Engineering Evaluation and Cost Analysis

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Western Nuclear, Inc.

Ruby Mines Site
September 2023

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Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirements
ASAOC	Administrative Settlement Agreement and Order on Consent, CERCLA Docket No. 2016-10
bgs	below ground surface
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMP	best management practice
BTV	background threshold value
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	constituent of concern
COEC	constituent of ecological concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CSEM	conceptual site exposure model
EE/CA	Engineering Evaluation and Cost Analysis
EPC	exposure point concentration
GHG	greenhouse gas
GSR	green and sustainable remediation
HHRA	human health risk assessment
HQ	hazard quotient
LOEC	lowest observed effect concentration
mg/kg	milligrams per kilogram
MMD	Mining and Minerals Division
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NNEPA	Navajo Nation Environmental Protection Agency
No.	number
NORM	Naturally Occurring Radioactive Material
pCi/g	picocuries per gram

PRG	preliminary remediation goal
Ra-226	Radium-226
RAO	response action objective
RBSL	risk-based screening level
RSE	Removal Site Evaluation
RSL	regional screening level
Site	Ruby Mines Site
SPCC	spill prevention control and countermeasure plan
SWPPP	stormwater pollution prevention plan
TBC	to be considered
TENORM	technologically enhanced naturally occurring radioactive material
U.S. EPA	U.S. Environmental Protection Agency, Region 9
USGS	U.S. Geological Survey
WNI	Western Nuclear, Inc.

1. Executive Summary

1.1 Purpose of Engineering Evaluation/Cost Analysis

This engineering evaluation and cost analysis (EE/CA) was prepared to evaluate a range of potential response action alternatives for waste rock and soil to reduce or eliminate potential risks to human health and the environment at the Ruby Mines Site, located in the Smith Lake Chapter of the Navajo Nation, approximately 30 miles east of Gallup, New Mexico.

This EE/CA defines the scope, goals, and objectives of the response action based on findings in the Removal Site Evaluation (RSE) reports and human health and ecological risk assessments. The scope, goals, and objectives were developed in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process and United States Environmental Protection Agency's U.S. EPA's Guidance on Conducting Non-Time-Critical Removal Actions under CERCLA (NTCRA Guidance) (U.S. EPA 1993).

"Remediation" is the process of addressing contamination; this EE/CA evaluates a range of potential solutions (or remedies) the former Ruby Mines Site. A remedy is an action that is undertaken to reduce the potential for contaminant exposure and therefore reduce potential human health and ecological risks. The potential solutions or remedies evaluated are called "response action alternatives" for the purposes of this EE/CA.

The EE/CA meets the terms of the Administrative Settlement Agreement and Order on Consent, CERCLA Docket Number (No.) 2016-10 (ASAOC), which was executed on February 8, 2017 (U.S. EPA 2017). The ASAOC was issued by U.S. EPA Region 9 after consulting with the Navajo Nation Environmental Protection Agency (NNEPA). The EE/CA has been prepared in accordance with U.S. EPA policies and procedures, implementing CERCLA and consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Specifically, guidance is found in the NTCRA Guidance (U.S. EPA 1993). This EE/CA was prepared in accordance with the Final EE/CA Work Plan (CH2M 2017), which was approved by U.S. EPA on October 25, 2017 (Ripperda, pers. comm. 2017).

Consistent with its "Policy on Consultation and Coordination with Indian Tribes," U.S. EPA will consult with the Navajo Nation during the EE/CA process and before making a remedy decision. Draft EE/CAs were submitted in June 2018 and January 2019 and were revised in response to U.S. EPA and NNEPA comments. Once the Ruby Mines ASAOC and EE/CA are finalized, the design and implementation of the selected response action will fall under the Consent Decree (CD) in United States v. Cyprus Amax Minerals Co., No. 17-00140-PHX-DLR (D. Ariz.) (U.S. EPA 2017d).

1.2 CERCLA Process

CERCLA, also known as Superfund, was developed to allow U.S. EPA to facilitate or direct contaminated site cleanups, with the overarching goals of protecting human health and the environment, imposing financial accountability on the responsible parties, involving communities in the process, and returning sites to productive use. Cleaning up Superfund sites is a multi-phase process that includes assessment, decision making, cleanup, and post removal site control (monitoring and maintenance). The CERCLA process for abandoned uranium mines (AUMs) on the Navajo Nation is depicted on Figure 1-1. During the assessment phase, RSEs are conducted to evaluate the extent of contamination and associated risks. During the decision-making phase, potential cleanup solutions are evaluated and compared in an EE/CA and then presented to the public for input. Following the public comment period, the cleanup solution is documented and implemented. During the cleanup phase, the cleanup solution is designed and implemented. Through the post removal site control phase, the sites will be monitored and maintained to keep the public and the environment safe.

Community involvement, coordination with applicable Navajo Nation agencies, and planning for a site's future are ongoing throughout the process.

U.S. EPA's NTCRA Guidance (1993) requires public engagement in the form of community relations activities (including designating a Community Relations Spokesperson, conducting community interviews, preparing a Community Relations Plan, establishing an information repository, and providing public notice of the EE/CA's availability) and administrative record requirements (including establishing the administrative record file, publishing notice of the administrative record file's availability, holding a public comment period, and developing written response to significant comments). In this way, Navajo Chapter input will be considered in selecting a preferred alternative.

Developing the EE/CA requires great thought. A nested, circular model of problem solving[1], known as the Diné Education Philosophy based on the Diné way of life, including four nested stages that represent the four cardinal directions, is considered in this EE/CA. It starts in the east with thinking (nitsáhákees), then flows to the south with planning (nahat'á), then to the west with implementation (Iiná/jina'), and finally to the north with eventual results (sihasin). Each phase represents cultural elements and values associated with the natural processes of life, such as daily living activities. The circular model of the decision-making is shown on Figure 1-2. When possible, the Navajo Fundamental Law with respect to alternatives that are consistent with the inherent beliefs of members of the Navajo Nation and incorporate traditional ecological knowledge, which may include considerations pertaining to the importance of plants, animals, landscapes, cultural resources, and natural phenomena, were considered.

This EE/CA, which is based on an outline and guidance provided by U.S. EPA (2021), primarily describes the approach for the thinking (nitsáhákees) and planning (nahat'á) stages. It describes methods for gathering the information to make thoughtful decisions, to answer the questions that arise with careful examination and consideration of the interests of people and knowledge holders, and to make choices that will bring the desired results. The EE/CA includes the following sections that detail this approach:

- Nitsáhákees – Thinking to Understand the Problem
  - Site description and background
  - Previous reclamation and removal actions
  - Previous site investigations and available data
  - Source, type, and extent of contamination (contaminants associated with uranium mining)
  - Approach to human health and ecological risk assessments
- Nahat'á – Planning to Resolve the Problem
  - Response action objectives
  - Identification and analysis of response action alternatives
  - Comparative analysis of alternatives
  - Stakeholder involvement
  - Data management

The EE/CA discusses the schedule for implementing (Iiná) and achieving results (sihasin) from the work planned in the EE/CA. The ultimate goal of this EE/CA is to lead to the implementation of a response action that works toward living in harmony and restoring balance (hózhó) to the Navajo people.

[1] The decision process uses the "traditional characteristics of each of the Four Directions: nitáhákees, for intuition, discovery and thinking of the East [2 N.N.C§110(N)]; nahat'á, or planning [2 N.N.C.§110 (M)], and nahat'á or naat'aahji, or the talk of planning, of the South to carefully examine and involve all interests and knowledge holders in the process; jina' to implement thought and consensual plans actively and for good results in the West [2 N.N.C§110(G)]; and sihasin, or reflection and reconsideration, to assess the result of thinking, talking, planning and doing, of the North [2 N.N.C§110(T)], naabik'yai [2 N.N.C§110(M)]." Source: Roux Associates, Inc. (2015). Initial White Paper on Cleanup Options for Navajo Abandoned Uranium Mines.

1.3 Site Characterization

The Ruby Mines Site is located in the Smith Lake Chapter of the Navajo Nation, on Tribal Trust Land (Figure 1-3). The Ruby Mines Site was operated by Western Nuclear, Inc. (WNI). WNI mined uranium ore from four currently inactive, contiguous, mines (Ruby Mines Nos. 1, 2, 3, and 4) by underground methods, and associated surface features, with active operations occurring between 1975 and 1985 (Tables 1-1 and 1-2). There was no surface disturbance at Ruby Mines Nos. 2 and 4 other than the shafts constructed to ventilate the underground mines (that is, vents). Ore from the mines was transported offsite for processing. Reclamation activities occurred in 1985 and included sealing adits and known vents, capping waste rock piles at Ruby Mines Nos. 1 and 3, and revegetation. Figure 1-4 presents the locations of reclaimed mining features.

Mining occurred in the Brushy Basin Member of the Morrison Formation at a depth of approximately 200to 400 feet below ground surface (bgs). Waste rock piles at the Ruby Mines Site are assumed to consist of material from this formation. No uraniferous formations are exposed at the surface at the Ruby Mines Site. The depth to groundwater at the site is more than 400 feet.

