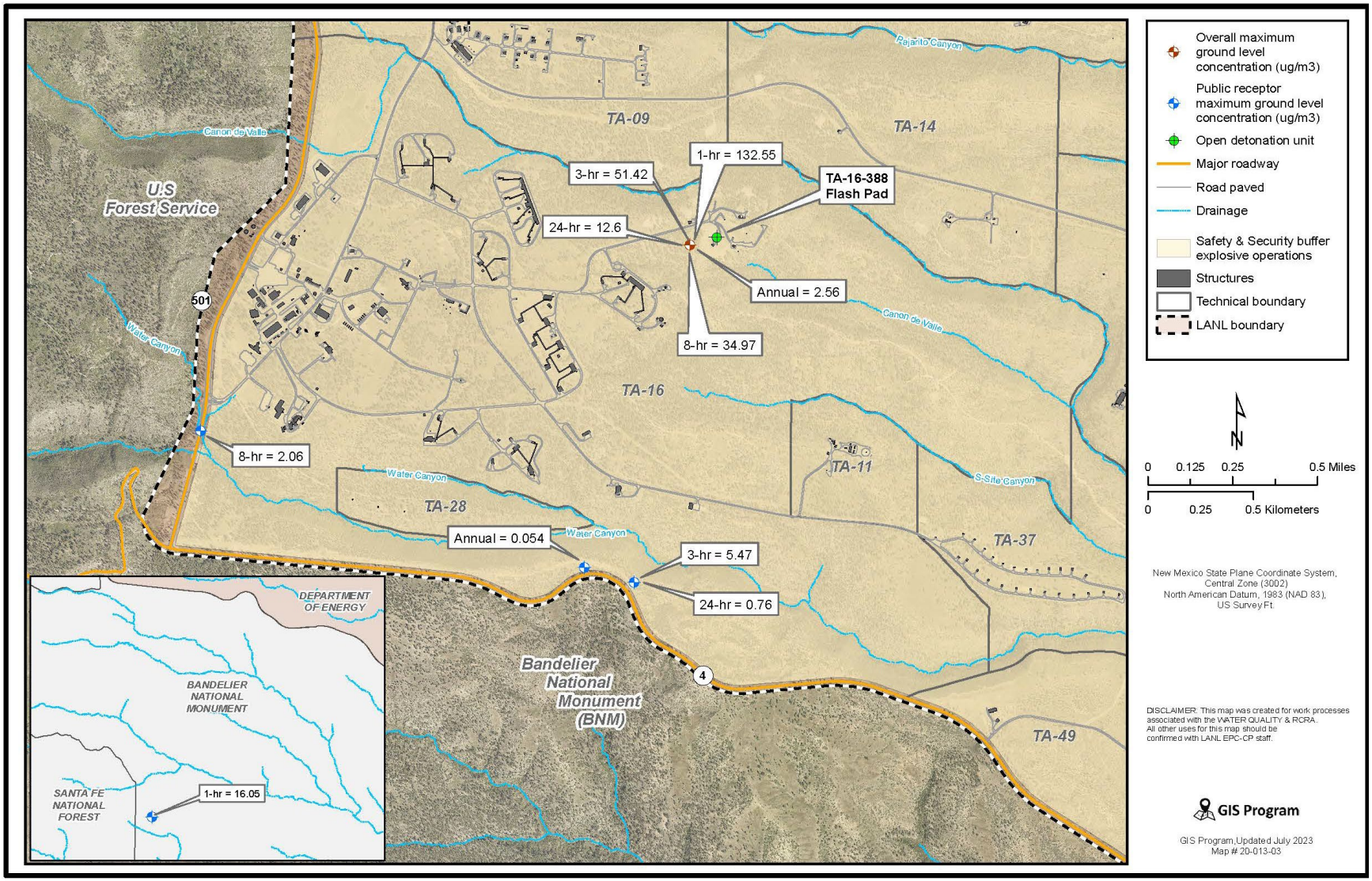

Figure 4-13. OBTA-16-388 - Maximum AERMOD concentrations for unitized emissions and location of results for All Receptors and Public Receptors

5 Results for Assessment of the Criteria Pollutant Air Quality Standards and Acute Health, Chronic Health, and Soil Deposition and LANL ESL Screening Levels

The AERMOD analysis of TA-16-388, TA-36-8, and TA-39-6 had similar results for the assessment of NAAQS and NMAAQS criteria pollutants. Based on the hybrid air modeling dispersion methods described herein, none of the evaluations resulted in exceedances of the criteria listed in Tables 5-1 to 5-6c. For criteria pollutants, only a few Significant Impact Levels (SIL) were exceeded, but for each exceedance of a SIL, the subsequent cumulative impact analyses were less than the respective NAAQS or NMAAQS.

AERMOD predicted that the CO, SO2, Lead, annual PM2.5, and annual NO2 emissions result in insignificant impacts to the ambient air and did not require further analysis. The emissions of regulated pollutants 1-hour NO_2, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ resulted in significant impacts (exceedance of a SIL) for ambient air, and each pollutant required a cumulative impact determination. AERMOD analysis used an extensive receptor grid extending beyond 10 kilometers from the LANL property boundary, together with property boundary receptors, as well as receptors at public locations within the LANL boundary. The cumulative impacts for gaseous pollutants 1-hour NO_2, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ were determined by adding the NMED-recommended ambient monitor background to the ambient impact of each pollutant for each OB/OD site. The cumulative ambient impact for particulate emissions was determined by modeling all nearby permitted sources and combining this result with the maximum AERMOD OB and OD modeling results where a unitized emission rate was used. These were combined with the recommended ambient monitor background to the model predicted ambient impact. $PM_{2.5}$ also included an estimate of secondary emissions calculated based on NMED modeling guidance (NMEDa 2022).

Again, the dispersion model results predict that the OB and OD emissions of Pb, CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$ comply with the air quality standards and do not cause or contribute to exceedance of the NAAQS or NMAAQS. Additionally, this study demonstrates that the cumulative impacts, when surrounding source emissions, background pollutant concentrations, and secondary formation for $PM_{2.5}$ are included, do not cause or contribute to exceedance of NAAQS and NMAAQS.

Excel spreadsheets were used to calculate constituent-specific air and soil concentrations and for comparison to appropriate screening levels. For each OD site the following calculations and comparisons were made:

- Maximum 1-, 3-, 8-, 24-hour, quarterly (Pb) concentrations, and annual average concentrations were calculated and compared to the NAAQS and NMAAQS for public receptors;
- Maximum 1-hour concentrations were calculated and compared to the lesser of the AIEC acute values and CA-OEHHA acute Reference Exposure Level (REL) (CA OEHHA 2023) where values exist;
- Annual average air concentrations were calculated and compared to the lesser of the CA-OEHHA Non-Cancer REL Chronic (µg/m3) (CA OEHHA 2023) and EPA Resident Air Non-carcinogenic SL for THI = 0.1 (µg/m3) (EPA 2023);
- Soil concentrations from deposition were calculated and compared to NMED Human Health Cancer and Non-Cancer Residential Soil SSLs (NMED 2022b and NMED 2022c). Where both Cancer and Non-Cancer values existed, both values were compared to the maximum concentration based on AERMOD results. Where NMED data was not available, EPA RSL screening levels for Residential Soil were applied (EPA 2023). EPA Carcinogenic SL values are based on a target risk of $TR=1E^{-06}$ and Non-Carcinogenic SL Child values are based on a Target Hazard Index (THI) of 0.1 (mg/kg). The LANL-derived ESLs are also included for review and comparison and in some cases was the only value available for soil concentration analysis.

- Concentrations for emission products were calculated whether there was a screening level or not. A comparison of the calculated values from model results with the EPA and NMED ambient air quality standards are summarized in Tables 5-1, 5-2, and 5-3. In cases where there is a NAAQS and NMAAQS for the same pollutant and same averaging period, the more stringent standard was evaluated. Background concentrations for all forms of particulate matter have been added to model results as specified by NMED and the total value is shown in the tables for comparison to standards (NMEDa, 2022).

The Ambient Air Quality Standard (AAQS) included within Tables 5-1, 5-2, and 5-3 includes both an EPA NAAQS and a New Mexico NMAAQS where applicable. All calculations used in providing results, as well as all NAAQS and NMAAQS, are shown in the following tables.

This AAQS analysis was conducted using the highest maximum model result that occurred at any public receptor. Receptors on LANL property were not used as is the protocol under NMED modeling guidelines when demonstrating compliance with ambient air quality standards for permit purposes (NMEDa, 2022). In this respect, NMED follows EPA direction regarding the definition of *ambient air*, which defines where the air quality standards are applicable.

As demonstrated in the tables, no AAQS were exceeded. All results are conservatively predicted and presented in Tables 5-1, 5-2, and 5-3. Tables 5-4a, 5-4b, 5-4c, 5-5a, 5-5b, 5-5c, 5-6a, 5-6b, and 5-6c compare the calculated values from model results with the acute and chronic air health screening levels and the soil deposition screening and LANL ESL levels. Gravitational deposition would be significant only for relatively large particles deposited close to the detonation sites. Wet deposition should be insignificant for detonations which occur infrequently and never during precipitation events. Thus, non-gravitational dry deposition should be the major contributor to soil concentrations of contaminants. This type of deposition was conservatively estimated using the calculation provided by the California EPA for air toxics analyses found in the document *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (CA OEHHA, 2015).

There are several levels of conservatism present in the deposition estimates using this approach. First, the annual contaminant air concentration used in the calculation is based on running AERMOD using the unitized emissions rate of 1 gram/second to calculate an annual concentration to be used for each pollutant assessment, and the pollutant emission factor is applied to the maximum annual waste to be treated to calculate the maximum annual concentration. Second, the single maximum annual air concentration is used, which is a non-depleted value (e.g., there is no removal of contaminant mass from the detonation cloud as a function of downwind distance). In the calculation, it is assumed there is no degradation of organic compounds in the soil over time, which again results in an over prediction of soil concentrations during the 10-year estimate. The deposition rate or Dep-rate used was the CAL EPA recommended value for an uncontrolled source, which is 0.05 meters/second.

Using this procedure, soil concentrations were calculated using the maximum annual air concentrations for each contaminant. The calculation is shown below:

$C_s = Dep \times X / (K_s \times SD \times BD \times T_t)$

Dep = Deposition on the affected soil area per day ($\mu g/m^2/d$)

Dep = GLC × Dep-rate × 86,400

GLC = chemical specific annual ground level concentration from the AERMOD result and emission factor ($\mu g/m^3$)

Dep-rate = 0.05 m/sec (default value for uncontrolled source)

86,400 = Seconds per day conversion factor

$X = [\{e^{-K_s \times T_f} - e^{-K_s \times T_o}\} \div K_s] + T_t$

e = 2.718

K_s = Soil elimination constant = 6.93×10^{-9} (no degradation of contaminant in soil assumed)

T_f = End of evaluation period (d) = 3650

T_o = Beginning of evaluation period (d) = 0

T_t = Total days of exposure period $T_f - T_o$ (d) = 3650 (10-year period)

SD = Soil mixing depth (m) = 0.01 for soil ingestion or dermal pathway (analysis is on Laboratory property)

BD = Soil bulk density (kg/m^3) = 1,333

Table 5-1. Air Quality Standards Results for TA-36-8

Basis								
2000	**lb/hr detonation**							
1	detonations/hr							
0.0044	Lead compounds fraction - lb Pb/lb waste (1)(1a)							
15000	lb/yr detonation							
1	g/sec contaminant emission rate							
AERMOD Results (X/Q)								
-	**ODTA36-8 1-21-2021 0900hr 1-3-8-24hr PublicReceptors CO2_2021_CO2**							
-	**ODTA36-8 1-21-2021 0900hr Annual PublicReceptors CO2_2021_CO2**							
6.1820	1-hour maximum value, µg/m³ per g/sec contaminant							
3.8079	4th highest 1-hour maximum value, µg/m³ per g/sec contaminant for SO2							
2.9686	8th highest 1-hour value, µg/m³ per g/sec contaminant for NO2							
2.0659	3-hour maximum value, µg/m³ per g/sec contaminant							
1.4412	8-hour maximum value, µg/m³ per g/sec contaminant							
0.4807	24-hour maximum value, µg/m³ per g/sec contaminant							
0.2995	2nd highest 24-hour maximum value, µg/m³ per g/sec contaminant for PM10 only							
0.1802	8th highest 24-hour value, µg/m³ per g/sec contaminant for PM2.5 only							
0.0552	Monthly maximum value, µg/m³ per g/sec contaminant							
0.0289	Annual maximum value, µg/m³ per g/sec contaminant							

					Secondary PM2.5			
						NO2 tpy	**SO2 tpy**	
					Annual Emissions	0.3975	0.0036	
					MERP 24-hr	42498	9753	
						PM2.5 24-hr	**1.1667E-05**	**µg/m3**
					MERP Annual	130260	53898	
						PM2.5 Annual	**6.24E-07**	**µg/m3**

Pollutant	Averaging Time	Emission Factor lb/lb waste	Emission Rate g/sec	Maximum Concentration µg/m³	Significance Level (SIL) µg/m³	NAAQS µg/m³	NMAAQS µg/m³	Air Quality Standard Exceeded or SIL?
Nitrogen Dioxide (3)		0.053						
	1-hour		13.36	39.65	7.52			Yes
	Background			81.20				
	1-hour Total			120.85		188.03	none	No
	24-hour (4)				none	none	188.0	No
	Annual		0.011	0.0003	1.0	99.66	none	No
Carbon Monoxide		0.071						
	1-hour		17.89	110.61	2000	40,069.6	14,997.5	No
	8-hour		17.89	25.79	500	10,303.6	9,960.1	No
Sulfur Dioxide		0.00048						
	1-hour		0.121	0.46	7.8	196.4	none	No
	3-hour		0.121	0.25	25.0	1309.30	none	No
	24-hour		0.121	0.06	5.0	none	261.9	No
	Annual		0.000104	0.000003	1.0	none	52.4	No

PM10 (5)(6)(7)		0.29						
	24-hour		73.08	21.88	5.0			Yes
	Background			19.00				
	Nearby Sources			3.206				
	24-hour Total			40.88		150.0	none	No
PM2.5 (5)(6)(8)		0.42						
	24-hour		105.84	19.07	1.2			Yes
	Background			9.20				
	Secondary Formation			0.000012				
	Nearby Sources			2.006				
	24-hour Total			30.28		35.0	none	No
PM2.5 (5)	Annual	0.42	0.09	0.0026	0.2	12.0	none	No
Lead (1a)	Quarterly(9)	0.0044	1.109	0.0612	0.03			Yes
						0.15	none	No

Notes:

1. Based on all waste being treated by OD at TA-36-8, the explosive waste with overall metal contamination is less than 7.7%. See Attachment 4 for the calculation.

1a. The metal fraction of total waste for lead is calculated separately in Attachment 4.

2. Both federal and state AAQS values are listed in the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines dated July 2022.
3. NO_2 1-hour: If one year of onsite meteorological data are used, the 98th-percentile value associated with the 1-year period of meteorological data modeled is the design value.
4. Demonstration of compliance with 1-hour standard is automatically a demonstration of compliance with the 24-hour NMAAQS. Otherwise, the 24-hour NO_2 standard is compared with the highest 24-hour average calculated by the model.
5. Emission factor for $PM_{2.5}$ and PM_{10} is based on the paper, "Aerostat-based sampling of emissions from OB and OD of military ordnance," J. Aurell, et.al., *Journal of Hazardous Materials*, Oct. 2014.
6. Particulate matter background concentrations added as specified from NMED Air Dispersion Modeling Guidelines, July 2022.
7. PM10 24-h background – July 2022 - North Central - Santa Fe - 19.0 $\mu g/m^3$ max. for 24-hour 2nd high background.
8. PM2.5 24-h background – July 2022 - North Central - Santa Fe - 98 percentile - 9.2 $\mu g/m^3$.
9. For modeling quarterly lead (Pb) averages, use the monthly averaging period as a conservative approach. Model the entire facility without surrounding sources and compare the high month concentration to the standard. No background concentration is added.

Table 5-2. Air Quality Standards Results for TA-39-6

Basis	**TA39-6 OD Volume Source 1-3-8-24 1000 lb Public Receptors 10am-3pm**					**Secondary PM2.5**			
1000	lb/hr detonation						**NO2 tpy**	**SO2 tpy**	
1	detonations/hr					**Annual Emissions**	0.3975	0.0036	
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)					**MERP 24-hr**	42498	9753	
15000	lb/yr detonation						**PM2.5 24-hr**	**1.1667E-05**	**µg/m3**
1	g/sec contaminant emission rate					**MERP Annual**	130260	538989	
AERMOD Results (X/Q)							**PM2.5 Annual**	**6.12E-07**	**µg/m3**
	ODTA39-6 1-8-2021 0800hr 1-3-8-24hr PublicRec 1000-lb 10am-3pmOps_2021_CO2								
	ODTA39-6 1-8-2021 0800hr Annual+Monthly PublicRec 1000-lb 10am-3pmOps_2021_CO2								
10.376	1-hour maximum value, µg/m³ per g/sec contaminant								
7.156	4th highest 1-hour maximum value, µg/m3 per g/sec contaminant for SO2								
5.851	8th highest 1-hour value, µg/m3 per g/sec contaminant for NO2								
5.514	3-hour maximum value, µg/m³ per g/sec contaminant								
2.606	8-hour maximum value, µg/m³ per g/sec contaminant								
0.869	24-hour maximum value, µg/m³ per g/sec contaminant								
0.627	2nd highest 24-hour maximum value, µg/m³ per g/sec contaminant for PM10 only								
0.416	8th highest 24-hour value, µg/m³ per g/sec contaminant for PM2.5 only								
0.1085	Monthly maximum value, µg/m³ per g/sec contaminant								
0.0432	Annual maximum value, µg/m³ per g/sec contaminant								

Pollutant	Averaging Time	Emission Factor lb/lb waste	Emission Rate g/sec	Maximum Concentration µg/m³	Significance Level µg/m³	NAAQS µg/m³	NMAAQS µg/m³	Air Quality Standard Exceeded?
Nitrogen Dioxide (3)		0.053						
	1-hour		6.68	39.07	7.52			Yes
	Background			81.20				
	1-hour Total			120.27		188.03	none	No
	24-hr. (4)					none	188.0	No
	Annual		0.011	0.0005	1.0	99.66	94.02	No
Carbon Monoxide		0.071						
	1-hour		8.95	92.82	2000	40,069.6	14,997.5	No
	8-hour		8.95	23.31	500	10,303.6	9,960.1	No
Sulfur Dioxide		0.00048						
	1-hour		0.060	0.43	7.8	196.4	none	No
	3-hour		0.060	0.33	25.0	1,309.30	none	No
	24-hour		0.060	0.05	5.0	NA	261.9	No
	Annual		0.000104	0.000004	1.0	NA	52.4	No
PM10 (5)(6)(7)		0.29						
	24-hour		36.54	22.92	5.0			Yes
	Background			19.00				
	Nearby Sources			3.206				
	24-hour Total			41.92		150.0	none	No

PM2.5 (5)(6)(8)		0.42						
	24-hour		52.92	22.00	1.2			Yes
	Background			9.20				
	Secondary Formation			0.000012				
	Nearby Sources			2.006				
	24-hour Total			.21		35.0	none	No
PM2.5 (5)	Annual	0.42	0.09	0.0039	0.2	12.0	none	No
Lead	Quarterly(9)	0.0044	0.554	0.0601	0.03			Yes
						0.15	none	No

Notes:

1. Based on all waste being treated by OD at TA-36-8, the explosive waste with overall metal contamination is less than 7.7%. See Attachment 4 for the calculation.

1a. The metal fraction of total waste for Lead is calculated separately in Attachment 4.

2. Both federal and state AAQS values are listed in the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines dated July 2022.
3. NO2 1-hour: If one year of on-site meteorological data are used, the 98th-percentile value associated with the 1-year period of meteorological data modeled is the design value.
4. Demonstration of compliance with 1-hour standard is automatically a demonstration of compliance with the 24-hour NMAAQS. Otherwise, the 24-hour NO2 standard is compared with the highest 24-hour average calculated by the model.
5. Emission factor for PM2.5 and PM10 is based on the paper "Aerostat-based sampling of emissions from OB and OD of military ordnance," J. Aurell, et.al., *Journal of Hazardous Materials*, Oct. 2014.
6. Particulate matter background concentrations added as specified from NMED Air Dispersion Modeling Guidelines, July 2022.
7. PM10 24-h background – July 2022 - North Central - Santa Fe - 19.0 $\mu g/m^3$ max. for 24-hour 2nd high background
8. PM2.5 24-h background – July 2022 - North Central - Santa Fe - 98 percentile - 9.2 $\mu g/m^3$
9. For modeling quarterly Lead (Pb) averages, use the monthly averaging period as a conservative approach. Model the entire facility without surrounding sources and compare the high month concentration to the standard. No background concentration is added.

Table 5-3. Air Quality Standards Results for TA-16-388

Basis

			Secondary PM2.5	
			NO2 tpy	SO2 tpy
200	lb waste/hr	**Annual Emissions**	0.0128	0.0006
6000	lb waste/yr	**MERP 24-hr**	42498	9753
254.4	lb propane/hr		**PM2.5 24-hr**	**4.409E-07** **µg/m³**
7632.0	lb propane/yr			

1 g/sec contaminant emission rate

Model Results (X/Q) **OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr Public rec_2021_CO2 and OBTA16-388-2023 12-11-2021 0900hr Annual Public rec_2021_CO2**

16.047 1-hour maximum value, µg/m³ per g/sec contaminant
7.576 8th highest overall 1-hour maximum value, µg/m³ per g/sec contaminant (as applied to 1-hour NO_2 NAAQS)
5.469 3-hour maximum value, µg/m³ per g/sec contaminant
2.063 8-hour maximum value, µg/m³ per g/sec contaminant
0.761 24-hour maximum value, µg/m³ per g/sec contaminant
0.655 2nd high 24-hour maximum value, µg/m³ per g/sec contaminant (as applied to 24-hr PM_{10})
0.520 8th highest overall 24-hour maximum value, µg/m³ per g/sec contaminant (as applied to 24-hour $PM_{2.5}$ NAAQS)
0.054 Annual maximum value, µg/m³ per g/sec contaminant

Pollutant	Averaging Time	OB Waste Emission Factor lb/lb waste	OB Waste Emission Rate g/sec	OB Waste Maximum Concentration µg/m³	Propane Emission Factor, lb/lb propane	Propane Emission Rate, g/sec	Propane Maximum Concentration µg/m³	Maximum Concentration Total µg/m³	Significance Level µg/m³	NAAQS(1) µg/m³	NMAAQS(1) µg/m³	Air Quality Standard Exceeded or SIL?
Nitrogen Dioxide		0.075			0.0031							
	1-hour (2)		1.890	14.32		0.10	0.7445	15.1	7.52			Yes
	Background							81.2				
	1-hour Total							96.3		188.03	none	No
	24-hour (3)		1.890	1.44		0.10	0.0748	1.5	None	none	188.03	No
	Annual		0.006	0.00035		0.00	0.000018	0.00037	1.0	99.66	94.02	No
Carbon Monoxide		0.030			0.00177							
	1-hour		0.751	12.05		0.06	0.91	13.0	2000	40069.6	14997.5	No
	8-hour		0.751	1.55		0.06	0.12	1.7	500	10303.6	9960.1	No
Sulfur Dioxide		0.0012			0.00212							
	1-hour		0.031	0.493		0.07	1.09	1.6	7.8	196.40	none	No
	3-hour		0.031	0.168		0.07	0.37	0.54	25.0	1309.30	none	No
	24-hour		0.031	0.023		0.07	0.05	0.08	5.0	none	261.90	No
	Annual		0.00011	0.0000057		0.00	0.00	0.0000183	1.0	none	52.40	No
PM10 (4)(5)(6)		0.910			0.00017							
	24-hour		22.932	15.03		0.0053	0.00347	15.035	5.0			Yes
	Background			19.00								
	Nearby Sources			3.206								
	24-hour Total			37.24			0.00347	37.241		150	none	No

PM2.5 (4)(7)(8)		0.910			0.00017							
	24-hour		22.932	11.92		0.0053	0.0028	11.923	1.2			Yes
	Background			9.20								
	Secondary Formation			0.00000044								
	Nearby Sources			2.006								
	24-hour Total			23.13			0.0028	23.13		35	none	No
PM2.5 (7)	Annual	0.910	0.079	0.00426	0.00017	0.000018	0.00000098	0.00426	0.2	12.0	none	No

Notes:

1. Both federal and state AAQS values are listed in the New Mexico Air Quality Bureau Air Dispersion Modeling Guidelines dated July 2022.
2. NO_2 1-hour: If one year of on-site meteorological data are used, the 98th-percentile value associated with the 1-year period of meteorological data modeled is the design value.
3. Demonstration of compliance with 1-hour standard is automatically a demonstration of compliance with the 24-hour NMAAQS; otherwise, the 24-hour NO_2 standard is compared with the highest 24-hour average calculated by the model.
4. Particulate matter background concentrations added as specified from NMED Air Dispersion Modeling Guidelines, July 2022.
5. Calculated maximum concentration for the 24-hour PM_{10} NAAQS is based on 2nd high from AERMOD model runs. This is more conservative than the high-2nd-high as specified by NMED Air Dispersion Modeling Guideline, July 2022.
6. PM_{10} 24-h background – July 2022 - North Central - Santa Fe - 19.0 µg/m^3 max. for 24-hour 2nd high background
7. Emission factor for PM_{10} used also for $PM_{2.5}$ which overpredicts $PM_{2.5}$ concentrations.
8. Calculated maximum concentrations for 24-hour $PM_{2.5}$ NAAQS is based on the 8th high overall value from the AERMOD model runs using one year of met data. This is more conservative than the high 8th high as specified by NMED Air Dispersion Modeling Guideline, July 2022.
9. $PM_{2.5}$ 24-h background – July 2022 - North Central - Santa Fe – 98th percentile - 9.2 µg/m^3

Table 5-4a. Acute Health Screening Level Results for TA-36-8

	2000	lb/hr detonation
	0.077	Metal Waste fraction for metals emissions (see Explosives List explanation) - lb metal/lb waste (1a)
	0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a)
	0.0044	Lead compounds fraction - lb Pb/lb waste (1a)
	0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)
	1	g/sec contaminant emission rate
AERMOD Model Result (X/Q)		**ODTA36-8 1-21-2021 0900hr 1-3-8-24hr AllReceptors CO2_2021_CO2**
	51.920	1-hour maximum value, µg/m³ per g/sec contaminant
	28.130	1-hour 8th high value for NO2 only, µg/m³ per g/sec contaminant (5)

Contaminant	Emission Factor lb/lb waste	Emission Rate g/sec	1-Hour Concentration µg/m³	Air Inhalation Emission Concentration (AIEC) - acute (µg/m³)	CA-OEHHA Non-Cancer Reference Exposure Level (REL) - Acute (µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	1.79E+01	9.29E+02	NA	2.30E+04	No
Nitrogen Oxides (as NO_2 only)(1)	5.30E-02	1.34E+01	3.76E+02	NA	4.70E+02	No
Sulfur Dioxide (1)	4.80E-04	1.21E-01	6.28E+00	NA	6.60E+02	No
Benzene (1)	2.00E-04	5.04E-02	2.62E+00	1.30E+03	2.70E+01	No
TNMHC (1)	7.70E-03	1.94E+00	1.01E+02	NA	NA	NA
Acetylene (1)	7.70E-04	1.94E-01	1.01E+01	NA	NA	NA
Ethylene (1)	7.10E-04	1.79E-01	9.29E+00	NA	NA	NA
Propylene (1)	1.30E-04	3.28E-02	1.70E+00	NA	NA	NA
Toluene (1)	6.70E-05	1.69E-02	8.77E-01	3.70E+04	5.00E+03	No
Naphthalene (2)	2.80E-07	7.06E-05	3.66E-03	7.50E+04	NA	No
Methylene Chloride (1)	6.20E-04	1.56E-01	8.11E+00	1.40E+04	1.40E+04	No
Aluminum Oxide (1a)	7.70E-02	1.94E+01	1.01E+03	NA	NA	NA
Barium(1a)	4.20E-02	1.06E+01	5.50E+02	1.50E+03	NA	No
Copper (1a)	5.90E-04	1.49E-01	7.72E+00	NA	1.00E+02	No
Lead (1a)	4.40E-03	1.11E+00	5.76E+01	1.50E+02	NA	No
Trioctyl phosphate (3)	2.60E-01	6.55E+01	3.40E+03	NA	NA	NA
Aluminum (1a)	7.70E-02	1.94E+01	1.01E+03	NA	NA	NA
Titanium (1a)	7.70E-02	1.94E+01	1.01E+03	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Nitrocellulose (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Nitroguanidine (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Nitromethane (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
Tetryl (Trinitrophenylmethylnitramine)(2)	2.80E-07	7.06E-05	3.66E-03	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	7.06E-05	3.66E-03	1.50E+03	NA	No
Acrylonitrile (4)	1.00E-08	2.52E-06	1.31E-04	2.18E+04	NA	No
Bis(2-ethylhexyl)adipate (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA
tris-2-chloroethyl phosphate (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	2.52E-06	1.31E-04	1.50E+04	NA	No
Dinitrotoluene (2,4-) (4)	1.00E-08	2.52E-06	1.31E-04	6.00E+02	NA	No

Dioctyladipate (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA
Dioctylphthalate (4)	1.00E-08	2.52E-06	1.31E-04	1.00E+04	NA	No
Diphenylamine (4)	1.00E-08	2.52E-06	1.31E-04	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is less than 7.7%. See Attachment 4 for the calculation. The metal fractions of total waste for lead, barium and copper are calculated separately in Attachment 4.

2 Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics.

3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.

4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Anti-oxidants in Attachment 4. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.

5. 8th highest concentration for NO_2, same the NAAQS/NMAAQS design value or 98th percentile concentration.

6. NA - Chemical Not Available in database

7. Screening concentrations from acute (1 hr) inhalation exposures concentrations (AIEC) from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2016). https://archive.epa.gov/epawaste/hazard/tsd/td/web/mdb/05hhrapchemdat.mdb

8. REL 1-hour acute screening concentrations are from the CA OEHHA, October 2023, Consolidated Table of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf

9. An exceedance is based on the maximum 1-hr concentration being greater than or equal to the NMED or EPA standards.

Table 5-4b. Chronic Health Screening Level Results for TA-36-8

Basis

15,000	lb/yr detonation
1	g/sec contaminant emission rate
0.077	lb metal / lb waste (1a)
0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a)
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)
0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)

AERMOD Results (X/Q) **ODTA36-8 1-21-2021 0900hr Annual AllReceptors CO2_2021_CO2**

1.0672 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Emission Factor (1) (lb/lb waste)	Emission Rate (g/sec)	Maximum Annual Concentration µg/m³	CA-OEHHA Non-Cancer Reference Exposure Level (REL) Chronic (6) (µg/m³)	EPA Resident Air Non-carcinogenic (RSL) for THI = 0.1 (7) (µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	1.53E-02	1.63E-02	NA	NA	NA
Nitrogen Oxides (as NO_2 only) (1)	5.30E-02	1.14E-02	1.22E-02	NA	NA	NA
Sulfur Dioxide (1)	4.80E-04	1.04E-04	1.11E-04	NA	NA	NA
Benzene (1)	2.00E-04	4.32E-05	4.60E-05	3.00E+00	3.1E+00	No
TNMHC (1)	7.70E-03	1.66E-03	1.77E-03	NA	NA	NA
Acetylene (1)	7.70E-04	1.66E-04	1.77E-04	NA	NA	NA
Ethylene (1)	7.10E-04	1.53E-04	1.63E-04	NA	NA	NA
Propylene (1)	1.30E-04	2.80E-05	2.99E-05	3.00E+03	3.1E+02	No
Toluene (1)	6.70E-05	1.45E-05	1.54E-05	4.20E+02	5.2E+02	No
Naphthalene (2)	2.80E-07	6.04E-08	6.45E-08	9.00E+00	3.1E-01	No
Methylene Chloride (1)	6.20E-04	1.34E-04	1.43E-04	4.00E+02	6.3E+01	No
Aluminum Oxide (1a)	7.70E-02	1.66E-02	1.77E-02	NA	5.20E-01	No
Barium (1a)	4.20E-02	9.06E-03	9.67E-03	NA	5.20E-02	No
Copper (1a)	5.90E-04	1.27E-04	1.36E-04	NA	NA	NA
Lead (1a)	4.40E-03	9.49E-04	1.01E-03	NA	1.5E-01	No
Trioctyl phosphate (3)	2.60E-01	5.61E-02	5.99E-02	NA	NA	NA
Aluminum (1a)	7.70E-02	1.66E-02	1.77E-02	NA	5.20E-01	No
Titanium (1a)	7.70E-02	1.66E-02	1.77E-02	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Nitrocellulose (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Nitroguanidine (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Nitromethane (2)	2.80E-07	6.04E-08	6.45E-08	NA	5.20E-01	No
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Tetryl (Trinitrophenylmethylnitramine)(2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	6.04E-08	6.45E-08	NA	NA	NA
Acrylonitrile (4)	1.00E-08	2.16E-09	2.30E-09	5.00E+00	2.10E-01	No
Bis or Di(2-ethylhexyl)adipate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
tris-2-chloroethyl phosphate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA

Dinitrotoluene (2,4-) (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Dioctyladipate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Dioctylphthalate/Di-n-octyl phthalate (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA
Diphenylamine (4)	1.00E-08	2.16E-09	2.30E-09	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is 7.7% (not including Ba, Pb, or Cu). See Attachment 4 for the calculation. The metal fractions of total waste for lead, barium and copper are calculated separately in Attachment 4.

2. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics
3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.
4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Antioxidants in Attachment 2. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.
5. NA - Chemical Not Available in database
6. Chronic REL annual screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
7. U.S. EPA air non-carcinogenic screening levels are from the Regional Screening Levels (RSLs) – Generic Tables. November 2023. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
8. An exceedance is based on the maximum concentration being greater than or equal to the NMED or EPA standards.

Table 5-4c. Residential Soil Screening Level and LANL ESL Screening Level Results for TA-36-8

Basis

15,000 lb/yr detonation

1 g/sec contaminant emission rate

AERMOD Result (X/Q) **ODTA36-8 1-21-2021 0900hr Annual AllReceptors CO2_2021_CO2**

1.0672 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Maximum Annual Concentration µg/m³	10-Year Soil Concentration mg/kg	NMED Cancer - Residential Soil TR=1E-05 (mg/kg)	NMED Non-Cancer Residential Soil Screening Level (mg/kg)	Carcinogenic Target Risk - EPA SL - Resident Soil based on TR=1E-06 (mg/kg)	Noncancer Child HI EPA RSLs - Resident Soil based on THI = 0.1 (mg/kg)	Screening Level Exceeded?	Minimum LANL ESL mg/kg	Receptor	ESL Exceeded?
Carbon Monoxide	1.63E-02	9.67E+00	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxides (as NO_2 only)	1.22E-02	7.22E+00	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur Dioxide	1.11E-04	6.54E-02	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	4.60E-05	2.72E-02	1.78E+01	1.14E+02	1.20E+00	8.20E+00	No	2.40E+02	Deer mouse	No
TNMHC	1.77E-03	1.05E+00	NA	NA	NA	NA	NA	NA	NA	NA
Acetylene	1.77E-04	1.05E-01	NA	NA	NA	NA	NA	NA	NA	NA
Ethylene	1.63E-04	9.67E-02	NA	NA	NA	NA	NA	NA	NA	NA
Propylene	2.99E-05	1.77E-02	NA	NA	NA	2.20E+02	No	NA	NA	NA
Toluene	1.54E-05	9.12E-03	NA	5.23E+03	NA	4.90E+02	No	2.30E+01	Montane shrew	No
Naphthalene	6.45E-08	3.81E-05	2.26E+01	1.62E+02	2.00E+00	1.30E+01	No	1.00E+00	Plant	No
Methylene Chloride	1.43E-04	8.44E-02	7.66E+02	4.09E+02	5.70E+01	3.50E+01	No	2.60E+00	Deer mouse	No
Aluminum Oxide	1.77E-02	1.05E+01	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Barium	9.67E-03	5.72E+00	NA	1.56E+04	NA	1.50E+03	No	1.10E+02	Plant	No
Copper	1.36E-04	8.03E-02	NA	3.13E+03	NA	3.10E+02	No	1.40E+01	American robin	No
Lead	1.01E-03	5.99E-01	NA	NA	NA	4.00E+02	No	1.10E+01	American robin	No
Trioctyl phosphate	5.99E-02	3.54E+01	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	1.77E-02	1.05E+01	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Titanium	1.77E-02	1.05E+01	NA	NA	NA	NA	NA	7.70E+01	Montane shrew	No
Ammonium perchlorate	6.45E-08	3.81E-05	NA	NA	NA	5.50E+00	No	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX)	6.45E-08	3.81E-05	NA	3.85E+03	NA	3.90E+02	No	1.60E+01	Earthworm	No
Nitrocellulose	6.45E-08	3.81E-05	NA	NA	NA	1.90E+07	No	NA	NA	NA
Nitroguanidine	6.45E-08	3.81E-05	NA	NA	NA	6.30E+02	No	NA	NA	NA
Nitromethane	6.45E-08	3.81E-05	NA	NA	5.40E+00	8.80E+00	No	NA	NA	NA
Pentaerythritol tetranitrate (PETN)	6.45E-08	3.81E-05	NA	NA	1.30E+02	5.70E+01	No	1.00E+02	Deer mouse	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	6.45E-08	3.81E-05	8.31E+01	3.01E+02	8.30E+00	3.00E+01	No	2.30E+00	American robin	No
Tetryl (Trinitrophenylmethylnitramine)	6.45E-08	3.81E-05	NA	1.56E+02	NA	1.60E+01	No	1.50E+00	Deer mouse	No

2,4,6-trinitrotoluene (TNT)	6.45E-08	3.81E-05	2.11E+02	3.60E+01	2.10E+01	3.60E+00	No	7.50E+00	American robin	No
Acrylonitrile	2.30E-09	1.36E-06	4.93E+00	3.99E+01	2.50E-01	1.30E+00	No	NA	NA	NA
Bis(2-ethylhexyl)adipate	2.30E-09	1.36E-06	NA	NA	4.50E+02	3.80E+03	No	NA	NA	NA
tris-2-chloroethyl phosphate	2.30E-09	1.36E-06	NA	NA	2.70E+01	4.40E+01	No	NA	NA	NA
Di-n-butyl phthalate (Dibutyl phthalate)	2.30E-09	1.36E-06	NA	6.16E+03	NA	6.30E+02	No	1.10E-02	American robin	No
2,4-Dinitrotoluene (2,4-DNT)	2.30E-09	1.36E-06	1.71E+01	1.23E+02	1.70E+00	1.30E+01	No	6.00E+00	Plant	No
Dioctyladipate	2.30E-09	1.36E-06	NA	NA	NA	NA	NA	NA	NA	NA
Dioctyl Phthalate, (Bis(2-ethylhexyl)phthalate), (di(2-ethylhexyl)phthalate), DEHP)	2.30E-09	1.36E-06	3.80E+02	1.23E+03	3.90E+01	1.30E+02	No	9.10E-01	Montane shrew	No
Diphenylamine	2.30E-09	1.36E-06	NA	NA	NA	6.30E+02	No	1.00E+01	Robin insectivore	No

Notes:
1. The calculation methodology is described in Section 5.

Table 5-5a. Acute Health Screening Level Results for TA-39-6

Basis						
1000	lb/hr detonation					
1	detonation/hr					
0.077	Metal Waste fraction for metals emissions (see Explosives List explanation) - lb metal/lb waste (1a)					
0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a)					
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)					
0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)					
1	g/sec contaminant emission rate					
AERMOD Results (X/Q)	**TA39-6 OD Volume Source 1-3-8-24 1000 lb All Receptors 10am-3pm M-F**					
38.34	1-hour maximum value, µg/m³ per g/sec contaminant for 1 detonation/hr					
28.37	1-hour 8th high value for NO2 only, µg/m³ per g/sec contaminant for 1 detonation/hr (5)					
Contaminant	Mean Emission Factor (1) lb/lb waste	Emission Rate g/sec	Maximum 1-Hour Concentration µg/m³	Air Inhalation Emission Concentration (AIEC) - acute µg/m³)	CA-OEHHA Non-Cancer Reference Exposure Level (REL) – Acute (µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	8.95E+00	3.43E+02	NA	2.30E+04	No
Nitrogen Oxides (as NO_2 only)(1)	5.30E-02	6.68E+00	1.89E+02	NA	4.70E+02	No
Sulfur Dioxide (1)	4.80E-04	6.05E-02	2.32E+00	NA	6.60E+02	No
Benzene (1)	2.00E-04	2.52E-02	9.66E-01	1.30E+03	2.70E+01	No
TNMHC (1)	7.70E-03	9.70E-01	3.72E+01	NA	NA	NA
Acetylene (1)	7.70E-04	9.70E-02	3.72E+00	NA	NA	NA
Ethylene (1)	7.10E-04	8.95E-02	3.43E+00	NA	NA	NA
Propylene (1)	1.30E-04	1.64E-02	6.28E-01	NA	NA	NA
Toluene (1)	6.70E-05	8.44E-03	3.24E-01	3.70E+04	5.00E+03	No
Naphthalene (2)	2.80E-07	3.53E-05	1.35E-03	7.50E+04	NA	No
Methylene Chloride (1)	6.20E-04	7.81E-02	2.99E+00	1.40E+04	1.40E+04	No
Aluminum Oxide (1a)	7.70E-02	9.70E+00	3.72E+02	NA	NA	NA
Barium(1a)	4.20E-02	5.29E+00	2.03E+02	1.50E+03	NA	No
Copper (1a)	5.90E-04	7.43E-02	2.85E+00	NA	1.00E+02	No
Lead (1a)	4.40E-03	5.54E-01	2.13E+01	1.50E+02	NA	No
Trioctyl phosphate (3)	2.60E-01	3.28E+01	1.26E+03	NA	NA	NA
Aluminum (1a)	7.70E-02	9.70E+00	3.72E+02	NA	NA	NA
Titanium (1a)	7.70E-02	9.70E+00	3.72E+02	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Nitrocellulose (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Nitroguanidine (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Nitromethane (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
Tetryl (Trinitrophenylmethylnitramine)(2)	2.80E-07	3.53E-05	1.35E-03	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	3.53E-05	1.35E-03	1.50E+03	NA	No
Acrylonitrile (4)	1.00E-08	1.26E-06	4.83E-05	2.18E+04	NA	No
Bis(2-ethylhexyl)adipate (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA

tris-2-chloroethyl phosphate (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	1.26E-06	4.83E-05	1.50E+04	NA	No
Dinitrotoluene (2,4-) (4)	1.00E-08	1.26E-06	4.83E-05	6.00E+02	NA	No
Dioctyladipate (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA
Dioctylphthalate (4)	1.00E-08	1.26E-06	4.83E-05	1.00E+04	NA	No
Diphenylamine (4)	1.00E-08	1.26E-06	4.83E-05	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is less than 7.7%. See Attachment 4 for the calculation. The metal fractions of total waste for Lead, Barium and Copper are calculated separately in Attachment 4.

2 Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics.

3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.

4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Anti-oxidants in Attachment 4. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.

5. 8th highest concentration for NO2, same the NAAQS/NMAAQS design value or 98th percentile concentration

6. NA - Chemical Not Available in database

7. Screening concentrations from acute (1 hr) inhalation exposures concentrations (AIEC) from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2016). https://archive.epa.gov/epawaste/hazard/tsd/td/web/mdb/05hhrapchemdat.mdb

8. REL 1-hour acute screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf

9. An exceedance is based on the maximum 1-hr concentration being greater than or equal to the NMED or EPA standards.

Table 5-5b. Chronic Health Screening Level Results for TA-39-6

Basis

15,000	lb/yr detonation
1	g/sec contaminant emission rate
0.077	lb metal / lb waste (1a)
0.00059	Copper fraction of brass alloys - lb Cu/lb waste (1a
0.0044	Lead compounds fraction - lb Pb/lb waste (1a)
0.042	Barium compounds fraction as Baratol - lb Ba/lb waste (1a)
Model Result (X/Q)	**TA39-6 OD Volume Source Annual 1000 lb All Receptors 10am-3pm M-F**
0.790	Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Emission Factor (1) (lb/lb waste)	Emission Rate g/sec)	Maximum Annual Concentration µg/m³	CA-OEHHA Non-Cancer Reference Exposure Level (REL) Chronic (6) µg/m³)	EPA Resident Air Non-carcinogenic (RSL) for THI = 0.1 (7) µg/m³)	Screening Level Exceeded?
Carbon Monoxide (1)	7.10E-02	1.53E-02	1.21E-02	NA	NA	NA
Nitrogen Oxides (as NO_2 only) (1)	5.30E-02	1.14E-02	9.04E-03	NA	NA	NA
Sulfur Dioxide (1)	4.80E-04	1.04E-04	8.19E-05	NA	NA	NA
Benzene (1)	2.00E-04	4.32E-05	3.41E-05	3.00E+00	3.1E+00	No
TNMHC (1)	7.70E-03	1.66E-03	1.31E-03	NA	NA	NA
Acetylene (1)	7.70E-04	1.66E-04	1.31E-04	NA	NA	NA
Ethylene (1)	7.10E-04	1.53E-04	1.21E-04	NA	NA	NA
Propylene (1)	1.30E-04	2.80E-05	2.22E-05	3.00E+03	3.1E+02	No
Toluene (1)	6.70E-05	1.45E-05	1.14E-05	4.20E+02	5.2E+02	No
Naphthalene (2)	2.80E-07	6.04E-08	4.77E-08	9.00E+00	3.1E-01	No
Methylene Chloride (1)	6.20E-04	1.34E-04	1.06E-04	4.00E+02	6.3E+01	No
Aluminum Oxide (1a)	7.70E-02	1.66E-02	1.31E-02	NA	5.20E-01	No
Barium (1a)	4.20E-02	9.06E-03	7.16E-03	NA	5.20E-02	No
Copper (1a)	5.90E-04	1.27E-04	1.01E-04	NA	NA	NA
Lead (1a)	4.40E-03	9.49E-04	7.50E-04	NA	1.5E-01	No
Trioctyl phosphate (3)	2.60E-01	5.61E-02	4.43E-02	NA	NA	NA
Aluminum (1a)	7.70E-02	1.66E-02	1.31E-02	NA	5.20E-01	No
Titanium (1a)	7.70E-02	1.66E-02	1.31E-02	NA	NA	NA
Ammonium perchlorate (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Nitrocellulose (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Nitroguanidine (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Nitromethane (2)	2.80E-07	6.04E-08	4.77E-08	NA	5.20E-01	No
Pentaerythritol tetranitrate (PETN) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Tetryl (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
2,4,6-trinitrotoluene (TNT) (2)	2.80E-07	6.04E-08	4.77E-08	NA	NA	NA
Acrylonitrile (4)	1.00E-08	2.16E-09	1.71E-09	5.00E+00	2.10E-01	No
Bis(2-ethylhexyl)adipate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
tris-2-chloroethyl phosphate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Dibutylphthalate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA

Dinitrotoluene (2,4-) (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Dioctyladipate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Dioctylphthalate (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA
Diphenylamine (4)	1.00E-08	2.16E-09	1.71E-09	NA	NA	NA

Notes:

1. Based on Mean Emission Factors (EF) listed in Table 16.2-14 of the draft Chapter 16 of AP-42.

1a. Based on all waste being treated by OD at TA-36-8, the explosive waste with known metal contamination is 7.7% (not including Ba, Pb, or Cu). See Attachment 4 for the calculation. The metal fractions of total waste for Lead, Barium and Copper are calculated separately in Attachment 4.

2. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs Not in Energetics.
3. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for Metals in Energetics as Compounds.
4. Based on the Mean EFs listed in Table 16.2-14 of the draft Chapter 16 of AP-42 for SVOCs in Energetics. These are under the header of Binder/Plasticizer/Antioxidants in Attachment 2. Because no data are listed for this EP, the value for BDL was assigned as explained in Section 2.1.4.4 on Page 22 of the Ch. 16 Background Document.
5. NA - Chemical Not Available in database
6. Chronic REL annual screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values, https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
7. U.S. EPA air non-carcinogenic screening levels are from the Regional Screening Levels (RSLs) – Generic Tables. November 2023. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables
8. An exceedance is based on the maximum concentration being greater than or equal to the NMED or EPA standards.

Table 5-5c. Residential Soil Screening Level and LANL ESL Screening Level Results for TA-39-6

Basis

15,000 lb/yr detonation

1 g/sec contaminant emission rate

AERMOD Result (X/Q) **TA39-6 OD Volume Source Annual 1000 lb All Receptors 10am-3pm M-F**

0.7904 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	Maximum Annual Concentration µg/m³	10-Year Soil Concentration mg/kg	NMED Non-Cancer Residential Soil Screening Level (mg/kg)	NMED Cancer - Residential Soil TR = 1E-05 mg/kg)	Carcinogenic Target Risk - EPA SL - Resident Soil based on TR = 1E-06 (mg/kg)	Non-Cancer Child HI EPA RSLs - Resident Soil based on THI = 0.1 (mg/kg)	Screening Level Exceeded?	Minimum (No Effect) LANL ESL mg/kg	Receptor	ESL Exceeded?
Carbon Monoxide	1.21E-02	7.16E+00	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxides (as NO_2 only)	9.04E-03	5.35E+00	NA	NA	NA	NA	NA	NA	NA	NA
Sulfur Dioxide	8.19E-05	4.84E-02	NA	NA	NA	NA	NA	NA	NA	NA
Benzene	3.41E-05	2.02E-02	1.78E+01	1.14E+02	1.20E+00	8.20E+00	No	2.40E+02	Deer mouse	No
TNMHC	1.31E-03	7.77E-01	NA	NA	NA	NA	NA	NA	NA	NA
Acetylene	1.31E-04	7.77E-02	NA	NA	NA	NA	NA	NA	NA	NA
Ethylene	1.21E-04	7.16E-02	NA	NA	NA	NA	NA	NA	NA	NA
Propylene	2.22E-05	1.31E-02	NA	NA	NA	2.20E+02	No	NA	NA	NA
Toluene	1.14E-05	6.76E-03	NA	5.23E+03	NA	4.90E+02	No	2.30E+01	Montane shrew	No
Naphthalene	4.77E-08	2.82E-05	2.26E+01	1.62E+02	2.00E+00	1.30E+01	No	1.00E+00	Plant	No
Methylene Chloride	1.06E-04	6.25E-02	7.66E+02	4.09E+02	5.70E+01	3.50E+01	No	2.60E+00	Deer mouse	No
Aluminum Oxide	1.31E-02	7.77E+00	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Barium	7.16E-03	4.24E+00	NA	1.56E+04	NA	1.50E+03	No	1.10E+02	Plant	No
Copper	1.01E-04	5.95E-02	NA	3.13E+03	NA	3.10E+02	No	1.40E+01	American robin	No
Lead	7.50E-04	4.44E-01	NA	NA	NA	4.00E+02	No	1.10E+01	American robin	No
Trioctyl phosphate	4.43E-02	2.62E+01	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	1.31E-02	7.77E+00	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Titanium	1.31E-02	7.77E+00	NA	NA	NA	NA	NA	7.70E+01	Montane shrew	No
Ammonium perchlorate	4.77E-08	2.82E-05	NA	NA	NA	5.50E+00	No	NA	NA	NA
Octahydro-1,3,5,7-tertanitro-1,3,5,7-tetrazocine (HMX)	4.77E-08	2.82E-05	NA	3.85E+03	NA	3.90E+02	No	1.60E+01	Earthworm	No
Nitrocellulose	4.77E-08	2.82E-05	NA	NA	NA	1.90E+07	No	NA	NA	NA
Nitroguanidine	4.77E-08	2.82E-05	NA	NA	NA	6.30E+02	No	NA	NA	NA
Nitromethane	4.77E-08	2.82E-05	NA	NA	5.40E+00	8.80E+00	No	NA	NA	NA
Pentaerythritol tetranitrate (PETN)	4.77E-08	2.82E-05	NA	NA	1.30E+02	5.70E+01	No	1.00E+02	Deer mouse	No
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	4.77E-08	2.82E-05	8.31E+01	3.01E+02	8.30E+00	3.00E+01	No	2.30E+00	American robin	No
Tetryl (Trinitrophenylmethylnitramine)	4.77E-08	2.82E-05	NA	1.56E+02	NA	1.60E+01	No	1.50E+00	Deer mouse	No

2,4,6-trinitrotoluene (TNT)	4.77E-08	2.82E-05	2.11E+02	3.60E+01	2.10E+01	3.60E+00	No	7.50E+00	American robin	No
Acrylonitrile	1.71E-09	1.01E-06	4.93E+00	3.99E+01	2.50E-01	1.30E+00	No	NA	NA	NA
Bis(2-ethylhexyl)adipate	1.71E-09	1.01E-06	NA	NA	4.50E+02	3.80E+03	No	NA	NA	NA
tris-2-chloroethyl phosphate	1.71E-09	1.01E-06	NA	NA	2.70E+01	4.40E+01	No	NA	NA	NA
Di-n-butyl phthalate (Dibutyl phthalate)	1.71E-09	1.01E-06	NA	6.16E+03	NA	6.30E+02	No	1.10E-02	American robin	No
2,4-Dinitrotoluene (2,4-DNT)	1.71E-09	1.01E-06	1.71E+01	1.23E+02	1.70E+00	1.30E+01	No	6.00E+00	Plant	No
Dioctyladipate	1.71E-09	1.01E-06	NA	NA	NA	NA	NA	NA	NA	NA
Dioctyl Phthalate, (Bis(2-ethylhexyl)phthalate), (di(2-ethylhexyl)phthalate), DEHP)	1.71E-09	1.01E-06	3.80E+02	1.23E+03	3.90E+01	1.30E+02	No	9.10E-01	Montane shrew	No
Diphenylamine	1.71E-09	1.01E-06	NA	NA	NA	6.30E+02	No	1.00E+01	Robin insectivore	No

Notes:
1. The calculation methodology is described in Section 5.

Table 5-6a. Acute Health Screening Level Results for TA-16-388

Basis

200 lb/hr waste burn
254.4 lb propane/hr
1 g/sec contaminant emission rate

Model Result (X/Q) - AERMOD **OBTA16-388-2023 12-11-2021 0900hr 1-3-8-24hr AllRecs_2021_CO2**

132.55 1-hour maximum value, µg/m³ per g/sec contaminant
79.90 1-hour 8th high value for NO2 only, µg/m³ per g/sec contaminant (6)

Contaminant	CAS No.	Emission Factor (lb/lb of waste)	Emission Rate (g/sec)	Maximum 1-hour Concentration (2) (µg/m³)	Air Inhalation Emission Concentration (AIEC) – Acute (µg/m³)	CA-OEHHA Non-Cancer Reference Exposure Level (REL) – Acute (µg/m³)	Screening Level Exceeded(7)?
1,2,4-Trimethylbenzene	95-63-6	2.43E-04	6.12E-03	8.12E-01	NA	2.40E+03	No
sec-Butylbenzene	135-98-8	5.09E-04	1.28E-02	1.70E+00	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	5.57E-04	1.40E-02	1.86E+00	1.25E+05	2.40E+03	No
1,3-Butadiene	106-99-0	1.34E-06	3.38E-05	4.48E-03	NA	6.60E+02	No
1-Butene	106-98-9	4.69E-06	1.18E-04	1.57E-02	NA	NA	NA
1-Hexene	592-41-6	2.19E-06	5.52E-05	7.32E-03	NA	NA	NA
1-Pentene	109-67-1	1.72E-06	4.33E-05	5.75E-03	NA	NA	NA
2,2,4-Trimethylpentane	540-84-1	6.97E-06	1.76E-04	2.33E-02	NA	NA	NA
2,2-Dimethylbutane	75-83-2	4.29E-08	1.08E-06	1.43E-04	NA	NA	NA
2,3,4-Trimethylpentane	565-75-3	1.38E-06	3.48E-05	4.61E-03	NA	NA	NA
2,3-Dimethylbutane	79-29-8	2.06E-06	5.19E-05	6.88E-03	NA	NA	NA
2,3-Dimethylhexane	584-94-1	5.40E-06	1.36E-04	1.80E-02	NA	NA	NA
2,3-Dimethylpentane	565-59-3	3.33E-06	8.39E-05	1.11E-02	NA	NA	NA
2,4,4-Trimethyl-1-pentene	107-39-1	1.99E-07	5.01E-06	6.65E-04	NA	NA	NA
2,4-Dimethylhexane	589-43-5	6.42E-06	1.62E-04	2.14E-02	NA	NA	NA
2,4-Dimethylpentane	108-08-7	2.16E-06	5.44E-05	7.21E-03	NA	NA	NA
2,5-Dimethylhexane	592-13-2	1.11E-05	2.80E-04	3.71E-02	NA	NA	NA
2-Methyl-1-butene	563-46-2	1.05E-06	2.65E-05	3.51E-03	NA	NA	NA
2-Methyl-2-butene	513-35-9	9.07E-08	2.29E-06	3.03E-04	NA	NA	NA
2-Methylheptane	592-27-8	4.42E-05	1.11E-03	1.48E-01	NA	NA	NA
2-Methylhexane	591-76-4	1.38E-05	3.48E-04	4.61E-02	NA	NA	NA
2-Methylnaphthalene	91-57-6	2.18E-05	5.49E-04	7.28E-02	NA	NA	NA
2-Methylpentane	107-83-5	9.47E-06	2.39E-04	3.16E-02	NA	NA	NA
3-Ethylhexane, 3-Methylheptane	589-81-1	5.90E-05	1.49E-03	1.97E-01	NA	NA	NA
3-Methyl-1-butene	563-45-1	1.99E-07	5.01E-06	6.65E-04	NA	NA	NA
3-Methylhexane	589-34-4	1.55E-05	3.91E-04	5.18E-02	NA	NA	NA
3-Methylpentane	96-14-0	5.08E-06	1.28E-04	1.70E-02	NA	NA	NA
Acenaphthylene	208-96-8	6.71E-06	1.69E-04	2.24E-02	NA	NA	NA
Acetophenone	98-86-2	1.74E-07	4.38E-06	5.81E-04	3.00E+04	NA	No
Acetylene	74-86-2	9.52E-05	2.40E-03	3.18E-01	NA	NA	NA
Aluminum	7429-90-5	7.13E-07	1.80E-05	2.38E-03	NA	NA	NA
Anthracene	120-12-7	1.02E-07	2.57E-06	3.41E-04	6.00E+03	NA	No

Aromative (e.g. Styrene)		2.29E-03	5.77E-02	7.65E+00	NA	NA	NA
Barium	7440-39-3	4.20E-07	1.06E-05	1.40E-03	1.50E+03	NA	No
Benzene	71-43-2	7.84E-05	1.98E-03	2.62E-01	1.30E+03	2.70E+01	No
Benzo(a)anthracene	56-55-3	9.81E-07	2.47E-05	3.28E-03	3.00E+02	NA	No
Benzo(a)pyrene	50-32-8	7.42E-07	1.87E-05	2.48E-03	6.00E+02	NA	No
Benzo(b)fluoranthene	205-99-2	7.84E-07	1.98E-05	2.62E-03	6.00E+02	NA	No
Benzo(ghi)perylene	191-24-2	3.45E-07	8.69E-06	1.15E-03	NA	NA	NA
Benzo(k)fluoranthene	207-08-9	7.46E-07	1.88E-05	2.49E-03	6.00E+02	NA	No
Benzyl alcohol	100-51-6	3.96E-05	9.98E-04	1.32E-01	6.00E+04	NA	No
Biphenyl	92-52-4	6.45E-06	1.63E-04	2.15E-02	NA	NA	NA
Butyl benzyl phthalate	85-68-7	1.22E-07	3.07E-06	4.08E-04	1.50E+04	NA	No
Carbon Tetrachloride	56-23-5	6.89E-08	1.74E-06	2.30E-04	1.90E+03	1.90E+03	No
Chromium	7440-47-3	3.97E-07	1.00E-05	1.33E-03	1.50E+03	NA	No
Chrysene	218-01-9	9.33E-07	2.35E-05	3.12E-03	6.00E+02	NA	No
cis-2-Butene	590-18-1	1.99E-07	5.01E-06	6.65E-04	NA	NA	NA
cis-2-Pentene	627-20-3	9.07E-08	2.29E-06	3.03E-04	NA	NA	NA
Carbon Monoxide (2)	630-08-0	2.98E-02	7.51E-01	1.00E+02	NA	2.30E+04	No
Carbon Dioxide	124-38-9	1.63E+00	4.11E+01	5.44E+03	NA	NA	NA
Copper	7440-50-8	6.31E-06	1.59E-04	2.11E-02	NA	1.00E+02	No
Cyclohexane	110-82-7	2.67E-05	6.73E-04	8.92E-02	NA	NA	NA
Cyclopentane	287-92-3	1.53E-06	3.86E-05	5.11E-03	NA	NA	NA
Dibenz(a,h)anthracene / Dibenzo(a,h)anthracene	53-70-3	2.00E-07	5.04E-06	6.68E-04	3.00E+04	NA	No
Diethyl phthalate	84-66-2	7.00E-08	1.76E-06	2.34E-04	1.50E+04	NA	No
Dimethyl phthalate	113-11-3	1.88E-07	4.74E-06	6.28E-04	1.50E+04	NA	No
Di-n-butyl phthalate / Dibutyl Phthalate	84-74-2	3.30E-07	8.32E-06	1.10E-03	1.50E+04	NA	No
Di-n-octyl phthalate	117-84-0	9.19E-07	2.32E-05	3.07E-03	5.00E+04	NA	No
Ethane	74-84-0	1.15E-05	2.90E-04	3.84E-02	NA	NA	NA
Ethyl chloride / Chloroethane	75-00-3	6.89E-08	1.74E-06	2.30E-04	2.50E+06	NA	No
Ethylbenzene	100-41-4	5.49E-05	1.38E-03	1.83E-01	5.00E+05	NA	No
Ethylene	74-85-1	7.43E-05	1.87E-03	2.48E-01	NA	NA	NA
Fluoranthene	206-44-0	7.85E-07	1.98E-05	2.62E-03	1.50E+01	NA	No
HCL - Hydrochloric Acid	7647-01-0	9.97E-04	2.51E-02	3.33E+00	2.10E+03	2.10E+03	No
i-Butane	75-28-5	1.24E-06	3.12E-05	4.14E-03	NA	NA	NA
i-Butene	115-11-7	2.26E-06	5.70E-05	7.55E-03	NA	NA	NA
Indeno(1,2,3-cd)pyrene	193-39-5	2.83E-07	7.13E-06	9.45E-04	5.00E+02	NA	No
i-Pentane	78-78-4	1.08E-05	2.72E-04	3.61E-02	NA	NA	NA
i-Propylbenzene / Cumene	98-82-8	1.03E-04	2.60E-03	3.44E-01	2.46E+05	NA	No
m- & p-Xylene	108-38-3 & 106-42-3	4.52E-04	1.14E-02	1.51E+00	2.20E+04	2.20E+04	No
Methane	74-82-8	8.72E-05	2.20E-03	2.91E-01	NA	NA	NA
Methyl chloroform / Trichloroethane, 1,1,1-	71-55-6	3.44E-08	8.67E-07	1.15E-04	6.80E+04	6.80E+04	No
Methyl chloride	74-87-3	2.84E-07	7.16E-06	9.49E-04	2.00E+05	NA	No
Methylcyclohexane	108-87-2	1.56E-04	3.93E-03	5.21E-01	NA	NA	NA
Methylcyclopentane	96-37-7	9.93E-06	2.50E-04	3.32E-02	NA	NA	NA
Methylene chloride / dichloromethane	75-09-2	7.46E-07	1.88E-05	2.49E-03	1.40E+04	1.40E+04	No
m-Ethyltoluene	620-14-4	1.28E-04	3.23E-03	4.28E-01	NA	NA	NA

Naphthalene	91-20-3	8.38E-05	2.11E-03	2.80E-01	7.50E+04	NA	No
n-Butane	106-97-8	4.60E-06	1.16E-04	1.54E-02	NA	NA	NA
n-Decane	124-18-5	1.97E-03	4.96E-02	6.58E+00	NA	NA	NA
n-Heptane	142-82-5	5.90E-05	1.49E-03	1.97E-01	NA	NA	NA
n-Hexane	110-54-3	1.60E-05	4.03E-04	5.34E-02	NA	NA	NA
Nitrogen dioxide / Nitrogen peroxide	10102-44-0	4.69E-04	1.18E-02	9.44E-01	NA	4.70E+02	No
Nitrogen Oxide	10024-97-2	6.28E-03	1.58E-01	2.10E+01	NA	NA	NA
Nitrogen Oxides (2)		7.50E-02	1.89E+00	2.52E+02	NA	NA	NA
n-Nonane	111-84-2	1.03E-03	2.60E-02	3.44E+00	NA	NA	NA
n-Octane	111-65-9	2.48E-04	6.25E-03	8.28E-01	NA	NA	NA
Non-methane Organic Compound /NMHC (2)		7.84E-03	1.98E-01	2.63E+01	NA	NA	NA
n-Pentane	109-66-0	9.05E-06	2.28E-04	3.02E-02	NA	NA	NA
n-Propylbenzene	103-65-1	8.16E-05	2.06E-03	2.73E-01	NA	NA	NA
OCDD *Screening Limits are for TetraCDD, 2,3,7,8-	TCDD CAS no. 1746-01-6	1.03E-11	2.60E-10	3.44E-08	1.50E+00	NA	No
o-Ethyltoluene	611-14-3	3.90E-07	9.83E-06	1.30E-03	NA	NA	NA
o-Xylene	95-47-6	1.25E-04	3.15E-03	4.18E-01	2.20E+04	2.20E+04	No
Perylene	198-55-0	1.72E-07	4.33E-06	5.75E-04	NA	NA	NA
p-Ethyltoluene	622-96-8	1.53E-04	3.86E-03	5.11E-01	NA	NA	NA
Phenanthrene	85-01-8	7.17E-06	1.81E-04	2.39E-02	1.00E+03	NA	No
Phenol	108-95-2	1.56E-05	3.93E-04	5.21E-02	5.80E+03	5.80E+03	No
PM10 (2)(3)		9.10E-01	2.29E+01	3.04E+03	NA	NA	NA
Propane	74-98-6	2.22E-06	5.59E-05	7.42E-03	NA	NA	NA
Propene	115-07-1	1.30E-05	3.28E-04	4.34E-02	NA	NA	NA
Pyrene	129-00-0	7.06E-07	1.78E-05	2.36E-03	1.50E+04	NA	No
Styrene	100-42-5	4.99E-05	1.26E-03	1.67E-01	2.10E+04	2.10E+04	No
Sulfur Dioxide (2)	7446-09-5	1.22E-03	3.07E-02	4.79E+00	NA	6.60E+02	No
Toluene	108-88-3	1.22E-04	3.07E-03	4.08E-01	3.70E+04	5.00E+03	No
Total Alkanes (Paraffins)	NA	3.50E-03	8.82E-02	1.17E+01	NA	NA	NA
Total Alkenes (Olefins) (e.g. Ethylene)	NA	1.93E-04	4.86E-03	6.45E-01	NA	NA	NA
Total Non-methane Hydrocarbons - TNMHC (2)	NA	1.20E-02	3.02E-01	4.02E+01	NA	NA	NA
Total Unidentified Hydrocarbons	NA	6.04E-03	1.52E-01	2.02E+01	NA	NA	NA
trans-2-Butene	624-64-6	2.91E-06	7.33E-05	9.72E-03	NA	NA	NA
trans-2-Pentene	646-04-8	1.08E-06	2.72E-05	3.61E-03	NA	NA	NA
Vinyl Chloride	75-01-4	2.23E-07	5.62E-06	7.45E-04	1.80E+05	1.80E+05	No
Vinylidene Chloride / Dichloroethylene, 1,1-	75-35-4	2.15E-07	5.42E-06	7.18E-04	7.50E+04	NA	No
Volatile Organic Compounds		5.50E-04	1.39E-02	1.84E+00	NA	NA	NA
Zinc	7440-66-6	6.26E-05	1.58E-03	2.09E-01	3.00E+04	NA	No

Notes:

1. NA = Chemical not available in database.
2. Impacts from propane combustion have been added to waste impact concentrations for nitrogen oxides, carbon monoxide, PM10, sulfur dioxide and NMHC.
3. PM10 emissions factor and emissions are the same for PM2.5
4. Screening concentrations from acute (1 h) inhalation exposures concentrations (AIEC) from the Companion Database to EPA's Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities (EPA 2016). https://archive.epa.gov/epawaste/hazard/tsd/td/web/mdb/05hhrapchemdat.mdb
5. REL 1-hour acute screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values. https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
6. 8th highest concentration for NO2, same as the NAAQS/NMAAQS design value or 98th percentile concentration

Table 5-6b. Chronic Health Screening Level Results for TA-16-388

Basis

6,000 lb waste/yr

1 g/sec contaminant emission rate

Model Result (X/Q) **OBTA16-388-2023 12-11-2021 0900hr Annual AllReceptors_2021_CO2**

2.556 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	CAS No.	Emission Factor lb/lb waste	Emission Rate g/sec	Maximum Annual Concentration µg/m³	CA-OEHHA Non-Cancer Chronic Reference Exposure Level (REL)(5) (µg/m³)	EPA Resident Air Non-Carcinogenic (RSL)(6) for THI = 0.1 (µg/m³)	Screening Level Exceeded(6)?
1,2,4-Trimethylbenzene	95-63-6	2.43E-04	2.10E-05	5.36E-05	4.00E+00	6.30E+00	No
sec-Butylbenzene	135-98-8	5.09E-04	4.39E-05	1.12E-04	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	5.57E-04	4.81E-05	1.23E-04	4.00E+00	6.30E+00	No
1,3-Butadiene	106-99-0	1.34E-06	1.16E-07	2.96E-07	2.00E+00	2.10E-01	No
1-Butene	106-98-9	4.69E-06	4.05E-07	1.03E-06	NA	NA	NA
1-Hexene	592-41-6	2.19E-06	1.89E-07	4.83E-07	NA	NA	NA
1-Pentene	109-67-1	1.72E-06	1.48E-07	3.79E-07	NA	NA	NA
2,2,4-Trimethylpentane	540-84-1	6.97E-06	6.02E-07	1.54E-06	NA	NA	NA
2,2-Dimethylbutane	75-83-2	4.29E-08	3.70E-09	9.46E-09	NA	NA	NA
2,3,4-Trimethylpentane	565-75-3	1.38E-06	1.19E-07	3.04E-07	NA	NA	NA
2,3-Dimethylbutane	79-29-8	2.06E-06	1.78E-07	4.54E-07	NA	NA	NA
2,3-Dimethylhexane	584-94-1	5.40E-06	4.66E-07	1.19E-06	NA	NA	NA
2,3-Dimethylpentane	565-59-3	3.33E-06	2.87E-07	7.35E-07	NA	NA	NA
2,4,4-Trimethyl-1-pentene	107-39-1	1.99E-07	1.72E-08	4.39E-08	NA	NA	NA
2,4-Dimethylhexane	589-43-5	6.42E-06	5.54E-07	1.42E-06	NA	NA	NA
2,4-Dimethylpentane	108-08-7	2.16E-06	1.86E-07	4.77E-07	NA	NA	NA
2,5-Dimethylhexane	592-13-2	1.11E-05	9.58E-07	2.45E-06	NA	NA	NA
2-Methyl-1-butene	563-46-2	1.05E-06	9.06E-08	2.32E-07	NA	NA	NA
2-Methyl-2-butene	513-35-9	9.07E-08	7.83E-09	2.00E-08	NA	NA	NA
2-Methylheptane	592-27-8	4.42E-05	3.81E-06	9.75E-06	NA	NA	NA
2-Methylhexane	591-76-4	1.38E-05	1.19E-06	3.04E-06	NA	NA	NA
2-Methylnaphthalene	91-57-6	2.18E-05	1.88E-06	4.81E-06	NA	NA	NA
2-Methylpentane	107-83-5	9.47E-06	8.17E-07	2.09E-06	NA	NA	NA
3-Ethylhexane, 3-Methylheptane	589-81-1	5.90E-05	5.09E-06	1.30E-05	NA	NA	NA
3-Methyl-1-butene	563-45-1	1.99E-07	1.72E-08	4.39E-08	NA	NA	NA
3-Methylhexane	589-34-4	1.55E-05	1.34E-06	3.42E-06	NA	NA	NA
3-Methylpentane	96-14-0	5.08E-06	4.38E-07	1.12E-06	NA	NA	NA
Acenaphthylene	208-96-8	6.71E-06	5.79E-07	1.48E-06	NA	NA	NA
Acetophenone	98-86-2	1.74E-07	1.50E-08	3.84E-08	NA	NA	NA
Acetylene	74-86-2	9.52E-05	8.22E-06	2.10E-05	NA	NA	NA
Aluminum	7429-90-5	7.13E-07	6.15E-08	1.57E-07	NA	5.20E-01	No
Anthracene	120-12-7	1.02E-07	8.80E-09	2.25E-08	NA	NA	NA
Aromative (e.g. Styrene)		2.29E-03	1.98E-04	5.05E-04	NA	NA	NA
Barium	7440-39-3	4.20E-07	3.62E-08	9.27E-08	NA	5.20E-02	No

Benzene	71-43-2	7.84E-05	6.77E-06	1.73E-05	3.00E+00	3.10E+00	No
Benzo(a)anthracene	56-55-3	9.81E-07	8.47E-08	2.16E-07	NA	NA	NA
Benzo(a)pyrene	50-32-8	7.42E-07	6.40E-08	1.64E-07	NA	2.10E-04	No
Benzo(b)fluoranthene	205-99-2	7.84E-07	6.77E-08	1.73E-07	NA	NA	NA
Benzo(ghi)perylene	191-24-2	3.45E-07	2.98E-08	7.61E-08	NA	NA	NA
Benzo(k)fluoranthene	207-08-9	7.46E-07	6.44E-08	1.65E-07	NA	NA	NA
Benzyl alcohol	100-51-6	3.96E-05	3.42E-06	8.74E-06	NA	NA	NA
Biphenyl, 1,1'-	92-52-4	6.45E-06	5.57E-07	1.42E-06	NA	4.20E-02	No
Butyl benzyl phthalate	85-68-7	1.22E-07	1.05E-08	2.69E-08	NA	NA	NA
Carbon Tetrachloride	56-23-5	6.89E-08	5.95E-09	1.52E-08	4.00E+01	1.00E+01	No
Chromium	7440-47-3	3.97E-07	3.43E-08	8.76E-08	NA	NA	NA
Chrysene	218-01-9	9.33E-07	8.05E-08	2.06E-07	NA	NA	NA
cis-2-Butene	590-18-1	1.99E-07	1.72E-08	4.39E-08	NA	NA	NA
cis-2-Pentene	627-20-3	9.07E-08	7.83E-09	2.00E-08	NA	NA	NA
CO (2)	630-08-0	2.98E-02	2.57E-03	6.58E-03	NA	NA	NA
CO2	124-38-9	1.63E+00	1.41E-01	3.60E-01	NA	NA	NA
Copper	7440-50-8	6.31E-06	5.45E-07	1.39E-06	NA	NA	NA
Cyclohexane	110-82-7	2.67E-05	2.30E-06	5.89E-06	NA	6.30E+02	No
Cyclopentane	287-92-3	1.53E-06	1.32E-07	3.38E-07	NA	NA	NA
Dibenz(a,h)anthracene	53-70-3	2.00E-07	1.73E-08	4.41E-08	NA	NA	NA
Diethyl phthalate	84-66-2	7.00E-08	6.04E-09	1.54E-08	NA	NA	NA
Dimethyl phthalate	113-11-3	1.88E-07	1.62E-08	4.15E-08	NA	NA	NA
Di-n-butyl phthalate / Dibutyl Phthalate	84-74-2	3.30E-07	2.85E-08	7.28E-08	NA	NA	NA
Di-n-octyl phthalate	117-84-0	9.19E-07	7.93E-08	2.03E-07	NA	NA	NA
Ethane	74-84-0	1.15E-05	9.92E-07	2.54E-06	NA	NA	NA
Ethyl chloride	75-00-3	6.89E-08	5.95E-09	1.52E-08	3.00E+04	4.20E+02	No
Ethylbenzene	100-41-4	5.49E-05	4.74E-06	1.21E-05	2.00E+03	1.00E+02	No
Ethylene	74-85-1	7.43E-05	6.41E-06	1.64E-05	NA	NA	NA
Fluoranthene	206-44-0	7.85E-07	6.77E-08	1.73E-07	NA	NA	NA
HCL / Hydrogen Chloride	7647-01-0	9.97E-04	8.60E-05	2.20E-04	9.00E+00	2.10E+00	No
i-Butane	75-28-5	1.24E-06	1.07E-07	2.74E-07	NA	NA	NA
i-Butene	115-11-7	2.26E-06	1.95E-07	4.99E-07	NA	NA	NA
Indeno(1,2,3-cd)pyrene	193-39-5	2.83E-07	2.44E-08	6.24E-08	NA	NA	NA
i-Pentane	78-78-4	1.08E-05	9.32E-07	2.38E-06	NA	NA	NA
i-Propylbenzene / Cumene	98-82-8	1.03E-04	8.89E-06	2.27E-05	NA	4.20E+01	No
m- & p-Xylene	108-38-3 & 106-42-3	4.52E-04	3.90E-05	9.97E-05	7.00E+02	1.00E+01	No
Methane	74-82-8	8.72E-05	7.53E-06	1.92E-05	NA	NA	NA
Methyl chloroform / Trichloroethane, 1,1,1-	71-55-6	3.44E-08	2.97E-09	7.59E-09	1.00E+03	5.20E+02	No
Methylchloride / Chloromethane	74-87-3	2.84E-07	2.45E-08	6.27E-08	NA	9.40E+00	No
Methylcyclohexane	108-87-2	1.56E-04	1.35E-05	3.44E-05	NA	9.90E+00	No
Methylcyclopentane	96-37-7	9.93E-06	8.57E-07	2.19E-06	NA	NA	NA
Methylene chloride	75-09-2	7.46E-07	6.44E-08	1.65E-07	4.00E+02	6.30E+01	No

m-Ethyltoluene	620-14-4	1.28E-04	1.10E-05	2.82E-05	NA	NA	NA
Naphthalene	91-20-3	8.38E-05	7.23E-06	1.85E-05	9.00E+00	3.10E-01	No
n-Butane	106-97-8	4.60E-06	3.97E-07	1.01E-06	NA	NA	NA
n-Decane	124-18-5	1.97E-03	1.70E-04	4.35E-04	NA	NA	NA
n-Heptane	142-82-5	5.90E-05	5.09E-06	1.30E-05	NA	4.20E+01	No
n-Hexane	110-54-3	1.60E-05	1.38E-06	3.53E-06	7.00E+03	7.30E+01	No
Nitrogen dioxide (peroxide)	10102-44-0	4.69E-04	4.05E-05	1.03E-04	NA	NA	NA
Nitrogen Oxide	10024-97-2	6.28E-03	5.42E-04	1.39E-03	NA	NA	NA
Nitrogen Oxides (2)		7.50E-02	6.47E-03	1.65E-02	NA	NA	NA
n-Nonane	111-84-2	1.03E-03	8.89E-05	2.27E-04	NA	2.10E+00	No
n-Octane	111-65-9	2.48E-04	2.14E-05	5.47E-05	NA	NA	NA
Non-methane Organic Compound/NMHC (2)		7.84E-03	6.77E-04	1.73E-03	NA	NA	NA
n-Pentane	109-66-0	9.05E-06	7.81E-07	2.00E-06	NA	1.00E+02	No
n-Propylbenzene	103-65-1	8.16E-05	7.04E-06	1.80E-05	NA	1.00E+02	No
OCDD *Screening Limits are for TCDD,2,3,7,8-	TCDD CAS no. 1746-01-6	1.03E-11	8.89E-13	2.27E-12	4.00E-05	4.20E-06	No
o-Ethyltoluene	611-14-3	3.90E-07	3.37E-08	8.60E-08	NA	NA	NA
o-Xylene	95-47-6	1.25E-04	1.08E-05	2.76E-05	7.00E+02	1.00E+01	No
Perylene	198-55-0	1.72E-07	1.48E-08	3.79E-08	NA	2.10E-04	No
p-Ethyltoluene	622-96-8	1.53E-04	1.32E-05	3.38E-05	NA	NA	NA
Phenanthrene	85-01-8	7.17E-06	6.19E-07	1.58E-06	NA	NA	NA
Phenol	108-95-2	1.56E-05	1.35E-06	3.44E-06	2.00E+02	2.10E+01	No
PM10 (2)(3)		9.10E-01	7.85E-02	2.01E-01	NA	NA	NA
Propane	74-98-6	2.22E-06	1.92E-07	4.90E-07	NA	NA	NA
Propene / Propylene	115-07-1	1.30E-05	1.12E-06	2.87E-06	3.00E+03	3.10E+02	No
Pyrene	129-00-0	7.06E-07	6.09E-08	1.56E-07	NA	NA	NA
Styrene	100-42-5	4.99E-05	4.31E-06	1.10E-05	9.00E+02	1.00E+02	No
Sulfur Dioxide (2)	7446-09-5	1.22E-03	1.05E-04	2.71E-04	NA	NA	NA
Toluene	108-88-3	1.22E-04	1.05E-05	2.69E-05	4.20E+02	5.20E+02	No
Total Alkanes (Paraffins)	NA	3.50E-03	3.02E-04	7.72E-04	NA	NA	NA
Total Alkenes (Olefins) (e.g., Ethylene)	NA	1.93E-04	1.67E-05	4.26E-05	NA	NA	NA
Total Non-methane Hydrocarbons / TNMHC(2)	NA	1.20E-02	1.04E-03	2.65E-03	NA	NA	NA
Total Unidentified Hydrocarbons	NA	6.04E-03	5.21E-04	1.33E-03	NA	NA	NA
trans-2-Butene	624-64-6	2.91E-06	2.51E-07	6.42E-07	NA	NA	NA
trans-2-Pentene	646-04-8	1.08E-06	9.32E-08	2.38E-07	NA	NA	NA
Vinyl Chloride	75-01-4	2.23E-07	1.92E-08	4.92E-08	NA	1.00E+01	No
Vinylidene Chloride / Dichloroethylene (1,1)	75-35-4	2.15E-07	1.86E-08	4.74E-08	7.00E+01	2.10E+01	No
Volatile Organic Compounds	NA	5.50E-04	4.75E-05	1.21E-04	NA	NA	NA
Zinc	7440-66-6	6.26E-05	5.40E-06	1.38E-05	NA	NA	NA

Notes:

1. NA = Chemical not available in database.
2. Impacts from propane combustion have been added to waste impact concentrations for nitrogen oxides, carbon monoxide, PM10, sulfur dioxide and NMHC.
3. PM10 emissions factor and emissions are the same for PM2.5.
4. Chronic REL annual screening concentrations are from the CA OEHHA, October 2023, Consolidated Table Of OEHHA/ARB Approved Risk Assessment Health Values. https://ww2.arb.ca.gov/sites/default/files/classic/toxics/healthval/contable10062023.pdf
5. U.S. EPA air non-carcinogenic screening levels are from the Regional Screening Levels (RSLs) – Generic Tables. November 2023. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

Table 5-6c. Residential Soil Screening Level and LANL ESL Screening Level Results for TA-16-388

Basis

6,000 lb waste/yr

1 g/sec contaminant emission rate

Model Result (X/Q)

2.556 Annual maximum value, µg/m³ per g/sec contaminant

Contaminant	CAS Nos.	Maximum Annual Concentration µg/m³	10 Year Soil Concentration mg/kg	NMED Cancer - Residential Soil TR=1E-05 (mg/kg)	NMED Non-Cancer Residential Soil Screening Level (mg/kg)	Carcinogenic Target Risk - EPA SL - Resident Soil based on TR = 1E-06 (mg/kg)	Noncancer Child HI EPA RSLs - Resident Soil based on THI = 0.1 (mg/kg)	NMED or EPA Screening Levels Exceeded?	Minimum LANL ESL mg/kg	Receptor	LANL ESL Screening Levels Exceeded ?
1,2,4-Trimethylbenzene	95-63-6	5.36E-05	3.17E-02	NA	NA	NA	3.00E+01	No	NA	NA	NA
sec-Butylbenzene	135-98-8	1.12E-04	6.64E-02	NA	NA	NA	7.80E+02	No	NA	NA	NA
1,3,5-Trimethylbenzene	108-67-8	1.23E-04	7.27E-02	NA	NA	NA	2.70E+01	No	NA	NA	NA
1,3-Butadiene	106-99-0	2.96E-07	1.75E-04	9.48E-01	2.30E+00	7.60E-02	1.80E-01	No	NA	NA	NA
1-Butene	106-98-9	1.03E-06	6.12E-04	NA	NA	NA	NA	NA	NA	NA	NA
1-Hexene	592-41-6	4.83E-07	2.86E-04	NA	NA	NA	NA	NA	NA	NA	NA
1-Pentene	109-67-1	3.79E-07	2.24E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,2,4-Trimethylpentane	540-84-1	1.54E-06	9.09E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,2-Dimethylbutane	75-83-2	9.46E-09	5.60E-06	NA	NA	NA	NA	NA	NA	NA	NA
2,3,4-Trimethylpentane	565-75-3	3.04E-07	1.80E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,3-Dimethylbutane	79-29-8	4.54E-07	2.69E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,3-Dimethylhexane	584-94-1	1.19E-06	7.05E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,3-Dimethylpentane	565-59-3	7.35E-07	4.35E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,4,4-Trimethyl-1-pentene	107-39-1	4.39E-08	2.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylhexane	589-43-5	1.42E-06	8.38E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,4-Dimethylpentane	108-08-7	4.77E-07	2.82E-04	NA	NA	NA	NA	NA	NA	NA	NA
2,5-Dimethylhexane	592-13-2	2.45E-06	1.45E-03	NA	NA	NA	NA	NA	NA	NA	NA
2-Methyl-1-butene	563-46-2	2.32E-07	1.37E-04	NA	NA	NA	NA	NA	NA	NA	NA
2-Methyl-2-butene	513-35-9	2.00E-08	1.18E-05	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylheptane	592-27-8	9.75E-06	5.77E-03	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylhexane	591-76-4	3.04E-06	1.80E-03	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylnaphthalene	91-57-6	4.81E-06	2.84E-03	NA	2.32E+02	NA	2.40E+01	No	1.60E+01	Montane Shrew	No
2-Methylpentane	107-83-5	2.09E-06	1.24E-03	NA	NA	NA	NA	NA	NA	NA	NA
3-Ethylhexane, 3-Methylheptane	589-81-1	1.30E-05	7.70E-03	NA	NA	NA	NA	NA	NA	NA	NA
3-Methyl-1-butene	563-45-1	4.39E-08	2.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylhexane	589-34-4	3.42E-06	2.02E-03	NA	NA	NA	NA	NA	NA	NA	NA
3-Methylpentane	96-14-0	1.12E-06	6.63E-04	NA	NA	NA	NA	NA	NA	NA	NA
Acenaphthylene	208-96-8	1.48E-06	8.76E-04	NA	NA	NA	NA	NA	1.20E+02	Montane Shrew	No
Acetophenone	98-86-2	3.84E-08	2.27E-05	NA	7.82E+03	NA	7.80E+02	No	NA	NA	NA

Acetylene	74-86-2	2.10E-05	1.24E-02	NA	NA	NA	NA	NA	NA	NA	NA
Aluminum	7429-90-5	1.57E-07	9.30E-05	NA	7.80E+04	NA	7.70E+03	No	NA	NA	NA
Anthracene	120-12-7	2.25E-08	1.33E-05	NA	1.74E+04	NA	1.80E+03	No	6.80E+00	Generic Plant	No
Aromative (e.g. Styrene)		5.05E-04	2.99E-01	NA	NA	NA	NA	NA	NA	NA	NA
Barium	7440-39-3	9.27E-08	5.48E-05	NA	1.56E+04	NA	1.50E+03	No	1.10E+02	Generic Plant	No
Benzene	71-43-2	1.73E-05	1.02E-02	1.78E+01	1.14E+02	1.20E+00	8.20E+00	No	2.40E+01	Deer Mouse	No
Benzo(a)anthracene	56-55-3	2.16E-07	1.28E-04	1.53E+00	NA	1.10E+00	NA	No	7.30E-01	American Robin	No
Benzo(a)pyrene	50-32-8	1.64E-07	9.68E-05	1.12E+00	1.74E+01	1.10E-01	1.80E+00	No	6.20E+01	Montane Shrew	No
Benzo(b)fluoranthene	205-99-2	1.73E-07	1.02E-04	1.53E+00	NA	1.10E+00	NA	No	1.80E+01	Generic Plant	No
Benzo(ghi)perylene	191-24-2	7.61E-08	4.50E-05	NA	NA	NA	NA	NA	2.50E+01	Montane Shrew	No
Benzo(k)fluoranthene	207-08-9	1.65E-07	9.73E-05	1.53E+01	NA	1.10E+01	NA	No	7.10E+01	Montane Shrew	No
Benzyl alcohol	100-51-6	8.74E-06	5.17E-03	NA	NA	NA	6.30E+02	No	1.20E+02	Deer Mouse	No
Biphenyl, 1,1'-	92-52-4	1.42E-06	8.42E-04	8.48E+02	3.91E+04	8.70E+01	4.70E+00	No	NA	NA	NA
Butylbenzyl phthalate	85-68-7	2.69E-08	1.59E-05	NA	NA	2.90E+02	1.30E+03	No	9.00E+01	Montane Shrew	No
Carbon Tetrachloride	56-23-5	1.52E-08	8.99E-06	1.07E+01	1.44E+02	6.50E-01	1.00E+01	No	NA	NA	NA
Chromium (total)	7440-47-3	8.76E-08	5.18E-05	9.66E+01	4.52E+04	NA	NA	No	2.30E+01	American Robin	No
Chrysene	218-01-9	2.06E-07	1.22E-04	1.53E+02	NA	1.10E+02	NA	No	3.10E+00	Montane Shrew	No
cis-2-Butene	590-18-1	4.39E-08	2.60E-05	NA	NA	NA	NA	NA	NA	NA	NA
cis-2-Pentene	627-20-3	2.00E-08	1.18E-05	NA	NA	NA	NA	NA	NA	NA	NA
CO	630-08-0	6.58E-03	3.89E+00	NA	NA	NA	NA	NA	NA	NA	NA
CO2	124-38-9	3.60E-01	2.13E+02	NA	NA	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	1.39E-06	8.23E-04	NA	3.13E+03	NA	3.10E+02	No	1.40E+01	American Robin	NA
Cyclohexane	110-82-7	5.89E-06	3.48E-03	NA	3.91E+02	NA	6.50E+02	No	NA	NA	NA
Cyclopentane	287-92-3	3.38E-07	2.00E-04	NA	NA	NA	NA	NA	NA	NA	NA
Dibenz(a,h)anthracene	53-70-3	4.41E-08	2.61E-05	1.53E-01	NA	1.10E-01	NA	No	1.40E+01	Montane Shrew	No
Diethyl phthalate	84-66-2	1.54E-08	9.13E-06	NA	4.93E+04	NA	5.10E+03	No	1.00E+02	Generic Plant	No
Dimethyl phthalate	113-11-3	4.15E-08	2.45E-05	NA	NA	NA	NA	NA	1.00E+01	Earthworm	No
Di-n-butyl phthalate / Dibutyl Phthalate	84-74-2	7.28E-08	4.31E-05	NA	6.16E+03	NA	6.30E+02	No	1.10E-02	American Robin	No
Di-n-octyl phthalate	117-84-0	2.03E-07	1.20E-04	NA	NA	NA	6.30E+01	No	9.10E-01	Montane Shrew	No

Ethane	74-84-0	2.54E-06	1.50E-03	NA	NA	NA	NA	NA	NA	NA	NA
Ethyl chloride / Chloroethane	75-00-3	1.52E-08	8.99E-06	NA	1.90E+04	NA	5.40E+02	No	NA	NA	NA
Ethylbenzene	100-41-4	1.21E-05	7.16E-03	7.51E+01	3.93E+03	5.80E+00	2.40E+02	No	NA	NA	NA
Ethylene	74-85-1	1.64E-05	9.70E-03	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	206-44-0	1.73E-07	1.02E-04	NA	2.32E+03	NA	2.40E+02	No	1.00E+01	Earthworm	No
HCL / Hydrogen Chloride	7647-01-0	2.20E-04	1.30E-01	NA	NA	NA	2.80E+06	No	NA	NA	NA
i-Butane	75-28-5	2.74E-07	1.62E-04	NA	NA	NA	NA	NA	NA	NA	NA
i-Butene	115-11-7	4.99E-07	2.95E-04	NA	NA	NA	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	193-39-5	6.24E-08	3.69E-05	1.53E+00	NA	1.10E+00	NA	No	7.10E+01	Montane Shrew	No
i-Pentane	78-78-4	2.38E-06	1.41E-03	NA	NA	NA	NA	NA	NA	NA	NA
i-Propylbenzene / Cumene	98-82-8	2.27E-05	1.34E-02	NA	2.36E+03	NA	1.90E+02	No	NA	NA	NA
m- & p-Xylene	108-38-3 & 106-42-3	9.97E-05	5.90E-02	NA	7.64E+02	NA	5.50E+01	No	1.40E+00	Montane Shrew	No
Methane	74-82-8	1.92E-05	1.14E-02	NA	NA	NA	NA	NA	NA	NA	NA
Methyl chloroform/1,1,1-Trichloroethane (TCA)	71-55-6	7.59E-09	4.49E-06	NA	1.44E+04	NA	8.10E+02	No	2.60E+02	Montane Shrew	No
Methyl chloride/Chloromethane	74-87-3	6.27E-08	3.71E-05	4.11E+01	2.68E+02	NA	1.10E+01	No	NA	NA	NA
Methyl cyclohexane	108-87-2	3.44E-05	2.04E-02	NA	5.50E+03	NA	9.80E+00	No	NA	NA	NA
Methyl cyclopentane	96-37-7	2.19E-06	1.30E-03	NA	NA	NA	NA	NA	NA	NA	NA
Methylene chloride/Dicloromethane	75-09-2	1.65E-07	9.73E-05	7.66E+02	4.09E+02	5.70E+01	3.50E+01	No	2.60E+00	Deer Mouse	No
m-Ethyltoluene	620-14-4	2.82E-05	1.67E-02	NA	NA	NA	NA	NA	NA	NA	NA
Naphthalene	91-20-3	1.85E-05	1.09E-02	2.26E+01	1.62E+02	2.00E+00	1.30E+01	No	1.00E+00	Generic Plant	No
n-Butane	106-97-8	1.01E-06	6.00E-04	NA	NA	NA	NA	NA	NA	NA	NA
n-Decane	124-18-5	4.35E-04	2.57E-01	NA	NA	NA	NA	NA	NA	NA	NA
n-Heptane	142-82-5	1.30E-05	7.70E-03	NA	NA	NA	2.20E+00	No	NA	NA	NA
n-Hexane	110-54-3	3.53E-06	2.09E-03	NA	6.15E+02	NA	6.10E+01	No	NA	NA	NA
Nitrogen dioxide (peroxide)	10102-44-0	1.03E-04	6.12E-02	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxide	10024-97-2	1.39E-03	8.19E-01	NA	NA	NA	NA	NA	NA	NA	NA
Nitrogen Oxides		1.65E-02	9.79E+00	NA	NA	NA	NA	NA	NA	NA	NA
n-Nonane	111-84-2	2.27E-04	1.34E-01	NA	NA	NA	1.10E+00	No	NA	NA	NA
n-Octane	111-65-9	5.47E-05	3.24E-02	NA	NA	NA	NA	NA	NA	NA	NA
Non-methane Organic Compound		1.73E-03	1.02E+00	NA	NA	NA	NA	NA	NA	NA	NA
n-Pentane	109-66-0	2.00E-06	1.18E-03	NA	NA	NA	8.10E+01	No	NA	NA	NA
n-Propylbenzene	103-65-1	1.80E-05	1.06E-02	NA	NA	NA	3.80E+02	No	NA	NA	NA
OCDD *Screening Limits are for TCDD, 2,3,7,8	TCDD CAS no. 1746-01-6	2.27E-12	1.34E-09	4.90E-05	5.06E-05	4.80E-06	5.10E-06	No	2.90E-07	Montane Shrew	No
o-Ethyltoluene	611-14-3	8.60E-08	5.09E-05	NA	NA	NA	NA	NA	NA	NA	NA

o-Xylene	95-47-6	2.76E-05	1.63E-02	NA	8.05E+02	NA	6.40E+01	No	1.40E+00	Montane Shrew	No
Perylene	198-55-0	3.79E-08	2.24E-05	NA	NA	NA	5.40E-01	No	NA	NA	NA
p-Ethyltoluene	622-96-8	3.38E-05	2.00E-02	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	85-01-8	1.58E-06	9.36E-04	NA	1.85E+03	NA	NA	No	5.50E+00	Earthworm	No
Phenol	108-95-2	3.44E-06	2.04E-03	NA	1.85E+04	NA	1.90E+03	No	7.90E-01	Generic Plant	No
PM10		2.01E-01	1.19E+02	NA	NA	NA	NA	NA	NA	NA	NA
Propane	74-98-6	4.90E-07	2.90E-04	NA	NA	NA	NA	NA	NA	NA	NA
Propene / Propylene	115-07-1	2.87E-06	1.70E-03	NA	NA	NA	2.20E+02	No	NA	NA	NA
Pyrene	129-00-0	1.56E-07	9.21E-05	NA	1.74E+03	NA	1.80E+02	No	1.00E+01	Earthworm	No
Styrene / Ethenylbenzene	100-42-5	1.10E-05	6.51E-03	NA	7.26E+03	NA	6.00E+02	No	1.20E+00	Earthworm	No
Sulfur Dioxide	7446-09-5	2.71E-04	1.60E-01	NA	NA	NA	NA	NA	NA	NA	NA
Toluene / Methylbenzene	108-88-3	2.69E-05	1.59E-02	NA	5.23E+03	NA	4.90E+02	No	2.30E+01	Montane Shrew	No
Total Alkanes (Paraffins)	NA	7.72E-04	4.57E-01	NA	NA	NA	NA	NA	NA	NA	NA
Total Alkenes (Olefins) (e.g. Ethylene)	NA	4.26E-05	2.52E-02	NA	NA	NA	NA	NA	NA	NA	NA
Total Non-methane Hydrocarbons / NMHC	NA	2.65E-03	1.57E+00	NA	NA	NA	NA	NA	NA	NA	NA
Total Unidentified Hydrocarbons	NA	1.33E-03	7.88E-01	NA	NA	NA	NA	NA	NA	NA	NA
trans-2-Butene	624-64-6	6.42E-07	3.80E-04	NA	NA	NA	NA	NA	NA	NA	NA
trans-2-Pentene	646-04-8	2.38E-07	1.41E-04	NA	NA	NA	NA	NA	NA	NA	NA
Vinyl Chloride/Chlorothene	75-01-4	4.92E-08	2.91E-05	7.42E-01	1.13E+02	5.90E-02	7.00E+00	No	1.20E-01	Montane Shrew	No
Vinylidene Chloride / Dichloroethylene, 1,1-	75-35-4	4.74E-08	2.81E-05	NA	4.40E+02	NA	2.30E+01	No	1.10E+01	Montane Shrew	No
Volatile Organic Compounds	NA	1.21E-04	7.18E-02	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	1.38E-05	8.17E-03	NA	2.35E+04	NA	2.30E+03	No	4.70E+01	American Robin	No

Notes:
1. The calculation methodology is described in Section 5.