WNI performed reclamation efforts at the Ruby Mines Site between June and December 1985. As part of the reclamation efforts, the Ruby Mines Nos. 1 and 3 adits were physically closed, and waste rock piles were capped with compacted fill and revegetated. Known vents were sealed with concrete, and buildings were removed. The Site was subsequently inspected and maintained. WNI made repairs to the waste rock cap at Ruby Mines No. 1 in 1993 and 1995 and made improvements to a drainage diversion at Ruby Mines No. 3 in 1993.

Areas associated with the Ruby Mines Site are designated as tribal trust lands. Grazing permits are held within 1 quarter-mile of the Site. Two home site leases and a residential lease are located approximately 1 half-mile southwest of the Ruby Mines No. 1 capped waste rock pile; a home site lease is also held approximately 1 quarter-mile to the east of Ruby Mines No. 3. Allotment land is located between Ruby Mines No. 1 and 3; however, there are no mining features that require a cleanup action located within the allotments. Traditional land use by the Navajo includes growing plants for human or animal consumption, grazing animals that may be consumed by humans, and building homesites or residences. Currently, the Ruby Mines Site is used for livestock grazing, herding, and gathering firewood and pinon nuts.

An RSE study was performed at the site from 2012 to 2014 to close mine openings, such as adits and vents; reduce physical hazards; and characterize the nature and extent of contamination by assessing chemical and radiological conditions in soil (CH2M 2015). Primary contaminants of potential concern (COPCs) included radium-226 (Ra-226) and six metals (arsenic, mercury, molybdenum, selenium, uranium, and vanadium). Secondary COPCs included volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls, total petroleum hydrocarbons, perchlorate, and explosives. The RSE found that several metals (arsenic, selenium, uranium, and vanadium) and decay products of uranium, such as Ra-226, were present in the capped waste rock piles, in surface and near-surface soils near the waste rock piles, and in soils at several mine features (that is, former vents used to ventilate the underground workings and former haul roads) (Appendix A). These metals and Ra-226 also naturally occur in rock formations and soils found at the Ruby Mines Site. The naturally occurring presence of these metals and Ra-226 is referred to as the background level or naturally occurring radioactive material (NORM). In some locations, these metals and Ra-226 were present at concentrations exceeding background levels and were related to historical mining activities, primarily associated with the waste rock that contains uranium at levels that were not economical to process as ore. Because the ore body was historically mined at depth (200 to 400 feet below ground surface), the presence of Ra-226 and metals exceeding background levels at the surface in and around the waste rock piles and mine features were designated as technologically enhanced naturally occurring radioactive material (TENORM).

The term TENORM is not defined in federal environmental statutes or regulations. TENORM is used with the meanings provided in an April 2008 U.S. EPA guidance document (EPA 402-R-08-005). The term TENORM is defined as “naturally occurring radioactive materials that have been concentrated or exposed to the accessible environment as a result of human activities such as manufacturing, mineral extraction, or water processing." "Technologically enhanced" means that 'the radiological, physical, and chemical properties of the radioactive material have been concentrated or further altered by having been processed, or beneficiated, or disturbed in a way that increases the potential for human and/or environmental exposures.'

A risk assessment was completed for the Ruby Mines Site to evaluate the potential risk posed to human health and ecological receptors for TENORM contamination. Ra-226, selenium, vanadium and uranium were identified as the human health constituents of concern (COCs), and Ra-226, selenium, uranium (Ruby Mines No. 1 only), and vanadium were identified as constituents of ecological concern (COECs). Cleanup goals were established based on the lowest of the human health, ecological risk-based screening levels (RBSLs), and Los Alamos National Laboratory (LANL) preliminary remediation goal (PRG) if the RBSL is greater than the background threshold value (BTV). Otherwise, the cleanup goal for a constituent was set at the BTV (Appendix C).

The extent of site media requiring cleanup is inclusive of capped waste rock piles, dewatering areas, drainages, work areas, and vents. At Ruby Mines No. 1, approximately 12 acres and 164,000 cubic yards (cy) of waste rock and impacted soil require cleanup. At Ruby Mines No. 3, approximately 14 acres and 174,000 cy of waste rock and impacted soil require cleanup.

1.4 Response Action Objectives

The EE/CA identifies response action objectives (RAOs) or results (sihasin). The RAOs are based on the RSE results, the subsequent human health and ecological risk assessments, CERCLA requirements, and the applicable or relevant and appropriate requirements (ARARs) for the site (Appendix D).

The potential response action alternatives are evaluated in this EECA to determine whether they meet the following RAOs:

- Prevent exposure to soil with mining-related contaminants above cleanup goals from historical mining activities that would pose an unacceptable risk to human health with the reasonably anticipated future land use and traditional Navajo lifeways.
- Prevent exposure to soil with mining-related contaminants above cleanup goals from historical mining activities that would pose an unacceptable risk to plants, animals, and other ecological receptors.
- Prevent offsite migration of mining-related contaminants above cleanup goals from historical mining activities to surface water, groundwater, or air that pose an unacceptable risk to human health.

1.5 Identification of Response Action Alternatives

Each of the potential alternatives considered in this EE/CA will address the capped waste rock piles, impacted soils near the waste rock piles, and mine features associated with former mining and related WNI operations at the Ruby Mines Site.

Documented in this report is an evaluation of six potential response action alternatives, including a No Action alternative as required in the NCP (40 Code of Federal Regulations [CFR] Part 300). Alternatives are as follows:

1. No Action
2. Consolidate and Repair Existing Caps
3. Consolidate and Cap In-place at Each Site (Ruby Mines No. 1 and Ruby Mines No. 3)
4. Consolidate and Cap at One Site
5. Excavate and Manage at Regional Repository
6. Excavate and Manage Off-Reservation

1.6 Response Action Alternatives Analysis

Each alternative was evaluated and compared for its effectiveness, implementability, and cost, in accordance with the criteria established by U.S. EPA. Each alternative, except No Action, is protective of human health and the environment. An overview of the comparison of alternatives is shown on Figure 1-5, which presents the relative duration, protectiveness, future land use, waste trucking miles, water use during implementation, and cost of each alternative. The complexity of the action increases from Alternative 2 through Alternative 6, with increasing implementation duration, waste hauling and trucking miles, water use, and cost. Implementing Alternatives 2 and 3 would result in potential future land use suitable for herding, grazing, and gathering. Alternative 4 would additionally result in the potential for residential future land use at Ruby Mines No. 3 only. Alternatives 5 and 6 would result in the potential for residential future land use at both Ruby Mines Nos. 1 and 3; however, Alternative 5 would require long-term maintenance at a repository sited in another on-Reservation location.

1.7 Recommendation Response Alternative

Based on the evaluation presented herein, U.S. EPA has selected Alternative 3: Cap and Consolidate at Each Site as the recommended alternative.

2. Site Characterization

Before one can think about and develop a solution, one must understand the problem and its root causes. This requires knowledge and a process of thinking, nitsáhákees. This stage includes gathering and assessing information to gain knowledge, including traditional ecological knowledge. This section includes the information and knowledge gathered about the site conditions, including conditions of the past and today, which are important to think about and understand when developing response alternatives. Characterization provides the information needed to understand the problem, its root cause, and its consequences. Once this is understood, the planning (nahat'á) stage can begin.

2.1 Site Description and Background

The following subsections describe the site and provide site background information.

2.1.1 Site Location

The Ruby Mines are located in the Smith Lake Chapter of the Navajo Nation (Figure 1-3). The Smith Lake Chapter is approximately 8 miles north of the town of Thoreau, which is located at the intersection of Interstate Highway 40 and New Mexico Highway (State Highway) 371 (Figure 1-4). Table 1-1 lists the Ruby Mines Site's latitude, longitude, and elevation. The nearest mine sites to the Ruby Mines Site is Mac No. 2 and Black Jack No. 2, which are located approximately 1.3 miles and 2.3 miles to the northwest, respectively. Black Jack No. 1 is located approximately 3 miles to the north of the Ruby Mines Site.

The Ruby Mines and locations of known surface features are within the boundary of Navajo Nation trust and allotment lands in Township 15 North, Range 13 West, Sections 21, 25, 26, and 27 (New Mexico Energy, Minerals, and Natural Resources Department, Mining and Minerals Division [MMD] 1995). The surface ownership of Sections 21, 25, and 27 (where Ruby Mines Nos. 1, 2, and 3 are located) is vested by the United States government as lands held in trust for the Navajo Nation. Surface ownership of Section 26, where Ruby Mines No. 4 is located, is vested in four Navajo allottees. The Bureau of Indian Affairs (BIA) and the United States Geological Survey (USGS) are charged with managing the land surface on behalf of the allotment owners.

The Ruby Mines Sites are accessible by State Highway 371 and BIA Route 49 (also referred to as Navajo Scenic Route 49 or Route 11-49).

The Ruby Mines site consists of four inactive, related underground mines (Ruby Mines Nos. 1, 2, 3, and 4) located 3 to 4 miles from Smith Lake Chapter House. The Ruby Mines were connected and were mined by underground methods. Ores from Ruby Mines Nos. 2 and 4 were transported up declines through openings at the surface called adits located at Ruby Mines Nos. 1 and 3, respectively. Ruby Mines features are presented on Figure 1-4. The underground mines consisted of a primary drift and series of laterals (that is, underground workings) that were advanced to extract ore. The underground workings run from the Ruby Mines No. 1 adit in a south-southeastern direction to the Ruby Mines No. 3 adit. A number of shafts were constructed to ventilate the underground mines (vents). Six vents have been located, and the vents were closed either after mining ceased or during RSE work conducted in 2014. Ore[2] from the mines was transported offsite for processing. Waste rock (rock generated during the advancement of declines and development of the underground mines that did not contain uranium at levels that were economical to process) was placed outside the adits (entrances) of Ruby Mines Nos. 1 and 3 and subsequently reclaimed.

[2] In the mining industry and as used in the Atomic Energy Act, the definition of "ore" is an economic one, and materials containing target metals that are not "ore" at one price may well become "ore" if the price or circumstances change in the future. The terminology used to refer to materials that do not contain the minimum grade varies but these materials have been referred to as "protore/low-grade ore" or "waste rock" in different circumstances and contexts and depending upon their grades.

2.1.2 Type of Mine and Operation Status

The Ruby Mines operated between September 1975 and February 1985. Table 1-1 summarizes the mining operations and reclamation activity dates. Operating plans for Section 26, where Ruby Mines No. 4 is located, indicate the ore body would be developed by a modified room and pillar mining system (WNI 1979a, 1979b). Ore production at Ruby Mines Nos. 1 and 2 was estimated at 495,360 tons between 1975 and 1981. Ore production at Ruby Mines Nos. 3 and 4 was reported at 295,000 tons from 1980 to 1985 (New Mexico Bureau of Mines and Mineral Resources, 1991).

Ruby Mines Nos. 1 and 2 were connected by underground workings (tunnels), with ore extracted through the adit at Ruby Mines No. 1. Similarly, Ruby Mines Nos. 3 and 4 were connected by underground workings, and ore was produced through the adit at Ruby Mines No. 3. Underground workings are shown on Figure 1-4, based on available documentation. Ruby Mines Nos. 1 and 3 each had a main haulage drift at an approximate 21 degree decline, which was between 9 and 10 feet high and 10 to 14 feet wide. Cross cuts were driven from the drift laterally to intersect the ore at 400-foot intervals. Continued development of the ore zone included 7-foot-by-8-foot drifts at 50-foot intervals, driven from the cross-cuts (WNI 1977, 1979a, 1979b, 1979c).

2.1.3 Regulatory History

The Ruby Mines were constructed, operated, and reclaimed in compliance with federal and state regulatory agency requirements as follows:

- In 1971 and 1972, mining leases were obtained from BIA for Navajo-allotted lands in Section 26 (U.S. Department of the Interior BIA 1971, 1972). The leases gave WNI the right and license in connection with mine operations to construct buildings, structures, and improvements on the land needed to produce and transport minerals and did not require their removal upon lease termination.
- In 1973, WNI obtained archeological clearance for a power line and vents at the Ruby Mines (U.S. Department of the Interior National Park Service 1980a, 1980b, 1980c).
- In 1980, the USGS approved WNI's Section 26 Mining and Reclamation Plan (USGS 1980).
- On September 11, 1984, the NNEPA performed a site inspection at Ruby Mines No. 1 and recommended implementing reclamation and site restoration activities. Reclamation efforts were initiated shortly after mining operations at the Ruby Mines ended. Reclamation activities, including closing vents and adits and capping waste rock piles, addressed Navajo Nation and Nuclear Regulatory Commission concerns (Navajo Nation 1984).
- On October 25, 1985, the Bureau of Land Management (BLM) reviewed WNI documents on reclamation activities. BLM approved the measures in a letter dated May 8, 1991. BLM recommended continued inspections but no further reclamation (BLM 1991).
- On July 10, 1986, the New Mexico Environmental Improvement Division inspected Section 21, where Ruby Mines No. 1 is located, and proposed no further action under CERCLA (New Mexico Environmental Improvement Division 1986).
- On September 27, 1995, MMD inspected Ruby Mines Nos. 1 and 3 and approved reclamation efforts on September 29 (MMD 1995). After the BLM and MMD assessments, BIA released Surety Bond No. 8084-08-04 for WNI, and liability under the bond was released (BIA 1996).
- In May 2009, U.S. EPA performed preliminary radiation surveys of Ruby Mines Nos. 1 and 3 (Weston Solutions, Inc. 2009a, 2009b).
- From October 2012 through May 2014, WNI performed site reconnaissance to locate and secure (with fencing) open mine features, perform fence inspections, perform cultural resource assessments, interface with residents to obtain signatures on access agreements, and meet with Smith Lake Chapter officials to update them about ongoing activities.

- On July 15, 2013, U.S. EPA and WNI signed an ASAOC for RSE and Interim Removal Actions (U.S. EPA 2013). This ASAOC terminated on February 26, 2016 (Ripperda 2016).
- In May 2014, WNI performed mine feature closure activities, initial radiation surveys, and background studies. The activities were summarized in the RSE Report (CH2M 2015).
- In October and November 2014, WNI conducted additional radiation surveys and collected surface and subsurface soil borings. The activities were documented in the RSE Report (CH2M 2015). The RSE Report was approved by U.S. EPA on February 26, 2016 (Ripperda 2016).
- In February 2017, U.S. EPA and WNI signed an ASAOC for an EE/CA (U.S. EPA 2017a).
- In May 2017, WNI submitted a draft EE/CA work plan to U.S. EPA. The work plan was revised in response to U.S. EPA and NNEPA comments and was submitted as the final EE/CA Work Plan in September 2017 (CH2M 2017) and subsequently approved by U.S. EPA on October 25, 2017 (Ripperda, pers. comm. 2017).

2.1.4 Site Features and Landscape

The Ruby Mines Site is located on relatively flat terrain with no cliffs with little vegetation. Mine features associated with the Ruby Mines Site are summarized in Table 1-2 and shown on Figures 1-4, 2-1, and 2-2. Photographs showing the Ruby Mines Site's current conditions are included in Appendix B. Descriptions of specific site access, physical layout, and site features, including waste rock observed at the Ruby Mines Site, are provided as follows:

- **Mine features:** Following the closure activities conducted in May 2014, as described previously, there are no open mine features at the site. There was a small area of subsidence observed at the Ruby Mines No. 3 adit on February 7, 2018. This area of subsidence was only observed in a limited area where the adit itself caved in and cannot be correlated to historical dewatering or recharge activities. The subsidence area was fenced for safety. During closure activities in 2014, bat gates were installed at Ruby Mines Nos. 1 and 3 adits to create potential habitat for bats. Additionally, PVC pipes were installed at the RUBY-002 and RUBY-017 vents to enable groundwater drainage and mitigate pressure differentials that could destabilize the feature; to date, no drainage has been observed.
- **Waste rock piles:** Waste rock piles at Ruby Mines Nos. 1 and 3 were capped as part of the reclamation efforts conducted in 1985. In general, the cap surface at Ruby Mines No. 1 is relatively flat to the southeast and slopes off to the north and west following the natural drainage patterns in the area. Erosional rills were apparent on the northern and western slopes of the cap. In general, the cap surface at Ruby Mines No. 3 is relatively flat in the west and slopes off to the north, south, and east. The eastern portion of the cap is divided into two lobes located north and south of the former haul road and a natural topographic high, which is characterized by trees and rocky soils. Erosional rills were apparent on the southern and southeastern slopes of the cap. Vegetation is present at each waste rock pile but is limited because of grazing.
- **Drainages:** Natural drainages that convey water runoff from the capped waste rock piles at Ruby Mines Nos. 1 and 3 were evaluated in the site characterization process.
  - Four distinct water drainages are present at Ruby Mines No. 1 and were labeled A, B, C, and D. Drainages A, B, and C cross the northern edge of the capped waste rock pile, are typically 1 to 2 feet deep, and convey runoff to the west toward drainage D. Drainage D crosses the western edge of the capped waste rock pile, is incised to depths of 20 feet in places, and conveys runoff to the north.
  - The drainages at Ruby Mines No. 3 run along the northern and southern perimeter of the capped waste rock pile and discharge to a small pond and broad flat area east and south of the capped waste rock pile, along the unmaintained former haul road.
- **Dewatering area:** The dewatering area associated with Ruby Mines No. 3 was located topographically lower than the adjacent work area and capped waste rock pile. Water that was pumped from a nearby

well that dewatered underground mine workings was reportedly discharged to this area. There was no dewatering area at Ruby Mines No. 1.

- **Former haul roads:** The former haul road at Ruby Mines No. 1 begins at the capped waste rock pile and ends at the intersection with BIA Route 49, with a total length of approximately 11,000 feet. A short, unmaintained section of the former haul road extends from the capped waste rock pile to Wolf Canyon Road. The longer stretch of the former haul road (Wolf Canyon Road) is graveled and maintained to the intersection with BIA Route 49 (Figure 1-4).

The former haul road at Ruby Mines No. 3 begins at the eastern side of the capped waste rock pile and ends at the intersection with State Highway 371, with a total length of approximately 13,000 feet. A short, unmaintained section of the former haul road starts at the capped waste rock pile and extends to the maintained gravel roads (Horseshoe Pond Road and Mount Powell Road). The maintained gravel road continues to State Highway 371.

- **Work area:** The work areas associated with Ruby Mines Nos. 1 and 3 are areas where mining support activities occurred historically. The work areas included office areas, machine and maintenance buildings, and parking areas. There is a large, concrete building foundation present at the Ruby Mines No. 1 work area. A few smaller concrete building foundations are apparent at the work area at Ruby Mines No. 3.