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7 Acronyms and Abbreviations

Acronym/ Abbreviation	Definition
AERMOD	AMS/EPA Regulatory Model
AP	ammonium perchlorate
AQB	Air Quality Bureau
ARM2	Ambient Ratio Method Tier 2 option (EPA)
C	carbon
°C	degrees Celsius
DMSO	dimethyl sulfoxide
DoD	(U.S.) Department of Defense
DOE	(U.S.) Department of Energy
DPG	Dugway Proving Grounds, Utah
EPA	(U.S.) Environmental Protection Agency
ft	foot
°F	degrees Fahrenheit
g	gram
h	hour
GLC	ground level concentration
HMX	cyclotetramethylenetetranitramine
JMC	Joint Munitions Command
LANL	Los Alamos National Laboratory
lb	pounds
N	nitrogen
NAAQS	national ambient air quality standards
NAD 83	North American Datum of 1983
NEW	net explosive weight
NMAAQS	New Mexico ambient air quality standards
NMED	New Mexico Environment Department
OB	open burn
OBOD	open burn/open detonation
OBODM	Open Burn/Open Detonation Dispersion Model
OD	open detonation
POC	pollutant of concern
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
RDX	cyclonite
ROI	radius of impact
S	sulfur
SNL	Sandia National Laboratories
SR	state road
SVOC	semi-volatile organic compound

Acronym/ Abbreviation	Definition
TA	technical area
TAP	toxic air pollutant
TNMHCs	non-methane hydrocarbons
TNT	trinitrotoluene
U.S.	United States
UTM	Universal Transverse Mercator
VOC	volatile organic compound

Attachment 1 E-mail dated August 17, 2022

From: Gerhard, Sasha <Gerhard.Sasha@epa.gov>
Sent: Wednesday, August 17, 2022 7:03 PM
To: Littleton, Brian <Littleton.Brian@epa.gov>
Subject: FW: air modeling for open burning / open detonation

Hi Brian,

I searched back through my emails to find where R4 had provided their approach to modeling emissions from Holston Army Ammunition Plant's OB units. Hope this helps and again, if you have questions, I can provide the R4 contacts.

"OBODM is an older method but it does dispersions well if applying to open burn pans. However, this method is dated and has not been maintained to operate on current computer systems. AERMOD has replaced OBODM as the standard model to use for Open Burn and Open Detonation hazardous waste management units (HWMUs). EPA R4 recommends the following air modeling approach for OB and OD."

GENERAL MODELING APPROACH

EPA currently recommends a hybrid approach to modeling dispersion from open burning and open detonation processes. Using two separate regulatory models, the OBODM and the AERMOD Modeling System, in the analysis which allows facilities to draw on the strengths of both models while reducing the impacts of their weaknesses on the modeling results. For example, OBODM more closely models the source characteristics of an open burning operation compared to the elevated volume source algorithm in AERMOD, while AERMOD features more refined algorithms for handling meteorological data and predicting air concentrations and deposition fluxes. AERMOD also includes options that support the implementation of the 2005 HHRAP when modeling units such as the Burn Pan Unit at HSAAP.

Open burning results in combustion of the energetics and the rapid rise of the hot combustion products, due to buoyancy, until a final height is reached. At this point, the emission cloud has no upward momentum and begins to disperse downwind. This process can be estimated using OBODM to predict the final cloud height of the open burn plume. This height is then specified as the release height in the elevated volume source algorithm in AERMOD.
Note, the below information is provided as general guidance in the development of an air modeling methodology for the Burn Pan Unit at HSAAP. HSAAP should consult the 2005 HHRAP, Volume 1 and Volume 2 of the OBODM Users Guide, and the AERMOD Users Guide (along with other EPA air modeling related documents, to develop an effective air modeling protocol for the Burn Pan Unit. The final methodology should be documented and submitted in an air modeling protocol for review and approval by EPA before any air dispersion and deposition modeling is conducted.

OBODM Modeling

OBODM should be performed in the vapor phase (for CO_2) to determine the final plume height(s) to be used in the dispersion and deposition modeling analysis.
The OBODM modeling analysis should address all air modeling scenarios and waste stream types/combinations that represent typical open burns at HSAAP. In order to obtain the plume

height(s) for use in the AERMOD modeling, HSAAP should model every hour of meteorological data during which open burning can occur.
During rapid rise of the vapor cloud from the Burn Pan Unit, atmospheric air is entrained and the size of the cloud increases. If observational data on the initial size of the OB cloud at final plume height are not available for the Burn Pan Unit, equation 2-71 from Section 2.6.3 of Volume 2 of the OBODM Users Guide can be used.

Equation 2-71:

$r(x)= [\gamma_c][\Delta h_c(x)] + r_R$

where:

r(x) = radius of the cloud at final plume
height x = the distance at which final
plume height is achieved
γ_c = 0.6 (OBODM default value)
$\Delta h_c(x)$ = final plume height
r_R = radius of a circle with same area as burn pans

Assuming that the vapor cloud is a sphere, the sigmas for the AERMOD volume source can be calculated from the results obtained from equation 2-71. Thus, the initial vertical and horizontal sigmas for an elevated volume source, such as the vapor cloud, can be calculated by dividing the calculated cloud diameter by 4.3.

Meteorological Data

Sources of meteorological data should be evaluated based on distance, elevation, and surface roughness to determine the most representative meteorological data for use in the air modeling analysis. Tennessee may also have AERMOD-ready meteorological data available for HSAAP. Note that the model-ready meteorological data files for OBODM and AERMOD must be based on the same raw meteorological data set but have different formatting requirements, dictating the use of the appropriate meteorological data preprocessor (e.g., AERMET, PCRAMMET) in file preparation. Surface characteristics, including surface roughness values should be calculated using AERSURFACE, the surface characteristics preprocessor included in the AERMOD modeling system.

Five years of meteorological data should be used unless the data are collected at HSAAP, in which case only one year of meteorological data is required.

Operating Conditions

The Burn Pan Unit at HSAAP does not operate continuously. Section 2.2.4.1, Selection of Air COPCs, of Attachment 11-1 states that open burning operations area assumed to occur 5 days per week, 50 weeks per year, with each open burning event lasting one hour. According to Section E-2-4(c)(4), Burn Pan Unit Source Parameters, of Appendix III, open burning events were modeled daily, 5 days per week (Monday through Friday), between 12:00 pm and 4:00 pm with the first event beginning at 12 and the last event commencing at 3:00 pm. Each open burning event is limited to 5,000 lb of NEW. Thus, HSAAP modeled the open burning of 20,000 lb of NEW per day. However, HSAAP can treat no more than 5,000 lb of NEW per day. This resulted in HSAAP modeling 4 times the allowable NEW in the analysis of annual impacts from open burning. AERMOD includes options that allow for input of actual or simulations of actual operating schedules so that annual impacts predicted by the model do not require additional manipulation. More details are available from Section 3.3.12 Specifying an hourly emission rate file

(HOUREMIS), of the User's Guide for the AMS/EPA Regulatory Model (AERMOD), EPA-454/B-19-027, dated August 2019 (AERMOD Users Guide).

Unit Emission Rate

A unitized emission rate of 1.0 gram/second should be used in each model run to preclude modeling each potentially emitted constituent separately. Unitized emissions rates will be adjusted to COPC specific air parameters (air concentrations and deposition rates) using COPC specific emissions rates in the risk model. Concentration and deposition are directly proportional to air modeling results based on the unit emission rate employed in the AERMOD modeling analysis.

Receptor Grid and Terrain

The receptor grids and discrete receptor locations used in the Brown and Root Air Pathway Assessment should be reevaluated in concert with the recommendations for receptor locations in Section 3.6.3, Receptor Pathway, of the 2005 HHRAP and the AERMOD Modeling System. Based on that analysis, the modeled receptor locations can be specified for inclusion in the AERMOD modeling runs. Specification of model-ready receptor lists will likely involve application of AERMAP, a terrain data preprocessor that is part of the AERMOD Modeling System.

There are terrain features in the vicinity of the Burn Pan Unit; therefore, terrain options available in AERMOD should be used in the dispersion and deposition modeling. Again, AERMAP should be used to convert digital terrain data into model-ready files.

Particle Size Distribution

To estimate particle and particle-bound phase deposition rates, AERMOD needs an initial particle size distribution, broken out by particle diameter. HSAAP should provide the site-specific particle size data or surrogate data to be used with AERMOD. Constituents released from open burning as particulates are modeled using mass fractions allocated to each particle size while emitted organics released in the vapor and particle-bound phases and use a surface-area weighting scheme. Additional details on specifying the particle size distribution can be found in Sections 3.2.2 and 3.2.3 of the 2005 HHRAP and Section 3.3.4, Specifying Source Parameters for Particle Deposition, of the AERMOD Users Guide.

Partitioning of Emissions

Emissions from the Burn Pan Unit will partition into the vapor phase, particle phase, and particle bound phase. Due to the limitations of the AERMOD model, estimates of vapor phase, particle-phase, and particle bound phase impacts cannot be provided in a single AERMOD model run. Each of these phases should be modeled separately. Section 3.2, Partitioning Emissions, and Subsections 3.2.1 through 3.2.3 of the 2005 HHRAP provides additional information.

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Attachment 2 AP-42 Chapter 16 Draft

AP-42 CHAPTER 16

EMISSION FACTORS FOR DEMILITARIZATION PROCESSES: OPEN BURNING AND OPEN AIR DETONATION

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16.0 INTRODUCTION

When subjected to heat, impact, friction, or shock, energetic compounds undergo a very rapid, self-propagating, intramolecular oxidation-reduction reaction (combustion) that results in the formation of highly stable simple gases and the release of heat (energy). This chapter of AP-42 applies to the emissions resulting from the disposal of energetic compounds and materials containing these compounds by open burning in burn pans and by surface detonation. All of the explosive and propellant (energetic) materials covered by this chapter of AP-42 are solids at normal environmental temperatures and pressures and have melting points between 120 and 400^0F and vapor pressures less than 8E-05 kilopascals (7.9E-07 atmospheres).

The materials commonly disposed of by detonation are: reclaimed high explosives that cannot be reused, cased munitions, explosively-loaded ordnance components (e.g., primers and fuzes) and detonable rocket motor propellants. The materials commonly destroyed by open burning are: propellants, reclaimed high explosives that cannot be detonated and combustible materials contaminated with energetic residues from ammunition and ordnance manufacturing processes (Explosive Contaminated Waste, ECW).

16.1 AN OVERVIEW OF DETONATION AND OPEN BURN PROCESSES

The initial step in both open burning and detonation processes is an adiabatic, oxidation-reduction process, which involves oxidant (e.g., $-ONO_2$, $-NO_2$, $-NHNO_2$) and reductant (e.g., C_xH_y) radicals within the energetic molecule. Once this reaction is initiated, it will proceed to completion without any additional energy being required.

The major differences between the open burning and the detonation processes are the speed with which this adiabatic, oxidation-reduction reaction proceeds through the energetic material and the pressures and temperatures involved. In open burning the oxidation-reduction reaction occurs on the surface of the energetic material at close to atmospheric pressure and takes seconds to a few minutes to go to completion. The rate determining factors in open burning are the rate of heat transfer into the material and the rate of decomposition of the energetic material itself. There is no shock wave. In contrast, in detonation processes, the oxidation-reduction reaction proceeds through the material at a velocity (detonation velocity) between 7,000 and 35,000 ft/s and the reaction is completed within a few microseconds. Detonations produce pressures as high as 350,000 atmospheres (35,300,000 kPa) and temperatures as high as $6{,}300^0$F.

In detonations, this intramolecular rearrangement is so fast that only a small percentage of the atoms in one molecule have time to react with atoms in adjacent energetic molecules that are decomposing at the exact same time. Because the detonation of explosives does not require air, it can occur in a vacuum, in an inert atmosphere, or even under water. The initial detonation products are free carbon (soot), carbon monoxide, hydrogen, methane, ethane, formaldehyde, nitrogen, carbon dioxide, water vapor, small hydrocarbons and small C_xH_y fragments. The initial stage of the detonation process is over in less than 10 microseconds and is followed by a 2 to 10 second duration fireball (afterburn). In this second stage of the process, combustible detonation reaction products (e.g., carbon monoxide, methane, ethane, formaldehyde, hydrogen and the C_xH_y fragments) are spontaneously oxidized (combusted) to CO_2 and H_2O. Fireball temperatures are on the order of 1,700 to 3,100°F. As the plume expands it entrains additional air which allows further combustion reactions to take place until the plume temperature falls to approximately $1{,}500^0$F where these reactions stop (freeze out temperature). The air-entrainment and afterburning occur almost simultaneously and are highly coupled. As the gases rise and air is entrained, soil is pulled into the plume. This entrained soil, along with the dirt released from the crater, forms the visible plume associated with detonations. (The gaseous products produced by the detonation and the afterburning are not visible to the eye.) Plume formation takes seconds to hundreds of seconds to complete, and the subsequent dispersion of the plume in the atmosphere can take hours.

When easy-to-detonate materials are detonated, the detonation can often be initiated using an electric blasting cap (EBC) and plastic explosives such as C4 or A-3 or blocks of TNT. These latter materials are frequently referred as the detonation initiating charge and demolition charge. However, when difficult-to detonate materials are to be destroyed by detonation, its common practice to place an easy-to-detonate material (donor material or donor charge) in close contact with the difficult-to-detonate material and to use the detonation of this donor material to detonate the difficult-to-detonate material (sympathetic detonation). The manner in which the donor charges are placed, the methods used to prime or initiate the donor charges, and the amount of confinement (tamp), can strongly influence the effectiveness in the ability of the detonation to completely destroy all of the energetics, particularly in stacks of mixed ordnance. For example, common practice is to simultaneously initiate the detonation of the donor charges from both ends and also top center of the stack to minimize the possibility of munitions being expelled from the stack instead of being destroyed.

Open burning is generally conducted using steel pans sitting on concrete pads to avoid contact with the soil surface. The pans have sufficient depth and size to contain treatment residues and are kept covered when not in use. In open burning the materials are placed in a steel burn pan to a depth of four inches or less, and the burn is initiated with an electric match or a black powder train. Open burns of propellant materials, which usually involve between 1,000 and 5,000 lb of propellant generally go to completion in less than a minute, whereas the burns of the other materials generally take at least three minutes to go to completion. The ash is recovered, and unless chemical analysis recommends otherwise, is disposed of as a hazardous waste.

16.1.1 Emissions from Open Burning and Detonation Processes

Between 1961 and 1981, Ornellas conducted a series of detonation experiments in bomb calorimeters, and evaluated how the following factors affected the efficiency and effectiveness of the detonation process: explosive density, purity, and particle size; the degree of confinement; and the type of initiating charge.[1] These experiments involved detonating one-ounce cylindrical pellets of 43 energetic materials in a 5.3 L bomb calorimeter and determining the chemical composition of the detonation plume.

His experiments established that the major emission products (EPs) from an unconfined detonation are N_2, CO_2, and H_2O and the minor emission products were CO, H_2, CH_4, NO, NO_2, HCN, HCl, HF and small organic molecules that are gases at ambient temperatures and pressures (VOCs). Generally, at least 97% of the nitrogen in the energetic was released as nitrogen and the rest was released as NO and NO_2. He also showed that the chemical composition of the initial detonation products was not greatly affected by the degree of confinement. For example, the initial emission products formed by detonating an energetic in a pure carbon dioxide atmosphere will be essentially the same as those formed when the energetic is detonated in a vacuum, regardless of the degree the energetic is oxygen-balanced.

The first comprehensive Department of Defense (DOD) study to characterize the air emissions from real world open burning and detonation operations was conducted at Dugway Proving Ground (DPG), UT from 1984 through 1986. In this study, helicopters equipped with standard air pollutant sampling systems attempted to identify and quantify the pollutants in the plumes produced when 2,000 to 11,000 lb of bulk high explosives and propellants were open burned and detonated on a DPG test range. The results were inconclusive.[2]

In 1988, the United States Army conducted a highly successful follow-on study.[3-5] The first stage of this follow-on study involved detonating 0.5 lb quantities of TNT and open burning 5 lb quantities of a double-base and a composite propellant in a 32,900 ft^3 hemispherical chamber (BangBox) at Sandia National Laboratories (SNL) in Albuquerque, NM. A suite of state-of-the art sampling systems was then used to characterize the identities and quantities of the emission products present in the plumes. The results from these burns and detonations were used to select the plume sampling equipment subsequently used to measure chemicals of environmental concern in the plumes produced when large quantities of energetic materials were detonated and burned on an open test range at DPG. The sampling equipment selected was installed in a twin-engine turboprop aircraft and the aircraft was used to sample the plumes released when 2,000 lb of high explosives [contained in either wood boxes or steel barrels] were detonated and when 5,000 to 7,000 lb of propellants were open burned in steel pans at DPG.

Based on the test results, DOD concluded that the plumes released when energetic materials are destroyed by open burning and detonation processes do not contain sufficient quantities of toxic or hazardous pollutants to pose a danger to human health or the environment. It also concluded that the

emission factors for the predominant EPs produced in the BangBox (BB) emissions tests were statistically equivalent to those produced in the DPG open range tests and also those produced in Ornellas' calorimeter experiments. That is, the EPs did not change substantially even when the quantity of energetic material detonated increased by a factor of 32,000.

In 1992, the U.S. EPA concurred with DOD's conclusions and agreed to accept BangBox-produced emission factors as representative of those that would be derived through ground level, open-air detonation and burn tests.[4] The U. S. Army then installed a BangBox at DPG and conducted a series of studies that characterized the air emissions produced when bulk and cased high explosives were detonated and bulk propellants were burned . These studies were then followed by larger scale detonation and burn experiments in a larger chamber at the Nevada Test Site that involved detonating 155MM projectiles and burning Hawk and NIKE rocket motors.[6-10] All of these studies employed plume sampling and analysis systems that were similar to those used in the earlier DPG open range studies, but also added the following target analytes: 140 additional VOCs, 100 additional semi-volatile organic compounds (SVOCs) and d polycyclic organic matter (POMs), HCl, Cl_2, metals, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDDs) and SO_2.

These follow-on studies filled in some of the major data gaps left by the open range studies and reconfirmed the conclusions of Ornellas and the open range studies that the predominant emission products for open burning and detonation processes are: particulate, CO_2, N_2, soot, CO, NO_x, metals and the first members of the saturated, unsaturated and aromatic hydrocarbon series. Further, polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran compounds (PCDDs/PCDFs) were not detected in the plumes.

Further, in the few instances when SVOCs/POMs were detected, the concentrations were indistinguishable from those found in ambient air and it is very likely that these compounds were present in the ambient air, when the detonation was initiated. The failure to find PCDDs/PCDFs, SVOCs and POMs might seem surprising, because these compounds are detected in the combustion gases of hazardous waste incinerators and the second stage of open burn and detonation processes involves combustion reactions. The reasons they are not present are: (1) by the time the second stage begins, the energetic material has already decomposed into very small, mostly thermodynamically stable molecules, and (2) the short duration and high temperatures associated with the second stage prevent the reactions from occurring that would convert a meaningful number of these small molecules into polycyclic molecules. In contrast, the temperature associated with the combustion of hazardous wastes are on the order of 900 to $1,600^0$F, and the original waste material is held in this temperature range for more than a minute, conditions that promote the formation of polycyclic organic molecules.[11 - 15]

16.1.2 Emission Controls

There are no emissions controls on either detonations or open burning operations per se. However, some of the engineering controls used to reduce the intensity of the propagation of the blast (sound) and pressure waves and the release of shrapnel from detonations do affect the relative ratios of the emission products released into the environment. This is especially true when the formation of a full fireball is inhibited. For example, compared to an unconfined detonation of the same material, detonating an energetic material under a light soil cover, which provides some confinement, increases the quantity of soot, CO, and unsaturated hydrocarbon emission products released into the plume, but decreases the quantity of CO_2 and the height to which the plume rises.

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16.2 EMISSIONS FROM DETONATIONS
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16.2.1 Sources of the Emission Factors for Open Air Detonation

This section of Chapter 16 contains a compilation of the emission factors obtained from series of emissions characterization studies conducted on an open test range (OTR) and in a 32,900 ft^3, 50-ft diameter hemispherical detonation chamber (BangBox). These studies were conducted at Dugway Proving Grounds, UT (DPG) between 1989 and 1995.[1-3]

In the open range study, an instrumented airplane was used to collect samples from the plumes produced when 2000 lb of bulk high explosives (HE) were open detonated on and slightly above the ground on a test range at Dugway Proving Grounds. The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between three and seven seconds. For safety reasons and to allow all chemical reactions to go to completion, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted aluminum probe that outside the aircraft's boundary layer at a position forward and above the copilot's windshield. Each detonation trial consisted of three to five detonation events spaced 10 to 25 minutes apart.

In the BangBox study, air sampling equipment located inside the BangBox and in a building attached to it was used to collect samples from the plumes produced when 0.3 to 0.5 lb of bulk HE and munitions were detonated.

Table 16.2-1 identifies the test materials whose emissions were selected for inclusion in this section of Chapter 16 of AP-42, the energetic substances in these items and the number of detonation trials conducted on each test material. The chemical composition of these test materials, the detonation setup (configuration) used for each test material and the sampling systems used to characterize the emissions from these test materials are described in detail in Section 2.0 of the background document[4] This background document also describes the procedures used in selecting and grading the emission factors included in this section of Chapter 16 of AP-42.

16.2.2 Explanation of the Units of Measure Used

The emissions data are presented in two formats: (1) the traditional reporting unit (lb of emission product (EP) per lb net explosive weight (NEW) detonated; and (2) an alternate reporting unit (lb EP/ lb of a specific chemical substance in the material detonated. This alternate reporting unit is used when there was a known relationship between an emission product and a substance in the test material. This alternative unit is designated as the Environmental Fate Factor (EFF) and the traditional unit is designated as EF. The EF and EFF reporting units used for each EP and EP category are presented in Table 16.2-2. This alternate reporting unit was developed because there is no direct relationship between the mass of the EP and the NEW detonated. But there is such a relationship between the composition of the energetic material and the mass of the metal and some of the carbon and nitrogen containing EPs. Knowing these relationships can be very important when trying to use emissions data derived from chamber-based experiments to assess the true risk posed to human health and the environment by a specific detonation.

Table 16.2-1 TEST ITEMS FOR THE DETONATION EMISSION FACTORS

Study	Test Material	NSN	Major Energetiic Composition	Number of Detonation Trials
Open Test Range (OTR)	Surface Detonation, Reclaimed RDX	None	RDX	6
	Surface Detonation, Reclaimed Exoplosive D	None	Ammonium Picrate	6
	Surface Detonation, Reclaimed Composition B	None	RDX, TNT	6
	Surface Detonation, Reclaimed TNT	None	TNT	11
	Above Ground Detonation, Reclaimed TNT	None	TNT	3
BangBox (BB)	20mm HEI Cartridge, M56A4	1305-01-118-9928	RDX, NC, NG, Al, 2-Nitrodiphenylamine	3
	40mm HEI Catridge, M384	1310-00-039-1254	RDX, NC, NG	3
	Impulse Cartridge, M187	1377-00-516-9924	NC, NG	3
	Impulse Cartridge, BBU 36B	1377-01-037-8650	NC, NG	3
	Impulse Cartridge, MK107	1377-00-779-2601	NC, NG	3
	M206 Aircraft Flare	1370-01-048-2138	NC, Mg	3
	M43A2 Red Star Flare	1370-00-618-5790	$KClO_4$, MG	3
	M158 Red Star Flare	1370-00-490-7363	Black Powder, Mg	3
	FMU-139 Tail Bomb Fuze	1325-01-214-7311	Tetryl	3
	FMU-54A/B Tail Bomb Fuze	1325-01-613-0484	Tetryl	3
	M18A1 Claymore Mine	1345-00-710-6964	RDX	3
	Surrogate Composition B	None	RDX, TNT	3
	Surrogate HBX	None	RDX, TNT, Al	3
	TNT	None	TNT	3
	Surrogate Amatol	None	TNT, Ammonium Nitrate	3
	Surrogate Tritonal	None	TNT, Al	3
	Detonation Train	None	RDX, PETN	3

Table 16.2-2 EF AND EFF UNITS USED

EP/EP Category	Units
Carbon dioxide, carbon monoxide and volatile organic compounds (VOCs)(a)	lb EP/total lb carbon detonated
Nitrogen oxides	lb EP/lb total nitrogen detonated
Energetic compounds	lb EP/total lb related energetic
PM-10	lb EP/total lb NEW detonated
Semi-volatile organic compounds (SVOCs) and polycyclic organic matter (POMs) in the energetic material detonated (b)	lb EP/total lb related SVOC/POM detonated
SVOCs/POMs not in the energetic material	lb EP/total lb NEW detonated
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs)	lb EP/total lb NEW detonated
Metals(d)	lb EP/total lb related metal detonated
Sulfur dioxide	lb EP/total lb NEW detonated(c)

(a) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa.

(b) The terms SVOC (semi-volatile organic compounds) and POMs (polycyclic organic matter) apply to more than 100 organic compounds. They are defined in the Federal Clean Air Act as compounds with more than one benzene ring that also have boiling points greater than or equal to 100^0C. The terms are sometimes used interchangeably.

(c) EFF values could not be calculated because sulfur content of the test materials is uncertain.

(d) Most alloys contain a least one metal of environmental concern. S discussed in reference 1 of the Background Document there is an extensive body of theoretical and experimental data showing that these metals are not released from the alloy during the detonation.

16.2.3 Definitions of the Letter Codes Used in the Tables

When it was either not possible or not appropriate to enter a numerical EF or EFF value, the letter codes presented in Table 16.2-3 were used.

Table 16.2-3. EXPLANATION OF THE LETTER CODES USED

Letter Code	Explanation
NS (No Sample)	Not a target analyte.
NA (Not Applicable)	There is no information available to indicate that the test material contained a substance that could produce this EP.
ND (No Data)	Sample collected but either no result reported or data generator invalidated sampling result.
	Not possible to adjust the reported value for the contribution from test chamber surfaces and/or background air.
	Not possible to adjust the reported value for an erroneous background correction adjustment.
	Not possible to convert the traditional EF to the alternate EFF because critical composition data is not available for the test material.
BDL (Below Detection Limit)	Possible emission product, but either never detected or, if detected, never detected above the background level.

16.2.4 Tabulation of the Open Air Detonation Emissions Factors

16.2.4.1 Open Test Range (OTR) Emissions Factors

The TNT emission factors are presented in Table 16.2-4 and the RDX, Comp B, and Explosive D emission factors are presented in Table 16.2-5. The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

16.2.4.2 BangBox (BB) Emissions Factors

Table 16.2-6 contains the results for the Detonation Initiation Train and the Claymore mine, Tables 16.2-7 thru 16.2-9 present the results for the bulk HE, and Tables 16.2-10 thru 16.2-13 present the results for the cased materials (canon rounds, bomb fuzes, impulse cartridges and flares). The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

Table 16.2-4 EMISSION FACTORS FOR THE DETONATION OF TNT

EP Category	CASRN	EP	Units	Reclaimed TNT (Surface)		Reclaimed TNT (Suspended)	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	7.2E+00	D	1.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	B	BDL	B
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	B	BDL	B
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	7.5E-08	B	BDL	B
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	8.5E-09	B	BDL	B
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	B	BDL	B
	122-39-4	Diphenylamine	lb/lb NEW	BDL	B	BDL	B
	581-89-5	2-Nitronaphthalene	lb/lb NEW	4.0E-08	B	BDL	B
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	B	BDL	B
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B
	56-55-3	Benz(a)anthracene	lb/lb NEW	5.0E-08	B	3.2E-07	B
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	B	BDL	B
	132-64-9	Dibenzofuran	lb/lb NEW	9.0E-08	B	1.9E-07	B
	91-20-3	Naphthalene	lb/lb NEW	1.3E-06	B	1.8E-06	B
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	B	BDL	B
	85-01-8	Phenanthrene	lb/lb NEW	BDL	B	BDL	B
	108-95-2	Phenol	lb/lb NEW	1.0E-06	B	1.0E-06	B
	129-00-0	Pyrene	lb/lb NEW	1.1E-07	B	1.9E-08	B
	110-86-1	Pyridine	lb/lb NEW	BDL	B	BDL	B
Energetics	118-96-7	TNT	lb/lb TNT	1.4E-07(b)	B	9.3E-08(c)	B
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	A	3.8E+00	A
	630-08-0	Carbon monoxide	lb/lb C	1.5E-01	A	1.9E-02	A
	NA	Nitrogen oxides	lb/lb N	1.8E-02	A	2.6E-02	A
VOCs(d)	71-43-2	Benzene	lb/lb C	2.6E-04	B	1.7E-04	B
	74-82-8	Methane	lb/lb C	4.1E-03	B	4.0E-03	B
	NA	TNMHC	lb/lb C	4.9E-03	B	1.3E-02	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.4 of the background document for more information.[4]

(b) EFF is the average of the maximum EFF obtained for TNT across all detonation plumes in Phases A and C of the OTR study. See Section 2.1.4.5 of the background document for more information.[4]

(c) EFF is the largest EFF obtained for TNT across all of the plumes sampled. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.5 of the background document for more information.[4]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. The Army analyzed the plumes for 40 VOCs, but the test report contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 2.1.4.3 of the background document.[4]

Table 16.2-5 EMISSION FACTORS FOR THE DETONATION OF RDX, COMP B AND EXPLOSIVE D

EP Category	CASRN	EP	Units	Reclaimed Comp B		Reclaimed Explosive D		Reclaimed RDX	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	9.0E+00	D	1.1E+01	D	9.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	5.9E-08	B	1.8E-08	B	5.0E-08	B
	522-43-0	1-Nitropryene	lb/lb NEW	5.6E-08	B	1.1E-08	B	5.0E-08	B
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	B	BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	4.5E-07	B	5.9E-07	B	2.1E-07	B
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	2.4E-08	B	8.0E-08	B	4.1E-08	B
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	7.2E-08	B	5.8E-08	B	3.4E-08	B
	122-39-4	Diphenylamine	lb/lb NEW	6.6E-08	B	1.9E-08	B	3.1E-07	B
	581-89-5	2-Nitronaphthalene	lb/lb NEW	8.6E-08	B	4.3E-08	B	4.9E-08	B
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	B	BDL	B	BDL	B
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	B	1.9E-08	B	9.3E-08	B
	50-32-8	Benz(a)pyrene	lb/lb NEW	1.4E-08	B	3.8E-08	B	1.4E-07	B
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	B	1.1E-07	B	2.0E-06	B
	91-20-3	Naphthalene	lb/lb NEW	4.2E-07	B	6.3E-07	B	2.0E-07	B
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	3.6E-08	B	5.8E-08	B	BDL	B
	85-01-8	Phenanthrene	lb/lb NEW	BDL	B	BDL	B	BDL	B
	108-95-2	Phenol	lb/lb NEW	BDL	B	BDL	B	BDL	B
	129-00-0	Pyrene	lb/lb NEW	2.1E-07	B	1.8E-07	B	2.2E-07	B
	110-86-1	Pyridine	lb/lb NEW	BDL	B	BDL	B	BDL	B
Energetics	121-82-4	RDX	lb/lb RDX	8.3E-10(b)	B	NA	NA	2.0E-06(c)	B
	118-96-7	TNT	lb/lb TNT	ND	NA	NA	NA	NA	NA
	88-89-1	Picric acid	lb/lb PA	NA	NA	5.0E-10(b)	A	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	A	3.4E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide	lb/lb C	1.2E-01	A	1.8E-01	A	2.0E-01	A
	NA	Nitrogen oxides	lb/lb N	6.4E-03	A	9.6E-03	A	1.7E-03	A
VOCs(d)	71-43-2	Benzene	lb/lb C	2.4E-05	B	3.8E-04	B	4.4E-04	B
	74-82-8	Methane	lb/lb C	2.3E-03	B	2.6E-02	B	1.3E-03	B
	NA	TNMHC	lb/lb C	4.7E-03	B	6.8E-03	B	8.4E-03	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.4 of the background document for more information.[4]

(b) EFF derived by substituting 1/2MDL for a BDL value. See Section 2.1.4.5 of the background document for more information.[5]

(c) EFF is the largest EFF obtained for RDX across all of the plumes sampled. Even if the RDX was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 2.1.4.5 of the background document for more information.[5]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. The Army analyzed the plumes for 40 VOCs, but the test report contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 2.1.4.3 of the background document.[4]

Table 16.2-6 EFs & EFFs FOR THE CLAYMORE MINE AND THE DETONATION INITIATION TRAIN

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	2.3E-01	D	3.6E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	NA	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	479-45-8	TETRYL	lb/lb Tetryl	NA	NA	NS	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	4.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	ND	NA
	630-08-0	Carbon monoxide	lb/lb C	2.2E-02	C	6.1E-02	C
	NA	Nitrogen Oxides	lb/lb N	NS	NA	3.8E-02	B
Metals(b)	7429-90-5	Al (In alloy)	lb/lb Al	6.3E-02	D	ND	NA
	7440-47-3	Cr (In Alloy)	lb/lb Cr	ND	NA	NA	NA
	7440-50-8	Cu (In Alloy)	lb/lb Cu	2.2E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	4.0E-01	D
	7439-92-1	Pb (In Alloy)	lb/lb Pb	ND	NA	NA	NA

Table 16.2-6 EFs & EFFs FOR THE CLAYMORE MINE
AND THE DETONATION INITIATION TRAIN (Continued)

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-86-2	Acetylene	lb/lb C	7.3E-04	B	6.9E-04	D
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	B
	71-43-2	Benzene	lb/lb C	6.0E-04	B	1.3E-04	C
	74-85-1	Ethylene	lb/lb C	1.8E-04	B	2.1E-03	B
	75-09-2	Methylene chloride	lb/lb C	8.1E-05	C	1.5E-04	D
	74-98-6	Propane	lb/lb C	2.7E-06	C	2.5E-05	B
	115-07-1	Propylene	lb/lb C	1.8E-05	C	3.9E-04	C
	108-88-3	Toluene	lb/lb C	1.9E-04	C	2.2E-05	B
	NA	TNMHC	lb/lb C	4.7E-03	C	2.3E-02	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-7 EFs & EFFS FOR THE DETONATION OF COMP B AND HBX

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.8E-01	D	1.2E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	118-96-7	TNT	lb/lb TNT	ND	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.0E-03	B	1.3E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	C	3.9E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.8E-02	C	1.5E-02	C
	NA	Nitrogen Oxides	lb/lb N	5.7E-02	B	1.9E-02	B
Metals(b)	7429-90-5	Al (In Energetic As Particle)	lb/lb Al	5.1E-02	D	NA	NA
	7440-50-8	Cu (In Alloy)	lb/lb Cu	3.2E-02	D	ND	NA

Table 16.2-7 EFs & EFFS FOR THE DETONATION OF COMP B AND HBX (Continued)

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-86-2	Acetylene	lb/lb C	1.0E-04	B	4.9E-05	C
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	71-43-2	Benzene	lb/lb C	2.5E-05	C	9.1E-05	C
	74-85-1	Ethylene	lb/lb C	1.1E-04	B	4.9E-05	C
	75-09-2	Methylene chloride	lb/lb C	3.2E-04	C	3.3E-04	C
	74-98-6	Propane	lb/lb C	3.0E-06	C	1.8E-06	C
	115-07-1	Propylene	lb/lb C	3.3E-05	C	1.1E-05	C
	108-88-3	Toluene	lb/lb C	1.2E-05	C	2.1E-05	C
	NA	TNMHC	lb/lb C	6.3E-04	C	3.9E-04	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.

Table 16.2-8 EFs & EFFs FOR THE DETONATION OF TNT AND AMATOL

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	7.3E-02	D	1.9E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	NA	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	NA	NA	ND	NA
	118-96-7	TNT	lb/lb TNT	BDL(b)	D	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	2.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.3E+00	C
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	C	4.6E-02	C
	NA	Nitrogen Oxides	lb/lb N	ND	NA	1.6E-01	B
Metals(c)	7440-39-3	Al (In alloy)	lb/lb Al	NA	NA	ND	NA
	7439-92-1	Cu (In Alloy)	lb/lb Cu	7.0E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	7.8E-01	D

Table 16.2-8 EFs & EFFs FOR THE DETONATION OF TNT AND AMATOL (Continued)

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(d)	107-05-1	Acetylene	lb/lb C	4.4E-05	C	4.5E-04	B
	71-43-2	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	142-29-0	Benzene	lb/lb C	1.1E-05	B	1.1E-04	B
	115-11-7	Ethylene	lb/lb C	5.7E-05	C	1.5E-04	B
	106-97-8	Methylene chloride	lb/lb C	4.7E-04	C	7.1E-04	C
	100-42-5	Propylene	lb/lb C	1.9E-05	C	2.6E-05	C
	NA	Toluene	lb/lb C	9.1E-06	C	3.1E-05	C
	624-64-6	TNMHC	lb/lb C	2.0E-04	C	2.1E-03	B

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) It is not appropriate to substitute 1/2 MDL for the energetic BDL values. The BB nominal MDL (3E-07 lb/lb energetic compound) is several orders of magnitude higher than the OTR energetic MDL and the OTR EFFs are at least an order of magnitude lower than the BB MDL.

(c) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-9 EFs & EFFs FOR THE DETONATION OF TRITONAL

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	3.7E-01	D	2.6E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	118-96-7	TNT	lb/lb TNT	ND	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.8E-05	B	1.2E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	3.8E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.3E-03	C	7.8E-03	C
	NA	Nitrogen Oxides	lb/lb N	5.4E-02	B	6.3E-02	B
Metals(b)	7429-90-5	Al (In Energetic As Particle)	lb/lb Al	1.4E-01	D	9.9E-02	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	NA	NA	4.9E-03	D
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	ND	NA

Table 16.2-9 EFs & EFFs FOR THE DETONATION OF TRITONAL (Continued)

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-86-2	Acetylene	lb/lb C	3.8E-04	B	5.5E-05	C
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	71-43-2	Benzene	lb/lb C	1.8E-05	C	9.0E-06	C
	74-85-1	Ethylene	lb/lb C	8.0E-05	C	7.3E-05	C
	75-09-2	Methylene chloride	lb/lb C	8.0E-06	D	4.6E-04	C
	115-07-1	Propylene	lb/lb C	2.3E-06	C	1.8E-05	B
	108-88-3	Toluene	lb/lb C	4.2E-06	C	BDL	D
	NA	TNMHC	lb/lb C	3.8E-03	C	6.4E-04	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-10 EFs & EFFs FOR THE DETONATION OF CANON ROUNDS

EP Category	CASRN	EP	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	ND	D	4.7E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	55-63-0	Nitroglycerin	lb/lb NG	BDL(b)	NA	BDL(b)	NA
	2691-41-0	HMX	lb/lb HMX	BDL(c)	NA	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	C	3.7E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.7E-01	C	5.8E-02	C
Metals(d)	7429-90-5	Al (In alloy)	lb/lb Al	2.9E-02	D	1.1E-02	D
	7440-39-3	Ba (In Energetic As Compound)	lb/lb Ba	3.1E-02	D	NA	D
	7440-47-3	Cr (In Alloy)	lb/lb Cr	1.7E-03	D	1.0E-02	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	1.6E-02	D	2.1E-02	D
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	D	6.4E-01	D
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	9.1E-03	D	7.0E-02	D

Table 16..2-10 EFs & EFFs FOR THE DETONATION OF CANON ROUNDS (Continued)

EP Category	CASRN	EP	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(e)	74-86-2	Acetylene	lb/lb C	2.9E-04	C	1.2E-04	C
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	BDL	D
	71-43-2	Benzene	lb/lb C	1.8E-04	C	7.8E-05	C
	74-85-1	Ethylene	lb/lb C	4.6E-04	C	2.3E-04	C
	75-09-2	Methylene chloride	lb/lb C	7.2E-04	C	2.4E-03	C
	115-07-1	Propylene	lb/lb C	8.2E-05	C	4.5E-05	C
	108-88-3	Toluene	lb/lb C	4.8E-05	D	2.4E-05	D
	NA	TNMHC	lb/lb C	1.9E-03	C	9.2E-04	C

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(b) Even if all of the NG had entered the plume, the NG plume concentration would have been too small to measure.

(c) Even if all of the HMX had entered the plume, the HMX plume concentration would have been too small to measure.

(d) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(e) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-11 EFs & EFFs FOR THE DETONATION OF BOMB FUZES

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.3E+01	D	7.0E+00	D
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA
	479-45-8	TETRYL	lb/lb Tetryl	BDL(c)	D	BDL(c)	D
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.8E-03	B	4.0E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.2E+00	C
	630-08-0	Carbon monoxide	lb/lb C	6.0E-02	C	6.2E-02	C
	NA	Nitrogen oxides	lb/lb N	ND	NA	1.9E-01	B
Metals(d)	7429-90-5	Al (In alloy)	lb/lb Al	4.1E-02	D	8.8E-02	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	2.2E-02	D	5.6E-03	D
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	8.0E-02	D	ND	NA

Table 16.2-11 EFs & EFFs FOR THE DETONATION OF BOMB FUZES (Continued)

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(e)	74-86-2	Acetylene	lb/lb C	8.9E-03	C	6.1E-02	C
	107-05-1	Allyl Chloride	lb/lb C	4.6E-04	B	2.1E-03	B
	71-43-2	Benzene	lb/lb C	1.7E-03	B	1.5E-02	B
	74-85-1	Ethylene	lb/lb C	3.6E-03	B	1.5E-02	B
	75-09-2	Methylene chloride	lb/lb C	1.6E-03	B	6.2E-03	B
	115-07-1	Propylene	lb/lb C	6.0E-04	B	3.8E-03	B
	108-88-3	Toluene	lb/lb C	3.3E-04	B	4.4E-03	B
	NA	TNMHC	lb/lb C	3.8E-02	B	3.5E-01	B

(a) Even though the measurement system had a nominal MDL of 7E-11 lb/lb NEW, none of the seventeen PCDD/PCDF target analytes were detected in the detonation plumes for these test items, which had the highest chance of producing PCDDs/PCDFs EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDD/PCDF compound. The complete list of PCDF/PCDD analytes can be found in Section 2.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the BB SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(c) It is not appropriate to substitute 1/2 MDL for the tetryl BDL value. The BB MDL (2E-07 lb/lb tetryl) is several orders of magnitude higher than the OTR energetic MDL and the OTR energetic EFFs are at least an order of magnitude lower than the BB MDL.

(d) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(e) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-12 EFs & EFFs FOR THE DETONATION OF IMPULSE CARTRIDGES

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E+00	D	4.9E+00	D	4.5E-01	D
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	BDL	C	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA	ND	NA
	55-63-0	Nitroglycerin	lb/lb NG	NA	NA	BDL(c)	D	BDL(d)	D
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.6E-05	B	2.8E-04	B	9.9E-05	B
	124-38-9	Carbon dioxide	lb/lb C	3.3E+00	C	3.4E+00	C	3.6E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.0E-02	C	5.8E-02	C	6.0E-02	C
	NA	Nitrogen oxides	lb/lb N	2.9E-01	B	ND	NA	ND	NA
Metals(e)	7429-90-5	Al (In alloy)	lb/lb Al	5.1E-03	D	4.2E-03	D	ND	NA
	7440-39-3	Ba (In Energetic As Compound)	lb/lb Cd	NA	NA	NA	NA	4.6E-03	D
	7440-47-3	Cr (In Alloy)	lb/lb Cr	ND	NA	ND	NA	7.2E-05	D
	7440-50-8	Cu (In Alloy)	lb/lb Cu	ND	NA	5.1E-03	D	1.6E-02	D
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	8.6E-02	D	4.4E-02	D	ND	NA
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	1.1E-02	D	1.8E-03	D	ND	D

Table 16.2-12 EFs & EFFs FOR THE DETONATION OF IMPULSE CARTRIDGES (Continued)

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(f)	74-86-2	Acetylene	lb/lb C	1.8E-02	B	3.6E-02	B	1.0E-03	B
	107-05-1	Allyl Chloride	lb/lb C	BDL	D	5.5E-03	B	2.2E-05	C
	71-43-2	Benzene	lb/lb C	6.1E-03	B	2.4E-03	B	2.8E-04	B
	74-85-1	Ethylene	lb/lb C	1.7E-02	B	3.2E-03	B	7.7E-04	C
	75-09-2	Methylene chloride	lb/lb C	4.1E-03	C	8.9E-02	B	9.9E-04	C
	74-98-6	Propane	lb/lb C	4.0E-04	C	1.8E-04	C	6.0E-06	D
	115-07-1	Propylene	lb/lb C	3.1E-03	B	BDL	D	1.1E-04	C
	108-88-3	Toluene	lb/lb C	1.6E-03	C	3.7E-03	C	3.9E-05	D
	NA	TNMHC	lb/lb C	BDL	C	BDL	C	6.5E-03	D

(a) Even though the measurement system had a nominal MDL of 7E-11 lb/lb NEW, none of the seventeen PCDDs/PCDFs target analytes were detected in the detonation plumes for these test items, which had the highest chance of producing PCDD/PCDF EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDD/PCDF compound. The complete list of PCDF/PCDD analytes can be found in Section 2.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(c,) It is not appropriate to substitute 1/2 MDL for the NG BDL values. The BB nominal MDL (6E-07 lb/lb NG) is several orders of magnitude higher than the OTR energetic MDL and the OTR energetic EFFs are at least an order of magnitude lower than the BB MDL.

(c,) It is not appropriate to substitute 1/2 MDL for the NG BDL values. The BB nominal MDL (2E-07 lb/lb NG) is several orders of magnitude higher than the OTR energetic MDL and the OTR energetic EFFs are at least an order of magnitude lower than the BB MDL.

(e) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(f) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

Table 16.2-13 EFs & EFFs FOR THE DETONATION OF FLARES

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	9.2E+00	D	7.1E+00	D	1.2E+00	D
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte	lb/lb NEW	NA	C	BDL	C	BDL	C
	91-20-3	Naphthalene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	108-95-2	Phenol	lb/lb NEW	BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine	lb/lb NEW	BDL	C	BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb PETN	ND	NA	ND	NA	ND	NA
	121-82-4	RDX	lb/lb RDX	ND	NA	ND	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.6E-03	B	ND	NA	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.5E+00	C	3.4E+00	C
	630-08-0	Carbon monoxide	lb/lb C	3.8E-02	C	7.1E-02	C	8.0E-02	C
	NA	Nitrogen Oxides	lb/lb N	2.5E-01	B	1.7E-01	B	8.9E-02	B

Table 16.2-13 EFs & EFFs FOR THE DETONATION OF FLARES (Continued)

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Metals(c)	7429-90-5	Al (In alloy)	lb/lb Al	7.7E-02	D	3.8E-02	D	9.5E-04	D
	7440-39-3	Ba (In Energetic As Compound)	lb/lb Cd	1.5E-01	D	1.4E-01	D	NA	NA
	7440-47-3	Cr (In Alloy)	lb/lb Cr	ND	NA	ND	NA	4.6E-04	D
	7440-47-3	Cr (In Protective Coating)	lb/lb Cr	3.8E-03	D	NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)	lb/lb Cu	ND	NA	8.6E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	ND	NA	3.2E-01	D	ND	NA
	7440-66-6	Zinc (In Alloy)	lb/lb Zn	2.0E-01	D	8.0E-02	D	2.0E-02	D
VOCs(d)	74-86-2	Acetylene	lb/lb C	6.8E-03	B	4.4E-03	B	7.3E-03	B
	107-05-1	Allyl Chloride	lb/lb C	5.1E-04	C	3.0E-04	C	5.4E-04	C
	71-43-2	Benzene	lb/lb C	1.0E-03	B	4.1E-04	B	6.8E-04	B
	74-85-1	Ethylene	lb/lb C	BDL	D	1.3E-03	B	2.5E-03	B
	75-09-2	Methylene chloride	lb/lb C	1.1E-02	B	BDL	C	3.0E-03	B
	74-98-6	Propane	lb/lb C	BDL	D	1.5E-05	C	9.9E-05	C
	115-07-1	Propylene	lb/lb C	BDL	D	1.4E-04	C	9.1E-04	C
	108-88-3	Toluene	lb/lb C	7.5E-04	C	4.7E-04	C	7.8E-04	C
	NA	TNMHC	lb/lb C	3.0E-02	C	1.3E-02	C	1.2E-01	C

(a) Even though the measurement system had a nominal MDL of 7E-11 lb/lb NEW, none of the seventeen PCDDs/PCDFs target analytes were detected in the detonation plumes for these test items, which had the highest chance of producing PCDD/PCDF EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDDs/PCDFs compound. The complete list of PCDF/PCDD analytes can be found in Section 2.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one to two orders of magnitude less than the BB MDL . The complete list of the SVOC/POM target analytes can be found in Table 12 of the background document.[4]

(c) The reasons for placing the metal EFFs in these categories are presented in Section 1.5 of the background document.[4]

(d) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These eight compounds were the only ones found in most detonation plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 43 individual VOC compounds detected in at least one detonation plume can be found in Tables 13 thru 20 of the background document.[4] The complete list of VOC target analytes can be found in Tables 10 and 11 of the background document.[4]

16.2.5 Comparability of the BangBox and Open Test Range Detonation Emissions Data Sets

A statistical comparison of means was done between the following BangBox (BB) and open test range (OTR) EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene and TNMHC. When this comparison determined that all of the pairs, except the PM-10 data sets, were statistically the same, each pair of statistically-equivalent data sets was combined and the following summary statistics determined for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev) and relative standard deviation (RSD, std dev/mean).

Table 16.2-14 presents these summary statistics along with proposed EPA quality rating codes. These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EFs or EFFs, the conformance to detonation reaction theory and representativeness to real world open detonation activities.

Table 16.2-14 also contains summary statistics for the following EP/EP categories for which there was either only BB data or the OTR open range data were judged to be far superior to the BB data.

OTR PM-10. Because the OTR and BB data sets are statistically different, they could not be combined. The OTR EFs were selected because they more closely reflect real world detonation processes than the soil-free BB detonations. However, the quality rating of D indicates that these PM-10 values are of poor quality and therefore must be used with extreme caution. (NOTE _ Summary statistics for the BB PM-10 EFs are presented in Table 21 of the background document.[4])

OTR *Energetics*. The OTR energetic EFFs were selected because all of the BB EFFs were BDL and the BB MDL was higher than the OTR EFFs.

OTR SVOCs/POMs Not In Energetic. The OTR EFs were selected because all of the BB EFs were BDL and the BB MDL was higher than the OTR EFs.

BB SO_2 There are no corresponding OTR EFs.

BB EFFs for Acetylene, Ethylene, Methylene Chloride, Allyl Chloride, Propylene and Toluene. There are no corresponding OTR EFFs

BB Metals. There are no corresponding OTR EFs.

Table 16.2-14. SUMMARY STATISTICS FOR THE DETONATION DATA SETS

EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD(a)	Quality Rating
PM-10	lb/lb NEW	5	1.1E+01	1.6E+00	9.0E+00	7.7E+00	3.6E+00	0.47	D
Carbon Monoxide	lb/lb C	23	2.0E-01	7.8E-03	6.0E-02	7.1E-02	5.7E-02	0.81	B
Carbon Dioxide	lb/lb C	22	3.9E+00	2.5E+00	3.5E+00	3.5E+00	3.0E-01	0.09	B
Nitrogen Oxides	lb/lb N	19	3.2E-01	1.7E-03	3.3E-02	5.3E-02	7.2E-02	1.36	B
Sulfur Dioxide	lb/lb NEW	12	1.4E-03	7.8E-05	3.3E-04	4.8E-04	4.2E-04	0.88	B
Energetics	lb/lb Energetic	5	2.0E-06	5.0E-10	9.3E-08	4.5E-07	8.7E-07	1.95	C
SVOCs In Energetic	lb/lb SVOC	No Data							
SVOCs Not In Energetic	lb/lb NEW	49	2.0E-06	8.5E-09	8.0E-08	2.8E-07	4.8E-07	1.71	B
Benzene	lb/lb C	23	6.0E-04	9.0E-06	1.7E-04	2.0E-04	1.6E-04	0.82	B
TNMHC	lb/lb C	23	3.4E-02	2.0E-04	7.2E-03	7.7E-03	7.9E-03	1.03	B
Acetylene	lb/lb C	18	1.8E-03	4.4E-05	7.3E-04	7.7E-04	6.1E-04	0.80	B
Ethylene	lb/lb C	18	2.3E-03	4.9E-05	6.5E-04	7.1E-04	7.4E-04	1.05	B
Methylene Chloride	lb/lb C	18	2.4E-03	8.0E-06	4.0E-04	6.2E-04	6.5E-04	1.05	B
Propylene	lb/lb C	18	4.1E-04	2.3E-06	1.1E-04	1.3E-04	1.4E-04	1.08	B
Toluene	lb/lb C	17	1.9E-04	4.2E-06	5.7E-05	6.7E-05	5.7E-05	0.85	B
Metals In Energetic As Particle	lb/lb Metal	3	1.4E-01	5.1E-02	9.9E-02	9.8E-02	4.6E-02	0.47	D
Metals In Alloys	lb/lb Metal	35	2.0E-01	7.2E-05	1.1E-02	3.1E-02	4.1E-02	1.35	D
Metals In Energetic As Compound	lb/lb Metal	10	7.8E-01	4.6E-03	1.5E-01	2.6E-01	2.7E-01	1.04	D

(a) As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

16.2.6 Application of the EFs/EFFs to Real World Open Detonation Activities

The term open detonation (OD) is commonly used to describe both open air surface detonations and buried/soil-covered detonations.

16.2.6.1 Open Air Surface Detonations

Open air surface detonations are usually done at facilities where blast noise, blast wave transmission and fragment travel are of little concern. This type of detonation promotes the formation of a full fireball and the efficient oxidation of the initial detonation products to nontoxic compounds. Any of the materials normally detonated can be destroyed through a surface detonation and the NEW of the detonation process can be thousands of pounds. Because the EFs/EFFs in this chapter of AP-42 were developed from open air detonations, they can be applied to open air detonations with confidence.

16.2.6.2 Buried and Soil-Covered Detonations

Buried and soil-covered detonations are done at facilities where blast noise, blast wave transmission and/or fragment travel can cause problems. The NEW of the detonation pile is usually less than 400 lb. When munitions are detonated under these conditions, the fireball is partially or fully suppressed, a situation that is very different from the conditions under which the EFs/EFFs in this chapter of AP-42 were derived. There are no emissions data specific to soil-covered and buried detonations, and it would not be appropriate to apply the EFs/EFFs in this chapter of AP-42 to buried and soil-covered detonations without considering the effect that suppression of the fire ball could have on the emissions. Fortunately, there are emissions data from studies in bomb calorimeters and detonation chambers that can provide insight on the effect that fireball suppression has on the emissions from detonations. These studies are discussed in Appendix A of the background document.[4]

References for Section 16.2

1a. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Field Test Series A, B and C, Volume II, Part A, Quality Assurance and Quality Control*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

1b. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Field Test Series A, B and C, Volume II, Part B, Quality Assurance and Quality Control Appendices*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

2a. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 1, Test Summary*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

2b. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 2, Test Development*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

2c. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 3, Quality Control and Quality Assurance*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

3. W. J. Mitchell and J. C. Suggs. *Emission Factors for the Disposal of Energetic Materials by Open Burning and Open Detonation (OB/OD)*. EPA Report - EPA/600/R-98/103, August 1998. 130p.

4. *Background Document for AP-42 Chapter 16 – Emission Factors for Demilitarization Processes: Open Burning and Open Detonation*. Report prepared for the U. S. Army Defense Ammunition Center, McAlester, OK by Chemical Compliance Systems, Inc. February, 2009.

5. *Procedures for Preparing EF Documents*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Durham, NC. EPA Report - EPA 454/R-95-015 (Revised), September 1997.

16.3 EMISSIONS FROM OPEN BURNING

16.3.1 Sources of the Emission Factors for Open Burning

This section of Chapter 16 contains a compilation of the emission factors obtained from series of emissions characterization studies conducted on an open test range (OTR) and in a 32,900 ft^3, 50-ft diameter hemispherical detonation chamber (BangBox). These studies were conducted at Dugway Proving Grounds, UT (DPG) between 1989 and 1995.[1-3]

In the open range study, an instrumented airplane was used to collect samples from the plumes produced when 4,600 to 7,000 lb of five individual propellant materials were burned in steel pans on a test range at DPG, UT.[1, 2] The burn pans were approximately 4 ft wide, 36 ft long, and 0.8 ft high and were placed side by side. Three pans were used in each burn trial. The propellant materials were placed in the pans to a depth of 2.5 to 3.5 inches, and the burns were initiated using black powder trains placed at both ends of
each pan. The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between three and seven seconds. For safety reasons and to allow all chemical reactions to go to completion, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted aluminum probe that outside the aircraft's boundary layer at a position forward and above the copilot's windshield. Each burn trial was comprised of two or three burn events spaced 15 to 20 minutes apart.

In the BangBox study, air sampling equipment located inside the BangBox and in a building attached to it was used to collect samples from the plumes produced when 2.2 to 5.0 lb quantities of propellants were open burned on a bed of pea gravel in a stainless steel pan sitting on a steel pad located in the center of the BangBox.[3]

Table 16.3-1 identifies the test materials whose emissions were selected for inclusion in this section of Chapter 16 of AP-42, the energetic substances in these items and the number of detonation trials conducted on each test material. The chemical composition of these test materials, the test configuration used for each test material and the sampling systems used to characterize the emissions from these test materials are described in detail in Section 3.0 of the background document.[4] This background document also describes the procedures used in selecting and grading the emission factors included in this section of Chapter 16 of AP-42.

16.3.2 Explanation of the Units of Measure Used

The emissions data are presented in two formats: (1) the traditional reporting unit (lb of emission product (EP) per lb net explosive weight (NEW) burned); and (2) an alternate reporting unit (lb EP/ lb of a specific chemical substance in the material burned). This alternate reporting unit is used when there was a known relationship between an emission product and a substance in the test material. This alternative unit is designated as the Environmental Fate Factor (EFF), and the traditional unit is designated as EF. The EF and EFF reporting units used for each EP and EP category are presented in Table 16.3-2. This alternate reporting unit was developed because there is no direct relationship between the mass of the EP and the NEW burned. But there is such a relationship between the composition of the energetic material and the mass of the metal and some of the carbon and nitrogen containing EPs. Knowing these relationships can be very important when trying to use emissions data derived from chamber-based experiments to assess the

true risk posed to human health and the environment by a specific open burn.

Table 16.3-1 TEST ITEMS USED FOR THE OPEN BURN EMISSION FACTORS

Study	Material	NSN of Test Material	Major Energetic Components	Number of Burn Trials Sampled
Open Test Range (OTR)	Waste Propellant Mix A	Unknown	AP, NC, NG, 2-Nitrodiphenylamine	2
	Waste Propellant Mix B	Unknown	NC, NG, 2-Nitrodiphenylamine	2
	M1 Propellant	Unknown	NC, 2-Nitrodiphenylamine, Dibutylphalate, 2, 4 - DNT	6
	M6 Propellant	Unknown	NC, 2-Nitrodiphenylamine, Dibutylphalate, 2, 4 - DNT	12
	M30 Propellant	Unknown	NC, NG, NQ	4
BangBox (BB)	Aluminized AP Propellant	Unknown	AP, Al, Rubberized binder	2
	AP Propellant	Unknown	AP, Rubberized binder	2
	MK-6 Propellant	Unknown	AP, Al, Rubberized binder	1
	Double Base Propellant	Unknown	NC, NG, Diphenylamine	3
	NOSIH- AA2 Propellant	Unknown	NC, NG, Ethyl centralite, Di-n-propyl- adipate	1
	M1 Propellant	Unknown	NC, 2.4-DNT, Diphenylamine	3
	M43 Propellant	Unknown	NC, RDX, polymeric binders	1
	M9 Propellant	Unknown	NC, NG, Diphenylamine	3
	M31AE1 Popellant	1376-01-213-5669	NC, NG, NQ, Ethyl centralite	3
	PBXN-110 Propellant	Unknown	HMX, Hydroxyl-terminated butadiene	1

Table 16.3-2 EF AND EFF UNITS USED

EP/EP Category	Units
Carbon dioxide, carbon monoxide and volatile organic compounds (VOCs)(a)	lb EP/total lb C in material burned
Nitrogen oxides	lb EP/total lb N in material burned
Hydrogen chloride and chlorine	lb EP/total lb Cl in material burned
Energetic compound	lb EP/total lb related energetic in material burned
PM-10	lb EP/total lb NEW burned
Semi-volatile organic compounds (SVOCs) and polycyclic organic matter (POM) in the energetic material (b)	lb EP/total lb related SVOC in material burned
SVOCs/POMs not in the energetic material	lb EP/total lb NEW burned
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs)	lb EP/total lb NEW burned
Metals(d)	lb EP/total lb related metal in material burned
Sulfur dioxide	lb EP/total lb NEW burned(c)

(a) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa.

(b) The terms SVOC (semi-volatile organic compounds) and POMs (polycyclic organic matter) apply to more than 100 organic compounds. They are defined in the Federal Clean Air Act as compounds with more than one benzene ring that also have boiling points greater than or equal to 100^0C. The terms are sometimes used interchangeably.

(c) EFF could not be calculated because sulfur content of test items is uncertain.

(d) Most alloys contain a least one metal of environmental concern. S discussed in reference 1 of the Background Document there is an extensive body of theoretical and experimental data showing that these metals are not released from the alloy during the detonation.

16.3.3 Definitions of the Letter Codes Used in the Tables

When it was either not possible or not appropriate to enter a numerical EF or EFF value, the letter codes presented in Table 16.3-3 were used.

Table 16.3-3 EXPLANATION OF THE LETTER CODES USED

Letter Code	Explanation
NS (No Sample)	Not a target analyte.
NA (Not Applicable)	There is no information available to indicate that the test material contained a substance that could produce this EP.
ND (No Data)	Sample collected but either no result reported or data generator invalidated sampling result.
	Not possible to adjust the reported value for the contribution from test chamber surfaces and/or background air.
	Not possible to adjust the reported value for an erroneous background correction adjustment.
	Not possible to convert the traditional EF to the alternate EFF because critical composition data is not available for the test material.
BDL (Below Detection Limit)	Possible emission product, but either never detected or, if detected, never detected above the background level.

16.3.4 Tabulation of the Open Burn Emission Factors

16.3.4.1 Open Test Range (OTR) Emissions Factors

The waste propellant emission factors are presented in Table 16.3-4 and the single base and triple base propellant emission factors are presented in Table 16.3-5. The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

16.3.4.2 BangBox (BB) Emissions Factors

Table 16.3-6 presents the results for the AP-propellants, Table 16.3-7 presents the results for single base and triple base propellants, Table 16.3-8 presents the results for double base propellants and Table 16.3-9 presents the results for the PBX propellants. The EPA quality rating code[5] assigned to each EF/EFF value is also presented in these tables.

Table 16.3-4 EFs & EFFs FOR THE OPEN BURNING OF WASTE PROPELLANTS

EP Category	CASRN	EP	Units	Waste Propellant A		Waste Propellant B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.6E-02	B	1.0E-02	B
SVOC and POM(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	A	BDL	A
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	A	1.6E-07	A
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	NA	A	1.4E-07	A
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	A	BDL	A
	122-39-4	Diphenylamine	lb/lb NEW	2.0E-08	A	3.1E-07	A
	581-89-5	2-Nitronaphthalene	lb/lb NEW	3.7E-09	A	8.3E-08	A
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	A	BDL	A
	56-55-3	Benz(a)anthracene	lb/lb NEW	3.8E-08	A	1.4E-07	A
	50-32-8	Benz(a)pyrene	lb/lb NEW	2.3E-08	A	8.1E-08	A
	132-64-9	Dibenzofuran	lb/lb NEW	2.6E-07	A	1.2E-07	A
	91-20-3	Naphthalene	lb/lb NEW	1.5E-06	A	5.4E-07	A
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	1.9E-08	A	2.7E-08	A
	85-01-8	Phenanthrene	lb/lb NEW	BDL	A	BDL	A
	108-95-2	Phenol	lb/lb NEW	8.0E-06	A	BDL	A
	88-72-2	Nitrobenzene	lb/lb NEW	BDL	A	BDL	A
	110-86-1	Pyridine	lb/lb NEW	BDL	A	BDL	A
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	A	BDL	A
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	A	BDL	A
	129-00-0	Pyrene	lb/lb NEW	7.1E-09	A	3.2E-07	A
Energetics	55-63-0	Nitroglycerin	lb/lb NG	1.1E-09(b)	B	8.7E-10(b)	B
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.6E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide	lb/lb C	2.3E-03	A	2.6E-03	A
	NA	Nitrogen oxides	lb/lb N	7.1E-02	A	2.9E-02	A
VOCs(c)	71-43-2	Benzene	lb/lb C	*2.3E-06*	A	2.6E-03	A
	74-82-8	Methane	lb/lb C	*2.3E-06*	A	2.8E-03	A
	NA	TNMHC	lb/lb C	2.1E-04	A	2.1E-03	A
SVOCs in Energetic	119-75-5	2-Nitrodiphenylamine	lb/lb 2-NDPA	3.1E-08	B	9.4E-07	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 3.1.4.4 of the background document for more information.[4]

(b) EFFs derived by substituting 1/2 MDL for BDL value.

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa . The Army analyzed the plumes for 40 VOCs, but the test report contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 3.1.4.3 of the Background Document.[4]

Table 16.3-5 EFs & EFFs FOR OPEN BURNING OF SINGLE & TRIPLE BASE PROPELLANTS

EP Category	CASRN	EP	Units	M1 Propellant		M6 Propellant		M30 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	6.9E-03	B	1.1E-02	B	2.0E-02	B
SVOCs and POMs(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	A	BDL	A	BDL	A
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	A	BDL	A	BDL	A
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	A	BDL	A	BDL	A
	91-20-3	Naphthalene	lb/lb NEW	1.9E-08	A	7.5E-08	A	BDL	A
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	A	BDL	A	BDL	A
	85-01-8	Phenanthrene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	108-95-2	Phenol	lb/lb NEW	3.4E-09	A	1.5E-09	A	BDL	A
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	A	BDL	A	BDL	A
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	129-00-0	Pyrene	lb/lb NEW	BDL	A	BDL	A	BDL	A
Energetics	55-63-0	Nitroglycerin	lb/lb NG	NA	NA	NA	NA	1.5E-09(b)	B
	556-88-7	Nitroguanidine	lb/lb NQ	NA	NA	NA	NA	6.9E-10(b)	B
Iniorganic Gases	124-38-9	Carbon dioxide	lb/l. C	3.6E+00	A	3.7E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide	lb/l. C	8.2E-04	A	3.3E-04	A	1.4E-04	A
	NA	Nitrogen oxides	lb/lb N	2.0E-02	A	4.3E-02	A	2.9E-02	A
VOCs(c)	71-43-2	Benzene	lb/lb C	1.4E-05	A	5.4E-06	A	3.1E-06	A
	74-82-8	Methane	lb/lb C	2.4E-02	A	1.5E-04	A	3.1E-06	A
	NA	TNMHC	lb/lb C	1.5E-03	A	4.5E-05	A	8.4E-06	A
SVOC in Energetic	122-39-4	Diphenylamine	lb/lbDPA	9.6E-08(d)	B	5.6E-08(d)	B	NA	B
	121-14-2	2,4-Dinitrotoluene	lb/lb DNT	1.1E-08	B	1.0E-08(d)	B	NA	B

(a) Numerical values represent the largest EF obtained for the SVOC/POM compound across all of the plumes sampled for the test material in that phase of the OTR study. Even if the analyte was found in only one plume, it was reported as if it was the representative EP for that test material. See Section 3.1.4.4 of the background document for more information.[4]

(b) EFFs derived by substituting 1/2 MDL for BDL value.

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa . The Army analyzed the plumes for 40 VOCs, but the test report

contained EFs for only benzene, methane and Total Nonmethane Hydrocarbons (TNMHC). The Army did not report the emission results for the other VOC target analytes for the reasons discussed in Section 3.1.4.3 of the Background Document.[4]

Table 16.3-6 EFs & EFFs FOR THE OPEN BURNING OF AP PROPELLANTS

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	4.2E-01	B	1.5E-02	B	ND	B
PCDD & PCDF(a)	1746-01-6	2,3,7,8-TCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
SVOC & POM(b)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol	lb/lb NEW	1.1E-05	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
VOCs(c)	74-86-2	Acetylene	lb/lb C	9.1E-05	B	BDL	B	2.1E-04	C
	71-43-2	Benzene	lb/lb C	BDL	C	BDL	C	5.7E-04	C
	74-85-1	Ethylene	lb/lb C	BDL	C	BDL	C	ND	NA
	115-11-7	Isobutene	lb/lb C	4.5E-05	C	BDL	D	ND	NA
	115-07-1	Propylene	lb/lb C	BDL	C	BDL	C	ND	NA
	NA	TNMHC	lb/lb C	4.5E-04	C	3.6E-04	C	ND	NA
	108-88-3	Toluene	lb/lb C	BDL	D	BDL	D	ND	NA

Table 16.3-6 EFs & EFFs FOR THE OPEN BURNING OF AP PROPELLANTS (Continued)

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	4.7E-05	B	1.1E-04	B	1.5E-04	B
	NA	Nitrogen oxides	lb/lb N	3.3E-02	B	8.6E-02	B	1.9E-02	B
	7782-50-5	Chlorine	lb/lb Cl	2.1E-02	B	3.5E-02	B	NS	NA
	7647-01-0	Hydrogen chloride	lb/lb Cl	9.4E-01	B	8.5E-01	B	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.0E+00	B	3.4E+00	B	4.1E+00	B
	630-08-0	Carbon monoxide	lb/lb C	1.1E-02	B	1.3E-03	B	4.1E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Al	5.5E-02	C	NA	NA	2.9E-02	C

(a) Even though the measurement system had a nominal MDL of 9E-12 lb/lb NEW, none of the seventeen PCDDs/PCDFs target analytes were detected in the detonation plumes for these test items which had the highest chance of producing PCDD/PCDF EPs. Rather than list seventeen BDL values for each test material, it was decided to include in Chapter 16 only the result for 2,3,7,8- tetrachlorodibezo-p-dioxin (2,3,7,8-TCDD), the most toxic PCDDs/PCDFs compound. The complete list of PCDF/PCDD analytes can be found in Section 3.2.4.2.1 of the background document.[4]

(b) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (9E-06 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one or two orders of magnitude less than the BB MDL. The complete list of the BB SVOC/POM target analytes can be found in Table 33 of the background document.[4]

(c) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

Table 16.3-7 EFs & EFFs FOR THE OPEN BURNING OF SINGLE AND TRIPLE BASE PROPELLANTS.

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	8.6E-03	B	9.1E-01	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D
	108-95-2	Phenol	lb/lb NEW	BDL	D	BDL	D
	85-01-8	Phenanthrene	lb/lb NEW	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	D	BDL	D
	91-20-3	Naphthalene	lb/lb NEW	BDL	D	BDL	D
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	D	BDL	D
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	D	BDL	D
	95-57-8	2-Chlorophenol	lb/lb NEW	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D
VOCs(b)	74-86-2	Acetylene	lb/lb C	2.5E-05	B	BDL	C
	71-43-2	Benzene	lb/lb C	1.9E-05	B	BDL	C
	74-85-1	Ethylene	lb/lb C	1.5E-05	B	BDL	C
	115-11-7	Isobutene	lb/lb C	5.1E-07	C	BDL	D
	115-07-1	Propylene	lb/lb C	3.8E-06	B	BDL	C
	NA	TNMHC	lb/lb C	1.8E-04	C	6.7E-04	C
	108-88-3	Toluene	lb/lb C	3.4E-06	D	BDL	D
Energetics	55-63-0	Nitroglycerin	lb/lb NG	NA	NA	ND	NA
	556-88-7	Nitroguanidine	lb/lb NQ	NA	NA	ND	NA

Table 16.3-7 EFs & EFFs FOR THE OPEN BURNING OF SINGLE AND TRIPLE BASE PROPELLANTS (Continued)

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	NS	NA	1.2E-03	B
	NA	Nitrogen oxides	lb/lb N	NS	NA	6.3E-03	B
	124-38-9	Carbon dioxide	lb/lb C	2.3E+00	B	4.0E+00	B
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	B	8.7E-04	B
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb DNT	BDL(c)	D	NA	NA
	122-39-4	Diphenylamine	lb/lb DPA	BDL(c)	D	NA	NA

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (9E-06 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one or two orders of magnitude less than the BB MDL. The complete list of the BB SVOC/POM target analytes can be found in Table 33 of the background document.[4]

(b) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

(c) It is not appropriate to substitute 1/2 MDL for the DNT and DPA BDL values. The BB nominal MDL (1E-06 lb/lb) is several orders of magnitude higher than the OTR MDL and the OTR EFFs are at least an order of magnitude lower than the BB MDL.

Table 16.3-8 EFs & EFFs FPR THE OPEN BURNING OF DOUBLE BASE PROPELLANTS

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.9E-02	B	ND	NA	1.6E-02	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran	lb/lb NEW	BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol	lb/lb NEW	BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine	lb/lb NEW	BDL	D	BDL	D	BDL	D
VOCs(b)	74-86-2	Acetylene	lb/lb C	BDL	C	6.0E-04	B	3.5E-05	B
	71-43-2	Benzene	lb/lb C	BDL	C	6.0E-04	B	1.2E-05	B
	74-85-1	Ethylene	lb/lb C	BDL	C	NA	NA	2.5E-05	B
	115-11-7	Isobutene	lb/lb C	BDL	D	NA	NA	1.0E-06	C
	115-07-1	Propylene	lb/lb C	BDL	C	NA	NA	2.8E-06	B
	NA	TNMHC	lb/lb C	5.2E-04	C	NA	NA	5.8E-05	C
	108-88-3	Toluene	lb/lb C	BDL	D	NA	NA	BDL	D
Energetics	55-63-0	Nitroglycerin	lb/lb NG	ND	NA	BDL(b)	D	BDL(b)	D

Table 16.3-8 EFs & EFFs FPR THE OPEN BURNING OF DOUBLE BASE PROPELLANTS (Continued)

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	2.5E-05	B	3.6E-04	B	NS	NA
	NA	Nitrogen oxides	lb/lb N	9.4E-03	B	6.5E-02	B	NS	B
	124-38-9	Carbon dioxide	lb/lb C	3.2E+00	B	ND	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	7.3E-03	B	4.8E-03	B	1.0E-02	B
Metals	7439-92-1	Pb (In Energetic As Compound)	lb/lb Pb	6.3E-01	C	7.2E-01	C	NA	NA

(a) None of the 120 SVOC/POM target analytes were detected either above the nominal MDL of the measurement system (9E-06 lb /lb NEW) or above the background level in any of the detonation plumes for these test items. To avoid cluttering the tables with 120 BDLs for each test material, it was decided to include in Chapter 16 only the EFs for the BB SVOC/POM that were also target analytes in the OTR study. The failure to detect SVOCs/POMs in the BB plumes is understandable because the OTR SVOC/POM EFs are one or two orders of magnitude less than the BB MDL. The complete list of the BB SVOC/POM target analytes can be found in Table 33 of the background document.[4]

(b) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

Table 16.3-9 EFs & EFFs FOR THE OPEN BURNING OF PBX PROPELLANTS

EP Category	CASRN	EP	Units	M43 Propellant		PBXN-110 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E-03	B	4.9E-01	B
VOCs(a)	74-86-2	Acetylene	lb/lb C	3.0E-05	B	1.1E-05	B
	71-43-2	Benzene	lb/lb C	8.5E-06	B	1.8E-05	B
	115-11-7	Isobutene	lb/lb C	2.7E-06	C	4.8E-06	C
	115-07-1	Propylene	lb/lb C	5.5E-06	B	1.1E-05	B
	NA	TNMHC	lb/lb C	2.1E-04	C	1.9E-04	C
	108-88-3	Toluene	lb/lb C	2.7E-06	D	BDL	D
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.2E-04	B	3.5E-04	B
	NA	Nitrogen Oxides	lb/lb N	3.1E-02	B	1.2E-02	B
	124-38-9	Carbon dioxide	lb/lb C	3.9E+00	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	3.3E-03	B	4.4E-03	B

(a) A VOC is any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa. These six compounds were the only ones found in most burn plumes. They account for more than 98% of the mass of carbon in the VOC EPs. EFFs for the 37 individual VOC compounds detected in at least one burn plume can be found in Tables 34 thru 37 of the background document.[4] The complete list of VOC target analytes can be found in Tables 31 and 32 of the background document.[4]

16.3.5 Comparability of the BangBox and Open Test Range Detonation Emissions Data Sets

A statistical comparison of means was done between the following BangBox (BB) and open test range (OTR) EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene and TNMHC. When this comparison determined that all of the pairs were statistically the same, each pair of statistically-equivalent data sets was combined and the following summary statistics determined for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev) and relative standard deviation (RSD, std dev/mean).

Table 16.3-10 presents these summary statistics along with proposed EPA quality rating codes.[5] These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance to detonation reaction theory and representativeness to real world open burn activities.

Table 16.3-10 also contains summary statistics for the following EP/EP categories for which there was either only BB data or the OTR open range data were judged to be far superior to the BB data.

OTR *Energetics*. The OTR energetic EFFs were selected because all of the BB EFFs were BDL and the BB MDL was higher than the OTR EFFs.

OTR SVOCs/POMs Not In Energetic. The OTR EFs were selected because all of the BB EFs were BDL and the BB MDL was higher than the OTR EFs.

BB SO_2 There are no corresponding OTR EFs.

BB HCl. There are no corresponding OTR EFs

BB EFFs for Acetylene, Ethylene, Isobutene Propylene and Toluene. There are no corresponding OTR EFFs

BB Metals. There are no corresponding OTR EFs.

Table 16.3.10 SUMMARY STATISTICS FOR THE OPEN BURN DATA SETS

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD(a)	Quality Rating
PM-10	PM-10	lb/lb NEW	13	9.1E-01	1.2E-03	1.6E-02	1.5E-01	2.8E-01	1.89	B
Inorganic Gases	Sulfur Dioxide	lb/lb NEW	8	1.2E-03	2.5E-05	1.4E-04	3.0E-04	3.9E-04	1.31	B
	Nitrogen Oxides	lb/lb N	13	8.6E-02	6.3E-03	2.9E-02	3.5E-02	2.5E-02	0.71	A
	Hydrogen Chloride	lb/lb Cl	2	9.4E-01	8.5E-01	8.9E-01	8.9E-01	6.7E-02	0.07	B
	Carbon Dioxide	lb/lb C	15	4.1E+00	2.3E+00	3.7E+00	3.5E+00	4.6E-01	0.13	A
	Carbon Monoxide	lb/lb C	15	4.1E-02	1.5E-04	3.3E-03	7.8E-03	1.1E-02	1.46	B
Energetics	Energetics	lb/lb Energetic	4	1.5E-09	6.9E-10	9.7E-10	1.0E-09	3.3E-10	0.32	B
SVOCs	SVOCs in Energetics	lb/lb SVOC	6	9.4E-07	1.0E-08	4.4E-08	1.9E-07	3.7E-07	1.93	B
	SVOCs Not In Energetics	lb/lb NEW	29	8.0E-06	5.0E-10	2.7E-08	4.1E-07	1.5E-06	3.62	B
VOCs	Benzene	lb/lb C	11	6.0E-04	2.3E-06	1.6E-05	1.2E-04	2.3E-04	1.93	B
	TNMHC	lb/lb C	13	2.1E-03	8.4E-06	2.1E-04	5.0E-04	6.2E-04	1.24	B
	Acetylene	lb/lb C	7	6.0E-04	1.1E-05	3.5E-05	1.4E-04	2.1E-04	1.49	B
	Ethylene	lb/lb C	4	2.5E-05	1.5E-05	2.4E-05	2.2E-05	5.0E-06	0.22	B
	Isobutene	lb/lb C	5	4.5E-05	5.1E-07	2.7E-06	1.1E-05	1.9E-05	1.78	C
	Propylene	lb/lb C	4	1.1E-05	2.8E-06	4.6E-06	5.8E-06	3.7E-06	0.64	B
Metals In Energetic	Metal In Energetic As Particle	lb/lb Metal	2	5.5E-02	2.9E-02	4.2E-02	4.2E-02	1.8E-02	0.43	C
	Metal In Energetic As Compound	lb/lb Metal	2	7.2E-01	6.3E-01	6.7E-01	6.7E-01	6.2E-02	0.09	C

(a) As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

16.3.6 Application of the EFs/EFFs to Real World Open Burn Activities

16.3.6.1 Open Burning of Bulk Waste Propellants and High Explosives in Burn Pans.

Uncased waste propellants and high explosives comprise more than 90% of the energetic materials destroyed by open burning in burn pans. Because the EFs and EFFs in this chapter of AP-42 were derived from the open burning of bare propellants and high explosives in burn pans, they can be applied directly to these materials.

16.3.6.2 Open Burning of Missiles and Rockets

The following procedures are used to destroy missiles and rockets by open burning: (1) holding down the missile and firing it in its design mode, (2) removing the nozzle from a missile, holding it down, and igniting it, and (3) placing a shape charge along one side of a rocket motor or missile and using the initiation of that shape charge to crack open the item and ignite the energetics. Each of these processes results in different temperatures and pressures and different emissions. In general, all these burns involve a two stage decomposition process. The first stage involves a white cloud predominately composed of the substances released when the propellant deflagrates (decomposes). The second stage involves a black cloud predominately comprised of the substances released by the combustion of the liner and combustible parts of the casing.

There are no emissions data for the open burning of missiles and rockets. Because the propellant burn is essentially complete before the combustion of the liner and casing begins, one could assume that the emissions for each stage are additive. Under this assumption, one could use the EFs/EFFs in this Chapter of AP-42 to estimate the emissions from the open burning of the propellant and another source (e. g., the emissions for the combustion of materials similar in composition to the liner/casing) to estimate the emissions from the liner and casing.

16.3.6.3 Open Burning of Combustible Explosive Contaminated Waste in Burn Pans

Combustible Explosive Contaminated Waste is a byproduct of explosive loading, unloading, packaging and related activities. Usually, a weight of propellant and HE scrap equal to 30 to 60% of the weight of the combustible explosive contaminated waste is used to initiate and support the combustible explosive contaminated waste burn. Although the exact composition of the combustible explosive contaminated waste varies from day to day, it usually contains rags, cotton gloves, wood sticks, polyethylene bags, corrugated cardboard and pressed cardboard propellant cups along with 1% HE and propellant materials. There are no emissions data for the burning of combustible explosive contaminated waste. Until these data become available, the emissions data presented in Appendix B of the background document could probably be used to estimate the emissions from the open burning of combustible explosive contaminated waste.[4]

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2a. *Development of Methodology and Techniques for Identifying and Quantifying Products from Open Burning and Open Detonation Thermal Treatment Methods - Bang Box Test Series, Volume 1, Test Summary*. U.S. Army, AMMCOM, Rock Island, IL 61299-6000, January 1992.

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5. *Procedures for Preparing EF Documents*. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Durham, NC. EPA Report - EPA 454/R-95-015 (Revised), September 1997.

Attachment 3 Background Document for AP-42 Chapter 16 (draft)

BACKGROUND DOCUMENT

AP-42 CHAPTER 16 -

EMISSION FACTORS FOR DEMILITARIZATION PROCESSES: OPEN BURNING AND OPEN AIR DETONATION

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DEMILITARIZATION PROCESSES

1.0 INTRODUCTION

1.1 Properties of the Materials Treated by Demilitarization

When subjected to heat, impact, friction, or shock, energetic compounds undergo a very rapid, self-propagating, intramolecular oxidation-reduction reaction (combustion) that results in the formation of highly stable simple gases and the release of heat (energy). This chapter of AP-42 applies to the emissions resulting from the disposal of energetic compounds and materials containing these compounds by open burning in burn pans and surface detonation. All of the explosive and propellant (energetic) materials covered by this chapter of AP-42 are solids at normal environmental temperatures and pressures and have melting points between 120 and 400^0F and vapor pressures less than 8E-05 kilopascals (7.9E-07 atmospheres).

The materials commonly disposed of by detonation are: reclaimed high explosives that cannot be reused, cased munitions, explosively-loaded ordnance components (e.g., primers and fuzes) and detonable rocket motor propellants. The materials commonly destroyed by open burning are: propellants, reclaimed high explosives that cannot be detonated and combustible materials contaminated with energetic residues from ammunition and ordnance manufacturing processes (Explosive Contaminated Waste, ECW).

1.2 Overview of Open Detonation and Open Burn Detonation Processes

NOTE - The information presented in this section was taken primarily from three U. S. Government reports - two issued by the Naval Air Warfare Center Weapons Division (NAVAIR), China Lake, CA[1, 2] and the other by Lawrence Livermore National Laboratories (LLNL).[3] The LLNL (Ornellas) report was the primary source for the information on the initial stage of the detonation process and the NAVAIR reports were the sources for the information on the remaining four stages of the detonation process.

The initial step in both open burning and detonation processes is an adiabatic, oxidation- reduction process, which involves oxidant (e.g., $-ONO_2$, $-NO_2$, $-NHNO_2$) and reductant (e.g., C_xH_y) radicals within the energetic molecule. Once this reaction is initiated, it will proceed to completion without any additional energy being required.

The major differences between the open burning and the detonation processes are the speed with which this adiabatic, oxidation-reduction reaction proceeds through the energetic material and the pressures and temperatures involved. In open burning the oxidation-reduction reaction occurs on the surface of the energetic material at close to atmospheric pressure and takes seconds to a few minutes to go to completion. The rate determining factors in open burning are the rate of heat transfer into the material and the rate of decomposition of the energetic material itself. There is no shock wave. In contrast, in detonation processes, the oxidation-reduction reaction proceeds through the material at a velocity (detonation velocity) between 7,000 and 35,000 ft/s, and the reaction is completed within a few microseconds. Detonations produce pressures as high as 350,000 atmospheres (35,300,000 kPa) and temperatures as high as $6{,}000^0$K.

Ornellas has demonstrated through experimentation that in detonations this intramolecular

rearrangement is so fast that only a small percentage of the atoms in one molecule have time to react with atoms in adjacent energetic molecules that are decomposing at the exact same time.[3] He demonstrated this through a series of bomb calorimeter experiments in which he detonated 20:80 (w/w) mixtures of ammonium nitrate (AN) and TNT. In these experiments, Ornellas used unlabeled AN (99.8% ^{14}N), labeled AN (99.1% ^{15}N isotope) and unlabeled TNT (99.8% ^{14}N). In one of the experiments, he made a slurry of TNT and AN in toluene, dried the slurry, blended it, sieved it through a 30-mesh screen and pressed the resulting powder into one-ounce, 0.5 in- diameter pellets, which he then detonated in the calorimeter. In the other experiment he detonated 0.5 in- diameter pellets containing a 0.25 in- diameter core of labeled AN and a 0.25 in annulus of unlabeled AN. After each detonation, he measured the isotopic content of the N_2 formed, i.e., $^{14}N\,^{14}N$, $^{14}N\,^{15}N$, and $^{15}N\,^{15}N$. The two experiments yielded similar results, i.e., only about 13% of the nitrogen in the TNT and the AN mixed.

Because the detonation of explosives does not require air, it can occur in a vacuum, in an inert atmosphere, or even under water. The initial detonation products are C (soot), carbon monoxide, hydrogen, methane, ethane, formaldehyde, nitrogen, carbon dioxide, water vapor, small hydrocarbons and small C_xH_y fragments. The initial stage of the detonation process is over in less than 10 microseconds and is followed by a 2 to 10 second duration fireball (afterburn). In this second stage of the process, combustible detonation reaction products (e.g., carbon monoxide, methane, ethane, formaldehyde, hydrogen and the C_xH_y fragments) are spontaneously oxidized (combusted) to CO_2 and H_2O. Fireball temperatures are on the order of 1,700 to 3,100°F. As the plume expands it entrains additional air which allows further combustion reactions to take place until the plume temperature falls to approximately $1{,}500^0$F where these reactions stop (freeze out temperature). The air-entrainment and afterburning occur almost simultaneously and are highly coupled. As the gases rise and air is entrained, soil is pulled into the plume. This entrained soil, along with the dirt released from the crater, forms the visible plume associated with detonations. Plume formation takes seconds to hundreds of seconds to complete and the subsequent dispersion of the plume in the atmosphere can take hours.

When easy-to-detonate materials are detonated, the detonation can often be initiated using an electric blasting cap (EBC) and plastic explosives such as C4 or A-3 or blocks of TNT. These latter materials are frequently referred as the detonation initiating charge and demolition charge. However, when difficult-to detonate materials are to be destroyed by detonation, its common practice to place an easy-to-detonate material (donor material or donor charge) in close contact with the difficult-to-detonate material and to use the detonation of this donor material to detonate the difficult-to-detonate material (sympathetic detonation). The manner in which the donor charges are placed, the methods used to prime or initiate the donor charges, and the amount of confinement (tamp), can strongly influence the effectiveness in the ability of the detonation to completely destroy all of the energetics, particularly in stacks of mixed ordnance. For example, common practice is to simultaneously initiate the detonation of the donor charges from both ends and also top center of the stack to minimize the possibility of munitions being expelled from the stack instead of being destroyed.

Open burning is generally conducted using steel pans sitting on concrete pads to avoid contact with the soil surface. The pans have sufficient depth and size to contain treatment residues and are kept covered when not in use. In open burning the materials are placed in a steel burn pan to a depth of four inches or less, and the burn is initiated with an electric match or a black powder train. Open burns of propellant materials, which usually involve between 1,000 and 5,000 lb of propellant generally go to completion in less than a minute, whereas, the burns of the other materials generally take at least three minutes to go to completion. The ash is recovered and, unless chemical analysis recommends otherwise, is disposed of as a hazardous waste.

1.3 Emissions from Open Burning and Detonation Processes

Between 1961 and 1981, Ornellas conducted a series of detonation experiments in bomb calorimeters, and evaluated how the following factors affected the efficiency and effectiveness of the detonation process: explosive density, purity, and particle size; the degree of confinement; and the type of initiating charge.[3] These experiments involved detonating one ounce cylindrical pellets of 43 energetic materials in a 5.3L bomb calorimeter and determining the chemical composition of the detonation plume.

Most of the detonations were done with the calorimeter evacuated to prevent afterburn from occurring, but a few were done when the calorimeter was pressurized with either CO_2 or O_2. Some of the detonations were done with the energetic simply suspended by a string to simulate unconfined detonations, and the others were done with the energetic encased in glass or metal cylinders. Sometimes the ends of these cylinders were open to simulate partially-confined detonations, but at other times they were closed to simulate fully-confined detonations.

Approximately 90 minutes after the detonation, gas samples were taken from the bomb calorimeter and analyzed for N_2, CO, CO_2, H_2, H_2O, CH_4, NO, NO_2, HCN, HCl, HF and volatile organic compounds (VOCs). The calorimeter itself was also rinsed out and the rinse analyzed for solid carbon (particulate), and when appropriate, for Al_2O_3 and Zr_2O_3.