During the RSE conducted in 2014, cultural resources were identified at Ruby Mines No. 3. Cultural items were fenced and not disturbed. Cultural resources will be avoided during the implementation of the response action. Cultural resources were not identified at Ruby Mines No.1.

2.1.5 Geology and Hydrology

The soil and rock that makes up the earth in the region includes Quaternary-, Cretaceous-, and Jurassic-age sedimentary units (Figures 2-3a and 2-3b). Unconsolidated Quaternary alluvium and colluvium are present along incised drainage features and surrounding prominent topographic features, including Hosta Butte north of the site. Alluvial and colluvial deposits are present on the weathered, upper Cretaceous sedimentary rocks, from which they are largely derived (USGS 1990). Cretaceous sandstones of the Point Lookout and Crevasse Canyon formations, which form Hosta Butte to the north, overlie the Mancos Shale Formation. The Mancos Shale Formation overlies the Cretaceous-age Dakota Sandstone Formation. The Dakota Sandstone Formation unconformably overlies the Jurassic-age Morrison Formation (USGS 1990). The Morrison Formation includes lithologic units with uranium ore and contains aquifers that supply agricultural and domestic water to users in the area (Cooper and John 1968; Myers 2010). The basement rocks that underlie Jurassic sedimentary units consist of Precambrian granite and quartzite (Brister and Hoffman 2002). A stratigraphic column cross-section is provided for reference on Figure 2-4.

The surficial geology (landforms and soil underneath them) near the Ruby Mines includes the following three formations (Table 2-1 and Figures 2-3a and 2-3b):

- Colluvium is the unconsolidated Quaternary-age sediment present near several historical mine features. Colluvium consists of sediments of various textures, from silt to gravel, which are recently or actively weathering from upland bedrock units. The materials are mapped on steep declines and adjacent to rocky outcrops (USGS 1990). Colluvium units are present in narrow, discontinuous bands in low areas of large topographic relief. The thickness of the colluvium is variable, ranging from a few feet to 100 feet, with the greatest thicknesses present on slopes of valleys and ravines (USGS 1990). Features where the colluvium is the predominant surface geologic unit are the Ruby Mines No. 1 capped waste rock pile and adjacent areas, drainages, former haul road, and work area; the Ruby Mines No. 3 drainages; and the RUBY-018 and RUBY-019 vents.
- The Cretaceous-age Mancos Shale Formation consists of three members, and are predominantly composed of shale, mudstone, and siltstone, but also include layers of limestone and sandstone. The Mancos Shale Formation is a lithified unit, ranging in thicknesses up to 100 feet. The formation weathers readily, has eroded away from upland areas, and is covered by soils and vegetation across

much of the Hosta Butte quadrangle (USGS 1990). The Mancos Shale Formation is present at the surface at the RUBY-001 adit, the RUBY-003 adit, and the RUBY-004 vent. It is also encountered at the Ruby Mines No. 3 capped waste rock pile, dewatering area, former haul road, and work area, and the residence near the Ruby Mines No. 3.

- The Cretaceous-age Dakota Sandstone Formation consists of fine- to medium-grained, well-sorted sandstone with inter-bedded siltstone and shale (USGS 1990). Uranium roll-front deposits have been noted in a few regions within the Dakota Sandstone Formation (Myers 2010). The Dakota Sandstone Formation is present beneath the entire Ruby Mines Site and is overlain in some areas by Mancos Shale Formation, alluvium, colluvium, and other formations. The Dakota Sandstone Formation is relatively resistant to erosion when compared to the Mancos Shale; therefore, it forms much of the rocky outcrops and is exposed on many of the upland areas. The formation thickness ranges between approximately 140 and 190 feet (USGS 1990). The Dakota Sandstone is exposed at the surface across large, upland areas of the site, but it is thinner, with thicknesses up to approximately 60 feet (USGS 1990). The Dakota Sandstone Formation is the surface geologic unit at the RUBY-002, RUBY-015, and RUBY-022 vents; and the residences near Ruby Mines No. 1.

Mining occurred in the Brushy Basin Member of the Morrison Formation. It is assumed that waste rock piles at the Ruby Mines Site consist of material from this formation. Sandstone ore formed intervals from 10 to 40 feet thick in the lower third of the Brushy Basin, which has a total thickness of approximately 160 feet. The nature of uranium occurrence appeared to be that of a typical solution front deposit. Mineralization occurred in a poorly sorted arkosic sandstone bounded above and below by impermeable mudstone. The greatest concentration of uranium usually occurred in the lower third to half of the host sandstone, between 290 and 403 feet from the surface (WNI 1979b). No uraniferous formations are exposed at the surface at the Ruby Mines. The depth to groundwater at the site is more than 400 feet.

Stormwater drainage from the Ruby Mines area is typically along incised drainage channels. Surface flow in the channels occurs from time to time during and after high rainfall events and during rapid snowmelt events.

2.1.6 Land Use and Populations

The current use of surface land in Township 15 North, Range 13 West, Sections 21, 25, 26, and 27 includes the following:

- Portions of Section 21 that are associated with known mine features of Ruby Mines No. 1 are designated as tribal trust lands. Grazing permits are located within approximately 1 quarter-mile of mine features associated with Ruby Mines No. 1. Two home site leases and a residential lease (located in Section 20 on allotment land) are located approximately 1 half-mile southwest of the Ruby Mines No. 1 capped waste rock pile.
- According to the Navajo Nation Land Department (Navajo Nation 1984), the portions of Section 25 that are associated with known mine features of Ruby Mines No. 3 are held as tribal trust lands. Reportedly, two grazing permits are held in this area. A home site lease is also held approximately 1 quarter mile to the east of Ruby Mines No. 3.
- Section 26, where Ruby Mines No. 4 is located, is divided into four Navajo allotments.
- Portions of Section 27 that are associated with known mine features of Ruby Mines No. 2 are tribal trust lands. There are known grazing permits that encompass areas where several vents are located.

Traditional land use by the Navajo includes growing plants for human and or animal consumption, grazing animals that may be consumed by humans, and building homesites or residences. Currently, the Ruby Mines Site is used for livestock grazing, herding, and gathering firewood and pinon nuts. The Ruby Mines Site sits within Unit 13, defined in the Navajo Nation Fish and Wildlife (NNFW) Fall Hunting Proclamation (July 1, 2021 to June 20, 2022). In this unit, hunting is allowed for elk and deer by archery and rifle (NNFW 2021). There is no “traditional” hunting allowed; all hunting must be done in accordance with the NNFW regulations. Recreational uses may include rodeos conducted in arenas belonging to local residents; however, none of these arenas are observed within a mile of the Ruby Mines Site. Livestock branding may also be conducted by local residents.

The nearest residences are located approximately 600 to 1,500 feet from the waste rock piles and soil with mining-related contaminants.

Five future land uses were identified for the former uranium mining sites, as follows:

- **Kee'da'whíí tééh (Residential):** A residential land use scenario involves a Diné community member who lives full time onsite, practicing traditional Diné lifeways, living in a traditional Diné home, harvesting plants, crops, and raising animals onsite.
- **Kǫǫh bí łíí nakaí (sheep camp user):** Navajo sheep camp workers who live part time (5 months per year) at a location to graze sheep. Includes external exposure to radiation, incidental ingestion of soil, dermal exposure to soil (metals only), inhalation of soil (or dust), ingestion of a limited number of homegrown produce and gathered wild plants, and ingestion of raised animal products and hunted animals, as well as plant exposures from Diné lifeways practices, including medicinal and ceremonial exposures.
- **Kǫǫ eí nahaazáh (easy access open space user):** Areas that are easily accessible because of proximity to roads and sheep camp areas above the contact between Salt Wash Member and San Rafael Group geologic formations but that are not available for sheep camp use because of steep topography. Also includes roads within difficult access open space areas.
- **Kǫǫ eí doo nahaazáh dah (difficult access open space user):** Areas that are difficult to access because of steep topography located below the contact between Recapture Member, Salt Wash Member, and San Rafael Group geologic formations. Also includes drainages that are difficult to access because of inaccessible terrain, such as waterfalls.
- **Chíí dah wiih łeezh (washes and drainages user):** Areas in all washes and drainages except those that are difficult to access because of inaccessible terrain, such as waterfalls. The drainage located to the east of the site has low flow and quickly infiltrates. The lack of a reliable water source makes use of the land for full-time residential, commercial, or agricultural activities unlikely. As with all mines located in the Lukachukai Mountains, mine waste is migrating down the drainage systems and could impact agricultural activity in the Cove Valley during diversion of seasonal flow for irrigation and stock ponds.

Future land use, as it applies to the Ruby Mines Site, are Washes and Drainages and Residential, as presented on Figure 2-5.

2.1.7 Sensitive Ecosystems and Habitat

A Navajo Natural Heritage Program resource review identified the golden eagle (Aquila chrysaetos), peregrine falcon (Falco peregrinus), and Heil's milkvetch (Astragalus heilii) as three protected species potentially present in the site area. A review of suitable habitat for the three species determined that it is highly unlikely that Heil's milkvetch is present, or that golden eagles or peregrine falcons would nest within the protective buffer for the remedial activities. Bats were identified to potentially use the mine adits and vents as habitat. Therefore, mine closure design included bat gates to allow access to the subsurface.

2.1.8 Meteorology and Climate

The climate at the Ruby Mines Site is semiarid, with large daily and seasonal temperature fluctuations. The area is characterized by broken terrain and includes steep mountains, plateaus, mesas, incised valleys, and dry arroyos. The average annual maximum temperature is 66 degrees Fahrenheit, and the average minimum temperature is 32 degrees Fahrenheit (WRCC 2022). The annual prevailing wind direction in the area near Gallup, New Mexico, is in the west-southwesterly direction (Figure 2-6) (WRCC 2021). Average annual runoff is less than 5% of annual precipitation in this area because of the dry air and vegetation uptake (Fizber 2013). The average annual total precipitation near Gallup, New Mexico, is 11.08 inches, and the average annual total snowfall is 30.6 inches (WRCC 2022).

2.2 Previous Reclamation and Removal Actions

WNI performed reclamation efforts at the Ruby Mines between June and December 1985. The efforts were approved by the U.S. Department of the Interior BLM (BLM 1991) and U.S. Department of the Interior BIA (BIA 1996). WNI performed the following reclamation activities:

- Ruby Mines No. 1 adit was sealed with a concrete wall and backfilled, and the Ruby Mines No. 3 adit was closed and capped with fill (MMD 1995).
- Topsoil was removed from the waste rock pile areas and building sites before initiating mining (WNI 1979b). The stockpiled topsoil was used to cap the waste rock when mining ceased. The capped waste rock piles were revegetated with annual rye grass for stabilization in December 1985.
- Known vents were filled and sealed with concrete. Buildings associated with mining were removed, except for the shop building at Ruby Mines No. 1, which was left at the Navajo Nation's request (MMD 1995). The shop building was not present during an October 2012 site visit. No information about its removal has been found. Power lines were salvaged by subcontractors or predecessors of the Navajo Tribal Utility Authority in 1987 (MMD 1995). A historical document makes mention of WNI's negotiating with Continental Divide Electric to supply power (WNI 1977). Water systems were turned over to unnamed subcontractors or predecessors of the Navajo Tribal Utility Authority.
- Maintenance improvements for reclamation measures included repairing erosion of the waste rock cap. The cap at Ruby Mines No. 1 was repaired in 1993. A drainage diversion around Ruby Mines No. 3 was incised to prevent the capped waste rock pile from eroding. In September 1995, WNI inspectors observed that the cap at Ruby Mines No. 1 had erosional rills. The rills were filled with rock, and the deeper rills were capped with geotextile fabric and backfilled (WNI 1995).
- In May 2014, WNI performed closure activities for mine features found to be open or needing repair. These features were physically closed using polyurethane foam (PUF), native fill, and borrow fill, and are inspected annually. Closure activities are summarized in the Phase 1 Report (CH2M 2014).

2.3 Previous Site Investigations

An RSE study was performed at the site from 2012 to 2014 to close mine openings, such as adits and vents; reduce physical hazards; and assess chemical and radiological conditions in soil (CH2M 2015). The findings of the RSE report are highlighted herein. Field work was conducted to achieve the following:

- Identify and close historical mine features.
- Identify cultural resources in and adjacent to the Ruby Mines Site.
- Review protected biological resources potentially within the site.
- Post bilingual warning signs at each of the mine sites.
- Characterize background concentrations of primary COPCs.
- Characterize surface radiological conditions at Ruby Mines features and nearby residences.
- Characterize the lateral and vertical extents of COPC concentrations in soil at the site.

Characterization findings, summarized in Section 2.4, were used in conducting the human health and ecological risk assessments presented in Section 2.5.

2.4 Source, Nature, and Extent of Contamination

As the stage of gaining knowledge and thinking continues, understanding the extent and types of contamination and risks to human health and the environment, including living beings other than humans, is important when considering remedies. This section summarizes investigation results about the locations and degree of contamination and the associated potential risks to humans and the environment. The COPCs and the extent of contamination were determined during the RSE at each feature, including lateral extent in surface soils (surface area boundaries) and vertical extent in subsurface soils (subsurface boundaries). Analytical results from the RSE are presented in Appendix A.

2.4.1 Contaminants of Potential Concern and Background Threshold Values

During the RSE investigations, sampling was conducted to establish a BTV for Ra-226 and each metal, based on the 95-95 upper tolerance limit. The ASAOC scope of work defined the RSE investigation level for Ra-226 as 1.24 picocuries per gram (pCi/g) greater than the BTV to determine the extent of impacts for Ra-226. For metals, risk-based screening levels were based on U.S. EPA unrestricted residential use regional screening levels (RSLs). The higher of the BTV or the RSL for each metal was used as the screening criterion to determine the extent of impacted soil. The RSL was higher than the BTV for each metal except arsenic.

Since the approval of the Ruby Mines RSE in 2015, U.S. EPA revised the RSLs (May 2022). Data from the RSE were reviewed using these updated values, and the conclusions remain consistent with the conclusions made in the RSE. Table A-1 provides the revised RSLs and RSE data for reference. Mercury and molybdenum were not reported at levels greater than their respective RSLs during the RSE investigation. COPCs detected at concentrations exceeding the screening criteria at multiple locations include Ra-226, arsenic, and uranium. Vanadium exceeded the RSL in one sample (RM01-STEP05-00) (Appendix A) (CH2M 2015).

A complete description of the background assessment and the extent and type of contamination is presented in the Ruby Mines Removal Site Evaluation Report (CH2M 2015).

2.4.2 Sources and Nature of Contamination

The source of waste rock and impacted soil is the historical mining activities conducted at the Ruby Mines Site. Ores of native rock were mined underground and transported to the surface through adits. The ore was transported offsite for processing. Waste rock was placed outside the adits of Ruby Mines Nos. 1 and 3 and ultimately reclaimed as described in Section 2.2.

In general, contaminants at the site are potentially subject to migration, which is the movement of contaminants outside of the originally impacted area. The primary potential migration pathway at the site is transport of contaminated soils by wind or water erosion; however, analytical results suggest minimal transport via these pathways (primary wind direction is from the south, as indicated by the wind rose on Figure 2-3a and 2-3b). Soil particles may be transported by stormwater runoff and deposited along drainage ways. Contaminant migration within the capped areas is limited because waste rock is currently capped, except where erosion has occurred. Outside of capped areas, contaminants in surface soil are more susceptible to migration via erosion; however, analytical results suggest minimal transport via this pathway. The Ruby Mines Site is located within a semiarid environment resulting in minimal precipitation contributing to stormwater runoff and infiltration. Depth to groundwater is more than 400 feet and intervening geologic materials provide both hydraulic and geochemical barriers (Appendix E); therefore, infiltration is not expected to contribute to contaminant leaching through the soil column to groundwater. Mining operations ceased more than 30 years ago in 1985. The extent of impacts surrounding the capped waste rock piles and along drainages is limited, suggesting that the caps currently in place have generally been effective and that limited COPC migration has occurred.

2.4.3 Extent

Site characterization data collected during the RSE investigation at the Ruby Mines Sites were used to determine the area of mining-impacted material, including TENORM, resulting from historical mining activities using multiple lines of evidence. The multiple lines of evidence include the following activities:

- Reviewing historical activities, including reclamation
- Conducting interviews with residents and consultation with NAML staff
- Analyzing geologic stratigraphy, hydrogeology, and hydrology

- Identifying prominent wind direction
- Conducting visual observations of disturbed areas for evidence of historical mining operations
- Conducting a field investigation, including gamma scanning and surface and subsurface soil sample analysis.

This information is summarized in Sections 2.1, 2.2, 2.3 and detailed in the RSE report. The RSE investigation concluded that mining-related impacts, including TENORM, at the Ruby Mines Site were primarily in the areas described in the following subsection and presented on Figures 2-7 through 2-10 and Appendix A, Figures A-1 through A-4.

2.4.4 Ruby Mines No. 1

2.4.4.1 Capped Waste Rock Pile

The Ruby Mines No. 1 capped waste rock pile sampling sites and summary of soil exceedances are shown on Figure 2-7. Visual observations of the cap material at the eight borings indicated that the cap averages approximately 1 foot in thickness. In general, the cap is relatively flat to the southeast and slopes off to the north and west following the natural drainage patterns in the area. Erosional rills are apparent on the northern and western slopes of the cap.

Ra-226 was detected in surface soil samples (collected from the cap) at relatively low concentrations ranging from 2.3 to 8.6 pCi/g, with concentrations exceeding the PRG (defined for the RSE) of 2.89 pCi/g in six of the seven surface soil samples collected from the cap (Figure A-1). The flat section of the cap had lower Ra-226 concentrations in the southeast than in the northern and western sections of the cap (Figure 2-7).

Higher Ra-226 concentrations exceeding the PRG were detected in waste rock materials beneath the cap. The deepest Ra-226 concentrations were detected in a waste rock sample collected 25 feet bgs in the center of the pile (RM01-CWRP07). The presence of waste rock at 25 feet bgs likely represents the land surface before placement. Generally, the thickest part of the waste rock was in the central and western portions of the pile. The far eastern portion the pile, RM01-CWRP04, showed minimal evidence of waste rock and concentrations of Ra-226 less than the PRG, indicating that this area may not be part of the capped waste rock pile.

Uranium exceeded its RSL at soil boring locations RM01-CWRP01, RM01-CWRP02, RM01-CWRP05, RM01-CWRP06, RM01-CWRP07, and RM01-CWRP08, with a maximum concentration of 140 milligrams per kilogram (mg/kg) at RM01-CWRP01.