His experiments established that the major emission products from an unconfined detonation are N_2, CO_2, and H_2O and the minor emission products were CO, H_2, CH_4, NO, NO_2, HCN, HCl, HF and volatile organic compounds (VOCs). Generally, at least 97% of the nitrogen in the energetic was released as N_2 and the rest was released as NO and NO_2. He also showed that the [chemical] composition of the initial detonation products was not greatly affected by the degree of confinement. For example, the initial emission products formed by detonating an energetic in a pure carbon dioxide atmosphere will be essentially the same as those formed when the energetic is detonated in a vacuum, regardless of the degree the energetic is oxygen-balanced.

The first comprehensive Department of Defense (DOD) study to characterize the air emissions from real-world open burning and detonation operations was conducted at Dugway Proving Ground (DPG), UT from 1984 through 1986. In this study, helicopters equipped with standard air pollutant sampling systems attempted to identify and quantify the pollutants in the plumes produced when 2,000 to 11,000 lb of bulk high explosives and propellants were open burned and detonated on a DPG test range. The results were inconclusive.[4]

In 1988, the United States Army conducted a highly successful follow-on study.[5-7] The first stage of this follow-on study involved detonating 0.5 lb quantities of TNT and open burning 5 lb quantities of a double-base and a composite propellant in a 32,900 ft^3 hemispherical chamber (BangBox) at Sandia National Laboratories (SNL) in Albuquerque, NM. A suite of state-of-the art sampling systems was then used to characterize the identities and quantities of the emission products present in the plumes. The results from these burns and detonations were used to select the plume sampling equipment subsequently used to measure chemicals of environmental concern in the plumes produced when large quantities of energetic materials were detonated and burned on an open test range at DPG. The sampling equipment selected was installed in a twin-engine, turboprop aircraft and the aircraft was used to sample the plumes released when 2,000 lb of high explosives [contained in either wood boxes or steel barrels] were detonated and when

5,000 to 7,000 lb of propellants were open burned in steel pans at DPG.

Based on the test results, DOD concluded that the plumes released when energetic materials are destroyed by open burning and detonation processes do not contain sufficient quantities of toxic or hazardous pollutants to pose a danger to human health or the environment. For example, the average emission factors (EF) for the semi-volatile organic compounds (SVOCs) and polycyclic organic matter (POMs) detected was approximately 2E-07 lb/lb NEW detonated/burned and the average EF for benzene, the most toxic volatile organic compound (VOC) was approximately 1E-04 lb/lb NEW detonated/burned. It also concluded that the emission factors for the predominant emission products (EPs) produced in the BangBox (BB) emissions tests were statistically equivalent to those produced in the DPG open range tests and those produced in Ornellas' bomb calorimeter experiments.. That is, the EPs did not change substantially even when the quantity of energetic material detonated increased by a factor of 32,000.

In 1992, the U.S. EPA concurred with DOD's conclusions and agreed to accept BangBox-produced emission factors as representative of those that would be derived through ground level, open-air detonation and burn tests.[6] The U. S. Army then installed a BangBox at DPG and conducted a series of studies that characterized the air emissions produced when bulk and cased high explosives were detonated and bulk propellants were burned. These studies were then followed by larger scale detonation and burn experiments in a larger chamber at the Nevada Test Site that involved detonating 155MM projectiles and burning Hawk and NIKE rocket motors.[8-13] All of these studies employed plume sampling and analysis systems that were similar to those used in the earlier DPG open range studies, but also added the following target analytes: 140 additional VOCs, 100 additional SVOCs/POMs, HCl, Cl_2, metals, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDs/PCDDs) and SO_2.

These follow-on studies filled in some of the major data gaps left by the open range studies and reconfirmed the conclusions of Ornellas and the DPG open range studies that the predominant emission products for open burning and detonation processes are: particulate, CO_2, N_2, soot, CO, NO_x, metals and the first members of the saturated, unsaturated and aromatic hydrocarbon series. Further, polychlorinated dibenzo-p-dioxin and polychlorinated dibenzofuran compounds (PCDDs/PCDFs) were not detected in the plumes. (The nominal minimum detection limit (MDL) of the PCDD/PCDF measurement system used in the detonation trials was 7E-11 lb/ lb NEW and that used in the open burn trials was 9E-12 lb/lb NEW.)

Further, in the few instances when SVOCs/POMs were detected, the concentrations were indistinguishable from those found in ambient air and it IS very likely that these compounds were present in the ambient air when the detonation was initiated. The failure to find PCDDs/PCDFs, SVOCs and POMs might seem surprising because these compounds are detected in the combustion gases of hazardous waste incinerators and the second stage of open burn and detonation processes involves combustion reactions. The reasons they are not present are: (1) by the time the second stage begins, the energetic material has already decomposed into very small, mostly thermodynamically stable molecules, and (2) the short duration and high temperatures associated with the second stage prevent the reactions from occurring that would convert a meaningful number of these small molecules into polycyclic molecules. In contrast, the temperature associated with the combustion of hazardous wastes are on the order of 900 to $1,600^0$F, and the original waste material is held in this temperature range for more than a minute, conditions that promote the formation of polycyclic organic molecules.[14-18]

This background document to Chapter 16 of AP-42 (Demilitarization Processes) contains a compilation of the EFs produced in the above studies that were judged to be reasonably representative of real-world open burn and detonation practices. It was funded by the U.S. Army's Defense Ammunition

Center (DAC), McAlester, OK, to provide the environmental community with a database of emission factors that could be applied to: ambient air pollutant fate and transport modeling, pollutant control strategy development, permit applications, preparing Toxic Release Inventory (TRI) reports, screening detonation disposal practices to identify the materials which could be a significant source of the toxic pollutants of concern to the environmental community, demil workload planning, and developing green munitions.

The emission factors were selected and graded in accordance with the Essential Characteristics of Emission factors (Table 1) and the quality rating factors for emissions data sets (Table 2) and databases (Table 3) contained in the USEPA guidance document entitled: *Procedures for Preparing Emission Factor Documents*.[19] In carrying out this selection and grading, the composition data on the materials detonated in the individual test reports was supplemented with information in the Munitions Items Disposition Action System (MIDAS). (MIDAS is a set of relational databases that provide information on the weight and chemical composition of more than 8,500 munitions and munition components. It was developed and is continuously updated by the U.S. Army Defense Ammunition Center, McAlester, OK.)

The following procedure was used to select the emissions data contained in AP-42. First, the existing emission data sets were reviewed to identify data sets that did not meet the minimum criteria specified in the EPA guidance, and therefore, should be rejected from further consideration. Second, the data sets that passed this preliminary evaluation were entered into an Excel workbook along with information on the test conditions and chemical compositions of the energetic materials whose emissions were characterized. Third, for each individual data set the information in the Excel workbook and the test reports was then evaluated against the EPA data quality rating criteria in Section 4.4.2 of Reference 19. The results of this evaluation were used to select the emissions data selected for inclusion in Chapter 16 of AP-42.

1.4 Emission Controls

There are no emissions controls on either detonations or open burning operations per se. However, some of the engineering controls used to reduce the intensity of the propagation of the blast (sound) and pressure waves and the release of shrapnel from detonations do affect the relative ratios of the emission products released into the environment. This is especially true when the formation of a full fireball is inhibited. For example, compared to an unconfined detonation of the same material, detonating an energetic material under a light soil cover, which provides some confinement, increases the quantity of soot, CO and unsaturated hydrocarbon emission products released into the plume but decreases the quantity of CO_2 and the height to which the plume rises.

1.5 Definitions of the Units of Measure Used

The emissions data are presented in two formats: (1) the traditional reporting unit (mass released per mass of the net explosive weight (NEW) detonated or burned; and (2) an alternate reporting unit (mass released per mass of a specific chemical substance in the material detonated or burned. This alternate reporting unit was used when there was a known relationship between an emission product and a substance in the test material. This alternative unit is designated as the Environmental Fate Factor (EFF) and the traditional unit is designated as EF. The EF and EFF reporting units used for each EP and EP category are presented in Table 1.

This alternate reporting unit was developed because there is no direct relationship between the mass of the EP and the NEW detonated or burned. But there is such a relationship between the composition of the energetic material and the mass of the metal and some of the carbon and nitrogen containing EPs. Knowing these relationships can be very important when trying to use emissions data derived from chamber-based experiments to assess the true risk posed to human health and the environment by a specific detonation or burn process. For example, because of limitations on the quantity

of the energetic material that could be detonated in the BangBox, the ratio of the explosive mass used to initiate some detonations (demolition charge) to test item explosive mass was many times higher than the ratio that is used in real-world detonations.

Table 1. EF and EFF Units Used.

EP/EP Category	Units
CO_2, CO, VOCs	lb EP/ total lb C in material detonated/burned
NO_x	lb EP/ total lb N in material detonated/burned
HCl, Cl_2	lb EP/ total lb Cl in material detonated/burned
Energetics	lb EP/ total lb related energetic in material detonated/burned
PM-10	lb EP/ total lb NEW
SVOCs/POMs in the energetic material	lb EP/ total lb related SVOC in material detonated/burned
SVOCs/POMs not in the energetic material	lb EP/ total lb NEW
PCDDs/PCDFs	lb EP/ total lb NEW
Metals	lb EP/ total lb related metal in material detonated/burned
SO_2	lb EP/ total lb NEW(a)

(a) Although it would be more appropriate to use EFF values for the SO_2 emissions, it is not possible to convert the EFs to EFFs at this time due to uncertainties about the actual sulfur content of the test items.

1.6 Special Handling for Metal Emissions Data Sets

Metals of environmental concern are present in energetic materials in a wide variety of forms and matrices. For example, MIDAS shows that the 20mm HEI cartridge detonated in the DPG BangBox contained metals in the following forms and locations:

- As an energetic compound, i.e., lead styphnate in the fuze.
- As propellant and explosive performance modifiers, i.e., tin oxide in the propellant and barium nitrate in the explosive.
- As an alloy, i.e., copper, zinc, and lead in the brass casing and the primer cup and manganese in the steel projectile body.
- As a protective coating, i.e., zinc phosphate and zinc chromate in the paint on the projectile body and cadmium chromate plating on some of the internal metal parts in the fuze.

- As a particle, i.e., zirconium pellets in the incendiary material.

When the 20mm HEI round is detonated, one would intuitively expect that a significant fraction of the lead in the lead styphnate would be released into the plume, whereas only a very small fraction of the lead in the brass casing and primer cup would be. Further, because the brass would not have melted or vaporized, the lead in the brass parts would stay in the brass and this would restrict its biological availability.[2] Since the location and form of the metal in a munition can be very helpful in assessing the potential risk posed by the metals released into the detonation plume, it was decided to enter the metal EF and corresponding EFF values in AP-42 under the following categories, whenever possible:

- Metals in Alloy (includes casings and interior metal parts)
- Metals in Energetic as Particle
- Metals in Energetic as Compound
- Metals in Protective Coating (includes paints and platings)

NOTE - Most alloys contain at least one metal of environmental concern. There is an extensive body of theoretical and experimental data showing that these metals are not released from the alloy during the detonation or burn.[1]

1.7 Definitions of the Letter Codes Used

When it was not possible or not appropriate to enter a numerical EF or EFF value, the letter codes presented in Table 2 were used.

Table 2. Explanation of Letter Codes Used in This Chapter of AP-42.

Letter Code	Explanation
NS (No Sample)	Not a target analyte.
NA (Not Applicable)	There is no information available to indicate that the test material contained a substance that could produce this EP or there is no definable relationship between the traditional EF and the test material that would permit calculating the corresponding EFF value.
ND (No Data)	Sample collected but either no result reported or data generator invalidated sampling result.
	Not possible to adjust the reported value for the contribution from test chamber surfaces and/or background air.
	Not possible to adjust the reported value for an erroneous sample background correction adjustment.
	Not possible to convert the traditional EF to the alternate EFF because critical composition data is not available for the test material.
BDL (Below Detection Limit)	Possible emission product, but either never detected or, if detected, never detected above the background level.

2.0 SELECTION OF DETONATION EMISSIONS DATA

2.1 DPG Open Range Detonation Emissions Data Sets

2.1.1 Test Description

The five detonation emissions data sets were produced in 1989 and 1990 when 2,000 lb of four explosives were open detonated on a test range at DPG.[5-7] The detonations were initiated with 10 to 20 lb of either C4 or TNT block. Four of the data sets were derived from uncovered, ground-level detonation experiments (surface detonations) and the fifth was derived from a set of detonation experiments in which the explosive was suspended in a steel barrel approximately 35 feet above the ground (suspended detonation). The testing was done in three phases designated by the Army as Phase A, Phase B and Phase C. (NOTE - Below ground TNT detonations planned for Phase C were not conducted because of a lack of funds.)

Samples were collected from 43 detonation plumes by means of a twin-engine turboprop airplane that traversed the plume at 90 knots (150 ft/ second). The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between three and seven seconds. For safety reasons and to allow all chemical reactions to go to completion, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted, 10 ft long, 3-in I.D. aluminum probe, which exited into a 11 ft long, 4 in. ID sampling manifold inside the airplane. The probe extended outside the aircraft's boundary layer at a position forward and above the copilot's windshield. A sliding valve located at the union of the probe and sampling manifold directed the plume gases into either the manifold (sampling mode) or back into the atmosphere (bypass mode).

The following sampling equipment was attached to the sampling manifold: an 80 L, Tedlar bag; three high volume samplers containing Teflon-coated quartz fiber filters (sampling at a rate of three to four m^3/min); and an evacuated 6 L stainless steel canister. As the airplane approached the plume for its initial pass, the high volume sampler motors were started, but the manifold sampling valve was left in the bypass mode. When the nephelometer mounted in the front of the airplane indicated that the airplane was entering the plume (sharp increase in nephelometer reading), the manifold sliding valve was moved to the sampling mode. When the nephelometer indicated that the airplane was exiting the plume (sharp drop off in the nephelometer reading), the sliding valve was placed in the bypass mode, where it remained until the airplane was ready to make its next pass through the plume. After each pass through the plume, the VOC canister sampler was removed from the sampling manifold and replaced with a clean evacuated one while the other samplers remained unchanged. After the final pass through the plume, the high volume sampler motors were turned off and the CO_2, CO, NO and NO_2 concentrations in the Tedlar bag were determined using continuous emission monitors (CEMs) on board the aircraft. The crew then prepared to sample the next detonation plume by evacuating the 80 L Teflon bag and attaching a clean, evacuated 6 L canister to the manifold. The crew then prepared to sample the next detonation plume by evacuating the 80 L Teflon bag and attaching a clean, evacuated 6 L canister to the manifold.

Each detonation trial consisted of three to five detonation events spaced 10 to 25 minutes apart. To ensure that sufficient particulate would be collected to allow characterization of the SVOC and energetic compound content of the particulate, the same high volume filters were used for all detonations comprising a trial. This approach produced total high volume sampling volumes from 280 to 350 ft^3 (8 to 10 m^3).

No attempt was made to collect plume samples for analysis for HCl or for dioxins and furans, because detonation tests conducted in the SNL BangBox indicated that either none of these compounds would be emitted or, if they were emitted, the concentrations would be too low to detect with the available equipment. In addition, no attempt was made to sample for toxic metals, because none of the materials detonated contained them.

Each test day, before the first detonation or burn trial was conducted, the airplane collected a 20-minute background air sample 1,000 ft above the test range using the same sampling procedures and equipment that would be used to collect plume samples. The concentrations of target analytes found in these background samples were used to correct the emission factors produced that day for the contribution from ambient air pulled into the plume. (NOTE - This approach assumes that the only background air species present in the plume are those present in the air before the detonation. It ignores species knocked off surfaces by the shock wave and turbulence produced in the detonation. Because these latter materials are not included in the background sample, they become part of the reported emissions. Since many of the SVOC/POM and energetic target analytes were known to be present in the soil, and most of the particulate matter was soil.[6] Thus, it is likely that some of the SVOC/POM and energetic EPs were actually extraneous material pulled into the plume along with or from the soil.)

At the conclusion of each trial or background sample collection effort, the aircraft returned to the airfield where the high volume filters were recovered, placed in an ice-cooled container, and transported to a laboratory in Provo, UT (where they were stored in a freezer). The filters were subsequently weighed, Soxhlet-extracted, and the extract analyzed for the target SVOCs/POMs and energetics by GC/MS and Super Critical Fluid Chromatography/MS-selective ion monitoring (SFC/MS-SIM), respectively. The 6 L canisters were sent to a laboratory in Beaverton, OR for analysis for EPA Method TO-14 for volatile organic compounds (VOCs).

A description of the measurement systems used in these tests is presented in Table 3, and a list of the target analytes is presented in Table 4. Because of the prove-out nature of the project and funding limitations, the number of SVOC target analytes was kept small.

Table 3. Emissions Test Methods Used in DPG OD Field Studies.

Target Analyte or Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (CSI Model 1600) [Sampling and Analysis]
PM-10	40 CFR 50, Appendix B combined with aircraft sampling probe
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOCs/POMs	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and GC/MS [Analysis]
Energetics	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and analysis by Supercritical Fluid Chromatography/MS (SFC / MS)
CO, CO_2 (Primary CO and CO2 Sampling System)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)

Table 4. DPG Detonation Field Test Target Analytes.

Inorganic Gases and Particulate Matter	NO, NO_2, CO, CO_2 , PM-10
Volatile Organic Compounds (VOCs)	Aromatic hydrocarbons, C_1 to C_{10} saturated and unsaturated hydrocarbons and chlorinated hydrocarbons.
SVOCs/POMs	Benz(a)anthracene, benz(a)pyrene, dibenzofuran, N–nitrosodiphenylamine, 2-methylnaphthalene, naphthalene, nitrobenzene, phenol, 4-nitrophenol, phenanthrene, pyrene, pyridine, 1-nitropyrene, 1,3,5-trinitrobenzene, 2-nitrotoluene, 4-nitrotoluene; 2-nitronaphthalene, diphenylamine, 2-nitrodiphenylamine, 2,4-dinitrophenol, 2,4-dinitrotoluene and 2,6-dinitrotoluene.
Energetics	Nitroglycerine (NG), HMX, TNT, RDX, Picric acid (Surrogate for Explosive D which is ammonium picrate).

2.1.2 Description of the Test Materials and Detonation Piles

The composition of the four materials characterized and the number of plumes sampled for each are presented below.

2.1.2.1 Reclaimed TNT

Ground Level TNT (Surface) Detonations. Ground level TNT detonations were conducted in all three phases of the test series (Figure 1). Phase A contained a single trial consisting of five, 898 kg (1,975 lb) detonations, Phases B, and C each contained two, three-detonation trials that involved detonating 909 kg (2,000 lb) of TNT. The detonation events were spaced between 10 and 25 minutes apart.

Above Ground Level (Suspended) Detonations. Suspended TNT detonations were conducted in Phases B and C and involved detonating 909 kg (2,000 lb) of TNT in a barrel that was suspended approximately 35 ft above the ground (Figure 2). The Phase B suspended detonations involved two three-detonation trials and the Phase C involved one three-detonation trial. The detonation events were spaced approximately 15 minutes apart. (NOTE - Although the suspended TNT detonations did not reflect real-world detonation practice, it was decided to include their emissions data because a comparison between the suspended and surface TNT detonation data sets provides the user of AP-42 some insight into the effect of soil on the final mix of detonation EPs.)

Figure 1. 2,000 lb Surface TNT Detonation at DPG

Figure 2. Suspended TNT Detonation at DPG

2.1.2.2 Reclaimed RDX Materials

RDX. The reclaimed RDX was detonated in the pasteboard boxes in which it was received. Two three-detonation trials were conducted. The material detonated contained approximately 836 kg (1,840 lb) of RDX and 45.5 kg (100 lb) of Viton A rubber. The average NEW for the three detonations in the first trial was 875 kg (1,926 lb), and the average NEW for three detonations in the second trial was 886 kg (1,950 lb). The three detonations in the first trial and the first two in the second trial were spaced approximately 15 minutes apart. The third detonation in the second trial was initiated approximately 20 minutes after the second detonation.

Composition B. The composition B was reclaimed material in flake form and contained approximately 360 kg (790 lb) of TNT, 525 kg (1,155 lb) of RDX, and 10 kg (22 lb) of wax. Two three-detonation trials were conducted. In each trial, the detonations were spaced approximately 15 minutes apart. The NEW of each detonation was 886 kg (1,950 lb).

2.1.2.3 Reclaimed Explosive D

The reclaimed Explosive D was in granular form and contained more than 99% ammonium picrate (Explosive D). Two three-detonation trials were conducted. The NEW of each of the six detonations was approximately 916 kg (2,015 lb). During the first trial, the second detonation was initiated approximately 10 minutes after the first and the third was initiated approximately 21 minutes after the second detonation. In the second trial, the three detonations were spaced approximately 20 minutes apart.

2.1.3 Calculation of the Emission Factors

The Army used the ratio of the carbon content of the material detonated to the carbon content of the plume sample (as represented by the sum of the CO_2, CO and CH_4 concentrations) to calculate the plume volume at the time the plume samples were collected. This method for determining plume volume which is usually referred to as the Carbon Mass Balance Approach rests on the following two premises whose validity was confirmed in tests in the SNL BangBox[5] and in Ornellas' calorimeter-based detonation experiments[3] before the Phase A field tests were conducted.

- In an unconfined (open) detonation essentially all of the carbon in the materials detonated is converted to CO_2, CO and CH_4.

- The proportional distribution among the carbon-containing gaseous emission products within individual micro-regions of the detonation plume remains relatively constant, even though the individual concentrations may be different within the macro-regions of the plume.

Thus, by determining the mass of the carbon in a known volume of the plume and the total mass of carbon in the material detonated, one can determine the volume of the plume at the time the plume sample was collected. This plume volume can then be multiplied by the concentration of any target analyte in the same plume sample (or one taken at the same time and location) and divided by the NEW of the material detonated to derive an emission factor for that analyte (Equation 1).

$$EF_i = (f_c)[\text{analyte i}]/[C_j] \qquad \text{(Equation 1)}$$

where:

EF_i = EF for target analyte i (lb/lb NEW)

f_C = mass of C in the energetic divided by mass of the explosive (NEW) detonated.

[analyte i] = background-corrected concentration (lb C /ft^3) of the target analyte collected from volume element j of the plume.

$[C_j]$ = background-corrected concentration of carbon (lbC /ft^3) collected from volume element j of the plume [as represented by the CO_2, CO and CH_4 compounds found in the canister VOC sample taken from the 80L bag].

2.1.4 Identification of Emissions Data Sets Appropriate for Inclusion In AP-42

Each emissions data set was examined and evaluated to determine if the EF in the data sets were suitable for inclusion in AP-42 and the quality rating that should be assigned to it. This evaluation used the Army-derived MDL values, the compositions of the material detonated contained in the test reports, information about the pretest concentrations and distribution of VOC, energetic and SVOC compounds in the background soil and air samples at the test site, mass balance calculations, the QA and QC reports included in the Appendices of the test report, the results from Ornellas experiments and the EPA guidance

document.

Based on this evaluation, the decision was made to exclude the Phase B TNT emission test results because the test report had noted that the TNT did not meet the test specifications. It was described as being wet, nonhomogeneous, some portions were very friable and others not so friable, and the TNT was severely discolored. Even though it did not meet the test plan quality specifications, it was used for the following reasons. First, because it was not possible to obtain another batch of TNT before the test. Second, a considerable portion of the Phase II funds had already been spent preparing to conduct the Phase B tests, and postponing the tests would mean that either the Phase B test program would have to be scaled back considerably or the scope of the Phase C experiments would have to be reduced substantially.

The following decisions were made regarding the individual emissions data sets.

2.1.4.1 Inorganic Gases

CO and CO_2. For each material detonated the Army reported two sets of emission factors for CO and CO_2. Each set contained a minimum, maximum, and average emission factor. One set represented the results for the continuous emissions monitors located in the airplane, and the other set represented the analytical results from the canister samples. Although the two sets of values compared very well, the Army designated the canister results as the most representative emissions data for CO and CO2. Therefore, only the emission factors attributable to the canister samples were examined in detail. This examination showed that for the four test materials, the mass of carbon represented by the CO and CO_2 emission factors accounted for more than 99% of the mass of carbon in the test materials. Since these values are reasonable and consistent with the work of Ornellas and the results from other studies, the canister-sampling results were entered in the AP-42 Excel workbook.

NO_x. For each material detonated the Army reported only a minimum, maximum, and average EF for NO and NO_2. For all of the materials detonated, the mass of nitrogen represented by the NOx emission factors was less than 1% of the mass of nitrogen in the explosive. Because the values were reasonable and consistent with detonation reaction theory and the results from other emission characterization studies, the NO and NO_2 values for each material were converted to the equivalent NO_X EFF value (as NO_2 equivalent) and the results entered in the AP-42 Excel workbook.

2.1.4.2 Particulate Results

The Army reported the following average particulate plume concentration for each material detonated: RDX (200 mg/m^3), Composition B (200 mg/m^3), Explosive D (250 mg/m^3), TNT surface (Phase A - 45 mg/m^3, Phase C - 258 mg/m^3) and TNT suspended (Phase C - 37 mg/m^3). It noted that almost all of the particulate mass consisted of soil particles, but it did not provide detailed information on the exact percentage for each test material detonated. Further, it did not report the associated plume volumes required to convert these concentrations to the equivalent emission factors, and the original test reports were destroyed in 1998 because of the possibility that they were contaminated with the hantavirus. (Mice had made nests in the boxes containing the original data sheets and the hantavirus was known to be present in the rodent populations at DPG at the time.) However, there was a statement on page 4-2 of Volume 1 of the Field Test Report[6] that the average carbon plume concentration for one set of the TNT detonations was 34.95 mg C/ m^3 and that almost all of the carbon in the plume was in the form of CO_2. Therefore, it was decided to use this value to convert the particulate concentrations to the equivalent EF by multiplying each average particulate concentration by the mass of carbon in the material detonated and

dividing the resulting product by the NEW detonated and 34.95 mg C/ m^3.

2.1.4.3 Volatile Organic Compounds

The Army report contained emission factors for only three VOC analytes: benzene, methane, and Total Nonmethane Hydrocarbons (TNMHC). For each energetic material detonated in each phase of the testing, the Army reported only the minimum, maximum, and average emission factors for these three VOC target analytes. Since the average EF for each of these emission products was consistent with Ornellas' work and the results from other OD emission characterization studies, the values were entered in the AP-42 Excel workbook.

The Army used the following justification for not including the emissions results for the other VOC target analytes in the test report. First, the SNL BangBox and the DPG field test results had demonstrated conclusively that the VOCs emitted were almost exclusively the first members of the alkane, alkene, and alkyne classes of hydrocarbons (which are not toxic), and the first members of the aromatic hydrocarbon class, of which benzene is the most toxic. Second, it wanted to avoid overwhelming the reader with nonessential emissions data. Third, for every energetic material detonated in the BangBox and on the test range at DPG, benzene represented a substantial percentage of the total mass of the aromatic hydrocarbons found, but was only 2.0 % of the total mass for all of the nonmethane hydrocarbons (TNMHCs). Thus, the benzene EF would serve as a reasonable estimate for the toxic aromatic emissions, and the reader would realize how small the toxic VOC emissions were with respect to all the other hydrocarbons released.

2.1.4.4 Semi-Volatile Organic Compounds and Polycyclic Organic Matter (SVOCs/POMs)

For each test material, the Army reported a single, background-corrected EF for each SVOC/POM target analyte found. This value was the largest EF obtained for that analyte across all of the plumes sampled in that phase of the study. Even if the analyte was found in only one plume, it was reported as if it was a representative emission product for that test material. The Army did not provide information on the total number of plumes in which the analyte was detected for the test material. If a target analyte was detected at a concentration that was either less than the MDL of the measurement system (1E-08 lb/lb NEW) or was less than the concentration found in the background air sample, the Army reported the result as BDL. Analytical results contained in the test report and background documents[6] show that most of the SVOC/POM found in the plume were also present in either the background air sample taken 1,000 feet above the test range or the soil samples taken at the detonation sites prior to the detonations. Thus, these EFs represent very conservative emission estimates.

There are three sources for the SVOCs/POMs found in detonation plumes:

- SVOCs/POMs, such as, 2, 4-dinitrotoluene, diphenylamine, 2-nitrodiphenylamine and dioctylphthalate that were added to the energetic material during the manufacturing process. Generally, these SVOCs/POMs are added either to modify the performance of the energetic material or to inhibit degradation and separation of the ingredients.

- SVOCs/POMs pulled into the plume with the soil and the ambient air during plume rise and dilution.

- SVOCs/POMs formed by the reaction of the small molecules and molecular fragments produced in the initial stages of the detonation or burn event.

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Since there was no information in the test report to indicate that any of the SVOC target analytes were present in the energetic test materials detonated, the SVOC emissions were evaluated on the assumption that none of the SVOCs/POMs detected in the plumes were in the test material. Based on the assumption, the following decisions were made about entering the SVOC/POM results in the Excel workbook.

- For the Comp B, RDX, Explosive D, and Suspended TNT detonations for which there were only one maximum EF value, the reported EF value was entered.

- For the surface TNT detonations for which there were sometimes two maximum EF values for each target analyte (one from the Phase A detonations and the other from the Phase C detonations), the following actions were taken:

  - When there were two numerical EF values, the average EF was included.

  - When one of the two EFs was a BDL entry, the BDL entry was replaced with 5E-09 lb/lb NEW (a value equal to ½ of the MDL) and the average of the two EFs was entered.

- A value of BDL (Below Detection Limit) was entered for the target analytes that were not detected in any detonation plume for that test material.

2.1.4.5 Energetics

For each test material, the Army reported a single, background-corrected EF for each energetic target analyte found. This value was the largest EF obtained for that analyte across all of the plumes sampled in that phase of the study. Even if the analyte was found in only one plume, it was reported as if it was a representative emission product for that test material. The Army did not provide information on the number of plumes in which the analyte was detected for the test material. When an energetic target analyte was detected at a concentration that was either less than the MDL of the measurement system (1E-09) or was less than the concentration found in the background air sample, the Army reported the test result as BDL. Analytical results contained in Appendix G of the report show that most of the energetic target analytes found in the plume were also present in soil samples taken at the detonation sites prior to the detonations. Thus, these EFs represent very conservative emission estimates.

The following decisions were made regarding entering the energetic emission test results in the Excel workbook:

TNT Surface Detonations: The average of the two maximum EF values for TNT (one from the Phase A detonations and the other from the Phase C detonations) was entered.

RDX and Explosive D and Suspended TNT Detonations:

- If the Army had reported a numerical EF for an energetic target analyte that was a possible emission product, the reported value was entered.

- If the Army had reported a BDL value for an energetic target analyte that was a possible emission product, the original MDL value (1E-09 lb/lb NEW) was converted to the

equivalent EFF MDL value (lb/lb energetic compound) and 1/2 of the resulting EFF value was entered. (The EFF MDL was calculated by multiplying the EF value by 2,000 lbs and then dividing the resulting value by the lbs of the energetic in the detonation pile.)

Comp B Detonations. The numerical EF value for TNT was entered as ND and the BDL EF value for RDX was entered as 5E-10 lb RDX / lb NEW. The TNT EF value was changed to ND based on the following analysis. First, Comp B is comprised of 60% RDX, 39% TNT, and 11% wax by weight, and RDX was not detected in any of the detonation plumes even though the MDL value (1E-09 lb RDX / lb NEW) was over 100 times less than the EF value reported for TNT. Second, RDX was not found in any of the soil samples collected before the Comp B detonations were initiated but TNT was detected. Third, RDX was not found in any of the soil samples collected in the ejecta pans, but TNT was detected. Fourth, if the Comp B did not detonate completely, RDX should have been present in the plumes and soil samples at levels above those found for TNT. Therefore, it was concluded that the TNT EF was an artifact produced by TNT contaminated soil that was present before the detonations were done.

For All Detonations: If a data set contained a numerical EF or a BDL value for an energetic compound that was not a possible emission product (because it was not in the detonation pile), the emissions result was entered as NA.

2.1.5 Emissions Test Data Quality Ratings Assigned to Each EF/EFF

With the exception of the PM-10 EFs, the EFs reported by the Army possessed the following characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology under conditions representative of real-world detonation processes. Second, the test reports contained detailed descriptions of the substances in the materials detonated. Third, the assumptions underlying the plume volume calculation were sound. Fourth, the test reports showed that all field testing and laboratory analysis activities were extensively and continuously audited by an independent DPG contractor and also by the EPA over the life of the project. Fifth, although the raw data sheets are no longer available, the report shows that they were used to construct the EFs presented in the test report. Sixth, the test reports showed that before the final report was issued, the raw data and the test results had been subjected to an extensive technical peer review by a widely respected set of scientists and a comprehensive audit by an EPA Region VIII contract chemist, who had not been involved in any part of the test program.

Based on these characteristics and the quality rating criteria recommendations in Section 4.4.2 of EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of B.

2.1.5.1 Inorganic and Volatile Organic Gases

The inorganic gases were subsequently upgraded to a quality rating of A based primarily on the following: the number of plume samples collected for each material, the close agreement between the test materials and the agreement of the test results with both detonation reaction theory and the work of Ornellas.[3]

2.1.5.2 Energetics and SVOCs/POMs

The EPA quality rating of B was retained. Although the environmentally conservative nature of the results and the high sensitivity of the measurement systems (1E-08 lb/lb NEW for SVOC / POM and 1E-09 lb/lb NEW for the energetic target analytes) could justify upgrading the rating to A, the lack of information on the number of times the analyte was detected could justify lowering the rating to C.

2.1.5.3 PM-10

The PM-10 results were assigned a rating of D for the following reasons. First, the results were calculated using a single plume volume. Second, the report noted that more than 85% of the PM-10 collected was soil and, because the soil at DPG is very powdery, the results may be very specific to DPG. Third, the PM-10 values were derived by assuming that most particles above PM-10 dropped out in the sampling probe/manifold, but the researchers reported that it was likely that a meaningful number of these deposited particles were re-entrained. Fourth, the researchers also noted that the wetness of the soil also influenced the quantity of soil entrained in the detonation plume.

2.1.6 Tabulation of the Emissions Data

The TNT emissions data are presented in Table 5 and the RDX, Comp B, and Explosive D emissions data are presented in Table 6. The quality rating factor assigned to each EF/EFF value are also presented in these tables. In these tables, EFF values derived by substituting a value equal to 1/2MDL for a BDL value are in italics.

Table 5 EFs & EFFs for the Detonation of TNT.

EP Category	CASRN	EP	Units	Reclaimed TNT (Surface)		Reclaimed TNT (Suspended)	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	7.2E+00	D	1.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	B	BDL	B
	522-43-0	1-Nitropryene		BDL	B	BDL	B
	51-28-5	2,4-Dinitrophenol		BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene		7.5E-08	B	BDL	B
	606-20-2	2,6-Dinitrotoluene		8.5E-09	B	BDL	B
	91-57-6	2-Methylnaphthalene		BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine		BDL	B	BDL	B
	122-39-4	Diphenylamine		BDL	B	BDL	B
	581-89-5	2-Nitronaphthalene		4.0E-08	B	BDL	B
	88-72-2	2-Nitrotoluene		BDL	B	BDL	B
	100-02-7	4-Nitrophenol		BDL	B	BDL	B
	99-99-0	4-Nitrotoluene		BDL	B	BDL	B
	56-55-3	Benz(a)anthracene		5.0E-08	B	3.2E-07	B
	50-32-8	Benz(a)pyrene		BDL	B	BDL	B
	132-64-9	Dibenzofuran		9.0E-08	B	1.9E-07	B
	91-20-3	Naphthalene		1.3E-06	B	1.8E-06	B
	98-95-3	Nitrobenzene		BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine		BDL	B	BDL	B
	85-01-8	Phenanthrene		BDL	B	BDL	B
	108-95-2	Phenol		1.0E-06	B	1.0E-06	B
	129-00-0	Pyrene		1.1E-07	B	1.9E-08	B
	110-86-1	Pyridine		BDL	B	BDL	B
Energetics	121-82-4	RDX	lb/lb Energetic	NA	NA	NA	NA
	118-96-7	TNT		1.4E-07	B	9.3E-08	B
	88-89-1	Picric acid		NA	NA	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	A	3.8E+00	A
	630-08-0	Carbon monoxide		1.5E-01	A	1.9E-02	A
	NA	Nitrogen Oxides	lb/lb N	1.8E-02	A	2.6E-02	A
VOCs	71-43-2	Benzene	lb/lb C	2.6E-04	B	1.7E-04	B
	74-82-8	Methane		4.1E-03	B	4.0E-03	B
	NA	TNMHC		4.9E-03	B	1.3E-02	B
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA
(a) MDL = 1.0E-08 lb/lb NEW							

Table 6. EFs & EFFs for the Detonation of RDX, Comp B and Explosive D.

EP Category	CASRN	EP	Units	Reclaimed Comp B		Reclaimed Explosive D		Reclaimed RDX	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM -10	lb/lb NEW	9.0E+00	D	1.1E+01	D	9.6E+00	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	5.9E-08	B	1.8E-08	B	5.0E-08	B
	522-43-0	1-Nitropryene		5.6E-08	B	1.1E-08	B	5.0E-08	B
	51-28-5	2,4-Dinitrophenol		BDL	B	BDL	B	BDL	B
	121-14-2	2,4-Dinitrotoluene		4.5E-07	B	5.9E-07	B	2.1E-07	B
	606-20-2	2,6-Dinitrotoluene		2.4E-08	B	8.0E-08	B	4.1E-08	B
	91-57-6	2-Methylnaphthalene		BDL	B	BDL	B	BDL	B
	119-75-5	2-Nitrodiphenylamine		7.2E-08	B	5.8E-08	B	3.4E-08	B
	122-39-4	Diphenylamine		6.6E-08	B	1.9E-08	B	3.1E-07	B
	581-89-5	2-Nitronaphthalene		8.6E-08	B	4.3E-08	B	4.9E-08	B
	88-72-2	2-Nitrotoluene		BDL	B	BDL	B	BDL	B
	100-02-7	4-Nitrophenol		BDL	B	BDL	B	BDL	B
	99-99-0	4-Nitrotoluene		BDL	B	BDL	B	BDL	B
	56-55-3	Benz(a)anthracene		BDL	B	1.9E-08	B	9.3E-08	B
	50-32-8	Benz(a)pyrene		1.4E-08	B	3.8E-08	B	1.4E-07	B
	132-64-9	Dibenzofuran		BDL	B	1.1E-07	B	2.0E-06	B
	91-20-3	Naphthalene		4.2E-07	B	6.3E-07	B	2.0E-07	B
	98-95-3	Nitrobenzene		BDL	B	BDL	B	BDL	B
	86-30-6	N-Nitrosodiphenylamine		3.6E-08	B	5.8E-08	B	BDL	B
	85-01-8	Phenanthrene		BDL	B	BDL	B	BDL	B
	108-95-2	Phenol		BDL	B	BDL	B	BDL	B
	129-00-0	Pyrene		2.1E-07	B	1.8E-07	B	2.2E-07	B
	110-86-1	Pyridine		BDL	B	BDL	B	BDL	B
Energetics	121-82-4	RDX	lb/lb Energetic	*8.3E-10*	B	NA	NA	2.0E-06	B
	118-96-7	TNT		ND	NA	NA	NA	NA	NA
	88-89-1	Picric acid		NA	NA	*5.0E-10*	A	NA	NA
Inorganic Gases	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	A	3.4E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide		1.2E-01	A	1.8E-01	A	2.0E-01	A
	NA	Nitrogen Oxides	lb/lb N	6.4E-03	A	9.6E-03	A	1.7E-03	A
VOCs	71-43-2	Benzene	lb/lb C	2.4E-05	B	3.8E-04	B	4.4E-04	B
	74-82-8	Methane		2.3E-03	B	2.6E-02	B	1.3E-03	B
	NA	TNMHC		4.7E-03	B	6.8E-03	B	8.4E-03	B
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA	NA	NA

(a) MDL = 1.0E-08 lb/lb NEW

2.1.7 Discussion of the DPG Open Range Detonation Test Results

Table 7 compares the emission results for the four materials and the two test conditions for emission products of environmental concern. As discussed below, Table 7 shows definitively that the DPG open range detonation test results conform to detonation reaction theory and to the results of

Ornellas. This latter point is particularly important because the quantities detonated at DPG were 32,000 times larger than the quantities detonated by Ornellas. That is, it shows that the quantity and composition of the energetic material detonated does not substantially influence the emission products which is consistent with detonation reaction theory.

2.1.7.1 Surface Detonation Results

The high explosives (HE) in the materials detonated were TNT, RDX, and Ammonium Picrate (Explosive D). Although the formulas, carbon and nitrogen content, and structures of these compounds differed markedly, the percentage of the original carbon and nitrogen that ended up in CO_2, CO, CH_4, and nitrogen oxides for each test material were very similar. For example, essentially all of the carbon was converted to carbon oxides, and less than 0.8% of the nitrogen was converted to nitrogen oxides.

Based on Ornellas' work and detonation reaction theory, the mass of benzene emitted would be much less than the mass of methane, which is indeed the case. Also, based on detonation reaction theory, SVOCs/POMs should not form in meaningful amounts and this was indeed the case. According to the test report, benzene was the predominant aromatic hydrocarbon emitted which is consistent with Ornellas' work and detonation reaction theory. Further, because benzene would be produced by the same reaction pathways as the SVOCs/POMs, the quantity of SVOCs/POMs present in the plume should be much less than that of benzene, which is indeed the case.

2.1.7.2 Comparison of the Surface and Above Ground TNT Detonation Results

A comparison of the CO and PM-10 emissions for the surface and above ground TNT detonations (Table 7) indicates that the presence of soil increased the particulate and CO emissions and reduced the CO_2 emissions considerably. However, the presence of soil did not seem to meaningfully influence the CO_2, NO_x, benzene or methane emissions. These results are fully consistent with detonation reaction theory. (NOTE – No conclusions can be drawn from the energetic and SVOC & POM emission factors presented in Table 7 because these values represent only the maximum emission factor measured for the emission product across all of the detonations in each of the two phases.)

2.1.7.3 Selected Summary Statistics for the DPG Open Detonation Emissions Characterization Study

Table 8 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev) and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

Table 8 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the preliminary quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory, and the

representativeness of the EF/EFF values to real-world detonation activities.

Table 7. Comparison of the Emissions Produced by Each Test Material.

EP	Units	Comp B	Explosive D	RDX	TNT Surface	TNT Suspended
Energetics						
RDX	lb/lb Energetic	8.3E-10	NA	2.0E-06	NA	NA
TNT		ND	NA	NA	1.4E-07	1.4E-07
Picric acid		NA	5.0E-10	NA	NA	NA
Particulates						
PM-10	lb/lb NEW	9.0E+00	1.1E+01	9.6E+00	7.2E+00	1.6E+00
VOCs						
Benzene	lb/lb C	2.4E-05	3.8E-04	4.4E-04	2.6E-04	1.7E-04
SVOCs and POMs						
Phenol	lb/lb NEW	BDL	BDL	BDL	1.0E-06	1.0E-06
Naphthalene		4.2E-07	6.3E-07	2.0E-07	1.3E-06	1.8E-06
Dibenzofuran		BDL	1.1E-07	2.0E-06	9.0E-08	1.9E-07
Benz(a)anthracene		BDL	1.9E-08	9.3E-08	5.0E-08	3.2E-07
Benz(a)pyrene		1.4E-08	3.8E-08	1.4E-07	BDL	BDL
2-Nitronaphthalene		8.6E-08	4.3E-08	4.9E-08	4.0E-08	BDL
2,6-Dinitrotoluene		2.4E-08	8.0E-08	4.1E-08	8.5E-09	BDL
1,3,5-Trinitrobenzene		5.9E-08	1.8E-08	5.0E-08	BDL	BDL
Diphenylamine		6.6E-08	1.9E-08	9.8E-08	BDL	BDL
N-Nitrosodiphenylamine		3.6E-08	5.8E-08	BDL	BDL	BDL
Pyrene		2.1E-07	1.8E-07	2.2E-07	1.1E-07	1.9E-08
1-Nitropryene		5.6E-08	1.1E-08	5.0E-08	BDL	BDL
2,4-Dinitrotoluene		4.5E-07	5.9E-07	2.1E-07	7.5E-08	BDL
2-Nitrodiphenylamine		7.2E-08	5.8E-08	3.4E-08	1.0E-09	BDL
Inorganic and Organic Gases						
%C in CO2	%C	94.5%	92.5%	93.2%	93.6%	101.6%
% C in CO	% C	5.1%	7.7%	9.1%	6.4%	0.8%
% C in Methane	% C	0.18%	1.97%	0.10%	0.30%	0.30%
% C in Benzene	% C	0.002%	0.035%	0.041%	0.024%	0.016%
% N in NOX	% N	0.20%	0.29%	0.05%	0.53%	0.78%

Table 8. Summary Statistics for the DPG Open Range OD EFs/EFFs.

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	5	1.1E+01	1.6E+00	9.0E+00	7.7E+00	3.6E+00	0.47	D
Inorganic Gases	Carbon Monoxide	lb/lb C	5	2.0E-01	1.9E-02	1.5E-01	1.3E-01	7.1E-02	0.53	A
	Carbon Dioxide	lb/lb C	5	3.8E+00	3.4E+00	3.5E+00	3.5E+00	1.8E-01	0.05	A
	Nitrogen Oxides	lb/lb N	5	2.6E-02	1.7E-03	9.6E-03	1.2E-02	9.4E-03	0.78	A
Energetics	Energetics	lb/lb Energetic	5	2.0E-06	5.0E-10	9.3E-08	4.5E-07	8.7E-07	1.95	C
SVOCs	SVOCs In Energetic	lb/lb SVOC	No Data							
	SVOCs Not In Energetic	lb/lb NEW	49	2.0E-06	8.5E-09	8.0E-08	2.8E-07	4.8E-07	1.71	B
VOCs	Benzene	lb/lb C	5	4.4E-04	2.4E-05	2.6E-04	2.5E-04	1.7E-04	0.65	B
	TNMHC	lb/lb C	5	1.3E-02	4.7E-03	6.8E-03	7.6E-03	3.6E-03	0.47	B

2.2 BangBox Detonation Emissions Data Sets

2.2.1 Test Description

The 25 sets of emission test results were produced by detonating 0.3 to 0.5 lb of bulk explosives and munitions in a detonation chamber (BangBox) at DPG between 1993 and 1997.[8, 9] BangBoxes are air-supported, rubber-coated hemispherical chambers, which sit on concrete pads (Figure 3). Each BangBox is divided into two sections: an inflatable, 32,900 ft^3, a 50-ft diameter hemispherical test chamber made from a flexible polyvinyl-coated polyester fabric, and a 17.8 x 7.1 x 8.1 ft building (airlock) with a plywood front and a wood frame covered with the same material as the BangBox. The test chamber is kept pressured at 0.17 inches of water pressure using two high-capacity blowers and a damper. Six fans spaced 60^0 apart circulate the air in the test chamber to produce a homogeneous pollutant mix that can be sampled with instruments in the chamber and the attached air lock.

Figure 3. External View of the BangBox at DPG

The bulk high explosive materials and the munitions were detonated while suspended 1.5 to 3 ft above the bottom of a 3.2 ft square by 3.2 ft deep steel-lined cavity in the center of the concrete floor of the BangBox and the bulk propellants were detonated sitting on a steel plate in the bottom of this cavity. Before the munitions were detonated, a cylindrical steel cage constructed of three offset rows of 2-in angle iron was placed over the detonation pit. This cage was approximately 10 ft in diameter and 10 ft high. (Spaces between the angle iron allowed the detonation gases to pass freely, but stopped the shrapnel.)

The test chamber was purged with air for at least 60 minutes (two to three air exchanges) between detonations, but no attempt was made to clean the surfaces of the BangBox. When the detonation was initiated, a known quantity of SF_6 was released into the chamber from a pressured cylinder located approximately 3 meters from the detonation. The concentration of the SF_6 was then measured periodically after the detonation was initiated. A separate, evacuated canister was used each time a sample was collected. The average SF_6 concentration measured was used to calculate the extent to which the emissions plume had been diluted (due to the chamber blowers) between the detonation and the completion of the sample collection activities. This dilution factor was used to correct the measured emission product concentrations to the concentrations that were present immediately after the detonation was initiated.

The plume characterization (measurement) systems used across the 25 BangBox tests are shown in Table 9. With the exception of the SF_6 and VOC samples, the samplers were operated from 10 to 15 minutes before the detonation until 30 to 40 minutes after the detonation. The SF_6 and VOC grab samples were collected at intervals starting approximately 5-minutes after the detonation was initiated, e. g., 5, 7, 11, 19 and 35 minutes.

The EPA's Office of Research and Development (ORD) provided technical assistance and quality assurance support to the DOD project officer when 23 of the emissions data sets were collected between 1993 and 1995 and issued a summary report on the results of these emission tests.[8] EPA was not involved with the collection of the remaining two data sets which involved the detonation of C3 and C4 rocket propellants in 1997.[9]

Generally, each set of emissions data represent the results from three detonation trials. With the exception of the continuous emissions monitor (CEM) data, replicate sampling trains were used for each target analyte. For the 23 materials detonated between 1993 and 1995, background samples for all target analytes were collected in the test chamber at the beginning of each test day. In the 1997 tests, the background samples were collected the day before the first propellant detonation experiment was conducted. In all of the BangBox tests, the background samples were collected and analyzed in a manner identical to the test samples and the results were used to correct the emission factors for any contribution the background air made to the measured emission factors. Seventy-four detonation plumes were sampled across the 25 sets of emissions test results. (NOTE - This approach assumes that the only background air species present in the plume are those present in the air before the detonation. It ignores species knocked off surfaces by the shock wave and turbulence produced in the detonation. Because these latter materials are not included in the background sample, they become part of the reported emissions.)

1 Table 9. Emissions Test Methods Used in the BangBox Studies.

Target Analyte / Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (Teco Model 42) [Sampling and Analysis]
SO_2	40 CFR 60, Appendix A, EPA Method 6C (Teco Model 43A) [Sampling and
HCl	Teco Model 15 HCl Continuous Emissions Monitor (No corresponding EPA test
HCl, Cl_2	40 CFR 60, Appendix A, EPA Method 26 [Sampling and Analysis]
TSP	40 CFR 50, Appendix B [Sampling and Analysis]
PM -10	40 CFR 50, Appendix J [Sampling and Analysis]
Metals	40 CFR 50, Appendix B [Sampling], 40 CFR 60, Appendix A, EPA Method 29
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOCs/ POMs	EPA Method TO - 13 - Determination of Polycyclic Aromatic Hydrocarbons in Ambient Air Using GC/MS [Sampling and Analysis]
Energetics	EPA Method TO - 13 [Sampling] with analysis by Supercritical Fluid Chromatography/MS (SFC/MS)
PCDDs/ PCDFs	EPA Method TO - 9 - Determination of Polychlorinated, Polybrominated and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air [Sampling], EPA - SW - 846 Method 8290 [Analysis]
CO, CO_2 (Primary Sampling System for CO & CO_2)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)
SF_6	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography/Electron Capture Detection (ECD)

2.2.2 Description of the Test Materials and Detonation Piles

The air emissions from 25 energetic materials were characterized in the DPG BangBox between 1993 and 1997. The three standard components of detonation piles were characterized, i.e., demolition charge, bulk (donor) explosive and munition/munition part (cased energetic materials). The compositions of these test materials and the conditions under which they were detonated are described below under each category. For unknown reasons, in some cases a surrogate test material that was prepared on site was detonated instead of the actual bulk explosive.

The composition data were taken from the EPA report and from MIDAS. In the few cases where there was a conflict between MIDAS and the description in the EPA report, the EPA information was used. (When the BangBox emissions characterization tests were conducted, MIDAS was not available to the project personnel. Because most of the composition data was available only in hard copy and was mostly confined to the major components of the test material, it was very difficult for the project personnel to obtain accurate or detailed information on most of the minor constituents present in the test materials. This was particularly true for cased munitions.)

2.2.2.1 Demolition Charges (Detonation Initiating Charges) and Detonation Initiation Train

Detonation Initiation Charge (DIC). This initiating charge, which was comprised of a block of C4 and one EBC, was used to initiate the detonations of the 20mm and 40mm HEI rounds. The 20mm rounds were detonated using a 60 g block of C4 and the 40mm round was detonated using a 40 g block of C4. Because the DIC was not detonated as a standalone item, there are no emissions data specific to this item.

Detonation Initiation Train (DIT). This item was called the *Detonation Train* in the EPA report. It was used to initiate the detonation of the impulse cartridges and flares described in Section 2.2.2.3 below, and a scaled down version was used to initiate the detonation of the bomb fuzes that are also described in Section 2.2.2.3. Three, single-detonation trials were conducted using two DITs in each trial. Each DIT contained 57 g C4, 32 g detonation cord (PETN), and an EBC. The C4 was in the form of blocks approximately 7.7 x 2.5 x 2.5 cm, and the detonation cord was cut into three meter lengths and coiled around the polyethylene-wrapped C4. The two DITs were tied together with 16 gauge iron wire, wired in parallel to the firing line, and detonated above the floor of the detonation pit. The total NEW used in each detonation was 190 g. The purpose of the standalone detonation of this item was to obtain emission data that could be used to adjust the emissions data sets from the fuzes, impulse cartridges and flares for the contribution of the initiating charge. However, for unknown reasons, neither DOD nor EPA adjusted the emissions test results from the cased items for the contribution from the DIT.

2.2.2.2 Bulk (Donor) Energetic Test Materials

Flake TNT. Three single-detonation trials each using 226 g of flake TNT were conducted. An EBC and a 1 g block of C4 were used to initiate each detonation. The total NEW detonated was 227 g.

TNT Block. One single-detonation trial using three small blocks of TNT was conducted. The three TNT blocks (total NEW of 221 g) were tied together with 16-gauge iron wire, wrapped with 1.9 g of polyethylene sheeting and detonated (using an EBC inserted in the bottom of the assembly). The total NEW detonated was 227 g. This was an Operational Readiness Test (ORI).

Surrogate Composition B. Three single-detonation trials were conducted using 227 g quantities of Composition B in a half-gallon polyethylene food storage bag tied off with cotton cord. The Composition B was prepared on-site by mixing TNT powder (obtained by crushing a TNT block) with C4 to produce a material containing 128 g RDX, 86.3 g TNT and 12.7 g of mineral oil/polyisobutylene (from the C4). An EBC and a 6.4 g block of C4 were used to initiate each detonation. The total NEW detonated was 235 g.

Surrogate HBX. HBX is an aluminized form of Composition B. Three single-detonation trials were conducted using 227 g quantities of the surrogate HBX material contained in a half-gallon polyethylene food storage bag tied off with cotton cord bag. The HBX surrogate was prepared on-site by mixing aluminum powder with Composition B surrogate. The energetic composition of the HBX surrogate detonated consisted of 109 g RDX, 72 g TNT, 7.8 g mineral oil/ polyisobutylene, and 38.5 g Al. An EBC was used to initiate the detonation. The total NEW of the material detonated was 235 g.

*Surrogate Tritona*l. Tritonal contains 80% TNT and 20% finely powdered aluminum by weight. The surrogate was prepared on-site using crushed TNT block and aluminum powder. These components were placed in a jar and mixed until the mixture appeared to be homogeneous. This mix contained 1274 g TNT and 431 g Al. Three, 227 g portions of this mix were placed in a half-gallon polyethylene food storage bag and the bags closed with cotton string. One bag was used in each detonation. The following two detonation configurations were evaluated.

- *Unsuppressed Tritonal Detonation*. The bag was suspended approximately 3.2 ft above the concrete floor of the Bang Box. Three single-detonation trials were done. In the first two trials, a single M6 EBC was used to initiate the detonation and in the last detonation the EBC was inserted into a 6.5 g block of C4. The NEW of the material detonated in the three detonations was 229 g for the first two detonations and 235 g for the last detonation.

- *Water-Suppressed Tritonal Detona*tion. Soil-cover and below ground (buried) detonations are frequently used in the U.S. to mitigate the sound and blast waves released when military energetic materials are destroyed by detonation. Water-suppressed detonations were done primarily to assess how detonating a severely oxygen-negative energetic under a soil cover could change the emission products compared to detonating the same weight of the energetic material on the ground. (Tritonal was selected for this experiment because it contains only 20% of the oxygen required to convert all its carbon to CO_2 and H_2O.) Three water-suppressed tritonal detonations were done using 227 g of tritonal surrogate, 1,362 g of water, a 6.5 g block of C4, and an EBC. For the first two detonations, the tritonal was in contact with three quart-size food storage bags, each containing 1 lb of water. (The four bags (3 water, 1 tritonal) were placed in a half-gallon food storage plastic bag which was tied off with cotton string such that the water bags remained in contact with the tritonal-containing bag.). In the third detonation, 3 lb (1,362 g) of water was divided equally among five quart-size polyethylene food storage bags. (This was done to increase the tritonal surface area covered by the water.) In this latter detonation, three of the water bags were in the same plane as the tritonal bag, one was on top and the last was underneath. The five bags were held in a half-gallon polyethylene bag which was tied with cotton string to keep the water bags in contact with the tritonal bag. The total NEW detonated in each trial was 235 g.

*Tritonal with 2.5% Calcium Stearat*e. The calcium stearate served as a surrogate for the organic materials associated with tritonal when it is steamed out of 750 lb bombs. Three single-detonation trials were done. The material detonated was contained in half-gallon size polyethylene bags in a manner identical to the tritonal surrogate detonations. Each bag contained 216 g of the tritonal surrogate mix

described above and 11 g of calcium stearate. An EBC and 6.4 g block of C4 were used to initiate each detonation. The total NEW of the material detonated was 226 g.

*Surrogate Amato*l. Amatol contains 50% TNT and 50% ammonium nitrate (AN) by weight. The surrogate was prepared on-site by mixing crushed TNT blocks with AN powder in a manner similar to that used to prepare the tritonal. In each detonation trial, 227 g of the amatol mixture were detonated using an EBC and a 6.4 g block of C4 to initiate the detonation. Two detonation configurations were evaluated.

- *Unsuppressed Amatol Detonation*. Three single-detonation trials were conducted with the amatol using 227 g of the amatol. The amatol surrogate was placed in a half-gallon polyethylene food storage bag and detonated in the same manner as used for the tritonal detonations described above. The total NEW of the material detonated in each trial was 235 g.

- *Water-Suppressed Amatol Detonation*. Soil-cover and below ground (buried) detonations are frequently used in the U.S. to mitigate the sound and blast waves released when military energetic materials are destroyed by detonation. Water - suppressed detonations were done primarily to assess how detonating an oxygen-balanced energetic under a soil cover could change the emission products compared to detonating the same weight of the energetic material on the ground. (Amatol was selected for this experiment because it contains sufficient oxygen to convert all of its C and H to CO_2 and H_2O.) Three 227 g detonations of amatol were conducted. In each detonation, the bag containing the amatol was surrounded with five quart-size bags, each containing 0.6 lb of water. The five water bags were distributed around the amatol surrogate bag in a manner similar to that used for the third water-suppressed tritonal detonation described above. The total NEW detonated was 235 g.

C4 Propellant. C4 is a rocket propellant comprised primarily aluminum, ammonium perchlorate, nitroglycerin and nitrocellulose. Three, single-detonation trials were conducted using a 225 g cube of the propellant. An M130 EBC inserted into the cube was used to detonate it. When the cubes detonated, the shock wave cut a hole in the 12 mm thick steel plate on the floor of the pit in which the propellant cube sat. The exact composition of the propellant is classified.

C3 Propellant. C3 is a rocket propellant comprised of aluminum, ammonium perchlorate (AP), nitroglycerin (NG), and nitrocellulose (NC). Four single-detonation trials were conducted using a 225 g cube of the propellant. A M130 EBC inserted into the cube was used to detonate it. When the cube detonated, the shock wave cut a hole in the 12 mm thick steel plate on the floor of the pit in which the propellant cube sat. The exact energetic composition of the propellant is classified.

2.2.2.3 Cased Test Items

2.2.2.3.1 Canon Rounds

20mm HEI Cartridge M56A4 (NSN: 1305-01-118-9928). Three single-detonation trials were conducted. For each detonation, three, 20mm [brass] cartridges were placed on a 60 g block of C4 and tied in place with 16-gauge iron wire. Each cartridge contained 8.8 g RDX, 0.43 g HMX (explosive charge), 30.4 g NC, 3.7 g NG, 0.2 g lead, 0.44 g chromium, 93.1 g copper, 37.3 g zinc, 0.13 g aluminum, 67.3 g iron, 0.078 g cadmium, and 0.076 g of barium. An EBC inserted into the C4 block was used to initiate each detonation. The total NEW detonated in each trial was 189 g.

40mm HEI Cartridge, M384 (NSN: 1310-00-039-1254). Three single-detonation trials were conducted. For each detonation, two 40mm aluminum alloy cartridges were placed on a 40 g block of C4 and tied in place with 16-gauge iron wire. Each cartridge contained 54.4 g of RDX, 3.5 g NC, 0.9 g NG, 112 g aluminum, 24.4 g copper, 1.2 g zinc, 0.04 g lead, 109 g iron, 0.72 g chromium and 0.03 g barium. An EBC inserted into the C4 block was used to initiate each detonation. The NEW detonated in each trial was 158 g.

2.2.2.3.2 Impulse Cartridges

Cartridge, Impulse, Mod O, ARD446- (NSN: 1377-00-516-9924). This item has a NEW of 12.5 g. Three single-detonation trials were conducted. In each trial, ten aluminum alloy cartridges were tied to a 57 g block of C4 using 32 g of detonation cord and the suspended assembly was detonated using an EBC. The NEW of the assembly was 216 g. Each cartridge contained 20 g of aluminum, 0.63 g of copper, 0.29 g of zinc, 0.214 g lead, and approximately 5.8 g of smokeless powder.

Cartridge, Impulse, BBU 36B (NSN: 1377-01-037-8650). This item deploys chaff from aircraft and contains a pyrotechnic filler which readily burns when initiated. Each aluminum alloy cartridge has a NEW of 0.88 g. Three single-detonation trials were conducted. Sixty cartridges were used in each of the detonations: 42 cartridges were clustered around a 57 g block of C4, and 18 cartridges were placed on the sides of a 0.5 m length of detonation cord, which had been folded into a 0.25 m length. In trial 1, the two assemblies were hung separately with one end of the detonation cord inserted in the block of C4, and an EBC was used to detonate the C4. In trials 2 and 3, the C4 and detonation cord assemblies were bound together using 16 gauge iron wire. The NEW of the assemblies detonated was 144 g. Each cartridge contained 38 g of powdered boron, 0.15 g of potassium nitrate, 5.2 g aluminum, 0.38 g chromium, 0.3 g copper, 0.02 g lead, 0.016 g zinc. 0.6 g NC and 0.7 g NG.

Cartridge, Impulse, MK107, Mod 01 (NSN: 1377-00-779-2601). This cartridge has a NEW of 24.5 g. Three single-detonation trials were conducted. For each detonation, five steel cartridges were placed around a 57 g block of C4. They were parallel to each other, but alternated tip to base. This assembly was wrapped with 32 g of detonation cord and detonated suspended above the detonation pit using an EBC. The NEW of each assembly was 208 g. The energetic composition of the MK107 cartridge is 16 g NC, 4.1 g NG, 1 g barium nitrate, 0.2 g of potassium nitrate, 71.7 g iron, 19.3 g chromium, 0.025 g lead and a classified amount of aluminum.

2.2.2.3.3 Flares

Flare, Countermeasure, Aircraft, M206 (NSN:1370-01-048-2138). This flare is used to decoy heat-seeking missiles away from aircraft. Each flare has a NEW of 150.2 g and contains 102 g magnesium powder, 1 g potassium nitrate, 5 g NC, 1.4 g potassium perchlorate, 13 g rubber, 0.4 g chromium, 49 g aluminum, 0.18 g zinc and 0.24 g barium. Three single detonation, single flare trials were conducted The flare was prepared for detonation as follows. A 57 g block of C4 was cut in half lengthwise, and the two halves placed on the long axis of the flare such that the two halves remained in contact. This assembly was wrapped in polyethylene sheeting, and then 32 g of detonation cord was wrapped around the assembly starting at the end opposite the C4. The plastic plug in the forward end of the flare was left in place. An EBC was used to detonate the final assembly while it was suspended 1.5 ft above the floor of the detonation pit. The total NEW of the final assembly was 241 g.

Signal, Illumination, Aircraft, Red Star M43A2 (NSN: 1370-00-618-5790). This aluminum alloy-encased flare has a NEW of 56.8 g with 56.6 g of this NEW in the illuminating charge. The illuminating charge contains 10.2 g magnesium powder, 13.6 g potassium perchlorate, 24.9 g strontium nitrate, 4 g asphaltum, 0.02 g barium, 0.02 g lead, 0.36 g zinc and 0.8 g of copper. The aluminum casing weighs 45.4 g. Three single detonation trials using three flares (and their bandoliers) per detonation were conducted. The three flares were tied to a 57 g block of C4, which was then wrapped in polyethylene sheeting. Thirty-two g of detonation cord was then wrapped around this assembly and secured with 16-gauge iron wire. An EBC was used to detonate the final assembly while it was suspended 1.5 ft above the floor of the detonation pit. The NEW of each assembly detonated was 260 g.

Signal, Illumination, Ground, Red Star, M158 (NSN: 1370-00-490-7363). This flare is housed in an cylindrical aluminum alloy casing with a steel liner. It has a NEW of 36.8 g and contains 177 g aluminum, 19.9 g chromium, 1.5 g copper, 0.5 g zinc, 0.016 g lead, 102 g iron, 7 g strontium nitrate and 0.03 g barium nitrate and 27 g potassium nitrate. Three single detonation trials using four flares (and their bandoliers) per detonation were conducted. Two flares were placed on one side of a 57 g block of C4 and two were placed on the opposite side and the assembly was wrapped in polyethylene sheeting and detonated employing a procedure similar to that used for the M43A2 flares. The NEW of each assembly was 239 g. A portion of the energetic composition of the item is classified.

2.2.2.3.4 Fuzes

Fuze, Tail Bomb, Fuze Mechanical Unit, 139A/B (NSN: 1325-01-214-7311). This fuze contains 131 g of Tetryl. Three single detonation, single fuze trials were conducted. Each fuze was prepared for detonation as follows. A 28.5 g block of C4 was taped to the side of the fuze near its main explosive charge and the assembly wrapped in polyethylene sheeting. Sixteen g of detonation cord was then wrapped around the fuze and the fuze was screwed onto a threaded shaft. (The opposite end of the shaft was attached to a 1.9 cm thick by 30.5 cm diameter steel plate. The purpose of the steel plate was to break up any focused blast effect resulting from the detonation.) The fuze was detonated 0.5 m above the floor of the detonation pit using an EBC. The total NEW of the each assembly detonated was 177 g. Each fuze also contained 2.9 g lead, 139 g aluminum, 25 g chromium, 31.7 g copper, 610 g iron and 13.8 g zinc.

Fuze, Tail Bomb, Fuze Mechanical Unit FMU-54A/B (NSN: 1325-00-613-0484). This fuze contains 163 g of Tetryl. Three single detonation, single fuze trials were conducted. Each fuze was prepared for detonation as follows. A 28.5 g block of C4 was taped to the side of the fuze near its main explosive charge and the assembly wrapped in polyethylene sheeting. Sixteen g of detonation cord was then wrapped around the fuze and the fuze was screwed onto a threaded shaft. (The opposite end of the shaft was attached to a 1.9 cm thick by 30.5 cm diameter steel plate. The purpose of the steel plate was to break up any focused blast effect resulting from the detonation.) The fuze was detonated 0.5 m above the floor of the detonation pit using an EBC. The NEW detonated was 209 g. Each fuze also contained 0.09 g lead, 11.6 g copper, 108 g iron, 25 g aluminum, and 5.7 g zinc. (Note - 0.086 g of the lead is in alloy form and other 0.004 g of Pb is in the energetic)

2.2.2.3.5 Miscellaneous Cased Items

Generator, Gas Pressure, Propellant Actuated, GCU-2/A (NSN 1336-00-420-2980). This item, which is used in the Minuteman missile, has a NEW of 95.3 g. Its composition is classified. Three single detonation, single item detonation trials were conducted The gas generator was prepared for detonation by removing the outer metal jacket to expose the solid propellant which is cast as a short hollow cylinder.

Twenty-eight and a half grams of C4 was packed into the hollow cylinder and wrapped in polyethylene sheeting. This assembly was then wrapped with 1.5 meters of detonation cord, and the gas generator's plastic shipping plug was taped on top of the detonation cord. The gas generator was then oriented with its steel plug facing into the detonation pit and detonated with an EBC. The NEW of each assembly detonated was 139 g.

M18A1 (Claymore) Antipersonnel Mine (NSN: 1345-00-710-6964). Three single-detonation, single-mine trials were conducted. The NEW detonated in each trial was 227 g. Because the mine contained 681 g of C4, it was necessary to remove 454 g of the C4 before detonating it in the BangBox, which has a detonation NEW limit of approximately 230 g. The mine was opened and the seven hundred 22-caliber steel balls and 454 g of C4 were removed from the 360 g of fiberglass resin casing. The case was a composite of fiberglass and a polystyrene/polybutadiene resin. The mine was suspended in the detonation pit, an EBC inserted in the 227 g of C4 remaining and the mine was detonated. The mine also contained 1.67 g of lead (0.43 g of the Pb in the energetic and 1.24 g in alloys), 513 g copper, 20 g aluminum and 38.2 g dioctyl sebacate.

Adapter-Booster, T45E7 (NSN: 1325-00-827-3851). Three single-detonation, single-adapter-booster trials were conducted. The adapter-booster contained 73 g of Tetryl, a booster pellet, and a hollow bursted well which was closed with a 980 g steel plug and housed in a 440 g steel cylinder 17.3 cm long and 7.2 cm in diameter. It also contained two 7.5 g pressed wool wafers (to protect the booster casing), 2.9 g chromium, 1.2 g copper, 412 g aluminum, 2.0 g cadmium, 4.1 g zinc, and approximately 2 g of lead (in lead chromate). To reduce the chance for the blast pulse to become focused, a steel wool plug was placed in the large end of the burster well and the end was closed with a 31 g plastic plug. A 1.6 cm diameter x 25 cm long steel rod was screwed into the fuze well and a 2.5 cm thick x 23 cm diameter steel disk was fastened to the other end of the rod. This assembly was suspended horizontally in the detonation pit. A 10 g charge of C4 with an EBC initiated the detonation. However, significant focusing of the blast still occurred because: (1) a hole was punched through the steel plate lining of the pit; and (2) the paper on the fiberglass insulation behind the steel plate and portions of the wood witness shield approximately three meters from the pit were charred. The NEW detonated was 83 g.

2.2.3 Identification of BangBox Data Sets That Should Be Rejected In Their Entirety

The following data sets were judge unsuitable for inclusion in AP-42 for the reasons given.

TNT Block Detonation. This data set was rejected for the following reasons. First, it was comprised of only one detonation. Second, it was an operational readiness test (ORI). Third, there was another BangBox TNT detonation emissions data set available (Flake TNT) that involved three detonation trials, and there were also emissions test results for the detonation of TNT on the open range at DPG.[6, 7]

GCU-2/A Gas Pressure Generator Detonation. This data set was rejected because the composition of the test item is classified, so the accuracy and representativeness of the test results could not be determined.

Adapter-Booster, T45E7 Detonation. The test report noted that significant focusing of the blast had occurred because: (1) a hole was punched through the steel plate lining of the pit, and (2) the paper on the fiberglass insulation behind the steel plate and the top of the wood witness shield approximately 3 meters above the pit were charred. Therefore, the carbon oxide, VOC, SVOC/POM and metals emissions data was suspect.

C3 and C4 Propellant Detonations. This data set was rejected for the following reasons. First, it was the first detonation conducted in 25 months in the BangBox, and the floor was known to be a source of particulate, SVOCs/POMs, and metals. (The BangBox was kept continually inflated using a blower during this 25-month period.) Second, the exact compositions of the propellants are partially classified, so the accuracy and representativeness of the test results can not be determined. Third, the detonation experiments were designed around one specific disposal site, and it was doubtful that the data sets could be applied to other sites. Fourth, there was no evidence to show that the test results were reviewed or evaluated by a disinterested third part and the raw data sheets are no longer available. Fifth, the detonations burned holes in the steel plate on which the propellant rested, and some of the plate material entered the plume. Sixth, the sampling results had been corrected for background air concentrations using background air samples collected one and two days before the propellants were detonated, and the EPA report[7] showed that these concentrations sometimes changed markedly between days.

Water-Suppressed Amatol and Tritonal Detonations. The emissions test results were excluded because real-world detonations are not done under a water-blanket. However, because these test results do provide insight into how suppressing the formation of the fireball affects the emissions from detonations, it was decided to include the results in Appendix A (Effect of Confinement on the Emissions from Detonations).

2.2.4 Identification of BangBox Test Results Suitable for Inclusion in AP-42

The remaining 20 data sets had been produced in five studies that had been funded by different DOD units and had been conducted for a variety of reasons. After three DOD contractors had failed to accomplish the task, the EPA compiled the emissions data sets from these studies into a validated emission factors data base.[8] During its validation effort, EPA consulted the background information that was available on the emissions tests, including test design plans, final reports, field notes, calibration data, laboratory reports, and EPA and DOD contractor QA and QC reports.

Because it had provided independent QA support to these studies and because of its knowledge of the requirements for EF databases, EPA had a good understanding of the issues that needed to be addressed during its data assessment and validation effort if it was to produce a credible, validated database. For example, EPA selected only emissions data that had been collected using methods that would have produced credible and comparable data. EPA also provided a set of minimum quantitation limits (MQLs, expressed as the equivalent emission factor) for each measurement system. In addition, EPA conducted mass balance checks on the carbon, nitrogen and aluminum containing emission products to confirm that the results adhered to detonation reaction theory and to previous laboratory-based emissions characterization tests on energetic materials. Further, because most of the detonation emission products were commonly occurring air pollutants that were present in the background air samples, EPA assessed and provided information in the report on the extent to which the emission factors had been corrected for background.

Some of the conventions and procedures used by EPA in assessing and reporting the emissions test results that are pertinent to this review are:

- If the background corrected EF for a detonation trial was less than or equal to 0.0E+00, EPA reported the EF as 0.0E+00.

- If the emissions test report contained an EF that was less than the MDL of the

measurement system, EPA reported the EF as 0.0E+00.

- If the background corrected EF for an SVOC target analyte was less than 30% of the uncorrected EF, EPA reported the EF as 0.0E+00.

- In calculating the average EF for data sets containing a combination of 0.0E+00 and non-zero values, EPA did not include the 0.0E+00 values in the calculation.

- In order to conduct a statistical analysis of the data using its SAS program, EPA had to differentiate between instances where either no sample was collected (NS) or no data was available because the sampling result had been invalidated (NA) and instances where the target analyte was either never detected, or if detected, never detected above the background level (ND). Because the SAS program would not accept letter code entries, EPA substituted a period (.) for all NS and NA values and the value 0.0E+00 for all ND values.

2.2.4.1 Modifications Made to the EPA EFs to Conform to AP-42 Guidance

The following modifications were made to the metal, VOC and SVOC/POM EFs for the 20 data sets, so that they would conform to the EPA AP-42 guidance.

2.2.4.1.1 Volatile Organic Compounds

The EPA report contained numerical emission factors for 43 of the 160 plus individual VOC compounds on the BangBox target analyte list. According to the EPA report, these compounds were the only VOC target analytes measured above the background level in the emissions from at least one of the test materials. (The VOC target analytes that were either never detected or were never detected above the background level are identified in Table 10, VOC Target Analytes Not Detected in Any of the BangBox Detonation Plumes.)

EPA noted that one of the most vexing problems associated with characterizing the VOC air emissions from detonations was that most of the emission products are compounds that are commonly found in ambient air. This can be seen by examining the information in Table 11, which shows the average EF for the 43 VOCs detected in the detonation plumes along with: (1) the number of materials (N) for which the VOC was listed as an EP; (2) the number of materials for which the VOC was detected in all of the plumes; and (3) the percentage that the background air contributed to the plume concentration.

Table 10. VOC Target Analytes Not Detected in Any BangBox Detonation Plumes.

CASRN	Compound	CASRN	Compound	CASRN	Compound
7642-09-3	Cis-3-hexene	124-41-1	Dibromochloromethane	691-38-3	Cis-4-methyl-2-pentene
619-99-8	3-Ethylhexane	126-99-8	Chloroprene	71-23-8	1-Propanol
627-20-3	Cis-2-pentene	138-86-3	Methylcyclohexene	71-36-3	1-Butanol
79-09-4	Propanoic acid	141-32-2	Butyl acrylate	73513-42-5	Isohexane
83847-49-8	Bromochloromethane	141-93-5	m-Diethylbenzene	7359-72-0	Trans-1,3-trichloropropene
100-44-7	Benzyl chloride	156-60-5	Trans-1,2-dichloroethene	7443-70-1	Cis-2-octene
100-47-0	Benzonitrile	1634-04-4	Methyl t-butyl ether	74-83-9	Methyl Bromide
100-51-6	Benzyl alcohol	2198-23-4	4-Nonene	75-00-3	Chloroethane
100-52-7	Benzaldehyde	24-11-8	1-Nonene	75-05-8	Acetonitrile
10061-01-5	Cis-1,3-dichloropropene	25168-05-2	Chlorotoluenes	75-07-0	Acetaldehyde
103-65-1	N-propylbenzene	271-89-6	Benzofuran	75-25-2	Bromoform
104-51-8	N-butylbenzene	31394-54-4	Isoheptane	75-27-4	Bromodichloromethane
105-05-5	p-diethylbenzene	3522-94-9	2,2,5-trimethylhexane	75-34-3	1,1-Dichloroethane
106-42-3	p-Xylene	463-82-1	Neopentane	75-35-4	1,1-Dichloroethene
106-43-4	P-chlorotoluene	496-11-7	Indane	75-45-6	Chlorodifluoromethane
106-46-7	p-Dichlorobenzene	513-35-9	2-Methyl-2-butene	75-52-5	Nitromethane
107-02-8	Acrolein	526-73-8	1,2,3-Trimethylbenzene	75-69-4	Trichlorofluoromethane
107-05-1	Allyl Chloride	538-93-2	Isobutylbenzene	75-71-8	Dichlorodifluoromethane
107-06-2	1,2-Dichloroethane	540-59-2	Cis-1,2-dichloroethene	75-83-2	2,3-Dimethylbutane
1071-26-7	2,2-Dimethylheptane	540-84-1	2,2,4-trimethylpentane	760-21-4	2-Ethyl-1-butene
107-13-1	Acrylonitrile	541-73-1	m-Dichlorobenzene	763-29-1	2-Methyl-1-pentene
107-39-1	2,4,4-Trimethyl-l-pentene	563-45-1	3-Methyl-1-butene	7688-21-3	Cis-2-hexene
107-40-4	2,4,4-Trimethyl-2-pentene	563-46-2	2-Methyl-1-butene	78-87-5	1,2-Dichloropropane
107-85-5	2-Methylpentane	564-02-3	2,2,3-Trimethylpentane	78-93-3	2-Butanone
108-05-4	Vinyl acetate	565-59-3	2,3-Dimethylpentane	79-00-5	1,1,2-trichloroethane
108-08-7	2,4-Dimethylpentane	565-75-3	2,3,4-Trimethylpentane	79-01-6	Trichloroethene
108-10-1	Methylisobutylketone	584-94-1	2,3-Dimethylhexane	79-34-5	1,1,2,2-tetrachloroethane
108-38-3	m- Xylene	589-34-4	3-Methylhexane	821-95-4	1-Undecene
108-41-8	m-Chlorotoluene	589-81-1	3-Methylheptane	87-68-3	Hexachloro-1,3-butadiene
108-67-8	1,3,5-trimethylbenzene	590-18-1	cis-2-Butene	9003-31-0	Isoprene
108-90-7	Chlorobenzene	592-13-2	2,5-Dimethylhexane	922-62-3	Cis-3-methyl-2-pentene
110-00-9	Furan	592-27-8	2-Methylheptane	92-52-4	Biphenyl
110-62-3	Pentanal	592-76-7	1-Heptene	95-13-6.	Indene
110-83-8	Cyclohexene	60-29-7	Diethyl ether	95-47-6	o-Xylene
NA	4-methyl-2-pentanone	611-14-3	o-Ethyltoluene	95-49-8	o-Chlorotoluene
111-66-0	1-Octene	624-91-9	Methylnitrite	95-50-1	o-Dichlorobenzene
111-71-7	Heptanal	625-27-4	2-Methyl-2-pentene	95-63-6	1,2,4-Trimethylbenzene
1120-21-4	N-undecane	64-17-5	Ethanol	96-14-0	3-Methylpentane
1120-72-5	Methylcyclopentene	64-19-7	Acetic Acid	98-01-1	2-Furaldehyde
112-31-2	Decanal	66-25-1	Hexanal	98-06-6	Tert-butylbenzene
120-82-1	1,2,4-Trichlorobenzene	6747-26-2	2,2,4-Trimethylhexane	98-82-8	Isopropylbenzene
121-14-2	1,3-Dinitrobenzene	674-76-0	Trans-4-methyl-2-pentene	98-86-2	Acetophenone
123-72-8	Butyraldehyde	67-63-0	2-Propanol	99-65-0	1,3-Dinitrobenzene
123-91-1	1,4-Dioxane	67-64-1	Acetone	99-87-8	p-Isopropyltoluene
124-13-0	Octanal	68037-01-4	1-Decene		
124-19-6	Nonanal	691-37-2	4-Methyl-1-pentene		

Table 11. Average EF and Background Correction for the VOC Compounds.

EP Class	Pollutant	Background-Corrected Average EF	% Background Contributed to Uncorrected Average EF	Detected in the Plumes for N Materials	Detected in All Plumes for N Materials
Aromatic HC	Benzene	9.4E-05	24%	20	19
	Styrene	8.5E-05	8%	15	13
	Toluene	3.3E-05	58%	20	17
	p-Ethyltoluene	6.1E-06	63%	17	1
	Ethylbenzene	4.5E-06	63%	20	15
	m-Ethyltoluene	9.1E-07	74%	15	6
	i-Propylbenzene	4.0E-07	34%	6	1
Chlorinated HC	Methylenechloride	2.5E-04	48%	20	15
	Allylchloride	9.6E-06	0%	8	8
	Tetrachloroethylene	3.3E-06	40%	8	6
	Vinyl chloride	2.5E-06	0%	10	6
	Methyl chloride	2.1E-06	33%	17	14
	Methyl chloroform	1.1E-06	86%	6	3
	Carbon tetrachloride	8.8E-07	80%	10	5
	Ethyl chloride	3.7E-07	0%	3	2
	Chloroform	1.6E-07	64%	5	2
Saturated HC	Ethane	6.5E-05	50%	20	11
	Propane	1.4E-05	52%	20	16
	n-Butane	4.9E-06	58%	18	13
	n-Pentane	3.2E-06	68%	19	9
	n-Hexane	2.4E-06	63%	18	13
	Methylcyclohexane	2.3E-06	49%	14	7
	Methylcyclopentane	2.1E-06	48%	20	7
	i-Pentane	2.1E-06	66%	14	1
	n-Heptane	1.8E-06	62%	19	14
	n-Octane	1.8E-06	54%	19	7
	n-Decane	1.5E-06	55%	17	10
	i-Butane	1.2E-06	52%	18	9
	n-Nonane	9.5E-07	47%	17	8
	Cyclohexane	7.1E-07	60%	9	2
	Cyclopentane	4.6E-07	42%	10	3
Unsaturated HC	Acetylene	4.2E-04	12%	20	20
	Ethylene	2.7E-04	11%	20	20
	Propylene	5.7E-05	12%	20	20
	1-Butene	1.7E-05	0%	20	15
	1-Hexene	1.1E-05	5%	21	21
	i-Butene	9.1E-06	2%	17	13
	trans-2-Butene	9.0E-06	1%	19	18
	1-Pentene	7.5E-06	10%	20	19
	1,3-Butadiene	7.2E-06	2%	19	19
	Cyclopentene	1.9E-06	0%	18	8
	trans-2-Pentene	1.5E-06	28%	16	10
	cis-2-Pentene	9.3E-07	25%	15	11

Based on the information in the EPA report and the information in Table 11 the following modifications were made to the original EFs to ensure that the VOC EFs conform to the EPA guidance before they were entered in the AP-42 Excel workbook.

- If the average EF value for a test material had been derived from a data set that included only non-zero numeric values, the EF value was converted to the corresponding EFF value and the EFF value entered. (The EF value (lb/lb NEW) was converted to the equivalent EFF value (lb/lb C) by multiplying the EF value by the NEW detonated and then dividing by the lb of C in the detonation pile.)

- If the average EF for a test material had been derived from a data set containing a mix of 0.0E+00 and non-zero numeric values, the 0.0E+00 value was replaced with a value of 7.1E-08 lb/ lb NEW (1/2 the MDL) and the new average was calculated. This value was then converted to the equivalent EFF value and the EFF value was entered.

- If the EF for a test material was 0.0E+00 for all detonation trials, the 0.0E+00 value was changed to BDL.

- If one of the 43 VOC analytes was a target analyte in a test, but no sampling result was reported, the letter code ND was entered in the AP-42 workbook.

2.2.4.1.2 Metals

Although EPA noted that the location and chemical form of the metal influenced the quantity of the metal released into the plume, it did not provide information on the location and chemical form of most of the metals in the test materials. Therefore, it was decided to enter the metal emissions data under the following categories whenever the information on the location and form of the metal was available from MIDAS or the EPA report: *Metals in Alloy*, *Metals in Energetic as Particle*, *Metals in Energetic as Compound* and *Metals in Protective Coating*.

The EPA report contained EFs for the following nine metals: Al, Sb, Ba, Cu, Cd, Cr, Pb, Ti and Zn. (NOTE – Although some of the test materials contained alkali and alkaline earth metals, these metals were not target analytes in these studies.) In the report EPA noted that many of the metals found in the plume samples were likely metal-containing soil particles and residues (from prior detonations and burns) lifted into the plume from the concrete floor of the BangBox by turbulence from the detonation. Therefore, they were not actual emission products from the material detonated. EPA made this observation based on the many instances where metal emission factors about 1E-04 lb/ lb NEW had been produced when metal-free energetic materials had been detonated.

EPA attempted to remove some of the positive bias in the metal emissions data by calculating an EF- correction factor for the following five metals (Al, Ba, Cu, Pb and Zn) for which it felt it had sufficient data points to develop a correction factor. This *floor-residue* correction factor was calculated using the EFs from materials that EPA believed did not contain the metal. EPA calculated the following average correction factor (expressed as an emission factor) for each metal: Al (7.2E-04 lb/ NEW), Ba (3.7E-04 lb/NEW), Cu (4.8E-04 lb/NEW), Pb (5.9E-04 lb/NEW), and Zn (3.8E-04 lb/NEW). EPA then subtracted these correction factors (along with the results from the background sample collected that day) from the individual detonation trial emission factors measured for materials known to or suspected to contain that metal and placed the results in the database. When this adjustment resulted in a negative emission factor,

1 EPA entered 0.0E+00 in the database.

While this correction was probably appropriate for Ba and Zn, it was not appropriate for Al, Cu and Pb because, unbeknownst to the EPA authors, the EBCs used to initiate each BangBox detonation contained 0.74 g of Al, 25.6 g of Cu and 0.19 g of Pb (as lead azide). In an attempt to reverse the inappropriate correction for Al, Cu and Pb made by EPA, the following actions were taken regarding these three metals:

- If the average EPA EF for a material was greater than 0.0E+00, the EPA correction factor was added to the EF and the EPA value was replaced with the new value.

- If the average EPA EF for a material was 0.0E+00, it was replaced with the letter code ND. (Simply entering the correction factor was not appropriate because the original value was unknown.)

The emission factors for Sb and Ti were rejected because there were only two non-zero emission factors for each metal and, according to MIDAS, these metals were not present in the materials with which the EFs were associated.

The following actions were taken regarding the remaining four metals (Ba, Cd, Cr and Zn):

- If the detonation pile did not contain the metal, and the EPA EF was equal to or greater than 0.0E+00, the EPA EF was replaced with the letter code NA.

- If the detonation pile contained the metal, and the EPA EF was:

    - Greater than 0.0E+00, the EPA EF was not changed.

    - Equal to 0.0E+00, the EPA value was replaced with one equal to ½ of the MDL value expressed as an EF, i.e., Ba = 1.1E-04 lb/NEW, Zn = 1.5E-04 lb/NEW, Cd = 6.5E-06 lb/NEW and Cr = 6.5E-06 lb/NEW.

2.2.4.1.3 Energetics

The EPA report contained a number of 0.0E+00 entries for some of the energetic compounds that MIDAS and/or the EPA report indicated were not present in the detonation pile, so therefore, the 0.0E+00 value was misleading. In addition, the EPA report also contained EFs greater than 0.0E+00 for energetic compounds that were not present in the detonation pile. To address these misleading EF values, the following actions were taken:

- If the energetic compound was present in the detonation pile, and the EPA report contained an EF greater than 0.0E+00, the EPA value was not changed.

- If the energetic compound was present in the detonation pile and the EPA report contained an EF of 0.0E+00, the EPA value was changed to BDL. (Because the BangBox MDL for the energetic plume measurement (1.5E-07 lb/ lb NEW) was 100 times higher than that for the system used in the DPG open range tests, it was not appropriate to change a BDL value to a value equal to 1/2MDL.[19])

- If the energetic compound was not present in the detonation pile (hence not a possible emission

product), and the EPA report contained an EF equal to or greater than 0.0E+00, the EPA value was replaced with the letter code NA

- If the EPA report indicated that either no sample was collected or that the sample collected was judged to be invalid by EPA or the DOD, the letter code NS was entered in the spreadsheet.

2.2.4.1.4 SVOC/POM

SVOC/POM samples were collected from the plumes for all of the test materials and analyzed for the SVOC/POMs target analytes listed in Table 12. Phthalates were the only SVOC target analytes detected in the plumes above the background level. Further, diethylphthalte was the only phthalate detected in all detonation trials for at least one of the test materials and it was the only SVOC/POM target analyte included in the EPA report. It was also detected at concentrations equivalent to EFs between 3.8E-04 and 1.8E−06 lb/ lb NEW (median = 1.4E-05 lb/lb NEW) in the background air samples associated with four of the materials, including one of the two materials for which it was reported as an emission product. Because it was possible that one or more of the materials detonated may have contained diethylphthalate, EPA decided to include the diethylphthalte EFs in its report. However, according to information in the EPA report and in MIDAS, diethylphthalate was not present in any of the four materials for which EPA listed it as a possible EP. In addition, none of the other SVOC/POM target analytes is known to have been present in the detonation piles. Therefore, the diethylphthalate EFs and those of the other SVOC/POM target analytes were entered as BDL (MDL = 6.6E-05 lb/ lb NEW).

Table 12. BangBox SVOC/POM Detonation Target Analytes.

CASRN	Compound	CASRN	Compound
100-01-6	4-Nitroaniline	56-55-3	Benz(a)anthracene
100-02-7	4-Nitrophenol	56-57-5	4-Nitroquinoline-1-oxide
100-51-6	Benzyl alcohol	57-97-6	Dimethylbenz(a)anthracene
100-75-4	Nitrosopiperdine,N-	581-89-5	2-Nitronaphthalene
101-55-3	Bromophenylphenylether	59-50-7	4-Chloro-3-methylphenol
105-67-9	2,4-Dimethylphenol	59-89-2	N-Nitrosomorpholine
10595-95-6	Nitrosomethylethylamine,N-	59-90-2	2,3,4,6-Tetrachlorophenol
106-44-5	Methylphenol,4-	60-11-7	p-Dimethylaminoazobenzene
106-46-7	1,4-Dichlorobenzene	606-20-2	2,6-Dinitrotoluene
106-47-8	p-Chloroaniline	98-95-3	Nitrobenzene
108-39-4	3-Methylphenol	608-93-5	Pentachlorobenzene
108-95-2	Phenol	621-64-7	Nitrosodi-n-propylamine,N-
109-06-8	2-Picoline	62-44-2	Phenacetin
110-86-1	Pyridine	62-50-0	Ethyl Methanesulfonate
111-41-4	Bis(2-chloroethyl)ether	62-75-9	Nitrosodimethylamine,N-
111-91-1	Bis(2-chloroethoxy)methane	65-85-0	Benzoic acid
117-81-7	Bis(2-ethylhexyl)phthalate	66-27-3	Methyl Methanesulfonate
117-84-0	Di-n-octyl phthalate	67-72-1	Hexachloroethane
118-74-1	Hexachlorobenzene	7005-72-3	4-Chlorophenylphenyl Ether
119-75-5	2-Nitrodiphenylamine	76-01-7	Pentachloroethane
119-93-7	Dimethylbenzidine,3,3'-	77-47-4	Hexachlorocyclopentadiene
120-12-7	Anthracene	78-59-1	Isophorone
120-58-1	Isosafrole	84-66-2	Diethylphthalate
120-82-1	1,2,4-Trichlorobenzene	84-74-2	Di-n-butylphthalate
120-83-2	1-Methylnaphthalene	85-01-8	Phenanthrene
120-833-2	2,4-Dichlorophenol	85-68-7	Butyl benzyl phthalate
121-14-2	2,4-Dinitrotoluene	86-30-6	N-Nitrosodiphenylamine
122-09-8	Dimethylphenethylamine	86-73-7	Fluorene
122-39-4	Diphenylamine	87-65-1	2,6-Dichlorophenol
122-66-7	1,2 Diphenylhydrazine	87-86-5	Pentachlorophenol
126-68-1	Triethylphosphorothioate	88-06-2	2,4,6-Trichlorophenol
129-00-0	Pyrene	88-72-2	2-Nitrotoluene
130-15-4	1,4-Naphthoquinone	88-74-4	2-Nitroaniline
131-11-3	Dimethylphthalate	88-75-5	2-Nitrophenol
132-64-9	Dibenzofuran	91-20-3	Naphthalene
134-32-7	1-Naphthylamine	91-57-6	2-Methylnaphthalene
143-50-0	Kepone	91-58-7	2-Chloronaphthalene
1888-71-7	Hexachloropropene	91-59-8	2-Naphthylamine
191-24-2	Benzo(g,h,i)perylene	91-80-5	Methapyrilene
193-39-5	Indeno[1,2,3-cd]pyrene	91-94-1	3,3'-Dichlorobenzidine
19406-51-0	4-Amino-2,6-Dinitrotoluene	924-16-3	Nitrosodi-n-butylamine,N-
205-99-2	Benzo(b)fluoranthene	92-52-4	Biphenyl
206-44-0	Fluoranthene	92-67-1	Aminobiphenyl,4-
207-08-9	Benzo(k)fluoranthene	92-87-5	Benzidine
208-96-8	Acenaphthylene	930-55-2	Nitrosopyrrolidine,N-
218-01-9	Chrysene	94-59-7	Safrole
2303-16-4	Diallate	95-48-7	Methylphenol,2-
23950-58-5	Pronamide	95-50-1	1,2-Dichlorobenzene
39638-32-9	Bis(2-chloroisopropyl)ether	95-53-4	o-Toluidine
50-32-8	Benz(a)pyrene	95-57-8	2-Chlorophenol
510-15-6	Chlorobenzilate	95-57-8	2-Methylphenol
51-28-5	2,4-Dinitrophenol	95-94-3	1,2,4,5-Tetrachlorobenzene
522-43-0	1-Nitropryene	95-95-4	2,4,5-Trichlorophenol
534-52-1	4,6-Dinitro-2-methylphenol	98-86-2	Acetophenone
53-70-3	Dibenz[a,h]anthracene	98-95-3	Nitrobenzene
53-96-3	Acetylaminofluorene,2-	99-09-2	3-Nitroaniline
540-73-8	Dimethylhydrazine,1,2-	99-35-4	1,3,5-Trinitrobenzene
541-73-1	1,3-Dichlorobenzene	99-55-8	5-Nitro-o-toluidine
55-18-5	Nitrosodiethylamine,N-	99-65-0	1,3-Dinitrobenzene
56-49-5	3-Methylcholanthrene	99-99-0	4-Nitrotoluene

2.2.4.2 Adjustments Specific to the Emissions from Cased Test Materials

2.2.4.2.1 Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDDs/PCDFs)

The BangBox PCDD/PCDD target analytes were: 1,2,3,4,6,7,8,9-Octachlorodibenzodioxin, 1,2,3,4,6,7,8-Heptachlorodibenzodioxin, 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8-Pentachlorodibenzo-p-dioxin, 2,3,7,8-Tetrachlorodibenzo-p-Dioxin, 1,2,3,4,7,8,9-Heptachlorodibenzofuran, 1,2,3,4,6,7,8,9-Octachlorodibenzofuran, 1,2,3,4,6,7,8-Heptachlorodibenzofuran, 1,2,3,4,7,8-hexachlorodibenzofuran, 1,2,3,6,7,8-hexachlorodibenzofuran, 1,2,3,7,8,9-Hexachlorodibenzofuran, 1,2,3,7,8-Pentachlorodibenzofuran, 2,3,4,6,7,8-Hexachlorodibenzofuran, 2,3,4,7,8-Pentachlorodibenzofuran and 2,3,7,8-Tetrachlorodibenzofuran.

The detonation plumes from the following eight cased materials were the only ones sampled for the PCDD/PCDF analytes: M-158, M43A2 and M-206 flares, ARD-446, BBU-36B and MK-107 impulse cartridges and FMU-139A/B and FMU-54A/B tail fuzes. These items were evaluated for PCDD/PCDF emissions because they contained a combination of materials (e.g., rubber, metal chlorides, chlorinated hydrocarbons, wool and chlorinated and non-chlorinated plastics) that had the potential to produce PCDD/PCDF emission products,

No furans were detected in any of the detonation plumes and the only dioxin detected was octachlorinated dibenzo-p-dioxin (OCDD). This latter compound was detected only in the M43A2 flare detonation plumes. Because dioxins were not found in the background air sample associated with the M43A2 detonations and because the OCDD EF (1.8E-09 lb/lb NEW) was 25 times larger than the EPA-derived MQL EF for OCDD, EPA included the OCDD EF in its report.[7] But, EPA also raised the following concerns about the validity of this EF:

- It seemed highly unlikely that the fully-chlorinated OCDD molecule would be the only PCDD compound produced from a process in which the starting materials were the small molecular fragments and did not produce SVOC emission products.

- Because the OCDD EF was much larger than the MDL for the PCDD target analytes (7.0E-11 lb/lb NEW), it seemed likely that other PCDDs would have been detected if they were present.

- The GC/MS used to analyze the sample was operated in the selective ion mode which provided high sensitivity but low specificity.

- OCDD is a common contaminant in laboratories which process PCDD compounds.

Based on the above facts, it seems highly likely that the OCDD EF resulted from either sample contamination or compound misidentification. Therefore, it was decided to enter BDL in the spreadsheet for all of the PCDD and PCDF emission results for these eight materials and to enter NS for these analytes for the other test materials.

2.2.4.2.2 Adjusting the EFs for the Contribution from the DIC and DIT

The detonations of the canon rounds were initiated using an EBC and a block of C4 (Detonation

Initiating Charge, DIC) and the detonations of the fuzes, impulse cartridges and flares were initiated using detonating cord, C4, and an EBC assembly (Detonation Initiating Train, DIT).

As noted earlier, none of the data sets in the EPA report had been adjusted for the emissions contributed by these assemblies. However, in real-world practice the explosive weight (NEW) of the detonation initiating assembly usually comprises less than 1% of the total NEW of the detonation pile. For example, the initiating charges used in the DPG open range detonations comprised between 0.5 and 1% of the total NEW of the detonation pile. In addition, a review of the items detonated between 2001 and 2007 at one of DOD's largest ammunition manufacturing and demilitarizing facilities determined that over this five-year period, the detonation initiating assemblies comprised less than 0.2% of the 1,960,000 lb (NEW) detonated. In contrast, the BangBox DIC assembly comprised approximately one third of the NEW in the canon round detonation piles, and the DIT comprised between 21 and 62% of the NEW in the detonation piles for the fuzes, impulse cartridges, and flares. To make the emissions data sets more closely represent real-world practice, the emissions data sets for the ten metal-cased test materials were adjusted as described below for the contribution from the initiating assemblies (to the extent that it was possible to do so).

2.2.4.2.2.1 Canon Rounds.

Energetics. The three 20mm rounds in the detonation pile contained 26.4 g of RDX and the two, 40mm rounds contained 108.8 g of RDX, values that account for 30% of the RDX in the 20mm detonation pile and 73% of the RDX in the 40mm detonation pile. Since there were no emissions data available for the DIC, the choices were to either exclude the RDX emission results for the canon rounds from consideration for inclusion in AP-42 or to assume that the RDX in the C4 had produced an EF that was equivalent to that produced by the RDX in the rounds. There were no emission test results to support the validity of this assumption, but as discussed in Section 2.2.4.2.2.2, there was experimental data indicating that the assumption was not valid. Therefore, it was decided to exclude the RDX EFs for the canon rounds from AP-42 and enter ND instead. The only other energetic compounds in the canon rounds that could be measured were HMX (20mm only) and NG (20 and 40mm) and they were not detected in the detonation plumes. Therefore, BDL was entered on the spreadsheet for these energetic compounds.

PM-10. For the following reasons, the EPA PM-10 EFs were entered in the AP-42 spreadsheet without modification. First, the PM-10 EFs for the other cased test items indicated that the particulate produced by the casing materials far overwhelmed that produced by the DIT and the DIC contained considerably less mass than the DIT. Second, the mass of metal in the detonation piles attributable to the canon rounds was 20 to 25 times greater than that attributable to the DIC.

Inorganic and Organic Gases. Because both the DIC and the canon rounds would have produced these EPs, there was no straightforward means to use the EFs to adjust the canon round emissions data sets for the contribution from the DIC. However, based on the emissions data sets from the DPG open range detonations and the results from Ornellas, it seemed reasonable to assume that the source of the predominant carbon-containing emission products (CO_2, CO and VOCs) was the carbon in the detonation pile and to assume that the emissions attributable to the canon rounds and the DIC would be approximately proportional to the mass of carbon in each. Therefore, they would have the same EFFs. Based on this line of reasoning, the EFs for the above inorganic and organic gases were converted to the corresponding EFFs and the EFFs entered into the spreadsheet. If the EF value was BDL, BDL was entered into the spreadsheet. NOTE - SO_2 and NOx samples were not collected in the canon round detonation tests.

Metals. The EBC used in the DIC contained 0.2 g of lead azide, 25.8 g Cu and 0.7 g Al. Because

the canon rounds also contained these metals in the same matrices, it seemed highly likely that the DIC and the canon rounds both contributed to the metal EFs in the EPA report. Further, since the metals were in the same matrices (i.e., alloys and energetic), it seemed reasonable to assume that the EFFs for these metals would be approximately the same for the DIC and the canon rounds. Based on this line of reasoning and the fact that there was no way to correct for the contribution from the DIC, the total weight (mass) of Al, Pb, and Cu in the detonation pile was used when the metal EFs were converted to the corresponding EFF values. These latter values were then placed in the AP-42 Excel workbook along with the EFFs for the other metals found in the canon round plumes.

2.2.4.2.2.2 Fuzes, Impulse Cartridges and Flares

Energetics. The FMU-139A/B fuze, which was the only one of the eight test items that contained a meaningful quantity of RDX, contained twice as much RDX as the DIT. Because of this large quantity of RDX, the RDX emissions could only be adjusted if one assumed that the RDX in the C4 had produced an EFF that was equivalent to that produced by the RDX in the fuze. But the emission test results from the isolated DIT detonations and the test results for the other seven cased materials, whose emissions were characterized in the BangBox, indicated that this assumption was not valid. For example, the average RDX EFF for the DIT was ten times larger than the average RDX EFF for the FMU-139 detonation trials. Further, the RDX EFFs for three of the seven cased test materials (none of which contained meaningful amounts of RDX) were also considerably higher than the RDX EFF for the FMU-139 fuze. Therefore, it was decided to not include a numerical RDX EFF for the FMU-39A/B fuze in AP-42, and instead report it as ND and to invalidate the PETN and RDX EFs for the other seven cased test materials. One other option considered was to combine the PETN EFs into one data set and the RDX EFs into a second data set and assign the average PETN and RDX EFs to the DIT. However, this option was subsequently rejected when emissions data collected in a series of detonation studies conducted at the Naval Air Warfare Center, Weapons Division at China Lake CA indicated that the unconfined nature of the DIT would have caused some of the PETN and RDX closest to the EBC to be kicked out.[20a, 20b] Therefore, the RDX and PETN EFs were invalidated.

PM-10. The PM-10 EFs for the cased items were 10 to 25 times larger than those for the DIT and the weight of the metal in the cased items comprised more than 90% of the metal in the detonation pile. On the other hand, the DIT comprised from 25 to 50% of the NEW of the detonation pile and the NEW is the denominator for the PM-10 EF (lb PM-10 / lb NEW). Thus, if the PM-10 EFs were not corrected for the contribution from the DIT, the EFs would be biased low. Based on these considerations, it was decided to adjust the PM-10 emissions using the following five step procedure.

Step 1: The PM-10 EFs reported for the DIT and the eight cased test materials were multiplied by the detonation pile NEW to produce an estimate of the average total mass of PM-10 produced in each detonation.

Step 2. The PM-10 mass for the DIT detonation (which involved the detonation of two full DITs) was divided by two (to obtain an estimate of the PM-10 mass produced by the full DIT used in the detonations of the flares and impulse cartridges) and also by four (to obtain an estimate of the PM-10 mass produced by the scaled down DIT used in the detonations of the fuzes).

Step 3. The PM-10 mass attributable to the DIT was subtracted from the total PM-10 mass on an item by item basis to obtain an estimate of the PM-10 mass attributable to the cased test item.

Step 4. The NEW of the detonation train was subtracted from the total NEW of the detonation pile to obtain the NEW attributable to the cased item.

Step 5. The PM-10 EFs produced in Step 3 were divided by the appropriate value from Step 4 to produce an adjusted EF for each test material and the result was entered on the AP-42 spreadsheet.

Inorganic and Organic Gases. Because both the DIT and the cased test materials would have produced these EPs, there was no straightforward means to use the EFs to adjust the cased test material data sets for the contribution from the DIT. However, based on the emissions data sets from the DPG open range detonations and the results from Ornellas, it seemed reasonable to assume that the source of the predominant carbon and nitrogen-containing emission products was the carbon in the detonation pile and to assume that the emissions attributable to the cased test materials and the DIT would be approximately proportional to the mass of carbon in each. Therefore, they would have the same EFFs. Based on this line of reasoning, the EFs for these inorganic and organic gases were converted to the corresponding EFFs and the EFFs entered on the spreadsheet. If the EF value was BDL, BDL was entered into the spreadsheet. NOTE - The SO_2 EFs for the cased test materials could not be converted to EFF values because the sulfur content of the test materials was uncertain.

Metals. The EBC used in the DIT contained 0.2 g of lead azide, 25.8 g Cu and 0.7 g Al and each cased test material also contained at least one of these metals in the same matrix as the DIT. Thus, it seemed reasonable to assume that when these metals were present in both the DIT and the cased test material, both items had contributed to the metal EFs in the EPA report. Also, since the metals were in the same matrices (i.e., alloys and energetic), it seemed reasonable to assume that the EFFs for these metals would be approximately the same for the DIT and the cased test materials. Further, the EPA EFs for Al and Cu associated with the isolated DIT detonations were ND, so there was no credible means to adjust the cased test material metal EFs for the contribution from the DIT. Therefore, the total weight (mass) of Al, Pb, and Cu in the detonation pile was used when the EFs were converted to the corresponding EFF values. These latter were then placed in the AP-42 Excel workbook along with the EFFs for the other metals found in the cased test materials. (NOTE – In the few cases where the metal was present in the detonation pile in two or more matrices at levels that prevented it from being assigned to a specific matrix, the letter code ND was entered in the AP-42 workbook.

2.2.5 Emissions Test Data Quality Ratings Assigned To Each BangBox EF/EFF

All of the BangBox EF/EFFs possessed the following positive characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology. Second, because the detonations were conducted either over or in a steel-lined pit, the test conditions did not reflect real-world open detonation processes. Third, the SF6 method used to determine the volume of the detonation plumes was very reliable. Fourth, descriptions of the compositions for most of the test materials were either provided in the EPA report and/or were available in MIDAS. Fifth, documentation in the EPA report and its appendices showed that all field testing and laboratory analyses activities were extensively and continuously audited by independent DOD contractors and also by the EPA over the life of the project, and that the EPA report itself was subjected to a highly credible peer review before it was released. Sixth, although the raw data sheets are no longer available, the EPA report shows they were used to construct the EFs presented in the test report. Seventh, the test results were consistent with detonation reaction theory

and the DPG open range detonation results, which involved much larger detonations under conditions that reflected real-world OD demil operations.

Based on these characteristics and the quality rating criteria recommendations in EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of C (average). This preliminary quality rating was converted to a final rating as described below.

2.2.5.1 Inorganic Gases

The EPA quality rating of C was retained for the CO and CO_2 because the lack of soil likely biased the CO EFFs low and the CO_2 EFFs high. Because the lack of soil would not have meaningfully influenced the NO_x EFFs, these NO_x EFFs were upgraded to B.

2.2.5.2 Volatile Organic Compounds (VOCs)

Most of the VOCs measured in the plume were also detected in the background samples at concentrations often similar to those measured in the detonation plumes. As discussed in Section 2.2.4.1.1, an attempt was made to adjust the EFFs for the contribution from the background air. In fact, the EFFs for 19 of the 43 VOCs detected had been corrected by more than 50%, which raises concerns about the accuracy and representativeness of these EFFs. The extent to which the EFF value had been adjusted for the background along with the absolute value of the EFF and the number of times it was detected were used to assign the final quality rating to each VOC emission product. For example, if the EFF had either not been adjusted or had been adjusted by less than 20% and the numerical value was at least an order of magnitude above the MDL, the quality rating was upgraded to B.

2.2.5.3 Metals

The metal EFFs had been adjusted for residues from the floor of the BangBox and it was highly likely that metal residues from previous tests were entrained in the detonation plumes of many of the detonation trials. In addition, the lack of soil probably influenced the metal emissions substantially in an unpredictable way. Based on these considerations, the quality rating code was lowered to D.

2.2.5.4 Energetic Compounds

All of the EFFs were BDL. Further, the MDL of the BangBox measurement system was several orders of magnitude higher than that for the DPG open range detonation trials and the energetic EFFs associated with the DPG open range tests (Tables 5 and 6) were also orders of magnitude lower than the BangBox MDL. Therefore, the quality rating code was reduced to D.

2.2.5.5 SVOCs/POMs

All of the EFs and EFFs were BDL. The MDL of the BangBox measurement system is three orders of magnitude higher than that for the DPG open range detonation tests, and all but a few of the SVOC/POM EFFs associated with the DPG open range detonation trials (Tables 5 and 6) were at least two orders of magnitude lower than the BangBox MDL. In addition, the lack of soil should favor reducing the quantity of SVOC/POMs emissions. Based on these considerations, the preliminary quality rating was downgraded to D.

2.2.5.6 PCDDs and PCDFs

Although all the EFs were BDL, the MDL of the measurement system was very low, i.e., 7E-11 lb/lb NEW. It was decided to upgrade the quality rating to B, based primarily on this fact and the consistency of the sampling results with detonation reaction theory.

2.2.5.7 PM-10

Particulates was the one EP category that would have been strongly influenced by the lack of soil, because soil comprises most of the particulate in detonation plumes. Based on this consideration, the PM-10 EFs were downgraded to D.

2.2.6 Tabulation of the Emissions Data

The BangBox open detonation emissions data selected for inclusion in AP-42 are presented in Tables 13 through 21 along with the EPA quality rating factor assigned to each EF/EFF value. Table 13 contains the results for the DIT and the Claymore mine. Tables 14, 15 and 16 present the results for the uncased high explosives. Tables 17, 18, 19 and 20 present the results for the difficult-to-detonate metal-cased materials (canon rounds, bomb fuzes, impulse cartridges and flares).

NOTE – As discussed earlier, none of the 120 SVOC/POM target analytes identified in Table 12 were detected in the detonation plumes. To avoid cluttering the tables with 120 BDLs for the SVOCs/POMs, it was decided to list in Tables 13 through 20 only the SVOC/POM that were also target analytes in the DPG open range tests.

Table 13. EFs/EFFs for the Detonation of the Claymore Mine and DIT in the BangBox.

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	2.3E-01	D	3.6E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	NA	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NS	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	4.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	ND	NA
	630-08-0	Carbon monoxide	lb/lb C	2.2E-02	C	6.1E-02	C
	NA	Nitrogen Oxides	lb/lb N	NS	NA	3.8E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		6.3E-02	D	ND	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		ND	NA	NA	NA
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		2.2E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	4.0E-01	D
	7439-92-1	Pb (In Alloy)		ND	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		NA	NA	NA	NA

Table 13 EFs/EFFs for the Detonation of the Claymore Mine and DIT in the BangBox (continued).

EP Category	CASRN	EP	Units	M18A1 Claymore Mine		Detonation Train	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(b)	106-99-0	1,3-Butadiene	lb/lb C	2.0E-06	C	4.1E-04	B
	106-98-9	1-Butene		5.6E-06	C	5.3E-05	B
	592-41-6	1-Hexene		1.8E-06	C	1.3E-04	C
	109-67-1	1-Pentene		1.0E-06	C	7.5E-05	B
	74-86-2	Acetylene		7.3E-04	B	6.9E-04	D
	107-05-1	Allyl Chloride		BDL	D	BDL	B
	71-43-2	Benzene		6.0E-04	B	1.3E-04	C
	142-29-0	Cyclopentene		BDL	D	2.0E-05	C
	74-84-0	Ethane		3.9E-06	C	2.3E-05	D
	75-00-3	Ethyl chloride		BDL	D	3.7E-06	D
	100-41-4	Ethylbenzene		2.8E-05	C	3.2E-06	B
	74-85-1	Ethylene		1.8E-04	B	2.1E-03	B
	115-11-7	Isobutene		2.7E-06	D	1.3E-04	D
	78-78-4	Isopentane		9.6E-07	D	BDL	C
	74-87-3	Methyl chloride		3.3E-06	C	1.4E-05	C
	75-09-2	Methylene chloride		8.1E-05	C	1.5E-04	D
	106-97-8	n-Butane		1.3E-06	D	1.7E-05	D
	142-82-5	n-Heptane		2.7E-06	D	7.5E-06	D
	110-54-3	n-Hexane		9.6E-07	C	9.6E-06	D
	109-66-0	n-Pentane		6.7E-06	D	5.3E-06	D
	622-96-8	p-Ethyltoluene		1.3E-05	C	6.4E-06	C
	74-98-6	Propane		2.7E-06	C	2.5E-05	B
	115-07-1	Propylene		1.8E-05	C	3.9E-04	C
	100-42-5	Styrene		1.3E-03	B	2.2E-05	C
	127-18-4	Tetrachloroethylene		BDL	D	5.9E-05	C
	108-88-3	Toluene		1.9E-04	C	2.2E-05	B
	NA	TNMHC		4.7E-03	C	2.3E-02	C
	624-64-6	trans-2-Butene		1.3E-05	C	2.1E-05	D
	646-04-8	trans-2-Pentene		BDL	D	4.7E-06	B
	75-01-4	Vinyl chloride		8.1E-07	D	2.6E-06	C
	1330-20-7	Xylenes		ND	NA	1.1E-04	D
	56-23-5	Carbon tretrachloride		BDL	D	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	C
	627-20-3	cis-2-pentane		BDL	D	2.3E-06	C
	110-82-7	Cyclohexane		9.6E-07	D	4.2E-06	D
	287-92-3	Cyclopentane		5.3E-07	D	8.7E-07	D
	75-28-5	isobutane		3.8E-07	D	BDL	D
	92-82-8	isopropylbenzene		BDL	D	BDL	D
	71-55-6	Methylchloroform		1.7E-06	D	BDL	C
	108-87-2	Methylcyclohexane		3.9E-06	C	BDL	D
	96-37-7	Methylcyclopentane		1.2E-05	C	8.1E-07	D
	620-14-4	m-Ethyltoluene		4.1E-06	D	1.3E-06	D
	124-18-5	n-decane		7.4E-06	D	3.5E-06	D
	111-84-2	n-nonane		9.6E-07	D	4.6E-06	D
	111-65-9	n-octane		5.3E-06	D	3.2E-06	NA
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW

(b) MDL= 6.0E-07 lb/lb C

Table 14. EFs/EFFs for the Detonation of Comp B and HBX in the BangBox.

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.8E-01	D	1.2E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		ND	NA	ND	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.0E-03	B	1.3E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.5E+00	C	3.9E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.8E-02	C	1.5E-02	C
	NA	Nitrogen Oxides	lb/lb N	5.7E-02	B	1.9E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	5.1E-02	D	NA	NA
	7429-90-5	Al (In alloy)		NA	NA	ND	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		NA	NA	NA	NA
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		3.2E-02	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	ND	NA
	7439-92-1	Pb (In Alloy)		NA	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		NA	NA	ND	NA

Table 14. EFs/ EFFs for the Detonation of Comp B and HBX in the BangBox (continued).

EP Category	CASRN	EP	Units	HBX		Comp B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(b)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BDL	D
	106-98-9	1-Butene		2.2E-05	C	3.0E-06	C
	592-41-6	1-Hexene		9.5E-06	C	5.6E-06	C
	109-67-1	1-Pentene		5.3E-06	C	BDL	B
	74-86-2	Acetylene		1.0E-04	B	4.9E-05	C
	107-05-1	Allyl Chloride		BDL	D	BDL	D
	71-43-2	Benzene		2.5E-05	C	9.1E-05	C
	142-29-0	Cyclopentene		1.4E-06	B	BDL	D
	74-84-0	Ethane		5.6E-06	C	3.2E-06	C
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		6.3E-06	C	7.0E-06	C
	74-85-1	Ethylene		1.1E-04	B	4.9E-05	C
	115-11-7	Isobutene		1.2E-05	C	3.4E-06	C
	78-78-4	Isopentane		BDL	D	6.0E-07	D
	74-87-3	Methyl chloride		2.2E-06	C	2.6E-06	C
	75-09-2	Methylene chloride		3.2E-04	C	3.3E-04	C
	106-97-8	n-Butane		1.8E-06	D	BDL	D
	142-82-5	n-Heptane		1.4E-06	D	1.8E-06	D
	110-54-3	n-Hexane		1.4E-06	D	1.4E-06	D
	109-66-0	n-Pentane		1.8E-06	D	9.5E-07	D
	622-96-8	p-Ethyltoluene		2.6E-06	D	3.4E-06	D
	74-98-6	Propane		3.0E-06	C	1.8E-06	C
	115-07-1	Propylene		3.3E-05	C	1.1E-05	C
	100-42-5	Styrene		BDL	D	BDL	D
	127-18-4	Tetrachloroethylene		BDL	D	6.3E-05	B
	108-88-3	Toluene		1.2E-05	C	2.1E-05	C
	NA	TNMHC		6.3E-04	C	3.9E-04	C
	624-64-6	trans-2-Butene		1.6E-05	C	BDL	D
	646-04-8	trans-2-Pentene		6.0E-07	C	BDL	D
	75-01-4	Vinyl chloride		BDL	D	BDL	D
	1330-20-7	Xylenes		2.8E-05	C	3.3E-05	C
	56-23-5	Carbon tretrachloride		9.8E-07	D	1.3E-06	C
	67-66-3	Chloroform		9.8E-07	D	BDL	D
	627-20-3	cis-2-pentane		9.8E-07	D	BDL	D
	110-82-7	Cyclohexane		BDL	D	BDL	D
	287-92-3	Cyclopentane		1.4E-06	C	BDL	D
	75-28-5	isobutane		1.4E-06	D	1.3E-06	D
	92-82-8	isopropylbenzene		BDL	D	BDL	D
	71-55-6	Methylchloroform		1.3E-06	D	BDL	D
	108-87-2	Methylcyclohexane		2.1E-06	D	8.1E-06	D
	96-37-7	Methylcyclopentane		2.2E-06	D	6.0E-07	D
	620-14-4	m-Ethyltoluene		BDL	D	9.5E-07	D
	124-18-5	n-decane		6.0E-07	D	6.0E-07	D
	111-84-2	n-nonane		BDL	D	4.6E-06	D
	111-65-9	n-octane		1.8E-06	D	1.3E-06	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA
(a) MDL = 6.6E-05 lb/lb NEW							
(b) MDL = 6.0E-07 lb/lb C							

Table 15. EFs/EFFs for the Detonation of TNT and Amatol in the BangBox.

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	7.3E-02	D	1.9E-02	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	NA	NA	ND	NA
	121-82-4	RDX		NA	NA	ND	NA
	118-96-7	TNT		BDL(b)	D	ND	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	NA	2.6E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.3E+00	C
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	C	4.6E-02	C
	NA	Nitrogen Oxides	lb/lb N	ND	NA	1.6E-01	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7440-39-3	Al (In alloy)		NA	NA	ND	NA
	7440-43-9	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-47-3	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		NA	NA	NA	NA
	7440-50-8	Cr (In Protective Coating)		NA	NA	NA	NA
	7439-92-1	Cu (In Alloy)		7.0E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	7.8E-01	D
	7440-66-6	Pb (In Alloy)		NA	NA	NA	NA
	106-99-0	Zinc (In Alloy)		ND	NA	NA	NA

Table 15. EFs/EFFs for the Detonation of TNT and Amatol in the BangBox (continued).

EP Category	CASRN	EP	Units	TNT		Amatol	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
	106-98-9	1,3-Butadiene		4.4E-06	C	BDL	D
	592-41-6	1-Butene		4.9E-06	C	5.6E-06	C
	109-67-1	1-Hexene		5.7E-06	C	9.4E-06	C
	74-86-2	1-Pentene		3.6E-06	C	5.6E-06	C
	107-05-1	Acetylene		4.4E-05	C	4.5E-04	B
	71-43-2	Allyl Chloride		BDL	D	BDL	D
	142-29-0	Benzene		1.1E-05	B	1.1E-04	B
	74-84-0	Cyclopentene		1.2E-06	C	BDL	D
	75-00-3	Ethane		8.8E-07	D	1.3E-05	C
	100-41-4	Ethyl chloride		BDL	D	BDL	D
	74-85-1	Ethylbenzene		8.8E-07	D	5.6E-06	C
	115-11-7	Ethylene		5.7E-05	C	1.5E-04	B
	78-78-4	Isobutene		9.4E-06	C	4.7E-06	C
	74-87-3	Isopentane		1.3E-06	D	4.7E-06	D
	75-09-2	Methyl chloride		BDL	D	3.5E-06	C
	106-97-8	Methylene chloride		4.7E-04	C	7.1E-04	C
	142-82-5	n-Butane		BDL	D	2.9E-06	D
	110-54-3	n-Heptane		1.7E-06	D	3.5E-06	D
	109-66-0	n-Hexane		1.7E-06	D	2.6E-06	D
	622-96-8	n-Pentane		5.7E-06	D	BDL	D
	74-98-6	p-Ethyltoluene		3.1E-06	D	2.4E-05	C
	115-07-1	Propane		BDL	D	4.7E-06	C
VOCs(c)	100-42-5	Propylene	lb/lb C	1.9E-05	C	2.6E-05	C
	127-18-4	Styrene		BDL	D	BDL	D
	108-88-3	Tetrachloroethylene		BDL	D	1.7E-06	B
	NA	Toluene		9.1E-06	C	3.1E-05	C
	624-64-6	TNMHC		2.0E-04	C	2.1E-03	B
	646-04-8	trans-2-Butene		2.5E-06	C	2.6E-06	C
	75-01-4	trans-2-Pentene		5.2E-07	D	3.3E-07	D
	1330-20-7	Vinyl chloride		BDL	D	BDL	D
	56-23-5	Xylenes		ND	NA	2.4E-05	C
	67-66-3	Carbon tretrachloride		BDL	D	8.0E-07	D
	627-20-3	Chloroform		BDL	D	BDL	D
	110-82-7	cis-2-pentane		5.2E-07	D	BDL	D
	287-92-3	Cyclohexane		4.2E-07	D	BDL	D
	75-28-5	Cyclopentane		8.8E-07	D	BDL	D
	92-82-8	isobutane		5.2E-07	D	2.9E-06	D
	71-55-6	isopropylbenzene		1.7E-06	C	BDL	D
	108-87-2	Methylchloroform		BDL	D	1.7E-06	C
	96-37-7	Methylcyclohexane		8.8E-07	D	1.2E-05	C
	620-14-4	Methylcyclopentane		1.3E-06	D	8.0E-07	D
	124-18-5	m-Ethyltoluene		1.2E-06	D	8.0E-07	D
	111-84-2	n-decane		BDL	D	BDL	D
	111-65-9	n-nonane		BDL	D	1.7E-06	D
	NA	n-octane		2.6E-06	D	1.3E-06	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW

(b) MDL = 1.7E-07 lb/lb TNT

(c) MDL = 6.0E-07 lb/lb C

Table 16. EFs/EFFs for the Detonation of Tritonal in the BangBox

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	3.7E-01	D	2.6E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		ND	NA	ND	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.8E-05	B	1.2E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.8E+00	C	3.8E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.3E-03	C	7.8E-03	C
	NA	Nitrogen Oxides	lb/lb N	5.4E-02	B	6.3E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	1.4E-01	D	9.9E-02	D
	7429-90-5	Al (In alloy)		NA	NA	NA	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		NA	NA	NA	NA
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		NA	NA	4.9E-03	D
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	ND	NA
	7439-92-1	Pb (In Alloy)		NA	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		NA	NA	NA	NA

Table 16. EFs/EFFs for the Detonation of Tritonal in the BangBox (continued).

EP Category	CASRN	EP	Units	Tritonal		Tritonal with Calcium Stearate	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(b)	106-99-0	1,3-Butadiene	lb/lb C	2.1E-06	C	3.8E-06	C
	106-98-9	1-Butene		4.5E-06	C	1.1E-05	B
	592-41-6	1-Hexene		8.0E-06	C	8.1E-06	C
	109-67-1	1-Pentene		4.8E-06	C	2.6E-06	C
	74-86-2	Acetylene		3.8E-04	B	5.5E-05	C
	107-05-1	Allyl Chloride		BDL	D	BDL	D
	71-43-2	Benzene		1.8E-05	C	9.0E-06	C
	142-29-0	Cyclopentene		2.3E-06	C	1.0E-06	C
	74-84-0	Ethane		5.4E-07	D	2.1E-06	C
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		7.4E-06	C	4.6E-06	C
	74-85-1	Ethylene		8.0E-05	C	7.3E-05	C
	115-11-7	Isobutene		2.3E-06	D	5.8E-06	D
	78-78-4	Isopentane		3.5E-06	D	BDL	D
	74-87-3	Methyl chloride		1.2E-06	C	1.1E-06	C
	75-09-2	Methylene chloride		8.0E-06	D	4.6E-04	C
	106-97-8	n-Butane		2.5E-06	D	1.0E-06	D
	142-82-5	n-Heptane		BDL	D	BDL	D
	110-54-3	n-Hexane		BDL	D	BDL	D
	109-66-0	n-Pentane		9.3E-07	D	BDL	D
	622-96-8	p-Ethyltoluene		1.4E-05	C	8.4E-07	D
	74-98-6	Propane		2.3E-06	C	1.0E-06	C
	115-07-1	Propylene		2.3E-06	C	1.8E-05	B
	100-42-5	Styrene		BDL	D	BDL	D
	127-18-4	Tetrachloroethylene		9.3E-06	B	1.1E-06	B
	108-88-3	Toluene		4.2E-06	C	BDL	D
	NA	TNMHC		3.8E-03	C	6.4E-04	C
	624-64-6	trans-2-Butene		3.5E-06	C	5.2E-06	C
	646-04-8	trans-2-Pentene		8.6E-07	C	6.4E-07	C
	75-01-4	Vinyl chloride		BDL	D	BDL	D
	1330-20-7	Xylenes		4.5E-05	C	2.9E-05	C
	56-23-5	Carbon tretrachloride		5.4E-07	C	BDL	D
	67-66-3	Chloroform		1.2E-06	C	BDL	D
	627-20-3	cis-2-pentane		BDL	D	BDL	D
	110-82-7	Cyclohexane		BDL	D	BDL	D
	287-92-3	Cyclopentane		1.2E-06	D	BDL	D
	75-28-5	isobutane		1.2E-06	C	1.2E-06	C
	92-82-8	isopropylbenzene		BDL	D	1.2E-06	C
	71-55-6	Methylchloroform		BDL	D	BDL	D
	108-87-2	Methylcyclohexane		2.2E-05	C	6.4E-06	C
	96-37-7	Methylcyclopentane		1.2E-06	C	BDL	D
	620-14-4	m-Ethyltoluene		BDL	D	BDL	D
	124-18-5	n-decane		8.6E-07	D	1.0E-06	D
	111-84-2	n-nonane		4.2E-06	D	BDL	D
	111-65-9	n-octane		8.6E-07	D	BDL	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW.

(b) MDL 6.0E-07 lb/lb C

1 Table 17. EFs/EFFs for the Detonation of Canon Rounds in the BangBox.

EP Category	CASRN	EP	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	ND	D	4.7E-01	D
SVOC & POM(a)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C
Energetics(b)	78-11-5	PETN	lb/lb Energetic	NA	NA	NA	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA
	55-63-0	NG		BDL(b)	NA	BDL(b)	NA
	479-45-8	Tetryl		NA	NA	NA	NA
	2691-41-0	HMX		BDL(c)	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	ND	ND	ND	ND
	124-38-9	Carbon dioxide	lb/lb C	3.4E+00	C	3.7E+00	C
	630-08-0	Carbon monoxide	lb/lb C	1.7E-01	C	5.8E-02	C
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		2.9E-02	D	1.1E-02	D
	7440-39-3	Ba (In Energetic As Compound)		3.1E-02	D	NA	D
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA
	7440-47-3	Cr (In Alloy)		1.7E-03	D	1.0E-02	D
	7440-47-3	Cr (In Protective Coating)		NA	NA	ND	NA
	7440-50-8	Cu (In Alloy)		1.6E-02	D	2.1E-02	D
	7439-92-1	Pb (In Energetic As Compound)		ND	D	6.4E-01	D
	7439-92-1	Pb (In Alloy)		ND	NA	NA	NA
	7440-66-6	Zinc (In Alloy)		9.1E-03	D	7.0E-02	D

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Table 17. EFs/EFFs for the Detonation of Canon Rounds in the BangBox (continued).

Pollutant Category	CASRN	Pollutant	Units	20mm HEI Cartridge		40mm HEI Cartridge	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOC(d)	106-99-0	1,3-Butadiene	lb/lb C	8.2E-06	C	5.3E-06	C
	106-98-9	1-Butene		3.8E-05	C	1.4E-05	C
	592-41-6	1-Hexene		7.0E-06	C	3.9E-06	C
	109-67-1	1-Pentene		5.6E-06	C	2.4E-06	C
	74-86-2	Acetylene		2.9E-04	C	1.2E-04	C
	107-05-1	Allyl Chloride		BDL	D	BDL	D
	71-43-2	Benzene		1.8E-04	C	7.8E-05	C
	142-29-0	Cyclopentene		BDL	C	2.3E-06	C
	74-84-0	Ethane		1.5E-04	C	8.4E-05	D
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		7.4E-06	D	2.4E-06	D
	74-85-1	Ethylene		4.6E-04	C	2.3E-04	C
	115-11-7	Isobutene		3.5E-05	C	2.5E-05	C
	78-78-4	Isopentane		5.0E-06	D	2.5E-05	D
	74-87-3	Methyl chloride		2.1E-06	C	BDL	D
	75-09-2	Methylene chloride		7.2E-04	C	2.4E-03	C
	106-97-8	n-Butane		1.2E-05	D	3.9E-06	D
	142-82-5	n-Heptane		8.5E-06	D	4.8E-06	D
	110-54-3	n-Hexane		5.6E-06	D	1.8E-05	D
	109-66-0	n-Pentane		2.1E-05	D	1.2E-05	D
	622-96-8	p-Ethyltoluene		2.2E-05	D	1.5E-05	D
	74-98-6	Propane		2.1E-05	C	1.1E-05	C
	115-07-1	Propylene		8.2E-05	C	4.5E-05	C
	100-42-5	Styrene		1.9E-06	D	3.9E-05	D
	127-18-4	Tetrachloroethylene		BDL	D	BDL	D
	108-88-3	Toluene		4.8E-05	D	2.4E-05	D
	NA	TNMHC		1.9E-03	C	9.2E-04	C
	624-64-6	trans-2-Butene		1.5E-05	C	5.3E-06	C
	646-04-8	trans-2-Pentene		2.7E-06	C	1.4E-05	C
	75-01-4	Vinyl chloride		BDL	D	BDL	D
	1330-20-7	Xylenes		ND	NA	ND	NA
	56-23-5	Carbon tretrachloride		1.2E-05	D	1.3E-05	D
	67-66-3	Chloroform		BDL	D	BDL	D
	627-20-3	cis-2-pentane		4.3E-07	C	9.0E-07	C
	110-82-7	Cyclohexane		7.7E-07	D	7.0E-06	D
	287-92-3	Cyclopentane		1.1E-06	D	1.7E-06	D
	75-28-5	isobutane		2.2E-06	D	1.6E-06	D
	71-55-6	Methylchloroform		5.3E-06	D	BDL	D
	108-87-2	Methylcyclohexane		4.5E-06	D	2.5E-06	D
	96-37-7	Methylcyclopentane		4.5E-06	D	8.7E-06	D
	620-14-4	m-Ethyltoluene		5.9E-06	D	BDL	D
	124-18-5	n-decane		1.0E-05	D	1.5E-05	D
	111-84-2	n-nonane		7.7E-07	D	5.3E-06	D
	111-65-9	n-octane		1.5E-05	D	1.0E-05	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 6.6E-05 lb/lb NEW.

(b) Even if none of the NG had detonated, the plume concentration would be too small to measure.

(c) Even if none of the HMX had detonated, the plume cocentration would be too small to measure.

(d) MDL = 6.0E-07 lb/lb C

Table 18. EFs/EFFs for the Detonation of Bomb Fuzes in the BangBox.

Pollutant Category	CASRN	Pollutant	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.3E+01	D	7.0E+00	D
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C

Table 18. EFs/EFFs for the Detonation of Bomb Fuzes in the BangBox. (continued).

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA
	479-45-8	TETRYL		BDL(c)	D	BDL(c)	D
	2691-41-0	HMX		NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.8E-03	B	4.0E-04	B
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.2E+00	C
	630-08-0	Carbon monoxide	lb/lb C	6.0E-02	C	6.2E-02	C
	NA	Nitrogen Oxides	lb/lb N	ND	NA	1.9E-01	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		4.1E-02	D	8.8E-02	D
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA
	7440-43-9	Cd (In Protective Coating)		ND	NA	ND	NA
	7440-47-3	Cr (In Alloy)		ND	NA	ND	NA
	7440-47-3	Cr (In Protective Coating)		ND	NA	ND	NA
	7440-50-8	Cu (In Alloy)		2.2E-02	D	5.6E-03	D
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	ND	NA
	7439-92-1	Pb (In Alloy)		ND	NA	ND	NA
	7440-66-6	Zinc (In Alloy)		8.0E-02	D	ND	NA
VOCs(d)	106-99-0	1,3-Butadiene	lb/lb C	1.0E-05	C	BDL	D
	106-98-9	1-Butene		2.0E-04	C	1.2E-03	C
	592-41-6	1-Hexene		3.6E-05	C	2.5E-04	C
	109-67-1	1-Pentene		3.7E-05	C	2.8E-04	C
	74-86-2	Acetylene		8.9E-03	C	6.1E-02	C
	107-05-1	Allyl Chloride		4.6E-04	B	2.1E-03	B
	71-43-2	Benzene		1.7E-03	B	1.5E-02	B
	142-29-0	Cyclopentene		BDL	D	6.6E-05	C
	74-84-0	Ethane		3.0E-05	C	1.4E-03	B
	75-00-3	Ethyl chloride		BDL	D	BDL	D
	100-41-4	Ethylbenzene		4.6E-05	B	3.2E-04	B
	74-85-1	Ethylene		3.6E-03	B	1.5E-02	B
	115-11-7	Isobutene		BDL	D	BDL	D
	78-78-4	Isopentane		3.2E-06	D	1.3E-04	C
	74-87-3	Methyl chloride		6.1E-05	C	3.6E-04	C
	75-09-2	Methylene chloride		1.6E-03	B	6.2E-03	B
	106-97-8	n-Butane		2.4E-05	C	1.4E-04	C
	142-82-5	n-Heptane		4.3E-06	D	1.5E-05	D
	110-54-3	n-Hexane		2.7E-06	D	BDL	D
	109-66-0	n-Pentane		1.1E-05	D	1.3E-05	D
	622-96-8	p-Ethyltoluene		1.2E-05	C	2.3E-04	B
	74-98-6	Propane		4.0E-05	B	6.2E-05	B
	115-07-1	Propylene		6.0E-04	B	3.8E-03	B
	100-42-5	Styrene		4.2E-04	C	9.8E-04	C

Table 18. EFs/EFFs for the Detonation of Bomb Fuzes in the BangBox. (continued).

EP Category	CASRN	EP	Units	Fuze, FMU-139A/B		Fuze, FMU-54A/B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(d)	127-18-4	Tetrachloroethylene	lb/lb C	BDL	D	BDL	D
	108-88-3	Toluene		3.3E-04	B	4.4E-03	B
	NA	TNMHC		3.8E-02	B	3.5E-01	B
	624-64-6	trans-2-Butene		1.8E-04	C	9.8E-04	C
	646-04-8	trans-2-Pentene		2.5E-05	C	1.0E-04	C
	75-01-4	Vinyl chloride		2.5E-05	C	8.2E-05	C
	1330-20-7	Xylenes		BDL	D	BDL	D
	56-23-5	Carbon tretrachloride		1.4E-05	C	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	D
	627-20-3	cis-2-pentane		8.3E-06	C	6.2E-05	C
	110-82-7	Cyclohexane		2.6E-07	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D
	75-28-5	isobutane		3.5E-05	D	3.1E-05	D
	92-82-8	isopropylbenzene		BDL	D	2.1E-05	D
	71-55-6	Methylchloroform		2.4E-06	D	BDL	D
	108-87-2	Methylcyclohexane		BDL	D	BDL	D
	96-37-7	Methylcyclopentane		2.6E-06	D	1.4E-05	D
	620-14-4	m-Ethyltoluene		9.3E-06	D	5.0E-05	D
	124-18-5	n-decane		1.4E-05	D	BDL	D
	111-84-2	n-nonane		2.2E-06	D	3.9E-05	D
	111-65-9	n-octane		3.1E-06	D	3.9E-05	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA

(a) MDL = 7.0E-11 lb/lb NEW.

(b) MDL = 6.6E-05 lb/lb NEW.

(c) MDL = 2.0E-07 lb/lb Tetryl

(d) MDL = 6.0E-07 lb/lb C

Table 19. EFs/EFFs for the Detonation of Impulse Cartridges in the BangBox.

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E+00	D	4.9E+00	D	4.5E-01	D
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		BDL	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte		BDL	C	BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C	BDL	C

Table 19. EFs/EFFs for the Detonation of Impulse Cartridges in the BangBox (continued).

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA	NA	NA
	55-63-0	NG		NA	NA	BDL(c)	D	BDL(d)	D
	479-45-8	Tetryl		NA	NA	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	7.6E-05	B	2.8E-04	B	9.9E-05	B
	124-38-9	Carbon dioxide	lb/lb C	3.3E+00	C	3.4E+00	C	3.6E+00	C
	630-08-0	Carbon monoxide	lb/lb C	9.0E-02	C	5.8E-02	C	6.0E-02	C
	NA	Nitrogen Oxides	lb/lb N	2.9E-01	B	ND	NA	ND	NA
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		5.1E-03	D	4.2E-03	D	ND	NA
	7440-39-3	Ba (In Energetic As Compound)		NA	NA	NA	NA	4.6E-03	D
	7440-43-9	Cd (In Protective Coating)		NA	NA	NA	NA	ND	NA
	7440-47-3	Cr (In Alloy)		ND	NA	ND	NA	7.2E-05	D
	7440-47-3	Cr (In Protective Coating)		NA	NA	NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		ND	NA	5.1E-03	D	1.6E-02	D
	7439-92-1	Pb (In Energetic As Compound)		8.6E-02	D	4.4E-02	D	ND	NA
	7439-92-1	Pb (In Alloy)		ND	NA	NA	NA	ND	NA
	7440-66-6	Zinc (In Alloy)		1.1E-02	D	1.8E-03	D	ND	D
VOCs(e)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BDL	D	8.6E-06	C
	106-98-9	1-Butene		BDL	D	3.0E-04	B	4.3E-05	C
	592-41-6	1-Hexene		8.2E-04	C	1.6E-03	B	3.1E-05	C
	109-67-1	1-Pentene		3.1E-04	C	2.9E-04	C	1.9E-05	C
	74-86-2	Acetylene		1.8E-02	B	3.6E-02	B	1.0E-03	B
	107-05-1	Allyl Chloride		BDL	D	5.5E-03	B	2.2E-05	C
	71-43-2	Benzene		6.1E-03	B	2.4E-03	B	2.8E-04	B
	142-29-0	Cyclopentene		1.6E-04	B	1.1E-04	B	4.2E-06	C
	74-84-0	Ethane		2.4E-03	B	2.4E-04	B	6.9E-06	C
	75-00-3	Ethyl chloride		BDL	D	BDL	D	BDL	D
	100-41-4	Ethylbenzene		1.8E-04	C	1.2E-03	B	4.2E-06	D
	74-85-1	Ethylene		1.7E-02	B	3.2E-03	B	7.7E-04	C
	115-11-7	Isobutene		BDL	D	3.4E-03	B	2.1E-05	C
	78-78-4	Isopentane		BDL	D	4.0E-04	C	BDL	D
	74-87-3	Methyl chloride		8.3E-06	C	BDL	D	4.1E-06	C
	75-09-2	Methylene chloride		4.1E-03	C	8.9E-02	B	9.9E-04	C
	106-97-8	n-Butane		9.3E-05	C	1.6E-03	B	2.0E-06	D
	142-82-5	n-Heptane		1.3E-04	C	3.2E-04	C	4.3E-06	D
	110-54-3	n-Hexane		7.8E-05	D	2.8E-04	C	2.3E-06	D
	109-66-0	n-Pentane		7.2E-05	D	3.1E-04	C	8.6E-07	D
	622-96-8	p-Ethyltoluene		BDL	D	8.8E-04	C	BDL	D
	74-98-6	Propane		4.0E-04	C	1.8E-04	C	6.0E-06	D
	115-07-1	Propylene		3.1E-03	B	BDL	D	1.1E-04	C
	100-42-5	Styrene		3.9E-04	C	4.8E-04	C	4.0E-05	C

Table 19. EFs/EFFs for the Detonation of Impulse Cartridges in the BangBox (continued).

EP Category	CASRN	EP	Units	Impulse Cartridge, ARD-446		Impulse Cartridge, BBU-36/B		Impulse Cartridge, MK-107	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(e)	127-18-4	Tetrachloroethylene	lb/lb C	3.4E-03	C	BDL	D	BDL	D
	108-88-3	Toluene		1.6E-03	C	3.7E-03	C	3.9E-05	D
	NA	TNMHC		BDL	C	BDL	C	6.5E-03	D
	624-64-6	trans-2-Butene		7.1E-04	C	BDL	D	3.6E-05	C
	646-04-8	trans-2-Pentene		2.4E-05	C	2.5E-05	C	1.1E-06	D
	75-01-4	Vinyl chloride		BDL	D	8.1E-04	C	3.7E-06	C
	1330-20-7	Xylenes		BDL	D	BDL	D	ND	NA
	56-23-5	Carbon tretrachloride		BDL	D	BDL	D	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	D	BDL	D
	627-20-3	cis-2-pentane		3.7E-05	C	6.2E-05	C	1.1E-05	C
	110-82-7	Cyclohexane		BDL	D	BDL	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D	BDL	D
	75-28-5	isobutane		1.5E-04	D	BDL	D	1.8E-06	D
	92-82-8	isopropylbenzene		BDL	D	5.4E-04	C	9.5E-07	D
	71-55-6	Methylchloroform		4.5E-05	D	BDL	D	BDL	D
	108-87-2	Methylcyclohexane		BDL	D	1.8E-04	D	2.2E-06	D
	96-37-7	Methylcyclopentane		6.4E-04	C	1.9E-04	C	9.5E-07	D
	620-14-4	m-Ethyltoluene		4.5E-05	C	5.0E-04	C	2.0E-06	D
	124-18-5	n-decane		8.7E-06	D	2.2E-03	C	1.1E-06	D
	111-84-2	n-nonane		2.7E-05	D	1.6E-03	C	1.6E-06	D
	111-65-9	n-octane		3.2E-05	D	4.9E-04	C	1.9E-06	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA	NA	NA

(a) MDL = 7.0E-11 lb/lb NEW.

(b) MDL = 6.6E-05 lb/lb NEW.

(c) MDL = 6.E-07 lbs/lb NG

(d) MDL = 2.0E-07 lb/lb NG

(e) MDL = 6.0E-07 lb/lb C

Table 20. EFs/EFFs for the Detonation of Flares in the BangBox.

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	9.2E+00	D	7.1E+00	D	1.2E+00	D
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B	BDL	B
SVOC & POM(b)	99-35-4	1,3,5-Trinitrobenzene	lb/lb NEW	BDL	C	BDL	C	BDL	C
	51-28-5	2,4-Dinitrophenol		BDL	C	BDL	C	BDL	C
	121-14-2	2,4-Dinitrotoluene		NA	C	BDL	C	BDL	C
	606-20-2	2,6-Dinitrotoluene		BDL	C	BDL	C	BDL	C
	91-57-6	2-Methylnaphthalene		BDL	C	BDL	C	BDL	C
	122-39-4	Diphenylamine		BDL	C	BDL	C	BDL	C
	581-89-5	2-Nitronaphthalene		BDL	C	BDL	C	BDL	C
	88-72-2	2-Nitrotoluene		BDL	C	BDL	C	BDL	C
	100-02-7	4-Nitrophenol		BDL	C	BDL	C	BDL	C
	99-99-0	4-Nitrotoluene		BDL	C	BDL	C	BDL	C
	56-55-3	Benz(a)anthracene		BDL	C	BDL	C	BDL	C
	50-32-8	Benz(a)pyrene		BDL	C	BDL	C	BDL	C
	132-64-9	Dibenzofuran		BDL	C	BDL	C	BDL	C
	84-66-2	Diethylphthalte		NA	C	BDL	C	BDL	C
	91-20-3	Naphthalene		BDL	C	BDL	C	BDL	C
	98-95-3	Nitrobenzene		BDL	C	BDL	C	BDL	C
	86-30-6	N-Nitrosodiphenylamine		BDL	C	BDL	C	BDL	C
	85-01-8	Phenanthrene		BDL	C	BDL	C	BDL	C
	108-95-2	Phenol		BDL	C	BDL	C	BDL	C
	129-00-0	Pyrene		BDL	C	BDL	C	BDL	C
	110-86-1	Pyridine		BDL	C	BDL	C	BDL	C

Table 20. EFs/EFFs for the Detonation of Flares in the BangBox (continued).

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	78-11-5	PETN	lb/lb Energetic	ND	NA	ND	NA	ND	NA
	121-82-4	RDX		ND	NA	ND	NA	ND	NA
	118-96-7	TNT		NA	NA	NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA	NA	NA
	479-45-8	TETRYL		NA	NA	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.6E-03	B	ND	NA	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.7E+00	C	3.5E+00	C	3.4E+00	C
	630-08-0	Carbon monoxide	lb/lb C	3.8E-02	C	7.1E-02	C	8.0E-02	C
	NA	Nitrogen Oxides	lb/lb N	2.5E-01	B	1.7E-01	B	8.9E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA	NA	NA
	7429-90-5	Al (In alloy)		7.7E-02	D	3.8E-02	D	9.5E-04	D
	7440-39-3	Ba (In Energetic As Compound)		1.5E-01	D	1.4E-01	D	NA	NA
	7440-43-9	Cd (In Protective Coating)		NA	NA	ND	NA	ND	NA
	7440-47-3	Cr (In Alloy)		ND	NA	ND	NA	4.6E-04	D
	7440-47-3	Cr (In Protective Coating)		3.8E-03	D	NA	NA	NA	NA
	7440-50-8	Cu (In Alloy)		ND	NA	8.6E-03	D	ND	NA
	7439-92-1	Pb (In Energetic As Compound)		ND	NA	3.2E-01	D	ND	NA
	7439-92-1	Pb (In Alloy)		NA	NA	ND	NA	ND	NA
	7440-66-6	Zinc (In Alloy)		2.0E-01	D	8.0E-02	D	2.0E-02	D
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BDL	D	BDL	D
	106-98-9	1-Butene		1.2E-04	C	1.4E-04	C	6.4E-04	C
	592-41-6	1-Hexene		BDL	D	1.2E-05	C	2.5E-04	C
	109-67-1	1-Pentene		BDL	D	BDL	D	1.5E-04	C
	74-86-2	Acetylene		6.8E-03	B	4.4E-03	B	7.3E-03	B
	107-05-1	Allyl Chloride		5.1E-04	C	3.0E-04	C	5.4E-04	C
	71-43-2	Benzene		1.0E-03	B	4.1E-04	B	6.8E-04	B
	142-29-0	Cyclopentene		BDL	D	BDL	D	3.5E-05	C
	74-84-0	Ethane		BDL	D	8.3E-05	C	3.8E-04	C
	75-00-3	Ethyl chloride		8.1E-05	C	BDL	D	BDL	D
	100-41-4	Ethylbenzene		6.2E-05	C	4.0E-06	D	8.5E-06	D
	74-85-1	Ethylene		BDL	D	1.3E-03	B	2.5E-03	B
	115-11-7	Isobutene		BDL	D	BDL	D	BDL	D
	78-78-4	Isopentane		4.6E-06	D	2.7E-06	D	BDL	D
	74-87-3	Methyl chloride		BDL	D	1.3E-05	C	BDL	D
	75-09-2	Methylene chloride		1.1E-02	B	BDL	C	3.0E-03	B
	106-97-8	n-Butane		BDL	D	1.8E-05	C	BDL	D
	142-82-5	n-Heptane		BDL	D	1.1E-06	D	1.3E-05	D
	110-54-3	n-Hexane		BDL	D	2.5E-06	D	1.3E-05	D
	109-66-0	n-Pentane		9.2E-05	D	3.6E-06	D	6.2E-06	D
	622-96-8	p-Ethyltoluene		BDL	D	BDL	D	BDL	D

Table 20. EFs/EFFs for the Detonation of Flares in the BangBox (continued).

EP Category	CASRN	EP	Units	Flare, M206		Flare, Red Star, AN-M43A2		Flare, Red Star, M158	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	74-98-6	Propane	lb/lb C	BDL	D	1.5E-05	C	9.9E-05	C
	115-07-1	Propylene		BDL	D	1.4E-04	C	9.1E-04	C
	100-42-5	Styrene		1.6E-04	C	5.0E-05	C	1.9E-05	C
	127-18-4	Tetrachloroethylene		BDL	D	BDL	D	BDL	D
	108-88-3	Toluene		7.5E-04	C	4.7E-04	C	7.8E-04	C
	NA	TNMHC		3.0E-02	C	1.3E-02	C	1.2E-01	C
	624-64-6	trans-2-Butene		3.5E-05	C	1.1E-04	C	1.3E-04	C
	646-04-8	trans-2-Pentene		BDL	D	2.3E-06	D	1.6E-05	D
	75-01-4	Vinyl chloride		3.7E-05	C	3.5E-05	C	3.1E-05	C
	1330-20-7	Xylenes		BDL	D	BDL	D	BDL	D
	56-23-5	Carbon tretrachloride		BDL	D	BDL	D	BDL	D
	67-66-3	Chloroform		BDL	D	BDL	D	BDL	D
	627-20-3	cis-2-pentane		1.6E-07	D	3.5E-06	C	3.6E-06	C
	110-82-7	Cyclohexane		BDL	D	BDL	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D	BDL	D
	75-28-5	isobutane		7.7E-06	D	4.3E-06	D	5.0E-05	C
	92-82-8	isopropylbenzene		1.7E-05	C	BDL	D	BDL	D
	71-55-6	Methylchloroform		BDL	D	BDL	D	BDL	D
	108-87-2	Methylcyclohexane		4.6E-06	D	BDL	D	5.4E-06	D
	96-37-7	Methylcyclopentane		3.0E-06	D	1.8E-06	D	1.2E-05	D
	620-14-4	m-Ethyltoluene		4.7E-06	D	BDL	D	2.5E-06	D
	124-18-5	n-decane		2.9E-06	D	2.5E-06	D	1.2E-05	D
	111-84-2	n-nonane		1.0E-05	C	3.0E-06	D	2.1E-05	D
	111-65-9	n-octane		7.2E-06	D	9.8E-07	D	3.0E-05	D
SVOCs in Energetics	NA	SVOC	lb/lb SVOC	NA	NA	NA	NA	NA	NA

(a) MDL = 7.0E-11 lb/lb NEW

(b) MDL = 6.6E-05 lb/lb NEW

(c) MDL = 6.0E-07 lb/lb C

2.2.7 Discussion of the BangBox Open Detonation Test Results

Table 21 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation, of the mean (std dev) and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EP(s) that would be released into the plume.

Table 21 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory and the representativeness of the EF/EFF values to real-world detonation activities.

Inspection of the results presented in Tables 13 through 20 and Tables 5 and 6 lead to the following conclusions.

2.2.7.1 Particulate Matter

PM-10. The RSD value (0.77) for the 17 PM-10 values is rather good. However, the maximum PM-10 value is a factor of three less than the minimum PM-10 DPG value, which was associated with the suspended TNT detonation. This is not surprising because the BangBox detonations were not conducted on soil. In addition, on average, the PM-10 EFs associated with the cased test materials are a factor of three higher than those for the uncased ones. This would also be expected. At best, the BangBox PM-10 EFs provide a crude estimate of the PM-10 due to the munition itself.

2.2.7.2 Inorganic Gases

CO_2. The RSD value (0.74) for the 18 EFFs is rather good. On average, approximately 98% of the carbon in the test materials was converted to CO_2, compared to 95% in the DPG open range detonations. This is not surprising because of the lack of soil in the BangBox detonations.

CO. The RSD value (0.11) for the 18 EFFs is excellent. On average, approximately 2% of the carbon in the test materials was converted to CO compared to approximately 5% in the DPG open range detonations. This is not surprising because of the lack of soil during the BangBox detonations.

NO_x . The RSD value (1.17) for the 14 EFFs is rather good. On average, approximately 2% of the nitrogen in the test materials was converted to NO_x compared to 0.6% for the DPG open range detonations.

Table 21. Summary Statistics for the BangBox OD EFs/EFFs

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	17	6.0E-01	1.2E-02	2.3E-01	2.5E-01	1.9E-01	0.77	D
Inorganic Gases	Carbon Monoxide	lb/lbC	18	1.7E-01	7.8E-03	5.8E-02	5.3E-02	3.9E-02	0.74	B
	Carbon Dioxide	lb/lb C	17	3.9E+00	2.5E+00	3.5E+00	3.5E+00	3.4E-01	0.10	B
	Nitrogen Oxides	lb/lb N	14	3.2E-01	1.9E-02	3.8E-02	6.7E-02	7.9E-02	1.17	B
	Sulfur Dioxide	lb/lb NEW	12	1.4E-03	7.8E-05	3.3E-04	4.8E-04	4.2E-04	0.88	B
Energetics	Energetics	lb/lb Energetic	All Values BDL							
SVOCs	SVOCs In Energetic	lb/lb SVOC	No Data							
	SVOCs Not In Energetic	lb/lb NEW	All Values BDL							
VOCs	Benzene	lb/lb C	18	6.0E-04	9.0E-06	1.4E-04	1.9E-04	1.4E-04	0.74	B
	TNMHC		18	3.4E-02	2.1E-04	6.3E-03	7.9E-03	8.7E-03	1.11	B
	Acetylene		18	1.8E-03	4.4E-05	7.3E-04	7.7E-04	6.1E-04	0.80	B
	Ethylene		18	2.3E-03	4.9E-05	6.5E-04	7.1E-04	7.4E-04	1.05	B
	Methylene Chloride		18	2.4E-03	8.0E-06	4.0E-04	6.2E-04	6.5E-04	1.05	B
	Propylene		18	4.1E-04	2.3E-06	1.1E-04	1.3E-04	1.4E-04	1.08	B
	Toluene		17	1.9E-04	4.2E-06	5.7E-05	6.7E-05	5.7E-05	0.85	B
Metals	Metals In Energetic As Particle	lb/lb Metal	3	1.4E-01	5.1E-02	9.9E-02	9.8E-02	4.6E-02	0.47	D
	Metals In Alloy		35	2.0E-01	7.2E-05	1.1E-02	3.1E-02	4.1E-02	1.35	D
	Metals In Energetic As Compound		10	7.8E-01	4.6E-03	1.5E-01	2.6E-01	2.7E-01	1.04	D

2.2.7.3 Metals

As noted earlier, the location and chemical; form of the metal play a predominant role in determining the quantity of the metal released into the plume when energetic materials are detonated.[1,2, 3] The summary statistics in Table 21 assume that each metal EFF within a metal EP subcategory represents a robust estimate for all metals in that subcategory. The median EFFs (lb/lb Metal) for the three metal emissions subcategories (in decreasing order) are as follows: *Metals in Energetic As Compound* (1.5E-01), *Metals in Energetic As Particle* (9.9E-02) and *Metals in Alloys* (1.1E-02), which is consistent with what one would expect for these emission categories. For example, the *Metals In Energetic As Compound*. category has the largest median EFF value and this is not surprising because the metal compound decomposes when the detonation is initiated and this releases the metal from its chemical bonds. (NOTE – There was only one EFF (3.8E-03 lb/lb Metal) for the *Metals in Coating* subcategory. Further, it was associated with a test material containing an extremely small quantity of a cadmium chromate coating, so the EFF is rather tenuous. For these reasons, summary statistics were not calculated.)

2.2.7.4 VOCs

The EFFs for the 43 VOC emission products measured in the plume were very low and were dominated by the simplest unsaturated and aromatic hydrocarbons. In fact, on average, the following six VOC compounds account for more than 98% of the mass of carbon in the VOC analytes: benzene, acetylene, ethylene, methylene chloride, propylene and toluene. Further, the BangBox median EFFs for benzene and TNMHC (1.4E-04 lb/lb C and 6.3E-03 lb/lb C, respectively) agree well with the corresponding median for the open range study (2.6E-04 lb/lb C and 6.8E-03).

2.2.7.5 PCDDs/PCDFs

Even though the measurement system had an MDL equal to 7.0E-11 lb/lb NEW, PCDD and PCDF compounds were not detected in the plumes for the eight materials with compositions that had the highest chance to produce these compounds. (NOTE - These results also indirectly confirm the earlier conclusion that SVOC compounds did not form in meaningful amounts, because SVOCs/POMs would be intermediates in the formation of PCDDs/PCDFs.)

2.2.7.6 Energetics

All of the energetic results were either BDL or ND.

2.2.7.7 SVOCs/POMs

None of the 120 SVOC/POM target analytes were detected above either the MDL of the measurement system (6.6E-05 lb /lb NEW) or above the background level in any of the detonation plumes. The failure to detect SVOCs/POMs in the BangBox plumes is not surprising because: (1) benzene and toluene would be intermediate products in the formation of most of the SVOC/POM compounds; (2) the EFs for benzene and toluene were less than two orders of magnitude higher than the MDL of the BangBox SVOC/POM measurement system; and (3) the SVOC/POM EFs obtained in the open range detonations were one or two orders of magnitude below this MDL.

2.3 NTS 155MM Projectile Detonation Emissions Data Set

2.3.1 Description of the Tests

This set of emissions data was obtained from sampling the plumes released when 155MM projectiles containing Composition B were detonated at the Nevada Test Site in 1997 and 1999.[9, 10] The test chamber was a large room mined out of a volcanic ash fall tuff lying within Little Skull Mountain in Area 25 of the NTS. A 430 ft tunnel leads to the chamber, which is approximately 36 ft high by 49 ft wide by 100 ft long. The chamber has a nominal volume of 64,000 ft^3. The interior surfaces of the chamber, including the stainless steel door leading into it, are coated with fiber-reinforced shot-crete.

The 1997 tests involved four detonations. Six projectiles were detonated in the first trial (BANSHEE) , which was an operational readiness test (ORI). Twenty-four projectiles were detonated in each of the next two tests (POLARIS and BEAST), and 60 projectiles were detonated in the last test (COLOSSUS). In the POLARIS test the projectiles were lying horizontally on a steel plate, but in the BEAST AND COLOSSUS tests they were lying horizontally on the gravel that had been used to fill in the crater produced by the POLARIS test.

The 1999 tests involved three 24-projectile detonations. The first two detonations were replicates of the 1997 BEAST detonation (24 projectiles lying on a bed of gravel), and the last one involved a new stacking configuration in which 24 projectiles were placed vertically on a bed of gravel.

The detonation chamber was sealed before the projectiles were detonated, and remained sealed for a considerable period of time after plume sampling had been completed. The plume samples were collected from the sealed chamber using probes inserted through four sampling ports in the chamber door (containment plug). The measurement systems used and the suite of target analytes (CO_2, CO, NO, NO_2, HCN, N_2, O_2, VOCs, SVOCs/POMs, metals, TSP and PM-10 were similar to those used in the BangBox tests described earlier with two notable exceptions. First, a mixture of helium and neon was used as the plume (volume) tracer instead of SF_6. Second, no attempt was made to measure the energetic compounds in the detonation plumes.

Samples of the residue on the floor of the chamber were also collected after detonation. These samples were analyzed for energetics using EPA Methods SW-846 Methods 8330 and 8320, and for SVOCs/POMs using SW-846 Method 8270. The samples were also analyzed for metals using SW-846 Methods 1311, 6010 and 7470.

2.3.2 Evaluation of the NTS Detonation Test Results for Inclusion in AP-42

Between 1997 and 2000, the U.S. Army and its contractors released a number of test reports on these detonations and on some rocket motor burns that were conducted in the same chamber shortly after the 1997 projectile detonations. In all these reports, the results were reported in concentration units standardized to normal temperature and pressure. Before an evaluation of the test results for possible inclusion in this chapter of AP-42 could be initiated, it was necessary to convert the concentration units to the equivalent emission factors. This was accomplished by multiplying the concentrations by the appropriate plume volume and dividing the product by the mass of the energetic detonated. The resulting emission factors and associated test conditions under which they were derived were then evaluated to determine if the NTS detonation EFs should be included in AP-42.

The following documents were consulted in this evaluation:

- The suite of reports associated with the 1997 and 1999 detonations.[9, 10, 21 -23]

- The composition of the 155MM M107 projectile in MIDAS.

- Emission characterization study results involving the detonation of Hawk and NIKE rocket motors conducted in the same NTS chamber after the 1997 detonations.[11, 12, 24-26]

- Articles on the formation and measurement of SVOC compounds from combustion processes.[27, 28]

This evaluation determined the following:

- Stratification of both solid and gaseous EPs was present in the detonation plumes when the 1997 and 1999 plume samples were collected. For example, large differences were observed in the paired metal emission product sampling trains.

- The shot-crete coating on the chamber surfaces removed CO_2 from the detonation plume during the 1997 detonation tests and caused a rapid conversion of NO to NO_2 during the 1997 and 1999 detonation tests.

- 99% of the nitrogen in the 155MM projectiles was converted to nitrogen gas.

- Most of the VOC compounds detected are common air pollutants, and the concentrations reported were within what might be expected in a shot-crete lined chamber that is purged continuously with air collected above the dirt-covered parking lot at the entrance to the tunnel leading to the detonation chamber. In fact, the background samples collected before the rocket motor burns indicated that many of the VOC target analytes were present in the NTS chamber at concentrations much higher than found in normal ambient air. When these background VOC concentrations were converted to the equivalent emission factors, they produced values which were very similar to those reported for many of the VOC emissions products, i.e., 1E-06 to 1E-07.

- Because of the blast shielding used to protect the thermocouples in the 1997 detonations, it is very likely that the thermocouples were measuring the wall temperature and not the detonation plume temperature.

- Most of the SVOC analytes detected in the plume are commonly occurring air pollutants that were present in the chamber air and/or on the interior surfaces of the chamber.

- The five most concentrated SVOCs/POMs measured on the detonation chamber walls are the same five most concentrated SVOCs/POMs found in diesel exhaust. (Diesel-fired machinery was frequently used in the detonation chamber prior to and between the detonation and burn tests.

- Plume sampling began 15 to 18 minutes after the detonation was initiated. Based on the

results from the real-time particle concentration monitors used in the 1999 detonation tests, it is highly likely that substantial particle losses attributable to deposition and agglomeration processes occurred long before the plume sampling began in 1997 and 1999 and these losses continued throughout the 152 to 230-minute plume sampling periods.

- Hi-Vol particulate results from background air samples collected in the chamber during the 1997 detonations showed that the air in the detonation chamber contained elevated particle concentrations. For example, the average particulate mass concentration for the two Hi-Vol samples collected before the BEAST detonation was 184 mg/m^3.

- Every metal measured in the detonation plumes was already present in at least one of the following chamber materials before the detonation tests were initiated: shot-crete, concrete, and gravel. Further, the metal content of the total filterable particulate samples indicated that a substantial portion of the particulate mass came from the interior surfaces of the chamber. In addition, the concentration ratios of the metals in these materials varied from one sampling point to the next.

- Cross-contamination of metals and possibly other solid and SVOC emission products occurred from one test to the next. For example, the EFF for Pb for the HAWK rocket motor burn was three orders of magnitude higher than the amount of Pb in the rocket motor. This strongly indicates that the Pb came from the two NIKE rocket motors burns conducted several months before the Hawk burn. (The NIKE contains approximately 12 lb of Pb whereas the Hawk contains less than one lb)

Because this evaluation showed that the detonations did not reflect real-world detonation events, the decision was made to exclude the NTS emissions data from AP-42.

2.4 Summary and Conclusions

2.4.1 Comparability of the BangBox (BB) and DPG Open Detonation Emission Data Sets

A statistical comparison of means was done between the following BB and DPG EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene, and TNMHC. This comparison determined that all of the pairs except the PM-10 data sets were statistically the same. So, each pair of statistically-equivalent data sets was combined and the summary statistics calculated. Table 22 presents these summary statistics along with proposed EPA quality rating codes. These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance to detonation reaction theory and representativeness to real-world open detonation activities.

Table 22 also contains summary statistics for the following EP/EP categories for which there was either only BangBox data or the DPG open range data were far superior to the BangBox data.

PM-10. The DPG open range data set. Because the open range and BangBox data sets are statistically different, they could not be combined. The PM-10 DPG open range EF data set was selected because it more closely reflects real-world detonation processes than the soil-free BangBox detonations. However, the quality rating of D indicates that these PM-10 values are of poor quality, and therefore must be used with extreme caution.

SO_2 The BangBox SO_2 EF values.

VOCs. The BangBox EFFs for acetylene, ethylene, methylene chloride, propylene, and toluene. Together with benzene these six VOCs comprised essentially all of the carbon in the BangBox VOC emissions.

Energetics. The DPG open range energetic EFFs

SVOCs/POMs Not In Energetic. The DPG open range EFs.

Metals. The BangBox EFFs.

Table 22. Summary Statistics for the BangBox and DPG Open Range Detonation Data Sets

EP Category	EP	Units	Data Source	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	DPG	5	1.1E+01	1.6E+00	9.0E+00	7.7E+00	3.6E+00	0.47	D
Inorganic Gases	Carbon Monoxide	lb/lb C	DPG + BB	23	2.0E-01	7.8E-03	6.0E-02	7.1E-02	5.7E-02	0.81	B
	Carbon Dioxide	lb/lb C	DPG + BB	22	3.9E+00	2.5E+00	3.5E+00	3.5E+00	3.0E-01	0.09	B
	Nitrogen Oxides	lb/lb N	DPG + BB	19	3.2E-01	1.7E-03	3.3E-02	5.3E-02	7.2E-02	1.36	B
	Sulfur Dioxide	lb/lb NEW	BB	12	1.4E-03	7.8E-05	3.3E-04	4.8E-04	4.2E-04	0.88	B
Energetics	Energetics	lb/lb Energetic	DPG	5	2.0E-06	5.0E-10	9.3E-08	4.5E-07	8.7E-07	1.95	C
SVOC	SVOCs In Energetic	lb/lb SVOC	No Data								
	SVOCs Not In Energetic	lb/lb NEW	DPG	49	2.0E-06	8.5E-09	8.0E-08	2.8E-07	4.8E-07	1.71	B
VOCs	Benzene	lb/lb C	DPG + BB	23	6.0E-04	9.0E-06	1.7E-04	2.0E-04	1.6E-04	0.82	B
	TNMHC		DPG + BB	23	3.4E-02	2.0E-04	7.2E-03	7.7E-03	7.9E-03	1.03	B
	Acetylene		BB	18	1.8E-03	4.4E-05	7.3E-04	7.7E-04	6.1E-04	0.80	B
	Ethylene		BB	18	2.3E-03	4.9E-05	6.5E-04	7.1E-04	7.4E-04	1.05	B
	Methylene Chloride		BB	18	2.4E-03	8.0E-06	4.0E-04	6.2E-04	6.5E-04	1.05	B
	Propylene		BB	18	4.1E-04	2.3E-06	1.1E-04	1.3E-04	1.4E-04	1.08	B
	Toluene		BB	17	1.9E-04	4.2E-06	5.7E-05	6.7E-05	5.7E-05	0.85	B
Metals	Metals In Energetic As Particle	lb/lb Metal	BB	3	1.4E-01	5.1E-02	9.9E-02	9.8E-02	4.6E-02	0.47	D
	Metals In Alloy		BB	35	2.0E-01	7.2E-05	1.1E-02	3.1E-02	4.1E-02	1.35	D
	Metals In Energetic As Compound		BB	10	7.8E-01	4.6E-03	1.5E-01	2.6E-01	2.7E-01	1.04	D

2.4.2 Representativeness and Adequacy of the Detonation EFs/EFFs

2.4.2.1 Open Air Surface Detonations

As noted earlier, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. The RSDs for ten of the 19 data sets are less than 1.0 and the RSDs for all 19 are less than 2.0. These results show that within most of the data sets the EFs or EFFs are well correlated, i.e., that the results are of good quality. This close correlation is not surprising based on detonation reaction theory and the limited number of substances found in the explosive materials open detonated.

The vast majority of open detonation operations in the U. S. involve the disposal of aluminized and non-aluminized cased and uncased energetic materials. Although the types of items detonated number in the hundreds, the actual number of metals and explosives involved is small. That is, the casings and interior metal parts are almost exclusively aluminum, iron or copper alloys, and the high explosives are comprised of one or more of the following: TNT, RDX, aluminum particles, wax, plasticizers and performance modifiers. Thus, the actual number of uniquely different explosive–containing materials detonated is quite small. This narrow range in explosive materials can be seen by a review of the information in Table 23, which shows the major components of the explosives in the 3,500,000 lb GWT (1,960,000 lb NEW) of energetic materials detonated over a 5-year period at a large DOD ammunition manufacturing and demilitarization facility. In this 5-year period, the facility detonated: 16,700 steel-cased propelling charges, 16,800 large calibre steel cartridges, 712,000 steel or brass-cased primers, 16,200 steel-cased landmines, 750,000 steel-cased fuzes, 28,600 copper-cased blasting caps, 184,000 lbs of reclaimed aluminized explosive, 205,000 lb of reclaimed Composition B and TNT (used as donor material), and 7,500 lb of C4 (used to initiate the detonations). As a group, the 25 test materials whose emissions were selected for AP-42 include all of these explosives and metals. Thus, their emissions should cover most of the substances of environmental concern that could be released into the environment via the detonation plume.

Table 23. Compositions of the HE and Propellant Open Detonated Over Five Years.

Compound	Comp B	C-4	CXM-7	H-6	PBX	TNT	Destex	Tritonal
RDX	59.5%	91.0%	95.0%	45.1%	90.0%	.	.	.
TNT	39.5%	.	.	29.2%	.	100.0%	72.0%	80.0%
Wax	1.0%	.	.	4.7%	.	.	5.0%	.
Aluminum	.	.	.	21.0%	.	.	20.0%	20.0%
Polystyrene	.	.	.	.	8.5%	.	.	.
Dioctylphalate	.	.	.	.	1.5%	.	.	.
Dioctyladipate	.	.	5.0%	.	.	.	.	.
Graphite	.	.	.	.	.	.	3.0%	.
Plasticizers	.	9.0%	.	.	.	.	.	.

Based on the summary statistics shown in Table 22, the EFs/EFFs in the following EP/EP categories can be used with confidence for estimating the emissions from most routine open air detonation activities: CO, NO_x, SO_2, benzene, acetylene, methylene chloride, propylene, toluene, allyl chloride and *SVOCs/POMs Not In The Energetic*. This conclusion is based on the following considerations: (1) the RSDs, (2) the number of EFs / EFFs used to calculate the summary statistics, (3) the representativeness of the test conditions (under which the EF/EFFs were derived) to real-world detonation operations, (4) the EPA Quality Rating Code; (5) the absolute magnitude of the EF/EFFs, (6) the potential toxicity of exposure to the emission product via air pathways, (7) the manner in which real detonation activities are conducted (i.e., multiple detonations in the same area over a one hour timeframe) and (8) the agreement of the EF/EFF to detonation reaction theory.

Based on the very limited number of EF/.EFFs available and the EPA Quality Rating Codes assigned to them, the EFs/EFFs in the following EP/EP categories are probably not adequate for estimating the emissions from many surface open air detonations: (1) PM-10, (2) the four metal subcategories, (3)

Energetics and (4) SVOCs/POMs In Energetics. Obtaining additional emissions characterization data for these categories is recommended, particularly the effect of detonating under a soil cover.

2.4.2.2 Buried and Soil Covered Detonations

Buried and soil-covered detonations are done at facilities where blast noise, blast wave transmission and/or fragment travel can cause problems. The NEW of the detonation pile is usually less than 400 lb. When munitions are detonated under these conditions, the fireball is partially or fully suppressed, a situation that is very different from the conditions under which the EFs/EFFs in Chapter 16 of AP-42 were derived. There are no emissions data specific to soil-covered and buried detonations, and it would not be appropriate to apply the EFs/EFFs in Chapter 16 to buried and soil-covered detonations without considering the effect that suppression of the fire ball could have on the emissions. Fortunately, there are emissions data from studies in bomb calorimeters and detonation chambers that can provide insight on the effect that fireball suppression has on the emissions from detonations. These studies are discussed in Appendix A.

3.0 SELECTION OF OPEN BURN EMISSIONS DATA

3.1 DPG Open Range Open Burn Emissions Data Sets

3.1.1 Test Description

These emission data were produced in 1989 and 1990 when 4,600 to 7,000 lb of five individual propellant materials were burned in steel pans on a test range at DPG, UT. The burn pans were approximately 4 ft wide, 36 ft long, and 0.8 ft high and were placed side by side. Three pans were used in each burn trial. The propellant materials were placed in the pans to a depth of 2.5 to 3.5 inches (6-9 cm), and the burns were initiated using black powder trains placed at both ends of each pan.[6, 7] The testing was done in two phases.

Samples were collected from 28 burn plumes by means of a twin engine turboprop airplane that traversed the plume at 90 knots (150 ft/s). The airplane made three passes through each plume over a three-minute period at an altitude of 1,000 ft. Each pass lasted between 3 to 7 seconds. For safety reasons and also to provide time for all important chemical reactions to end, the first pass occurred approximately 60 seconds after the detonation was initiated. Plume samples were collected at an approximate isokinetic sampling rate through an externally mounted, 10 ft long, 3-in I.D. aluminum probe, which exited into a 11 ft long, 4 in ID sampling manifold inside the airplane. The probe extended outside the aircraft's boundary layer at a position forward and above the copilot's windshield. A sliding valve located at the union of the probe and sampling manifold directed the plume gases into either the manifold (sampling mode) or back into the atmosphere (bypass mode).

The following sampling equipment was attached to the sampling manifold: an 80 L, Tedlar bag; three high volume samplers containing Teflon-coated quartz fiber filters (sampling at a rate of 3 to 4 m^3/min); and an evacuated 6 L stainless steel canister. As the airplane approached the plume for its initial pass, the high volume sampler motors were started, but the manifold sampling valve was left in the bypass mode. When the nephelometer mounted in the front of the airplane indicated that the airplane was entering the plume (sharp increase in nephelometer reading), the manifold sliding valve was moved to the sampling mode. When the nephelometer indicated that the airplane was exiting the plume (sharp drop off in the nephelometer reading), the sliding valve was placed in the bypass mode, where it remained until the airplane was ready to make its next pass through the plume. After each pass through the plume, the VOC canister sampler was removed from the sampling manifold and replaced with a clean evacuated one while the other samplers remained unchanged. After the final pass through the plume, the high volume sampler motors were turned off and the CO_2, CO, NO, and NO_2 concentrations in the Tedlar bag were determined using continuous emission monitors (CEMs) on board the aircraft. The crew then prepared to sample the next detonation plume by evacuating the 80 L Teflon bag and attaching a clean, evacuated 6 L canister to the manifold.

Each burn trial was comprised of two or three burn events spaced 15 to 20 minutes apart. To ensure that sufficient particulate would be collected to allow characterization of the SVOC and energetic compound content of the particulate, the same high volume filters were used for all detonations comprising a trial. This approach produced total high volume sampling volumes from 280 to 350 ft^3 (8 to 10 m^3).

No attempt was made to collect plume samples for analysis for HCl or for polychlorinated dioxin and furan compounds, because an AP-propellant burn test conducted in the SNL BangBox had determined that the concentrations of any HCl or dioxin and furan compounds in the plumes would be too low to

detect with the available equipment. No attempt was made to sample for toxic metals.

Each test day before the first detonation or burn trial was conducted the airplane collected a 20-minute background air sample 1,000 ft above the test range using the same sampling procedures and equipment that would be used to collect plume samples. The concentrations of target analytes found in these background samples were used to correct the emission factors produced that day for the contribution from ambient air pulled into the plume. (NOTE - This approach assumes that the only background air species present in the plume are those present in the air before the burn. It ignores species pulled into the plume from the soil by turbulence produced by rapidly rising plume. Because these latter materials are not included in the background sample, they become part of the reported emissions. Many of the SVOC/POM and energetic target analytes were known to be present in the soil.[6] Thus, it's likely that some of the SVOC/POM and energetic EPs were actually extraneous material pulled into the plume from or with the soil.)

At the conclusion of each trial or background sample collection effort, the aircraft returned to the airfield where the high volume filters were recovered, placed in an ice-cooled container, and transported to a laboratory in Provo, UT where they were stored in a freezer. The filters were subsequently weighed, Soxhlet-extracted, and the extract was analyzed for the target SVOCs/POMs and energetics by GC/MS and Super Critical Fluid Chromatography/MS-selective ion monitoring (SFC/MS-SIM), respectively. The 6 L canisters were sent to a laboratory in Beaverton, OR for analysis for VOCs.

A description of the plume measurement systems used in these tests can be found in Table 24 and a list of the target analytes can be found in Table 25. Because of the prove-out nature of the project and funding limitations, the number of SVOC target analytes was kept small.

Samples of the materials thrown out (sputter) from the burn pan and materials which fell out of the plume (fallout) near the burn pan were also collected using one meter square aluminum pans. The 10 sputter pans were located on the outside edges of the burn pans, and the 12 fallout pans were located at 20 and 38 ft from the center of the burn pan array. At the conclusion of each trial, the materials in the burn pan (ash), sputter pans and fallout pans were recovered and placed in separate sample jars. All samples were then placed in a freezer until they could be extracted and analyzed for SVOCs/POMs and energetics using the same procedures as used for the filter samples.

Table 24. Emissions Test Methods Used in DPG OB Field Studies.

Target Analyte or Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (CSI Model 1600) [Sampling and Analysis]
PM-10	40 CFR 50, Appendix B combined with aircraft sampling probe.
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOCs/POMs	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and GC/MS [Analysis]
Energetics	40 CFR 50, Appendix B [Sampling] followed by Soxhlet extraction and analysis by Supercritical Fluid Chromatography/MS (SFC / MS)
CO, CO_2 (Primary CO and CO_2 Sampling System)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)

Table 25. DPG OB Field Test Target Analytes.

Inorganic Gases and Particulate Matter	NO; NO_2, CO, CO_2 , PM-10
VOCs	Aromatic hydrocarbons, C_1 to C_{10} saturated and unsaturated hydrocarbons and chlorinated hydrocarbons
SVOCs/POMs	Benz(a)anthracene; benz(a)pyrene; dibenzofuran; N−nitrosodiphenylamine; 2-methylnaphthalene; naphthalene; nitrobenzene; phenol; 2-nitrophenol; 4-nitrophenol; phenanthrene; pyrene; pyridine; 1-nitropyrene, 1,3,5-trinitrobenzene, 2-nitrotoluene, 4-nitrotoluene; 2-nitronaphthalene, diphenylamine, 2-nitrodiphenylamine, 2,4-dinitrotoluene and 2,6-dinitrotoluene
Energetics	NG, NQ, HMX and RDX

3.1.2 Description of the Test Materials and Burn Piles

The compositions of the five propellant materials used in this emissions characterization study are presented below along with information on the number of plumes sampled and the target analytes detected in the ash and throw-out pans.

3.1.2.1 Waste Propellants

Waste Propellant Mixture A. This material was comprised of four double-base propellants and one ammonium perchlorate (AP) propellant. Some of the double-base propellants were in pellet form and the others were sheet form. The AP propellant was in the form of chunks. The AP propellant, which represented approximately 25% of the material burned, was placed in the middle burn pan, and the double-base propellants were placed in the outer pans. The material burned contained 1135 kg NC, 865 kg NG, 45 kg 2-nitrodiphenylamine, 606 kg AP, 85 kg triacetin, 70 kg of Pb, and 30 kg Al. A single trial comprised two, 3,000 kg burns spaced approximately 11 minutes apart. One burn required 180 seconds to complete; the other required 240 seconds. The average mass of ash recovered from the burn pans for the two burns was 5.4kg, which is equal to 0.2% of the energetic mass burned. The ash contained 2.9mg of phenol; no other SVOC or energetic target analytes were found.

Waste Propellant Mixture B. This material was comprised of two double-base propellants in sheet form. The propellants were open burned while rolled out flat in the burn pans. The two propellants together contained 1115 kg NC, 793 kg NG, 43 kg 2-nitrodiphenylamine, 13 kg triacetin, 55 kg Pb and 184 kg dibutylphthalate. Two two-burn trials were conducted. The first trial consisted of one open burn with a NEW of 2,253 kg, and the second burn with a NEW of 2,184 kg. In the second trial, two 2,218 kg quantities of the propellant were burned. The two burns in the first trial were initiated approximately 12 minutes apart, and the two burns in the second trial were initiated approximately 15 minutes apart. The burn times for the four burns ranged from 63 to 68 seconds. The average mass of ash recovered from the burn pan for the four burns was 0.6kg, which is equal to 0.1% of the energetic mass burned. The ash contained low nanogram quantities of 2,4-DNT; no other SVOC or energetic target analytes were found.

3.1.2.2 Single-base Propellants

M1 Propellant. This single-base propellant was burned as multi-perforated pellets approximately 1 cm long and 0.4 cm in diameter. The material burned contained 2,729kg NC, 16 kg diphenylamine, 321 kg 2.4-DNT, and 160 kg dibutylphthalate. Two three-burn trials were conducted. Each trial involved the open burning of three 3,159 kg quantities of propellant. In the first trial, the second burn was initiated approximately 14 minutes after the first, and the third burn was initiated approximately 21 minutes after the second. In the second trial, the three burns were initiated approximately 13 minutes apart. The burn times for the six burns ranged from 16 to 19 seconds. The average mass of ash recovered from the burn pan for the six burns was 4.0 kg, which is equal to 0.1% of the energetic mass burned. The ash contained 76 mg of 2,4-DNT and 6 mg of 2,6-DNT; no other SVOC or energetic target analytes were found.

M6 Propellant. This single-base propellant was burned as multi-perforated pellets approximately 1.7 cm long and 0.8 cm in diameter. The material burned contained 2,793 kg NC, 28 kg diphenylamine, 309 kg 2,4-dinitrotoluene (2,4-DNT), and 80 kg dibutylphthalate. Four three-burn trials were conducted. In the first three trials, the burns were initiated approximately 12 minutes apart and in the fourth they were initiated approximately 15 minutes apart. The NEW in each of the first nine burns was 3,184 kg and in the last three burns, the NEW was 3,320 kg. The burn times for the 12 burns ranged from 12 to 20 seconds.

The average mass of ash recovered from the burn pan for the four trials was 2.6 kg, which is equal to 0.08% of the energetic mass burned. The ash contained 30 mg of 2,4-DNT and 91 mg of dibenzofuran; no other SVOC/POM or energetic target analytes were found.

3.1.2.3 Triple-base Propellant

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M30 Propellant. This triple-base rocket propellant was burned as perforated pellets. The material burned contained approximately 890 kg NC, 715 kg of NG, 1510 kg NQ, and 50 kg of ethyl centralite (N,N-diethyl-N,N-diphenylurea). Two two-burn trials were conducted. The average NEW of the first burn was 1510 kg and the average NEW of the second burn was 3,170 kg. The two burns in the first trail were initiated approximately 135 minutes apart (because there was a problem initiating the second burn event), but in the second trial the second burn event was initiated approximately 13 minutes after the first event. The burn time for each burn was approximately 20 seconds. The ash left in the burn pan contained milligram quantities of phenol, ethyl centralite, NQ, NG, and 2-nitrophenylamine. The total mass of the ash was not determined.

3.1.3 Calculation of The Emission Factors

The Army used the ratio of the carbon content of the material burned to the carbon content of the plume sample (as represented by the sum of the CO_2, CO, and CH_4 concentrations) to calculate the plume volume at the time the plume samples were collected. This method for determining plume volume which is usually referred to as the Carbon Mass Balance Approach rests on the following two premises whose validity was confirmed in tests in the SNL BangBox[5] before the propellant burn tests were conducted.

- In an open burn essentially all of the carbon in the materials burned is converted to CO_2, CO, and CH_4.

- The proportional distribution among the carbon-containing gaseous emission products within individual micro-regions of the burn plume remains relatively constant, even though the individual concentrations may be different within the macro-regions of the plume.

Thus, by determining the mass of the carbon in a known volume of the plume and the total mass of carbon in the material burned, one can determine the volume of the plume at the time the plume sample was collected. This plume volume can then be multiplied by the concentration of any target analyte in the same plume sample (or one taken at the same time and location) and divided by the NEW of the material burned to derive an EF for that analyte (Equation 2).

$$EF_i = (f_c)[\text{analyte i}]/[C_j] \qquad \text{(Equation 2)}$$

where:

EF_i = EF for target analyte i (lb/lb NEW)

f_C = mass of C in the energetic divided by mass of the explosive (NEW) burned.

[analyte i] = background-corrected concentration (lb C/ft^3) of the target analyte collected from volume element j of the plume.

[C_j] = background-corrected concentration of carbon (lb C/ft^3) collected from volume element j of the plume [as represented by the CO_2, CO, and CH_4 compounds found in the canister VOC sample taken from the 80L bag].

3.1.4 Identification of Emissions Data Sets Appropriate for Inclusion in AP-42

Each data set was examined and evaluated to determine if the EF in the data sets were suitable for inclusion in this chapter of AP-42 and the quality rating that should be assigned to it. This evaluation used the Army-derived MDL expressed as an EF values, the compositions of the material burned given in the test reports, information about the pre-test concentrations and distribution of the VOC, energetic and SVOC compounds in the background soil and air samples at the test site, mass balance calculations, the QA and QC reports included in the Appendices of the test report, and the EPA guidance document. Based on this evaluation, the following decisions were made concerning including each emissions data set in AP-42.

3.1.4.1 Inorganic Gases

CO and CO_2. For each material burned the Army reported two sets of emission factors for CO and CO_2. Each set contained a minimum, maximum, and average emission factor. One set represented the results for the continuous emissions monitors located in the airplane, and the other set represented the analytical results from the canister samples. Although the two sets of values compared very well, the Army had designated the canister results as the most representative emissions data for CO and CO2. Therefore, only the emission factors attributable to the canister samplers were examined in detail. This examination showed that for all five propellant materials, the mass of C represented by the CO and CO_2 emission factors accounted for more than 99% of the mass of C in the propellant. Since these values are reasonable and consistent with the work of Ornellas and with the results from other studies, the average canister EF for CO and CO_2 for each material was entered in the AP-42 Excel workbook.

NO_2. For each material burned the Army reported only a minimum, maximum, and average EF for NO and NO_2. For all of the materials burned, the mass of nitrogen represented by the NOx emission factors was less than 2% of the mass of nitrogen in the explosive. These values are reasonable and consistent with detonation reaction theory and the results from other emission characterization studies. Therefore, the average EFF values for NO and NO_2 for each material were converted to the equivalent NO_X EF value (as NO_2 equivalent) and this value was entered in the AP-42 workbook.

3.1.4.2 Particulate Results.

For each material burned the Army reported only the average EF. These averages were entered in the AP-42 workbook.

3.1.4.3 Volatile Organic Compounds (VOCs)

The Army report contained emission factors for only three VOC analytes: benzene, methane and Total Non-methane Hydrocarbons (TNMHC). For each energetic material burned, the Army reported only the minimum, maximum, and average emission factors for these three VOC target analytes. Since the

average EF for each of these emission products was consistent with detonation reaction theory and the results from other OB emission characterization studies, the average EF for each material was entered on the AP-42 OB spreadsheet along with the corresponding EFF.

NOTE - The Army used the following justification for not including the emissions results for the other VOC target analytes in the test report. First, the SNL BangBox and the DPG field open burn test results had demonstrated conclusively that the VOCs emitted were almost exclusively the first members of the alkane, alkene, and alkyne classes of hydrocarbons (which are not toxic), and the first members of the aromatic hydrocarbon class of which benzene is the most toxic. Second, it wanted to avoid overwhelming the reader with nonessential emissions data.

3.1.4.4 SVOCs/POMs

For each test material, the Army reported a single background-corrected EF for each SVOC target analyte found. This value was the largest EF obtained for that target analyte across all of the plumes sampled for that propellant. Even if the analyte was found in only one plume, it was reported as if it was a representative emission product for that test material. The Army did not provide information on the total number of plumes in which the analyte was detected. If a SVOC target analyte was either never detected above the background level or never detected in the plume at all (MDL = 1E-09 lb/ lb NEW), the Army reported the test result as BDL. Thus, these EFs represent very conservative emission estimates.