Arsenic, mercury, molybdenum, selenium, and vanadium concentrations did not exceed BTVs or RSLs in the capped waste rock pile.

2.4.4.2 Drainages

The Ruby Mines No. 1 Ra-226 concentrations in drainages soil are shown on Figure A-1. Soil samples were collected from Drainages A, B, and C, and Ra-226 concentrations ranged from 5.73 to 18.9 pCi/g. Subsurface soil samples in Drainage A, B, and C exceeded the PRG of 2.89 pCi/g but were vertically delineated by concentrations less than the PRG at depths 1.0 feet bgs for Drainage A and B and 5.0 feet bgs at Drainage C.

Uranium exceeded its RSL in one surface sampling location from Drainage A with a concentration of 17 mg/kg, which also exceeded Ra-226 concentrations.

Arsenic, selenium, and vanadium were not detected at concentrations exceeding BTVs or RSLs in the drainages.

2.4.4.3 Former Haul Road

According to gamma scanning results, nine locations were sampled along the Ruby Mines No. 1 former haul road (Figure 2-8). Six of the locations were along the unmaintained former haul road near the capped waste rock pile, and three were at an isolated location near the intersection of the former haul road and BIA Route 49. Samples for the six locations along the unmaintained former haul road were from surface soil only or soil borings that were advanced to a depth of 5 feet bgs. Each of the nine locations along the haul road exceeded the PRG of 2.89 pCi/g. The maximum concentrations for Ra-226 up in surface soil was 1,680 pCi/g at RM01-HR02-00, which was delineated by a Ra-226 concentration less than the PRG at 5.0 feet bgs. The remaining three subsurface soil sample locations were delineated by concentrations below the PRG at 5.0 feet bgs (RM01-HR07 and RM01-HR01) and 1.0 foot bgs (RM01-HR03).

Arsenic exceeded its BTV and uranium exceeded its RSL in surface samples from borings RM01-HR02, RM-01-HR03, RM01-HR05, and RM01-HR07. Arsenic also exceeded its BTV in the surface samples collected from RM01-HR05, RM01-HR06, and RM01-HR07. Uranium also exceeded its RSL in the surface samples collected from RM-01-HR02, RM01-HR03, RM-01-HR05, RM-01-HR06, and RM-01-H07. Concentrations decreased sharply with depth at the locations where subsurface samples were collected. Ra-226 was also detected in each of these samples. These results indicate that the presence of metals at concentrations exceeding RSLs is limited to surface (0.5 to 1.0 foot bgs) and near surface soils (up to 5.0 feet bgs) and are co-located with elevated Ra-226.

Mercury, molybdenum, selenium, and vanadium were not detected at concentrations exceeding BTVs or RSLs along the former haul road.

2.4.4.4 Step-out Area

Gamma scanning conducted as part the RSE found levels exceeding the BTV in some areas outside of known mine-related-impacted areas. These areas are called “step-out” areas because gamma field crews continued to step out and scan until gamma levels decreased to less than 2 times the BTV. The Ruby Mines No. 1 step-out areas are shown on Figure 2-7. As shown, on Figure 2-1, portions of the step-out area are heavily vegetated with trees and shrubs. Surface soil samples were collected at 18 locations. Ra-226 levels exceeding the PRG (2.89 pCi/g) were detected in surface soil samples, with a maximum reported concentration of 1,330 pCi/g (RM01-8MAY14-05). Soil boring samples were collected to evaluate vertical extent at 5 locations (RM01-STEP01 through RM01-STEP05) to the north and east of the capped waste rock pile. The 5 soil borings were advanced to a depth of 5 feet bgs where Ra-226 concentrations were found to be slightly greater than the BTV (1.65 pCi/g) at depth (maximum detection of 2.45 pCi/g at RM01-STEP05). These results indicate that the presence of Ra-226 is limited to surface and near-surface soils.

Arsenic exceeded its BTV (which is higher than its RSL) at RM01-STEP02 and RM01-STEP05; uranium and vanadium exceeded their RSLs at RM01-STEP05; arsenic and uranium exceeded their RSLs at RM01-STEP02, RM01-STEP05-00; and uranium exceeded its RSL all five step-out area sample locations. The highest detections of uranium and vanadium were in the surface sample collected at boring RM01-STEP05, which also had an elevated Ra-226 concentration. Arsenic exceeded its BTV in the 5-foot sample at RM01-STEP02, but this was not associated with elevated Ra-226 or other elevated metals concentrations. This exceedance may represent natural variability in soil mineralogy. No other analytical detections indicated soil contamination in the 5-foot sample of boring RM01-STEP02. As before, these results indicate that the presence of metals at concentrations exceeding RSLs is limited to surface and near-surface soils.

Mercury, molybdenum, and selenium were not detected at concentrations exceeding BTVs or RSLs in the step-out areas.

2.4.4.5 Work Area

During mining operations, there was a mechanics shop, changing room, and office buildings located to the east of the capped waste rock pile; a concrete foundation is still present in this area and is referred to as the "work area." Soil borings were collected at four locations in the work area. The surface and subsurface soil concentrations for Ra-226 exceeded the PRG of 2.89 pCi/g in the four soils sample locations (Figure 2-7). Surface soil ranged from 2.99 to 39.9 pCi/g (Figure A-1; Table A-1). The four soil borings were advanced to a final depth of 5 feet bgs. Ra-226 concentrations in soils near 5.0 feet bgs ranged from 1.11 to 4.84 pCi/g (Table A-1 and Figure A-1).

Uranium exceeded the RSL in surface and subsurface locations RM01WRK01, RM01-WRK02, RM01-WRK03, and RM01WRK04. Concentrations in the deepest interval at each location had uranium concentrations that were less than the RSL.

Arsenic, mercury, molybdenum, selenium, and vanadium were not detected at concentrations exceeding BTVs or RSLs in the work area.

2.4.4.6 Summary

Figure A-5 provides a view of the calculated Ra-226 concentrations in surface soil for the capped waste rock pile, work area, and step-out area. These results indicate relatively low Ra-226 concentrations in areas north of the step-out area, east of the work area, and south of the step-out area. Data gaps in lateral and vertical extents of TENORM were evaluated after risk assessment was completed and are discussed in Section 2.5.6.

2.4.5 Ruby Mines No. 3

2.4.5.1 Capped Waste Rock Pile

In general, the Ruby Mines No. 3 capped waste rock pile is relatively flat in the west and slopes off to the north, south, and east. The eastern portion of the cap is divided into two lobes, located north and south of the former haul road and a natural topographic high, which is characterized by trees and rocky soil. Channels where erosion is occurring were apparent on the southern and southeastern slopes of the cap.

Figure 2-9 summarizes the analytical concentration exceedances at the Ruby Mines No. 3 capped waste rock pile. The Ruby Mines No. 3 capped waste rock pile surface soil samples (from the cap) were collected at nine locations, including two surface-soil-only locations and seven soil boring locations. Visual observations of the cap material suggest that the cap averages approximately 1 foot in thickness. Concentrations in eight of nine surface soil locations were at or less than 2.27 pCi/g (less than the PRG of 2.89 pCi/g defined for the RSE); one of the nine surface soil samples had a concentration of 1,240 pCi/g (RM03-8MAY14-09) at a location visually confirmed to be a piece of exposed waste rock.

Higher Ra-226 concentrations were detected in waste rock materials beneath the cap. The deepest Ra-226 concentrations were detected in a waste rock sample collected 13 feet bgs in the western portion of the pile (RM03-CWRP06).

Uranium exceeded the RSL in subsurface soil samples collected in six of the nine cap sample locations. Surface and subsurface soil did not exceed the uranium RSL at RM03-CWRP05. Uranium concentrations exceeding the RSL were identified up to 13.5 feet bgs (RM03-CWRP02).

Arsenic, mercury, molybdenum, selenium, and vanadium were not detected at concentrations exceeding BTVs or RSLs in the capped waste rock pile.

2.4.5.2 Dewatering Area

Records indicate that during mining, water was pumped from the underground mine to the surface and discharged into the "dewatering area." Six surface soil samples and three soil borings were collected from the Ruby Mines No. 3 dewatering area (Figure 2-9). Ra-226 and uranium were detected at concentrations exceeding the PRG or RSLs across the area, with the maximum concentrations of 50.7 pCi/g (Ra-226) at RM03-DTWR03-00, which is adjacent to the capped waste rock pile, and 110 mg/kg (uranium) at RM03-DTWR02 at a depth of 5 feet, also adjacent to the capped waste rock pile.

Ra-226 was detected up to a depth of 6.5 feet bgs at a concentration of 32 pCi/g (RM03-DWTR02).

Arsenic, mercury, molybdenum, selenium, and vanadium were not detected at concentrations exceeding BTVs or RSLs in the dewatering area.

2.4.5.3 Drainages

Three soil borings were collected from the Ruby Mines No. 3 drainages (Figure 2-9). RM03-DRN01, located in the northwestern drainage, was extended to a depth of 5 feet bgs, and Ra-226 was detected at maximum concentration of 2.35 pCi/g in the surface soil sample collected at that location. For RM03-DRN02 and RM03-DRN03, located in the southeastern drainage, the concentrations were up to 10.2 pCi/g in the surface soil samples collected at those locations and decreased to slightly above background at depth (5 feet bgs).