As discussed earlier, there are three sources for the SVOCs/POMs found in burn plumes: (1) SVOCs/POMs added to the energetic material during the manufacturing process; (2) SVOCs/POMs pulled into the plume with the soil and ambient air: and (3) SVOCs/POMs formed by the reaction of small molecules, and molecular fragments produced in the initial stages of the burn event. Three of the thirteen target analytes detected in at least one of the burn plumes fell into the first category, (*SVOCs/POMs in Energetic Material Burned*), and the remaining ten fell into the latter two categories.

Consequently, the following actions were taken concerning entering the SVOC/POM emissions data in the AP-42 workbook.

SVOCs/POMs in the Material Burned. The three compounds in this category were diphenylamine (DPA), 2-nitrodiphenylamine (2-NDPA) and 2, 4-dinitrotoluene (2, 4-DNT). When these items were present in the material burned and the Army had reported an EF value:

- Greater than the MDL, the EF value was converted to the equivalent EFF value, and the EFF value was entered. (The EFF value was calculated by multiplying the EF value by 7,000 lb and dividing by the lb of the SVOC in the burn pile.)

- If BDL, the BDL value was replaced with a value equal to 5.0E-10 lb/ lb NEW (1/2 the MDL) and this value was then converted to the equivalent EFF value, and the resulting value was entered.

*SVOCs/POMs Not in the Energetic Material Burn*ed. If the Army had reported an EF larger than the Army-derived MDL (expressed as an EF), the reported value was entered, and when the Army had reported a value of BDL, BDL was entered.

3.1.4.5 Energetics

For each test material, the Army reported a single background-corrected EF for each energetic target analyte found. This value was the largest EF obtained for that target analyte across all of the plumes sampled in that phase of the study. Even if the analyte was found in only one plume, the Army reported as if it was a representative emission product for that test material. The Army did not provide information on the total number of plumes in which the analyte was detected. When an energetic target analyte was detected at a concentration that was either less than the MDL of the measurement system (6.6E-10 lb/lb NEW) or was less than the concentration found in the background air sample, the Army reported the test result as BDL. Thus, these EFs represent very conservative emission estimates.

The following decisions were made regarding entering the energetic emission test results:

- If a data set contained a numerical EF or a BDL value for an energetic compound that was not a possible emission product (because it was not in the burn pile and would not be formed during the burn), the letter code NA was entered.

- Because the Army reported BDL values for all of the energetics that were in the materials burned and these were possible emission products, the EF MDL value of 6.6E-10 lb/lb NEW was converted to the equivalent EFF MDL value and 1/2 of the EFF MDL entered.

3.1.5 Emissions Test Data Quality Ratings Assigned to Each Data Set

All of the EF/EFFs reported by the Army possessed the following characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology under conditions representative of real-world detonation processes. Second, the test reports contained detailed descriptions of the substances in the materials detonated. Third, the assumptions underlying the plume volume calculation were sound. Fourth, the test reports showed that all field testing and laboratory analysis activities were extensively and continuously audited by an independent DPG contractor and also by the EPA over the life of the project. Fifth, although the raw data sheets are no longer available, the report shows that they were used to construct the EFs presented in the test report. Sixth, the test reports showed that before the final report was issued, the raw data and the test results had been subjected to an extensive technical peer review by a widely respected set of scientists and a comprehensive audit by an EPA Region VIII contract chemist, who had not been involved in any part of the test program.

Based on these characteristics and the quality rating criteria recommendations in EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of B. This preliminary quality rating was converted to a final rating as described below.

3.1.5.1 Inorganic and Volatile Organic Gases

The inorganic gases were subsequently upgraded to a quality rating of A based primarily on the following: the number of plume samples collected for each material, the close agreement between the emission results across the test materials, and the agreement of the test results with both detonation reaction theory and the work of Ornellas.[3]

3.1.5.2 Energetics and SVOCs/POMs

The EPA quality rating of B was retained. Although the environmentally conservative nature of the results and the high sensitivity of the measurement systems (1E-09 lb/lb NEW for SVOC/POM and 6.6E-10 lb/lb NEW for the energetic target analytes) could justify upgrading the rating to A, the lack of information on the number of times the analyte was detected could justify lowering the rating to C.

3.1.5.3 PM-10

The EPA quality rating of B was retained for the PM-10 EFs. The only issue of concern was the Army's suggestion that the PM-10 values were biased high due to re-entrainment and subsequent collection of some of the larger particles that had deposited in the probe.[6] Because there was no data to show whether or not meaningful re-entrainment occurred, it was decided to retain the quality rating of B.

3.1.6 Tabulation of the Emissions Data

The waste propellant emissions data are presented in Table 26 and the single-base and triple-base propellant emissions data are presented in Table 27**.** The quality rating factor assigned to each EF/EFF value are also presented in these tables. Values in italics were derived by replacing a BDL value with one equal to 1/2 MDL.

Table 26. EFs/EFFs for the Open Burning of Waste Propellants.

EP Category	CASRN	EP	Units	Waste Propellant A		Waste Propellant B	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.6E-02	B	1.0E-02	B
SVOC and POM(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A
	522-43-0	1-Nitropryene		BDL	A	BDL	A
	121-14-2	2,4-Dinitrotoluene		BDL	A	1.6E-07	A
	606-20-2	2,6-Dinitrotoluene		NA	A	1.4E-07	A
	91-57-6	2-Methylnaphthalene		BDL	A	BDL	A
	122-39-4	Diphenylamine		2.0E-08	A	3.1E-07	A
	581-89-5	2-Nitronaphthalene		3.7E-09	A	8.3E-08	A
	100-02-7	4-Nitrophenol		BDL	A	BDL	A
	56-55-3	Benz(a)anthracene		3.8E-08	A	1.4E-07	A
	50-32-8	Benz(a)pyrene		2.3E-08	A	8.1E-08	A
	132-64-9	Dibenzofuran		2.6E-07	A	1.2E-07	A
	91-20-3	Naphthalene		1.5E-06	A	5.4E-07	A
	86-30-6	N-Nitrosodiphenylamine		1.9E-08	A	2.7E-08	A
	85-01-8	Phenanthrene		BDL	A	BDL	A
	108-95-2	Phenol		8.0E-06	A	BDL	A
	88-72-2	Nitrobenzene		BDL	A	BDL	A
	110-86-1	Pyridine		BDL	A	BDL	A
	88-75-5	2-Nitrophenol		BDL	A	BDL	A
	88-72-2	2-Nitrotoluene		BDL	A	BDL	A
	99-99-0	4-Nitrotoluene		BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene		BDL	A	BDL	A
	129-00-0	Pyrene		7.1E-09	A	3.2E-07	A
Energetics	55-63-0	NG	lb/lb Energetic	*1.1E-09*	B	*8.7E-10*	B
	556-88-7	Nitroguanidine		NA	NA	NA	NA
Inorganic Gases	124-38-9	Carbon Dioxide	lb/lb C	3.6E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide		2.3E-03	A	2.6E-03	A
	NA	Nitrogen Oxides	lb/lb N	7.1E-02	A	2.9E-02	A
VOCs	71-43-2	Benzene	lb/lb C	*2.3E-06*	A	2.6E-03	A
	74-82-8	Methane		*2.3E-06*	A	2.8E-03	A
	NA	TNMHC		2.1E-04	A	2.1E-03	A
SVOCs in Energetic	119-75-5	2-Nitrodiphenylamine	lb/lb 2-NDPA	3.1E-08	B	9.4E-07	B

(a) MDL = 1.0E-09 lb/lb NEW

Table 27. EFs/EFFs for the Open Burning of Single and Triple-base Propellants.

EP Category	CASRN	EP	Units	M1 Propellant		M6 Propellant		M30 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	6.9E-03	B	1.1E-02	B	2.0E-02	B
SVOCs and POMs(a)	99-35-4	1,3,5 -Trinitrobenzene	lb/lb NEW	BDL	A	BDL	A	BDL	A
	522-43-0	1-Nitropryene		BDL	A	BDL	A	BDL	A
	606-20-2	2,6-Dinitrotoluene		BDL	A	BDL	A	BDL	A
	91-57-6	2-Methylnaphthalene		BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine		BDL	A	BDL	A	BDL	A
	581-89-5	2-Nitronaphthalene		BDL	A	BDL	A	BDL	A
	100-02-7	4-Nitrophenol		BDL	A	BDL	A	BDL	A
	56-55-3	Benz(a)anthracene		BDL	A	BDL	A	BDL	A
	50-32-8	Benz(a)pyrene		BDL	A	BDL	A	BDL	A
	132-64-9	Dibenzofuran		BDL	A	BDL	A	BDL	A
	91-20-3	Naphthalene		1.9E-08	A	7.5E-08	A	BDL	A
	86-30-6	N-Nitrosodiphenylamine		BDL	A	BDL	A	BDL	A
	85-01-8	Phenanthrene		BDL	A	BDL	A	BDL	A
	108-95-2	Phenol		3.4E-09	A	1.5E-09	A	BDL	A
	88-75-5	2-Nitrophenol		BDL	A	BDL	A	BDL	A
	119-75-5	2-Nitrodiphenylamine		BDL	A	BDL	A	BDL	A
	88-72-2	2-Nitrotoluene		BDL	A	BDL	A	BDL	A
	99-99-0	4-Nitrotoluene		BDL	A	BDL	A	BDL	A
	581-89-2	2-Nitronaphthalene		BDL	A	BDL	A	BDL	A
	129-00-0	Pyrene		BDL	A	BDL	A	BDL	A
Energetics	55-63-0	NG	lb/lb Energetic	NA	NA	NA	NA	*1.5E-09*	B
	556-88-7	Nitroguanidine		NA	NA	NA	NA	*6.9E-10*	B
Iniorganic Gases	124-38-9	Carbon Dioxide	lb/lb C	3.6E+00	A	3.7E+00	A	3.7E+00	A
	630-08-0	Carbon monoxide		8.2E-04	A	3.3E-04	A	1.4E-04	A
	NA	Nitrogen Oxides	lb/lb N	2.0E-02	A	4.3E-02	A	2.9E-02	A
VOCs	71-43-2	Benzene	lb/lb C	1.4E-05	A	5.4E-06	A	3.1E-06	A
	74-82-8	Methane		2.4E-02	A	1.5E-04	A	3.1E-06	A
	NA	TNMHC		1.5E-03	A	4.5E-05	A	8.4E-06	A
SVOC in Energetic	122-39-4	Diphenylamine	lb./lb SVOC	*9.6E-08*	B	*5.6E-08*	B	NA	B
	121-14-2	2,4-Dinitrotoluene		1.1E-08	B	*1.0E-08*	B	NA	B
(a) MDL = 1.0E-09 lb/lb NEW									

3.1.7 Discussion of the DPG Open Range Open Burn Test Results

Table 28 compares the emissions test results for the five propellant materials evaluated at DPG. Important conclusions drawn from the data in Table 28 that are relevant to the development of EFs and EFFs for the disposal of energetic materials by open burning follow. NOTE - All of these conclusions are consistent with what one would expect from an intramolecular oxidation-reduction reaction that produces small, simple, stable molecules:

- Even though the chemical compositions and physical shape varied markedly across the five propellant materials, the PM-10 EFs were very similar (6.9E-03 to 2.0E-03 lb/ lb NEW) and the percentage of the original carbon and nitrogen that ended up in CO, CH_4, benzene, and NO_x was also very similar.

- Efficient destruction of the energetic compounds is clearly demonstrated by the fact that all of the plume measurements yielded BDL results for these compounds.

- SVOCs/POMs were not produced in meaningful amounts. Nineteen of the 23 EF values were associated with the two manufacturing waste propellant materials. These burns took from 60 to 240 seconds to go to completion, whereas, all of the straight propellant burns took less than 20 seconds. Because they represent the maximum EF measured across all of the burn plumes of the test material (and may represent the one time the compound was detected across all of the plumes for that material), environmentally speaking, all of the EF and EFF values are very conservative.

- According to the test report, benzene was the predominant aromatic hydrocarbon emitted which is consistent with Ornellas' work and detonation reaction theory. Further, because benzene would be produced by the same reaction pathways as the SVOCs/POMs, the quantity of SVOCs/POMs present in the plume should be much less than that of benzene, which is indeed the case.

Table 28. Comparison of the Emissions Produced by Each Test Material.

EP	Units	Waste Propellant A	Waste Propellant B	M1 Propellant	M6 Propellant	M30 Propellant
Energetic Compounds						
Nitroglycerin	lb/lb NG	*1.1E-09*	*8.7E-10*	NA	NA	*1.5E-09*
Nitroguanadine	lb/lb NQ	NA	NA	NA	NA	*6.9E-10*
Inorganic Gases and Particulates						
Carbon Dioxide	lb/lb C	3.6E+00	3.7E+00	3.6E+00	3.7E+00	3.7E+00
Carbon monoxide		2.3E-03	2.6E-03	8.2E-04	3.3E-04	1.4E-04
Nitrogen Oxides	lb/lb N	7.1E-02	2.9E-02	2.0E-02	4.3E-02	2.9E-02
PM-10	lb/lb NEW	1.6E-02	1.0E-02	6.9E-03	1.1E-02	2.0E-02
Volatile Organic Compounds						
Benzene	lb/lb C	3.0E-06	5.4E-05	1.4E-05	5.4E-06	3.1E-06
Methane		3.0E-06	2.5E-03	2.4E-02	1.5E-04	3.1E-06
TNMHC		2.7E-04	1.9E-03	1.4E-03	4.2E-05	9.1E-06
SVOCs in Energetic						
2-Nitrodiphenylamine	lb/lb 2-NDPA	*3.1E-08*	*9.4E-07*	NA	NA	NA
Diphenylamine	lb/lb DPA	NA	NA	***9.6E-08***	***5.6E-08***	NA
2,4-Dinitrotoluene	lb/lb DNT	NA	NA	1.1E-08	***1.0E-08***	NA
SVOCs and POMs						
Pyrene	lb/lb NEW	7.1E-09	3.2E-07	BDL	BDL	BDL
2,6-Dinitrotoluene		BDL	1.4E-07	BDL	BDL	BDL
Diphenylamine		2.0E-08	3.1E-07	*NA*	*NA*	BDL
2-Nitronaphthalene		3.7E-09	8.3E-08	BDL	BDL	BDL
Benz(a)anthracene		3.8E-08	1.4E-07	BDL	BDL	BDL
Benz(a)pyrene		2.3E-08	8.1E-08	BDL	BDL	BDL
Dibenzofuran		2.6E-07	1.2E-07	BDL	BDL	BDL
Naphthalene		1.5E-06	5.4E-07	1.9E-08	7.5E-08	BDL
N-Nitrosodiphenylamine		1.9E-08	2.7E-08	BDL	BDL	BDL
Phenol		8.0E-06	BDL	3.4E-09	1.5E-09	BDL
2,4-Dinitrotoluene		BDL	1.6E-07	*NA*	*NA*	BDL
Fate of Carbon and Nitrogen in Energetic						
% C in CO2	% C	98.2%	100.9%	98.2%	100.9%	100.9%
% C in CO	% C	0.0986%	0.1114%	0.0351%	0.0141%	0.0060%
% C in Benzene		0.0003%	0.0050%	0.0013%	0.0005%	0.0003%
% N in NOX	% N	2.1498%	0.8950%	0.6055%	1.3179%	0.8853%

3.1.7.2 Summary Statistics for the DPG Open Burn Emissions Characterization Study

Table 29 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev),, and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

Table 29 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory, and the representativeness of the EF/EFF values to real-world detonation activities.

Table 29. Summary Statistics for the DPG Open Burn Test Results.

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	5	2.0E-02	6.9E-03	1.1E-02	1.3E-02	5.2E-03	0.41	B
Inorganic Gases	Nitrogen Oxides	lb/lb N	5	7.1E-02	2.0E-02	2.9E-02	3.8E-02	2.0E-02	0.52	A
	Carbon Dioxide	lb/lb C	5	3.7E+00	3.6E+00	3.7E+00	3.7E+00	6.2E-02	0.02	A
	Carbon Monoxide	lb/lb C	5	2.6E-03	1.4E-04	8.2E-04	1.2E-03	1.1E-03	0.92	A
Energetics	Energetics	lb/lb Energetic	4	1.5E-09	6.9E-10	9.7E-10	1.0E-09	3.3E-10	0.32	B
SVOCs in Energetic	SVOCs in Energetics	lb/lb SVOC	6	9.4E-07	1.0E-08	4.4E-08	1.9E-07	3.7E-07	1.93	B
SVOCs Not In Energetic	SVOCs Not In Energetics	lb/lb NEW	29	8.0E-06	5.0E-10	2.7E-08	4.1E-07	1.5E-06	3.62	B
VOCs	Benzene	lb/lb C	5	5.9E-05	2.3E-06	5.8E-06	1.7E-05	2.4E-05	1.40	B
	TNMHC	lb/lb C	5	2.1E-03	8.4E-06	2.1E-04	7.7E-04	9.6E-04	1.24	B

3.2 BangBox Open Burn Emissions Data Sets

3.2.1 Test Description

The 15 sets of emissions data had been produced by burning 2.2 to 5.0 lb quantities of propellants and a dunnage surrogate (dunnage was a material that use to be used to support the open burning of propellant-containing waste materials) in BangBoxes between 1989 and 1995.[5, 8] BangBoxes are air-supported, rubber-coated hemispherical chambers, which sit on concrete pads. Each BangBox is divided into two sections: an inflatable, 32,900 ft^3, 50-ft diameter hemispherical test chamber made from a flexible polyvinyl-coated polyester fabric and a 17.8 x 7.1 x 8.1 ft building (airlock) with a plywood front, and a wood frame covered with the same material as the BangBox. The test chamber is kept pressured at 0.17 inches of water pressure using two high-capacity blowers and a damper. Six fans spaced 60^0 apart circulate the air in the test chamber to produce a homogeneous pollutant mix that can be sampled with instruments in the chamber and the attached air lock. The materials were burned on a bed of pea gravel in a thin-wall stainless steel pan sitting on a steel pad located in the center of the BangBox. The purpose of the pea gravel was to prevent burning holes in the steel burn pans. The pea gravel was replaced each burn test day.

The test chamber was purged with air for at least 60 minutes (two to three air exchanges) between burns, but no attempt was made to clean the surfaces of the BangBox. When the burn was initiated, a known quantity of SF_6 was released into the chamber from a pressured cylinder located approximately 10 ft from the burn pan. The concentration of the SF_6 was then measured periodically after the burn was initiated. A separate, evacuated canister was used each time a sample was collected. The average SF_6 concentration measured was used to calculate the extent to which the emissions plume had been diluted (due to the chamber blowers) between the burn and the completion of the sample collection activities. This dilution factor was used to correct the measured emission product concentrations to the concentrations that were present immediately after the burn was initiated.

The sampling systems shown in Table 30 were used to characterize the plumes from the 15 test materials burned. Only the VOC, CO, CO_2 and PM-10 measurement systems were used in all 15 tests. The number of tests for which the other measurement systems were used were: NO_x (11), SO_2 (12), SVOC and energetics (11), metals (9), HCl and Cl_2 (3) and PCDDs/PCDFs (5). However, because the energetic plume samples from six of the test materials were not analyzed within the six month sample holding time specified by EPA guidance (due to problems with the analytical instrumentation), the DOD project officer invalidated these six sets of energetic results. With the exception of the SF_6 and VOC samples, the samplers were operated from 10 to 15-minutes before the burn until 30 to 40 minutes after the burn. The SF_6 and VOC grab samples were collected at intervals starting approximately 5-minutes after the burn was initiated, e. g., 5, 7, 11, 19 and 35 minutes.

The EPA's Office of Research and Development (ORD) provided technical assistance and quality assurance support to the DOD project officer when the 15 emissions data sets were collected and issued a summary report on the results of these emissions tests.[8]

Table 30. Emissions Test Methods Used in the BangBox OB Studies.

Target Analyte / Analyte Class	Test Method
CO_2 (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 3A (Teco Model 41 H) [Sampling and Analysis]
CO (Backup Sampling System)	40 CFR 60, Appendix A, EPA Method 10 (Teco Model 48) [Sampling and Analysis]
NO, NO_2	40 CFR 60, Appendix A, EPA Method 7E (Teco Model 42) [Sampling and Analysis]
SO_2	40 CFR 60, Appendix A, EPA Method 6C (Teco Model 43A) [Sampling and
HCl	Teco Model 15 HCl [by Gas Filter Correlation] Continuous Emissions Monitor (No
HCl, Cl_2	40 CFR 60, Appendix A, EPA Method 26 [Sampling and Analysis]
TSP	40 CFR 50, Appendix B [Sampling and Analysis]
PM -10	40 CFR 50, Appendix J [Sampling and Analysis]
Metals	40 CFR 50, Appendix B [Sampling], 40 CFR 60, Appendix A, EPA Method 29
VOC (TNMHC)	EPA Method TO - 12 - Method for the Determination of Non-Methane Organics
VOC (Speciated)	EPA Method TO - 14 - Determination of Volatile Organic Compounds(VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography / Mass Spectrometry (GC/MS) [Sampling and Analysis]
SVOC / POM	EPA Method TO - 13 - Determination of Polycyclic Aromatic Hydrocarbons in Ambient Air Using GC/MS [Sampling and Analysis]
Energetics	EPA Method TO - 13 [Sampling] with analysis by Supercritical Fluid Chromatography/MS (SFC/MS)
PCDDs/ PCDFs	EPA Method TO - 9 - Determination of Polychlorinated, Polybrominated and Brominated/Chlorinated Dibenzo-p-Dioxins and Dibenzofurans in Ambient Air [Sampling], EPA - SW - 846 Method 8290 [Analysis]
CO, CO_2 (Primary Sampling System for CO & CO_2)	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography with Thermal Conductivity Detector (GC / TCD)
SF_6	EPA Method TO -14 [Sampling] with analysis by Gas Chromatography / Electron Capture Detection (ECD)

With the exception of the CEM data, replicate sampling trains were used for each target analyte. Background samples for all target analytes were collected in the test chamber at the beginning of each test day. The samples were analyzed in a manner identical to that used for the burn plume sample, and the results were used to correct the emission factors for any contribution the background air made to the measured emission factors. A total of 28 burn plumes were sampled across the 15 sets of emissions test results. (NOTE - This approach assumes that the only background air species present in the plume are

those present in the air before the burn. It ignores species pulled into the plume from the surfaces of the BangBox by turbulence produced by rapidly rising plume. Because these latter materials are not included in the background sample, they become part of the reported emissions.)

3.2.2 Description of the Test Materials

The air emissions from the following materials were characterized: four ammonium perchlorate (AP) propellants, two single-base propellants, three double-base propellants, one triple-base propellant, two PBX (Plastic Bonded Explosive) propellants, one smoke, one surrogate AP manufacturing waste and one energetic-free, surrogate dunnage material. The compositions of these test materials and the conditions under which they were burned are described below. The chemical composition data were taken from the EPA report and from MIDAS. (NOTE - When the BangBox emissions characterization tests were conducted, MIDAS was not available to the project personal. Because most of the composition data was available only in hard copy and was mostly confined to the major components of the test material, it was very difficult for the project personal to obtain information on most of the minor constituents present in the test materials.)

3.2.2.1 AP -Based Propellants

AP Propellant A. The AP propellant used in this test was delivered to the BangBox as blocks and was divided into pieces weighing approximately 2.2 kg for the test burn. A 2.2 kg block was burned in each trial. The block was prepared for the test as follows. First, the block was placed in a 30.5 by 50.8 by 15.2 cm deep burn pan containing a bed of pea gravel. Then a flap was cut in the top of the block and an 81-mm propellant bag containing 4 g of Hercules unique smokeless powder was placed in the hole along with two electric squibs. The flap was then placed back over the hole, and the burn was initiated. Other than the following elemental composition, no information is available for this propellant: 25.87% Cl, 11.32% C, 4.31% H, 10.35% N, 47.31%O, and 0.89% Zr. This formulation implies that the propellant was 85% AP. Two single-burn trials were conducted. The NEW burned in each of the two trials was 2,270 g, including the 4 g of smokeless powder used to initiate each burn. Based on the above elemental composition, the 2,270 g of propellant burned contained: 1946 g AP, 3.8 g NC, 0.2 g NG and 20 g Zr.

Aluminized AP Propellant. The AP propellant used in this test was delivered to the BangBox as blocks and was divided into pieces weighing approximately 1.2 kg each for the testing. A 1.2 kg block was burned in each trial. The block was prepared for the test as follows. First, the block was placed in a 30.5 by 50.8 by 15.2 cm deep burn pan containing a bed of pea gravel. Then a flap was cut in the top of the block and an 81-mm propellant bag containing 4 g of Hercules unique smokeless powder was placed in the hole along with two electric squibs. The flap was then placed back over the hole and the burn was initiated. Other than the following elemental composition, no information is available for this propellant: 19% Al, 20.8% Cl, 10.09% C, 3.7% H, 8.3% N, 38.1% O and 0.008% P. This formulation implies that the propellant contained 69% AP by weight. Two single-burn trials were conducted. The NEWs for the first and second trials were 1,216 g and 1,159 g, respectively for an average NEW of 1192 g. This average mass would contain: 3.8 g NC, 0.2 g NG, 821 g AP and 226 g Al.

MK6 Propellant. 448 g of MK6 propellant chips were placed in a stainless steel burn pan containing a bed of pea gravel and the burn was initiated using two electric matches. The NEW burned was 448 g. The major energetic constituents of the propellant were: 381 g AP, 35.9 g hydroxy-terminated polybutadiene, 20.2 g dioctyl sebacate and 4.5 g aluminum. One single-burn trial was conducted.

MK23 CTBN Propellant. One single-burn trial was conducted. The NEW of energetic material burned was 1030 g, including 30 g Hercules smokeless powder. The major energetic components of the 1000 g of MK23 burned were 800 g AP, 142 g carboxyl-terminated polybutadiene, and 20 g Al.

3.2.2.2 Single-base Propellants

M1 Propellant. Three single-burn trials were conducted. The NEW burned in each trial was 2,273 g, including 4 g of smokeless powder and 113 g of reducer charge. The M1 propellant was contained in Number 4 and Number 5 M3 propellant bags. The Number 4 bag weighed 15 g and the Number 5 bag weighed 19.5 g. Two Number 4 bags and two Number 5 bags were burned during each trial. Each Number 4 bag contained 428 g of M1 propellant and 29 g of reducer charge, and each Number 5 bag contained 650 g of M1 propellant and 27.5 g of reducer charge. The composition of the reducer charge was not given in the final report. The major energetic constituents of the 2,156 g of M1 propellant burned were: 1,815 g NC, 213 g dinitrotoluene, and 22 g diphenylamine.

3.2.2.3 Double-base Propellants

Double-Base Propellant A. 2,223 g of pelletized propellant was placed in a stainless steel burn pan containing a bed of pea gravel, along with an 81-mm propellant bag containing 4 g of smokeless powder, and the burn was initiated using an electric match. Two single-burn trials were conducted. The propellant contained NC, NG, and 2-nitrodiphenylamine. Its elemental composition was 20.36% C, 2.97% H, 28.73% N, 46.14% O, 0.89% Pb, 0.89% Zr and 0.02% Sn which corresponds to 454.4 g C, 66.1 g H, 639.8 g N, 1027.5 g O, 19.8 g Pb, 19.8 g Zr and 0.5 g Sn.

NOSIH AA2 Propellant. 454 g of propellant chips and 26.6 g of ethyl cellulose were placed in a stainless steel burn pan containing a bed of pea gravel, and the burn was initiated using an electric match. One single-burn trial was conducted. The major constituents of the propellant were: 240 g NC, 184 g NG, 26.6 g ethyl cellulose, 12.3 g triacetin, 9.1 g of di-n-propyl adipate and 8.5 g lead.

M9 Propellant. Three single-burn trials were conducted. Two hundred and thirty two (232) unopened bags of M9 propellant were placed in a burn pan containing a bed of pea gravel, and the propellant was ignited using 4 g of smokeless powder and two electric matches. Each bag weighed 11.5 g and contained approximately 10.4 g of M9 propellant. The NEW used in each burn was 2405 g, including 4 g of smokeless powder. The energetic composition of the 2,401 g of M9 propellant burned was: 1,387 g NC, 960 g NG, 36 g potassium nitrate, and 18 g 2-nitrodiphenylamine. The propellant bags were identical to those used to fire the 81 mm mortar, but their chemical composition was not given in the final report. Based on 1.1 g per bag, the total mass of the 232 bags was 255 g.

Hercules Unique Smokeless Powder. One single-burn trial was conducted. The NEW burned was 454 g and was composed of 431.3 g NC and 22.7 g NG.

3.2.2.4 Triple-base Propellant.

M31A1E1 Propellant (NSN: 1376 -01-213-5669). Three single-burn trials were conducted. During the first trial, the stick propellant was burned in an upright position on the pea gravel bed, which resulted in extensive propellant kick out. To reduce propellant kick out, in the second and third trial burns, the propellant sticks were placed horizontally on the pea gravel bed. For these latter burns, four propellant sticks were broken into fourths (18.4 cm) and placed in the pan. Then additional propellant sticks were

broken in half (36.8 cm) and placed crosswise on top of the other propellant sticks. The NEW (including the 4 g of smokeless powder) used in the three trials conducted were 2,284 g, 2,280 g, and 2,264 g, for the first, second and third burns, respectively. The major energetic constituents of the M31A1E1 propellant burned were: 492 g NC, 410 g NG, 1,245 g NQ, 34 g ethyl centralite, and 1 g of charcoal.

3.2.2.5 PBX Propellants

MK43 LOVA Propellant. A single-burn trial was conducted. The NEW of energetic material burned was 1060 g, including 40 g Hercules smokeless powder. The energetic composition of the MK43 propellant burned was: 775 g RDX, 41 g NC, 122 g cellulose acetate butyrate (CAB), and 78 g of a mix of bis(2,2-dinitropropyl)acetal, and bis(2,2-dinitropropyl)formal.

PBXN 110 Propellant. A single-burn trial was conducted. The NEW burned was 1064 g, which included 14 g of smokeless powder. The major energetic components of the 1050 g of PBXN-110 burned were: 924.1 g HMX, 53 g hydroxyl-terminated polybutadiene, and 53 g isodecyl pelargonate.

3.2.2.6 Miscellaneous Materials

Smokey Sam. The NEW of energetic material burned was 273 g, including 23 g of Hercules smokeless powder. One smokey sam was burned in the single trial conducted. The energetic components of the smokey sam were: 110.0 g AP, 100.2 g Zn, 30 g hydroxyl-terminated polybutadiene, and 7.5 g dioctyl adipate. The burn was very dirty; the BangBox airlock was filled with a pungent, noxious odor, and the BangBox test chamber was filled with a dense fog.

Aluminized Propellant Manufacturing Waste. This surrogate waste simulated the mix of plastic gloves, cotton rags, kimwipes, wood towel rods, and similar materials that result from the clean-up of the vessels used to manufacture propellants. This material is usually disposed of through open burning. The composition of the surrogate waste burned was: 65% aluminized AP (69% AP, 19% aluminum), 20% plastic material (gloves, anti-static polyethylene), 11% paper/wood/cloth and 4% diesel fuel. The propellant in one inch cubes was randomly dispersed in the combustible materials. Because the first burn resulted in a hole in the bottom of the pan, the second and third burns were done with the surrogate waste sitting on top of a 7.6 cm layer of pea gravel. At the completion of each of these last two burns, holes were found in the side of the burn pan, and melted plastic was found in the pea gravel. The weight of waste surrogate burned in the three trials was 1,139 g, including the 4 g of Hercules Unique Smokeless Powder used to initiate each burn. Since this burn was done to characterize the emissions from the waste itself, the mass of the material burned (1,139 g), rather than the mass of energetic burned (741.8 g) was used to calculate the emission factors.

Diesel Fuel and Dunnage Surrogate. A surrogate diesel fuel-soaked dunnage was burned on August 29, 1995 to determine the emissions released when dunnage is burned. Three burns were done in unlined stainless steel pans using 909 g of the surrogate material and 4 g of smokeless powder. The composition of the surrogate material, which was prepared using styrofoam, pasteboard and irregularly shaped pieces of wood, was: 87.5% cellulose (795.4 g) and 12.5% plastic/diesel fuel (114 g). Since this burn was done to characterize the emissions from the diesel fuel and dunnage mixture itself, i.e., the mixture did not contain any energetic materials, the mass of the material burned (909 g) was used to calculate the emission factors. (When this test was conducted, the USAF was sometimes using scrap wood from ammunition boxes, dead branches from bushes/trees, styrofoam packing materials, and other combustible materials (dunnage) and diesel fuel to assist in the open burning of munitions and other energetic materials found on training ranges. This practice is now prohibited by DOD.)

3.2.3 Identification of BangBox Data Sets That Should Be Rejected In Their Entirety

The first step in the assessment of the BangBox data sets was to determine if any of the 15 data sets had characteristics that made them unsuitable for inclusion in AP-42. Based on this assessment, the following data sets were judge unsuitable for inclusion for the reasons given below.

Smokey Sam Burn. The emissions data for this burn were excluded because: (1) only one Smokey Sam was burned; (2) some of the sampling equipment was overwhelmed by the emissions; and (3) DOD policy prohibits disposing of smokes by open burning.

Aluminized AP Manufacturing Waste Burn. The emissions data for this burn were excluded because both EPA and the commercial sponsor of the burn had concluded independently that the test conditions were not representative of any real-world OB process. In addition, the test sponsor, a rocket propellant manufacturer, had determined that the test protocol had not been followed.

Surrogate Diesel Fuel and Dunnage Burn. The emissions data for this burn were excluded because: (1) no energetic was burned; and (2) the EPA authors had determined that the test conditions were not representative of any real-world OB process.

Hercules Smokeless Powder Burn. This burn was excluded because only one burn was conducted and the emissions data were limited to CO_2, CO, PM-10, SO_2 and a few VOC compounds.

MK-23 Propellant Burn. This burn was excluded because: (1) only one burn was conducted; (2) the emissions data consisted of inorganic gases; and a few VOCs; and (3) the composition of the test material was deficient in several critical areas.

3.2.4 Selection of BangBox OB Emission Test Results For Inclusion in AP-42

The remaining ten materials covered in the EPA report were produced in four studies that had been funded by different DOD units for a variety of reasons. EPA compiled the emissions data sets from these studies into a validated emission factors data base after three DOD contractors had failed to accomplish the task. During its validation effort, EPA consulted the background information that was available on the emissions tests, such as, test design plans, final reports, field notes, calibration data, laboratory reports, and EPA and DOD contractor QA and QC reports.

Because it had provided independent QA support to these studies and because of its knowledge of the requirements for EF databases, EPA had a good understanding of the issues that needed to be addressed during its data assessment and validation effort if it was to produce a credible, validated database. For example, EPA selected only emissions data that had been collected using methods that would have produced credible and comparable data. EPA also provided a set of minimum quantitation limits (MQLs, expressed as the equivalent emission factor) for each measurement system. In addition, EPA conducted mass balance checks on the C, N, Cl, and Al-containing emission products to confirm that the results adhered to detonation reaction theory and to previous laboratory-based emissions characterization tests on energetic materials. Further, because most of the burn emission products were commonly occurring air pollutants that were present in the background air samples, EPA assessed and provided estimates in their report of the extent to which the emission factors had been corrected for background.

Some of the conventions and procedures used by EPA in assessing and reporting the emissions test results that are pertinent to this review are:

- If the background corrected EF for a burn trial was less than or equal to 0.0E+00, EPA reported the EF as 0.0E+00.

- If the emissions test report contained a value that was less than the MDL of the measurement system, EPA reported the EF as 0.0E+00.

- If the background corrected EF for an SVOC target analyte was less than 30% of the original (i.e., uncorrected) emission factor, EPA reported the EF as 0.0E+00.

- In calculating the average EF for data sets containing a combination of 0.0E+00 and non-zero values, EPA did not include the 0.0.E+00 values in the calculation.

- In order to conduct a statistical analysis of the data using its SAS program, EPA had to differentiate between instances where either no sample was collected (NS) or no data was available because the sampling result had been invalidated (NA) and instances where the target analyte was either never detected, or if detected, never detected above the background level (ND). Because the SAS program would not accept letter code entries, EPA substituted a period (.) for all NS and NA values and the value 0.0E+00 for all ND values.

The following decisions were then made concerning the inclusion of some or all of the EFs in the remaining 10 data sets in the AP-42 spreadsheet.

3.2.4.1 Inorganic Gases

The CO, CO_2, NO, NO_2, HCl, Cl_2, and SO_2 EF values were entered as reported and, with the exception of SO_2, also as the equivalent EFF value. (Because sulfur is present in small quantities in many energetic materials, it was likely an emission product when it was measured above the background level. However, since the mass of the sulfur in the items treated is unknown, EFF values could not be calculated.)

NOTE - The HCl results were accepted as reported because EPA had noted that a special test conducted in the BangBox in 1995 had determined that the loss of HCl to the surfaces of the BangBox would be less than 15 % over the 30-minute sampling interval.

3.2.4.2 Particulate Results

The PM-10 EF values were entered as reported. EFF values were not calculated because there is no known relationship between the composition of the energetic material and the PM-10 emissions.

3.2.4.3 Volatile Organic Compounds (VOCs)

The EPA report contained numerical emission factors for 37 of the 160 plus individual VOC compounds on the BangBox target analyte list. These compounds were the only VOC target analytes measured above the background level in the emissions from at least one of the test materials. (The VOC

target analytes that were either never detected or were never detected above the background level are identified in Table 31, *VOC Target Analytes Not Detected in Any of the BangBox Burn Plumes*.

EPA noted that one of the most vexing problems associated with characterizing the VOC air emissions from burns was that most of the emission products are compounds that are commonly found in ambient air. This can be seen by examining the information in Table 32, which shows the average EF for the 37 VOCs detected in the burn plumes along with: (1) the number of materials for which the VOC was listed as an EP; (2) the number of materials for which the VOC was detected in all of the burn plumes; and (3) the percentage that the background air contributed to the plume concentration. Based on the information in the EPA report and the information in Table 32 the following actions were taken to ensure that the VOC EFs conform to the EPA guidance before they were entered in the AP-42 Excel workbook.

- If the average EF value for a test material had been derived from a data set that included only non-zero numeric values, the EF value was converted to the corresponding EFF value and the EFF value entered. (The EF (lb/lb NEW) was converted to the equivalent EFF value (lb/lb C) by multiplying the EF value by the NEW burned and then dividing by the lb of C in the burn pile.)

- If the average EF for a test material had been derived from a data set containing a mix of 0.0E+00 and non-zero numeric values, the 0.0E+00 value was replaced with a value of 7.1E-08 lb/ lb NEW (1/2 the MDL) and the new average was calculated. This value was then converted to the equivalent EFF value and the EFF value was entered.

- If the EF for a test material was 0.0E+00 for all burn trials, the 0.0E+00 value was entered as BDL.

- If no sampling result was reported, the letter code ND was entered.

Table 31. VOC Target Analytes Not Detected in Any of the BangBox Burn Plumes.

CASRN	Compound	CASRN	Compound	CASRN	Compound
7642-09-3	Cis-3-hexene	127-18-4	Tetrachloroethylene	71-36-3	1-Butanol
619-99-8	3-Ethylhexane	138-86-3	1-Methylcyclohexene	71-55-6	Methyl chloroform
627-20-3	Cis-2-pentene	141-32-2	Butyl acrylate	73513-42-5	Isohexane
79-09-4	Propanoic acid	141-93-5	m-Diethylbenzene	7359-72-0	Trans-1,3-trichloropropene
83847-49-8	Bromochloromethane	156-60-5	Trans-1,2-dichloroethene	7443-70-1	Cis-2-octene
100-44-7	Benzyl chloride	1634-04-4	Methyl t-butyl ether	74-83-9	Methyl Bromide
100-47-0	Benzonitrile	2198-23-4	4-Nonene	75-00-3	Chloroethane
100-51-6	Benzyl alcohol	24-11-8	1-Nonene	75-05-8	Acetonitrile
100-52-7	Benzaldehyde	25168-05-2	Chlorotoluenes	75-07-0	Acetaldehyde
10061-01-5	Cis-1,3-dichloropropene	271-89-6	Benzofuran	75-25-2	Bromoform
103-65-1	N-propylbenzene	31394-54-4	Isoheptane	75-27-4	Bromodichloromethane
104-51-8	N-butylbenzene	3522-94-9	2,2,5-trimethylhexane	75-34-3	1,1-Dichloroethane
105-05-5	p-Diethylbenzene	463-82-1	Neopentane	75-35-4	1,1-Dichloroethene
106-42-3	p-Xylene	496-11-7	Indane	75-45-6	Chlorodifluoromethane
106-43-4	p-Chlorotoluene	513-35-9	2-methyl-2-butene	75-52-5	Nitromethane
106-46-7	p-Dichlorobenzene	526-73-8	1,2,3-Trimethylbenzene	75-69-4	Trichlorofluoromethane
107-02-8	Acrolein	538-93-2	Isobutylbenzene	75-71-8	Dichlorodifluoromethane
107-05-1	Allyl Chloride	540-59-2	Cis-1,2-dichloroethene	75-83-2	2,3-Dimethylbutane
107-06-2	1,2-Dichloroethane	540-84-1	2,2,4-Trimethylpentane	760-21-4	2-Ethyl-1-butene
1071-26-7	2,2-dimethylheptane	541-73-1	m-Dichlorobenzene	763-29-1	2-Methyl-1-pentene
107-13-1	Acrylonitrile	563-45-1	3-Methyl-1-butene	7688-21-3	Cis-2-hexene
107-39-1	2,4,4-Trimethyl-l-pentene	563-46-2	2-Methyl-1-butene	78-87-5	1,2-Dichloropropane
107-40-4	2,4,4-Trimethyl-2-pentene	564-02-3	2,2,3-Trimethylpentane	78-93-3	2-Butanone
107-85-5	2-Methylpentane	565-59-3	2,3-Dimethylpentane	79-00-5	1,1,2 Trichloroethane
108-05-4	Vinyl acetate	565-75-3	2,3,4-Trimethylpentane	79-01-6	Trichloroethene
108-08-7	2,4-Dimethylpentane	584-94-1	2,3-Dimethylhexane	79-34-5	1,1,2,2-Tetrachloroethane
108-10-1	Methylisobutylketone	589-34-4	3-Methylhexane	821-95-4	1-Undecene
108-38-3	m-Xylene	589-81-1	3-Methylheptane	87-68-3	Hexachloro-1,3-butadiene
108-41-8	m-Chlorotoluene	590-18-1	cis-2-Butene	9003-31-0	Isoprene
108-67-8	1,3,5-Trimethylbenzene	592-13-2	2,5-Dimethylhexane	922-62-3	Cis-3-methyl-2-pentene
108-90-7	Chlorobenzene	592-27-8	2-Methylheptane	92-52-4	Biphenyl
110-00-9	Furan	592-76-7	1-Heptene	95-13-6.	Indene
110-62-3	Pentanal	60-29-7	Diethyl ether	95-47-6	o-Xylene
110-8-27	Cyclohexane	611-14-3	o-Ethyltoluene	95-49-8	o-Chlorotoluene
110-83-8	Cyclohexene	624-91-9	Methylnitrite	95-50-1	o-Dichlorobenzene
111-66-0	1-Octene	625-27-4	2-Methyl-2-pentene	95-63-6	1,2,4-Trimethylbenzene
111-71-7	Heptanal	64-17-5	Ethanol	96-14-0	3-Methylpentane
1120-21-4	N-undecane	64-19-7	Acetic Acid	98-01-1	2-Furaldehyde
1120-72-5	Methylcyclopentene	66-25-1	Hexanal	98-06-6	Tert-butylbenzene
112-31-2	Decanal	6747-26-2	2,2,4-Trimethylhexane	98-82-8	Isopropylbenzene
120-82-1	1,2,4-Trichlorobenzene	674-76-0	Trans-4-methyl-2-pentene	98-86-2	Acetophenone
123-72-8	Butyraldehyde	67-63-0	2-Propanol	121-14-2	1,3-Dinitrobenzene
123-91-1	1,4-Dioxane	67-64-1	Acetone	99-87-8	p-Isopropyltoluene
124-13-0	Octanal	68037-01-4	1-Decene	NA	4-Methyl-2-pentanone
124-19-6	Nonanal	691-37-2	4-Methyl-1-pentene	126-99-8	Chloroprene
124-41-1	Dibromochloromethane	691-38-3	Cis-4-Methyl-2-pentene	71-23-8	1-Propanol

Table 32. Average Emission Factor and Background Correction for the VOC Compounds Detected.

Pollutant Category	Pollutant	Background Corrected Average EF	% Background Contributed to Uncorrected Average EF	Detected in Burn Plume of N Materials
Aromatic HC	Benzene	1.7E-05	3%	10
	p-Ethyltoluene	5.9E-07	56%	10
	Toluene	5.7E-07	93%	10
	Ethylbenzene	9.5E-08	83%	10
	m-Ethyltoluene	6.1E-08	89%	9
	Styrene	5.9E-08	96%	8
Chlorinated HC	Methylenechloride	2.1E-06	80%	8
	Vinyl chloride	2.2E-07	0%	7
	Carbon tetrachloride	1.3E-07	68%	9
	Methyl chloride	1.1E-07	53%	9
	Chloroform	4.2E-08	0%	9
Saturated HC	n-Hexane	2.2E-06	79%	9
	Methylcyclopentane	3.2E-07	79%	10
	Ethane	3.0E-07	70%	10
	n-Decane	2.7E-07	88%	10
	n-Pentane	1.8E-07	78%	10
	Propane	1.5E-07	80%	8
	i-Pentane	1.3E-07	79%	9
	n-Heptane	1.1E-07	79%	9
	n-Butane	8.1E-08	87%	8
	Cyclohexane	6.6E-08	80%	9
	Methylcyclohexane	5.3E-08	82%	9
	n-Octane	5.2E-08	86%	10
	n-Nonane	3.2E-08	81%	10
	Cyclopentane	4.8E-09	94%	8
	i-Butane	4.3E-09	99%	10
Unsaturated HC	Acetylene	2.2E-05	0%	10
	Ethylene	2.7E-06	0%	8
	Propylene	9.7E-07	4%	7
	i-Butene	8.8E-07	39%	9
	1-Butene	1.7E-07	0%	9
	1,3-Butadiene	1.1E-07	0%	6
	trans-2-Butene	9.7E-08	0%	9
	1-Pentene	2.9E-08	51%	10
	1-Hexene	2.7E-08	30%	10
	Cyclopentene	2.1E-08	0%	9
	cis-2-Pentene	9.1E-09	69%	10

3.2.4.4 Metals

EPA had noted that many of the plume samples had been contaminated with metals from: (a) the concrete floor of the BangBoxes, (b) residues on the BangBox floor left from earlier detonation and burn tests, (c) the decomposition of the pea gravel on which many of the test materials rested while they burned, and (d) the plated steel burn pans holding the pea gravel. However, EPA did not attempt to correct the metal emissions data for this contamination. EPA made this observation based on a number of instances where metal emission factors on the order of 1E-04 to 1E-05 had been produced when metal-free propellant materials had been burned in the Dugway Proving Ground (DPG) and Sandia National Laboratories (SNL) BangBoxes.

To remove spurious metal EFs from the data sets, all of the information available on the metals content of the materials burned was compiled using the composition data in the EPA report and in MIDAS. This review determined that Al and Pb were the only target metals definitely present in the materials burned. (NOTE – Although some of the test materials contained alkali and alkaline earth metals, these metals were not target analytes in these studies.) Based on these findings, the following actions were taken:

- The EFs for the materials containing Al and Pb were converted to the equivalent EFF values and the values entered. The Al values were entered under the Metals in Energetic as Particle category and the Pb were entered under the Metals in Energetic as Compound category.

- If EPA had reported a non-zero EF value for either Al or Pb for a test material that did not contain the metal, the letter code NA was entered in the AP-42 workbook.

- If EPA had reported an EF value of 0.0E+00 for Al or Pb for a test material that might have contained these metals, the letter code ND was entered.

- If the EPA report did not contain an entry for Al or Pb, the letter code NA was entered.

- The results for the other metals were rejected.

3.2.4.5 Energetics

The plumes from eight of the test materials were sampled for energetic compounds, but because of instrument failure, valid samples were obtained for only three of the test materials. None of the target energetic analytes were detected in the plumes for these three materials. The following actions were taken regarding entering the energetic emissions data in the workbook.

- If the energetic compound was present in the material and a valid sample was collected, BDL was entered. NOTE - Because the BangBox MDL for the energetic plume measurement (1E-08 lb/ lb NEW) was 660 times higher than that for the system used in the DPG open range burn tests (MDL = 6.6E-10 lb/ lb NEW), it was not appropriate to change a BDL value to a value equal to 1/2MDL before entering the value in the AP-42 workbook.[19]

- If the energetic compound was present in the material, but a valid sample was not collected, ND was entered.

- If the energetic compound was not present in the material (hence not a possible emission product), the letter code NA was entered.

3.2.4.6 SVOC/POM Compounds

SVOC/POM samples were collected from the plumes from eight of the ten materials and analyzed for 120 SVOCs/POMs, including two SVOCs/POMs (2,4-dinitrotoluene and diphenylamine) that were present in some of the test materials (Table 33). However, 2-chlorophenol was the only SVOC/POM target analyte detected above either the measurement system MDL (9E-06 lb/ lb NEW) or the background level. It was detected in two of the three aluminized AP propellant burn plumes. Based on these observations, the following actions were taken regarding entering the SVOC EFs on the AP-42 candidate spreadsheet:

SVOCs/POMs in the Material Burned. BDL was entered for the two compounds in this category -- diphenylamine (DPA) and 2, 4-dinitrotoluene (2, 4-DNT) -- when they were present in the test material. When they were not present, NA was entered. (NOTE - Entering a value equal to 1/2 of the MDL was not appropriate because these compounds had been detected in the open range burn study at levels 10 to 150 times lower than the BangBox SVOC MDL).

*SVOCs/POMs Not in the Energetic Material Burn*ed. The 2-chlorophenol EF value was entered as reported by EPA. To facilitate a comparison between the DPG open range and the BangBox emissions data sets, BDL (MDL = 4.5E-06 lb/ lb NEW) was entered for the BangBox SVOC analytes that were also target analytes in the DPG open range burn tests. (Entering a value equal to 1/2 of the MDL was not appropriate because these compounds had been detected in the open range burn study at levels 10 to 150 times lower than the BangBox SVOC/POM MDL.)

3.2.4.7 Polychlorinated Dioxin and Furans (PCDDs/PCDFs)

The PCDD/PCDD target analytes were: 1,2,3,4,6,7,8,9-Octachlorodibenzodioxin, 1,2,3,4,6,7,8-Heptachlorodibenzodioxin, 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin, 1,2,3,7,8-Pentachlorodibenzo-p-dioxin, 2,3,7,8-Tetrachlorodibenzo-p-Dioxin, 1,2,3,4,7,8,9-Heptachlorodibenzofuran, 1,2,3,4,6,7,8,9-Octachlorodibenzofuran, 1,2,3,4,6,7,8-Heptachlorodibenzofuran, 1,2,3,4,7,8-hexachlorodibenzofuran, 1,2,3,6,7,8-hexachlorodibenzofuran, 1,2,3,7,8,9-Hexachlorodibenzofuran, 1,2,3,7,8-Pentachlorodibenzofuran, 2,3,4,6,7,8-Hexachlorodibenzofuran, 2,3,4,7,8-Pentachlorodibenzofuran and 2,3,7,8-Tetrachlorodibenzofuran.

` The burn plumes from the following three propellants were the only ones sampled for the PCDD/PCDF target analytes: AP propellant, Aluminized AP propellant, and MK6 propellant. These items were evaluated for PCDD/PCDF emissions because they contained the plastic and chlorine compounds necessary to produce PCDD/PCDF EPs. All sampling results were BDL. Therefore, BDL (MDL = 9.0E-12 lb/ lb NEW) was entered on the AP-42 candidate spreadsheet for the three AP-containing materials, and ND was entered for the other seven test materials.

1 Table 33. SVOC/POM Open Burn Target Analytes.

CASRN	Compound	CASRN	Compound
100-01-6	4-Nitroaniline	56-55-3	Benz(a)anthracene
100-02-7	4-Nitrophenol	56-57-5	4-Nitroquinoline-1-oxide
100-51-6	Benzyl alcohol	57-97-6	Dimethylbenz(a)anthracene
100-75-4	Nitrosopiperdine,N-	581-89-5	2-Nitronaphthalene
101-55-3	Bromophenylphenylether	59-50-7	4-Chloro-3-methylphenol
105-67-9	2,4-Dimethylphenol	59-89-2	N-Nitrosomorpholine
10595-95-6	Nitrosomethylethylamine,N-	59-90-2	2,3,4,6-Tetrachlorophenol
106-44-5	Methylphenol,4-	60-11-7	p-Dimethylaminoazobenzene
106-46-7	1,4-Dichlorobenzene	606-20-2	2,6-Dinitrotoluene
106-47-8	p-Chloroaniline	98-95-3	Nitrobenzene
108-39-4	3-Methylphenol	608-93-5	Pentachlorobenzene
108-95-2	Phenol	621-64-7	Nitrosodi-n-propylamine,N-
109-06-8	2-Picoline	62-44-2	Phenacetin
110-86-1	Pyridine	62-50-0	Ethyl Methanesulfonate
111-41-4	Bis(2-chloroethyl)ether	62-75-9	Nitrosodimethylamine,N-
111-91-1	Bis(2-chloroethoxy)methane	65-85-0	Benzoic acid
117-81-7	Bis(2-ethylhexyl)phthalate	66-27-3	Methyl Methanesulfonate
117-84-0	Di-n-octyl phthalate	67-72-1	Hexachloroethane
118-74-1	Hexachlorobenzene	7005-72-3	4-Chlorophenylphenyl Ether
119-75-5	2-Nitrodiphenylamine	76-01-7	Pentachloroethane
119-93-7	Dimethylbenzidine,3,3'-	77-47-4	Hexachlorocyclopentadiene
120-12-7	Anthracene	78-59-1	Isophorone
120-58-1	Isosafrole	84-66-2	Diethylphthalate
120-82-1	1,2,4-Trichlorobenzene	84-74-2	Di-n-butylphthalate
120-83-2	1-Methylnaphthalene	85-01-8	Phenanthrene
120-833-2	2,4-Dichlorophenol	85-68-7	Butyl benzyl phthalate
121-14-2	2,4-Dinitrotoluene	86-30-6	N-Nitrosodiphenylamine
122-09-8	Dimethylphenethylamine	86-73-7	Fluorene
122-39-4	Diphenylamine	87-65-1	2,6-Dichlorophenol
122-66-7	1,2 Diphenylhydrazine	87-86-5	Pentachlorophenol
126-68-1	Triethylphosphorothioate	88-06-2	2,4,6-Trichlorophenol
129-00-0	Pyrene	88-72-2	2-Nitrotoluene
130-15-4	1,4-Naphthoquinone	88-74-4	2-Nitroaniline
131-11-3	Dimethylphthalate	88-75-5	2-Nitrophenol
132-64-9	Dibenzofuran	91-20-3	Naphthalene
134-32-7	1-Naphthylamine	91-57-6	2-Methylnaphthalene
143-50-0	Kepone	91-58-7	2-Chloronaphthalene
1888-71-7	Hexachloropropene	91-59-8	2-Naphthylamine
191-24-2	Benzo(g,h,i)perylene	91-80-5	Methapyrilene
193-39-5	Indeno[1,2,3-cd]pyrene	91-94-1	3,3'-Dichlorobenzidine
19406-51-0	4-Amino-2,6-Dinitrotoluene	924-16-3	Nitrosodi-n-butylamine,N-
205-99-2	Benzo(b)fluoranthene	92-52-4	Biphenyl
206-44-0	Fluoranthene	92-67-1	Aminobiphenyl,4-
207-08-9	Benzo(k)fluoranthene	92-87-5	Benzidine
208-96-8	Acenaphthylene	930-55-2	Nitrosopyrrolidine,N-
218-01-9	Chrysene	94-59-7	Safrole
2303-16-4	Diallate	95-48-7	Methylphenol,2-
23950-58-5	Pronamide	95-50-1	1,2-Dichlorobenzene
39638-32-9	Bis(2-chloroisopropyl)ether	95-53-4	o-Toluidine
50-32-8	Benz(a)pyrene	95-57-8	2-Chlorophenol
510-15-6	Chlorobenzilate	95-57-8	2-Methylphenol
51-28-5	2,4-Dinitrophenol	95-94-3	1,2,4,5-Tetrachlorobenzene
522-43-0	1-Nitropryene	95-95-4	2,4,5-Trichlorophenol
534-52-1	4,6-Dinitro-2-methylphenol	98-86-2	Acetophenone
53-70-3	Dibenz[a,h]anthracene	98-95-3	Nitrobenzene
53-96-3	Acetylaminofluorene,2-	99-09-2	3-Nitroaniline
540-73-8	Dimethylhydrazine,1,2-	99-35-4	1,3,5-Trinitrobenzene
541-73-1	1,3-Dichlorobenzene	99-55-8	5-Nitro-o-toluidine
55-18-5	Nitrosodiethylamine,N-	99-65-0	1,3-Dinitrobenzene
56-49-5	3-Methylcholanthrene	99-99-0	4-Nitrotoluene

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3.2.5 Emissions Test Data Quality Ratings Assigned To Each EF/EFF

All of the BangBox EF/EFFs possessed the following positive characteristics. First, the emissions data were collected using sound and credible sampling and analysis methodology under conditions reasonably representative of real-world open burn processes. Second, the SF_6 method used to determine the burn plume volume was very reliable. Third, descriptions of the compositions for most of the test materials were either provided in the EPA report and/or were available in MIDAS. Fourth, documentation in the report and its appendices showed that all field testing and laboratory analyses activities were extensively and continuously audited by independent DOD contractors and also by the EPA over the life of the project, and that the EPA report itself was subjected to a highly credible peer review before it was released. Fifth, although the raw data sheets are no longer available, the EPA report shows they were used to construct the EFs presented in the test report. Sixth, the test results reported were consistent with detonation reaction theory and the DPG open range results, which involved much larger burns under conditions that reflected real-world OB demil operations.

Based on these characteristics and the quality rating criteria recommendations in Section 4.4.2 of EPA's AP-42 guidance document for preparing AP-42 documents,[19] the data sets were assigned a preliminary EPA quality rating of B. This preliminary quality rating was converted to a final rating as described below.

3.2.5.1 Inorganic Gases

The EPA quality rating of B was retained.

3.2.5.2 Volatile Organic Compounds (VOCs)

As discussed earlier, most of the VOCs measured in the plume were also detected in the background samples at concentrations often similar to those measured in the burn plumes. As discussed in Section 3.2.4.3, an attempt was made to adjust the EFFs for the contribution from the background air. In fact, the EFFs for 23 of the 37 VOCs detected had been corrected by more than 50%, which raises concerns about the accuracy and representativeness of these EFFs. The extent to which the EFF value had been adjusted for the background along with the absolute value of the EFF and the number of times it was detected were used to assign the final quality rating to each VOC EP.

3.2.5.3 Metals

The quality rating was lowered to C, primarily because of the limited number of plumes sampled. That is, three of the four values were derived through duplicate burns and the other from a single test burn.

3.2.5.4 Energetic Compounds

All of the EFFs were BDL. Further, the MDL of the BangBox measurement system was several orders of magnitude higher than that for the DPG open range burn tests and the energetic EFFs associated with the DPG open range tests (Tables 26 and 27) were also orders of magnitude lower than the BangBox MDL. Therefore, the quality rating was reduced to D.

3.2.5.5 SVOCs/POMs

All of the EFs and EFFs were BDL. Further, the MDL of the BangBox measurement system was several orders of magnitude higher than that for the DPG open range burn tests and the SVOC/POM EFFs associated with the DPG open range tests (Tables 26 and 27) were also at least an order of magnitude lower than the BangBox MDL. Therefore, the quality rating was reduced to D.

3.2.5.6 PCDDs and PCDFs

Although all the EFs were BDL, the MDL of the measurement system was very low, i.e., 9E-12 lb/lb NEW. It was decided to retain the quality rating of B based primarily on this fact and the consistency of the sampling results with detonation reaction theory.

3.2.5.7 PM-10

The EPA quality rating of B was retained.

3.2.6 Tabulation and Presentation of the Emissions Data

The BangBox open burn emissions data selected for inclusion in AP-42 are presented in Tables 34 through 37 along with the EPA quality rating factor assigned to each EF/EFF value. To facilitate comparing the EFs/EFFs for similar materials, the emissions data for similar materials were placed in the same table. Table 34 presents the results for the AP-propellants, Table 35 presents the results for single-base and triple-base propellants, Table 36 presents the results for double-base propellants and Table 37 presents the results for the PBX propellants.

NOTE – As discussed earlier, 2-chlorophenol was the only SVOC/POM detected in any burn plume and it was associated with only one test material. To avoid cluttering the tables with 120 plus BDLs for the other SVOCs/POMs, it was decided to list in Tables 34 through 37 only 2-chlorophenol and the SVOCs/POMs that were also target analytes in the DPG open range tests

Table 34. EFs/EFFs for the Open Burning of AP Propellants in the BangBox.

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	4.2E-01	B	1.5E-02	B	ND	B
PCDD & PCDF(a)	3268-87-9	1,2,3,4,6,7,8,9-OCDD	lb/lb NEW	BDL	B	BDL	B	BDL	B
	35822-46-9	1,2,3,4,6,7,8-HpCDD		BDL	B	BDL	B	BDL	B
	55673-89-7	1,2,3,4,7,8,9-HpCDD		BDL	B	BDL	B	BDL	B
	39227-28-6	1,2,3,4,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	57653-85-7	1,2,3,6,7,8-HxCDD		BDL	B	BDL	B	BDL	B
	19408-74-3	1,2,3,7,8,9-HxCDD		BDL	B	BDL	B	BDL	B
	40321-76-4	1,2,3,7,8-PeCDD		BDL	B	BDL	B	BDL	B
	1746-01-6	2,3,7,8-TCDD		BDL	B	BDL	B	BDL	B
	39001-02-0	1,2,3,4,6,7,8,9-OCDF		BDL	B	BDL	B	BDL	B
	67562-39-4	1,2,3,4,6,7,8-HpCDF		BDL	B	BDL	B	BDL	B
	70648-26-9	1,2,3,4,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-44-9	1,2,3,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	72918-21-9	1,2,3,7,8,9-HxCDF		BDL	B	BDL	B	BDL	B
	57117-41-6	1,2,3,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	60851-34-5	2,3,4,6,7,8-HxCDF		BDL	B	BDL	B	BDL	B
	57117-31-4	2,3,4,7,8-PeCDF		BDL	B	BDL	B	BDL	B
	51207-31-9	2,3,7,8-TCDF		BDL	B	BDL	B	BDL	B
SVOC & POM(b)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol		BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene		BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine		BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene		BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran		BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene		BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene		BDL	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol		BDL	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene		BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol		1.1E-05	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene		BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol		BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene		BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene		BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D

Table 34. EFs/EFFs for the Open Burning of AP Propellants in the BangBox (continued).

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	BDL	D	BND	D	ND	NA
	106-98-9	1-Butene		BDL	D	BDL	D	ND	NA
	592-41-6	1-Hexene		BDL	D	BDL	D	ND	NA
	109-67-1	1-Pentene		BDL	D	BDL	D	ND	NA
	74-86-2	Acetylene		9.1E-05	B	BDL	B	2.1E-04	C
	71-43-2	Benzene		BDL	C	BDL	C	5.7E-04	C
	56-23-5	Carbon tetrachloride		BDL	D	BDL	D	ND	NA
	627-20-3	cis-2-Pentene		BDL	D	BDL	D	ND	NA
	110-82-7	Cyclohexane		BDL	D	BDL	D	ND	NA
	287-92-3	Cyclopentane		BDL	D	BDL	D	ND	NA
	142-29-0	Cyclopentene		BDL	D	BDL	D	ND	NA
	74-84-0	Ethane		BDL	D	BDL	D	ND	NA
	100-41-4	Ethylbenzene		BDL	D	BDL	D	ND	NA
	74-85-1	Ethylene		BDL	C	BDL	C	ND	NA
	75-28-5	Isobutane		BDL	D	BDL	D	ND	NA
	115-11-7	Isobutene		4.5E-05	C	BDL	D	ND	NA
	78-78-4	Isopentane		BDL	D	BDL	D	ND	NA
	74-87-3	Methyl chloride		BDL	D	BDL	D	ND	NA
	108-87-2	Methylcyclohexane		BDL	D	BDL	D	ND	NA
	96-37-7	Methylcyclopentane		BDL	D	BDL	D	ND	NA
	75-09-2	Methylene chloride		BDL	D	BDL	D	ND	NA
	620-14-4	m-Ethyltoluene		BDL	D	BDL	D	ND	NA
	106-97-8	n-Butane		BDL	D	BDL	D	ND	NA
	124-18-5	n-Decane		BDL	D	BDL	D	ND	NA
	142-82-5	n-Heptane		BDL	D	BDL	D	ND	NA
	110-54-3	n-Hexane		BDL	D	BDL	D	ND	NA
	111-84-2	n-Nonane		BDL	D	BDL	D	ND	NA
	111-65-9	n-Octane		BDL	D	BDL	D	ND	NA
	109-66-0	n-Pentane		BDL	D	BDL	D	ND	NA
	622-96-8	p-Ethyltoluene		BDL	D	BDL	D	ND	NA
	74-98-6	Propane		BDL	D	BDL	D	ND	NA
	115-07-1	Propylene		BDL	C	BDL	C	ND	NA
	100-42-5	Styrene		BDL	D	BDL	D	ND	NA
	NA	TNMHC		4.5E-04	C	3.6E-04	C	ND	NA
	108-88-3	Toluene		BDL	D	BDL	D	ND	NA
	624-64-6	trans-2-Butene		BDL	D	BDL	D	ND	NA
	75-01-4	Vinyl chloride		BDL	D	BDL	D	ND	NA

Table 34. EFs/EFFs for the Open Burning of AP Propellants in the BangBox (continued).

EP Category	CASRN	EP	Units	Aluminized AP Propellant		Non- Aluminized AP Propellant		MK-6 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
Energetics	121-82-4	RDX	lb/lb Energetic	NA	NA	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA	NA	NA
	55-63-0	NG		NA	NA	NA	NA	NA	NA
	556-88-7	NQ		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lbNEW	4.7E-05	B	1.1E-04	B	1.5E-04	B
	NA	Nitrogen Oxides	lb/lb N	3.3E-02	B	8.6E-02	B	1.9E-02	B
	7782-50-5	Chlorine	lb/lb Cl	2.1E-02	B	3.5E-02	B	NS	NA
	7647-01-0	Hydrogen chloride	lb/lb Cl	9.4E-01	B	8.5E-01	B	ND	NA
	124-38-9	Carbon dioxide	lb/lb C	3.0E+00	B	3.4E+00	B	4.1E+00	B
	630-08-0	Carbon monoxide	lb/lb C	1.1E-02	B	1.3E-03	B	4.1E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	5.5E-02	C	NA	NA	2.9E-02	C
	7439-92-1	Pb (In Energetic As Compound)		NA	NA	NA	NA	NA	NA
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb SVOC	NA	NA	NA	NA	NA	NA
	122-39-4	Diphenylamine		NA	NA	NA	NA	NA	NA

(a) MDL = 9.0E-12 /b/lb NEW

(b) MDL = 4.5E-06 lb/lb NEW

(c) MDL = 8.0E-08 lb/lb C

1 Table 35. EFs/EFFs for the Open Burning of Single-base and Triple-base Propellants in the BangBox.

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	8.6E-03	B	9.1E-01	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D
	108-95-2	Phenol		BDL	D	BDL	D
	85-01-8	Phenanthrene		BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine		BDL	D	BDL	D
	91-20-3	Naphthalene		BDL	D	BDL	D
	132-64-9	Dibenzofuran		BDL	D	BDL	D
	50-32-8	Benz(a)pyrene		BDL	D	BDL	D
	56-55-3	Benz(a)anthracene		BDL	D	BDL	D
	100-02-7	4-Nitrophenol		BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene		BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene		BDL	D	BDL	D
	95-57-8	2-Chlorophenol		BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene		BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D
	522-43-0	1-Nitropryene		BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene		BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D
	88-75-5	2-Nitrophenol		BDL	D	BDL	D
	88-72-2	2-Nitrotoluene		BDL	D	BDL	D
	99-99-0	4-Nitrotoluene		BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene		BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D
Energetics	121-82-4	RDX	lb/lb Energetic	NA	NA	NA	NA
	2691-41-0	HMX		NA	NA	NA	NA
	55-63-0	NG		NA	NA	ND	NA
	556-88-7	NQ		NA	NA	ND	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	NS	NA	1.2E-03	B
	NA	Nitrogen Oxides	lb/lb N	NS	NA	6.3E-03	B
	124-38-9	Carbon dioxide	lb/lb C	2.3E+00	B	4.0E+00	B
	630-08-0	Carbon monoxide	lb/lb C	2.6E-02	B	8.7E-04	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7439-92-1	Pb (In Energetic As Compound)		NA	NA	NA	NA
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb SVOC	BDL(b)	D	NA	NA
	122-39-4	Diphenylamine		BDL(b)	D	NA	NA

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Table 35. EFs/EFFs for the Open Burning of Single-base and Triple-base Propellants in the BangBox (continued)

EP Category	CASRN	EP	Units	M1 Propellant		M31A1E1 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	ND	NA	ND	NA
	106-98-9	1-Butene		BDL	C	BDL	C
	592-41-6	1-Hexene		1.2E-07	C	BDL	C
	109-67-1	1-Pentene		1.1E-07	C	BDL	C
	74-86-2	Acetylene		2.5E-05	B	BDL	C
	71-43-2	Benzene		1.9E-05	B	BDL	C
	56-23-5	Carbon tetrachloride		ND	NA	BDL	D
	627-20-3	cis-2-Pentene		BDL	D	BDL	D
	110-82-7	Cyclohexane		1.7E-06	C	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D
	142-29-0	Cyclopentene		BDL	C	BDL	C
	74-84-0	Ethane		2.5E-06	C	BDL	D
	100-41-4	Ethylbenzene		2.8E-07	D	BDL	D
	74-85-1	Ethylene		1.5E-05	B	BDL	C
	75-28-5	Isobutane		BDL	D	BDL	D
	115-11-7	Isobutene		5.1E-07	C	BDL	D
	78-78-4	Isopentane		2.5E-08	D	BDL	D
	74-87-3	Methyl chloride		1.7E-07	D	BDL	D
	108-87-2	Methylcyclohexane		1.0E-07	D	BDL	D
	96-37-7	Methylcyclopentane		4.7E-06	D	BDL	D
	75-09-2	Methylene chloride		3.6E-05	B	3.3E-08	D
	620-14-4	m-Ethyltoluene		1.2E-07	D	BDL	D
	106-97-8	n-Butane		1.7E-07	D	BDL	D
	124-18-5	n-Decane		1.1E-06	D	BDL	D
	142-82-5	n-Heptane		5.8E-07	D	BDL	D
	110-54-3	n-Hexane		3.6E-05	D	BDL	D
	111-84-2	n-Nonane		2.3E-07	D	BDL	D
	111-65-9	n-Octane		8.1E-07	D	BDL	D
	109-66-0	n-Pentane		1.6E-06	D	BDL	D
	622-96-8	p-Ethyltoluene		1.8E-06	D	BDL	D
	74-98-6	Propane		9.4E-07	D	BDL	D
	115-07-1	Propylene		3.8E-06	B	BDL	C
	100-42-5	Styrene		BDL	D	BDL	D
	NA	TNMHC		1.8E-04	C	6.7E-04	C
	108-88-3	Toluene		3.4E-06	D	BDL	D
	624-64-6	trans-2-Butene		3.6E-07	C	BDL	C
	75-01-4	Vinyl chloride		BDL	C	BDL	C

(a) MDL = 4.5E-06 lb/lb NEW

(b) MDL = 1.0E-06 lb/lb DNT

(c) MDL = 8.0E-08 lb/lb C

Table 36. EFs/EFFs for the Open Burning of Double-base Propellants in the BangBox.

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lbNEW	1.9E-02	B	ND	NA	1.6E-02	B
SVOC & POM(a)	129-00-0	Pyrene	lb/lb NEW	BDL	D	BDL	D	BDL	D
	108-95-2	Phenol		BDL	D	BDL	D	BDL	D
	85-01-8	Phenanthrene		BDL	D	BDL	D	BDL	D
	86-30-6	N-Nitrosodiphenylamine		BDL	D	BDL	D	BDL	D
	91-20-3	Naphthalene		BDL	D	BDL	D	BDL	D
	132-64-9	Dibenzofuran		BDL	D	BDL	D	BDL	D
	50-32-8	Benz(a)pyrene		BDL	D	BDL	D	BDL	D
	56-55-3	Benz(a)anthracene		ND	D	BDL	D	BDL	D
	100-02-7	4-Nitrophenol		ND	D	BDL	D	BDL	D
	581-89-5	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	91-57-6	2-Methylnaphthalene		BDL	D	BDL	D	BDL	D
	95-57-8	2-Chlorophenol		BDL	D	BDL	D	BDL	D
	606-20-2	2,6-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	522-43-0	1-Nitropryene		BDL	D	BDL	D	BDL	D
	99-35-4	1,3,5 -Trinitrobenzene		BDL	D	BDL	D	BDL	D
	122-39-4	Diphenylamine		BDL	D	BDL	D	BDL	D
	121-14-2	2,4-Dinitrotoluene		BDL	D	BDL	D	BDL	D
	88-75-5	2-Nitrophenol		BDL	D	BDL	D	BDL	D
	88-72-2	2-Nitrotoluene		BDL	D	BDL	D	BDL	D
	99-99-0	4-Nitrotoluene		BDL	D	BDL	D	BDL	D
	581-89-2	2-Nitronaphthalene		BDL	D	BDL	D	BDL	D
	119-75-5	2-Nitrodiphenylamine		BDL	D	BDL	D	BDL	D
Energetics	121-82-4	RDX	lb/lb Energetic	ND	NA	NA	NA	NA	NA
	2691-41-0	HMX		ND	NA	NA	NA	NA	NA
	55-63-0	NG		ND	NA	BDL(b)	D	BDL(b)	D
	556-88-7	NQ		NA	NA	NA	NA	NA	NA
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	2.5E-05	B	3.6E-04	B	NS	NA
	NA	Nitrogen Oxides	lb/lb N	9.4E-03	B	6.5E-02	B	NS	B
	124-38-9	Carbon dioxide	lb/lb C	3.2E+00	B	ND	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	7.3E-03	B	4.8E-03	B	1.0E-02	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA	NA	NA
	7439-92-1	Pb (In Energetic As Compound)		6.3E-01	C	7.2E-01	C	NA	NA
SVOCs in Energetics	121-14-2	2,4-Dinitrotoluene	lb/lb SVOC	NA	NA	NA	NA	NA	NA
	122-39-4	Diphenylamine		NA	NA	NA	NA	NA	NA

Table 36. EFs/EFFs for the Open Burning of Double-base Propellants in the BangBox (continued).

EP Category	CASRN	EP	Units	Double- Base Propellant		NOSIH AA2 Propellant		M9 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating	EF/EFF	Quality Rating
VOCs(c)	106-99-0	1,3-Butadiene	lb/lb C	BDL	C	BDL	C	BDL	C
	106-98-9	1-Butene		BDL	D	NA	NA	1.0E-06	C
	592-41-6	1-Hexene		BDL	D	NA	NA	8.1E-07	C
	109-67-1	1-Pentene		BDL	D	NA	NA	1.7E-07	C
	74-86-2	Acetylene		BDL	C	6.0E-04	B	3.5E-05	B
	71-43-2	Benzene		BDL	C	6.0E-04	B	1.2E-05	B
	56-23-5	Carbon tetrachloride		BDL	D	NA	NA	7.7E-07	D
	627-20-3	cis-2-Pentene		BDL	D	NA	NA	BDL	D
	110-82-7	Cyclohexane		BDL	D	NA	NA	BDL	D
	287-92-3	Cyclopentane		BDL	D	NA	NA	1.7E-07	D
	142-29-0	Cyclopentene		BDL	C	NA	NA	BDL	C
	74-84-0	Ethane		BDL	D	NA	NA	2.2E-06	D
	100-41-4	Ethylbenzene		BDL	D	NA	NA	BDL	D
	74-85-1	Ethylene		BDL	C	NA	NA	2.5E-05	B
	75-28-5	Isobutane		BDL	D	NA	NA	1.7E-07	D
	115-11-7	Isobutene		BDL	D	NA	NA	1.0E-06	C
	78-78-4	Isopentane		BDL	D	NA	NA	BDL	D
	74-87-3	Methyl chloride		BDL	D	NA	NA	BDL	D
	108-87-2	Methylcyclohexane		BDL	D	NA	NA	BDL	D
	96-37-7	Methylcyclopentane		BDL	D	NA	NA	BDL	D
	75-09-2	Methylene chloride		BDL	D	NA	NA	1.9E-08	D
	620-14-4	m-Ethyltoluene		BDL	D	NA	NA	1.7E-07	D
	106-97-8	n-Butane		BDL	D	NA	NA	BDL	D
	124-18-5	n-Decane		BDL	D	NA	NA	BDL	D
	142-82-5	n-Heptane		BDL	D	NA	NA	BDL	D
	110-54-3	n-Hexane		BDL	D	NA	NA	BDL	D
	111-84-2	n-Nonane		BDL	D	NA	NA	BDL	D
	111-65-9	n-Octane		BDL	D	NA	NA	BDL	D
	109-66-0	n-Pentane		BDL	D	NA	NA	BDL	D
	622-96-8	p-Ethyltoluene		BDL	D	NA	NA	1.5E-05	C
	74-98-6	Propane		BDL	D	NA	NA	BDL	D
	115-07-1	Propylene		BDL	C	NA	NA	2.8E-06	B
	100-42-5	Styrene		BDL	D	NA	NA	1.8E-06	C
	NA	TNMHC		5.2E-04	C	NA	NA	5.8E-05	C
	108-88-3	Toluene		BDL	D	NA	NA	BDL	D
	624-64-6	trans-2-Butene		BDL	D	NA	NA	BDL	D
	75-01-4	Vinyl chloride		ND	NA	NA	NA	BDL	D

(a) MDL = 4.5E-06 lb/lb NEW

(b) MDL = 1E-07 lb/lb NG

(c) MDL = 8.0E-08 lb/lb C

Table 37. EFs/EFFs for the Open Burning of PBX Propellants in the BangBox.

EP Category	CASRN	EP	Units	M43 Propellant		PBXN-110 Propellant	
				EF/EFF	Quality Rating	EF/EFF	Quality Rating
PM-10	NA	PM-10	lb/lb NEW	1.2E-03	B	4.9E-01	B
VOCs(a)	106-99-0	1,3-Butadiene	lb/lb C	4.6E-02	B	1.9E-06	B
	106-98-9	1-Butene		1.4E-06	C	2.2E-06	C
	592-41-6	1-Hexene		BDL	C	BDL	C
	109-67-1	1-Pentene		4.6E-07	D	3.7E-07	D
	74-86-2	Acetylene		3.0E-05	B	1.1E-05	B
	71-43-2	Benzene		8.5E-06	B	1.8E-05	B
	56-23-5	Carbon tetrachloride		BDL	D	BDL	D
	627-20-3	cis-2-Pentene		4.6E-07	D	BDL	D
	110-82-7	Cyclohexane		4.6E-07	D	BDL	D
	287-92-3	Cyclopentane		BDL	D	BDL	D
	142-29-0	Cyclopentene		4.6E-07	C	3.7E-07	C
	74-84-0	Ethane		9.0E-07	D	3.7E-06	D
	100-41-4	Ethylbenzene		BDL	D	3.0E-06	D
	74-85-1	Ethylene		2.4E-05	B	2.5E-05	B
	75-28-5	Isobutane		BDL	D	BDL	D
	115-11-7	Isobutene		2.7E-06	C	4.8E-06	C
	78-78-4	Isopentane		4.6E-07	D	BDL	D
	74-87-3	Methyl chloride		BDL	D	6.7E-07	D
	108-87-2	Methylcyclohexane		BDL	D	BDL	D
	96-37-7	Methylcyclopentane		BDL	D	BDL	D
	75-09-2	Methylene chloride		BDL	D	2.2E-06	D
	620-14-4	m-Ethyltoluene		BDL	D	7.4E-07	D
	106-97-8	n-Butane		4.6E-07	D	3.7E-07	D
	124-18-5	n-Decane		4.1E-06	D	4.8E-06	D
	142-82-5	n-Heptane		4.6E-07	D	BDL	D
	110-54-3	n-Hexane		4.6E-07	D	1.9E-08	D
	111-84-2	n-Nonane		BDL	D	7.4E-07	D
	111-65-9	n-Octane		4.6E-07	D	BDL	D
	109-66-0	n-Pentane		BDL	D	BDL	D
	622-96-8	p-Ethyltoluene		9.0E-07	D	1.1E-06	D
	74-98-6	Propane		BDL	D	1.1E-06	D
	115-07-1	Propylene		5.5E-06	B	1.1E-05	B
	100-42-5	Styrene		BDL	D	BDL	D
	NA	TNMHC		2.1E-04	C	1.9E-04	C
	108-88-3	Toluene		2.7E-06	D	BDL	D
	624-64-6	trans-2-Butene		9.0E-07	C	1.5E-06	B
	75-01-4	Vinyl chloride		BDL	D	8.1E-07	C
Inorganic Gases	7446-09-5	Sulfur dioxide	lb/lb NEW	1.2E-04	B	3.5E-04	B
	NA	Nitrogen Oxides	lb/lb N	3.1E-02	B	1.2E-02	B
	124-38-9	Carbon dioxide	lb/lb C	3.9E+00	B	3.7E+00	B
	630-08-0	Carbon monoxide	lb/lb C	3.3E-03	B	4.4E-03	B
Metals	7429-90-5	Al (In Energetic As Particle)	lb/lb Metal	NA	NA	NA	NA
	7439-92-1	Pb (In Energetic As Compound)		NA	NA	NA	NA

(a) MDL = 8.0E-08 lb/lb C

3.2.7 Discussion of the BangBox Open Burn Test Results

Table 38 presents the following summary statistics across all of the test materials for each EP/EP category: N (number of numerical values used to calculate the statistical parameters), maximum, minimum, median, mean, standard deviation of the mean (std dev), and relative standard deviation (RSD, std dev / mean). NOTE: As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. These statistics were calculated by pooling the results for each EP or EP category on the assumption that all EF/EFF values within an EP category provided a "reasonable" estimate of the quantity of the EPs that would be released into the plume.

Table 38 also contains a proposed EPA Quality Rating Code for each EP/EP Category. These quality rating codes were derived by applying the guidance in Section 4.6.8 in Reference 19 to the data sets. The following factors were considered in this evaluation: the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance of the EF/EFFs to detonation reaction theory and the representativeness of the EF/EFF values to real-world detonation activities.

Table 38. Summary Statistics for the BangBox Open Burn EFs/EFFs

EP Category	EP	Units	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	8	9.1E-01	1.2E-03	1.8E-02	2.3E-01	3.4E-01	1.44	B
Inorganic Gases	Sulfur Dioxide	lb/lb NEW	8	1.2E-03	2.5E-05	1.4E-04	3.0E-04	3.9E-04	1.31	B
	Nitrogen Oxides	lb/lb N	8	8.6E-02	6.3E-03	2.5E-02	3.3E-02	2.9E-02	0.87	B
	Hydrogen Chloride	lb/lb Cl	2	9.4E-01	8.5E-01	8.9E-01	8.9E-01	6.7E-02	0.07	B
	Carbon Dioxide	lb/lb C	10	4.1E+00	2.3E+00	3.7E+00	3.5E+00	5.8E-01	0.17	B
	Carbon Monoxide	lb/lb C	10	4.1E-02	8.7E-04	6.0E-03	1.1E-02	1.3E-02	1.16	B
VOCs	Benzene	lb/lb C	6	6.0E-04	8.5E-06	1.9E-05	2.0E-04	2.9E-04	1.44	B
	TNMHC		8	6.7E-04	5.8E-05	2.8E-04	3.3E-04	2.1E-04	0.63	B
	Acetylene		7	6.0E-04	1.1E-05	3.5E-05	1.4E-04	2.1E-04	1.49	B
	Ethylene		4	2.5E-05	1.5E-05	2.4E-05	2.2E-05	5.0E-06	0.22	B
	Isobutene		5	4.5E-05	5.1E-07	2.7E-06	1.1E-05	1.9E-05	1.78	C
	Propylene		4	1.1E-05	2.8E-06	4.6E-06	5.8E-06	3.7E-06	0.64	B
Metals In Energetic	Metal In Energetic As Particle	lb/lb Metal	2	5.5E-02	2.9E-02	4.2E-02	4.2E-02	1.8E-02	0.43	C
	Metal In Energetic As Compound		2	7.2E-01	6.3E-01	6.7E-01	6.7E-01	6.2E-02	0.09	C
SVOCs in Energetic	SVOCs in Energetics	lb/lb SVOC	1	NM	NM	NM	NM	NM	NM	NM

Inspection of the results presented in Tables 34 through 37 and Tables 26 and 27 lead to the following conclusions.

3.2.7.1 Particulate Matter

PM-10. The PM-10 EFs for the single, double and triple-base propellants are not markedly different from those for the AP and PBX propellants. In addition, the median BangBox PM-10 EF for these materials (1.8E-02 lb/lb NEW) agrees well with the corresponding median DPG open range PM-10 EF (1.1E-02 lb/lb NEW).

3.2.7.2 Inorganic Gases

CO_2. Essentially all of the carbon in the test materials was converted to CO_2 and the median EFF value for the BangBox tests (3.7E+00 lb/lb C) is identical to that from the DPG open range tests.

CO. Only a very small percentage of the carbon in the test material was converted to CO and the median for these materials (6.0E-03 lb/lb C) agrees reasonably well with the median EFF (8.2E-04 lb/lb C) for the five materials that were open burned on the DPG test range.

NO_x . Only a very small percentage of the nitrogen in the test material was converted to NO_x and the median for these materials (2.5E-02 lb/lb N) agrees well with the median DPG EFF (2.9E-02 lbs/lb N).

HCl and Cl_2. The median EFFs for HCl and Cl_2 indicate that 90 % of the Cl in the AP propellant materials was converted to HCl and 3% was converted to Cl_2. Based on the results from an HCl-loss study conducted in the DPG BangBox before the AP burns, it's likely that the missing 7% of the original Cl was lost through the reaction of HCl with particulate and the surfaces of the BangBox. Thus, it would be reasonable to assume going forward that essentially all of the Cl in AP propellants is released as HCl when they are open burned.

3.2.7.3 Metals

The EFF values indicate that approximately 4% of the Al and 70% of the Pb in the propellant were released into the plume. This large difference between the Al and Pb EFFs is not surprising because the Al was present as 50 to 200 micron-sized particles, whereas the Pb was present as an energetic compound.

3.2.7.4 VOCs

The EFFs for the 37 VOC emission products measured in the plume were very low and were dominated by the simplest unsaturated and aromatic hydrocarbons. In fact, the following five compounds, account for more than 97.5% of the carbon in the VOC emission products: benzene, acetylene, ethylene, isobutene, and propylene.

3.2.7.5 PCDDs/PCDFs

Even though the MDL of the measurement system was 9.0E-12 lb/ lb NEW, PCDD and PCDF compounds were not detected in the plumes for the three materials with chemical compositions that had the highest chance to produce these compounds. The failure to detect these compounds in the plumes was expected, because the reaction conditions present in open burns are not conducive to the formation of these

compounds. These compounds were not target analytes in the DPG open range study.

3.2.7.6 Energetics

All of the energetic results were BDL. This result is consistent with the results from the DPG open range burn study, which produced energetic emission factors that were much lower than the BangBox energetic MDL.

3.2.7.6 SVOCs/POMs

Although the plumes from eight of the ten test materials were sampled for more than 120 SVOCs/POMs of environmental concern, 2-chlorophenol was the only SVOC detected above the background level, and it was associated with only one of the eight materials. The failure to find these SVOCs/POMs is consistent with the results from the DPG open range burn study, which produced SVOC/POM EFs that were much lower than the BangBox SVOC MDL.

3.3 NTS Rocket Motor Burn Emissions Data Sets

3.3.1 Description of the Tests

This set of emissions data was obtained from sampling the plumes released when NIKE and Hawk rocket motors were open burned at the Nevada Test Site in 1997.[11, 12] The test chamber was a large room mined out of a volcanic ash fall tuff lying within Little Skull Mountain in Area 25 of the NTS. A 430 ft tunnel leads to the chamber, which is approximately 36 ft high by 49 ft wide by 100 ft long. The chamber has a nominal volume of 64,000 ft^3. The interior surfaces of the chamber, including the stainless steel door leading into it are coated with fiber-reinforced shot-crete.

Three rocket motor burn events were conducted. One (DAZZLER) involved two Improved HAWK rocket motors (composite propellant). The other two (SUNSPOT AND THUNDERBIRD) involved two and four NIKE HERCULES M88 (NIKE) rocket motors (double-base propellant), respectively. These two types of rocket motors were selected for evaluation because they represent the two most common rocket motor propellant formulations in the demilitarization inventory.

The chamber was sealed before the rocket motor burn was initiated and remained sealed for a considerable period of time after plume sampling had been completed. The plume samples were collected from the sealed chamber using probes inserted through four sampling ports in the chamber door (containment plug). The measurement systems used and the suite of target analytes (CO_2, CO, NO,NO_2, VOCs, SVOCs/POMs, polychlorinated dioxins and furans, TSP, PM-10, HCl and metals) were similar to those used in the BangBox tests described earlier with two notable exceptions. First, a mixture of helium and neon was used as the plume (volume) tracer instead of SF6 . Second, no attempt was made to measure the energetic compounds in the plumes.

Samples of the residue on the floor of the chamber were also collected after each burn. These samples were analyzed for energetics using EPA Methods SW-846 Methods 8330 and 8320, and for SVOCs/POMs using SW-846 Method 8270. The samples were also analyzed for metals using SW-846 Methods 1311, 6010 and 7470.

3.3.2 Evaluation of the NTS Rocket Motor Burn Test Results for Inclusion in AP-42

Between 1997 and 2000, the U.S. Army and its contractors released a number of test reports on these burns and on some 155MM projectile detonations that were conducted in the same chamber in 1997 and 1999. In all these reports, the results were reported in concentration units standardized to normal temperature and pressure. Before an evaluation of the test results for possible inclusion in this chapter of AP-42 could be initiated, it was necessary to convert the concentration units to the equivalent emission factors. This was accomplished by multiplying the concentrations by the appropriate plume volume and dividing the product by the mass of the energetic detonated. The resulting emission factors and associated test conditions under which they were derived were then evaluated to determine if the NTS burn EFs should be included in AP-42.

The following documents were consulted in this evaluation:

- The suite of reports associated with the projectile detonations and the rocket motor burns.[9-12, 21-26]

- The composition of the Hawk rocket motor contained in MIDAS. (The NIKE rocket motor is not

in MIDAS.)

- Articles on the formation and measurement of PCDD, PCDF and SVOC compounds from combustion processes.[13-17, 27, 28]

This evaluation determined the following:

- Plume sampling did not begin until 10 to 22 minutes after the burn was initiated. Based on the results from the real-time particle concentration monitors used in the 1999 detonation tests, it is highly likely that substantial particle losses attributable to deposition and agglomeration processes occurred long before plume sampling began and continued throughout the 65 to 90 minute plume sample collection period.

- More than 99% of the nitrogen in the rocket motors was converted to nitrogen gas

- Stratification of the gaseous and solid EPs was likely present in the burn plumes when the plume samples were collected and the plumes were held in a hot, pressurized environment for the entire sample collection period.

- The shot-crete coating on the chamber surfaces removed CO2 from the burn plume and caused a rapid conversion of NO to NO2.

- Most of the VOC compounds detected are common air pollutants and the concentrations reported were within what might be expected in a shot-crete lined chamber that is purged continuously with air collected above the dirt-covered parking lot at the entrance to the tunnel leading to the chamber. In fact, the background samples collected before the rocket motor burns indicated that many of the VOC target analytes were present in the NTS chamber at concentrations much higher than found in normal ambient air. When these background VOC concentrations were converted to the equivalent emission factors, they produced values which were very similar to those reported for many of the VOC emissions products, i.e., 1E-06 to 1E-07.

- Because of the blast shielding used to protect the thermocouples it is very likely that the thermocouples were measuring the wall temperature and not the burn plume temperature.

- Thermocouples and pressure sensors installed inside the chamber showed that the burn plumes were held at elevated temperatures and pressures in an hot, humid alkaline and carbonaceous - particle laden environment from the initiation of the burn until plume sampling was completed 80 to 100 minutes later. These conditions would promote the formation of SVOC and dioxin and furan compounds and are not representative of real-world OB processes where the plume is always at atmospheric pressure and reaches ambient temperature in less than two minutes.

- Most of the SVOC analytes detected in the plume are commonly occurring air pollutants that were present in the chamber air and/or on the interior surfaces of the chamber before the burns were initiated.

- Hi-volume particulate results from background air samples collected in the chamber several months before the rocket motor burns showed that the air in the chamber contained elevated particle concentrations. For example, the average particulate mass concentration for the two hi-

volume samples collected before the February 26, 1997, 155MM projectile detonation test was 184 mg/m^3. This concentration was equal to 20% of the TSP concentrations measured for the NIKE and HAWK burns and only slightly less than the PM-10 Micron value for the NIKE burn.

- Every metal measured in the burn plumes was present in at least one of the following chamber materials before the burn tests were initiated: shot-crete, concrete and gravel. Further, the metal content of the FPM samples indicated that a substantial portion of the particulate mass came from the interior surfaces of the chamber. In addition, the concentration rations of the metals in the shotcrete varied from one sampling point to the next.

- Cross-contamination of metals and possibly other solid and SVOC emission products occurred from one test to the next. For example, the EF for Pb for the HAWK rocket motor burn was three orders of magnitude higher than the amount of Pb in the rocket motor. This strongly indicates that the Pb came from the two NIKE rocket motors burns conducted several months before the Hawk burn. (The NIKE contains approximately 12 lb of Pb whereas the Hawk contains less than one lb.)

Because this evaluation showed that the burns did not reflect real-world burn events, the decision was made to exclude the NTS emissions data from AP-42.

3.4 Summary and Conclusions

3.4.1 Comparability of the BangBox (BB) and DPG Open Burn Emission Data Sets

A statistical comparison of means was done between the following BB and DPG EP/EP categories for which there were corresponding data sets: PM-10, CO_2, CO, NO_x, benzene, and TNMHC. When this comparison showed that the six pairs of data sets were statistically the same, each pair was combined and the summary statistics calculated. Table 39 presents these summary statistics along with proposed EPA quality rating codes. These quality ratings are based on the number of EFs or EFFs in the data set, the dispersion within the data set as measured by the RSD, the original quality rating assigned to the individual EF or EFF, the conformance to detonation (burn) reaction theory, and representativeness to real-world open burn activities.

Table 39. Combined Summary Statistics for the DPG and BangBox OB EFs/EFFs

EP Category	EP	Units	Data Source	N	Maximum	Minimum	Median	Mean	Std Dev	RSD	Quality Rating
PM-10	PM-10	lb/lb NEW	DPG + BB	13	9.1E-01	1.2E-03	1.6E-02	1.5E-01	2.8E-01	1.89	B
Inorganic Gases	Sulfur Dioxide	lb/lb NEW	BB	8	1.2E-03	2.5E-05	1.4E-04	3.0E-04	3.9E-04	1.31	B
	Nitrogen Oxides	lb/lb N	DPG + BB	13	8.6E-02	6.3E-03	2.9E-02	3.5E-02	2.5E-02	0.71	A
	Hydrogen Chloride	lb/lb Cl	BB	2	9.4E-01	8.5E-01	8.9E-01	8.9E-01	6.7E-02	0.07	B
	Carbon Dioxide	lb/lb C	DPG + BB	15	4.1E+00	2.3E+00	3.7E+00	3.5E+00	4.6E-01	0.13	A
	Carbon Monoxide	lb/lb C	DPG + BB	15	4.1E-02	1.5E-04	3.3E-03	7.8E-03	1.1E-02	1.46	B
Energetics	Energetics	lb/lb Energetic	DPG	4	1.5E-09	6.9E-10	9.7E-10	1.0E-09	3.3E-10	0.32	B
SVOCs	SVOCs in Energetics	lb/lb SVOC	DPG	6	9.4E-07	1.0E-08	4.4E-08	1.9E-07	3.7E-07	1.93	B
	SVOCs Not In Energetics	lb/lb NEW	DPG	29	8.0E-06	5.0E-10	2.7E-08	4.1E-07	1.5E-06	3.62	B
VOCs	Benzene	lb/lb C	DPG + BB	11	6.0E-04	2.3E-06	1.6E-05	1.2E-04	2.3E-04	1.93	B
	TNMHC		DPG + BB	13	2.1E-03	8.4E-06	2.1E-04	5.0E-04	6.2E-04	1.24	B
	Acetylene		BB	7	6.0E-04	1.1E-05	3.5E-05	1.4E-04	2.1E-04	1.49	B
	Ethylene		BB	4	2.5E-05	1.5E-05	2.4E-05	2.2E-05	5.0E-06	0.22	B
	Isobutene		BB	5	4.5E-05	5.1E-07	2.7E-06	1.1E-05	1.9E-05	1.78	C
	Propylene		BB	4	1.1E-05	2.8E-06	4.6E-06	5.8E-06	3.7E-06	0.64	B
Metals In Energetic	Metal In Energetic As Particle	lb/lb Metal	BB	2	5.5E-02	2.9E-02	4.2E-02	4.2E-02	1.8E-02	0.43	C
	Metal In Energetic As Compound		BB	2	7.2E-01	6.3E-01	6.7E-01	6.7E-01	6.2E-02	0.09	C

Table 39 also contains summary statistics for the following EP/EP categories for which there was either only BangBox data or the DPG open range data were judged to be far superior to the BangBox data.

SO_2 The BangBox SO_2 EF values.

VOCs. The BangBox EFFs for acetylene, ethylene, isobutane and propylene, which together with benzene accounted for essentially all of the carbon in the BangBox VOC emissions. (NOTE – There were many BDL values associated with these VOCs. Because these BDL values were not included in the summary statistics, the average and median EFFs in Table 39 are definitely biased high.)

Energetics. The DPG open range energetic EFFs

SVOCs/POMs in Energetic. The DPG open range EFFs. (NOTE – There were many BDL values associated with the SVOC/POM target analytes. Because these BDL values were not included in the summary statistics and only the maximum EF value measured for each test material was used, the average and median EFFs in Table 39 are definitely biased high.)

SVOCs/POMs Not In Energetic. The DPG open range EFs. (The 2-chlorophenol value from the BangBox was excluded because had a quality rating of D and because it could not be statistically compared to the DPG data set.)

Metals. The BangBox EFFs.

3.4.2 Representativeness, Adequacy, and Limitations of the Open Burn EF/EFFs

3.4.2.1 Open Burning of Propellants and HE in Pans

As noted earlier, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation, and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation. The RSDs for eight of the 17 data sets are less than 1.0 and the RSDs for 16 are less than 2.0. These results show that within most of the data sets the EFs or EFFs are well correlated, i.e., that the results are of good quality. This close correlation is not surprising based on detonation reaction theory and the limited number of substances found in the explosive materials open burned.

The vast majority of open burning operations in the U. S. involve the disposal of single-base (NC) and double-base (NC + NG) propellants, and most of the remainder involve the disposal of triple-base (NC + NG + NQ) and PBX (plastic bonded explosive) propellants, waste high explosives that cannot be detonated and combustible explosive contaminated waste. If we exclude the burning of combustible explosive contaminated waste (which usually comprises less than 2% of the weight of the materials open burned annually), the number of explosive compositions demilled by open burning is quite limited. This limited range can be seen by a review of the information in Tables 40 and 41 which show the compositions of the 14,000,000 pounds of propellant and 1,100,000 pounds of explosive materials, respectively that were open burned over a five year period at a large DOD ammunition manufacturing and demilitarization facility. As a group the 15 test materials whose open burn emissions were selected for AP-42 include almost all of these explosives and propellants. Thus, their emissions data sets cover most of the substances of environmental concern that could be released into the environment via the burn plume.

Most demil activities in the U. S. are associated with facilities that are testing, manufacturing, and/or assembling energetic-containing materials, such as propellants, munitions and ammunition. Consequently, most demil facilities will open burn a variety of propellant and HE materials in any twelve month period. Further, most open burn activities involve conducting a number of independent burns over a short time period (e.g., one hour) in the same area and one hour is the shortest air pathway exposure time

interval used in environmental assessments.

Table 40. Compositions of the Propellants Open Burned Over a Five Year Period

Compound	Single Base Propellants				Double Base Propellants		Triple Base Propellants		
	SB-1	SB-2	SB-3	SB-4	DB-1	DB-2	TB-1	TB-2	TB-3
Nitrocellulose	82.5%	84.0%	85.3%	94.0%	57.8%	78.1%	19.0%	21.5%	27.0%
Nitroglycerine	.	.	.	.	40.0%	9.5%	18.7%	18.0%	22.5%
Nitroguanidine	.	.	.	.	.	.	55.0%	54.7%	46.2%
Potassium Nitrate	.	.	.	.	1.5%	0.8%	.	.	2.8%
Dinitrotoluene	9.2%	10.0%	9.8%	.			.	.	.
Dibutylphthalate	4.9%	5.0%	2.9%	.	.	7.5%	.	3.0%	.
Diphenylamine	1.0%	1.0%	1.0%	.	.	1.1%	.	.	.
Butyl Stearate				3.0%			.	.	.
Potassium Sulfate	1.2%	.	1.0%	1.0%	.		.	1.3%	.
Calcium Carbonate	.	.	.	.	.	1.0%	.	.	.
Ethyl Centralite	.	.	.	1.0%	0.8%	.	7.3%	1.5%	1.5%
Sodium Sulfate	.	.	.	.	.	0.5%	.	.	.
Graphite	.	.	.	.	.	0.4%	.	0.1%	0.2%
Lead Carbonate	1.1%	1.0%	.	.	.	.	.	.	.
Stannic Oxide	.	.	.	.	.	1.1%	.	.	.

Table 41. Compositions of the Explosives Open Burned Over a Five Year Period

Compound	Comp B	CXM-7	H-6	PBX	TNT	Destex	Tritonal
RDX	59.5%	95.0%	45.1%	90.0%	.	.	.
TNT	39.5%	.	29.2%	.	100.0%	72.0%	80.0%
Wax	1.0%	.	4.7%	.	.	5.0%	.
Aluminum	.	.	21.0%	.	.	20.0%	20.0%
Polystyrene	.	.	.	8.5%	.	.	.
Dioctylphalate	.	.	.	1.5%	.	.	.
Dioctyladipate	.	5.0%	.	.	.	.	.
Graphite	.	.	.	.	.	3.0%	.

The summary statistics associated with the following EP/EP categories in Table 38 can be used with confidence for estimating the emissions from the routine open burning of propellants in burn pans: PM-10, HCl, CO, NO_x, SO_2, benzene, acetylene, ethylene, propylene, isobutene, and *SVOCs/POMs Not In Energetic*. This conclusion is based on the following considerations: (1) the RSDs, (2) the number of values used to calculate the summary statistics, (3) the representativeness of the test conditions (under which the EF/EFFs were derived) to real-world open burn operations, (4) the EPA Quality Rating Code; (5) the magnitude of the EF/EFFs, (6) the potential toxicity of exposure to the emission product via air pathways, (7) the manner in which real-world burn activities are conducted (i.e., multiple open burns in the same area over a one hour timeframe) and (8) the agreement of the EF/EFF to detonation reaction theory.

The summary statistics associated with the following EP/EP categories are not adequate for estimating the emissions from the open burning of propellants: *Energetics, Metals In Energetic As Compound, Metals In Energetic As Particle and SVOCs/POMs In Energetics.* Obtaining additional

3.4.2.2 Open burning of Combustible Explosive Contaminated Waste

There are no emissions data for the burning of combustible explosive contaminated waste per se and the emissions data for the open burning of HE is very limited. Until these data become available, the emissions data presented in Appendix B could probably be used to estimate the emissions from combustible explosive contaminated waste and the emissions data for the open burning of propellants should be used as the default values for the burning of HE.

3.4.2.3 Open Burning of Missiles and Rocket Motors

The following procedures are used to destroy missiles and rockets by open burning: (1) holding down the missile and firing it in its design mode, (2) removing the nozzle from a missile, holding it down, and igniting it and (3) placing a shape charge along one side of a rocket motor or missile and using the initiation of that shape charge to crack open the item and ignite the energetics. Each of these processes results in different temperatures and pressures and, hence, different emissions. In general, all these burns involve a two stage decomposition process. The first stage involves a white cloud predominately composed of the substances released when the propellant deflagrates (decomposes). The second stage involves a black cloud predominately comprised of the substances released by the combustion of the liner and combustible parts of the casing.

There are no emissions data for the open burning of missiles and rockets. Because the propellant burn is essentially complete before the combustion of the liner and casing begins, one could assume that the emissions for each stage are additive. Under this assumption, one could use the EFs/EFFs in this Chapter of AP-42 to estimate the emissions from the open burning of the propellant and another source (e. g., the emissions for the combustion of materials similar in composition to the liner/casing) to estimate the emissions from the liner and casing.

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APPENDIX A

Effect of Confinement on the Air Emissions from Detonations

To reduce noise and shrapnel travel, its standard practice at many demilitarization facilities to detonate energetic materials under a soil cover, which can inhibit the formation of a full fireball. When munitions are detonated under these conditions, the fireball is partially or fully suppressed. Because the emissions from these types of detonations have never been studied, there are no emissions data available. But, as discussed more fully below, there are data from studies in bomb calorimeters and detonation chambers that provide some insight on the emissions that will result when munitions are detonated under a soil covering. For example, compared to the equivalent surface detonation, the plume will be cooler and the conversion of the combustible detonation products will also be reduced as will the PM-10 emissions. Until emissions data from actual buried detonations becomes available, the insights provided by these confined-detonation studies in conjunction with numerical modeling should be helpful in using the surface detonation EF/EFFs in this background document for estimating the emissions from soil-covered and buried detonations.

Bomb Calorimeter Detonations Experiments

Ornellas showed that completely suppressing the fireball produces a cooler plume, decreases the CO2 emissions and increases the soot, CO and soot emissions.[1] He showed this by detonating TNT under the following conditions: (1) in an oxygen–rich environment, (2) in a 100% CO_2 environment and (3) in a vacuum. In the oxygen-rich environment, approximately 97% of the carbon was converted to CO_2 and the remaining was converted to CO. The results from the vacuum and CO_2-atmosphere detonation were very similar to each other, but noticeably different from the results from the oxygen-rich detonation. That is, approximately 18% of the carbon ended up as CO_2, 29% ended up as CO and an additional 52% ended up as soot. These results are fully consistent with detonation reaction theory.

BangBox Water-Suppressed Detonation Experiments

A set of experiment was conducted in the BB at DPG that involved partial suppression of the fireball. The goal of these water-suppressed detonation experiments was to obtain a robust assessment of the impact that fireball suppression had on the emissions from the detonation of oxygen-balanced (amatol) and oxygen-negative (tritonal) HE. These experiments involved detonating amatol (an oxygen-rich HE) and tritonal (a severely oxygen-negative HE) in the presence and absence of water bags. The compositions of these materials and the test conditions are described in Section 2.2.3 of this background document.

Table A-1 compares the average EFs produced by the water-suppressed detonation to those produced by the corresponding unsuppressed detonation. This table was constructed by dividing each suppressed detonation EF by the corresponding unsuppressed EF.

Table A-1. Comparison of Water Suppressed and Unsuppressed Detonation Emissions Results.

Pollutant Category	Pollutant	Supressed Detontion EF / Unsuppressed Detonation EF	
		Amatol	Tritonal
PM-10	PM -10	1.68	0.51
Metals	Al (In Energetic As Particle)	NA	0.03
Inorganic gases	Carbon dioxide	0.44	0.23
	Carbon monoxide	23.71	93.10
	Nitrogen Oxides	0.46	0.68
Aromatic HC	Benzene	11.7	35.1
	Toluene	17.9	56.2
	p-Ethyltoluene	6.3	6.3
	Ethylbenzene	13.3	2.7
Unsaturated HC	Acetylene	1.5	36.7
	Ethylene	31.6	44.0
	Propylene	65.5	219.2
	1-Butene	83.3	17.9
Saturated HC	Ethane	392.9	705.9
	Propane	190.0	75.3
	n-Butane	83.9	19.2
	isobutane	10.3	10.8
TNMHC	TNMHC	8.4	6.0
SVOCs & POMs(a)	Phenol	BDL	BDL
	Naphthalene	BDL	BDL
	2-Methylnaphthalene	BDL	BDL
	Dibenzofuran	BDL	BDL
	Benz(a)anthracene	BDL	BDL
	Benz(a)pyrene	BDL	BDL
	2-Nitronaphthalene	BDL	BDL
	2,6-Dinitrotoluene	BDL	BDL
	1,3,5-Trinitrobenzene	BDL	BDL
	N-Nitrosodiphenylamine	BDL	BDL
	Hexachlorobenzene	BDL	BDL
	Pyrene	BDL	BDL
	2,4-Dinitrophenol	BDL	BDL
	2-Nitrotoluene	BDL	BDL
	4-Nitrophenol	BDL	BDL
	4-Nitrotoluene	BDL	BDL
	Nitrobenzene	BDL	BDL
	Phenanthrene	BDL	BDL
	Pyridine	BDL	BDL
	2,4-Dinitrotoluene	BDL	BDL
	Diphenylamine	BDL	BDL

(a) MDL = 6.6E-05 lb/lb NEW

Inspection of the results in Table A-1 shows the following:

Carbon Dioxide. The CO_2 emissions decreased sharply for both materials, but the decrease for the severely oxygen-negative tritonal was twice that for the oxygen-balanced amatol. (Tritonal contains only 24% of the oxygen required to convert all of its carbon and hydrogen to CO_2 and H_2O, so it's considerably more dependent on the fireball to accomplish these conversions than amatol.)

Carbon Monoxide. The CO emissions increased for both materials, but the increase for the severely oxygen-deficient tritonal was 20 times larger than that for amatol.

Nitrogen Oxides. Although The NOx emissions decreased by 50 to 65%, they still accounted for only a very small amount of the original mass of N in the test materials.

VOC*s*. The aromatic and unsaturated hydrocarbon emissions increased substantially for both materials, but the increase for the severely oxygen-deficient tritonal was much larger than for the oxygen-balanced amatol.

SVOCs/POMs. There was no detectable increase in the SVOC emissions, all values remained below the MDL of the measurement system (6.6E-05 lb / lb NEW).

PM-10. At first glance the increase in the PM-10 emissions for amatol and the decrease in those for tritonal might seem an anomaly. However, upon reflection, one finds that the results are consistent with detonation reaction theory. That is, although the PM-10 EF for the unsuppressed amatol (1.9E-02 lb/ lb NEW) is 20 times lower than that for the unsuppressed tritonal (3.7E-01 lb/lb NEW), the absolute increase in the amatol EF was only 1.3E-02 lb/lb NEW and likely resulted from an increase in soot. It's likely that this increase in soot emissions also occurred in tritonal, but it was masked by the 35-fold decrease in the aluminum emissions (the aluminum EF went from 2.6E-02 to 7.6E-04 lb/ lb NEW).

ODOBI Detonation Chamber Experiments

The ODOBi detonation chamber is located at Dugway proving ground, UT. It comprises of a one-inch thick, 12 ft. diameter steel cylinder and two one-inch thick, hemispherical end caps. The top end cap has a 5 ft opening through which the energetic material to be detonated is lowered. There is also a 5 ft diameter, 12 ft long stack that can be attached to the top cap of the ODOBi. The ODOBi stands approximately 12 ft high, has an internal volume of 36 m^3 and has an explosive capacity rating of 33 lb NEW. It also has 21 sampling ports.

In June 1997, the U.S. Army conducted a series of TNT detonations in the ODOBi to accomplish the following goals.[2] First, to evaluate the structural integrity of the ODOBi to confirm that it met the explosive performance criteria specified in the contract for its construction. Second, to obtain more information on the potential for replacing soil-covered detonations with detonations in vented chambers as a means of reducing the pollutants released to the environment. Third, to determine if the emissions from vented detonation chambers would scale as a function of the net explosive weight (NEW) of energetic material detonated, i.e., determine if the emission factors would remain constant as the NEW detonated changed.

To accomplish these goals, the Army detonated flaked-TNT in the ODOBi and measured the quantities of CO_2, CO, NOx and selected VOC and SVOC compounds in the portion of the detonation

plume that remained in the ODOBi. (PM-10 was not measured.) After the 0.5 lb TNT detonation Operational Readiness Test was completed, the Army detonated the following quantities of TNT in the ODOBi and measured the emission products: 5, 10, 15, 20, 15, 20 lb. The TNT was contained in clear plastic bags that were wrapped in a copper mesh-type screen. This screen provided both structural strength and a location for attaching the wire that was used to lower the bag into the ODOBi test chamber, and to hold it approximately 6 ft above the floor of the ODOBi. The items detonated ranged from 20 to 100 inches in diameter. Before each detonation, a Tedlar bag containing a known quantity of a 50:50 He/Ne mix was placed approximately 6 ft from the center of the TNT-containing bag. When the TNT was detonated, the Tedlar bag ruptured releasing the He and Ne into the detonation plume. The concentration of Ne in each plume sample was subsequently used to determine the plume volume and to derive the emission factors for the detonation. The inorganic gases were measured on-site with continuous emission monitors and the VOC emission products were collected in evacuated canisters and analyzed off-site using EPA TO-14 (GC/FID). The SVOC emissions were collected using EPA SW-846 Method 0010 and analyzed using EPA SW-846 Method 8270 (Soxhlet extraction followed by analysis by GC/MS.

TNT is severely oxygen deficient. Based on the TNT quantities used, the fireball should have been fully suppressed for at least the 15 and 20 lb detonations. In addition, the ODOBi was observed to flex and lift slightly off the ground at the instant of detonation even for the smaller charges. This indicates that a meaningful amount of the detonation energy was absorbed by the steel walls of the 90,000 lb ODOBi. In buried and soil covered detonations, fireball formation is also partially or fully suppressed and a meaningful amount of the detonation energy is used up pushing soil out of the way. This is why the ODOBi emissions test results can provide some insight into the affect that soil covering has on the emissions from detonations.

Table A-2 presents summary statistics for the emissions from the ODOBi that provide insight into the effect that the degree of confinement has on the emissions. A comparison of the results in Table A-2 to the corresponding results for unconfined open test range TNT detonations presented in Table 4 of this background document yields the following conclusions.

Carbon Oxides. The average ODOBi EFFs for CO_2 and CO indicate that 32% of the carbon in the TNT was converted to CO_2, whereas in the unconfined detonations approximately 97% of the carbon was converted to CO_2. In contrast, the amount of carbon converted to CO in the ODOBi (0.2%) was not markedly different from the value of 0.03% associated with the unconfined detonations.

Nitrogen Oxides. The average ODOBi EFF for NOx (3.4E-02 lb / lb N) agrees very closely with the corresponding value of 5.3E-02 lb / lb N) for the unconfined TNT detonations.

VOCs. As was the case for the unconfined detonations, the amount of carbon converted to benzene was greater than the sum of the carbon converted to toluene and xylenes. Even more interesting is the finding the ODOBi benzene and toluene EFFs are lower than the corresponding values for the unconfined TNT detonation. Another interesting finding is the observation that the ODOBi EFF values for the predominant unsaturated hydrocarbons are higher than those for the unconfined detonations. This indicates that there was insufficient detonation energy to convert the unsaturated hydrocarbons to aromatic saturated hydrocarbon compounds.

Energetics. The ODOBi TNT results agree very well across the six detonations and the average EFF value (7.3E-05 lb/lb TNT) is approximately 500 times larger than the corresponding value for the surface detonation shown in Table 5 of this background document (1.4E-07 lb/lb TNT).

Table A-2. Summary Statistics for the Emissions from the ODOBi TNT Detonation Study.

EP Category	EP	Units	N(a)	Maximum	Minimum	Median	Mean	RSD(b)
Inorganic Gases	Carbon dioxide	lb/lb C	6	1.4E+00	1.0E+00	1.2E+00	1.2E+00	0.17
	Carbon monoxide		6	1.7E-02	2.4E-03	6.9E-03	8.2E-03	0.80
	Cyanogen		5	9.5E-06	BDL	1.3E-07	3.2E-06	1.68
	NOx	lb/lb N	6	7.6E-02	6.5E-03	2.6E-02	3.4E-02	0.89
TNT	TNT	lb/lb TNT	6	1.8E-04	1.7E-05	4.8E-05	7.3E-05	1.01
SVOCs & POMs	Naphthalene	lb/lb TNT	6	1.5E-05	3.5E-06	7.4E-06	8.3E-06	0.61
	2-Amino-4,6-Dinitrotoluene		6	8.9E-06	2.3E-07	3.6E-07	2.5E-06	1.74
	4-Amino-2,6-Dinitrotoluene		6	2.3E-06	1.0E-06	1.6E-06	1.6E-06	0.36
	1,3,5-Trinitrobenzene		6	5.5E-06	9.6E-08	1.6E-07	1.5E-06	1.82
	2,4-Dinitrotoluene		6	1.0E-06	2.1E-07	2.3E-07	4.2E-07	0.94
	2,6-Dinitrotoluene		6	1.3E-07	4.8E-08	7.7E-08	8.3E-08	0.41
	4-Nitrotoluene		6	4.3E-08	1.9E-08	4.0E-08	3.6E-08	0.32
	2-Nitrotoluene		6	2.4E-08	1.1E-08	1.6E-08	1.7E-08	0.38
Aromatic VOCs	Benzene	lb/lb C	6	8.4E-05	2.7E-05	6.8E-05	6.2E-05	0.40
	Toluene		6	3.2E-06	1.3E-06	2.6E-06	2.4E-06	0.34
	m,p Xylenes		6	3.8E-06	6.0E-07	1.0E-06	1.6E-06	0.94
	o-Xylene		6	2.2E-06	4.6E-07	7.2E-07	1.0E-06	0.79
	1,3-Dinitrobenzene		3	6.8E-07	4.6E-07	5.7E-07	5.7E-07	0.27
	Phenol		4	1.1E-06	5.4E-07	6.2E-07	7.6E-07	0.41
	Ethylbenzene		6	1.1E-06	3.0E-07	4.7E-07	5.9E-07	0.63
	Nitrobenzene		6	2.1E-07	4.3E-08	9.2E-08	1.1E-07	0.65
	p-Ethyltoluene		6	BDL	BDL	BDL	BDL	NM
Aldehydes and Ketones	Benzaldehyde	lb/lb C	6	1.2E-05	3.0E-06	7.7E-06	7.7E-06	0.50
	Benzoic acid		6	2.6E-05	2.1E-06	8.1E-06	1.2E-05	1.03
	Acetone		6	4.6E-06	1.4E-06	2.2E-06	2.6E-06	0.56
	Acrolein		3	2.5E-06	BDL	1.7E-06	1.5E-06	0.73
	Acrylonitrile		6	2.1E-05	4.6E-07	1.2E-06	5.9E-06	1.67
	Benzofuran		6	6.0E-06	1.9E-07	9.6E-07	2.0E-06	1.32
	Acetaldehyde		3	3.0E-06	BDL	9.9E-07	1.4E-06	0.81
	Benzonitrile		6	1.0E-06	2.0E-07	5.1E-07	5.7E-07	0.71
	Acetonitrile		6	1.0E-05	1.9E-07	4.1E-07	2.8E-06	1.76
	Furan		6	4.6E-07	6.5E-08	3.2E-07	2.9E-07	0.60
Unsaturated VOCs	Ethane	lb/lb C	6	BDL	BDL	BDL	BDL	NM
	Propane		6	BDL	BDL	BDL	BDL	NM
	n-Butane		6	BDL	BDL	BDL	BDL	NM
	n-Heptane		6	BDL	BDL	BDL	BDL	NM
	n-Hexane		6	BDL	BDL	BDL	BDL	NM
	n-Pentane		6	BDL	BDL	BDL	BDL	NM

Table A-2. Summary Statistics for the Emissions from the ODOBi TNT Detonation Study (continued).

EP Category	EP	Units	N(a)	Maximum	Minimum	Median	Mean	RSD(b)
Unsaturated VOCs	Acetylene	lb/lb C	6	1.3E-04	1.1E-05	3.9E-05	5.5E-05	0.95
	Ethylene		6	5.1E-05	2.3E-05	3.1E-05	3.4E-05	0.35
	Propylene		6	6.8E-06	3.8E-06	6.0E-06	5.6E-06	0.26
	Isobutene		6	1.2E-06	3.8E-07	6.0E-07	6.8E-07	0.49
	trans-2-Butene		6	BDL	BDL	BDL	BDL	NM
	1-Butene/ I-Butene		6	BDL	BDL	BDL	BDL	NM
	1-Hexene		6	BDL	BDL	BDL	BDL	NM
	1-Pentene		6	BDL	BDL	BDL	BDL	NM
	1,3-Butadiene		6	BDL	BDL	BDL	BDL	NM
	trans-2-Pentene		6	BDL	BDL	BDL	BDL	NM
	cis-2-Pentene		6	BDL	BDL	BDL	BDL	NM
TNMHC	TNMHC	lb/lb C	6	7.3E-04	1.1E-04	2.6E-04	3.4E-04	0.78

(a) N = the number of EFs/EFFs used to calculate the summary statistics.

(b) RSD is obtained by dividing the standard deviation by the corresponding mean (average). As a general rule of thumb, if the RSD for a data set is less than 1.0, the individual values within the data set are assumed to have very good to excellent correlation and if the RSD is between 1.0 and 2.0, the EF/EFFs are considered to have fair to good correlation.

SVOCs/POMs. The eight SVOCs/POMs presented in Table 6 are all possible decomposition products of TNT and they were found in all of the detonation plumes. All but one of the RSD's are less than one. In addition, the tracer gas results showed that between 20 and 30% of the detonation plume remained in the ODOBi after the detonation gases had vented. Thus, it's unlikely that these SVOC compounds came from the ambient air. Further, three of the eight SVOCs (2,4- DNT, 2,6-DNT and naphthalene) were also detected in at least one of the detonation plumes for each of the four HE materials detonated on soil in the DPG open range tests and the corresponding emissions factors agree closely between the two data sets. The NEW detonated in these unconfined open range tests (in which more than 99.8% of the carbon was released as carbon oxides) was 100 to 400 times larger than that used in the partially-confined ODOBi tests (where only 32% of the carbon was released as carbon oxides). These observations lead to the following tentative conclusions. First, fireball suppression does not substantially increase the SVOC/POM EFs. Second, the SVOC/POM emissions scale with the NEW detonated. Third, these SVOC/POM compounds would not have been detected in the BangBox detonation plumes where the MDL of the SVOC measurement system was at least an order of magnitude higher than even the largest ODOBi and open range EF values. Together, these observations provide strong evidence that the SVOCs/POMs are actual emission products from the decomposition of the TNT

Conclusions

At this point it's not clear exactly how credible it would be to use the bomb calorimeter and detonation chamber data presented above for estimating the emissions from buried and soil covered detonations. The results from the suppressed-fireball detonations are certainly consistent with detonation reaction theory. For the simple gaseous species, similar results might be produced using DOD numerical models. Perhaps, the most useful conclusions from the studies described above is the observation that the SVOC emissions do not seem to increase significantly when the fireball is suppressed.

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2. ODOBi Interim Initial Air Sampling Report, Volume 1-Summary. Prepared by Radian International LLC, Oak Ridge, TN for the U.S. Army, Dugway Proving ground, UT. Copies available from R.J. Black, U.S. Army West Desert Test Center, (Attention STEDP-WD-M-OE), Dugway, UT.

APPENDIX B

Estimating the Emissions from the Burning of Combustible Explosive Contaminated Waste

Combustible explosive contaminated waste is a byproduct of explosive loading, unloading, packaging and related activities. The combustible explosive contaminated waste is burned in burn pans. Usually, a weight of propellant and HE scrap equal to 30 to 60% of the weight of the combustible explosive contaminated is used to initiate and support the burn. Although the exact composition of this material varies from day to day, it usually contains rags, cotton gloves, wood sticks, polyethylene bags, corrugated cardboard and pressed cardboard propellant cups along with 1% HE and propellant materials.

At this time there are no emissions data available for the open burning of explosive contaminated waste. However, since the burns are initiated and supported using a large quantity of HE or propellant, the 1% of energetic material in the explosive contaminated waste itself will be an insignificant source of emissions. Thus, if we ignore these latter energetic materials, the composition of the waste is similar to that from a household that recycles the glass, metal and plastic materials commonly found in household waste -- a material for which EPA characterized the emission products through a two-part study[1-4]

The EPA study used burn times and burn conditions that are similar to those used when combustible explosive contaminated waste is burned, i.e., initial flame followed by smoldering fire and total burn times of 60 to 100 minutes. EPA evaluated how the following factors affected the POM (Polycyclic Organic Matter), potentially hazardous VOC, PCDD/PCDF and PCB emissions from the burning of household waste from households that recycled and those that did not recycle: availability of combustion air, density of the waste, unconfined (open burning) versus confined burning (open top barrel), chlorine content, metal content, and wetness of the waste. These experiments showed that none of the experimental variables affected the VOC, POM, PCDD/PCDF and PCB emissions in a meaningful way.

The first part of the study produced credible emission factors for the POM and VOC emission products, but not for the PCDD/PCDF and PCB emission products. So, the second part of the EPA study focused on these latter emission products. Combining the POM and VOC EFs for recycler household waste from the first part of the study with the PCDD/PCDF and PCB EFs for the recycler household waste from the second part of the study yields the EFs presented in Table B.1.

Table B.1 EFs from the EPA Waste Burn Study.[1-4]

	A	C
3	Emission Product	lb/lb Waste
4	1,2, 3 trichlorobenzene	1.10E-07
5	1,2, 4-Trichlorobenzene	9.80E-08
6	1,2,3,4 tetrachlorobenzene	4.00E-08
7	1,2,4,5-Tetrachlorobenzene	2.10E-08
8	1,2,4-Trichlorobenzene	5.30E-06
9	1,3, 5- trichlorobenzene	1.50E-08
10	1,3-Butadiene	1.41E-04
11	2-Methyl phenol	2.10E-05
12	4-Methylphenol	4.50E-05
13	Acenaphthene	6.40E-07
14	Acenaphthylene	1.80E-05
15	Acetaldehyde	4.30E-07
16	Anthacene	1.30E-06
17	Benzo(a)anthracene	1.50E-06
18	Benz(a)pyrene	1.40E-06
19	Benzaldehyde	1.50E-07
20	Benzene	9.80E-04
21	Benzo(b)fluoranthene	1.80E-06
22	Benzo(k)fluoranthene	6.70E-07
23	Chloromethane	1.63E-04
24	Chrysene	1.80E-06
25	Dibenzo(a,h)anthacene	4.20E-07
26	Dioxin/Furan (as TEQ)	2.65E-09
27	Ethylbenzene	1.82E-04
28	PM-10	1.20E-02
29	Fluoranthene	2.80E-06
30	Fluorene	3.00E-06
31	Formaldehyde	4.30E-07
32	Hexachlorobenzene	3.50E-07
33	Hydrogen chloride	1.34E-03
34	Hydrogen Cyanide	3.34E-04
35	Indo(1,2,3 cd)pyrene	1.30E-06
36	m-Dichlorobenzene	1.60E-07
37	Naphthalene	1.43E-04
38	o-Dichlorobenzene	8.20E-08
39	PCB (as TEQ)	1.1E-10(a)
40	p-Dichlorobenzene	3.00E-08
41	Pentachlorobenzene	7.60E-08
42	Phenanthrene	5.30E-06
43	Phenol	4.02E-04
44	Pyrene	3.20E-06
45	Toluene	3.72E-04

(a) Value is the average EF from four PVC –spiked waste burns

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4. Lemieux, P. M. et. al. Variables Affecting the Emissions of PCDD/Fs from Uncontrolled Combustion of Household Waste in Barrels. J. Air and Waste Management Association, 53, 523 -531, 2003.

APPENDIX C

List of Acronyms

AN	Ammonium nitrate
Analyte	Emission product being measured
AP	Ammonium perchlorate
BDL	Below method detection limit
Comp B	High explosive containing 60% RDX, 39% TNT and 1% wax
CEM	Continuous emission monitor
DAC	U. S. Army Defense Ammunition Center, McAlester, OK
DPG	Dugway Proving Ground, UT
DOD	U. S. Department of Defense
Explosive D	Ammonium picrate
EF	Emission factor (lb/lb NEW)
EFF	Environmental fate factor (lb/lb of related substance in material treated)
EP	Emission product
HE	High explosive
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
MDL	Minimum detection limit (EF/EFF below which the analytical result is suspect or otherwise unreliable.
MIDAS	Munitions Items Disposition Action System
NC	Nitrocellulose
NG	Nitroglycerin
NQ	Nitroguanidine
NEW	Net explosive weight
OB	Open burning
OD	Open air detonation
PAH	Polycyclic aromatic hydrocarbon – substances containing two or more benzene rings with all lying in the same plane with the electron cloud above and below this plane. PAHs are a subset of POM.

PCDD	Polychlorinated Dibenzo-p-Dioxin
PCDF	Polychlorinated Dibenzofurans
POM	Polycyclic organic matter. The term POM applies to more than 100 compounds. It's defined by the Federal Clean Air Act as organic compounds with more than one benzene ring that have a boiling point greater than or equal to 100^0C. In general, POM with molecular weights less than or equal to 230 g/mol are found in the gaseous state in the atmosphere and those with molecular weights greater than this are partitioned between the gaseous and solid states.
PM-10	Particulate matter with an aerodynamic diameter equal or less than 10 microns.
RDX	Cyclotrimethylene trinitramine
RSD	Standard deviation divided by the mean
SVOC	Semi-volatile organic compound. This is an alternate term for POM.
TNT	Trinitrotoluene
TPM	Total particulate matter
TNMHC	Total nonmethane hydrocarbons
Tritonal	High explosive comprised of 20-% aluminum and 80% TNT
VOC	Volatile organic compound (any organic compound having an initial boiling point less than or equal to 250 °C measured at a standard atmospheric pressure of 101.3 kPa)

Attachment 4 Metals Analysis for Waste in Explosives Treated in 2006

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
Excess HE	34760	D003	No	02/21/06	0.03			95% HMX, 5% carbon black		0.03	-						Shot contained classified plastic shapes for sanitization	(1) det; (1) pellet, 122 lbs. ANFO; (4) PBX-9501 cylinders = 17.2 lbs.
Classified explosives	34760	D003	Yes		1.00	<1	CHNO detonators			1.00	-							
HE on cellulosics	28345	D003	No		0.33					0.33	-	PETN on filter cartridge						
Excess Baratol	35762	D001, D003, D005, D030	No	03/08/06	21.90	Baratol, 21.9 lbs.				5.26	16.64						Barium Content	(1) det; (7) pellets
Excess HE	35763	D003, D030	Yes		289.40	PBX-9501, 15.6 lbs.	CHNO Dets, <1 lb.			289.40					Octol, 2.18 lbs.		Shot contained classified HE shapes	
						PBX-9502, 33.26 lbs.												
						PBX-9404, 0.66 lbs.												
						PBX-9407, 0.01 lbs.												
						PBX-9205, 11.02 lbs.												
						PBXN-9, 33 lbs.												
						Comp B, 52.8 lbs												
						Detasheet, 12.58 lbs												
						RDX, 5 lbs.												
						TNT, 76.91 lbs.												
						CHNO HE, 41.38 lbs.												
						Black Powder, 5.0 lbs.												
Excess HE	35763	D003, D030	Yes	03/09/06	429.97	Comp B, 35.11 lbs.	CHNO Dets, <1 lb.			429.97					RDX, 13.0 lbs.			(1) det; (8) pellets; (11) PBX-9501 cylinders = 46.2 lbs.; 103 lbs. PBX-9501 bulk material
						Nitroguanidine, 49.90 lbs.									MDF (PETN), 5.0 lbs.			
						PBX-9205, 26.03 lbs.												
						PBX-9404, 0.66 lbs.												
						PBX-9407, 0.04 lbs.												
						PBX-9501, 238.08 lbs.												
						PBX-9502, 23.76 lbs.												
						TNT, 1.87lbs.												
						X-0533, 35.9 lbs.												
						Primacord (CHNO), 0.62 lbs.												
Excess Baratol	35762	D001, D003, D005, D030	No	05/03/06	34.21	Baratol, 34.21 lbs.				8.21	26.00						Barium content	(1) det; (7) pellets
Excess HE	35763	D003, D030	Yes		650.89					650.89							Shot contained classified HE shapes	
						ANFO, 13.56 lbs.	PETN/HMX, 33.16 lbs.											
						CHNO Classified, 11.18 lbs.												
						Comp. B, 82.94 lbs.												
						Comp. C-4, 4.98 lbs.												
						Cyclotol, 30.00 lbs.												
						Detasheet, 0.26 lbs.												
						LX-14, 170.61 lbs.												
						Octol, 1.10 lbs.												
						PBX-9404, 192.29 lbs.												
						PBX-9407, 0.24 lbs.												
						PBX-9501, 95.61 lbs.												
						PBX-9502, 10.01 lbs.												
						XTX-8003, 4.89 lbs.												
						XTX-8004, 0.04 lbs.												
M-100, M-105 Electric Matches	37092	D003, D008	No	05/04/06	11.00		(50) M-105 (Lead azide, RDX) (50) M-100 (Lead azide, lead styphnate, HMX)				11.00						Lead based primary HE, RDX, HMX. SENSITIVE	(1) det; (6) pellets; 19 lbs. PBX-9501 bulk material; (1) PBX-9501 cylinder = 4.2 lbs.
HE contaminated debris	28345	D003	No	05/11/06	0.01					0.01		PETN on filter cartridge						(1) det; (1) pellet; 21 lbs. PBX-9501 bulk material; (1) PBX-9501 cylinder = 4.2 lbs.
HE contaminated debris w/ ethanol	39254	D001, D003	No		2.00					2.00		HE contaminated lab debris with trace ethanol (kimwipes, swabs, weigh boats)						
Classified explosives	34760	D003	YES		2.00	<2.0	Classified CHNO dets			2.00								
HE contaminated debris	30373	D003	No		0.53					0.53		CHNO contaminated lab debris (kimwipes, swabs, weigh boats)						
Excess HE	37560	D003, D030	No		39.81	AN, 29.93 lbs.	Black powder dets, 0.002 lbs.	Total lab quantity HE in this section = 9.677 lbs.	PLG/UW (RDX/AP/Al), 0.05 lbs.	39.81		Nitroguanidine, 0.11 lbs + 40 lb Fiberboard drum	Developmental propellant HMX/NC/NG/Al/AP, 0.04 lbs.					
								Bullseye Powder, 0.29 lbs.	DNAZ/DNPA/EtGDMA, 0.002 lbs.									
								Comp. B, 0.02 lbs.										
								Cyclotol, 0.01 lbs.										

DE Interim OD TSD Waste Treatment CY 2006
TA36-8 Minie

Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
								DAAF, 0.02 lbs.										
								HMX, 4.602 lbs.										
								IMR Smokeless Powder, 0.084 lbs.										
								PETN, 0.123 lbs.										
								RDX, 0.032 lbs.										
								TATB, 0.12 lbs.										
								Tetryl, 0.02 lbs.										
								Tetrytol, 0.292 lbs.										
								TNT, 0.002 lbs.										
								Semtex 10, 0.070 lbs.										
								Semtex 1A, 0.13 lbs.										
								LX-04, 0.01 lbs.										
								LX-07, 0.007 lbs.										
								LX-14, 0.01 lbs.										
								LX-16, 0.001 lbs.										
								PBX-9404, 0.011 lbs.										
								PBX-9407, 0.113 lbs.										
								PBX-9501, 2.25 lbs.										
				05/16/06				PBX-9502, 0.616 lbs.										(2) dets; (1) pellet; 50 lbs. PBX-9501 bulk material; (1) PBX-9501 cylinder = 4.2 lbs.
								X-0298, 0.066 lbs.										
								X-0319, 0.015 lbs.										
								X-0407, 0.055 lbs.										
								X-0557, 0.075 lbs.										
								X-0564, 0.012 lbs.										
								X-0565, 0.011 lbs.										
								X-0567, 0.002 lbs.										
								X-0569, 0.062										
								XTX-8003, 0.037 lbs.										
								XTX-8004, 0.509 lbs.										
Excess HE	37845	D003	No		0.21			Total lab quantity HE in this section = 0.21 lbs. .		0.21								
								HMX, 0.002 lbs.										
								PBX-9501, 0.137 lbs.										
								PBX-9502, 0.07 lbs.										
Excess HE	37560	D003, D030	No		0.04			Total lab quantity HE in this section = 0.04 lbs. .		0.04								
								Explosive D, 0.012 lbs.										
								BP, 0.011 lbs.										
								PETN, 0.002 lbs.										
								TNT, 0.011 lbs.										
PBX-9501 on brass bar	37446	D003	No		0.55						0.55					PBX-9501, PBX-9502 bonded to brass		
HE (PETN) on cellulosics	28345	D003, D030	No		0.10					0.10		PETN on filter cartridge						
Classified explosives	34760	D003, D030	Yes		2.00	<2.0	CHNO Dets, 1.03 lbs.			2.00								
Type 6S Primaries	34760	D003	No	06/14/06	2.22		HMX Primaries, 2.00 lbs.			2.22								(1) det; (1) pellet; 25 lbs. ANFO; (1) PBX-9501 cylinder = 4.2#
Lead-based Primaries	37092	D003, D008	No		1.00		Lead Primaries, 1.00 lbs.				1.00						Lead styphnate, lead azide	
HE Contaminated Debris	30373	D003, D030	No		0.61					0.61		CHNO contaminated lab debris (kimwipes, swabs, weigh boats)						
Excess HE	37560	D003, D030	No		175.36	Total quantity HE in this section = 151.61 lbs.		Total lab quantity HE in this section = 19.45 lbs.		175.36			Gun Propellant (NC/NG/NQ/DNT), 0.52 lb.			PBX-9501 HE from Spigot Gun Targets, Modified Stevens Targets, 3.78 lbs.		
						ANFO, 1.0 lbs.												
						Comp A, 0.77 lb												
						Comp B		Comp B, 0.07 lb.										
						Comp. C-4, 0.73 lb.												
						Cyclotol, 0.33 lb.		Cyclotol, 0.71 lb.										
						DINGU, 0.62		DINGU										
						EDC-32		EDC-32, 0.11 lb.										
						EDC-35		EDC-35, 0.22 lb.										
						EDC-37		EDC-37, 5.14 lb.										
						Exp. D, 2.0 lb.		Exp D, 0.06 lb.										
						Octol, 0.55 lb.												
						Pentolite, 1.5 lb.		Pentolite, 0.49										
				06/27/06		PYX		PYX, 0.19 lb.										(1) det; (4) pellets; 50 lbs. PBX-9501 bulk material; 50lbs. ANFO; 10 ft Primacord; (2) PBX-9501 cylinders = 8.4 lbs.
						TATB, 15.55lb.		TATB										
						Tetryl		Tetryl, 0.30 lbs.										
						TNT, 2.26 lb.		TNT										
						PBX-9010, 0.56 lbs.		08/31/24										
						PBX-9404		PBX-9404, 0.08 lb.										
						PBX-9501, 89.57 lbs.		PBX-9501, 10.81										
						PBX-9502, 14.37 lbs.		PBX-9502										
						LX-10		LX-10, 0.04 lb.										
						LX-14		LX-14, 0.04 lb.										
						LX-17		LX-17, 0.24 lb.										
						X-0211		X-0211, 0.04 lb.										

DE Interim OD TSD Waste Treatment CY 2006
TA36-8 Minie

Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
						X-0233,		X-0233, 0.01 lb.										
						X-0242, 19.6		X-0242, 0.03 lb.										
						X-0523,		X-0523, 0.02 lb.										
						X-0527,		X-0527, 0.77 lb.										
						X-0533		X-0533, 0.04 lb.										
						X-0534		X-0534, 0.03 lb.										
						X-0544, 2.2 lb.												
						XTX-8003		XTX-8003, 0.01 lb.										
HE	37560	D003, D030	No	08/02/06	172.99	Total HE this section = 142.93 lbs.		Total Lab Quantity this section = 30.06 lbs.		172.99								(1) det; (1) pellet; (1) PBX-9501 cylinder = 2 lbs.; 45 lbs. PBX-9501 bulk material
						PBX-9501, 129.02 lbs.		PBX-9501, 28.58 lbs.										
						PBX-9502, 11.88 lbs.		PBX-9502, 0.91 lbs.										
						TATB, 0.88 lbs.		TATB, 0.29 lbs.										
						X-0562, 0.50 lbs.		PBX-9407, 0.28 lbs.										
						X-0563, 065 lbs.												
PBX 9501 on brass	37446	D003, D030	No	08/10/06	0.01						0.01					5 grams PBX-9501 bonded to brass piece		(3) dets; (1) PBX-9407 pellet; 22 lbs. PBX-9501 hemi; 135 lbs. PBX-9501 bulk material
Excess HE in metal cylinders	37560	D003, D030	No		100.00						100.00					(10) PBX 9501 charges, each 6" dia. X 10" tall encased in welded steel cylinders. 10 pounds each.		
Classified explosives	34760	D003	YES	08/28/06	1.00	<1.0	CHNO Dets, 0.16 lbs.			1.00								(1) det; (4) pellets; (2) PBX-9501 boosters = 10 lbs.; 1 lb. LX17 booster; 1 lb PBX-9404 booster; (2) PBX-9502 cylinders = 16 lbs.;164 lbs. PBX-9501 bulk material; 5 lbs. TNT
HE contaminated debris	28345	D003	No		0.32					0.32		PETN on filter cartridge; CHNO contaminated lab debris (kimwipes, swabs, weigh boats)						
HE contaminated debris	39522	D003, D030	No		4.50					4.50		CHNO contaminated lab debris (kimwipes, swabs, gloves, adhesives, paper, weigh boats)						
HE contaminated debris	39521	D003, D030	No		4.00					4.00		CHNO contaminated lab debris (kimwipes, swabs, gloves, adhesives, paper, weigh boats)						
Excess HE in metal cylinders	37560	D003, D030	No	08/30/06	110.00						110.00	Not applicable for metals analysis?				(11) PBX 9501 charges, each 6" dia. X 10" tall encased in welded steel cylinders. 10 pounds each.		(1) det; (1) pellet; (1) PBX-9501 hemi = 22 lbs.; 140 lbs. PBX-9501 bulk material
Picric acid, partially wetted	37560	D003, D030	No		1.10	Picric Acid, partially wetted, 1.10 lbs.				1.10							EXTREME CAUTION--in jar, wetted Handle as 1.1 D	
Box 4220 TA09 Magazine 0208A	37560	D003, D030	No		1.11			Total Lab Quantity this section = 1.11 lbs.		1.11								
								PBX-9404, 0.12 lbs.										
								PBX-9407, 0.09 lbs.										
								PBX-9501, 0.65 lbs.										
								PBX-9502, 0.22 lbs.										
								TNT, 0.03 lbs.										
Damaged HE from compression testing, spigot gun tests, and impact samples. L category	37560	D003, D030	No		4.04					4.04						PBX-9502, 2.31 lbs. PBX-9501, 1.73 lbs.		
Excess HE in metal boxes	37560	D003, D030	No		0.28						0.28					Black Powder in metal box, 0.22 lbs.; Mixed DINGU/TNT/ TATB in metal box, 0.06 lbs.		

DE Interim OD TSD Waste Treatment CY 2006
TA36-8 Minie

Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
Excess HE and mixed propellants	37560	D003, D030	No	08/31/06	230.92	Total HE this section = 213.68 lbs.		Total Lab Quantity HE this section = 17.24 lbs.		230.92							Propellants and smokeless powders appeared to have been mixed with other materials for	(1) det; (3) pellets; (1) PBX-9501 hemi = 22 lbs.; (2) PBX-9501 cylinders = 4 lbs.; 148 lbs. PBX-9502 bulk material; 80 lbs. PBX-9501 bulk material; 52 lbs. Comp B; 46 lbs. X-0557 .
						M1 Propellant, 28.39 lbs.		M1 Propellant, 1.424 lbs.										
						M8 Propellant, 2.0 lbs.		PBX-9501, 6.727 lbs.										
						PBX-9501, 5.11 lbs.	5.11	PBX-9502, 1.285 lbs.										
						PBX-9502, 24.21 lbs.	24.21	Tetritol, 2.0 lbs.										
						TATB, 40.87 lbs.	40.87	Tritonal, 0.17 lbs.										
						Smokeless Powder, 7.97 lbs.		TATB, 0.22 lbs.										
						X-0407, 62.63 lbs.		X-0407, 1.97 lbs.										
						X-0450, 19.50 lbs.		HMX/RDX/PETN Mixed, 1.35 lbs.										
						X-0541, 23.00 lbs.		DAAF, 0.006 lbs.										
								PBXN-110, 0.55 lbs.										
								PBXN-9, 0.06 lbs.										
								Comp B, 0.522 lbs.										
								Semtex, 0.008 lbs.										
								ANFO, 0.68 lbs.										
								EDC-29, 0.06										
								LAX-112, 0.01 lbs.										
								PBX-9404, 0.075 lbs.										
								X-0541, 0.06 lbs.										
								EDC-37, 0.06 lbs.										
Excess HE, lab quantity, and mixed HE samples from TA37 Magazines	39555	D003, D030	No	10/04/06	221.98	Total HE this section = 203.30 lbs.		Total Lab Quantity and HE Samples this section = 18.68 lbs.		221.98							Some of this HE originated in TA16-340, TA16-430, and TA16-460 and was transferred to TA37 magazines when facilities were vacated	(1) det, (5) pellets, 20 feet Primacord
						PBX-9501, 16.5 lbs.		HNS Mixed, 0.25 lbs.										
						PBX-9502, 11.5 lbs.		Tripeon, 0.27 lbs.										
						PBX-9205, 3.0 lbs.		NC/TNT Mixed, 0.06 lbs.										
						LX-07, 3.0 lbs.		NC, 0.06 lbs.										
						PBX-9501 Mixed, 20 lbs.		TNT, 0.81 lbs.										
						PBX-9502 Mixed, 16 lbs.		TNT Mixed, 0.61 lbs.										
						TNT Mixed, 5.0 lbs.		1,3,5-Trinitrobenzene / HE Samples, 0.03 lbs.										
						DAAF, 0.8 lbs.		2,4,6-Trinitrobenzoic Acid / HE Samples, 0.23 lbs.										
						XTX-8003 Mixed, 3.5 lbs.		1,3 Dichloro-2,4,6-Trinitrobenzene / HE Samples, 0.17 lbs.										
						XTX-8004, 10 lbs.		2,4,6-Trinitroanisole / HE Samples, 0.22 lbs.										
						9007, 1 lbs.		2,4,6-Trinitroresorcinol / HE Samples, 0.06 lbs.										
						NQ, 11.5 lbs.		Nitroguanidine Mixed , 0.25 lbs.										
						AN, 1.25 lbs.		PBX-9501, 13.3 lbs.										
						9001, 1 lbs.		PBX-9502, 0.2 lbs.										
						PBX-9404, 0.5 lbs.		Comp B Mixed, 0.06 lbs.										
						PBX-9407, 1.0 lbs.		Dipicrylamine Mixed, 0.02 lbs.										
						RDX, 0.5 lbs.		DINGU, 0.01 lbs.										
						TATB, 4.5 lbs.		X-0290, 0.75 lbs.										
						X-0182, 2.0 lbs.		LX-07, 0.17 lbs.										
						X-0224, 8.25 lbs.		Nitro Urea/Urea Nitrate, 0.03 lbs.										
						X-0228, 2.5 lbs.		PBX-9407, 0.06 lbs.										
						X-0233, 3.5 lbs.		2,4,6-Trinitrometaxylene Samples, 0.11 lbs.										
						X-0234, 5 lbs.		DATB, 0.25 lbs.										
						X-0242, 3 lbs.		(6) Vials Mixed HE Samples										
						X-0280, 10 lbs.		RDX, 0.2 lbs.										
						X-0282, 2.5 lbs.												
						X-0283, 6.0 lbs.												
						X-0286, 1.5 lbs.												
						X-0298, 22 lbs.												
						X-0301, 1 lbs.												

DE Interim OD TSD Waste Treatment CY 2006
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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
						X-0303, 1.5 lbs.												
						X-0306, 4.5 lbs.												
						X-0308, 3.25 lbs.												
						X-0312, 1 lbs.												
						X-0406, 1 lbs.												
						X-0409, 0.5 lbs.												
						X-0410, 0.5 lbs.												
						X-0418, 1 lbs.												
						X-0419, 0.5 lbs.												
						X-0430, 0.5 lbs.												
						X-0438, 0.5 lbs.												
						X-0444, 1.5 lbs.												
						X-0463, 3.0 lbs.												
						X-0464, 0.5 lbs.												
						X-0513, 1.0 lbs.												
						X-0515, 1 lbs.												
						X-0516, 1.25 lbs.												
						X-0517, 1 lbs.												
						X-0521, 1 lbs.												
						RX-03-AT, 0.5 lbs.												
Excess HE and HE samples	39555	D003, D030	No	10/20/06	6.50	Total HE this section = 4.5 lbs.		Total Lab quantity HE and HE samples this section = 2.0 lbs.		6.50								(1) det; (1) pellet; 83 lbs. PBX-9501 pieces; 135 lbs. PBX-9501 bulk material; 9 lbs. PBX-9502 pieces; 46.5 lbs. TNT
						X-0233, 0.5 lbs.		(28) Misc HE Samples, 2.0 lbs. HE										
						X-0298, 1.5 lbs.												
						X-0407, 0.5 lbs.												
						PBX-9407, 0.5 lbs.												
						PBX-9502, 1 lbs.												
						EDD, 0.5 lbs.												
Excess Barium-based HE	39554	D001, D003, D005, D030	No		52.70	Total HE this section = 52.7 lbs.												
						X-0256, 0.50 lbs.				0.50								
						X-0262, 7.10 lbs.				7.10								
						X-0264, 7.10 lbs.				7.10								
						Baratol, 38 lbs.				9.12	28.88							
												-						
HE-contaminated shot debris B/C 10055613	30373	D003	YES	11/17/06	1.06						1.06	Polyamide film, cellulosics, copper, wood, plastics, 5% CHNO dets						(1) det; (1) pellet; 2 lbs. PBX-9501 piece; 45 lbs. PBX-9501 bulk material
HE and ethanol contaminated lab cleaning debris	39254	D001, D003	No		0.66					0.66		HE contaminated lab debris with trace ethanol (kimwipes, swabs, weigh boats)						
Classified explosives	34760	D003	YES		1.00	<1.0	CHNO dets			1.00								
HE contaminated cellulosics (PETN filter)	28345	D003	No		0.15					0.15		PETN on filter cartridge						
Excess explosives	39693	D003, D030	No	12/06/06	13.53	Total HE this section = 1 lbs.		Total lab quantity HE this section = 0.48 lbs.		1.48						Total HE Assemblies this section = 12.05 lbs.		(1) det; (1) pellet; (1) PBX-9501 disc; 2 lbs.; 172.7 lbs. PBX-9501 bulk material; 102.5 lbs. PBX-9502 bulk material; 10 lbs. Octol; 2.5 lbs. PBX-9407; 24 lbs. TNT; 8 lbs. Comp B; 7 lbs. LX-07
						IMR 4198 Powder (NC / 2,4-DNT), 1.0 lbs.		IMR 4198 Powder (NC/2,4-DNT), 0.33 lbs.								LX-07/PBX-9502 Assemblies, 12 lbs.		
								TATB, 0.04 lbs.								DAAF Assemblies, 0.05 lbs.		
								Aluminum powder/HE/oil, 0.06 lbs.										
								Comp C-4, 0.02 lbs.										
								PBX-9502, 0.03 lbs.										
						Total HE Assemblies				12.05								
HE contaminated debris	39611	D003, D030	No		15.98					15.98		Total HE contaminated debris this section = 15.98 lbs.						
												HE contaminated debris with PBX-9501 chips and PBX-9502 pieces, 1.0 lbs.						
												HE contaminated debris with PBX-9502 pieces, 0.54 lbs.						
												HE contaminated debris (primarily cellulosics) with chunks of PBX-9501, PBX-9502, TATB, and PETN, 5.42 lbs.						
												HE contaminated debris, PETN and C-4, 0.06 lbs.						

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Description	WPF	EPA Waste Code(s)	Classified?	Date Treated	Waste Wt, lbs.	HE	Detonators, initiators	Lab Quantity HE	Developmental CHNO Explosives	Combined HE / Excess Explosives (non-metal) - lbs	Combined HE / Excess Explosives - Metal Content - lbs	HE Contaminated Debris	Propellants	Munitions	Shaped Charges	Other	Comments	Fuel (1) detonator = 0.625 g CHNO HE (1) pellet = 3 g PBX-9407
												HE contaminated debris and sweepings TATB, LX-07, PBX-9501, PETN , C-4 8.75 lbs.						
												HE contaminated debris TATB, 0.06 lbs.						
												HE contaminated debris, X-0565, 0.06 lbs.						
Excess barium-based HE	39554	D001, D003, D005, D030	No	12/13/06	116.50	Baratol, 56.5 lbs.	56.50			13.56	42.94							(1) det; (1) pellet; 67 lbs. PBX-9502 bulk material; 45 lbs. PBX-9501 bulk material; 8 lbs. X-0242; 12 lbs. PBX-9501 pieces
						LX-10, 60 lbs.	60.00			60.00								
Totals		**LBS.**			**2725.50**					2387.13	338.36							
									Potential Metal Waste - lbs	338.36	210.28	**From steel cylinders**						
									Factor for Metal containing waste	0.124	0.077	**Factor for Metal containing waste (minus Ba,Cu,Pb)**						
									Barium compound (based on Baratol)		114.46							
									Factor for Barium containing waste		0.042							
									Lead compound fraction		12.00							
									Factor for Lead containing waste		0.0044							
									Copper compound/brass alloy fraction		1.62							
									Factor for copper (brass containing waste)		0.00059							

Supplement 4-4

Air Sampling at Open Detonation Units

Open Detonation Air Sampling Summary for Resource Conservation and Recovery Act (RCRA) Permitting at Los Alamos National Laboratory

Andrew Green and Shannon Allen
WES-EDA

During 2010 and 2011 the Environmental Data and Analysis Group (WES-EDA) AIRNET team conducted sampling of suites of dioxins, furans and metals in support of the RCRA permit for Los Alamos National Laboratory (LANL) operated by LANS, LLC.

This document is a brief description of the work that was performed by the AIRNET team. Shannon Allen headed up the field team of Joan Lujan, William Smith and Louis Naranjo. Shannon coordinated the equipment purchase and sample analysis. Andrew Green performed the data analysis with support from Luciana Vigil-Holterman.

Dioxin and Furan Detection Equipment and Methodology

Thirty samples were collected for analysis using the EPA TO-9A method. The samples were collected using appropriate specialized high volume air samplers (Model TE-1000 PUF Poly-Urethane Foam) which were purchased from Tisch Environmental, Inc.

Prior to sample collection the sampling equipment was calibrated as described in the Operations Manual for the TE-1000 PUF. Sample flow volumes were calculated as described in the manual. Average atmospheric pressure and temperature data used in the calculation were obtained from LANL's meteorological tower at TA-54.

Pre-prepared sample media for TO-9A was obtained from Test America. TO-9A filters included a poly-urethane foam filter in a glass cartridge, and an airborne particulate filter. The glass PUF cartridge and the particulate filter were installed in series into the PUF sample module and connected to the sampler.

After collection, samples were returned for analysis to Test America in the original pre-cleaned packaging which consisted of aluminum foil and zip lock bags. Samples were shipped from the LANL Sample Management Office using coolers and ice to preserve samples as required by the TO-9A method.

One field blank was collected for each day of sampling, for a total of 8 blank samples.

Nitrile gloves were used whenever sample media were handled.

Metals Detection Equipment and Methodology

Thirty metals samples were collected using high volume air samplers (Hi-Q Environmental Model HVP-3000 BRL). Polypropylene 8"x10" filters were used, which were pre-cut and sold by Hi-Q Environmental.

Three field blank samples were collected, one for every ten field samples.

Field samples were collected per SOP-5174 Rev. 1, "AIRNET – Using High Volume Samplers". Samples were shipped by LANL's Sample Management Office to the analytical laboratory, ALS.

Sampling Location Selection and Methodology

For each shot, two locations were sampled. Each location had one TE-1000 PUF sampler and one high-volume sampler from Hi-Q. Sampler locations were chosen the morning of each shot after observing the predominant wind direction at the site and looking at the wind direction reported on the LANL meteorology site. Samplers were set as closely as possible to the shot location in a down wind direction. Sampling equipment was started approximately 10 to 15 minutes prior to the shot, and run for at least 15 minutes after the shot. All samplers were powered with extension cords; no gas generators were used. Vehicles were not operated in the immediate area (within the shot exclusion zone) during the sampling period. Shots were monitored from inside the bunker, and any observed plume or wind direction during collection was documented in the field notes.

Data Analysis

The field data were coordinated with the data analysis results to derive volume concentrations which were then compared to acute air inhalation exposure concentrations listed in the companion database of the 2005 US Environmental Protection Agency (EPA) *Human Health Hazard Risk Assessment Protocol for Hazardous Waste Combustion Facilities* (EPA530-R-05-006) when available. Other acute inhalation screening levels were identified within the 1999 *Air Toxics Hot Spots Program Risk Assessment Guidelines Part I The Determination of Acute Reference Exposure Levels for Airborne Toxicants,* drafted by the Office of Environmental Health Hazard Assessment of the California Environmental Protection Agency. These comparisons are attached to this document.

Concluding Remarks

Data were collected following the standard protocol for such measurements.

Comparisons with identified screening levels indicate operations that were monitored did not exceed any appropriate state or federal levels specified for the analytes monitored.

==========end of document==========

Attachment

Summary of Analytical Results for Air Samples Collected at TA-36 and TA-39 Open Detonation Treatment Operations

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2834	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	1.2	pg/Filter	0.198	27	5.346	2.24E-01						
RE39-11-2842	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	0.93	pg/Filter	0.198	36.6	7.2468	1.28E-01						
RE39-11-4518	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzodioxins (Total)	50	pg/Filter			10.18	4.91E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2826	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzodioxins (Total)	2	pg/Filter	0.198	27	5.346	3.74E-01						
RE39-11-2842	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzodioxins (Total)	0.93	pg/Filter	0.198	36.6	7.2468	1.28E-01						
RE39-11-4518	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzodioxins (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	1	pg/Filter			10.18	9.82E-02						
RE36-11-2826	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2830	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	1.3	pg/Filter	0.198	27	5.346	2.43E-01						
RE39-11-2842	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2844	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2824	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Heptachlorodibenzofurans (Total)	1	pg/Filter			10.18	9.82E-02						
RE36-11-2826	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2827	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2844	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4185	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2836	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Heptachlorodibenzofurans (Total)	1.3	pg/Filter	0.198	27	5.346	2.43E-01						
RE39-11-2842	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4191	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4187	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4196	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Heptachlorodibenzofurans (Total)	50	pg/Filter			0							
RE39-11-4522	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Heptachlorodibenzofurans (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2840	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4193	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4195	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzodioxins (Total)	4	pg/Filter	0.153	39.6	6.0588	6.60E-01						
RE39-11-2845	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzodioxins (Total)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzodioxins (Total)	1.3	pg/Filter	0.189	44.4	8.3916	1.55E-01						
RE36-11-2833	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzodioxins (Total)	1.5	pg/Filter	0.193	27.6	5.3268	2.82E-01						
RE39-11-2836	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzodioxins (Total)	2.3	pg/Filter	0.189	25.2	4.7628	4.83E-01						
RE39-11-2839	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzodioxins (Total)	2.1	pg/Filter	0.198	27	5.346	3.93E-01						
RE39-11-2842	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzodioxins (Total)	4.4	pg/Filter	0.168	36	6.048	7.28E-01						
RE36-11-4194	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzodioxins (Total)	2.3	pg/Filter	0.198	36.6	7.2468	3.17E-01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4518	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzodioxins (Total)	1.3	pg/Filter	0.202	30.6	6.1812	2.10E-01						
RE39-11-4520	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzodioxins (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzodioxins (Total)	2.3	pg/Filter	0.211	28.8	6.0768	3.78E-01		0				0
RE39-11-2834	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4522	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[1,2,3,4,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[1,2,3,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2824	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[1,2,3,7,8,9-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2828	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofuran[2,3,4,6,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2824	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Hexachlorodibenzofurans (Total)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2827	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2832	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-2844	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4185	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4191	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4187	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE36-11-4196	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Hexachlorodibenzofurans (Total)	50	pg/Filter			0							
RE39-11-4522	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Hexachlorodibenzofurans (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	5.9	pg/Filter	0.153	39.6	6.0588	9.74E-01						
RE39-11-2845	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.8	pg/Filter			0							
RE36-11-2824	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	4	pg/Filter	0.183	33	6.039	6.62E-01						
RE36-11-2825	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.1	pg/Filter			10.18	2.06E-01						
RE36-11-2826	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.4	pg/Filter			0							
RE36-11-2827	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.7	pg/Filter	0.188	29.4	5.5272	6.69E-01						
RE36-11-2828	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.8	pg/Filter	0.186	37.8	7.0308	5.40E-01						
RE36-11-2829	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	4.3	pg/Filter	0.19	22.2	4.218	1.02E+00						
RE36-11-2830	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.178	45	8.01	1.25E+01						
RE36-11-2831	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2	pg/Filter	0.167	28.2	4.7094	4.25E-01						
RE36-11-2832	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	44.4	8.3916	1.19E+01						
RE36-11-2833	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.3	pg/Filter			0							
RE36-11-2844	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.5	pg/Filter			0							
RE36-11-4185	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.6	pg/Filter	0.178	36	6.408	4.06E-01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4186	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.7	pg/Filter	0.194	40.8	7.9152	3.41E-01						
RE39-11-2835	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.5	pg/Filter	0.193	27.6	5.3268	6.57E-01						
RE39-11-2836	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3	pg/Filter	0.192	19.2	3.6864	8.14E-01						
RE39-11-2837	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.1	pg/Filter	0.197	31.2	6.1464	5.04E-01						
RE39-11-2838	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.4	pg/Filter	0.189	25.2	4.7628	7.14E-01						
RE39-11-2839	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2	pg/Filter	0.198	30.6	6.0588	3.30E-01						
RE39-11-2840	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.7	pg/Filter	0.191	24	4.584	5.89E-01						
RE39-11-2841	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.4	pg/Filter	0.198	27	5.346	6.36E-01						
RE39-11-2842	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4191	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.196	33	6.468	1.55E+01						
RE36-11-4193	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.3	pg/Filter	0.168	36	6.048	3.80E-01						
RE36-11-4194	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4187	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	8.6	pg/Filter	0.198	23.4	4.6332	1.86E+00						
RE36-11-4188	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	38.4	7.2576	1.38E+01						
RE36-11-4195	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4196	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	7.9	pg/Filter	0.197	101.4	19.9758	3.95E-01						
RE36-11-4198	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.169	111	18.759	5.33E+00						
RE39-11-2843	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.7	pg/Filter	0.198	36.6	7.2468	5.11E-01						
RE39-11-4518	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	4.1	pg/Filter	0.197	34.8	6.8556	5.98E-01						
RE39-11-4519	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.5	pg/Filter	0.202	30.6	6.1812	5.66E-01						
RE39-11-4520	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	3.2	pg/Filter	0.189	31.8	6.0102	5.32E-01						
RE39-11-4521	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE39-11-4522	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	1.6	pg/Filter	0.186	25.8	4.7988	3.33E-01						
RE39-11-4523	Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]	2.8	pg/Filter	0.211	28.8	6.0768	4.61E-01		0				0
RE39-11-2834	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.153	39.6	6.0588	1.65E+01						
RE39-11-2845	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-2824	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.183	33	6.039	1.66E+01						
RE36-11-2825	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			10.18	9.82E+00						
RE36-11-2826	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-2827	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.188	29.4	5.5272	1.81E+01						
RE36-11-2828	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.186	37.8	7.0308	1.42E+01						
RE36-11-2829	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.19	22.2	4.218	2.37E+01						
RE36-11-2830	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.178	45	8.01	1.25E+01						
RE36-11-2831	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.167	28.2	4.7094	2.12E+01						
RE36-11-2832	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	44.4	8.3916	1.19E+01						
RE36-11-2833	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-2844	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1.6	pg/Filter			0							
RE36-11-4185	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.178	36	6.408	1.56E+01						
RE36-11-4186	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.194	40.8	7.9152	1.26E+01						
RE39-11-2835	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1.6	pg/Filter	0.193	27.6	5.3268	3.00E-01						
RE39-11-2836	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.192	19.2	3.6864	2.71E+01						
RE39-11-2837	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.197	31.2	6.1464	1.63E+01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2838	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	25.2	4.7628	2.10E+01						
RE39-11-2839	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	30.6	6.0588	1.65E+01						
RE39-11-2840	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.191	24	4.584	2.18E+01						
RE39-11-2841	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	27	5.346	1.87E+01						
RE39-11-2842	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4191	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.196	33	6.468	1.55E+01						
RE36-11-4193	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.168	36	6.048	1.65E+01						
RE36-11-4194	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4187	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	23.4	4.6332	2.16E+01						
RE36-11-4188	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	38.4	7.2576	1.38E+01						
RE36-11-4195	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE36-11-4196	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.197	101.4	19.9758	5.01E+00						
RE36-11-4198	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.169	111	18.759	5.33E+00						
RE39-11-2843	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.198	36.6	7.2468	1.38E+01						
RE39-11-4518	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.197	34.8	6.8556	1.46E+01						
RE39-11-4519	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.202	30.6	6.1812	1.62E+01						
RE39-11-4520	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.189	31.8	6.0102	1.66E+01						
RE39-11-4521	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter			0							
RE39-11-4522	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.186	25.8	4.7988	2.08E+01						
RE39-11-4523	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	100	pg/Filter	0.211	28.8	6.0768	1.65E+01		0				0
RE39-11-2834	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2842	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzodioxin[1,2,3,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzodioxins (Total)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzodioxins (Total)	1.8	pg/Filter	0.198	27	5.346	3.37E-01						
RE39-11-2842	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4187	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzodioxins (Total)	1.5	pg/Filter	0.169	111	18.759	8.00E-02						
RE39-11-2843	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzodioxins (Total)	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzodioxins (Total)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4198	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzofuran[1,2,3,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.192	19.2	3.6864	1.36E+01						
RE39-11-2837	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4520	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzofuran[2,3,4,7,8-]	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0
RE39-11-2834	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.153	39.6	6.0588	8.25E+00						
RE39-11-2845	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-2824	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.183	33	6.039	8.28E+00						
RE36-11-2825	Pentachlorodibenzofurans (Totals)	50	pg/Filter			10.18	4.91E+00						
RE36-11-2826	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-2827	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.188	29.4	5.5272	9.05E+00						
RE36-11-2828	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.186	37.8	7.0308	7.11E+00						
RE36-11-2829	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.19	22.2	4.218	1.19E+01						
RE36-11-2830	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.178	45	8.01	6.24E+00						
RE36-11-2831	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.167	28.2	4.7094	1.06E+01						
RE36-11-2832	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	44.4	8.3916	5.96E+00						
RE36-11-2833	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-2844	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4185	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.178	36	6.408	7.80E+00						
RE36-11-4186	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.194	40.8	7.9152	6.32E+00						
RE39-11-2835	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.193	27.6	5.3268	9.39E+00						
RE39-11-2836	Pentachlorodibenzofurans (Totals)	2.6	pg/Filter	0.192	19.2	3.6864	7.05E-01						
RE39-11-2837	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.197	31.2	6.1464	8.13E+00						
RE39-11-2838	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	25.2	4.7628	1.05E+01						
RE39-11-2839	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	30.6	6.0588	8.25E+00						
RE39-11-2840	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.191	24	4.584	1.09E+01						
RE39-11-2841	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	27	5.346	9.35E+00						
RE39-11-2842	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4191	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.196	33	6.468	7.73E+00						
RE36-11-4193	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.168	36	6.048	8.27E+00						
RE36-11-4194	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4187	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	23.4	4.6332	1.08E+01						
RE36-11-4188	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	38.4	7.2576	6.89E+00						
RE36-11-4195	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE36-11-4196	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.197	101.4	19.9758	2.50E+00						
RE36-11-4198	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.169	111	18.759	2.67E+00						
RE39-11-2843	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.198	36.6	7.2468	6.90E+00						
RE39-11-4518	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.197	34.8	6.8556	7.29E+00						
RE39-11-4519	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.202	30.6	6.1812	8.09E+00						
RE39-11-4520	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.189	31.8	6.0102	8.32E+00						
RE39-11-4521	Pentachlorodibenzofurans (Totals)	50	pg/Filter			0							
RE39-11-4522	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.186	25.8	4.7988	1.04E+01						
RE39-11-4523	Pentachlorodibenzofurans (Totals)	50	pg/Filter	0.211	28.8	6.0768	8.23E+00		0				0

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2834	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.153	39.6	6.0588	1.65E+00						
RE39-11-2845	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			10.18	9.82E-01						
RE36-11-2826	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.19	22.2	4.218	2.37E+00						
RE36-11-2830	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2844	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.192	19.2	3.6864	2.71E+00						
RE39-11-2837	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.168	36	6.048	1.65E+00						
RE36-11-4194	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzodioxin[2,3,7,8-]	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		0				0
RE39-11-2834	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.153	39.6	6.0588	1.65E+00						
RE39-11-2845	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			10.18	9.82E-01						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2826	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.19	22.2	4.218	2.37E+00						
RE36-11-2830	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-2844	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.192	19.2	3.6864	2.71E+00						
RE39-11-2837	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.168	36	6.048	1.65E+00						
RE36-11-4194	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzodioxins (Total)	10	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzodioxins (Total)	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		0				0
RE39-11-2834	Tetrachlorodibenzofuran[2,3,7,8-]	2.4	pg/Filter	0.153	39.6	6.0588	3.96E-01						
RE39-11-2845	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			10.18	9.82E-01						
RE36-11-2826	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.19	22.2	4.218	2.37E+00						