Arsenic was detected at 13 mg/kg (slightly greater than the BTV) in the surface sample from RM03-DRN01. Other metals were not reported at elevated concentrations in the same sample. This sample was not associated with an elevated Ra-226 concentration or other elevated metals concentrations, and it may represent natural variability in soil mineralogy. Arsenic, molybdenum, selenium, uranium, and vanadium did not exceed the RSLs or BTVs in any other drainage samples.

2.4.5.4 Work Area

The Ruby Mines No. 3 work area soil samples were collected at four locations (Figure 2-9). Ra-226 concentrations ranged from 2.66 to 590 pCi/g at the surface, and 1.29 to 12.3 pCi/g at 1 foot bgs at the four locations. Elsewhere, surface samples collected in this area were at or below 1.74 pCi/g, indicating that the extent of impacts are primarily limited to the top foot of soil.

Two locations, RM03-WRK01 and RM03-WRK04, had concentrations that exceeded the RSL for uranium. Location RM03-WRK01 exceeded the RSL with a concentration of 51.0 mg/kg in soil collected at a depth of 1.0 foot bgs, whereas location RM03-WRK04 had concentrations exceeding the RSL in surface soil (440 mg/kg) and subsurface soil samples (130 mg/kg) at a depth of 1.0 foot bgs. Ra-226 also exceeded in surface soil at these locations.

2.4.5.5 Summary

Figure A-6 provides a view of the calculated Ra-226 concentrations in surface soil for the capped waste rock pile, work area, dewatering area, and step-out area. These results indicate relatively low Ra-226 concentrations north of the capped waste rock and in areas west of the dewatering area and work area. Data gaps in the lateral and vertical extents of TENORM were evaluated after the risk assessment was completed and are discussed in Section 2.5.6.

2.4.6 Ruby Mines Vents

At five vents, RUBY-018, RUBY-021, RUBY-011, RUBY-015, and RUBY-022, gamma scan measurements were less than 2 times their respective backgrounds; consequently, no soil samples were collected (CH2M 2015).

Soil samples were collected at three vents, RUBY-002, RUBY-004, and RUBY-019, that had gamma scan measurements greater than 2 times the BTVs (Figure 2-10).

- At RUBY-002, Ra-226 concentrations at sample locations close to the vent (RM02-VENT03) were reported to be 159 pCi/g at the ground surface and 10.3 pCi/g at 1 foot bgs. Approximately 12 feet farther north of the vent (RM02-VENT02), concentrations were reported to be 5.69 pCi/g at ground surface. Uranium concentrations in these samples also exceeded the RSL.
- At RUBY-004, sample location RM04-VENT03, closest to the vent, had a Ra-226 concentration of 111 pCi/g at the surface and 24.3 pCi/g at 2 feet bgs, which was the maximum depth possible with hand tools. RM04-VENT02 had concentrations of 6.38 pCi/g at the ground surface and 2.38 pCi/g at 1 foot bgs. Uranium and selenium concentrations exceeded their respective RSL at RM04-VENT03 at ground surface (350 mg/kg for uranium and 600 mg/kg for selenium) and uranium (56 mg/kg) at 2 feet bgs.
- At RUBY-019, samples collected from the area immediately adjacent to the vent (RM19-VENT02) had Ra-226 and uranium exceedances at concentrations of 107 pCi/g and 100 mg/kg at ground surface and 8.4 pCi/g and 76.0 mg/kg at 1 foot bgs, respectively. Samples collected approximately 25 feet south of the vent (RM19-VENT03) had concentrations of 32.2 pCi/g and 34.0 pCi/g at ground surface and 4.24 pCi/g at 1 foot bgs (uranium did not exceed the RSL at this interval).

2.4.7 Exposure Units

An exposure unit (EU) was assigned to the land area within the TENORM boundary for use in the risk assessment. Each EU is within a single geology and single Navajo Land Use (Section 2.1.6) to establish distinct cleanup goals. Table 2-2 presents the type, area, land use, geologic formation, and available samples for each of the EUs at the Ruby Mines Site. The EUs for the Ruby Mines Site, as shown on Figures 2-11 to 2-14, are as follows:

- EU 1: Ruby No. 1 Washes and Drainages
- EU 2: Ruby No. 3: Washes and Drainages
- EU 3: Ruby No. 1: Residential
- EU 4: Ruby No. 3: Residential

The capped waste rock piles will be evaluated as a residential EU for the risk assessment; however, future land use within the capped waste rock piles is dependent upon the response action evaluated. If the capped waste rock pile remains in place after remedy implementation, then residential use would be unrestricted outside the cap and restricted on the capped waste rock pile. If the waste rock pile is removed, then residential use would be unrestricted.

2.5 Risk Assessments

The following subsections describe the risk assessments conducted for the Ruby Mines Site.

2.5.1 Purpose

The purpose of the risk assessment is to evaluate current and future human health risk under Navajo-specific RME scenarios and ecological risk based on the known ecosystems for the region. The risk assessment identifies human health constituents of concern (COCs) and (COECs) in each EU. In addition, the risk assessment results are used to determine management-based cleanup goals and the extent of removal to meet the goals.

2.5.2 Human Health Risk Assessment

A human health risk assessment (HHRA) is the process for evaluating how humans will be impacted as a result of exposure to one or more environmental stressors, such as chemicals or radiation. The objective of the HHRA is to evaluate whether COPCs detected at each EU pose cancer risks or noncancer hazards greater than thresholds (that is, a target cancer risk of 1 in 10 thousand [1×10-4] and a target hazard quotient [HQ] of 1) for current or potential future human receptors, assuming no response action occurs. COPCs contributing to risks exceeding thresholds are then identified as COCs, and RAOs are identified.

The HHRA includes the following components: data evaluation and COPC selection, exposure assessment, toxicity assessment, and risk characterization.

For the Ruby Mines Site, the five potential Navajo-specific receptors (Section 2.1.6) were evaluated for potential exposure, but the Chíí dah wiih łeezh (washes and drainages user) and Kee'da'whíí tééh (Residential) exposure scenario were the only receptors applicable based on the landscape and geology for the Ruby Mines Site. The human health conceptual site exposure model (CSEM) (Figure 2-15) identifies potentially complete exposure pathways by which receptors could come in contact with site-related contaminants. The CSEM describes the various scenarios or relevant activities that could occur at the site and the pathways through which a contaminant may be contacted, internalized, or ingested by an individual at a site. The CSEM is used throughout the site investigation and removal processes to (1) provide a framework for addressing potential risks, (2) evaluate the need for additional data acquisition activities, and (3) evaluate health risks and the need for corrective measures.

In the context of the regulatory risk assessment process, potential effects of contaminants are separated into two categories: cancer and noncancer effects. For carcinogens, such as radionuclides and arsenic, U.S. EPA assumes that no dose is low enough to not cause a health effect and that there is some increased risk at every dose level. Noncancer COPCs, such as uranium, are toxic at levels exceeding a threshold dose. Health risks for radionuclide COPCs are evaluated only for cancer risks, whereas metals COPCs are evaluated for both cancer risks and noncancer hazards as appropriate.

Potential human exposure at the Ruby Mines is limited to radionuclides and metals in soils within the 0- to 18-inch depth interval. The depth of all samples is based on its bottom depth.

RBSLs were calculated for the Chíí dah wiih łeezh (washes and drainages user) and Kee'da'whíí tééh (Residential) exposure scenarios using U.S. EPA and NNEPA's Navajo Risk Calculator v1.00 (NNEPA 2022), a target cancer risk of 1 in 10 thousand (1×10-4), and a target HQ of 1. Exposure pathways include soil ingestion, inhalation, and dermal exposure, as well as external exposure for radionuclides, plant and animal consumption, and other Navajo Fundamental Law-based pathways. Exposure parameters applied in the calculations were default values, as selected based on consultation with NNEPA. Appendix C, Table C-1, presents the RBSLs calculated for cancer risk and noncancer hazards. For metal COPCs with both carcinogenic and noncarcinogenic toxicity, the human health RBSL is equal to the lesser (more conservative) of the carcinogenic- or noncarcinogenic-based goal. For Ra-226, the human health RBSL is the carcinogenic-based screening level, assuming secular equilibrium of Ra-226 and its decay products.

In the HHRA, EU-specific exposure point concentrations (EPCs) were compared with RBSLs to determine whether site concentrations pose risks above thresholds (Appendix C, Table C-2). For analytes with EPCs exceeding the RBSL, EPCs for each COPC were also compared with regional geological formation-specific BTVs. COCs were identified as those COPCs with a total cancer risk greater than 1x10-4 (radionuclides and metals) or a HQ greater than 1 (metals only), and EPCs greater than geologic formation-specific BTVs (Appendix C, Table C-3).

Ra-226 and uranium were identified as the human health COCs for the Drainages and Washes EU (EU 1 and EU 2). Ra-226, selenium, uranium, and vanadium were identified as the human health COCs for the Residential EU (EU 3 and EU4).

2.5.3 Ecological Risk Assessment

An ecological risk assessment (ERA) evaluates whether ecological receptors, including plant, invertebrates, birds, and mammals, may be adversely affected by exposure to site-related contaminants. The ERA is intended to provide input for risk management decision-making at each site while maintaining a conservative approach protective of receptor populations and communities (U.S. EPA 1992, 1997, 1998, 2001). Ecological risk-based screening levels were identified based on the results of this assessment.