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2830	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-2844	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzofuran[2,3,7,8-]	1.8	pg/Filter	0.192	19.2	3.6864	4.88E-01						
RE39-11-2837	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.168	36	6.048	1.65E+00						
RE36-11-4194	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzofuran[2,3,7,8-]	2.1	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzofuran[2,3,7,8-]	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		0				0
RE39-11-2834	Tetrachlorodibenzofurans (Totals)	2.4	pg/Filter	0.153	39.6	6.0588	3.96E-01						
RE39-11-2845	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-2824	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.183	33	6.039	1.66E+00						
RE36-11-2825	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			10.18	9.82E-01						
RE36-11-2826	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-2827	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.188	29.4	5.5272	1.81E+00						
RE36-11-2828	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.186	37.8	7.0308	1.42E+00						
RE36-11-2829	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.19	22.2	4.218	2.37E+00						
RE36-11-2830	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.178	45	8.01	1.25E+00						
RE36-11-2831	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.167	28.2	4.7094	2.12E+00						
RE36-11-2832	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	44.4	8.3916	1.19E+00						
RE36-11-2833	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2844	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4185	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.178	36	6.408	1.56E+00						
RE36-11-4186	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.194	40.8	7.9152	1.26E+00						
RE39-11-2835	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.193	27.6	5.3268	1.88E+00						
RE39-11-2836	Tetrachlorodibenzofurans (Totals)	49	pg/Filter	0.192	19.2	3.6864	1.33E+01	detect		1.50E-03		1.50E+06	
RE39-11-2837	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.197	31.2	6.1464	1.63E+00						
RE39-11-2838	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	25.2	4.7628	2.10E+00						
RE39-11-2839	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	30.6	6.0588	1.65E+00						
RE39-11-2840	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.191	24	4.584	2.18E+00						
RE39-11-2841	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	27	5.346	1.87E+00						
RE39-11-2842	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4191	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.196	33	6.468	1.55E+00						
RE36-11-4193	Tetrachlorodibenzofurans (Totals)	11	pg/Filter	0.168	36	6.048	1.82E+00						
RE36-11-4194	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4187	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	23.4	4.6332	2.16E+00						
RE36-11-4188	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	38.4	7.2576	1.38E+00						
RE36-11-4195	Tetrachlorodibenzofurans (Totals)	10	pg/Filter			0							
RE36-11-4196	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.197	101.4	19.9758	5.01E-01						
RE36-11-4198	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.169	111	18.759	5.33E-01						
RE39-11-2843	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.198	36.6	7.2468	1.38E+00						
RE39-11-4518	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.197	34.8	6.8556	1.46E+00						
RE39-11-4519	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.202	30.6	6.1812	1.62E+00						
RE39-11-4520	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.189	31.8	6.0102	1.66E+00						
RE39-11-4521	Tetrachlorodibenzofurans (Totals)	2.1	pg/Filter			0							
RE39-11-4522	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.186	25.8	4.7988	2.08E+00						
RE39-11-4523	Tetrachlorodibenzofurans (Totals)	10	pg/Filter	0.211	28.8	6.0768	1.65E+00		1				0
RE39-11-2936	Aluminum	230	ug/FILTER	1.11851544	36	40.26656	5.71E+00	detect		none specified			
RE39-11-2945	Aluminum	41	ug/FILTER			0		detect		none specified			
RE36-11-2914	Aluminum	34	ug/FILTER	1.104357017	30	33.13071	1.03E+00	detect		none specified			
RE36-11-2915	Aluminum	41	ug/FILTER	1.132673864	54	61.16439	6.70E-01	detect		none specified			
RE36-11-2916	Aluminum	39	ug/FILTER	1.132673864	30	33.98022	1.15E+00	detect		none specified			
RE36-11-2917	Aluminum	32	ug/FILTER	1.132673864	36	40.77626	7.85E-01	detect		none specified			
RE36-11-2918	Aluminum	65	ug/FILTER	1.104357017	18	19.87843	3.27E+00	detect		none specified			
RE36-11-2919	Aluminum	68	ug/FILTER	1.132673864	42	47.5723	1.43E+00	detect		none specified			
RE36-11-2920	Aluminum	100	ug/FILTER	1.132673864	24	27.18417	3.68E+00	detect		none specified			
RE36-11-2921	Aluminum	89	ug/FILTER	1.132673864	42	47.5723	1.87E+00	detect		none specified			
RE36-11-2922	Aluminum	54	ug/FILTER	1.104357017	36	39.75685	1.36E+00	detect		none specified			
RE36-11-2923	Aluminum	46	ug/FILTER	1.104357017	36	39.75685	1.16E+00	detect		none specified			
RE39-11-2935	Aluminum	47	ug/FILTER	1.132673864	30	33.98022	1.38E+00	detect		none specified			
RE39-11-2937	Aluminum	38	ug/FILTER	1.132673864	18	20.38813	1.86E+00	detect		none specified			
RE39-11-2938	Aluminum	190	ug/FILTER	1.132673864	30	33.98022	5.59E+00	detect		none specified			
RE39-11-2939	Aluminum	110	ug/FILTER	1.104357017	24	26.50457	4.15E+00	detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2940	Aluminum	300	ug/FILTER	1.104357017	30	33.13071	9.06E+00	detect		none specified			
RE39-11-2941	Aluminum	62	ug/FILTER	1.132673864	24	27.18417	2.28E+00	detect		none specified			
RE39-11-2942	Aluminum	250	ug/FILTER	1.132673864	24	27.18417	9.20E+00	detect		none specified			
RE36-11-4184	Aluminum	42	ug/FILTER	1.132673864	30	33.98022	1.24E+00	detect		none specified			
RE36-11-4189	Aluminum	49	ug/FILTER	1.132673864	30	33.98022	1.44E+00	detect		none specified			
RE36-11-4190	Aluminum	81	ug/FILTER			0		detect		none specified			
RE36-11-2934	Aluminum	32	ug/FILTER	1.132673864	42	47.5723	6.73E-01	detect		none specified			
RE36-11-4192	Aluminum	36	ug/FILTER	1.132673864	96	108.7367	3.31E-01	detect		none specified			
RE36-11-4197	Aluminum	74	ug/FILTER	1.061881747	108	114.6832	6.45E-01	detect		none specified			
RE36-11-4503	Aluminum	57	ug/FILTER	1.132673864	30	33.98022	1.68E+00	detect		none specified			
RE39-11-2943	Aluminum	45	ug/FILTER	1.132673864	30	33.98022	1.32E+00	detect		none specified			
RE39-11-2944	Aluminum	200	ug/FILTER	1.132673864	36	40.77626	4.90E+00	detect		none specified			
RE39-11-4524	Aluminum	46	ug/FILTER	1.104357017	30	33.13071	1.39E+00	detect		none specified			
RE39-11-4525	Aluminum	28	ug/FILTER	1.104357017	30	33.13071	8.45E-01	detect		none specified			
RE39-11-4526	Aluminum	5.5	ug/FILTER			0				none specified			
RE39-11-4527	Aluminum	9.7	ug/FILTER	1.132673864	24	27.18417	3.57E-01			none specified			
RE39-11-4528	Aluminum	38	ug/FILTER	1.132673864	24	27.18417	1.40E+00	detect	31	none specified			0
RE39-11-2936	Antimony	0.16	ug/FILTER	1.11851544	36	40.26656	3.97E-03	detect		1.5		1.50E+03	
RE39-11-2945	Antimony	0.024	ug/FILTER			0				1.5		1.50E+03	
RE36-11-2914	Antimony	0.08	ug/FILTER	1.104357017	30	33.13071	2.41E-03	detect		1.5		1.50E+03	
RE36-11-2915	Antimony	0.076	ug/FILTER	1.132673864	54	61.16439	1.24E-03	detect		1.5		1.50E+03	
RE36-11-2916	Antimony	0.044	ug/FILTER	1.132673864	30	33.98022	1.29E-03			1.5		1.50E+03	
RE36-11-2917	Antimony	0.042	ug/FILTER	1.132673864	36	40.77626	1.03E-03			1.5		1.50E+03	
RE36-11-2918	Antimony	0.038	ug/FILTER	1.104357017	18	19.87843	1.91E-03			1.5		1.50E+03	
RE36-11-2919	Antimony	0.028	ug/FILTER	1.132673864	42	47.5723	5.89E-04			1.5		1.50E+03	
RE36-11-2920	Antimony	0.044	ug/FILTER	1.132673864	24	27.18417	1.62E-03			1.5		1.50E+03	
RE36-11-2921	Antimony	0.046	ug/FILTER	1.132673864	42	47.5723	9.67E-04			1.5		1.50E+03	
RE36-11-2922	Antimony	0.06	ug/FILTER	1.104357017	36	39.75685	1.51E-03			1.5		1.50E+03	
RE36-11-2923	Antimony	0.06	ug/FILTER	1.104357017	36	39.75685	1.51E-03			1.5		1.50E+03	
RE39-11-2935	Antimony	0.034	ug/FILTER	1.132673864	30	33.98022	1.00E-03			1.5		1.50E+03	
RE39-11-2937	Antimony	0.05	ug/FILTER	1.132673864	18	20.38813	2.45E-03			1.5		1.50E+03	
RE39-11-2938	Antimony	0.14	ug/FILTER	1.132673864	30	33.98022	4.12E-03	detect		1.5		1.50E+03	
RE39-11-2939	Antimony	0.046	ug/FILTER	1.104357017	24	26.50457	1.74E-03			1.5		1.50E+03	
RE39-11-2940	Antimony	0.32	ug/FILTER	1.104357017	30	33.13071	9.66E-03	detect		1.5		1.50E+03	
RE39-11-2941	Antimony	0.06	ug/FILTER	1.132673864	24	27.18417	2.21E-03			1.5		1.50E+03	
RE39-11-2942	Antimony	0.16	ug/FILTER	1.132673864	24	27.18417	5.89E-03	detect		1.5		1.50E+03	
RE36-11-4184	Antimony	0.026	ug/FILTER	1.132673864	30	33.98022	7.65E-04			1.5		1.50E+03	
RE36-11-4189	Antimony	0.038	ug/FILTER	1.132673864	30	33.98022	1.12E-03			1.5		1.50E+03	
RE36-11-4190	Antimony	0.044	ug/FILTER			0				1.5		1.50E+03	
RE36-11-2934	Antimony	0.06	ug/FILTER	1.132673864	42	47.5723	1.26E-03			1.5		1.50E+03	
RE36-11-4192	Antimony	0.06	ug/FILTER	1.132673864	96	108.7367	5.52E-04			1.5		1.50E+03	
RE36-11-4197	Antimony	0.036	ug/FILTER	1.061881747	108	114.6832	3.14E-04			1.5		1.50E+03	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4503	Antimony	0.06	ug/FILTER	1.132673864	30	33.98022	1.77E-03			1.5		1.50E+03	
RE39-11-2943	Antimony	0.048	ug/FILTER	1.132673864	30	33.98022	1.41E-03			1.5		1.50E+03	
RE39-11-2944	Antimony	0.07	ug/FILTER	1.132673864	36	40.77626	1.72E-03	detect		1.5		1.50E+03	
RE39-11-4524	Antimony	0.036	ug/FILTER	1.104357017	30	33.13071	1.09E-03			1.5		1.50E+03	
RE39-11-4525	Antimony	0.06	ug/FILTER	1.104357017	30	33.13071	1.81E-03			1.5		1.50E+03	
RE39-11-4526	Antimony	0.06	ug/FILTER			0				1.5		1.50E+03	
RE39-11-4527	Antimony	0.06	ug/FILTER	1.132673864	24	27.18417	2.21E-03			1.5		1.50E+03	
RE39-11-4528	Antimony	0.032	ug/FILTER	1.132673864	24	27.18417	1.18E-03		7	1.5		1.50E+03	0
RE39-11-2936	Arsenic	0.052	ug/FILTER	1.11851544	36	40.26656	1.29E-03			1.90E-04		1.90E-01	
RE39-11-2945	Arsenic	0.4	ug/FILTER			0				1.90E-04		1.90E-01	
RE36-11-2914	Arsenic	0.052	ug/FILTER	1.104357017	30	33.13071	1.57E-03			1.90E-04		1.90E-01	
RE36-11-2915	Arsenic	0.034	ug/FILTER	1.132673864	54	61.16439	5.56E-04			1.90E-04		1.90E-01	
RE36-11-2916	Arsenic	0.042	ug/FILTER	1.132673864	30	33.98022	1.24E-03			1.90E-04		1.90E-01	
RE36-11-2917	Arsenic	0.4	ug/FILTER	1.132673864	36	40.77626	9.81E-03			1.90E-04		1.90E-01	
RE36-11-2918	Arsenic	0.044	ug/FILTER	1.104357017	18	19.87843	2.21E-03			1.90E-04		1.90E-01	
RE36-11-2919	Arsenic	0.4	ug/FILTER	1.132673864	42	47.5723	8.41E-03			1.90E-04		1.90E-01	
RE36-11-2920	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02			1.90E-04		1.90E-01	
RE36-11-2921	Arsenic	0.4	ug/FILTER	1.132673864	42	47.5723	8.41E-03			1.90E-04		1.90E-01	
RE36-11-2922	Arsenic	0.4	ug/FILTER	1.104357017	36	39.75685	1.01E-02			1.90E-04		1.90E-01	
RE36-11-2923	Arsenic	0.4	ug/FILTER	1.104357017	36	39.75685	1.01E-02			1.90E-04		1.90E-01	
RE39-11-2935	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE39-11-2937	Arsenic	0.4	ug/FILTER	1.132673864	18	20.38813	1.96E-02			1.90E-04		1.90E-01	
RE39-11-2938	Arsenic	0.068	ug/FILTER	1.132673864	30	33.98022	2.00E-03			1.90E-04		1.90E-01	
RE39-11-2939	Arsenic	0.048	ug/FILTER	1.104357017	24	26.50457	1.81E-03			1.90E-04		1.90E-01	
RE39-11-2940	Arsenic	0.11	ug/FILTER	1.104357017	30	33.13071	3.32E-03			1.90E-04		1.90E-01	
RE39-11-2941	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02			1.90E-04		1.90E-01	
RE39-11-2942	Arsenic	0.14	ug/FILTER	1.132673864	24	27.18417	5.15E-03			1.90E-04		1.90E-01	
RE36-11-4184	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE36-11-4189	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE36-11-4190	Arsenic	0.4	ug/FILTER			0				1.90E-04		1.90E-01	
RE36-11-2934	Arsenic	0.4	ug/FILTER	1.132673864	42	47.5723	8.41E-03			1.90E-04		1.90E-01	
RE36-11-4192	Arsenic	0.4	ug/FILTER	1.132673864	96	108.7367	3.68E-03			1.90E-04		1.90E-01	
RE36-11-4197	Arsenic	0.4	ug/FILTER	1.061881747	108	114.6832	3.49E-03			1.90E-04		1.90E-01	
RE36-11-4503	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE39-11-2943	Arsenic	0.4	ug/FILTER	1.132673864	30	33.98022	1.18E-02			1.90E-04		1.90E-01	
RE39-11-2944	Arsenic	0.068	ug/FILTER	1.132673864	36	40.77626	1.67E-03			1.90E-04		1.90E-01	
RE39-11-4524	Arsenic	0.4	ug/FILTER	1.104357017	30	33.13071	1.21E-02			1.90E-04		1.90E-01	
RE39-11-4525	Arsenic	0.4	ug/FILTER	1.104357017	30	33.13071	1.21E-02			1.90E-04		1.90E-01	
RE39-11-4526	Arsenic	0.4	ug/FILTER			0				1.90E-04		1.90E-01	
RE39-11-4527	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02			1.90E-04		1.90E-01	
RE39-11-4528	Arsenic	0.4	ug/FILTER	1.132673864	24	27.18417	1.47E-02		0	1.90E-04		1.90E-01	0
RE39-11-2936	Barium	3.8	ug/FILTER	1.11851544	36	40.26656	9.44E-02	detect		1.50E+00		1.50E+03	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2945	Barium	1.8	ug/FILTER			0		detect		1.50E+00		1.50E+03	
RE36-11-2914	Barium	0.97	ug/FILTER	1.104357017	30	33.13071	2.93E-02	detect		1.50E+00		1.50E+03	
RE36-11-2915	Barium	0.79	ug/FILTER	1.132673864	54	61.16439	1.29E-02	detect		1.50E+00		1.50E+03	
RE36-11-2916	Barium	0.95	ug/FILTER	1.132673864	30	33.98022	2.80E-02	detect		1.50E+00		1.50E+03	
RE36-11-2917	Barium	0.54	ug/FILTER	1.132673864	36	40.77626	1.32E-02	detect		1.50E+00		1.50E+03	
RE36-11-2918	Barium	1.1	ug/FILTER	1.104357017	18	19.87843	5.53E-02	detect		1.50E+00		1.50E+03	
RE36-11-2919	Barium	0.74	ug/FILTER	1.132673864	42	47.5723	1.56E-02	detect		1.50E+00		1.50E+03	
RE36-11-2920	Barium	0.69	ug/FILTER	1.132673864	24	27.18417	2.54E-02	detect		1.50E+00		1.50E+03	
RE36-11-2921	Barium	0.79	ug/FILTER	1.132673864	42	47.5723	1.66E-02	detect		1.50E+00		1.50E+03	
RE36-11-2922	Barium	0.47	ug/FILTER	1.104357017	36	39.75685	1.18E-02	detect		1.50E+00		1.50E+03	
RE36-11-2923	Barium	1.2	ug/FILTER	1.104357017	36	39.75685	3.02E-02	detect		1.50E+00		1.50E+03	
RE39-11-2935	Barium	1.8	ug/FILTER	1.132673864	30	33.98022	5.30E-02	detect		1.50E+00		1.50E+03	
RE39-11-2937	Barium	0.88	ug/FILTER	1.132673864	18	20.38813	4.32E-02	detect		1.50E+00		1.50E+03	
RE39-11-2938	Barium	3.8	ug/FILTER	1.132673864	30	33.98022	1.12E-01	detect		1.50E+00		1.50E+03	
RE39-11-2939	Barium	1.1	ug/FILTER	1.104357017	24	26.50457	4.15E-02	detect		1.50E+00		1.50E+03	
RE39-11-2940	Barium	7	ug/FILTER	1.104357017	30	33.13071	2.11E-01	detect		1.50E+00		1.50E+03	
RE39-11-2941	Barium	0.74	ug/FILTER	1.132673864	24	27.18417	2.72E-02	detect		1.50E+00		1.50E+03	
RE39-11-2942	Barium	5.6	ug/FILTER	1.132673864	24	27.18417	2.06E-01	detect		1.50E+00		1.50E+03	
RE36-11-4184	Barium	0.48	ug/FILTER	1.132673864	30	33.98022	1.41E-02	detect		1.50E+00		1.50E+03	
RE36-11-4189	Barium	0.98	ug/FILTER	1.132673864	30	33.98022	2.88E-02	detect		1.50E+00		1.50E+03	
RE36-11-4190	Barium	0.45	ug/FILTER			0		detect		1.50E+00		1.50E+03	
RE36-11-2934	Barium	0.89	ug/FILTER	1.132673864	42	47.5723	1.87E-02	detect		1.50E+00		1.50E+03	
RE36-11-4192	Barium	0.49	ug/FILTER	1.132673864	96	108.7367	4.51E-03	detect		1.50E+00		1.50E+03	
RE36-11-4197	Barium	0.74	ug/FILTER	1.061881747	108	114.6832	6.45E-03	detect		1.50E+00		1.50E+03	
RE36-11-4503	Barium	0.56	ug/FILTER	1.132673864	30	33.98022	1.65E-02	detect		1.50E+00		1.50E+03	
RE39-11-2943	Barium	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02	detect		1.50E+00		1.50E+03	
RE39-11-2944	Barium	2.9	ug/FILTER	1.132673864	36	40.77626	7.11E-02	detect		1.50E+00		1.50E+03	
RE39-11-4524	Barium	0.64	ug/FILTER	1.104357017	30	33.13071	1.93E-02	detect		1.50E+00		1.50E+03	
RE39-11-4525	Barium	0.28	ug/FILTER	1.104357017	30	33.13071	8.45E-03	detect		1.50E+00		1.50E+03	
RE39-11-4526	Barium	0.094	ug/FILTER			0				1.50E+00		1.50E+03	
RE39-11-4527	Barium	0.28	ug/FILTER	1.132673864	24	27.18417	1.03E-02	detect		1.50E+00		1.50E+03	
RE39-11-4528	Barium	0.65	ug/FILTER	1.132673864	24	27.18417	2.39E-02	detect	32	1.50E+00		1.50E+03	0
RE39-11-2936	Beryllium	0.1	ug/FILTER	1.11851544	36	40.26656	2.48E-03			5.00E-03		5.00E+00	
RE39-11-2945	Beryllium	0.1	ug/FILTER			0				5.00E-03		5.00E+00	
RE36-11-2914	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE36-11-2915	Beryllium	0.1	ug/FILTER	1.132673864	54	61.16439	1.63E-03			5.00E-03		5.00E+00	
RE36-11-2916	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE36-11-2917	Beryllium	0.1	ug/FILTER	1.132673864	36	40.77626	2.45E-03			5.00E-03		5.00E+00	
RE36-11-2918	Beryllium	0.1	ug/FILTER	1.104357017	18	19.87843	5.03E-03			5.00E-03		5.00E+00	
RE36-11-2919	Beryllium	0.1	ug/FILTER	1.132673864	42	47.5723	2.10E-03			5.00E-03		5.00E+00	
RE36-11-2920	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE36-11-2921	Beryllium	0.1	ug/FILTER	1.132673864	42	47.5723	2.10E-03			5.00E-03		5.00E+00	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2922	Beryllium	0.1	ug/FILTER	1.104357017	36	39.75685	2.52E-03			5.00E-03		5.00E+00	
RE36-11-2923	Beryllium	0.1	ug/FILTER	1.104357017	36	39.75685	2.52E-03			5.00E-03		5.00E+00	
RE39-11-2935	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2937	Beryllium	0.1	ug/FILTER	1.132673864	18	20.38813	4.90E-03			5.00E-03		5.00E+00	
RE39-11-2938	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2939	Beryllium	0.1	ug/FILTER	1.104357017	24	26.50457	3.77E-03			5.00E-03		5.00E+00	
RE39-11-2940	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE39-11-2941	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE39-11-2942	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE36-11-4184	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE36-11-4189	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE36-11-4190	Beryllium	0.1	ug/FILTER			0				5.00E-03		5.00E+00	
RE36-11-2934	Beryllium	0.1	ug/FILTER	1.132673864	42	47.5723	2.10E-03			5.00E-03		5.00E+00	
RE36-11-4192	Beryllium	0.1	ug/FILTER	1.132673864	96	108.7367	9.20E-04			5.00E-03		5.00E+00	
RE36-11-4197	Beryllium	0.1	ug/FILTER	1.061881747	108	114.6832	8.72E-04			5.00E-03		5.00E+00	
RE36-11-4503	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2943	Beryllium	0.1	ug/FILTER	1.132673864	30	33.98022	2.94E-03			5.00E-03		5.00E+00	
RE39-11-2944	Beryllium	0.1	ug/FILTER	1.132673864	36	40.77626	2.45E-03			5.00E-03		5.00E+00	
RE39-11-4524	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE39-11-4525	Beryllium	0.1	ug/FILTER	1.104357017	30	33.13071	3.02E-03			5.00E-03		5.00E+00	
RE39-11-4526	Beryllium	0.1	ug/FILTER			0				5.00E-03		5.00E+00	
RE39-11-4527	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03			5.00E-03		5.00E+00	
RE39-11-4528	Beryllium	0.1	ug/FILTER	1.132673864	24	27.18417	3.68E-03		0	5.00E-03		5.00E+00	0
RE39-11-2936	Cadmium	0.37	ug/FILTER	1.11851544	36	40.26656	9.19E-03	detect		3.00E-02		3.00E+01	
RE39-11-2945	Cadmium	1.2	ug/FILTER			0		detect		3.00E-02		3.00E+01	
RE36-11-2914	Cadmium	0.15	ug/FILTER	1.104357017	30	33.13071	4.53E-03	detect		3.00E-02		3.00E+01	
RE36-11-2915	Cadmium	0.26	ug/FILTER	1.132673864	54	61.16439	4.25E-03	detect		3.00E-02		3.00E+01	
RE36-11-2916	Cadmium	1.3	ug/FILTER	1.132673864	30	33.98022	3.83E-02	detect		3.00E-02		3.00E+01	
RE36-11-2917	Cadmium	0.12	ug/FILTER	1.132673864	36	40.77626	2.94E-03	detect		3.00E-02		3.00E+01	
RE36-11-2918	Cadmium	0.64	ug/FILTER	1.104357017	18	19.87843	3.22E-02	detect		3.00E-02		3.00E+01	
RE36-11-2919	Cadmium	17	ug/FILTER	1.132673864	42	47.5723	3.57E-01	detect		3.00E-02		3.00E+01	
RE36-11-2920	Cadmium	2.3	ug/FILTER	1.132673864	24	27.18417	8.46E-02	detect		3.00E-02		3.00E+01	
RE36-11-2921	Cadmium	0.49	ug/FILTER	1.132673864	42	47.5723	1.03E-02	detect		3.00E-02		3.00E+01	
RE36-11-2922	Cadmium	0.46	ug/FILTER	1.104357017	36	39.75685	1.16E-02	detect		3.00E-02		3.00E+01	
RE36-11-2923	Cadmium	1.1	ug/FILTER	1.104357017	36	39.75685	2.77E-02	detect		3.00E-02		3.00E+01	
RE39-11-2935	Cadmium	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		3.00E-02		3.00E+01	
RE39-11-2937	Cadmium	0.72	ug/FILTER	1.132673864	18	20.38813	3.53E-02	detect		3.00E-02		3.00E+01	
RE39-11-2938	Cadmium	2.3	ug/FILTER	1.132673864	30	33.98022	6.77E-02	detect		3.00E-02		3.00E+01	
RE39-11-2939	Cadmium	0.72	ug/FILTER	1.104357017	24	26.50457	2.72E-02	detect		3.00E-02		3.00E+01	
RE39-11-2940	Cadmium	4.1	ug/FILTER	1.104357017	30	33.13071	1.24E-01	detect		3.00E-02		3.00E+01	
RE39-11-2941	Cadmium	0.97	ug/FILTER	1.132673864	24	27.18417	3.57E-02	detect		3.00E-02		3.00E+01	
RE39-11-2942	Cadmium	7.1	ug/FILTER	1.132673864	24	27.18417	2.61E-01	detect		3.00E-02		3.00E+01	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4184	Cadmium	0.66	ug/FILTER	1.132673864	30	33.98022	1.94E-02	detect		3.00E-02		3.00E+01	
RE36-11-4189	Cadmium	3	ug/FILTER	1.132673864	30	33.98022	8.83E-02	detect		3.00E-02		3.00E+01	
RE36-11-4190	Cadmium	0.98	ug/FILTER			0		detect		3.00E-02		3.00E+01	
RE36-11-2934	Cadmium	2.2	ug/FILTER	1.132673864	42	47.5723	4.62E-02	detect		3.00E-02		3.00E+01	
RE36-11-4192	Cadmium	8.9	ug/FILTER	1.132673864	96	108.7367	8.18E-02	detect		3.00E-02		3.00E+01	
RE36-11-4197	Cadmium	2.5	ug/FILTER	1.061881747	108	114.6832	2.18E-02	detect		3.00E-02		3.00E+01	
RE36-11-4503	Cadmium	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02	detect		3.00E-02		3.00E+01	
RE39-11-2943	Cadmium	3.3	ug/FILTER	1.132673864	30	33.98022	9.71E-02	detect		3.00E-02		3.00E+01	
RE39-11-2944	Cadmium	0.19	ug/FILTER	1.132673864	36	40.77626	4.66E-03	detect		3.00E-02		3.00E+01	
RE39-11-4524	Cadmium	1.4	ug/FILTER	1.104357017	30	33.13071	4.23E-02	detect		3.00E-02		3.00E+01	
RE39-11-4525	Cadmium	0.46	ug/FILTER	1.104357017	30	33.13071	1.39E-02	detect		3.00E-02		3.00E+01	
RE39-11-4526	Cadmium	2	ug/FILTER			0		detect		3.00E-02		3.00E+01	
RE39-11-4527	Cadmium	0.36	ug/FILTER	1.132673864	24	27.18417	1.32E-02	detect		3.00E-02		3.00E+01	
RE39-11-4528	Cadmium	0.12	ug/FILTER	1.132673864	24	27.18417	4.41E-03	detect	33	3.00E-02		3.00E+01	0
RE39-11-2936	Calcium	230	ug/FILTER	1.11851544	36	40.26656	5.71E+00	detect		none specified			
RE39-11-2945	Calcium	110	ug/FILTER			0				none specified			
RE36-11-2914	Calcium	110	ug/FILTER	1.104357017	30	33.13071	3.32E+00			none specified			
RE36-11-2915	Calcium	94	ug/FILTER	1.132673864	54	61.16439	1.54E+00			none specified			
RE36-11-2916	Calcium	98	ug/FILTER	1.132673864	30	33.98022	2.88E+00			none specified			
RE36-11-2917	Calcium	71	ug/FILTER	1.132673864	36	40.77626	1.74E+00			none specified			
RE36-11-2918	Calcium	160	ug/FILTER	1.104357017	18	19.87843	8.05E+00			none specified			
RE36-11-2919	Calcium	84	ug/FILTER	1.132673864	42	47.5723	1.77E+00			none specified			
RE36-11-2920	Calcium	65	ug/FILTER	1.132673864	24	27.18417	2.39E+00			none specified			
RE36-11-2921	Calcium	60	ug/FILTER	1.132673864	42	47.5723	1.26E+00			none specified			
RE36-11-2922	Calcium	130	ug/FILTER	1.104357017	36	39.75685	3.27E+00			none specified			
RE36-11-2923	Calcium	140	ug/FILTER	1.104357017	36	39.75685	3.52E+00			none specified			
RE39-11-2935	Calcium	70	ug/FILTER	1.132673864	30	33.98022	2.06E+00			none specified			
RE39-11-2937	Calcium	140	ug/FILTER	1.132673864	18	20.38813	6.87E+00			none specified			
RE39-11-2938	Calcium	230	ug/FILTER	1.132673864	30	33.98022	6.77E+00	detect		none specified			
RE39-11-2939	Calcium	120	ug/FILTER	1.104357017	24	26.50457	4.53E+00			none specified			
RE39-11-2940	Calcium	450	ug/FILTER	1.104357017	30	33.13071	1.36E+01	detect		none specified			
RE39-11-2941	Calcium	86	ug/FILTER	1.132673864	24	27.18417	3.16E+00			none specified			
RE39-11-2942	Calcium	340	ug/FILTER	1.132673864	24	27.18417	1.25E+01	detect		none specified			
RE36-11-4184	Calcium	84	ug/FILTER	1.132673864	30	33.98022	2.47E+00			none specified			
RE36-11-4189	Calcium	100	ug/FILTER	1.132673864	30	33.98022	2.94E+00			none specified			
RE36-11-4190	Calcium	91	ug/FILTER			0				none specified			
RE36-11-2934	Calcium	71	ug/FILTER	1.132673864	42	47.5723	1.49E+00			none specified			
RE36-11-4192	Calcium	60	ug/FILTER	1.132673864	96	108.7367	5.52E-01			none specified			
RE36-11-4197	Calcium	71	ug/FILTER	1.061881747	108	114.6832	6.19E-01			none specified			
RE36-11-4503	Calcium	84	ug/FILTER	1.132673864	30	33.98022	2.47E+00			none specified			
RE39-11-2943	Calcium	110	ug/FILTER	1.132673864	30	33.98022	3.24E+00			none specified			
RE39-11-2944	Calcium	280	ug/FILTER	1.132673864	36	40.77626	6.87E+00	detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4524	Calcium	130	ug/FILTER	1.104357017	30	33.13071	3.92E+00			none specified			
RE39-11-4525	Calcium	41	ug/FILTER	1.104357017	30	33.13071	1.24E+00			none specified			
RE39-11-4526	Calcium	47	ug/FILTER			0				none specified			
RE39-11-4527	Calcium	53	ug/FILTER	1.132673864	24	27.18417	1.95E+00			none specified			
RE39-11-4528	Calcium	200	ug/FILTER	1.132673864	24	27.18417	7.36E+00		5	none specified			0
RE39-11-2936	Chromium	4.2	ug/FILTER	1.11851544	36	40.26656	1.04E-01	detect		1.5		1500	
RE39-11-2945	Chromium	2.1	ug/FILTER			0		detect		1.5		1500	
RE36-11-2914	Chromium	2.8	ug/FILTER	1.104357017	30	33.13071	8.45E-02	detect		1.5		1500	
RE36-11-2915	Chromium	0.81	ug/FILTER	1.132673864	54	61.16439	1.32E-02			1.5		1500	
RE36-11-2916	Chromium	0.78	ug/FILTER	1.132673864	30	33.98022	2.30E-02			1.5		1500	
RE36-11-2917	Chromium	0.5	ug/FILTER	1.132673864	36	40.77626	1.23E-02			1.5		1500	
RE36-11-2918	Chromium	2.1	ug/FILTER	1.104357017	18	19.87843	1.06E-01	detect		1.5		1500	
RE36-11-2919	Chromium	0.83	ug/FILTER	1.132673864	42	47.5723	1.74E-02			1.5		1500	
RE36-11-2920	Chromium	5	ug/FILTER	1.132673864	24	27.18417	1.84E-01	detect		1.5		1500	
RE36-11-2921	Chromium	7.9	ug/FILTER	1.132673864	42	47.5723	1.66E-01	detect		1.5		1500	
RE36-11-2922	Chromium	2.5	ug/FILTER	1.104357017	36	39.75685	6.29E-02	detect		1.5		1500	
RE36-11-2923	Chromium	1	ug/FILTER	1.104357017	36	39.75685	2.52E-02			1.5		1500	
RE39-11-2935	Chromium	0.67	ug/FILTER	1.132673864	30	33.98022	1.97E-02			1.5		1500	
RE39-11-2937	Chromium	1.1	ug/FILTER	1.132673864	18	20.38813	5.40E-02			1.5		1500	
RE39-11-2938	Chromium	2.4	ug/FILTER	1.132673864	30	33.98022	7.06E-02	detect		1.5		1500	
RE39-11-2939	Chromium	1.2	ug/FILTER	1.104357017	24	26.50457	4.53E-02			1.5		1500	
RE39-11-2940	Chromium	2.4	ug/FILTER	1.104357017	30	33.13071	7.24E-02	detect		1.5		1500	
RE39-11-2941	Chromium	0.67	ug/FILTER	1.132673864	24	27.18417	2.46E-02			1.5		1500	
RE39-11-2942	Chromium	2.3	ug/FILTER	1.132673864	24	27.18417	8.46E-02	detect		1.5		1500	
RE36-11-4184	Chromium	1.3	ug/FILTER	1.132673864	30	33.98022	3.83E-02			1.5		1500	
RE36-11-4189	Chromium	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02			1.5		1500	
RE36-11-4190	Chromium	2.8	ug/FILTER			0		detect		1.5		1500	
RE36-11-2934	Chromium	1.2	ug/FILTER	1.132673864	42	47.5723	2.52E-02			1.5		1500	
RE36-11-4192	Chromium	1	ug/FILTER	1.132673864	96	108.7367	9.20E-03			1.5		1500	
RE36-11-4197	Chromium	0.96	ug/FILTER	1.061881747	108	114.6832	8.37E-03			1.5		1500	
RE36-11-4503	Chromium	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02			1.5		1500	
RE39-11-2943	Chromium	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02			1.5		1500	
RE39-11-2944	Chromium	1.1	ug/FILTER	1.132673864	36	40.77626	2.70E-02			1.5		1500	
RE39-11-4524	Chromium	0.74	ug/FILTER	1.104357017	30	33.13071	2.23E-02			1.5		1500	
RE39-11-4525	Chromium	0.46	ug/FILTER	1.104357017	30	33.13071	1.39E-02			1.5		1500	
RE39-11-4526	Chromium	0.23	ug/FILTER			0				1.5		1500	
RE39-11-4527	Chromium	0.25	ug/FILTER	1.132673864	24	27.18417	9.20E-03			1.5		1500	
RE39-11-4528	Chromium	0.83	ug/FILTER	1.132673864	24	27.18417	3.05E-02		11	1.5		1500	0
RE39-11-2936	Cobalt	0.15	ug/FILTER	1.11851544	36	40.26656	3.73E-03			none specified			
RE39-11-2945	Cobalt	0.058	ug/FILTER			0				none specified			
RE36-11-2914	Cobalt	0.034	ug/FILTER	1.104357017	30	33.13071	1.03E-03			none specified			
RE36-11-2915	Cobalt	0.2	ug/FILTER	1.132673864	54	61.16439	3.27E-03			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2916	Cobalt	0.04	ug/FILTER	1.132673864	30	33.98022	1.18E-03			none specified			
RE36-11-2917	Cobalt	0.032	ug/FILTER	1.132673864	36	40.77626	7.85E-04			none specified			
RE36-11-2918	Cobalt	0.066	ug/FILTER	1.104357017	18	19.87843	3.32E-03			none specified			
RE36-11-2919	Cobalt	0.026	ug/FILTER	1.132673864	42	47.5723	5.47E-04			none specified			
RE36-11-2920	Cobalt	0.15	ug/FILTER	1.132673864	24	27.18417	5.52E-03			none specified			
RE36-11-2921	Cobalt	0.17	ug/FILTER	1.132673864	42	47.5723	3.57E-03			none specified			
RE36-11-2922	Cobalt	0.072	ug/FILTER	1.104357017	36	39.75685	1.81E-03			none specified			
RE36-11-2923	Cobalt	0.038	ug/FILTER	1.104357017	36	39.75685	9.56E-04			none specified			
RE39-11-2935	Cobalt	0.036	ug/FILTER	1.132673864	30	33.98022	1.06E-03			none specified			
RE39-11-2937	Cobalt	0.028	ug/FILTER	1.132673864	18	20.38813	1.37E-03			none specified			
RE39-11-2938	Cobalt	0.12	ug/FILTER	1.132673864	30	33.98022	3.53E-03			none specified			
RE39-11-2939	Cobalt	0.054	ug/FILTER	1.104357017	24	26.50457	2.04E-03			none specified			
RE39-11-2940	Cobalt	0.16	ug/FILTER	1.104357017	30	33.13071	4.83E-03			none specified			
RE39-11-2941	Cobalt	0.054	ug/FILTER	1.132673864	24	27.18417	1.99E-03			none specified			
RE39-11-2942	Cobalt	0.28	ug/FILTER	1.132673864	24	27.18417	1.03E-02	detect		none specified			
RE36-11-4184	Cobalt	0.024	ug/FILTER	1.132673864	30	33.98022	7.06E-04			none specified			
RE36-11-4189	Cobalt	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE36-11-4190	Cobalt	0.07	ug/FILTER			0				none specified			
RE36-11-2934	Cobalt	0.03	ug/FILTER	1.132673864	42	47.5723	6.31E-04			none specified			
RE36-11-4192	Cobalt	0.028	ug/FILTER	1.132673864	96	108.7367	2.58E-04			none specified			
RE36-11-4197	Cobalt	0.02	ug/FILTER	1.061881747	108	114.6832	1.74E-04			none specified			
RE36-11-4503	Cobalt	0.078	ug/FILTER	1.132673864	30	33.98022	2.30E-03			none specified			
RE39-11-2943	Cobalt	0.03	ug/FILTER	1.132673864	30	33.98022	8.83E-04			none specified			
RE39-11-2944	Cobalt	0.096	ug/FILTER	1.132673864	36	40.77626	2.35E-03			none specified			
RE39-11-4524	Cobalt	0.022	ug/FILTER	1.104357017	30	33.13071	6.64E-04			none specified			
RE39-11-4525	Cobalt	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			none specified			
RE39-11-4526	Cobalt	0.2	ug/FILTER			0				none specified			
RE39-11-4527	Cobalt	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			none specified			
RE39-11-4528	Cobalt	0.026	ug/FILTER	1.132673864	24	27.18417	9.56E-04		1	none specified			0
RE39-11-2936	Copper	22	ug/FILTER	1.11851544	36	40.26656	5.46E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2945	Copper	4.3	ug/FILTER			0		detect		none specified	1.00E+02	1.00E+02	
RE36-11-2914	Copper	8.5	ug/FILTER	1.104357017	30	33.13071	2.57E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2915	Copper	8.8	ug/FILTER	1.132673864	54	61.16439	1.44E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2916	Copper	9.4	ug/FILTER	1.132673864	30	33.98022	2.77E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2917	Copper	10	ug/FILTER	1.132673864	36	40.77626	2.45E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2918	Copper	7.7	ug/FILTER	1.104357017	18	19.87843	3.87E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2919	Copper	6.2	ug/FILTER	1.132673864	42	47.5723	1.30E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2920	Copper	3.6	ug/FILTER	1.132673864	24	27.18417	1.32E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2921	Copper	6.4	ug/FILTER	1.132673864	42	47.5723	1.35E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2922	Copper	3.6	ug/FILTER	1.104357017	36	39.75685	9.06E-02	detect		none specified	1.00E+02	1.00E+02	
RE36-11-2923	Copper	3.5	ug/FILTER	1.104357017	36	39.75685	8.80E-02	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2935	Copper	6.2	ug/FILTER	1.132673864	30	33.98022	1.82E-01	detect		none specified	1.00E+02	1.00E+02	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2937	Copper	9.4	ug/FILTER	1.132673864	18	20.38813	4.61E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2938	Copper	24	ug/FILTER	1.132673864	30	33.98022	7.06E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2939	Copper	18	ug/FILTER	1.104357017	24	26.50457	6.79E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2940	Copper	46	ug/FILTER	1.104357017	30	33.13071	1.39E+00	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2941	Copper	7.7	ug/FILTER	1.132673864	24	27.18417	2.83E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2942	Copper	28	ug/FILTER	1.132673864	24	27.18417	1.03E+00	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4184	Copper	6.1	ug/FILTER	1.132673864	30	33.98022	1.80E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4189	Copper	3.9	ug/FILTER	1.132673864	30	33.98022	1.15E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4190	Copper	2.5	ug/FILTER			0		detect		none specified	1.00E+02	1.00E+02	
RE36-11-2934	Copper	6	ug/FILTER	1.132673864	42	47.5723	1.26E-01	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4192	Copper	4	ug/FILTER	1.132673864	96	108.7367	3.68E-02	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4197	Copper	5.3	ug/FILTER	1.061881747	108	114.6832	4.62E-02	detect		none specified	1.00E+02	1.00E+02	
RE36-11-4503	Copper	10	ug/FILTER	1.132673864	30	33.98022	2.94E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2943	Copper	12	ug/FILTER	1.132673864	30	33.98022	3.53E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-2944	Copper	40	ug/FILTER	1.132673864	36	40.77626	9.81E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4524	Copper	8.9	ug/FILTER	1.104357017	30	33.13071	2.69E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4525	Copper	3.4	ug/FILTER	1.104357017	30	33.13071	1.03E-01	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4526	Copper	0.39	ug/FILTER			0				none specified	1.00E+02	1.00E+02	
RE39-11-4527	Copper	2.3	ug/FILTER	1.132673864	24	27.18417	8.46E-02	detect		none specified	1.00E+02	1.00E+02	
RE39-11-4528	Copper	12	ug/FILTER	1.132673864	24	27.18417	4.41E-01	detect	32	none specified	1.00E+02	1.00E+02	0
RE39-11-2936	Iron	270	ug/FILTER	1.11851544	36	40.26656	6.71E+00	detect		none specified			
RE39-11-2945	Iron	44	ug/FILTER			0		detect		none specified			
RE36-11-2914	Iron	99	ug/FILTER	1.104357017	30	33.13071	2.99E+00	detect		none specified			
RE36-11-2915	Iron	89	ug/FILTER	1.132673864	54	61.16439	1.46E+00	detect		none specified			
RE36-11-2916	Iron	67	ug/FILTER	1.132673864	30	33.98022	1.97E+00	detect		none specified			
RE36-11-2917	Iron	74	ug/FILTER	1.132673864	36	40.77626	1.81E+00	detect		none specified			
RE36-11-2918	Iron	74	ug/FILTER	1.104357017	18	19.87843	3.72E+00	detect		none specified			
RE36-11-2919	Iron	57	ug/FILTER	1.132673864	42	47.5723	1.20E+00	detect		none specified			
RE36-11-2920	Iron	77	ug/FILTER	1.132673864	24	27.18417	2.83E+00	detect		none specified			
RE36-11-2921	Iron	110	ug/FILTER	1.132673864	42	47.5723	2.31E+00	detect		none specified			
RE36-11-2922	Iron	36	ug/FILTER	1.104357017	36	39.75685	9.06E-01	detect		none specified			
RE36-11-2923	Iron	50	ug/FILTER	1.104357017	36	39.75685	1.26E+00	detect		none specified			
RE39-11-2935	Iron	56	ug/FILTER	1.132673864	30	33.98022	1.65E+00	detect		none specified			
RE39-11-2937	Iron	51	ug/FILTER	1.132673864	18	20.38813	2.50E+00	detect		none specified			
RE39-11-2938	Iron	190	ug/FILTER	1.132673864	30	33.98022	5.59E+00	detect		none specified			
RE39-11-2939	Iron	90	ug/FILTER	1.104357017	24	26.50457	3.40E+00	detect		none specified			
RE39-11-2940	Iron	390	ug/FILTER	1.104357017	30	33.13071	1.18E+01	detect		none specified			
RE39-11-2941	Iron	73	ug/FILTER	1.132673864	24	27.18417	2.69E+00	detect		none specified			
RE39-11-2942	Iron	340	ug/FILTER	1.132673864	24	27.18417	1.25E+01	detect		none specified			
RE36-11-4184	Iron	41	ug/FILTER	1.132673864	30	33.98022	1.21E+00	detect		none specified			
RE36-11-4189	Iron	43	ug/FILTER	1.132673864	30	33.98022	1.27E+00	detect		none specified			
RE36-11-4190	Iron	75	ug/FILTER			0		detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2934	Iron	43	ug/FILTER	1.132673864	42	47.5723	9.04E-01	detect		none specified			
RE36-11-4192	Iron	30	ug/FILTER	1.132673864	96	108.7367	2.76E-01	detect		none specified			
RE36-11-4197	Iron	48	ug/FILTER	1.061881747	108	114.6832	4.19E-01	detect		none specified			
RE36-11-4503	Iron	61	ug/FILTER	1.132673864	30	33.98022	1.80E+00	detect		none specified			
RE39-11-2943	Iron	61	ug/FILTER	1.132673864	30	33.98022	1.80E+00	detect		none specified			
RE39-11-2944	Iron	180	ug/FILTER	1.132673864	36	40.77626	4.41E+00	detect		none specified			
RE39-11-4524	Iron	55	ug/FILTER	1.104357017	30	33.13071	1.66E+00	detect		none specified			
RE39-11-4525	Iron	19	ug/FILTER	1.104357017	30	33.13071	5.73E-01			none specified			
RE39-11-4526	Iron	5.9	ug/FILTER			0				none specified			
RE39-11-4527	Iron	14	ug/FILTER	1.132673864	24	27.18417	5.15E-01			none specified			
RE39-11-4528	Iron	55	ug/FILTER	1.132673864	24	27.18417	2.02E+00	detect	30	none specified			0
RE39-11-2936	Lead	3.9	ug/FILTER	1.11851544	36	40.26656	9.69E-02	detect		0.15		150	
RE39-11-2945	Lead	0.49	ug/FILTER			0		detect		0.15		150	
RE36-11-2914	Lead	1.4	ug/FILTER	1.104357017	30	33.13071	4.23E-02	detect		0.15		150	
RE36-11-2915	Lead	3.5	ug/FILTER	1.132673864	54	61.16439	5.72E-02	detect		0.15		150	
RE36-11-2916	Lead	12	ug/FILTER	1.132673864	30	33.98022	3.53E-01	detect		0.15		150	
RE36-11-2917	Lead	2.3	ug/FILTER	1.132673864	36	40.77626	5.64E-02	detect		0.15		150	
RE36-11-2918	Lead	6.3	ug/FILTER	1.104357017	18	19.87843	3.17E-01	detect		0.15		150	
RE36-11-2919	Lead	26	ug/FILTER	1.132673864	42	47.5723	5.47E-01	detect		0.15		150	
RE36-11-2920	Lead	18	ug/FILTER	1.132673864	24	27.18417	6.62E-01	detect		0.15		150	
RE36-11-2921	Lead	1.9	ug/FILTER	1.132673864	42	47.5723	3.99E-02	detect		0.15		150	
RE36-11-2922	Lead	8.2	ug/FILTER	1.104357017	36	39.75685	2.06E-01	detect		0.15		150	
RE36-11-2923	Lead	5.9	ug/FILTER	1.104357017	36	39.75685	1.48E-01	detect		0.15		150	
RE39-11-2935	Lead	14	ug/FILTER	1.132673864	30	33.98022	4.12E-01	detect		0.15		150	
RE39-11-2937	Lead	1.8	ug/FILTER	1.132673864	18	20.38813	8.83E-02	detect		0.15		150	
RE39-11-2938	Lead	15	ug/FILTER	1.132673864	30	33.98022	4.41E-01	detect		0.15		150	
RE39-11-2939	Lead	6.9	ug/FILTER	1.104357017	24	26.50457	2.60E-01	detect		0.15		150	
RE39-11-2940	Lead	22	ug/FILTER	1.104357017	30	33.13071	6.64E-01	detect		0.15		150	
RE39-11-2941	Lead	22	ug/FILTER	1.132673864	24	27.18417	8.09E-01	detect		0.15		150	
RE39-11-2942	Lead	63	ug/FILTER	1.132673864	24	27.18417	2.32E+00	detect		0.15		150	
RE36-11-4184	Lead	13	ug/FILTER	1.132673864	30	33.98022	3.83E-01	detect		0.15		150	
RE36-11-4189	Lead	13	ug/FILTER	1.132673864	30	33.98022	3.83E-01	detect		0.15		150	
RE36-11-4190	Lead	8.3	ug/FILTER			0		detect		0.15		150	
RE36-11-2934	Lead	17	ug/FILTER	1.132673864	42	47.5723	3.57E-01	detect		0.15		150	
RE36-11-4192	Lead	120	ug/FILTER	1.132673864	96	108.7367	1.10E+00	detect		0.15		150	
RE36-11-4197	Lead	41	ug/FILTER	1.061881747	108	114.6832	3.58E-01	detect		0.15		150	
RE36-11-4503	Lead	2.1	ug/FILTER	1.132673864	30	33.98022	6.18E-02	detect		0.15		150	
RE39-11-2943	Lead	19	ug/FILTER	1.132673864	30	33.98022	5.59E-01	detect		0.15		150	
RE39-11-2944	Lead	4.5	ug/FILTER	1.132673864	36	40.77626	1.10E-01	detect		0.15		150	
RE39-11-4524	Lead	28	ug/FILTER	1.104357017	30	33.13071	8.45E-01	detect		0.15		150	
RE39-11-4525	Lead	3.7	ug/FILTER	1.104357017	30	33.13071	1.12E-01	detect		0.15		150	
RE39-11-4526	Lead	32	ug/FILTER			0		detect		0.15		150	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4527	Lead	2	ug/FILTER	1.132673864	24	27.18417	7.36E-02	detect		0.15		150	
RE39-11-4528	Lead	1.5	ug/FILTER	1.132673864	24	27.18417	5.52E-02	detect	33	0.15		150	0
RE39-11-2936	Magnesium	36	ug/FILTER	1.11851544	36	40.26656	8.94E-01	detect		none specified			
RE39-11-2945	Magnesium	6.8	ug/FILTER			0				none specified			
RE36-11-2914	Magnesium	12	ug/FILTER	1.104357017	30	33.13071	3.62E-01			none specified			
RE36-11-2915	Magnesium	6.7	ug/FILTER	1.132673864	54	61.16439	1.10E-01			none specified			
RE36-11-2916	Magnesium	9.8	ug/FILTER	1.132673864	30	33.98022	2.88E-01			none specified			
RE36-11-2917	Magnesium	10	ug/FILTER	1.132673864	36	40.77626	2.45E-01			none specified			
RE36-11-2918	Magnesium	15	ug/FILTER	1.104357017	18	19.87843	7.55E-01			none specified			
RE36-11-2919	Magnesium	8.2	ug/FILTER	1.132673864	42	47.5723	1.72E-01			none specified			
RE36-11-2920	Magnesium	6.5	ug/FILTER	1.132673864	24	27.18417	2.39E-01			none specified			
RE36-11-2921	Magnesium	11	ug/FILTER	1.132673864	42	47.5723	2.31E-01			none specified			
RE36-11-2922	Magnesium	6.1	ug/FILTER	1.104357017	36	39.75685	1.53E-01			none specified			
RE36-11-2923	Magnesium	7.2	ug/FILTER	1.104357017	36	39.75685	1.81E-01			none specified			
RE39-11-2935	Magnesium	12	ug/FILTER	1.132673864	30	33.98022	3.53E-01			none specified			
RE39-11-2937	Magnesium	5.8	ug/FILTER	1.132673864	18	20.38813	2.84E-01			none specified			
RE39-11-2938	Magnesium	36	ug/FILTER	1.132673864	30	33.98022	1.06E+00	detect		none specified			
RE39-11-2939	Magnesium	21	ug/FILTER	1.104357017	24	26.50457	7.92E-01	detect		none specified			
RE39-11-2940	Magnesium	53	ug/FILTER	1.104357017	30	33.13071	1.60E+00	detect		none specified			
RE39-11-2941	Magnesium	11	ug/FILTER	1.132673864	24	27.18417	4.05E-01			none specified			
RE39-11-2942	Magnesium	46	ug/FILTER	1.132673864	24	27.18417	1.69E+00	detect		none specified			
RE36-11-4184	Magnesium	8.9	ug/FILTER	1.132673864	30	33.98022	2.62E-01			none specified			
RE36-11-4189	Magnesium	6.7	ug/FILTER	1.132673864	30	33.98022	1.97E-01			none specified			
RE36-11-4190	Magnesium	4.6	ug/FILTER			0				none specified			
RE36-11-2934	Magnesium	7.4	ug/FILTER	1.132673864	42	47.5723	1.56E-01			none specified			
RE36-11-4192	Magnesium	20	ug/FILTER	1.132673864	96	108.7367	1.84E-01			none specified			
RE36-11-4197	Magnesium	7.6	ug/FILTER	1.061881747	108	114.6832	6.63E-02			none specified			
RE36-11-4503	Magnesium	13	ug/FILTER	1.132673864	30	33.98022	3.83E-01			none specified			
RE39-11-2943	Magnesium	8	ug/FILTER	1.132673864	30	33.98022	2.35E-01			none specified			
RE39-11-2944	Magnesium	30	ug/FILTER	1.132673864	36	40.77626	7.36E-01	detect		none specified			
RE39-11-4524	Magnesium	8.1	ug/FILTER	1.104357017	30	33.13071	2.44E-01			none specified			
RE39-11-4525	Magnesium	20	ug/FILTER	1.104357017	30	33.13071	6.04E-01			none specified			
RE39-11-4526	Magnesium	20	ug/FILTER			0				none specified			
RE39-11-4527	Magnesium	20	ug/FILTER	1.132673864	24	27.18417	7.36E-01			none specified			
RE39-11-4528	Magnesium	11	ug/FILTER	1.132673864	24	27.18417	4.05E-01		6	none specified			0
RE39-11-2936	Manganese	5.5	ug/FILTER	1.11851544	36	40.26656	1.37E-01	detect		none specified			
RE39-11-2945	Manganese	0.95	ug/FILTER			0		detect		none specified			
RE36-11-2914	Manganese	1.3	ug/FILTER	1.104357017	30	33.13071	3.92E-02	detect		none specified			
RE36-11-2915	Manganese	1.1	ug/FILTER	1.132673864	54	61.16439	1.80E-02	detect		none specified			
RE36-11-2916	Manganese	1.3	ug/FILTER	1.132673864	30	33.98022	3.83E-02	detect		none specified			
RE36-11-2917	Manganese	1	ug/FILTER	1.132673864	36	40.77626	2.45E-02	detect		none specified			
RE36-11-2918	Manganese	1.9	ug/FILTER	1.104357017	18	19.87843	9.56E-02	detect		none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2919	Manganese	0.73	ug/FILTER	1.132673864	42	47.5723	1.53E-02	detect		none specified			
RE36-11-2920	Manganese	1	ug/FILTER	1.132673864	24	27.18417	3.68E-02	detect		none specified			
RE36-11-2921	Manganese	1.6	ug/FILTER	1.132673864	42	47.5723	3.36E-02	detect		none specified			
RE36-11-2922	Manganese	0.77	ug/FILTER	1.104357017	36	39.75685	1.94E-02	detect		none specified			
RE36-11-2923	Manganese	1.2	ug/FILTER	1.104357017	36	39.75685	3.02E-02	detect		none specified			
RE39-11-2935	Manganese	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		none specified			
RE39-11-2937	Manganese	0.9	ug/FILTER	1.132673864	18	20.38813	4.41E-02	detect		none specified			
RE39-11-2938	Manganese	4.7	ug/FILTER	1.132673864	30	33.98022	1.38E-01	detect		none specified			
RE39-11-2939	Manganese	2.6	ug/FILTER	1.104357017	24	26.50457	9.81E-02	detect		none specified			
RE39-11-2940	Manganese	11	ug/FILTER	1.104357017	30	33.13071	3.32E-01	detect		none specified			
RE39-11-2941	Manganese	1.6	ug/FILTER	1.132673864	24	27.18417	5.89E-02	detect		none specified			
RE39-11-2942	Manganese	6.7	ug/FILTER	1.132673864	24	27.18417	2.46E-01	detect		none specified			
RE36-11-4184	Manganese	1.5	ug/FILTER	1.132673864	30	33.98022	4.41E-02	detect		none specified			
RE36-11-4189	Manganese	1.6	ug/FILTER	1.132673864	30	33.98022	4.71E-02	detect		none specified			
RE36-11-4190	Manganese	1	ug/FILTER			0		detect		none specified			
RE36-11-2934	Manganese	0.81	ug/FILTER	1.132673864	42	47.5723	1.70E-02	detect		none specified			
RE36-11-4192	Manganese	0.51	ug/FILTER	1.132673864	96	108.7367	4.69E-03	detect		none specified			
RE36-11-4197	Manganese	0.93	ug/FILTER	1.061881747	108	114.6832	8.11E-03	detect		none specified			
RE36-11-4503	Manganese	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		none specified			
RE39-11-2943	Manganese	1	ug/FILTER	1.132673864	30	33.98022	2.94E-02	detect		none specified			
RE39-11-2944	Manganese	3.8	ug/FILTER	1.132673864	36	40.77626	9.32E-02	detect		none specified			
RE39-11-4524	Manganese	1.2	ug/FILTER	1.104357017	30	33.13071	3.62E-02	detect		none specified			
RE39-11-4525	Manganese	0.3	ug/FILTER	1.104357017	30	33.13071	9.06E-03			none specified			
RE39-11-4526	Manganese	0.084	ug/FILTER			0				none specified			
RE39-11-4527	Manganese	0.21	ug/FILTER	1.132673864	24	27.18417	7.73E-03			none specified			
RE39-11-4528	Manganese	1.1	ug/FILTER	1.132673864	24	27.18417	4.05E-02	detect	30	none specified			0
RE39-11-2936	Nickel	8.6	ug/FILTER	1.11851544	36	40.26656	2.14E-01	detect		6.00E-03		6.00E+00	
RE39-11-2945	Nickel	1.3	ug/FILTER			0		detect		6.00E-03		6.00E+00	
RE36-11-2914	Nickel	4.9	ug/FILTER	1.104357017	30	33.13071	1.48E-01	detect		6.00E-03		6.00E+00	
RE36-11-2915	Nickel	0.16	ug/FILTER	1.132673864	54	61.16439	2.62E-03			6.00E-03		6.00E+00	
RE36-11-2916	Nickel	1.9	ug/FILTER	1.132673864	30	33.98022	5.59E-02	detect		6.00E-03		6.00E+00	
RE36-11-2917	Nickel	2	ug/FILTER	1.132673864	36	40.77626	4.90E-02	detect		6.00E-03		6.00E+00	
RE36-11-2918	Nickel	1.7	ug/FILTER	1.104357017	18	19.87843	8.55E-02	detect		6.00E-03		6.00E+00	
RE36-11-2919	Nickel	3.6	ug/FILTER	1.132673864	42	47.5723	7.57E-02	detect		6.00E-03		6.00E+00	
RE36-11-2920	Nickel	8.5	ug/FILTER	1.132673864	24	27.18417	3.13E-01	detect		6.00E-03		6.00E+00	
RE36-11-2921	Nickel	7	ug/FILTER	1.132673864	42	47.5723	1.47E-01	detect		6.00E-03		6.00E+00	
RE36-11-2922	Nickel	1	ug/FILTER	1.104357017	36	39.75685	2.52E-02			6.00E-03		6.00E+00	
RE36-11-2923	Nickel	0.58	ug/FILTER	1.104357017	36	39.75685	1.46E-02			6.00E-03		6.00E+00	
RE39-11-2935	Nickel	0.33	ug/FILTER	1.132673864	30	33.98022	9.71E-03			6.00E-03		6.00E+00	
RE39-11-2937	Nickel	0.8	ug/FILTER	1.132673864	18	20.38813	3.92E-02			6.00E-03		6.00E+00	
RE39-11-2938	Nickel	6	ug/FILTER	1.132673864	30	33.98022	1.77E-01	detect		6.00E-03		6.00E+00	
RE39-11-2939	Nickel	0.83	ug/FILTER	1.104357017	24	26.50457	3.13E-02			6.00E-03		6.00E+00	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2940	Nickel	9.3	ug/FILTER	1.104357017	30	33.13071	2.81E-01	detect		6.00E-03		6.00E+00	
RE39-11-2941	Nickel	0.86	ug/FILTER	1.132673864	24	27.18417	3.16E-02			6.00E-03		6.00E+00	
RE39-11-2942	Nickel	13	ug/FILTER	1.132673864	24	27.18417	4.78E-01	detect		6.00E-03		6.00E+00	
RE36-11-4184	Nickel	1.1	ug/FILTER	1.132673864	30	33.98022	3.24E-02	detect		6.00E-03		6.00E+00	
RE36-11-4189	Nickel	0.71	ug/FILTER	1.132673864	30	33.98022	2.09E-02			6.00E-03		6.00E+00	
RE36-11-4190	Nickel	1.9	ug/FILTER			0		detect		6.00E-03		6.00E+00	
RE36-11-2934	Nickel	0.82	ug/FILTER	1.132673864	42	47.5723	1.72E-02			6.00E-03		6.00E+00	
RE36-11-4192	Nickel	0.39	ug/FILTER	1.132673864	96	108.7367	3.59E-03			6.00E-03		6.00E+00	
RE36-11-4197	Nickel	0.91	ug/FILTER	1.061881747	108	114.6832	7.93E-03			6.00E-03		6.00E+00	
RE36-11-4503	Nickel	0.46	ug/FILTER	1.132673864	30	33.98022	1.35E-02			6.00E-03		6.00E+00	
RE39-11-2943	Nickel	4.7	ug/FILTER	1.132673864	30	33.98022	1.38E-01	detect		6.00E-03		6.00E+00	
RE39-11-2944	Nickel	8.6	ug/FILTER	1.132673864	36	40.77626	2.11E-01	detect		6.00E-03		6.00E+00	
RE39-11-4524	Nickel	1.4	ug/FILTER	1.104357017	30	33.13071	4.23E-02	detect		6.00E-03		6.00E+00	
RE39-11-4525	Nickel	1.2	ug/FILTER	1.104357017	30	33.13071	3.62E-02	detect		6.00E-03		6.00E+00	
RE39-11-4526	Nickel	1	ug/FILTER			0				6.00E-03		6.00E+00	
RE39-11-4527	Nickel	0.5	ug/FILTER	1.132673864	24	27.18417	1.84E-02			6.00E-03		6.00E+00	
RE39-11-4528	Nickel	2.4	ug/FILTER	1.132673864	24	27.18417	8.83E-02	detect	19	6.00E-03		6.00E+00	0
RE39-11-2936	Potassium	42	ug/FILTER	1.11851544	36	40.26656	1.04E+00			none specified			
RE39-11-2945	Potassium	200	ug/FILTER			0				none specified			
RE36-11-2914	Potassium	47	ug/FILTER	1.104357017	30	33.13071	1.42E+00			none specified			
RE36-11-2915	Potassium	81	ug/FILTER	1.132673864	54	61.16439	1.32E+00			none specified			
RE36-11-2916	Potassium	76	ug/FILTER	1.132673864	30	33.98022	2.24E+00			none specified			
RE36-11-2917	Potassium	24	ug/FILTER	1.132673864	36	40.77626	5.89E-01			none specified			
RE36-11-2918	Potassium	200	ug/FILTER	1.104357017	18	19.87843	1.01E+01			none specified			
RE36-11-2919	Potassium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-2920	Potassium	24	ug/FILTER	1.132673864	24	27.18417	8.83E-01			none specified			
RE36-11-2921	Potassium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-2922	Potassium	200	ug/FILTER	1.104357017	36	39.75685	5.03E+00			none specified			
RE36-11-2923	Potassium	200	ug/FILTER	1.104357017	36	39.75685	5.03E+00			none specified			
RE39-11-2935	Potassium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE39-11-2937	Potassium	35	ug/FILTER	1.132673864	18	20.38813	1.72E+00			none specified			
RE39-11-2938	Potassium	81	ug/FILTER	1.132673864	30	33.98022	2.38E+00			none specified			
RE39-11-2939	Potassium	24	ug/FILTER	1.104357017	24	26.50457	9.06E-01			none specified			
RE39-11-2940	Potassium	130	ug/FILTER	1.104357017	30	33.13071	3.92E+00			none specified			
RE39-11-2941	Potassium	32	ug/FILTER	1.132673864	24	27.18417	1.18E+00			none specified			
RE39-11-2942	Potassium	93	ug/FILTER	1.132673864	24	27.18417	3.42E+00			none specified			
RE36-11-4184	Potassium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE36-11-4189	Potassium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE36-11-4190	Potassium	200	ug/FILTER			0				none specified			
RE36-11-2934	Potassium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-4192	Potassium	200	ug/FILTER	1.132673864	96	108.7367	1.84E+00			none specified			
RE36-11-4197	Potassium	200	ug/FILTER	1.061881747	108	114.6832	1.74E+00			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4503	Potassium	23	ug/FILTER	1.132673864	30	33.98022	6.77E-01			none specified			
RE39-11-2943	Potassium	17	ug/FILTER	1.132673864	30	33.98022	5.00E-01			none specified			
RE39-11-2944	Potassium	62	ug/FILTER	1.132673864	36	40.77626	1.52E+00			none specified			
RE39-11-4524	Potassium	21	ug/FILTER	1.104357017	30	33.13071	6.34E-01			none specified			
RE39-11-4525	Potassium	16	ug/FILTER	1.104357017	30	33.13071	4.83E-01			none specified			
RE39-11-4526	Potassium	16	ug/FILTER			0				none specified			
RE39-11-4527	Potassium	17	ug/FILTER	1.132673864	24	27.18417	6.25E-01			none specified			
RE39-11-4528	Potassium	19	ug/FILTER	1.132673864	24	27.18417	6.99E-01		0	none specified			0
RE39-11-2936	Selenium	0.2	ug/FILTER	1.11851544	36	40.26656	4.97E-03			1.47E+00		1.47E+03	
RE39-11-2945	Selenium	0.2	ug/FILTER			0				1.47E+00		1.47E+03	
RE36-11-2914	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE36-11-2915	Selenium	0.2	ug/FILTER	1.132673864	54	61.16439	3.27E-03			1.47E+00		1.47E+03	
RE36-11-2916	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE36-11-2917	Selenium	0.2	ug/FILTER	1.132673864	36	40.77626	4.90E-03			1.47E+00		1.47E+03	
RE36-11-2918	Selenium	0.2	ug/FILTER	1.104357017	18	19.87843	1.01E-02			1.47E+00		1.47E+03	
RE36-11-2919	Selenium	0.2	ug/FILTER	1.132673864	42	47.5723	4.20E-03			1.47E+00		1.47E+03	
RE36-11-2920	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE36-11-2921	Selenium	0.2	ug/FILTER	1.132673864	42	47.5723	4.20E-03			1.47E+00		1.47E+03	
RE36-11-2922	Selenium	0.072	ug/FILTER	1.104357017	36	39.75685	1.81E-03			1.47E+00		1.47E+03	
RE36-11-2923	Selenium	0.2	ug/FILTER	1.104357017	36	39.75685	5.03E-03			1.47E+00		1.47E+03	
RE39-11-2935	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2937	Selenium	0.2	ug/FILTER	1.132673864	18	20.38813	9.81E-03			1.47E+00		1.47E+03	
RE39-11-2938	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2939	Selenium	0.2	ug/FILTER	1.104357017	24	26.50457	7.55E-03			1.47E+00		1.47E+03	
RE39-11-2940	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE39-11-2941	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE39-11-2942	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE36-11-4184	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE36-11-4189	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE36-11-4190	Selenium	0.2	ug/FILTER			0				1.47E+00		1.47E+03	
RE36-11-2934	Selenium	0.2	ug/FILTER	1.132673864	42	47.5723	4.20E-03			1.47E+00		1.47E+03	
RE36-11-4192	Selenium	0.2	ug/FILTER	1.132673864	96	108.7367	1.84E-03			1.47E+00		1.47E+03	
RE36-11-4197	Selenium	0.2	ug/FILTER	1.061881747	108	114.6832	1.74E-03			1.47E+00		1.47E+03	
RE36-11-4503	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2943	Selenium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			1.47E+00		1.47E+03	
RE39-11-2944	Selenium	0.2	ug/FILTER	1.132673864	36	40.77626	4.90E-03			1.47E+00		1.47E+03	
RE39-11-4524	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE39-11-4525	Selenium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			1.47E+00		1.47E+03	
RE39-11-4526	Selenium	0.2	ug/FILTER			0				1.47E+00		1.47E+03	
RE39-11-4527	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			1.47E+00		1.47E+03	
RE39-11-4528	Selenium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03		0	1.47E+00		1.47E+03	0
RE39-11-2936	Silver	0.19	ug/FILTER	1.11851544	36	40.26656	4.72E-03	detect		0.3		300	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-2945	Silver	0.15	ug/FILTER			0		detect		0.3		300	
RE36-11-2914	Silver	0.038	ug/FILTER	1.104357017	30	33.13071	1.15E-03	detect		0.3		300	
RE36-11-2915	Silver	0.03	ug/FILTER	1.132673864	54	61.16439	4.90E-04	detect		0.3		300	
RE36-11-2916	Silver	0.05	ug/FILTER	1.132673864	30	33.98022	1.47E-03	detect		0.3		300	
RE36-11-2917	Silver	0.016	ug/FILTER	1.132673864	36	40.77626	3.92E-04			0.3		300	
RE36-11-2918	Silver	0.088	ug/FILTER	1.104357017	18	19.87843	4.43E-03	detect		0.3		300	
RE36-11-2919	Silver	0.06	ug/FILTER	1.132673864	42	47.5723	1.26E-03	detect		0.3		300	
RE36-11-2920	Silver	0.22	ug/FILTER	1.132673864	24	27.18417	8.09E-03	detect		0.3		300	
RE36-11-2921	Silver	0.34	ug/FILTER	1.132673864	42	47.5723	7.15E-03	detect		0.3		300	
RE36-11-2922	Silver	0.064	ug/FILTER	1.104357017	36	39.75685	1.61E-03	detect		0.3		300	
RE36-11-2923	Silver	0.032	ug/FILTER	1.104357017	36	39.75685	8.05E-04	detect		0.3		300	
RE39-11-2935	Silver	0.038	ug/FILTER	1.132673864	30	33.98022	1.12E-03	detect		0.3		300	
RE39-11-2937	Silver	0.026	ug/FILTER	1.132673864	18	20.38813	1.28E-03	detect		0.3		300	
RE39-11-2938	Silver	0.092	ug/FILTER	1.132673864	30	33.98022	2.71E-03	detect		0.3		300	
RE39-11-2939	Silver	0.076	ug/FILTER	1.104357017	24	26.50457	2.87E-03	detect		0.3		300	
RE39-11-2940	Silver	0.13	ug/FILTER	1.104357017	30	33.13071	3.92E-03	detect		0.3		300	
RE39-11-2941	Silver	0.094	ug/FILTER	1.132673864	24	27.18417	3.46E-03	detect		0.3		300	
RE39-11-2942	Silver	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03	detect		0.3		300	
RE36-11-4184	Silver	0.048	ug/FILTER	1.132673864	30	33.98022	1.41E-03	detect		0.3		300	
RE36-11-4189	Silver	0.074	ug/FILTER	1.132673864	30	33.98022	2.18E-03	detect		0.3		300	
RE36-11-4190	Silver	0.15	ug/FILTER			0		detect		0.3		300	
RE36-11-2934	Silver	0.026	ug/FILTER	1.132673864	42	47.5723	5.47E-04	detect		0.3		300	
RE36-11-4192	Silver	0.072	ug/FILTER	1.132673864	96	108.7367	6.62E-04	detect		0.3		300	
RE36-11-4197	Silver	0.068	ug/FILTER	1.061881747	108	114.6832	5.93E-04	detect		0.3		300	
RE36-11-4503	Silver	0.074	ug/FILTER	1.132673864	30	33.98022	2.18E-03	detect		0.3		300	
RE39-11-2943	Silver	0.05	ug/FILTER	1.132673864	30	33.98022	1.47E-03	detect		0.3		300	
RE39-11-2944	Silver	0.04	ug/FILTER	1.132673864	36	40.77626	9.81E-04	detect		0.3		300	
RE39-11-4524	Silver	0.028	ug/FILTER	1.104357017	30	33.13071	8.45E-04	detect		0.3		300	
RE39-11-4525	Silver	0.01	ug/FILTER	1.104357017	30	33.13071	3.02E-04			0.3		300	
RE39-11-4526	Silver	0.01	ug/FILTER			0				0.3		300	
RE39-11-4527	Silver	0.02	ug/FILTER	1.132673864	24	27.18417	7.36E-04			0.3		300	
RE39-11-4528	Silver	0.014	ug/FILTER	1.132673864	24	27.18417	5.15E-04		28	0.3		300	0
RE39-11-2936	Sodium	62	ug/FILTER	1.11851544	36	40.26656	1.54E+00			none specified			
RE39-11-2945	Sodium	47	ug/FILTER			0				none specified			
RE36-11-2914	Sodium	70	ug/FILTER	1.104357017	30	33.13071	2.11E+00			none specified			
RE36-11-2915	Sodium	280	ug/FILTER	1.132673864	54	61.16439	4.58E+00	detect		none specified			
RE36-11-2916	Sodium	120	ug/FILTER	1.132673864	30	33.98022	3.53E+00			none specified			
RE36-11-2917	Sodium	48	ug/FILTER	1.132673864	36	40.77626	1.18E+00			none specified			
RE36-11-2918	Sodium	32	ug/FILTER	1.104357017	18	19.87843	1.61E+00			none specified			
RE36-11-2919	Sodium	51	ug/FILTER	1.132673864	42	47.5723	1.07E+00			none specified			
RE36-11-2920	Sodium	92	ug/FILTER	1.132673864	24	27.18417	3.38E+00			none specified			
RE36-11-2921	Sodium	31	ug/FILTER	1.132673864	42	47.5723	6.52E-01			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-2922	Sodium	22	ug/FILTER	1.104357017	36	39.75685	5.53E-01			none specified			
RE36-11-2923	Sodium	20	ug/FILTER	1.104357017	36	39.75685	5.03E-01			none specified			
RE39-11-2935	Sodium	34	ug/FILTER	1.132673864	30	33.98022	1.00E+00			none specified			
RE39-11-2937	Sodium	22	ug/FILTER	1.132673864	18	20.38813	1.08E+00			none specified			
RE39-11-2938	Sodium	70	ug/FILTER	1.132673864	30	33.98022	2.06E+00			none specified			
RE39-11-2939	Sodium	37	ug/FILTER	1.104357017	24	26.50457	1.40E+00			none specified			
RE39-11-2940	Sodium	170	ug/FILTER	1.104357017	30	33.13071	5.13E+00			none specified			
RE39-11-2941	Sodium	32	ug/FILTER	1.132673864	24	27.18417	1.18E+00			none specified			
RE39-11-2942	Sodium	110	ug/FILTER	1.132673864	24	27.18417	4.05E+00			none specified			
RE36-11-4184	Sodium	51	ug/FILTER	1.132673864	30	33.98022	1.50E+00			none specified			
RE36-11-4189	Sodium	38	ug/FILTER	1.132673864	30	33.98022	1.12E+00			none specified			
RE36-11-4190	Sodium	33	ug/FILTER			0				none specified			
RE36-11-2934	Sodium	200	ug/FILTER	1.132673864	42	47.5723	4.20E+00			none specified			
RE36-11-4192	Sodium	43	ug/FILTER	1.132673864	96	108.7367	3.95E-01			none specified			
RE36-11-4197	Sodium	30	ug/FILTER	1.061881747	108	114.6832	2.62E-01			none specified			
RE36-11-4503	Sodium	30	ug/FILTER	1.132673864	30	33.98022	8.83E-01			none specified			
RE39-11-2943	Sodium	200	ug/FILTER	1.132673864	30	33.98022	5.89E+00			none specified			
RE39-11-2944	Sodium	230	ug/FILTER	1.132673864	36	40.77626	5.64E+00	detect		none specified			
RE39-11-4524	Sodium	200	ug/FILTER	1.104357017	30	33.13071	6.04E+00			none specified			
RE39-11-4525	Sodium	200	ug/FILTER	1.104357017	30	33.13071	6.04E+00			none specified			
RE39-11-4526	Sodium	200	ug/FILTER			0				none specified			
RE39-11-4527	Sodium	200	ug/FILTER	1.132673864	24	27.18417	7.36E+00			none specified			
RE39-11-4528	Sodium	200	ug/FILTER	1.132673864	24	27.18417	7.36E+00		2	none specified			0
RE39-11-2936	Thallium	0.02	ug/FILTER	1.11851544	36	40.26656	4.97E-04			0.3		300	
RE39-11-2945	Thallium	0.006	ug/FILTER			0				0.3		300	
RE36-11-2914	Thallium	0.01	ug/FILTER	1.104357017	30	33.13071	3.02E-04			0.3		300	
RE36-11-2915	Thallium	0.04	ug/FILTER	1.132673864	54	61.16439	6.54E-04			0.3		300	
RE36-11-2916	Thallium	0.006	ug/FILTER	1.132673864	30	33.98022	1.77E-04			0.3		300	
RE36-11-2917	Thallium	0.04	ug/FILTER	1.132673864	36	40.77626	9.81E-04			0.3		300	
RE36-11-2918	Thallium	0.006	ug/FILTER	1.104357017	18	19.87843	3.02E-04			0.3		300	
RE36-11-2919	Thallium	0.01	ug/FILTER	1.132673864	42	47.5723	2.10E-04			0.3		300	
RE36-11-2920	Thallium	0.04	ug/FILTER	1.132673864	24	27.18417	1.47E-03			0.3		300	
RE36-11-2921	Thallium	0.04	ug/FILTER	1.132673864	42	47.5723	8.41E-04			0.3		300	
RE36-11-2922	Thallium	0.008	ug/FILTER	1.104357017	36	39.75685	2.01E-04			0.3		300	
RE36-11-2923	Thallium	0.008	ug/FILTER	1.104357017	36	39.75685	2.01E-04			0.3		300	
RE39-11-2935	Thallium	0.004	ug/FILTER	1.132673864	30	33.98022	1.18E-04			0.3		300	
RE39-11-2937	Thallium	0.016	ug/FILTER	1.132673864	18	20.38813	7.85E-04			0.3		300	
RE39-11-2938	Thallium	0.008	ug/FILTER	1.132673864	30	33.98022	2.35E-04			0.3		300	
RE39-11-2939	Thallium	0.006	ug/FILTER	1.104357017	24	26.50457	2.26E-04			0.3		300	
RE39-11-2940	Thallium	0.008	ug/FILTER	1.104357017	30	33.13071	2.41E-04			0.3		300	
RE39-11-2941	Thallium	0.056	ug/FILTER	1.132673864	24	27.18417	2.06E-03	detect		0.3		300	
RE39-11-2942	Thallium	0.012	ug/FILTER	1.132673864	24	27.18417	4.41E-04			0.3		300	

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE36-11-4184	Thallium	0.046	ug/FILTER	1.132673864	30	33.98022	1.35E-03	detect		0.3		300	
RE36-11-4189	Thallium	0.01	ug/FILTER	1.132673864	30	33.98022	2.94E-04			0.3		300	
RE36-11-4190	Thallium	0.04	ug/FILTER			0				0.3		300	
RE36-11-2934	Thallium	0.026	ug/FILTER	1.132673864	42	47.5723	5.47E-04			0.3		300	
RE36-11-4192	Thallium	0.01	ug/FILTER	1.132673864	96	108.7367	9.20E-05			0.3		300	
RE36-11-4197	Thallium	0.006	ug/FILTER	1.061881747	108	114.6832	5.23E-05			0.3		300	
RE36-11-4503	Thallium	0.04	ug/FILTER	1.132673864	30	33.98022	1.18E-03			0.3		300	
RE39-11-2943	Thallium	0.04	ug/FILTER	1.132673864	30	33.98022	1.18E-03			0.3		300	
RE39-11-2944	Thallium	0.04	ug/FILTER	1.132673864	36	40.77626	9.81E-04			0.3		300	
RE39-11-4524	Thallium	0.01	ug/FILTER	1.104357017	30	33.13071	3.02E-04			0.3		300	
RE39-11-4525	Thallium	0.04	ug/FILTER	1.104357017	30	33.13071	1.21E-03			0.3		300	
RE39-11-4526	Thallium	0.008	ug/FILTER			0				0.3		300	
RE39-11-4527	Thallium	0.04	ug/FILTER	1.132673864	24	27.18417	1.47E-03			0.3		300	
RE39-11-4528	Thallium	0.014	ug/FILTER	1.132673864	24	27.18417	5.15E-04		2	0.3		300	0
RE39-11-2936	Vanadium	0.15	ug/FILTER	1.11851544	36	40.26656	3.73E-03			none specified			
RE39-11-2945	Vanadium	0.2	ug/FILTER			0				none specified			
RE36-11-2914	Vanadium	0.082	ug/FILTER	1.104357017	30	33.13071	2.48E-03			none specified			
RE36-11-2915	Vanadium	0.092	ug/FILTER	1.132673864	54	61.16439	1.50E-03			none specified			
RE36-11-2916	Vanadium	0.06	ug/FILTER	1.132673864	30	33.98022	1.77E-03			none specified			
RE36-11-2917	Vanadium	0.058	ug/FILTER	1.132673864	36	40.77626	1.42E-03			none specified			
RE36-11-2918	Vanadium	0.14	ug/FILTER	1.104357017	18	19.87843	7.04E-03			none specified			
RE36-11-2919	Vanadium	0.052	ug/FILTER	1.132673864	42	47.5723	1.09E-03			none specified			
RE36-11-2920	Vanadium	0.17	ug/FILTER	1.132673864	24	27.18417	6.25E-03			none specified			
RE36-11-2921	Vanadium	0.15	ug/FILTER	1.132673864	42	47.5723	3.15E-03			none specified			
RE36-11-2922	Vanadium	0.11	ug/FILTER	1.104357017	36	39.75685	2.77E-03			none specified			
RE36-11-2923	Vanadium	0.12	ug/FILTER	1.104357017	36	39.75685	3.02E-03			none specified			
RE39-11-2935	Vanadium	0.22	ug/FILTER	1.132673864	30	33.98022	6.47E-03	detect		none specified			
RE39-11-2937	Vanadium	0.2	ug/FILTER	1.132673864	18	20.38813	9.81E-03			none specified			
RE39-11-2938	Vanadium	0.38	ug/FILTER	1.132673864	30	33.98022	1.12E-02	detect		none specified			
RE39-11-2939	Vanadium	0.27	ug/FILTER	1.104357017	24	26.50457	1.02E-02	detect		none specified			
RE39-11-2940	Vanadium	0.58	ug/FILTER	1.104357017	30	33.13071	1.75E-02	detect		none specified			
RE39-11-2941	Vanadium	0.26	ug/FILTER	1.132673864	24	27.18417	9.56E-03	detect		none specified			
RE39-11-2942	Vanadium	0.5	ug/FILTER	1.132673864	24	27.18417	1.84E-02	detect		none specified			
RE36-11-4184	Vanadium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE36-11-4189	Vanadium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE36-11-4190	Vanadium	0.2	ug/FILTER			0				none specified			
RE36-11-2934	Vanadium	0.084	ug/FILTER	1.132673864	42	47.5723	1.77E-03			none specified			
RE36-11-4192	Vanadium	0.11	ug/FILTER	1.132673864	96	108.7367	1.01E-03			none specified			
RE36-11-4197	Vanadium	0.12	ug/FILTER	1.061881747	108	114.6832	1.05E-03			none specified			
RE36-11-4503	Vanadium	0.13	ug/FILTER	1.132673864	30	33.98022	3.83E-03			none specified			
RE39-11-2943	Vanadium	0.2	ug/FILTER	1.132673864	30	33.98022	5.89E-03			none specified			
RE39-11-2944	Vanadium	0.076	ug/FILTER	1.132673864	36	40.77626	1.86E-03			none specified			

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte
RE39-11-4524	Vanadium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			none specified			
RE39-11-4525	Vanadium	0.2	ug/FILTER	1.104357017	30	33.13071	6.04E-03			none specified			
RE39-11-4526	Vanadium	0.2	ug/FILTER			0				none specified			
RE39-11-4527	Vanadium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03			none specified			
RE39-11-4528	Vanadium	0.2	ug/FILTER	1.132673864	24	27.18417	7.36E-03		6	none specified			0
RE39-11-2936	Zinc	33	ug/FILTER	1.11851544	36	40.26656	8.20E-01	detect		3.00E+01		3.00E+04	
RE39-11-2945	Zinc	11	ug/FILTER			0		detect		3.00E+01		3.00E+04	
RE36-11-2914	Zinc	20	ug/FILTER	1.104357017	30	33.13071	6.04E-01	detect		3.00E+01		3.00E+04	
RE36-11-2915	Zinc	21	ug/FILTER	1.132673864	54	61.16439	3.43E-01	detect		3.00E+01		3.00E+04	
RE36-11-2916	Zinc	14	ug/FILTER	1.132673864	30	33.98022	4.12E-01	detect		3.00E+01		3.00E+04	
RE36-11-2917	Zinc	15	ug/FILTER	1.132673864	36	40.77626	3.68E-01	detect		3.00E+01		3.00E+04	
RE36-11-2918	Zinc	12	ug/FILTER	1.104357017	18	19.87843	6.04E-01	detect		3.00E+01		3.00E+04	
RE36-11-2919	Zinc	18	ug/FILTER	1.132673864	42	47.5723	3.78E-01	detect		3.00E+01		3.00E+04	
RE36-11-2920	Zinc	10	ug/FILTER	1.132673864	24	27.18417	3.68E-01	detect		3.00E+01		3.00E+04	
RE36-11-2921	Zinc	15	ug/FILTER	1.132673864	42	47.5723	3.15E-01	detect		3.00E+01		3.00E+04	
RE36-11-2922	Zinc	11	ug/FILTER	1.104357017	36	39.75685	2.77E-01	detect		3.00E+01		3.00E+04	
RE36-11-2923	Zinc	11	ug/FILTER	1.104357017	36	39.75685	2.77E-01	detect		3.00E+01		3.00E+04	
RE39-11-2935	Zinc	15	ug/FILTER	1.132673864	30	33.98022	4.41E-01	detect		3.00E+01		3.00E+04	
RE39-11-2937	Zinc	20	ug/FILTER	1.132673864	18	20.38813	9.81E-01	detect		3.00E+01		3.00E+04	
RE39-11-2938	Zinc	40	ug/FILTER	1.132673864	30	33.98022	1.18E+00	detect		3.00E+01		3.00E+04	
RE39-11-2939	Zinc	16	ug/FILTER	1.104357017	24	26.50457	6.04E-01	detect		3.00E+01		3.00E+04	
RE39-11-2940	Zinc	46	ug/FILTER	1.104357017	30	33.13071	1.39E+00	detect		3.00E+01		3.00E+04	
RE39-11-2941	Zinc	14	ug/FILTER	1.132673864	24	27.18417	5.15E-01	detect		3.00E+01		3.00E+04	
RE39-11-2942	Zinc	35	ug/FILTER	1.132673864	24	27.18417	1.29E+00	detect		3.00E+01		3.00E+04	
RE36-11-4184	Zinc	19	ug/FILTER	1.132673864	30	33.98022	5.59E-01	detect		3.00E+01		3.00E+04	
RE36-11-4189	Zinc	11	ug/FILTER	1.132673864	30	33.98022	3.24E-01	detect		3.00E+01		3.00E+04	
RE36-11-4190	Zinc	12	ug/FILTER			0		detect		3.00E+01		3.00E+04	
RE36-11-2934	Zinc	9.8	ug/FILTER	1.132673864	42	47.5723	2.06E-01	detect		3.00E+01		3.00E+04	
RE36-11-4192	Zinc	12	ug/FILTER	1.132673864	96	108.7367	1.10E-01	detect		3.00E+01		3.00E+04	
RE36-11-4197	Zinc	15	ug/FILTER	1.061881747	108	114.6832	1.31E-01	detect		3.00E+01		3.00E+04	
RE36-11-4503	Zinc	22	ug/FILTER	1.132673864	30	33.98022	6.47E-01	detect		3.00E+01		3.00E+04	
RE39-11-2943	Zinc	18	ug/FILTER	1.132673864	30	33.98022	5.30E-01	detect		3.00E+01		3.00E+04	
RE39-11-2944	Zinc	42	ug/FILTER	1.132673864	36	40.77626	1.03E+00	detect		3.00E+01		3.00E+04	
RE39-11-4524	Zinc	17	ug/FILTER	1.104357017	30	33.13071	5.13E-01	detect		3.00E+01		3.00E+04	
RE39-11-4525	Zinc	6.4	ug/FILTER	1.104357017	30	33.13071	1.93E-01	detect		3.00E+01		3.00E+04	
RE39-11-4526	Zinc	2.1	ug/FILTER			0				3.00E+01		3.00E+04	
RE39-11-4527	Zinc	3.6	ug/FILTER	1.132673864	24	27.18417	1.32E-01			3.00E+01		3.00E+04	
RE39-11-4528	Zinc	17	ug/FILTER	1.132673864	24	27.18417	6.25E-01	detect	31	3.00E+01		3.00E+04	0

Sample Name	Analyte Description	Std Result	Std Result Unit	Flow rate (m^3/min)	Flow time (min)	Flow vol (m^3)	Conc. In Air (pg or ug /m^3)	Detection	# of Detects per Analyte	Acute Inhalation Exposure Conc. (mg/m^3)	CA Acute RELs (mg/m^3)	Conversion of screening level to ug/m^3	# of Exceeds per Analyte

ug = micrograms
m^3/min = cubic meters per minute
min = minute
pg or ug /m^3 = picograms or micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
ug/m^3 = microgams per cubic meter
CA Acute RELs = California Acute Reference Exposure Levels
Note: Blank samples have a flow volume of 0 m^3
Screening levels taken from:
EPA, 2005. "Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities," Office of Solid Waste and Emergency Response, EPA530-R-05-006, September 2005. EPA, 2010, "Environmental Protection Agency Region 6 Regional Screening Levels," November November 2010.
and
Office of Environmental Health Hazard Assessment (OEHHA), 1999. Air Toxics Hot Spots Program Risk Assessment Guidelines Part I The Determination of Acute Reference Exposure Levels for Airborne Toxicants. California Environmental Protection Agency, Air Toxicology and Epidemiology Section, Office of Environmental Health Hazard Assessment. March 1999.

Supplement 4-5

Soil Sampling Results Summary Report for the Open Detonation Unit at Technical Area (TA) 36-8

TA-36-8 Open Detonation Unit

This summary report includes discussion of the analytical results associated with soil sampling conducted at the Technical Area 36, Building 8 (TA-36-8) open detonation unit on September 19, 2018. Fifteen soil samples were collected from pre-selected locations (Figure 1) based on a defined area where deposition of particulates from air to soil, including predominant downwind locations, and areas of potential storm water runoff, is most likely to occur. Soil samples were analyzed for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total metals, dioxins/furans, perchlorates, and high explosives, gross alpha and beta and isotopic plutonium. Soil samples were collected as grab samples from a depth of 0 to 2 inches below the ground surface.

In 2010 and early 2011, soil data were previously collected to determine the baseline soil constituent of concern concentrations at the unit after more than 50 years of use. A summary of the soil analytical results for the sample collection events is included in Attachment D of the *Los Alamos National Laboratory Permit Modification Request for Open Detonation Units at Technical Areas 36 and 39 (TA-36-8 & TA-39-6), Revision 0* (Los Alamos National Laboratory [LANL], 2011). Soil samples were analyzed for high explosives, metals, dioxins/furans, SVOCs, VOCs, polychlorinated biphenyls (PCBs), perchlorates, and radiological constituents (gross alpha, gross beta, and isotopic uranium). Those analytical results indicate that the average soil constituent concentrations in and around the TA-36-8 open detonation unit were less than the New Mexico Environment Department (NMED) Residential Soil Screening Levels (RSSLs) (NMED, 2019).

PCB soil data was collected in 2010 and 2011, because the soil monitoring conducted at that time was designed to be a baseline data set to begin an assumed soil monitoring program at the detonation unit. Constituents chosen for the 2018 sampling effort were based on the likelihood that current operational activities may contribute to deposition of the constituents.

PCB waste is not treated or used in association with the current operational activities at either of the units; therefore, PCBs should not be added to the soil surface since initial detection. At the time of closure of the units, PCBs should be evaluated based on the sites historic use.

The results of the 2018 soil sampling event, discussed in detail below, indicate that current active operations at the unit also do not pose an unnecessary risk to human health based on the soil sample analytical results. Any potential contamination at the site is believed to be primarily limited to the surface (i.e., the first few inches in depth) of the site.

Laboratory Analysis and Reporting

The soil samples collected in 2018 were analyzed at a qualified offsite laboratory. The LANL Sample Management Office qualifies contract laboratories and ensures these laboratories adhere to U.S. Environmental Protection Agency (EPA) quality assurance and quality control (QA/QC) requirements. All sampling and analyses were conducted in accordance with QA/QC procedures defined by the latest revision of SW-846 (EPA 1986) or other NMED-approved procedures. Field sampling procedures and laboratory analyses are evaluated through the use of QA/QC samples to assess the overall quality of the

data produced. The field QC samples included trip blanks, field blanks, field duplicates, and equipment rinsate blanks. Field QC samples were given a unique sample identification number and submitted to the analytical laboratory as blind samples. Laboratory QC samples include calibrations, blanks, duplicates, and spike samples. QC sample results are included in the analytical results received from the laboratory so the results can be applied to the associated samples.

Samples were analyzed for the following constituents using the methods indicated in the parentheses:

- High explosives (SW-846-8330B)
- Metals (SW-846-6020, SW-846-6010C, and SW-846-7471A)
- Dioxins/Furans (SW-846-8290A)
- SVOCs (SW-846-8270D)
- VOCs (SW-846-8260B)
- Perchlorates (SW-846-6850)
- Gross alpha and beta (EPA Method 900)
- Isotopic plutonium (HASL-300:ISOPU)

Complete analytical results for this sampling are included in Table 1, *TA-36-8 Analytical Data Summary*. Data are reported with qualifiers that denote the following analytical situations:

- <u>For Dioxins/Furans</u>
    - U – Compound analyzed for, but not detected, reported quantity equals the contract required quantitation limit (CRQL)
    - J - Estimated value; the analyte is present, but at a concentration below the CRQL
    - B – Analyte detected in associated blank
    - K – Estimated Maximum Possible Concentration
    - NQ – No qualification
- <u>For Metals and Isotopic Plutonium</u>
    - U – reading was less than the method detection limit (MDL); reported value equals the CRQL
    - J – The reported value was obtained from a reading less than the CRQL but greater than or equal to the MDL
        - J+ – percent recovery is over the qualification standard
        - J- – percent recovery is below the qualification standard
    - B – Analyte detected in associated blank
    - NQ – No qualification
- <u>For VOCs and SVOCs</u>
    - U – Compound analyzed for, but not detected; reported value equals the CRQL
    - J – Estimated value; the analyte is present, but at a concentration below the CRQL
        - J+ – percent recovery is over the qualification standard
        - J- – percent recovery is below the qualification standard
    - B – Analyte detected in associated blank

- For Explosives
    - U – Compound analyzed for, but not detected; reported value equals the CRQL
    - J – Estimated value; the analyte is present, but at a concentration below the CRQL
        - J+ – percent recovery is over the qualification standard
        - J- – percent recovery is below the qualification standard
    - B – Analyte detected in associated blank
    - NQ – No qualification

Soil samples collected in 2018 were intended to be analyzed for isotopic uranium, but were analyzed for isotopic plutonium instead, which is not a constituent that should be present at the site. A miscommunication on the chain of custody forms for the sample suites led to analysis for isotopic plutonium and as expected, there was no plutonium detected at the site. However, previously collected data regarding isotopic uranium (the applicable constituent) concentration information, were included in the earlier 2011 sampling report (LANL 2011). The isotopic uranium data were also evaluated within the 2013 revised risk assessment included as Permit Application Supplement 4-9, *Revision of 2011 Open Detonation Risk Assessment*.

Summary of Results

Compiled data were compared to NMED RSSLs. It is important to note that very few constituents, when compared to the constituents that the soil was tested for, were detected. The compounds detected within the soil are presented below as well as other information about the analytical data that provide a more in depth discussion regarding the results.

Organic constituents detected within the soils at the TA-36-8 open detonation unit include:

- 2 of the 62 VOCs analyzed;
- 17 of the 69 SVOCs analyzed;
- 3 of the 20 explosives compounds analyzed; and
- 16 of the 25 dioxin or furan compounds analyzed.

All of the VOCs and SVOCs that were detected at the unit were detected below applicable NMED RSSLs. However, when a constituent concentration is reported as a CRQL which is greater than the screening level, it appears that the constituent is detected above the NMED RSSL. This is the case for n-nitrosodimethylamine within this dataset. It is not detected in any of the samples analyzed and is included within the 'U' qualifier. However, because the reported results are the same as the CRQL, and the CRQL is greater than the NMED RSSL, n- nitrosodimethylamine appears to be detected at a concentration higher than the NMED RSSLs. The method utilized by the analytical laboratory for the SVOC analysis can detect the presence of nitrosamines; however, it is not the most sensitive method and therefore, the detection limit is higher than the soil screening level.

The presence of n-nitrosodimethylamine due to operations at the TA-36-8 open detonation is not likely and a more focused analytical validation was deemed not necessary. N-nitrosodimethylamine is produced by industry only in small amounts for research. It was used to make rocket fuel, but this use was stopped after unusually high levels of the chemical were found in air, water, and soil samples collected near a rocket fuel manufacturing plant. It is currently used in some cosmetic and toiletry products and in cleansers. N-nitrosodimethylamine is unintentionally formed during various manufacturing processes and in air, water, and soil from reactions involving alkylamines. It is also found

in some foods and may be formed in the body. When released to the air, it is broken down by sunlight in a matter of minutes. When released to soil, it may evaporate into air or could sink down into deeper soil. It is unlikely that n-nitrosodimethylamine was deposited by past or current activities at the TA-36-8 open detonation unit as rocket fuel was never manufactured at LANL.

The three explosives compounds (HMX, RDX, and TATB) detected within the soil at the TA-36-8 open detonation unit were all found at concentrations below NMED RSSLs.

EPA has established 50 parts per trillion (ppt) Toxic Equivalency Quantity (TEQ) as being an acceptable limit for residential contamination for dioxins and furans. The TEQ system was developed for the purpose of comparing the relative risk of exposure in areas of contamination that vary widely in the composition and level of most toxic dioxins and furans. Each of the 17 highly toxic dioxins/furans are assigned a Toxic Equivalency Factor (TEF) based on a particular chemical's toxicity relative to 2,3,7,8-tetrachlorodibenzodioxin (TCDD), with the toxicity of TCDD being equal to 1.0. The concentration of each dioxin/furan is multiplied by its respective TEF and the results are summed. The summed results give the TEQ of the sample and it is this value that is compared to the 50 ppt screening level. This analysis is conducted as part of the health and ecological risk assessment included with this application and is included within Permit Application Supplement 4-7, *Technical Area 36 - Open Burn/Open Detonation (OB/OD) Area - Technical Area 36-8 Open Detonation Unit Human Health and Ecological Risk- Screening Assessments*.

Perchlorate was detected at 11 of the 15 soil sample locations. All detections were below NMED RSSLs.

Twenty-two (22) of the 23 analyzed metals were detected in the sampled soil at the TA-36-8 open detonation unit. Most of the detected metal concentrations are below the established background levels for Los Alamos National Laboratory. Eight of the metals detected are present at concentrations above background values.

- Cadmium (1 location)
- Chromium (1 location)
- Copper (13 locations)
- Lead (1 location)
- Mercury (1 location)
- Silver (2 locations)
- Thallium (1 location)
- Zinc (1 location)

The single detection of thallium is also above the NMED RSSL at that location. Human health and ecological risks associated with these detections are included in Permit Application Supplement 4-7, *Technical Area 36 - Open Burn/Open Detonation (OB/OD) Area - Technical Area 36-8 Open Detonation Unit Human Health and Ecological Risk- Screening Assessments*.

Conclusion

Soil sampling and analysis results indicate that the average soil constituent concentration in and around the TA-36-8 open detonation unit are generally less than the NMED RSSLs. Metal constituent concentrations greater than the screening levels (see Table 1) are indicated for a single soil sample when compared directly to the NMED RSSLs. The analytical results for high explosives, perchlorates, VOCs, SVOCs and dioxins/furans did not indicate the presence of any constituents greater than the selected screening levels. Detected metals at 13 soil sample locations were measured above established background values.

References

EPA, 1986 (and all approved updates). *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* SW-846, U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response, U.S Government Printing Office, Washington D.C.

LANL, 2011. *Los Alamos National Laboratory Permit Modification Request for Open Detonation Units at Technical Areas 36 and 39 (TA-36-8 & TA-39-6), Revision 0*. Los Alamos National Laboratory. July 2011. (http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-11-04739)

NMED, 2010. *Los Alamos National Laboratory Hazardous Waste Facility Permit,* EPA ID# NM0890010515, New Mexico Environment Department, Santa Fe, New Mexico.

NMED, 2019. *New Mexico Environment Department Risk Assessment guidance for Site Investigations and Remediation*, February 2019 (Revision 2, 6/19/19).

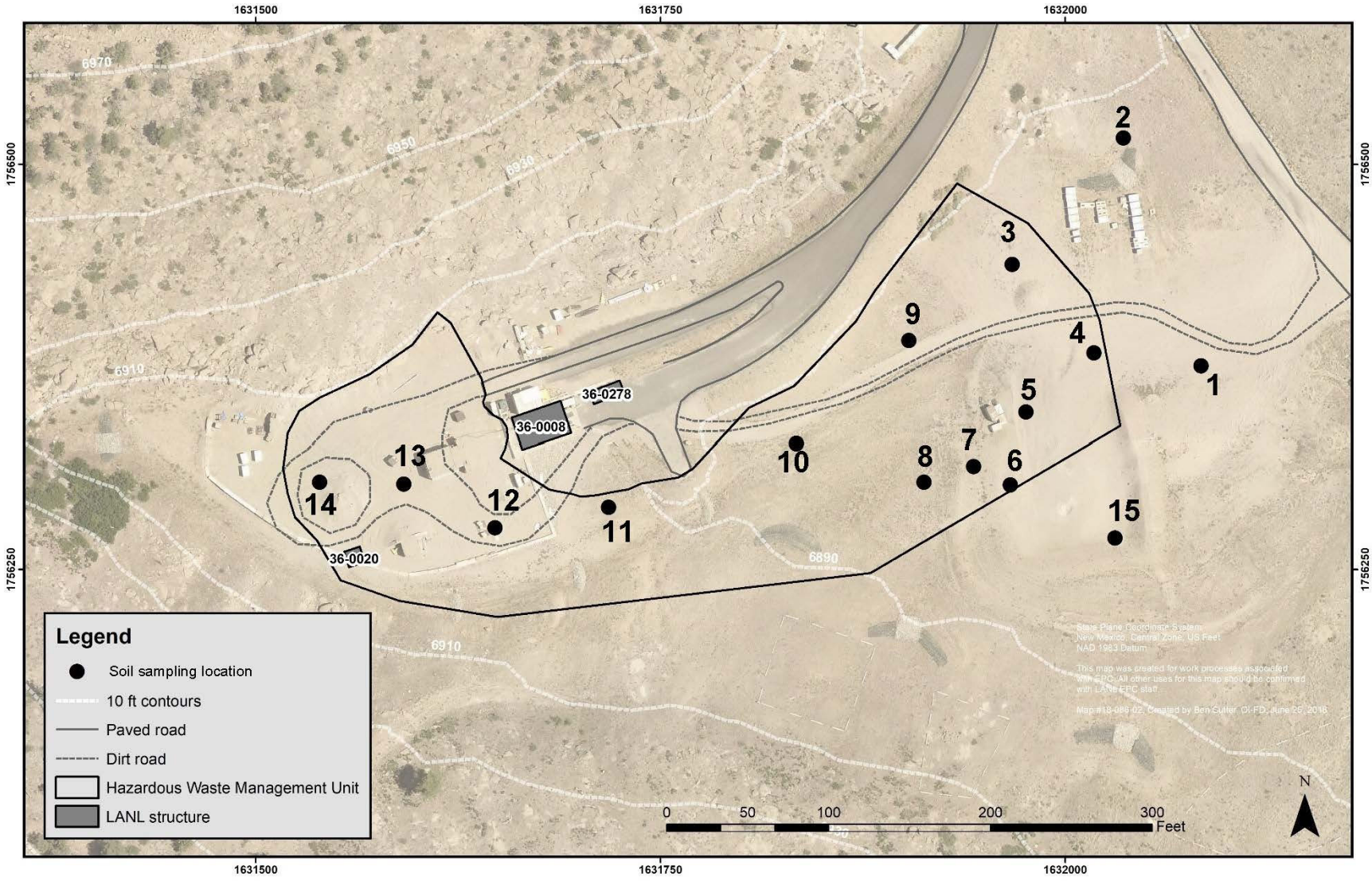

Figure 1. TA-36-8 Soil Sample Locations

Table 1. TA-36-8 2018 Analytical Data Summary

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**8.40E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Heptachlorodibenzodioxins (Total)**	**1.22E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**5.61E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzofuran[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzofuran[2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Tetrachlorodibenzodioxin[2,3,7,8-]	9.99E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
1	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.10E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
1	**Tetrachlorodibenzofurans (Totals)**	**1.10E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Aluminum**	**2.35E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
1	Antimony	3.14E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
1	**Arsenic**	**8.44E-01**	mg/kg	**Y**	J	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
1	**Barium**	**2.64E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
1	**Beryllium**	**2.09E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
1	Cadmium	9.52E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
1	**Calcium**	**4.49E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
1	**Chromium**	**7.38E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
1	**Cobalt**	**3.32E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
1	**Copper**	**1.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	FALSE
1	**Iron**	**9.51E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	**Lead**	**4.17E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
1	**Magnesium**	**2.58E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
1	**Manganese**	**1.43E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
1	Mercury	3.64E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
1	**Nickel**	**5.29E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
1	**Potassium**	**4.03E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
1	**Selenium**	**4.78E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
1	**Silver**	**2.95E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
1	**Sodium**	**4.14E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
1	Thallium	1.35E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
1	**Vanadium**	**2.13E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
1	**Zinc**	**2.01E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
1	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/Ap	FALSE	N/A	FALSE	N/A	FALSE
1	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1	HMX	1.49E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
1	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
1	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
1	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
1	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**RDX**	**2.27E-01**	mg/kg	**Y**	J	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
1	**TATB**	**1.27E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
1	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Perchlorate	4.98E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
1	**Gross alpha**	**1.24E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	**Gross beta**	**2.14E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Plutonium-238	1.36E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
1	Plutonium-239/240	-1.09E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
1	Acenaphthene	1.00E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Acenaphthylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Aniline	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Anthracene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
1	Azobenzene	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(a)anthracene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(a)pyrene	1.00E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
1	Benzo(b)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(g,h,i)perylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Benzo(k)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
1	Benzoic Acid	1.67E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Benzyl Alcohol	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bis(2-chloroethoxy)methane	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bis(2-chloroethyl)ether	1.00E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Bis(2-ethylhexyl)phthalate	1.00E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Bromophenyl-phenylether[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Butylbenzylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chloroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chloronaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
1	Chlorophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
1	Chlorophenyl-phenyl[4-] Ether	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Chrysene	1.00E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
1	Dibenz(a,h)anthracene	1.00E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
1	Dibenzofuran	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorobenzene[1,2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1	Dichlorobenzene[1,3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorobenzene[1,4-]	1.00E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1	Dichlorobenzidine[3,3'-]	1.00E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
1	Diethylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
1	Dimethyl Phthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
1	Dimethylphenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Di-n-butylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1	Dinitro-2-methylphenol[4,6-]	1.00E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
1	Dinitrophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
1	Dinitrotoluene[2,4-]	1.00E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1	Dinitrotoluene[2,6-]	1.00E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1	Di-n-octylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Diphenylamine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Fluoranthene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
1	Fluorene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
1	Hexachlorobenzene	1.00E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
1	Hexachlorobutadiene	1.00E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
1	Hexachlorocyclopentadiene	1.00E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
1	Hexachloroethane	1.00E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
1	Indeno(1,2,3-cd)pyrene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1	Isophorone	1.00E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
1	Methylnaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
1	Methylphenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Methylphenol[3-,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Naphthalene	1.00E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
1	Nitroaniline[2-]	1.10E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitroaniline[3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitrobenzene	1.00E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1	Nitrophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitrophenol[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Nitrosodimethylamine[N-]	1.00E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
1	Nitroso-di-n-propylamine[N-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Oxybis(1-chloropropane)[2,2'-]	1.00E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
1	Pentachlorophenol	1.00E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
1	Phenanthrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1	Phenol	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
1	Pyrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1	Pyridine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Trichlorobenzene[1,2,4-]	1.00E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
1	Trichlorophenol[2,4,5-]	1.00E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1	Trichlorophenol[2,4,6-]	1.00E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
1	Acetone	1.55E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
1	Benzene	3.10E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
1	Bromobenzene	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bromochloromethane	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Bromodichloromethane	3.10E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1	Bromoform	3.10E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Bromomethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
1	Butanone[2-]	1.55E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Butylbenzene[n-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Butylbenzene[sec-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Butylbenzene[tert-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Carbon Disulfide	1.55E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
1	Carbon Tetrachloride	3.10E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
1	Chlorobenzene	3.10E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
1	Chlorodibromomethane	3.10E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Chloroethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
1	Chloroform	3.10E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
1	Chloromethane	3.10E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
1	Chlorotoluene[2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
1	Chlorotoluene[4-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dibromo-3-Chloropropane[1,2-]	4.66E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
1	Dibromoethane[1,2-]	3.10E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
1	Dibromomethane	3.10E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
1	Dichlorobenzene[1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1	Dichlorobenzene[1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichlorobenzene[1,4-]	3.10E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1	Dichlorodifluoromethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
1	Dichloroethane[1,1-]	3.10E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
1	Dichloroethane[1,2-]	3.10E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
1	Dichloroethene[1,1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
1	Dichloroethene[cis-1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1	Dichloroethene[trans-1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
1	Dichloropropane[1,2-]	3.10E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
1	Dichloropropane[1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropane[2,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropene[1,1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropene[cis-1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Dichloropropene[trans-1,3-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Ethylbenzene	3.10E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
1	Hexanone[2-]	1.55E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Iodomethane	1.55E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Isopropylbenzene	3.10E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
1	Isopropyltoluene[4-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Methyl-2-pentanone[4-]	1.55E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
1	Methylene Chloride	1.55E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
1	Propylbenzene[1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1	Styrene	3.10E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
1	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Tetrachloroethane[1,1,1,2-]	3.10E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
1	Tetrachloroethane[1,1,2,2-]	3.10E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1	Tetrachloroethene	3.10E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
1	Toluene	3.10E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
1	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.55E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
1	Trichloroethane[1,1,1-]	3.10E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
1	Trichloroethane[1,1,2-]	3.10E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
1	Trichloroethene	3.10E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
1	Trichlorofluoromethane	3.10E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1	Trichloropropane[1,2,3-]	3.10E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
1	Trimethylbenzene[1,2,4-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Trimethylbenzene[1,3,5-]	3.10E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1	Vinyl Chloride	3.10E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
1	Xylene[1,2-]	3.10E-04	mg/kg	N	U	N/A	FALSE	8.05E+02	FALSE	N/A	FALSE
1	Xylene[1,3-]+Xylene[1,4-]	6.21E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
2	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**3.68E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Heptachlorodibenzodioxins (Total)**	**1.11E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**8.20E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Heptachlorodibenzofurans (Total)**	**8.20E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Hexachlorodibenzodioxins (Total)**	**5.77E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**3.41E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**2.54E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
2	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.31E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
2	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Aluminum**	**3.75E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
2	Antimony	3.24E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
2	**Arsenic**	**1.43E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
2	**Barium**	**7.34E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
2	**Beryllium**	**4.55E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
2	Cadmium	9.81E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
2	**Calcium**	**2.76E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
2	**Chromium**	**5.37E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
2	**Cobalt**	**3.06E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
2	**Copper**	**1.48E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
2	**Iron**	**1.09E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
2	**Lead**	**1.26E+01**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
2	**Magnesium**	**1.09E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
2	**Manganese**	**2.99E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
2	**Mercury**	**5.52E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
2	**Nickel**	**4.17E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
2	**Potassium**	**7.96E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
2	**Selenium**	**8.41E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
2	**Silver**	**1.25E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
2	**Sodium**	**5.06E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
2	Thallium	1.36E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
2	**Vanadium**	**1.37E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
2	**Zinc**	**4.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
2	2,4-Diamino-6-nitrotoluene	4.95E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	2,6-Diamino-4-nitrotoluene	6.53E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	3,5-Dinitroaniline	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
2	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
2	HMX	1.49E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
2	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
2	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
2	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
2	PETN	2.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	RDX	1.49E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
2	**TATB**	**1.40E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
2	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
2	Tris (o-cresyl) phosphate	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Perchlorate	5.04E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
2	**Gross alpha**	**1.69E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Gross beta**	**3.27E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Plutonium-238	1.16E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
2	Plutonium-239/240	7.22E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
2	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
2	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
2	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Benzo(a)anthracene**	**1.58E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
2	**Benzo(a)pyrene**	**1.34E-02**	mg/kg	**Y**	J	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
2	**Benzo(b)fluoranthene**	**1.61E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
2	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
2	**Benzoic Acid**	**4.58E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
2	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
2	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
2	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Chrysene**	**1.38E-02**	mg/kg	**Y**	J	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
2	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
2	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
2	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
2	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
2	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
2	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
2	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
2	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
2	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
2	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
2	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	**Fluoranthene**	**2.58E-02**	mg/kg	**Y**	J	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
2	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
2	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
2	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
2	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
2	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
2	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
2	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
2	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
2	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
2	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
2	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
2	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
2	**Phenanthrene**	**1.54E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
2	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
2	**Pyrene**	**2.58E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
2	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
2	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
2	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
2	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
2	Benzene	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
2	Bromobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bromochloromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Bromodichloromethane	3.23E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
2	Bromoform	3.23E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Bromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
2	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
2	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Butylbenzene[tert-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
2	Carbon Tetrachloride	3.23E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
2	Chlorobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
2	Chlorodibromomethane	3.23E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Chloroethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
2	Chloroform	3.23E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
2	Chloromethane	3.23E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
2	Chlorotoluene[2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
2	Chlorotoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dibromo-3-Chloropropane[1,2-]	4.85E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
2	Dibromoethane[1,2-]	3.23E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
2	Dibromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
2	Dichlorobenzene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
2	Dichlorobenzene[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichlorobenzene[1,4-]	3.23E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
2	Dichlorodifluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
2	Dichloroethane[1,1-]	3.23E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
2	Dichloroethane[1,2-]	3.23E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
2	Dichloroethene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
2	Dichloroethene[cis-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
2	Dichloroethene[trans-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
2	Dichloropropane[1,2-]	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
2	Dichloropropane[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropane[2,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropene[cis-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Dichloropropene[trans-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Ethylbenzene	3.23E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
2	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Isopropylbenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
2	Isopropyltoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
2	Methylene Chloride	1.62E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
2	Propylbenzene[1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Styrene	3.23E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
2	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Tetrachloroethane[1,1,1,2-]	3.23E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
2	Tetrachloroethane[1,1,2,2-]	3.23E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
2	Tetrachloroethene	3.23E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
2	**Toluene**	**2.23E-03**	mg/kg	**Y**	NQ	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
2	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
2	Trichloroethane[1,1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
2	Trichloroethane[1,1,2-]	3.23E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
2	Trichloroethene	3.23E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
2	Trichlorofluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
2	Trichloropropane[1,2,3-]	3.23E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
2	Trimethylbenzene[1,2,4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Trimethylbenzene[1,3,5-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
2	Vinyl Chloride	3.23E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
2	Xylene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	8.07E+02	FALSE	N/A	FALSE
2	Xylene[1,3-]+Xylene[1,4-]	6.47E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
3	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**7.96E-06**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Heptachlorodibenzodioxins (Total)**	**3.17E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**1.49E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	**Heptachlorodibenzofurans (Total)**	**5.35E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Hexachlorodibenzodioxins (Total)**	**2.86E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**7.74E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**5.55E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzofuran[1,2,3,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzofuran[2,3,4,7,8-]	5.03E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Tetrachlorodibenzodioxin[2,3,7,8-]	1.01E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
3	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Tetrachlorodibenzofuran[2,3,7,8-]**	**2.27E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
3	**Tetrachlorodibenzofurans (Totals)**	**2.27E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Aluminum**	**2.95E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
3	Antimony	4.32E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
3	**Arsenic**	**1.95E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
3	**Barium**	**1.15E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
3	**Beryllium**	**3.50E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
3	Cadmium	9.18E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
3	**Calcium**	**3.50E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
3	**Chromium**	**4.92E+01**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	TRUE
3	**Cobalt**	**4.12E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
3	**Copper**	**5.97E+02**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
3	**Iron**	**1.02E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
3	**Lead**	**3.52E+01**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	TRUE
3	**Magnesium**	**1.45E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
3	**Manganese**	**1.94E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
3	Mercury	3.43E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
3	**Nickel**	**7.70E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
3	**Potassium**	**8.10E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	**Selenium**	**6.31E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
3	**Silver**	**4.94E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
3	**Sodium**	**6.05E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
3	Thallium	1.41E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
3	**Vanadium**	**2.07E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
3	**Zinc**	**4.84E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
3	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
3	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
3	**HMX**	**1.45E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
3	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
3	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
3	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
3	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
3	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
3	**TATB**	**2.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
3	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
3	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Perchlorate**	**7.69E-04**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
3	**Gross alpha**	**1.24E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Gross beta**	**2.56E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Plutonium-238	-5.73E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
3	Plutonium-239/240	-1.00E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
3	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
3	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
3	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
3	**Benzoic Acid**	**4.97E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	**Benzyl Alcohol**	**1.46E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
3	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
3	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
3	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
3	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
3	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
3	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
3	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
3	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
3	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
3	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
3	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
3	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
3	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
3	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
3	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
3	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
3	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
3	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
3	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
3	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
3	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
3	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
3	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
3	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
3	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
3	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
3	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
3	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
3	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
3	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
3	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
3	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
3	Acetone	1.59E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
3	Benzene	3.17E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
3	Bromobenzene	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bromochloromethane	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Bromodichloromethane	3.17E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
3	Bromoform	3.17E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Bromomethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
3	Butanone[2-]	1.59E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
3	Butylbenzene[n-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Butylbenzene[sec-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Butylbenzene[tert-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Carbon Disulfide	1.59E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
3	Carbon Tetrachloride	3.17E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
3	Chlorobenzene	3.17E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Chlorodibromomethane	3.17E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Chloroethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
3	Chloroform	3.17E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
3	Chloromethane	3.17E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
3	Chlorotoluene[2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
3	Chlorotoluene[4-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dibromo-3-Chloropropane[1,2-]	4.75E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
3	Dibromoethane[1,2-]	3.17E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
3	Dibromomethane	3.17E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
3	Dichlorobenzene[1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
3	Dichlorobenzene[1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichlorobenzene[1,4-]	3.17E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
3	Dichlorodifluoromethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
3	Dichloroethane[1,1-]	3.17E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
3	Dichloroethane[1,2-]	3.17E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
3	Dichloroethene[1,1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
3	Dichloroethene[cis-1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
3	Dichloroethene[trans-1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
3	Dichloropropane[1,2-]	3.17E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
3	Dichloropropane[1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropane[2,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropene[1,1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropene[cis-1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Dichloropropene[trans-1,3-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Ethylbenzene	3.17E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
3	Hexanone[2-]	1.59E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Iodomethane	1.59E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Isopropylbenzene	3.17E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
3	Isopropyltoluene[4-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Methyl-2-pentanone[4-]	1.59E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
3	**Methylene Chloride**	**4.16E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
3	Propylbenzene[1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Styrene	3.17E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
3	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Tetrachloroethane[1,1,1,2-]	3.17E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
3	Tetrachloroethane[1,1,2,2-]	3.17E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
3	Tetrachloroethene	3.17E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
3	Toluene	3.17E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
3	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.59E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
3	Trichloroethane[1,1,1-]	3.17E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
3	Trichloroethane[1,1,2-]	3.17E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
3	Trichloroethene	3.17E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
3	Trichlorofluoromethane	3.17E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
3	Trichloropropane[1,2,3-]	3.17E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
3	Trimethylbenzene[1,2,4-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Trimethylbenzene[1,3,5-]	3.17E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
3	Vinyl Chloride	3.17E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
3	Xylene[1,2-]	3.17E-04	mg/kg	N	U	N/A	FALSE	8.08E+02	FALSE	N/A	FALSE
3	Xylene[1,3-]+Xylene[1,4-]	6.34E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
4	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.74E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Heptachlorodibenzodioxins (Total)**	**6.18E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Heptachlorodibenzofurans (Total)**	**5.37E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.40E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.94E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Tetrachlorodibenzodioxin[2,3,7,8-]	9.94E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
4	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.79E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
4	**Tetrachlorodibenzofurans (Totals)**	**3.36E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Aluminum**	**2.30E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Antimony	3.16E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
4	**Arsenic**	**1.30E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
4	**Barium**	**2.58E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
4	**Beryllium**	**2.47E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
4	Cadmium	9.58E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
4	**Calcium**	**3.29E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
4	**Chromium**	**6.17E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
4	**Cobalt**	**2.83E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
4	**Copper**	**1.29E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	FALSE
4	**Iron**	**7.68E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
4	**Lead**	**4.13E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
4	**Magnesium**	**1.39E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
4	**Manganese**	**1.19E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
4	Mercury	3.66E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
4	**Nickel**	**6.65E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
4	**Potassium**	**4.45E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
4	**Selenium**	**5.59E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
4	**Silver**	**1.81E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
4	**Sodium**	**4.73E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
4	Thallium	1.36E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
4	**Vanadium**	**1.49E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
4	**Zinc**	**1.85E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
4	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
4	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
4	**HMX**	**1.58E-01**	mg/kg	**Y**	J	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
4	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
4	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
4	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
4	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
4	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**RDX**	**6.08E-01**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
4	**TATB**	**1.48E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
4	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
4	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Perchlorate**	**1.31E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
4	**Gross alpha**	**9.87E+00**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	**Gross beta**	**2.25E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Plutonium-238	-2.04E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
4	Plutonium-239/240	-1.02E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
4	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
4	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
4	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
4	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
4	Benzoic Acid	1.69E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
4	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
4	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
4	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
4	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
4	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
4	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
4	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
4	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
4	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
4	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
4	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
4	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
4	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
4	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
4	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
4	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
4	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
4	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
4	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
4	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
4	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
4	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
4	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
4	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
4	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
4	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
4	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
4	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
4	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
4	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
4	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
4	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
4	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
4	Benzene	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
4	Bromobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bromochloromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Bromodichloromethane	3.30E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
4	Bromoform	3.30E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Bromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
4	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
4	Butylbenzene[n-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Butylbenzene[sec-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Butylbenzene[tert-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
4	Carbon Tetrachloride	3.30E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
4	Chlorobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
4	Chlorodibromomethane	3.30E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Chloroethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
4	Chloroform	3.30E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
4	Chloromethane	3.30E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
4	Chlorotoluene[2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
4	Chlorotoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dibromo-3-Chloropropane[1,2-]	4.96E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
4	Dibromoethane[1,2-]	3.30E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
4	Dibromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
4	Dichlorobenzene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
4	Dichlorobenzene[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichlorobenzene[1,4-]	3.30E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
4	Dichlorodifluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
4	Dichloroethane[1,1-]	3.30E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
4	Dichloroethane[1,2-]	3.30E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
4	Dichloroethene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
4	Dichloroethene[cis-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
4	Dichloroethene[trans-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
4	Dichloropropane[1,2-]	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
4	Dichloropropane[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichloropropane[2,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichloropropene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
4	Dichloropropene[cis-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Dichloropropene[trans-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Ethylbenzene	3.30E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
4	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Isopropylbenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
4	Isopropyltoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
4	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
4	Propylbenzene[1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Styrene	3.30E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
4	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Tetrachloroethane[1,1,1,2-]	3.30E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
4	Tetrachloroethane[1,1,2,2-]	3.30E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
4	Tetrachloroethene	3.30E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
4	Toluene	3.30E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
4	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
4	Trichloroethane[1,1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
4	Trichloroethane[1,1,2-]	3.30E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
4	Trichloroethene	3.30E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
4	Trichlorofluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
4	Trichloropropane[1,2,3-]	3.30E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
4	Trimethylbenzene[1,2,4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Trimethylbenzene[1,3,5-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
4	Vinyl Chloride	3.30E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
4	Xylene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	8.09E+02	FALSE	N/A	FALSE
4	Xylene[1,3-]+Xylene[1,4-]	6.61E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
5	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**8.19E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Heptachlorodibenzodioxins (Total)**	**2.69E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**8.29E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	1.00E-06	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzofuran[1,2,3,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzofuran[2,3,4,7,8-]	5.01E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetrachlorodibenzodioxin[2,3,7,8-]	1.00E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
5	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetrachlorodibenzofuran[2,3,7,8-]	2.36E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
5	**Tetrachlorodibenzofurans (Totals)**	**2.36E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Aluminum**	**3.16E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
5	Antimony	3.17E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
5	**Arsenic**	**1.17E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
5	**Barium**	**4.28E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
5	**Beryllium**	**2.68E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
5	Cadmium	9.60E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
5	**Calcium**	**4.04E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
5	**Chromium**	**1.01E+01**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
5	**Cobalt**	**4.49E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
5	**Copper**	**4.48E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
5	**Iron**	**1.29E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
5	**Lead**	**6.52E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
5	**Magnesium**	**1.74E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
5	**Manganese**	**1.90E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
5	Mercury	3.66E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
5	**Nickel**	**6.93E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
5	**Potassium**	**6.12E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
5	**Selenium**	**5.13E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
5	**Silver**	**4.14E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
5	**Sodium**	**9.85E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
5	Thallium	1.37E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
5	**Vanadium**	**2.90E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	N/A	FALSE
5	**Zinc**	**2.58E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
5	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
5	**HMX**	**3.79E-01**	mg/kg	**Y**	J	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
5	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
5	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
5	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
5	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
5	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**RDX**	**4.23E-01**	mg/kg	**Y**	J	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
5	**TATB**	**1.38E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
5	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
5	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Perchlorate**	**1.32E-02**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
5	**Gross alpha**	**1.38E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	**Gross beta**	**2.36E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Plutonium-238	-1.27E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
5	Plutonium-239/240	-8.49E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
5	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
5	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
5	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
5	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
5	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
5	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
5	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
5	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
5	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
5	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
5	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
5	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
5	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
5	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
5	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
5	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
5	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
5	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
5	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
5	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
5	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
5	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
5	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
5	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
5	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
5	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
5	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
5	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
5	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
5	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
5	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
5	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
5	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
5	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
5	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
5	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
5	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
5	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
5	Acetone	1.69E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
5	Benzene	3.37E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
5	Bromobenzene	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Bromochloromethane	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Bromodichloromethane	3.37E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
5	Bromoform	3.37E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Bromomethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
5	Butanone[2-]	1.69E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
5	Butylbenzene[n-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Butylbenzene[sec-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Butylbenzene[tert-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Carbon Disulfide	1.69E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
5	Carbon Tetrachloride	3.37E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
5	Chlorobenzene	3.37E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
5	Chlorodibromomethane	3.37E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
5	Chloroethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
5	Chloroform	3.37E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
5	Chloromethane	3.37E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
5	Chlorotoluene[2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
5	Chlorotoluene[4-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Dibromo-3-Chloropropane[1,2-]	5.06E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
5	Dibromoethane[1,2-]	3.37E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
5	Dibromomethane	3.37E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
5	Dichlorobenzene[1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
5	Dichlorobenzene[1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichlorobenzene[1,4-]	3.37E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
5	Dichlorodifluoromethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
5	Dichloroethane[1,1-]	3.37E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
5	Dichloroethane[1,2-]	3.37E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
5	Dichloroethene[1,1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
5	Dichloroethene[cis-1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
5	Dichloroethene[trans-1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
5	Dichloropropane[1,2-]	3.37E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
5	Dichloropropane[1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropane[2,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropene[1,1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropene[cis-1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Dichloropropene[trans-1,3-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Ethylbenzene	3.37E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
5	Hexanone[2-]	1.69E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Iodomethane	1.69E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Isopropylbenzene	3.37E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
5	Isopropyltoluene[4-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Methyl-2-pentanone[4-]	1.69E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
5	Methylene Chloride	1.69E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
5	Propylbenzene[1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Styrene	3.37E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
5	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Tetrachloroethane[1,1,1,2-]	3.37E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
5	Tetrachloroethane[1,1,2,2-]	3.37E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
5	Tetrachloroethene	3.37E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
5	Toluene	3.37E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
5	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.69E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
5	Trichloroethane[1,1,1-]	3.37E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
5	Trichloroethane[1,1,2-]	3.37E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
5	Trichloroethene	3.37E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
5	Trichlorofluoromethane	3.37E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
5	Trichloropropane[1,2,3-]	3.37E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
5	Trimethylbenzene[1,2,4-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Trimethylbenzene[1,3,5-]	3.37E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
5	Vinyl Chloride	3.37E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
5	Xylene[1,2-]	3.37E-04	mg/kg	N	U	N/A	FALSE	8.20E+02	FALSE	N/A	FALSE
5	Xylene[1,3-]+Xylene[1,4-]	6.75E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
6	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.06E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Heptachlorodibenzodioxins (Total)**	**4.75E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.02E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.94E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Tetrachlorodibenzodioxin[2,3,7,8-]	9.94E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
6	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.87E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
6	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Aluminum**	**3.06E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
6	Antimony	3.15E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
6	**Arsenic**	**1.29E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
6	**Barium**	**4.59E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
6	**Beryllium**	**3.82E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
6	Cadmium	9.56E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
6	**Calcium**	**2.15E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	**Chromium**	**6.90E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
6	**Cobalt**	**8.44E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
6	**Copper**	**6.72E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
6	**Iron**	**8.05E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
6	**Lead**	**5.42E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
6	**Magnesium**	**1.09E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
6	**Manganese**	**1.46E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
6	Mercury	3.68E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
6	**Nickel**	**7.27E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
6	**Potassium**	**6.54E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
6	**Selenium**	**5.57E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
6	**Silver**	**3.31E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
6	**Sodium**	**5.90E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
6	Thallium	1.29E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
6	**Vanadium**	**1.66E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
6	**Zinc**	**2.08E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
6	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
6	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
6	**HMX**	**2.10E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
6	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
6	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
6	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
6	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
6	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**RDX**	**2.57E+00**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
6	**TATB**	**1.01E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
6	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
6	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Perchlorate**	**6.37E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
6	**Gross alpha**	**1.49E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	**Gross beta**	**2.86E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Plutonium-238	-7.06E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
6	Plutonium-239/240	-7.06E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
6	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
6	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
6	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
6	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
6	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Benzyl Alcohol**	**3.11E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
6	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
6	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
6	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
6	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
6	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
6	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
6	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
6	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
6	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
6	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
6	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
6	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
6	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
6	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
6	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
6	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
6	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
6	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
6	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
6	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
6	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
6	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	**Naphthalene**	**1.51E-02**	mg/kg	**Y**	J	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
6	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
6	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
6	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
6	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
6	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
6	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
6	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
6	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
6	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
6	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
6	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
6	Benzene	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
6	Bromobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Bromochloromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	Bromodichloromethane	3.29E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
6	Bromoform	3.29E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Bromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
6	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
6	Butylbenzene[n-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Butylbenzene[sec-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Butylbenzene[tert-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
6	Carbon Tetrachloride	3.29E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
6	Chlorobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
6	Chlorodibromomethane	3.29E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Chloroethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
6	Chloroform	3.29E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
6	Chloromethane	3.29E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
6	Chlorotoluene[2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
6	Chlorotoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dibromo-3-Chloropropane[1,2-]	4.94E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
6	Dibromoethane[1,2-]	3.29E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
6	Dibromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
6	Dichlorobenzene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
6	Dichlorobenzene[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichlorobenzene[1,4-]	3.29E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
6	Dichlorodifluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
6	Dichloroethane[1,1-]	3.29E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
6	Dichloroethane[1,2-]	3.29E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
6	Dichloroethene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
6	Dichloroethene[cis-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
6	Dichloroethene[trans-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
6	Dichloropropane[1,2-]	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
6	Dichloropropane[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropane[2,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropene[cis-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Dichloropropene[trans-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Ethylbenzene	3.29E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
6	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Isopropylbenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
6	Isopropyltoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
6	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
6	Propylbenzene[1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Styrene	3.29E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
6	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Tetrachloroethane[1,1,1,2-]	3.29E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
6	Tetrachloroethane[1,1,2,2-]	3.29E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
6	Tetrachloroethene	3.29E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
6	**Toluene**	**3.95E-04**	mg/kg	**Y**	J	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
6	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
6	Trichloroethane[1,1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
6	Trichloroethane[1,1,2-]	3.29E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
6	Trichloroethene	3.29E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
6	Trichlorofluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
6	Trichloropropane[1,2,3-]	3.29E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
6	Trimethylbenzene[1,2,4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Trimethylbenzene[1,3,5-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
6	Vinyl Chloride	3.29E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
6	Xylene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	8.10E+02	FALSE	N/A	FALSE
6	Xylene[1,3-]+Xylene[1,4-]	6.59E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
7	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.11E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Heptachlorodibenzodioxins (Total)**	**2.68E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.01E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.95E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
7	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.71E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
7	**Tetrachlorodibenzofurans (Totals)**	**1.71E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Aluminum**	**3.76E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
7	Antimony	3.08E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
7	**Arsenic**	**1.44E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
7	**Barium**	**5.99E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
7	**Beryllium**	**4.53E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
7	Cadmium	9.32E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
7	**Calcium**	**2.24E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
7	**Chromium**	**6.86E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
7	**Cobalt**	**3.27E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
7	**Copper**	**9.02E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
7	**Iron**	**8.42E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
7	**Lead**	**6.49E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
7	**Magnesium**	**1.28E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
7	**Manganese**	**1.74E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
7	**Mercury**	**4.76E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
7	**Nickel**	**7.98E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
7	**Potassium**	**9.29E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
7	**Selenium**	**6.10E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
7	**Silver**	**2.19E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.91E+02	FALSE	1.00E+00	TRUE
7	**Sodium**	**5.98E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
7	Thallium	1.41E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
7	**Vanadium**	**1.64E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
7	**Zinc**	**2.53E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
7	2,4-Diamino-6-nitrotoluene	4.95E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	2,6-Diamino-4-nitrotoluene	6.53E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	3,5-Dinitroaniline	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
7	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
7	**HMX**	**9.78E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
7	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
7	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
7	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
7	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
7	PETN	2.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**RDX**	**2.49E+00**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
7	**TATB**	**1.13E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
7	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
7	Tris (o-cresyl) phosphate	2.97E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Perchlorate**	**2.01E-02**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
7	**Gross alpha**	**1.62E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	**Gross beta**	**2.49E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Plutonium-238	-2.62E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
7	Plutonium-239/240	-6.55E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
7	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
7	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
7	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
7	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
7	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
7	**Bis(2-ethylhexyl)phthalate**	**2.52E-01**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
7	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
7	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
7	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
7	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
7	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
7	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
7	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
7	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
7	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
7	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
7	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
7	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
7	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
7	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
7	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
7	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
7	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
7	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
7	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
7	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
7	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
7	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
7	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
7	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
7	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
7	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
7	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
7	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
7	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
7	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
7	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
7	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
7	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
7	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
7	Benzene	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
7	Bromobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bromochloromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Bromodichloromethane	3.30E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
7	Bromoform	3.30E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Bromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
7	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
7	Butylbenzene[n-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Butylbenzene[sec-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Butylbenzene[tert-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
7	Carbon Tetrachloride	3.30E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
7	Chlorobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
7	Chlorodibromomethane	3.30E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Chloroethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
7	Chloroform	3.30E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
7	Chloromethane	3.30E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
7	Chlorotoluene[2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
7	Chlorotoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dibromo-3-Chloropropane[1,2-]	4.95E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
7	Dibromoethane[1,2-]	3.30E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
7	Dibromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
7	Dichlorobenzene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
7	Dichlorobenzene[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichlorobenzene[1,4-]	3.30E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
7	Dichlorodifluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
7	Dichloroethane[1,1-]	3.30E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
7	Dichloroethane[1,2-]	3.30E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
7	Dichloroethene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
7	Dichloroethene[cis-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
7	Dichloroethene[trans-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
7	Dichloropropane[1,2-]	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
7	Dichloropropane[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropane[2,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropene[cis-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Dichloropropene[trans-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Ethylbenzene	3.30E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
7	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Isopropylbenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
7	Isopropyltoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
7	**Methylene Chloride**	**3.51E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
7	Propylbenzene[1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Styrene	3.30E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
7	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Tetrachloroethane[1,1,1,2-]	3.30E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
7	Tetrachloroethane[1,1,2,2-]	3.30E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
7	Tetrachloroethene	3.30E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
7	Toluene	3.30E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
7	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
7	Trichloroethane[1,1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
7	Trichloroethane[1,1,2-]	3.30E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
7	Trichloroethene	3.30E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
7	Trichlorofluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
7	Trichloropropane[1,2,3-]	3.30E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
7	Trimethylbenzene[1,2,4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Trimethylbenzene[1,3,5-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
7	Vinyl Chloride	3.30E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
7	Xylene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	8.11E+02	FALSE	N/A	FALSE
7	Xylene[1,3-]+Xylene[1,4-]	6.61E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**4.67E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Heptachlorodibenzodioxins (Total)**	**3.56E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Heptachlorodibenzofurans (Total)**	**8.79E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Hexachlorodibenzodioxins (Total)**	**1.46E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**4.30E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.33E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzofuran[1,2,3,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzofuran[2,3,4,7,8-]	4.99E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Tetrachlorodibenzodioxin[2,3,7,8-]	9.99E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
8	**Tetrachlorodibenzodioxins (Total)**	**2.42E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.44E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
8	**Tetrachlorodibenzofurans (Totals)**	**3.04E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Aluminum**	**4.14E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
8	Antimony	3.18E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
8	**Arsenic**	**1.63E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
8	**Barium**	**8.20E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
8	**Beryllium**	**5.30E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
8	Cadmium	9.64E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
8	**Calcium**	**2.62E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
8	**Chromium**	**6.67E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
8	**Cobalt**	**3.74E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
8	**Copper**	**3.72E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
8	**Iron**	**9.21E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
8	**Lead**	**8.26E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
8	**Magnesium**	**1.27E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	**Manganese**	**2.05E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
8	Mercury	3.96E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
8	**Nickel**	**6.45E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
8	**Potassium**	**1.26E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
8	**Selenium**	**7.73E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
8	**Silver**	**2.57E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
8	**Sodium**	**5.09E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
8	Thallium	1.37E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
8	**Vanadium**	**1.69E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
8	**Zinc**	**2.89E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
8	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
8	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
8	**HMX**	**5.91E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
8	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
8	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
8	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
8	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
8	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**RDX**	**4.76E+00**	mg/kg	**Y**	NQ	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
8	**TATB**	**1.62E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
8	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
8	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Perchlorate**	**2.96E-02**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
8	**Gross alpha**	**1.50E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	**Gross beta**	**2.98E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Plutonium-238	-3.05E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
8	Plutonium-239/240	-1.52E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
8	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
8	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
8	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
8	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
8	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
8	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
8	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
8	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
8	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
8	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
8	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
8	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
8	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
8	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
8	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
8	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
8	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
8	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
8	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
8	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
8	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
8	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
8	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
8	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
8	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
8	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
8	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
8	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
8	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
8	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
8	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
8	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
8	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
8	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
8	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
8	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
8	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
8	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
8	Benzene	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
8	Bromobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bromochloromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Bromodichloromethane	3.23E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
8	Bromoform	3.23E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Bromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
8	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
8	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Butylbenzene[tert-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
8	Carbon Tetrachloride	3.23E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
8	Chlorobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
8	Chlorodibromomethane	3.23E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Chloroethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
8	Chloroform	3.23E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
8	Chloromethane	3.23E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
8	Chlorotoluene[2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
8	Chlorotoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dibromo-3-Chloropropane[1,2-]	4.85E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
8	Dibromoethane[1,2-]	3.23E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
8	Dibromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
8	Dichlorobenzene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
8	Dichlorobenzene[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichlorobenzene[1,4-]	3.23E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
8	Dichlorodifluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
8	Dichloroethane[1,1-]	3.23E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
8	Dichloroethane[1,2-]	3.23E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
8	Dichloroethene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
8	Dichloroethene[cis-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
8	Dichloroethene[trans-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
8	Dichloropropane[1,2-]	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
8	Dichloropropane[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropane[2,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropene[cis-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Dichloropropene[trans-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Ethylbenzene	3.23E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
8	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Isopropylbenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
8	Isopropyltoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
8	**Methylene Chloride**	**4.70E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
8	Propylbenzene[1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Styrene	3.23E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
8	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
8	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Tetrachloroethane[1,1,1,2-]	3.23E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
8	Tetrachloroethane[1,1,2,2-]	3.23E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
8	Tetrachloroethene	3.23E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
8	**Toluene**	**5.63E-04**	mg/kg	**Y**	J	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
8	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
8	Trichloroethane[1,1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
8	Trichloroethane[1,1,2-]	3.23E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
8	Trichloroethene	3.23E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
8	Trichlorofluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
8	Trichloropropane[1,2,3-]	3.23E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
8	Trimethylbenzene[1,2,4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Trimethylbenzene[1,3,5-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
8	Vinyl Chloride	3.23E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
8	Xylene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	8.12E+02	FALSE	N/A	FALSE
8	Xylene[1,3-]+Xylene[1,4-]	6.48E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
9	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**2.20E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Heptachlorodibenzodioxins (Total)**	**1.75E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**3.44E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Heptachlorodibenzofurans (Total)**	**1.36E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**6.27E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Hexachlorodibenzodioxins (Total)**	**9.82E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Hexachlorodibenzofurans (Total)**	**3.52E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.82E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.01E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetrachlorodibenzodioxin[2,3,7,8-]	9.96E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetrachlorodibenzofuran[2,3,7,8-]	1.73E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
9	**Tetrachlorodibenzofurans (Totals)**	**1.55E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Aluminum**	**2.69E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
9	Antimony	3.25E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
9	**Arsenic**	**1.08E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
9	**Barium**	**7.05E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
9	**Beryllium**	**3.68E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
9	Cadmium	9.84E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
9	**Calcium**	**1.68E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
9	**Chromium**	**3.82E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
9	**Cobalt**	**2.28E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
9	**Copper**	**1.70E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
9	**Iron**	**6.94E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
9	**Lead**	**9.73E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
9	**Magnesium**	**8.53E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
9	**Manganese**	**2.10E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
9	Mercury	3.53E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
9	**Nickel**	**3.35E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
9	**Potassium**	**9.28E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
9	**Selenium**	**6.57E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
9	**Silver**	**1.58E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
9	**Sodium**	**4.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
9	Thallium	1.35E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
9	**Vanadium**	**9.50E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
9	**Zinc**	**3.69E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
9	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
9	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
9	HMX	1.48E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
9	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
9	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
9	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
9	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
9	**TATB**	**7.06E+00**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
9	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
9	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Perchlorate**	**3.21E-03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
9	**Gross alpha**	**2.10E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Gross beta**	**9.72E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Plutonium-238	1.32E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
9	Plutonium-239/240	-1.32E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
9	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
9	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
9	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(a)anthracene**	**1.98E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(a)pyrene**	**2.18E-02**	mg/kg	**Y**	J	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
9	**Benzo(b)fluoranthene**	**3.15E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(g,h,i)perylene**	**1.31E-02**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Benzo(k)fluoranthene**	**1.11E-02**	mg/kg	**Y**	J	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
9	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
9	**Bis(2-ethylhexyl)phthalate**	**1.16E+00**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
9	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
9	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Chrysene**	**1.88E-02**	mg/kg	**Y**	J	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
9	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
9	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
9	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
9	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
9	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
9	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
9	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
9	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
9	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
9	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
9	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
9	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
9	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	**Fluoranthene**	**3.38E-02**	mg/kg	**Y**	NQ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
9	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
9	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
9	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
9	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
9	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
9	**Indeno(1,2,3-cd)pyrene**	**1.31E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
9	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
9	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
9	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
9	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
9	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
9	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
9	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
9	**Phenanthrene**	**1.51E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
9	**Pyrene**	**3.12E-02**	mg/kg	**Y**	J	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
9	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
9	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
9	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
9	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
9	Benzene	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
9	Bromobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bromochloromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Bromodichloromethane	3.23E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
9	Bromoform	3.23E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Bromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
9	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
9	Butylbenzene[n-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Butylbenzene[sec-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Butylbenzene[tert-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
9	Carbon Tetrachloride	3.23E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
9	Chlorobenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
9	Chlorodibromomethane	3.23E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Chloroethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
9	Chloroform	3.23E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
9	Chloromethane	3.23E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
9	Chlorotoluene[2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
9	Chlorotoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dibromo-3-Chloropropane[1,2-]	4.84E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
9	Dibromoethane[1,2-]	3.23E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
9	Dibromomethane	3.23E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
9	Dichlorobenzene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
9	Dichlorobenzene[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichlorobenzene[1,4-]	3.23E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
9	Dichlorodifluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
9	Dichloroethane[1,1-]	3.23E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
9	Dichloroethane[1,2-]	3.23E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
9	Dichloroethene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
9	Dichloroethene[cis-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
9	Dichloroethene[trans-1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
9	Dichloropropane[1,2-]	3.23E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
9	Dichloropropane[1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropane[2,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropene[1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropene[cis-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Dichloropropene[trans-1,3-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Ethylbenzene	3.23E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
9	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Isopropylbenzene	3.23E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
9	Isopropyltoluene[4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
9	**Methylene Chloride**	**5.73E-03**	mg/kg	**Y**	NQ	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
9	Propylbenzene[1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Styrene	3.23E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
9	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Tetrachloroethane[1,1,1,2-]	3.23E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
9	Tetrachloroethane[1,1,2,2-]	3.23E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
9	Tetrachloroethene	3.23E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
9	**Toluene**	**2.09E-03**	mg/kg	**Y**	NQ	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
9	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
9	Trichloroethane[1,1,1-]	3.23E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
9	Trichloroethane[1,1,2-]	3.23E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
9	Trichloroethene	3.23E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
9	Trichlorofluoromethane	3.23E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
9	Trichloropropane[1,2,3-]	3.23E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
9	Trimethylbenzene[1,2,4-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Trimethylbenzene[1,3,5-]	3.23E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
9	Vinyl Chloride	3.23E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
9	Xylene[1,2-]	3.23E-04	mg/kg	N	U	N/A	FALSE	8.13E+02	FALSE	N/A	FALSE
9	Xylene[1,3-]+Xylene[1,4-]	6.46E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
10	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**8.35E-06**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Heptachlorodibenzodioxins (Total)**	**2.44E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**1.29E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Heptachlorodibenzofurans (Total)**	**1.29E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Hexachlorodibenzodioxins (Total)**	**1.04E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Hexachlorodibenzofurans (Total)**	**1.36E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**6.93E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**3.95E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachlorodibenzodioxin[2,3,7,8-]	9.97E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
10	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachlorodibenzofuran[2,3,7,8-]	1.67E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Aluminum**	**3.30E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
10	Antimony	3.32E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
10	**Arsenic**	**2.28E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
10	**Barium**	**4.92E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
10	**Beryllium**	**5.88E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
10	Cadmium	1.01E-01	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
10	**Calcium**	**2.35E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
10	**Chromium**	**4.43E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
10	**Cobalt**	**2.77E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
10	**Copper**	**8.21E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	FALSE
10	**Iron**	**6.62E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
10	**Lead**	**6.38E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
10	**Magnesium**	**1.12E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
10	**Manganese**	**1.51E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
10	Mercury	3.71E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
10	**Nickel**	**8.01E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
10	**Potassium**	**6.99E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
10	**Selenium**	**9.37E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
10	**Silver**	**1.55E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	**Sodium**	**4.06E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
10	**Thallium**	**1.58E-01**	mg/kg	**Y**	J	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
10	**Vanadium**	**1.20E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
10	**Zinc**	**1.88E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
10	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
10	HMX	1.48E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
10	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
10	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
10	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
10	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
10	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
10	**TATB**	**3.93E+00**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
10	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
10	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Perchlorate**	**1.07E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
10	**Gross alpha**	**1.54E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Gross beta**	**2.94E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Plutonium-238	1.05E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
10	Plutonium-239/240	9.04E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
10	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
10	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
10	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
10	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
10	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(a)anthracene**	**1.04E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(a)anthracene**	**2.95E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Benzo(a)pyrene	1.01E-02	mg/kg	N	UJ	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
10	**Benzo(a)pyrene**	**2.72E-02**	mg/kg	**Y**	J-	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
10	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(b)fluoranthene**	**3.25E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(g,h,i)perylene**	**2.21E-02**	mg/kg	**Y**	J-	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
10	**Benzo(k)fluoranthene**	**1.48E-02**	mg/kg	**Y**	J-	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	UJ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	UJ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
10	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
10	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
10	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
10	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
10	**Chrysene**	**2.95E-02**	mg/kg	**Y**	J-	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
10	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
10	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
10	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
10	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
10	Diethylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
10	Diethylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
10	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
10	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
10	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Di-n-butylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	**Di-n-butylphthalate**	**3.29E-02**	mg/kg	**Y**	J-	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
10	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
10	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
10	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
10	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
10	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	**Fluoranthene**	**1.55E-02**	mg/kg	**Y**	J-	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	**Fluoranthene**	**5.33E-02**	mg/kg	**Y**	J-	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
10	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
10	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
10	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
10	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
10	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
10	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	**Indeno(1,2,3-cd)pyrene**	**2.05E-02**	mg/kg	**Y**	J-	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
10	Isophorone	1.01E-01	mg/kg	N	UJ	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
10	Isophorone	1.01E-01	mg/kg	N	UJ	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
10	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
10	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
10	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
10	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
10	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
10	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
10	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
10	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
10	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
10	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
10	**Phenanthrene**	**1.14E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	**Phenanthrene**	**2.78E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
10	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
10	**Pyrene**	**1.51E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	**Pyrene**	**5.57E-02**	mg/kg	**Y**	J-	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
10	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
10	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
10	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
10	Benzene	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
10	Bromobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bromochloromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Bromodichloromethane	3.30E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
10	Bromoform	3.30E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Bromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
10	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
10	Butylbenzene[n-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzene[sec-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Butylbenzene[tert-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
10	Carbon Tetrachloride	3.30E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
10	Chlorobenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
10	Chlorodibromomethane	3.30E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Chloroethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
10	Chloroform	3.30E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
10	Chloromethane	3.30E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
10	Chlorotoluene[2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
10	Chlorotoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dibromo-3-Chloropropane[1,2-]	4.95E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
10	Dibromoethane[1,2-]	3.30E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
10	Dibromomethane	3.30E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Dichlorobenzene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
10	Dichlorobenzene[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichlorobenzene[1,4-]	3.30E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
10	Dichlorodifluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
10	Dichloroethane[1,1-]	3.30E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
10	Dichloroethane[1,2-]	3.30E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
10	Dichloroethene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
10	Dichloroethene[cis-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
10	Dichloroethene[trans-1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
10	Dichloropropane[1,2-]	3.30E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
10	Dichloropropane[1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropane[2,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropene[1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropene[cis-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Dichloropropene[trans-1,3-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Ethylbenzene	3.30E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
10	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Isopropylbenzene	3.30E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
10	Isopropyltoluene[4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
10	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
10	Propylbenzene[1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Styrene	3.30E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
10	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Tetrachloroethane[1,1,1,2-]	3.30E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
10	Tetrachloroethane[1,1,2,2-]	3.30E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
10	Tetrachloroethene	3.30E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
10	Toluene	3.30E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
10	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
10	Trichloroethane[1,1,1-]	3.30E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
10	Trichloroethane[1,1,2-]	3.30E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
10	Trichloroethene	3.30E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
10	Trichlorofluoromethane	3.30E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
10	Trichloropropane[1,2,3-]	3.30E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
10	Trimethylbenzene[1,2,4-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
10	Trimethylbenzene[1,3,5-]	3.30E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
10	Vinyl Chloride	3.30E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
10	Xylene[1,2-]	3.30E-04	mg/kg	N	U	N/A	FALSE	8.14E+02	FALSE	N/A	FALSE
10	Xylene[1,3-]+Xylene[1,4-]	6.61E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
11	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**4.84E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Heptachlorodibenzodioxins (Total)**	**1.54E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**4.02E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Heptachlorodibenzofurans (Total)**	**1.55E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxin[1,2,3,4,7,8-]**	**5.85E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**1.09E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxin[1,2,3,7,8,9-]**	**1.11E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzodioxins (Total)**	**1.73E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Hexachlorodibenzofurans (Total)**	**4.93E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**3.90E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.39E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Pentachlorodibenzodioxins (Total)**	**6.85E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Pentachlorodibenzofurans (Totals)**	**1.17E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetrachlorodibenzodioxin[2,3,7,8-]	1.05E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
11	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetrachlorodibenzofuran[2,3,7,8-]	2.19E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
11	**Tetrachlorodibenzofurans (Totals)**	**4.42E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Aluminum**	**3.54E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
11	Antimony	3.16E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
11	**Arsenic**	**1.47E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
11	**Barium**	**9.85E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
11	**Beryllium**	**4.43E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
11	Cadmium	9.57E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
11	**Calcium**	**2.05E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
11	**Chromium**	**4.93E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
11	**Cobalt**	**3.04E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
11	**Copper**	**2.10E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	**Iron**	**7.50E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
11	**Lead**	**1.44E+01**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
11	**Magnesium**	**1.14E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
11	**Manganese**	**1.95E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
11	**Mercury**	**5.90E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
11	**Nickel**	**4.85E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
11	**Potassium**	**1.16E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
11	**Selenium**	**5.83E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
11	**Silver**	**1.04E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.91E+02	FALSE	1.00E+00	TRUE
11	**Sodium**	**3.73E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
11	Thallium	1.30E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
11	**Vanadium**	**1.23E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
11	**Zinc**	**3.66E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
11	2,4-Diamino-6-nitrotoluene	4.93E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	2,6-Diamino-4-nitrotoluene	6.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	3,5-Dinitroaniline	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Amino-2,6-dinitrotoluene[4-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Amino-4,6-dinitrotoluene[2-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dinitrobenzene[1,3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dinitrotoluene[2,4-]	1.48E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
11	Dinitrotoluene[2,6-]	1.48E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
11	**HMX**	**1.26E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
11	Nitrobenzene	1.48E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
11	Nitrotoluene[2-]	1.48E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
11	Nitrotoluene[3-]	1.48E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
11	Nitrotoluene[4-]	1.48E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
11	PETN	2.46E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	RDX	1.48E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
11	**TATB**	**3.33E+00**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetryl	1.48E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
11	Trinitrobenzene[1,3,5-]	1.48E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Trinitrotoluene[2,4,6-]	1.48E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
11	Tris (o-cresyl) phosphate	2.96E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Perchlorate**	**4.16E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
11	**Gross alpha**	**2.26E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Gross beta**	**3.84E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Plutonium-238	5.70E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
11	Plutonium-239/240	1.71E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
11	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
11	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
11	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
11	Benzoic Acid	1.69E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	**Benzyl Alcohol**	**4.98E-01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
11	**Bis(2-ethylhexyl)phthalate**	**9.79E-01**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
11	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
11	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
11	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
11	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
11	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
11	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
11	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
11	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
11	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
11	**Di-n-butylphthalate**	**7.44E-01**	mg/kg	**Y**	NQ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
11	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
11	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
11	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
11	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
11	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
11	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
11	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
11	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
11	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
11	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
11	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
11	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
11	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
11	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
11	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
11	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
11	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
11	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
11	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
11	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
11	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
11	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
11	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
11	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
11	Benzene	3.31E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
11	Bromobenzene	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bromochloromethane	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Bromodichloromethane	3.31E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
11	Bromoform	3.31E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Bromomethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
11	Butylbenzene[n-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Butylbenzene[sec-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Butylbenzene[tert-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
11	Carbon Tetrachloride	3.31E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
11	Chlorobenzene	3.31E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
11	Chlorodibromomethane	3.31E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Chloroethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
11	Chloroform	3.31E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
11	Chloromethane	3.31E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
11	Chlorotoluene[2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
11	Chlorotoluene[4-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dibromo-3-Chloropropane[1,2-]	4.96E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
11	Dibromoethane[1,2-]	3.31E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
11	Dibromomethane	3.31E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
11	Dichlorobenzene[1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
11	Dichlorobenzene[1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichlorobenzene[1,4-]	3.31E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
11	Dichlorodifluoromethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
11	Dichloroethane[1,1-]	3.31E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
11	Dichloroethane[1,2-]	3.31E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
11	Dichloroethene[1,1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
11	Dichloroethene[cis-1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
11	Dichloroethene[trans-1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
11	Dichloropropane[1,2-]	3.31E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
11	Dichloropropane[1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropane[2,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropene[1,1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropene[cis-1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Dichloropropene[trans-1,3-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Ethylbenzene	3.31E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
11	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Isopropylbenzene	3.31E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
11	Isopropyltoluene[4-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
11	**Methylene Chloride**	**4.68E-03**	mg/kg	**Y**	J	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
11	Propylbenzene[1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Styrene	3.31E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
11	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Tetrachloroethane[1,1,1,2-]	3.31E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
11	Tetrachloroethane[1,1,2,2-]	3.31E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
11	Tetrachloroethene	3.31E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
11	Toluene	3.31E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
11	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
11	Trichloroethane[1,1,1-]	3.31E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
11	Trichloroethane[1,1,2-]	3.31E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
11	Trichloroethene	3.31E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
11	Trichlorofluoromethane	3.31E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
11	Trichloropropane[1,2,3-]	3.31E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
11	Trimethylbenzene[1,2,4-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Trimethylbenzene[1,3,5-]	3.31E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
11	Vinyl Chloride	3.31E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
11	Xylene[1,2-]	3.31E-04	mg/kg	N	U	N/A	FALSE	8.15E+02	FALSE	N/A	FALSE
11	Xylene[1,3-]+Xylene[1,4-]	6.62E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
12	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.13E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Heptachlorodibenzodioxins (Total)**	**8.48E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**3.66E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Heptachlorodibenzofurans (Total)**	**1.80E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxin[1,2,3,4,7,8-]**	**6.79E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**1.45E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxin[1,2,3,7,8,9-]**	**9.91E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzodioxins (Total)**	**5.36E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Hexachlorodibenzofurans (Total)**	**1.49E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**9.20E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**1.63E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Pentachlorodibenzofurans (Totals)**	**7.66E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
12	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachlorodibenzofuran[2,3,7,8-]	1.59E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Aluminum**	**1.77E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
12	Antimony	3.08E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
12	**Arsenic**	**1.21E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
12	**Barium**	**4.87E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
12	**Beryllium**	**2.49E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
12	**Cadmium**	**2.80E-01**	mg/kg	**Y**	J	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
12	**Calcium**	**2.12E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
12	**Chromium**	**4.66E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
12	**Cobalt**	**2.42E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
12	**Copper**	**2.54E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
12	**Iron**	**6.51E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
12	**Lead**	**6.36E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
12	**Magnesium**	**1.19E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
12	**Manganese**	**1.19E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
12	**Mercury**	**7.75E-01**	mg/kg	**Y**	NQ	N/A	FALSE	2.38E+01	FALSE	1.00E-01	TRUE
12	**Nickel**	**7.38E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
12	**Potassium**	**4.31E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
12	**Selenium**	**5.18E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
12	**Silver**	**1.26E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
12	**Sodium**	**3.81E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
12	**Thallium**	**2.22E+00**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E-01	TRUE	7.30E-01	TRUE
12	**Vanadium**	**1.36E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
12	**Zinc**	**2.16E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
12	2,4-Diamino-6-nitrotoluene	5.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	2,6-Diamino-4-nitrotoluene	6.60E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	3,5-Dinitroaniline	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Amino-2,6-dinitrotoluene[4-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Amino-4,6-dinitrotoluene[2-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dinitrobenzene[1,3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dinitrotoluene[2,4-]	1.50E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
12	Dinitrotoluene[2,6-]	1.50E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
12	**HMX**	**8.52E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Nitrobenzene	1.50E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
12	Nitrotoluene[2-]	1.50E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
12	Nitrotoluene[3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
12	Nitrotoluene[4-]	1.50E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
12	PETN	2.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	RDX	1.50E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
12	**TATB**	**1.70E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetryl	1.50E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
12	Trinitrobenzene[1,3,5-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Trinitrotoluene[2,4,6-]	1.50E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
12	Tris (o-cresyl) phosphate	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Perchlorate	5.05E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
12	**Gross alpha**	**2.48E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Gross beta**	**3.52E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Plutonium-238	4.66E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
12	Plutonium-239/240	-1.09E-02	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
12	Acenaphthene	1.02E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
12	Acenaphthylene	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Aniline	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Anthracene	1.02E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
12	Azobenzene	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	**Benzo(a)anthracene**	**1.15E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
12	**Benzo(a)pyrene**	**1.02E-02**	mg/kg	**Y**	J	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
12	**Benzo(b)fluoranthene**	**1.87E-02**	mg/kg	**Y**	J	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
12	Benzo(g,h,i)perylene	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Benzo(k)fluoranthene	1.02E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
12	Benzoic Acid	1.70E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Benzyl Alcohol	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bis(2-chloroethoxy)methane	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bis(2-chloroethyl)ether	1.02E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
12	Bis(2-ethylhexyl)phthalate	1.02E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Bromophenyl-phenylether[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Butylbenzylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Chloro-3-methylphenol[4-]	1.36E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Chloroaniline[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Chloronaphthalene[2-]	1.02E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
12	Chlorophenol[2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
12	Chlorophenyl-phenyl[4-] Ether	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Chrysene	1.02E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
12	Dibenz(a,h)anthracene	1.02E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
12	Dibenzofuran	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorobenzene[1,2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
12	Dichlorobenzene[1,3-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorobenzene[1,4-]	1.02E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
12	Dichlorobenzidine[3,3'-]	1.02E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorophenol[2,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
12	Diethylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
12	Dimethyl Phthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
12	Dimethylphenol[2,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Di-n-butylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
12	Dinitro-2-methylphenol[4,6-]	1.02E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
12	Dinitrophenol[2,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
12	Dinitrotoluene[2,4-]	1.02E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
12	Dinitrotoluene[2,6-]	1.02E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
12	Di-n-octylphthalate	1.02E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Diphenylamine	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Fluoranthene	1.02E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
12	Fluorene	1.02E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
12	Hexachlorobenzene	1.02E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
12	Hexachlorobutadiene	1.02E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
12	Hexachlorocyclopentadiene	1.02E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
12	Hexachloroethane	1.02E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
12	Indeno(1,2,3-cd)pyrene	1.02E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
12	Isophorone	1.02E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
12	Methylnaphthalene[2-]	1.02E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
12	Methylphenol[2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Methylphenol[3-,4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Naphthalene	1.02E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
12	Nitroaniline[2-]	1.12E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitroaniline[3-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitroaniline[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitrobenzene	1.02E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
12	Nitrophenol[2-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitrophenol[4-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Nitrosodimethylamine[N-]	1.02E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
12	Nitroso-di-n-propylamine[N-]	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Oxybis(1-chloropropane)[2,2'-]	1.02E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
12	Pentachlorophenol	1.02E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
12	Phenanthrene	1.02E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
12	Phenol	1.02E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
12	Pyrene	1.02E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
12	Pyridine	1.02E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Trichlorobenzene[1,2,4-]	1.02E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
12	Trichlorophenol[2,4,5-]	1.02E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
12	Trichlorophenol[2,4,6-]	1.02E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
12	Acetone	1.67E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
12	Benzene	3.33E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
12	Bromobenzene	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bromochloromethane	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Bromodichloromethane	3.33E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
12	Bromoform	3.33E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Bromomethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
12	Butanone[2-]	1.67E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
12	Butylbenzene[n-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Butylbenzene[sec-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Butylbenzene[tert-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Carbon Disulfide	1.67E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
12	Carbon Tetrachloride	3.33E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
12	Chlorobenzene	3.33E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
12	Chlorodibromomethane	3.33E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Chloroethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
12	Chloroform	3.33E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
12	Chloromethane	3.33E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
12	Chlorotoluene[2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
12	Chlorotoluene[4-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dibromo-3-Chloropropane[1,2-]	5.00E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
12	Dibromoethane[1,2-]	3.33E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
12	Dibromomethane	3.33E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
12	Dichlorobenzene[1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
12	Dichlorobenzene[1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichlorobenzene[1,4-]	3.33E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
12	Dichlorodifluoromethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
12	Dichloroethane[1,1-]	3.33E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
12	Dichloroethane[1,2-]	3.33E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
12	Dichloroethene[1,1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
12	Dichloroethene[cis-1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
12	Dichloroethene[trans-1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
12	Dichloropropane[1,2-]	3.33E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
12	Dichloropropane[1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropane[2,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropene[1,1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropene[cis-1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Dichloropropene[trans-1,3-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Ethylbenzene	3.33E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
12	Hexanone[2-]	1.67E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Iodomethane	1.67E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Isopropylbenzene	3.33E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
12	Isopropyltoluene[4-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Methyl-2-pentanone[4-]	1.67E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
12	Methylene Chloride	1.67E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
12	Propylbenzene[1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Styrene	3.33E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
12	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Tetrachloroethane[1,1,1,2-]	3.33E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
12	Tetrachloroethane[1,1,2,2-]	3.33E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
12	Tetrachloroethene	3.33E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
12	Toluene	3.33E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
12	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.67E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
12	Trichloroethane[1,1,1-]	3.33E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
12	Trichloroethane[1,1,2-]	3.33E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
12	Trichloroethene	3.33E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
12	Trichlorofluoromethane	3.33E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
12	Trichloropropane[1,2,3-]	3.33E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
12	Trimethylbenzene[1,2,4-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Trimethylbenzene[1,3,5-]	3.33E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
12	Vinyl Chloride	3.33E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
12	Xylene[1,2-]	3.33E-04	mg/kg	N	U	N/A	FALSE	8.16E+02	FALSE	N/A	FALSE
12	Xylene[1,3-]+Xylene[1,4-]	6.67E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
13	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**4.70E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Heptachlorodibenzodioxins (Total)**	**1.52E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**2.48E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Heptachlorodibenzofurans (Total)**	**1.03E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzodioxin[1,2,3,6,7,8-]**	**8.22E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzodioxin[1,2,3,7,8,9-]**	**6.55E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzodioxins (Total)**	**1.08E-05**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Hexachlorodibenzofurans (Total)**	**3.10E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**3.40E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**8.97E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzofuran[1,2,3,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Pentachlorodibenzofurans (Totals)**	**6.71E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorodibenzofuran[2,3,4,7,8-]	4.98E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Pentachlorodibenzofurans (Totals)**	**6.71E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetrachlorodibenzodioxin[2,3,7,8-]	9.95E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
13	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetrachlorodibenzofuran[2,3,7,8-]	2.51E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
13	**Tetrachlorodibenzofurans (Totals)**	**2.51E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Aluminum**	**1.90E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
13	Antimony	3.09E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
13	**Arsenic**	**1.45E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
13	**Barium**	**6.22E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
13	**Beryllium**	**2.08E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
13	**Cadmium**	**4.67E-01**	mg/kg	**Y**	J	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	TRUE
13	**Calcium**	**3.43E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
13	**Chromium**	**6.10E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
13	**Cobalt**	**2.90E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
13	**Copper**	**2.79E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
13	**Iron**	**7.73E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
13	**Lead**	**6.96E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
13	**Magnesium**	**1.48E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
13	**Manganese**	**1.19E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
13	**Mercury**	**4.67E-02**	mg/kg	**Y**	NQ	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
13	**Nickel**	**5.52E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	**Potassium**	**3.58E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
13	**Selenium**	**5.48E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
13	**Silver**	**2.00E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
13	**Sodium**	**6.60E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
13	**Thallium**	**2.82E-01**	mg/kg	**Y**	J	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
13	**Vanadium**	**1.69E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
13	**Zinc**	**2.41E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
13	2,4-Diamino-6-nitrotoluene	5.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	2,6-Diamino-4-nitrotoluene	6.60E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	3,5-Dinitroaniline	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Amino-2,6-dinitrotoluene[4-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Amino-4,6-dinitrotoluene[2-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dinitrobenzene[1,3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dinitrotoluene[2,4-]	1.50E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
13	Dinitrotoluene[2,6-]	1.50E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
13	**HMX**	**3.87E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
13	Nitrobenzene	1.50E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
13	Nitrotoluene[2-]	1.50E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
13	Nitrotoluene[3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
13	Nitrotoluene[4-]	1.50E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
13	PETN	2.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**RDX**	**1.96E-01**	mg/kg	**Y**	J	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
13	**TATB**	**1.42E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetryl	1.50E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
13	Trinitrobenzene[1,3,5-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Trinitrotoluene[2,4,6-]	1.50E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
13	Tris (o-cresyl) phosphate	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Perchlorate**	**5.72E-04**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
13	**Gross alpha**	**1.94E+01**	pCi/g	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	**Gross beta**	**3.32E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Plutonium-238	4.61E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
13	Plutonium-239/240	7.67E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
13	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
13	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
13	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
13	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
13	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
13	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Benzyl Alcohol	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
13	**Bis(2-ethylhexyl)phthalate**	**1.91E-01**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
13	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
13	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
13	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
13	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
13	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
13	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
13	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
13	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
13	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Di-n-butylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
13	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
13	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
13	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
13	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
13	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
13	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
13	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
13	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
13	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
13	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
13	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
13	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
13	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
13	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
13	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
13	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
13	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
13	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
13	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
13	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
13	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
13	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
13	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
13	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
13	Benzene	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
13	Bromobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bromochloromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Bromodichloromethane	3.29E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
13	Bromoform	3.29E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Bromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
13	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
13	Butylbenzene[n-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Butylbenzene[sec-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Butylbenzene[tert-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
13	Carbon Tetrachloride	3.29E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Chlorobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
13	Chlorodibromomethane	3.29E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Chloroethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
13	Chloroform	3.29E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
13	Chloromethane	3.29E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
13	Chlorotoluene[2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
13	Chlorotoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dibromo-3-Chloropropane[1,2-]	4.94E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
13	Dibromoethane[1,2-]	3.29E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
13	Dibromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
13	Dichlorobenzene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
13	Dichlorobenzene[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichlorobenzene[1,4-]	3.29E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
13	Dichlorodifluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
13	Dichloroethane[1,1-]	3.29E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
13	Dichloroethane[1,2-]	3.29E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
13	Dichloroethene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
13	Dichloroethene[cis-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
13	Dichloroethene[trans-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
13	Dichloropropane[1,2-]	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
13	Dichloropropane[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropane[2,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropene[cis-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Dichloropropene[trans-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Ethylbenzene	3.29E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
13	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Isopropylbenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
13	Isopropyltoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
13	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
13	Propylbenzene[1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Styrene	3.29E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
13	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Tetrachloroethane[1,1,1,2-]	3.29E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
13	Tetrachloroethane[1,1,2,2-]	3.29E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
13	Tetrachloroethene	3.29E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
13	Toluene	3.29E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
13	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
13	Trichloroethane[1,1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
13	Trichloroethane[1,1,2-]	3.29E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
13	Trichloroethene	3.29E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
13	Trichlorofluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
13	Trichloropropane[1,2,3-]	3.29E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
13	Trimethylbenzene[1,2,4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Trimethylbenzene[1,3,5-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
13	Vinyl Chloride	3.29E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
13	Xylene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	8.17E+02	FALSE	N/A	FALSE
13	Xylene[1,3-]+Xylene[1,4-]	6.59E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
14	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**1.59E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Heptachlorodibenzodioxins (Total)**	**5.98E-05**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Heptachlorodibenzofuran[1,2,3,4,6,7,8-]**	**9.11E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Heptachlorodibenzofurans (Total)**	**2.52E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Hexachlorodibenzodioxins (Total)**	**2.77E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[1,2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[1,2,3,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[1,2,3,7,8,9-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Hexachlorodibenzofuran[2,3,4,6,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Hexachlorodibenzofurans (Total)**	**7.43E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**1.14E-04**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]**	**2.47E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzodioxin[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzofuran[1,2,3,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzofuran[2,3,4,7,8-]	5.00E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachlorodibenzodioxin[2,3,7,8-]	9.99E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
14	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachlorodibenzofuran[2,3,7,8-]	1.78E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	**Aluminum**	**2.46E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
14	Antimony	3.20E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
14	**Arsenic**	**1.19E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
14	**Barium**	**5.56E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
14	**Beryllium**	**2.13E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
14	**Cadmium**	**2.52E-01**	mg/kg	**Y**	J	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
14	**Calcium**	**3.17E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
14	**Chromium**	**8.55E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
14	**Cobalt**	**3.83E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
14	**Copper**	**2.77E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
14	**Iron**	**1.10E+04**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
14	**Lead**	**9.29E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
14	**Magnesium**	**1.56E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
14	**Manganese**	**1.61E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
14	**Mercury**	**6.49E-03**	mg/kg	**Y**	J	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
14	**Nickel**	**4.97E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
14	**Potassium**	**4.58E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
14	**Selenium**	**5.49E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
14	**Silver**	**3.26E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
14	**Sodium**	**6.90E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
14	Thallium	1.36E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
14	**Vanadium**	**2.38E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
14	**Zinc**	**5.32E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	TRUE
14	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
14	**HMX**	**1.01E+00**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
14	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
14	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
14	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
14	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
14	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	RDX	1.49E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	**TATB**	**1.11E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
14	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
14	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Perchlorate	4.99E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
14	**Gross alpha**	**1.73E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	**Gross beta**	**3.01E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Plutonium-238	-1.29E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
14	Plutonium-239/240	6.44E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
14	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
14	Acenaphthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
14	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Acenaphthylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Aniline	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
14	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
14	Anthracene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
14	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Azobenzene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(a)anthracene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(a)anthracene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(a)pyrene	1.01E-02	mg/kg	N	UJ	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
14	Benzo(a)pyrene	1.01E-02	mg/kg	N	UJ	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
14	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	UJ	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzoic Acid	1.68E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Benzyl Alcohol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	UJ	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Bis(2-ethylhexyl)phthalate	1.01E-02	mg/kg	N	UJ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
14	**Bis(2-ethylhexyl)phthalate**	**2.55E-02**	mg/kg	**Y**	J-	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
14	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
14	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
14	Chlorophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
14	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
14	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
14	Chrysene	1.01E-02	mg/kg	N	UJ	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	UJ	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dibenzofuran	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	UJ	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
14	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	UJ	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
14	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
14	Diethylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
14	**Diethylphthalate**	**1.44E-02**	mg/kg	**Y**	J-	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
14	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
14	Dimethyl Phthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
14	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Di-n-butylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	**Di-n-butylphthalate**	**1.31E-02**	mg/kg	**Y**	J-	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
14	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
14	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	UJ	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
14	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
14	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	UJ	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
14	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Di-n-octylphthalate	1.01E-02	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Diphenylamine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Fluoranthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluoranthene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Fluorene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
14	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
14	Hexachlorobenzene	1.01E-01	mg/kg	N	UJ	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
14	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Hexachlorobutadiene	1.01E-01	mg/kg	N	UJ	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
14	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
14	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
14	Hexachloroethane	1.01E-01	mg/kg	N	UJ	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
14	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	UJ	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
14	Isophorone	1.01E-01	mg/kg	N	UJ	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
14	**Isophorone**	**3.24E-01**	mg/kg	**Y**	J-	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
14	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
14	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	UJ	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
14	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methylphenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
14	Naphthalene	1.01E-02	mg/kg	N	UJ	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[2-]	1.11E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[3-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroaniline[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
14	Nitrobenzene	1.01E-01	mg/kg	N	UJ	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
14	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrophenol[2-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrophenol[4-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
14	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	UJ	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
14	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	UJ	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
14	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
14	Pentachlorophenol	1.01E-01	mg/kg	N	UJ	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
14	Phenanthrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Phenanthrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
14	Phenol	1.01E-01	mg/kg	N	UJ	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
14	Pyrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Pyrene	1.01E-02	mg/kg	N	UJ	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
14	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Pyridine	1.01E-01	mg/kg	N	UJ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
14	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	UJ	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	UJ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	UJ	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
14	Acetone	1.65E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
14	Benzene	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
14	Bromobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Bromochloromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Bromodichloromethane	3.29E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
14	Bromoform	3.29E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Bromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
14	Butanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
14	Butylbenzene[n-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzene[sec-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Butylbenzene[tert-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Carbon Disulfide	1.65E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
14	Carbon Tetrachloride	3.29E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
14	Chlorobenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
14	Chlorodibromomethane	3.29E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Chloroethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
14	Chloroform	3.29E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
14	Chloromethane	3.29E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
14	Chlorotoluene[2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
14	Chlorotoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dibromo-3-Chloropropane[1,2-]	4.94E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
14	Dibromoethane[1,2-]	3.29E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
14	Dibromomethane	3.29E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
14	Dichlorobenzene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
14	Dichlorobenzene[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichlorobenzene[1,4-]	3.29E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
14	Dichlorodifluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
14	Dichloroethane[1,1-]	3.29E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
14	Dichloroethane[1,2-]	3.29E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
14	Dichloroethene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
14	Dichloroethene[cis-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
14	Dichloroethene[trans-1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
14	Dichloropropane[1,2-]	3.29E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
14	Dichloropropane[1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropane[2,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropene[1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropene[cis-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Dichloropropene[trans-1,3-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Ethylbenzene	3.29E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
14	Hexanone[2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Iodomethane	1.65E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Isopropylbenzene	3.29E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
14	Isopropyltoluene[4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Methyl-2-pentanone[4-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
14	Methylene Chloride	1.65E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
14	Propylbenzene[1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Styrene	3.29E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
14	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Tetrachloroethane[1,1,1,2-]	3.29E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
14	Tetrachloroethane[1,1,2,2-]	3.29E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
14	Tetrachloroethene	3.29E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
14	Toluene	3.29E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
14	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.65E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
14	Trichloroethane[1,1,1-]	3.29E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
14	Trichloroethane[1,1,2-]	3.29E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
14	Trichloroethene	3.29E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
14	Trichlorofluoromethane	3.29E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
14	Trichloropropane[1,2,3-]	3.29E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
14	Trimethylbenzene[1,2,4-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Trimethylbenzene[1,3,5-]	3.29E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
14	Vinyl Chloride	3.29E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
14	Xylene[1,2-]	3.29E-04	mg/kg	N	U	N/A	FALSE	8.18E+02	FALSE	N/A	FALSE
14	Xylene[1,3-]+Xylene[1,4-]	6.59E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
15	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**7.51E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Heptachlorodibenzodioxins (Total)**	**1.67E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**5.49E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.93E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachlorodibenzodioxin[2,3,7,8-]	1.12E-07	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
15	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachlorodibenzofuran[2,3,7,8-]	2.13E-07	mg/kg	N	U	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Aluminum**	**2.90E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
15	Antimony	3.23E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
15	**Arsenic**	**1.41E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
15	**Barium**	**4.44E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
15	**Beryllium**	**3.31E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
15	Cadmium	9.77E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
15	**Calcium**	**2.28E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
15	**Chromium**	**7.33E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
15	**Cobalt**	**3.23E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
15	**Copper**	**2.30E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
15	**Iron**	**8.63E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
15	**Lead**	**5.39E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
15	**Magnesium**	**1.17E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE
15	**Manganese**	**1.55E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
15	Mercury	3.83E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
15	**Nickel**	**7.63E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
15	**Potassium**	**6.91E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
15	**Selenium**	**5.71E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
15	**Silver**	**2.70E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
15	**Sodium**	**4.51E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
15	Thallium	1.41E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
15	**Vanadium**	**1.86E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
15	**Zinc**	**2.19E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
15	2,4-Diamino-6-nitrotoluene	4.98E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	2,6-Diamino-4-nitrotoluene	6.57E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	3,5-Dinitroaniline	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Amino-2,6-dinitrotoluene[4-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Amino-4,6-dinitrotoluene[2-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dinitrobenzene[1,3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Dinitrotoluene[2,4-]	1.49E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
15	Dinitrotoluene[2,6-]	1.49E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
15	HMX	1.49E-01	mg/kg	N	U	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
15	Nitrobenzene	1.49E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
15	Nitrotoluene[2-]	1.49E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
15	Nitrotoluene[3-]	1.49E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
15	Nitrotoluene[4-]	1.49E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
15	PETN	2.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	RDX	1.49E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
15	**TATB**	**1.26E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetryl	1.49E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
15	Trinitrobenzene[1,3,5-]	1.49E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Trinitrotoluene[2,4,6-]	1.49E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
15	Tris (o-cresyl) phosphate	2.99E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Perchlorate**	**1.10E-03**	mg/kg	**Y**	J-	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
15	**Gross alpha**	**1.52E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Gross beta**	**2.63E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Plutonium-238	4.88E-10	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
15	Plutonium-239/240	-7.31E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
15	Acenaphthene	1.01E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
15	Acenaphthylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Aniline	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Anthracene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
15	Azobenzene	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(a)anthracene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(a)pyrene	1.01E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
15	Benzo(b)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(g,h,i)perylene	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Benzo(k)fluoranthene	1.01E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
15	Benzoic Acid	1.68E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	**Benzyl Alcohol**	**1.18E-01**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bis(2-chloroethoxy)methane	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bis(2-chloroethyl)ether	1.01E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
15	**Bis(2-ethylhexyl)phthalate**	**1.32E+00**	mg/kg	**Y**	NQ	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Bromophenyl-phenylether[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Butylbenzylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Chloro-3-methylphenol[4-]	1.35E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Chloroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Chloronaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
15	Chlorophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
15	Chlorophenyl-phenyl[4-] Ether	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Chrysene	1.01E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
15	Dibenz(a,h)anthracene	1.01E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
15	Dibenzofuran	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorobenzene[1,2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
15	Dichlorobenzene[1,3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorobenzene[1,4-]	1.01E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
15	Dichlorobenzidine[3,3'-]	1.01E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
15	Diethylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
15	Dimethyl Phthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
15	Dimethylphenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
15	**Di-n-butylphthalate**	**1.67E-01**	mg/kg	**Y**	NQ	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
15	Dinitro-2-methylphenol[4,6-]	1.01E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
15	Dinitrophenol[2,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
15	Dinitrotoluene[2,4-]	1.01E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
15	Dinitrotoluene[2,6-]	1.01E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
15	Di-n-octylphthalate	1.01E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Diphenylamine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Fluoranthene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
15	Fluorene	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
15	Hexachlorobenzene	1.01E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
15	Hexachlorobutadiene	1.01E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
15	Hexachlorocyclopentadiene	1.01E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
15	Hexachloroethane	1.01E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
15	Indeno(1,2,3-cd)pyrene	1.01E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
15	Isophorone	1.01E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
15	Methylnaphthalene[2-]	1.01E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
15	Methylphenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Methylphenol[3-,4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Naphthalene	1.01E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
15	Nitroaniline[2-]	1.11E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitroaniline[3-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitroaniline[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitrobenzene	1.01E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
15	Nitrophenol[2-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Nitrophenol[4-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Nitrosodimethylamine[N-]	1.01E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
15	Nitroso-di-n-propylamine[N-]	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Oxybis(1-chloropropane)[2,2'-]	1.01E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
15	Pentachlorophenol	1.01E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
15	Phenanthrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
15	Phenol	1.01E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
15	Pyrene	1.01E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
15	Pyridine	1.01E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Trichlorobenzene[1,2,4-]	1.01E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
15	Trichlorophenol[2,4,5-]	1.01E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
15	Trichlorophenol[2,4,6-]	1.01E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
15	Acetone	1.62E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
15	Benzene	3.24E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
15	Bromobenzene	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bromochloromethane	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Bromodichloromethane	3.24E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
15	Bromoform	3.24E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Bromomethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
15	Butanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
15	Butylbenzene[n-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Butylbenzene[sec-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Butylbenzene[tert-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Carbon Disulfide	1.62E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
15	Carbon Tetrachloride	3.24E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
15	Chlorobenzene	3.24E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
15	Chlorodibromomethane	3.24E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Chloroethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
15	Chloroform	3.24E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
15	Chloromethane	3.24E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
15	Chlorotoluene[2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
15	Chlorotoluene[4-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dibromo-3-Chloropropane[1,2-]	4.87E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
15	Dibromoethane[1,2-]	3.24E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
15	Dibromomethane	3.24E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
15	Dichlorobenzene[1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
15	Dichlorobenzene[1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichlorobenzene[1,4-]	3.24E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
15	Dichlorodifluoromethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
15	Dichloroethane[1,1-]	3.24E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
15	Dichloroethane[1,2-]	3.24E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
15	Dichloroethene[1,1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
15	Dichloroethene[cis-1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
15	Dichloroethene[trans-1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
15	Dichloropropane[1,2-]	3.24E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
15	Dichloropropane[1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropane[2,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropene[1,1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropene[cis-1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Dichloropropene[trans-1,3-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Ethylbenzene	3.24E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
15	Hexanone[2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Iodomethane	1.62E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Isopropylbenzene	3.24E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
15	Isopropyltoluene[4-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Methyl-2-pentanone[4-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
15	Methylene Chloride	1.62E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
15	Propylbenzene[1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Styrene	3.24E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
15	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Tetrachloroethane[1,1,1,2-]	3.24E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
15	Tetrachloroethane[1,1,2,2-]	3.24E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
15	Tetrachloroethene	3.24E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
15	Toluene	3.24E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
15	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.62E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
15	Trichloroethane[1,1,1-]	3.24E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
15	Trichloroethane[1,1,2-]	3.24E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
15	Trichloroethene	3.24E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
15	Trichlorofluoromethane	3.24E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
15	Trichloropropane[1,2,3-]	3.24E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
15	Trimethylbenzene[1,2,4-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Trimethylbenzene[1,3,5-]	3.24E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
15	Vinyl Chloride	3.24E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
15	Xylene[1,2-]	3.24E-04	mg/kg	N	U	N/A	FALSE	8.19E+02	FALSE	N/A	FALSE
15	Xylene[1,3-]+Xylene[1,4-]	6.49E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	**Heptachlorodibenzodioxin[1,2,3,4,6,7,8-]**	**6.82E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzofuran[1,2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzofuran[1,2,3,4,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Heptachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxin[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxin[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxin[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[1,2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[1,2,3,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[1,2,3,7,8,9-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofuran[2,3,4,6,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Hexachlorodibenzofurans (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Octachlorodibenzodioxin[1,2,3,4,6,7,8,9-]**	**4.56E-06**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Octachlorodibenzofuran[1,2,3,4,6,7,8,9-]	9.94E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzodioxin[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzofuran[1,2,3,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzofuran[2,3,4,7,8-]	4.97E-07	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorodibenzofurans (Totals)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Tetrachlorodibenzodioxin[2,3,7,8-]	9.94E-08	mg/kg	N	U	4.90E-05	FALSE	5.06E-05	FALSE	N/A	FALSE
1 dup	Tetrachlorodibenzodioxins (Total)	0.00E+00	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Tetrachlorodibenzofuran[2,3,7,8-]**	**1.75E-07**	mg/kg	**Y**	J	4.90E-04	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Tetrachlorodibenzofurans (Totals)**	**1.75E-07**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Aluminum**	**2.19E+03**	mg/kg	**Y**	NQ	N/A	FALSE	7.80E+04	FALSE	2.92E+04	FALSE
1 dup	Antimony	3.16E-01	mg/kg	N	U	N/A	FALSE	3.13E+01	FALSE	8.30E-01	FALSE
1 dup	**Arsenic**	**1.44E+00**	mg/kg	**Y**	NQ	7.07E+00	FALSE	1.30E+01	FALSE	8.17E+00	FALSE
1 dup	**Barium**	**2.70E+01**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+04	FALSE	2.95E+02	FALSE
1 dup	**Beryllium**	**2.68E-01**	mg/kg	**Y**	NQ	6.44E+04	FALSE	1.56E+02	FALSE	1.83E+00	FALSE
1 dup	Cadmium	9.57E-02	mg/kg	N	U	8.59E+04	FALSE	7.05E+01	FALSE	4.00E-01	FALSE
1 dup	**Calcium**	**5.74E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.30E+07	FALSE	6.12E+03	FALSE
1 dup	**Chromium**	**6.25E+00**	mg/kg	**Y**	NQ	9.66E+01	FALSE	4.52E+04	FALSE	1.93E+01	FALSE
1 dup	**Cobalt**	**3.14E+00**	mg/kg	**Y**	NQ	1.72E+04	FALSE	2.34E+01	FALSE	8.64E+00	FALSE
1 dup	**Copper**	**1.03E+02**	mg/kg	**Y**	NQ	N/A	FALSE	3.13E+03	FALSE	1.47E+01	TRUE
1 dup	**Iron**	**9.24E+03**	mg/kg	**Y**	NQ	N/A	FALSE	5.48E+04	FALSE	2.15E+04	FALSE
1 dup	**Lead**	**4.00E+00**	mg/kg	**Y**	NQ	N/A	FALSE	4.00E+02	FALSE	2.23E+01	FALSE
1 dup	**Magnesium**	**1.34E+03**	mg/kg	**Y**	NQ	N/A	FALSE	1.56E+07	FALSE	4.61E+03	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	**Manganese**	**1.42E+02**	mg/kg	**Y**	NQ	N/A	FALSE	1.05E+04	FALSE	6.71E+02	FALSE
1 dup	Mercury	3.53E-03	mg/kg	N	U	N/A	FALSE	2.38E+01	FALSE	1.00E-01	FALSE
1 dup	**Nickel**	**6.34E+00**	mg/kg	**Y**	NQ	5.95E+05	FALSE	1.56E+03	FALSE	1.54E+01	FALSE
1 dup	**Potassium**	**3.90E+02**	mg/kg	**Y**	J+	N/A	FALSE	1.56E+07	FALSE	3.46E+03	FALSE
1 dup	**Selenium**	**5.07E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.52E+00	FALSE
1 dup	**Silver**	**2.37E-01**	mg/kg	**Y**	J	N/A	FALSE	3.91E+02	FALSE	1.00E+00	FALSE
1 dup	**Sodium**	**4.71E+01**	mg/kg	**Y**	NQ	N/A	FALSE	7.82E+06	FALSE	9.15E+02	FALSE
1 dup	Thallium	1.34E-01	mg/kg	N	U	N/A	FALSE	7.82E-01	FALSE	7.30E-01	FALSE
1 dup	**Vanadium**	**2.09E+01**	mg/kg	**Y**	NQ	N/A	FALSE	3.94E+02	FALSE	3.96E+01	FALSE
1 dup	**Zinc**	**1.96E+01**	mg/kg	**Y**	NQ	N/A	FALSE	2.35E+04	FALSE	4.88E+01	FALSE
1 dup	2,4-Diamino-6-nitrotoluene	5.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	2,6-Diamino-4-nitrotoluene	6.60E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	3,5-Dinitroaniline	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Amino-2,6-dinitrotoluene[4-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Amino-4,6-dinitrotoluene[2-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dinitrobenzene[1,3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,4-]	1.50E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,6-]	1.50E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1 dup	**HMX**	**6.52E-01**	mg/kg	**Y**	NQ	N/A	FALSE	3.85E+03	FALSE	N/A	FALSE
1 dup	Nitrobenzene	1.50E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1 dup	Nitrotoluene[2-]	1.50E-01	mg/kg	N	U	3.16E+01	FALSE	7.04E+01	FALSE	N/A	FALSE
1 dup	Nitrotoluene[3-]	1.50E-01	mg/kg	N	U	N/A	FALSE	6.16E+00	FALSE	N/A	FALSE
1 dup	Nitrotoluene[4-]	1.50E-01	mg/kg	N	U	3.33E+02	FALSE	2.47E+02	FALSE	N/A	FALSE
1 dup	PETN	2.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	RDX	1.50E-01	mg/kg	N	U	8.31E+01	FALSE	3.01E+02	FALSE	N/A	FALSE
1 dup	**TATB**	**1.16E+01**	mg/kg	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Tetryl	1.50E-01	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1 dup	Trinitrobenzene[1,3,5-]	1.50E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Trinitrotoluene[2,4,6-]	1.50E-01	mg/kg	N	U	2.11E+02	FALSE	3.60E+01	FALSE	N/A	FALSE
1 dup	Tris (o-cresyl) phosphate	3.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Perchlorate	5.03E-04	mg/kg	N	U	N/A	FALSE	5.48E+01	FALSE	N/A	FALSE
1 dup	**Gross alpha**	**9.73E+00**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	**Gross beta**	**2.04E+01**	pCi/g	**Y**	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Plutonium-238	1.60E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	2.30E-02	FALSE
1 dup	Plutonium-239/240	-6.41E-03	pCi/g	N	U	N/A	FALSE	N/A	FALSE	5.40E-02	FALSE
1 dup	Acenaphthene	1.00E-02	mg/kg	N	U	N/A	FALSE	3.48E+03	FALSE	N/A	FALSE
1 dup	Acenaphthylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Aniline	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Anthracene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+04	FALSE	N/A	FALSE
1 dup	Azobenzene	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(a)anthracene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(a)pyrene	1.00E-02	mg/kg	N	U	1.12E+00	FALSE	1.74E+01	FALSE	N/A	FALSE
1 dup	Benzo(b)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(g,h,i)perylene	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzo(k)fluoranthene	1.00E-02	mg/kg	N	U	1.53E+01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzoic Acid	1.67E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Benzyl Alcohol	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bis(2-chloroethoxy)methane	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bis(2-chloroethyl)ether	1.00E-01	mg/kg	N	U	3.11E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bis(2-ethylhexyl)phthalate	1.00E-02	mg/kg	N	U	3.80E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Bromophenyl-phenylether[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Butylbenzylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chloro-3-methylphenol[4-]	1.34E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chloroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chloronaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	6.26E+03	FALSE	N/A	FALSE
1 dup	Chlorophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	3.91E+02	FALSE	N/A	FALSE
1 dup	Chlorophenyl-phenyl[4-] Ether	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Chrysene	1.00E-02	mg/kg	N	U	1.53E+02	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dibenz(a,h)anthracene	1.00E-02	mg/kg	N	U	1.53E-01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dibenzofuran	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,4-]	1.00E-01	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1 dup	Dichlorobenzidine[3,3'-]	1.00E-01	mg/kg	N	U	1.18E+01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+02	FALSE	N/A	FALSE
1 dup	Diethylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	4.93E+04	FALSE	N/A	FALSE
1 dup	Dimethyl Phthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+04	FALSE	N/A	FALSE
1 dup	Dimethylphenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Di-n-butylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1 dup	Dinitro-2-methylphenol[4,6-]	1.00E-01	mg/kg	N	U	N/A	FALSE	4.93E+00	FALSE	N/A	FALSE
1 dup	Dinitrophenol[2,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	1.23E+02	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,4-]	1.00E-01	mg/kg	N	U	1.71E+01	FALSE	1.23E+02	FALSE	N/A	FALSE
1 dup	Dinitrotoluene[2,6-]	1.00E-01	mg/kg	N	U	3.56E+00	FALSE	1.85E+01	FALSE	N/A	FALSE
1 dup	Di-n-octylphthalate	1.00E-02	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Diphenylamine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Fluoranthene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Fluorene	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+03	FALSE	N/A	FALSE
1 dup	Hexachlorobenzene	1.00E-01	mg/kg	N	U	3.33E+00	FALSE	4.93E+01	FALSE	N/A	FALSE
1 dup	Hexachlorobutadiene	1.00E-01	mg/kg	N	U	6.83E+01	FALSE	6.16E+01	FALSE	N/A	FALSE
1 dup	Hexachlorocyclopentadiene	1.00E-01	mg/kg	N	UJ	N/A	FALSE	2.30E+00	FALSE	N/A	FALSE
1 dup	Hexachloroethane	1.00E-01	mg/kg	N	U	1.33E+02	FALSE	4.31E+01	FALSE	N/A	FALSE
1 dup	Indeno(1,2,3-cd)pyrene	1.00E-02	mg/kg	N	U	1.53E+00	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Isophorone	1.00E-01	mg/kg	N	U	5.61E+03	FALSE	1.23E+04	FALSE	N/A	FALSE
1 dup	Methylnaphthalene[2-]	1.00E-02	mg/kg	N	U	N/A	FALSE	2.32E+02	FALSE	N/A	FALSE
1 dup	Methylphenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Methylphenol[3-,4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Naphthalene	1.00E-02	mg/kg	N	U	4.97E+01	FALSE	1.62E+02	FALSE	N/A	FALSE
1 dup	Nitroaniline[2-]	1.10E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitroaniline[3-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitroaniline[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitrobenzene	1.00E-01	mg/kg	N	U	6.04E+01	FALSE	1.31E+02	FALSE	N/A	FALSE
1 dup	Nitrophenol[2-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitrophenol[4-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Nitrosodimethylamine[N-]	1.00E-01	mg/kg	N	U	2.34E-02	TRUE	4.93E-01	FALSE	N/A	FALSE
1 dup	Nitroso-di-n-propylamine[N-]	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Oxybis(1-chloropropane)[2,2'-]	1.00E-01	mg/kg	N	U	9.93E+01	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Pentachlorophenol	1.00E-01	mg/kg	N	U	9.85E+00	FALSE	2.34E+02	FALSE	N/A	FALSE
1 dup	Phenanthrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1 dup	Phenol	1.00E-01	mg/kg	N	U	N/A	FALSE	1.85E+04	FALSE	N/A	FALSE
1 dup	Pyrene	1.00E-02	mg/kg	N	U	N/A	FALSE	1.74E+03	FALSE	N/A	FALSE
1 dup	Pyridine	1.00E-01	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Trichlorobenzene[1,2,4-]	1.00E-01	mg/kg	N	U	2.40E+02	FALSE	8.29E+01	FALSE	N/A	FALSE
1 dup	Trichlorophenol[2,4,5-]	1.00E-01	mg/kg	N	U	N/A	FALSE	6.16E+03	FALSE	N/A	FALSE
1 dup	Trichlorophenol[2,4,6-]	1.00E-01	mg/kg	N	U	4.84E+02	FALSE	6.16E+01	FALSE	N/A	FALSE
1 dup	Acetone	1.58E-03	mg/kg	N	U	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
1 dup	Benzene	3.16E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
1 dup	Bromobenzene	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bromochloromethane	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Bromodichloromethane	3.16E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1 dup	Bromoform	3.16E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Bromomethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
1 dup	Butanone[2-]	1.58E-03	mg/kg	N	U	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
1 dup	Butylbenzene[n-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Butylbenzene[sec-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Butylbenzene[tert-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Carbon Disulfide	1.58E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
1 dup	Carbon Tetrachloride	3.16E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
1 dup	Chlorobenzene	3.16E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
1 dup	Chlorodibromomethane	3.16E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Chloroethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
1 dup	Chloroform	3.16E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
1 dup	Chloromethane	3.16E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
1 dup	Chlorotoluene[2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
1 dup	Chlorotoluene[4-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dibromo-3-Chloropropane[1,2-]	4.74E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
1 dup	Dibromoethane[1,2-]	3.16E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE
1 dup	Dibromomethane	3.16E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichlorobenzene[1,4-]	3.16E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
1 dup	Dichlorodifluoromethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
1 dup	Dichloroethane[1,1-]	3.16E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
1 dup	Dichloroethane[1,2-]	3.16E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
1 dup	Dichloroethene[1,1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
1 dup	Dichloroethene[cis-1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
1 dup	Dichloroethene[trans-1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
1 dup	Dichloropropane[1,2-]	3.16E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
1 dup	Dichloropropane[1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropane[2,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropene[1,1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropene[cis-1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Dichloropropene[trans-1,3-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Ethylbenzene	3.16E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
1 dup	Hexanone[2-]	1.58E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Iodomethane	1.58E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Isopropylbenzene	3.16E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
1 dup	Isopropyltoluene[4-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Methyl-2-pentanone[4-]	1.58E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
1 dup	Methylene Chloride	1.58E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
1 dup	Propylbenzene[1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Styrene	3.16E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
1 dup	Temperature	5.70E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
1 dup	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Tetrachloroethane[1,1,1,2-]	3.16E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
1 dup	Tetrachloroethane[1,1,2,2-]	3.16E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
1 dup	Tetrachloroethene	3.16E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
1 dup	Toluene	3.16E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
1 dup	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.58E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
1 dup	Trichloroethane[1,1,1-]	3.16E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
1 dup	Trichloroethane[1,1,2-]	3.16E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
1 dup	Trichloroethene	3.16E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
1 dup	Trichlorofluoromethane	3.16E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
1 dup	Trichloropropane[1,2,3-]	3.16E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
1 dup	Trimethylbenzene[1,2,4-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Trimethylbenzene[1,3,5-]	3.16E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
1 dup	Vinyl Chloride	3.16E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
1 dup	Xylene[1,2-]	3.16E-04	mg/kg	N	U	N/A	FALSE	8.06E+02	FALSE	N/A	FALSE
1 dup	Xylene[1,3-]+Xylene[1,4-]	6.33E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE
Trip Blank	**Acetone**	**2.99E-02**	mg/kg	**Y**	NQ	N/A	FALSE	6.63E+04	FALSE	N/A	FALSE
Trip Blank	Benzene	3.20E-04	mg/kg	N	U	1.78E+01	FALSE	1.14E+02	FALSE	N/A	FALSE
Trip Blank	Bromobenzene	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Bromochloromethane	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Bromodichloromethane	3.20E-04	mg/kg	N	U	6.19E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
Trip Blank	Bromoform	3.20E-04	mg/kg	N	U	6.74E+02	FALSE	1.23E+03	FALSE	N/A	FALSE
Trip Blank	Bromomethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.77E+01	FALSE	N/A	FALSE
Trip Blank	**Butanone[2-]**	**3.03E-03**	mg/kg	**Y**	J	N/A	FALSE	3.74E+04	FALSE	N/A	FALSE
Trip Blank	Butylbenzene[n-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Butylbenzene[sec-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Butylbenzene[tert-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Carbon Disulfide	1.60E-03	mg/kg	N	U	N/A	FALSE	1.55E+03	FALSE	N/A	FALSE
Trip Blank	Carbon Tetrachloride	3.20E-04	mg/kg	N	U	1.07E+01	FALSE	1.44E+02	FALSE	N/A	FALSE
Trip Blank	Chlorobenzene	3.20E-04	mg/kg	N	U	N/A	FALSE	3.78E+02	FALSE	N/A	FALSE
Trip Blank	Chlorodibromomethane	3.20E-04	mg/kg	N	U	1.39E+01	FALSE	1.23E+03	FALSE	N/A	FALSE
Trip Blank	Chloroethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.90E+04	FALSE	N/A	FALSE
Trip Blank	Chloroform	3.20E-04	mg/kg	N	U	5.90E+00	FALSE	3.06E+02	FALSE	N/A	FALSE
Trip Blank	Chloromethane	3.20E-04	mg/kg	N	U	4.11E+01	FALSE	2.68E+02	FALSE	N/A	FALSE
Trip Blank	Chlorotoluene[2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	1.56E+03	FALSE	N/A	FALSE
Trip Blank	Chlorotoluene[4-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dibromo-3-Chloropropane[1,2-]	4.81E-04	mg/kg	N	U	8.58E-02	FALSE	5.88E+00	FALSE	N/A	FALSE
Trip Blank	Dibromoethane[1,2-]	3.20E-04	mg/kg	N	U	6.72E-01	FALSE	1.35E+02	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
Trip Blank	Dibromomethane	3.20E-04	mg/kg	N	U	N/A	FALSE	5.79E+01	FALSE	N/A	FALSE
Trip Blank	Dichlorobenzene[1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	2.15E+03	FALSE	N/A	FALSE
Trip Blank	Dichlorobenzene[1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichlorobenzene[1,4-]	3.20E-04	mg/kg	N	U	1.29E+03	FALSE	5.48E+03	FALSE	N/A	FALSE
Trip Blank	Dichlorodifluoromethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.82E+02	FALSE	N/A	FALSE
Trip Blank	Dichloroethane[1,1-]	3.20E-04	mg/kg	N	U	7.86E+01	FALSE	1.56E+04	FALSE	N/A	FALSE
Trip Blank	Dichloroethane[1,2-]	3.20E-04	mg/kg	N	U	8.32E+00	FALSE	5.56E+01	FALSE	N/A	FALSE
Trip Blank	Dichloroethene[1,1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	4.40E+02	FALSE	N/A	FALSE
Trip Blank	Dichloroethene[cis-1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	1.56E+02	FALSE	N/A	FALSE
Trip Blank	Dichloroethene[trans-1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	2.95E+02	FALSE	N/A	FALSE
Trip Blank	Dichloropropane[1,2-]	3.20E-04	mg/kg	N	U	1.78E+01	FALSE	2.90E+01	FALSE	N/A	FALSE
Trip Blank	Dichloropropane[1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropane[2,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropene[1,1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropene[cis-1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Dichloropropene[trans-1,3-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Ethylbenzene	3.20E-04	mg/kg	N	U	7.51E+01	FALSE	3.93E+03	FALSE	N/A	FALSE
Trip Blank	**Hexanone[2-]**	**1.71E-03**	mg/kg	**Y**	J	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Iodomethane	1.60E-03	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Isopropylbenzene	3.20E-04	mg/kg	N	U	N/A	FALSE	2.36E+03	FALSE	N/A	FALSE
Trip Blank	Isopropyltoluene[4-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Methyl-2-pentanone[4-]	1.60E-03	mg/kg	N	U	N/A	FALSE	5.81E+03	FALSE	N/A	FALSE
Trip Blank	Methylene Chloride	1.60E-03	mg/kg	N	U	7.66E+02	FALSE	4.09E+02	FALSE	N/A	FALSE
Trip Blank	Propylbenzene[1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Styrene	3.20E-04	mg/kg	N	U	N/A	FALSE	7.26E+03	FALSE	N/A	FALSE
Trip Blank	Temperature	4.00E+00	deg C	Y	NQ	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Tetrachloroethane[1,1,1,2-]	3.20E-04	mg/kg	N	U	2.81E+01	FALSE	2.35E+03	FALSE	N/A	FALSE
Trip Blank	Tetrachloroethane[1,1,2,2-]	3.20E-04	mg/kg	N	U	7.98E+00	FALSE	1.56E+03	FALSE	N/A	FALSE
Trip Blank	Tetrachloroethene	3.20E-04	mg/kg	N	U	3.37E+02	FALSE	1.11E+02	FALSE	N/A	FALSE
Trip Blank	Toluene	3.20E-04	mg/kg	N	U	N/A	FALSE	5.23E+03	FALSE	N/A	FALSE
Trip Blank	Trichloro-1,2,2-trifluoroethane[1,1,2-]	1.60E-03	mg/kg	N	U	N/A	FALSE	5.08E+04	FALSE	N/A	FALSE
Trip Blank	Trichloroethane[1,1,1-]	3.20E-04	mg/kg	N	U	N/A	FALSE	1.44E+04	FALSE	N/A	FALSE
Trip Blank	Trichloroethane[1,1,2-]	3.20E-04	mg/kg	N	U	1.88E+01	FALSE	2.61E+00	FALSE	N/A	FALSE
Trip Blank	Trichloroethene	3.20E-04	mg/kg	N	U	1.55E+01	FALSE	6.77E+00	FALSE	N/A	FALSE
Trip Blank	Trichlorofluoromethane	3.20E-04	mg/kg	N	U	N/A	FALSE	1.23E+03	FALSE	N/A	FALSE
Trip Blank	Trichloropropane[1,2,3-]	3.20E-04	mg/kg	N	U	5.10E-02	FALSE	7.09E+00	FALSE	N/A	FALSE
Trip Blank	Trimethylbenzene[1,2,4-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE
Trip Blank	Trimethylbenzene[1,3,5-]	3.20E-04	mg/kg	N	U	N/A	FALSE	N/A	FALSE	N/A	FALSE

Table 1. TA-36-8 2018 Analytical Data Summary (continued)

Sample Location	Parameter Name	Report Result	Report Units	Detected	Validation Qualifier	Residential Soil, Cancer (mg/kg)	Residential Soil, Cancer Comparison	Residential Soil, Noncancer (mg/kg)	Residential Soil, Noncancer Comparison	Background Concentration	Background Comparison
Trip Blank	Vinyl Chloride	3.20E-04	mg/kg	N	U	7.42E-01	FALSE	1.13E+02	FALSE	N/A	FALSE
Trip Blank	Xylene[1,2-]	3.20E-04	mg/kg	N	U	N/A	FALSE	8.21E+02	FALSE	N/A	FALSE
Trip Blank	Xylene[1,3-]+Xylene[1,4-]	6.41E-04	mg/kg	N	U	N/A	FALSE	7.64E+02	FALSE	N/A	FALSE

BOLD TEXT Constituent detected above the detection limit, but below the select soil screening limit

Highlighted “TRUE” value – constituent detected above either the selected soil screening level or above the background value