The following representative receptor feeding guilds are evaluated in the ERA for the Ruby Mines Site.

- Plants
- Soil invertebrates
- Avian herbivores
- Avian ground insectivores
- Avian carnivores
- Mammalian herbivores
- Mammalian ground insectivores
- Mammalian carnivores

Soil data with the following sample depths were used in the ERA to evaluate ecological receptors:

- EU 1: 0 to 18 inches bgs
- EU 2: 0 to 18 inches bgs

The potentially complete ecological exposure pathways evaluated in the ERA, as shown on Figure 2-16, were as follows:

- Potential direct contact exposure of soil invertebrates and terrestrial plants to site-related contaminants present in soil.
- Potential exposure of wildlife (birds and mammals) to site-related contaminants through the ingestion of site-related contaminants in soil, forage, and prey items.

Ecological RBSLs were selected for each feeding guild from the (LANL) ECORISK database (Newport News Nuclear BWXT-Los Alamos, LLC 2020). RBSLs are based on the lowest observed effect concentration (LOEC), which represents the lowest concentration where an effect has been observed in chronic ecotoxicity studies and on conservative, generic (that is, non-site specific) assumptions about exposure and bioavailability, such as 100% site usage by mobile birds and mammals and 100% absorption of ingested contaminants. This approach is reasonable for the development of screening values intended to identify COECs that may require further ecological risk evaluation, but the RBSLs do not give site-specific risk assessments and are typically considered too uncertain to be used to establish cleanup values in the absence of further evaluation of ecological risk. To accommodate some of this uncertainty, where cleanup goals for vanadium and selenium were required because of exceedances of RBSLs, the cleanup goals were based on LANL preliminary remediation goals (PRGs) (Newport News Nuclear BWXT-Los Alamos, LLC 2020) rather than on LANL LOEC screening values.

In the ERA, EU-specific EPCs were compared with the ecological RBSLs to calculate an HQ. HQs greater than 1 indicate a potential for adverse ecological effects because the LOEC is based on an observed adverse effect concentration. The HQs for each EU for each representative feeding guild are provided in Appendix C, Table C-4.

For analytes with HQs exceeding 1, EU-specific EPCs for each contaminant of potential ecological concern (COPEC) were also compared with regional geological formation-specific BTVs developed for use in the EE/CA. Appendix C, Attachment 1 compares the calculated EPCs for the COPECs with a maximum HQ exceeding 1 to the RBSL and BTV to identify the COPECs that should be considered in the response action.

Ra-226, selenium, and vanadium were recommended for response action for the Washes and Drainages EU (EU 1 and EU2). Ra-226, selenium, uranium (Ruby Mines No. 1 only), and vanadium were recommended for response action for the Residential EU (EU 3 and EU 4).

2.5.4 Risk Assessment Results Summary

Human health and ecological cleanup goals were derived for each applicable receptor, EU, and COC or COEC recommended for removal. Table 2-3 summarizes the soil EPCs, human health and ecological RBSLs, and colluvium BTV.

2.5.5 Cleanup Goals

CERCLA does not allow response action objectives to require remediation of NORM or to remediate soil to concentrations less than background levels. For each COC and COEC, cleanup goal will be defined as the lower of the human health, ecological RBSL, or LANL PRG, if the RBSL is greater than the background threshold value. Otherwise, the cleanup goal for a constituent was set at the background threshold value. A comparison of the human health RBSL, ecological RBSL, and BTV is provided in Appendix C. Table 2-3 provides the selected cleanup goals for each COC and COEC for each EU.

2.5.6 Cleanup Extents

The area requiring cleanup was identified within EUs and was limited to areas identified as mining-related impacts, including TENORM, during the RSE investigation. COCs and COECs within a particular EU and identified as mining-related impacts, including TENORM, were compared with the cleanup goals.

The alternatives considered address waste rock piles and impacted soils. For this EE/CA, impacted soils are defined as soils in the work areas and step-out areas near the capped waste rock piles, near former vents, and along drainages and former haul roads, as identified in the RSE, where COC and COEC concentrations exceed the cleanup goals for the washes and drainages user and residential user, as defined in Section 2.1.6. The target areas for response action are based on locations where analytical soil data exceeded the cleanup goals for Ra-226, selenium, vanadium, or uranium at any depth and at areas determined to be impacted by mining activities, including TENORM. The extent of site media requiring cleanup is presented on Figures 2-17, 2-18, 2-19, and 2-20, inclusive of capped waste rock piles, a dewatering area, drainages, work areas, a step-out area, and vents as described previously. At Ruby Mines No. 1, approximately 12 acres and 164,000 cy of waste rock and impacted soil require cleanup. At Ruby Mines No. 2, approximately 14 acres and 174,000 cy of waste rock and impacted soil require cleanup. Table 2-4 summarizes the cleanup volume at the Ruby Mines Site.

2.5.7 Data Gap Summary

Additional work may be required to fill data gaps in advance of the design phase of implementation of the response action, if required. However, some data gaps may be permanent because of site constraints prohibiting further investigation. Data gaps and their significance to the EE/CA process are discussed as follows:

- Vent 23, located south of Ruby Mines No. 1 (Figure 1-4), was not evaluated during the RSE investigation, because the vent was not previously known and was discovered during field activities. This area will need to be evaluated during the design phase to refine the cleanup extent.
- Concentrations of contaminants in the restricted areas near Ruby Mines No. 3 cannot be fully investigated because intrusive activities are not allowed within this area.
- The extent of Ra-226 concentrations exceeding the cleanup goals in soil were not laterally bound in areas surrounding the cap waste rock piles at both Ruby No. 1 and No. 3, along the Ruby No. 1 Haul Road, or in areas surrounding the Ruby No. 3 Work Area, because the cleanup goal has been calculated to be lower than the Preliminary Remediation Goal established during the RSE. However, gamma count rates in these areas were consistently below the RSE field screening level (2 times background), which provides a line of evidence that these areas may not be affected. Additionally, the calculated Ra-226 surface soil concentration for the Ruby Mines, presented on Figures 2-21, 2-22, 2-23, and 2-24, support the lateral delineation in areas surrounding the Ruby

No. 1 and Ruby No. 3 cap. It should be noted that the calculated Ra-226 concentration in surface soil identifies the area to the east of the Ruby No. 3 Mine site as having concentrations greater than the cleanup goal (Figure 2-23). However, there are locations where the calculated Ra-226 concentrations in surface soil were below the cleanup goal (for example near the Dewatering Area at RM03-8MAY14-03 [Figure 2-19]) where analytical data is above the cleanup goal. Therefore, these areas will need to be evaluated during the design phase to refine the cleanup extent.

- The vertical extent of mining-impacted material, including TENORM, was not delineated at multiple sample locations. Collection of deeper soil samples may be required to refine the cleanup extent; however, in some this may not be feasible because of site conditions. The locations that are not vertically delineated are presented on Table 2-5 and summarized as follows:
  - At Ruby Mines No. 1, the vertical extent is not confirmed at several locations within the capped waste rock pile, along the haul road, in step-out areas and work areas, and near the vents.
  - At Ruby Mines No. 3, the vertical extent is not confirmed at several locations within the capped waste rock pile, in the dewatering area, in the drainage, and in the vent area.

3. Identification of Response Action Objectives

Once the root causes of the problem and its consequences (potential risks) are better understood, the planning stage (nahat'á) will begin. It is understood that the nitsáhákees stage will continue and is nested within planning efforts.

3.1 Response Action Objectives

The general goal for a response action is to reduce potential risks to an acceptable level. An early step in developing response action alternatives is to establish RAOs. Current and potential future land use and Navajo cultural considerations, including Diné Fundamental Law, are taken into account when establishing the RAOs.

Diné Fundamental Law (Diné Natural Law Section 1 NNC 205) declares and states the following:

- The four sacred elements of life, air, light/fire, water and earth/pollen in all their forms must be respected, honored and protected for they sustain life; and
- The six sacred mountains, Sisnajini, Tsoodził, Dook'o'oosłíid, Dibé Nitsaa, Dził Na'oodiłii, Dził Ch'ool'í'í, and all the attendant mountains must be respected, honored and protected for they, as leaders, are the foundation of the Navajo Nation; and
- All creation, from Mother Earth and Father Sky to the animals, those who live in water, those who fly and plant life have their own laws, and have rights and freedom to exist; and
- The Diné have a sacred obligation and duty to respect, preserve and protect all that was provided for we were designated as the steward of these relatives through our use of the sacred gifts of language and thinking; and
- Mother Earth and Father Sky are part of us as the Diné and the Diné are part of Mother Earth and Father Sky; The Diné must treat this sacred bond with love and respect without exerting dominance for we do not own our mother or father.
- The rights and freedoms of the people to the use of the sacred elements of life as mentioned above and to the use of the land, natural resources, sacred sites and other living beings must be accomplished through the proper protocol of respect and offering and these practices must be protected and preserved for they are the foundation of our spiritual ceremonies and the Diné life way; and
- It is the duty and responsibility of the Diné to protect and preserve the beauty of the natural world for future generations.

This section identifies the RAOs for the site. The RAOs are based on the RSE results, the subsequent human health and ecological risk assessments described in Section 2, CERCLA requirements, and the site ARARs.

The RAOs for the site include the following:

- Prevent exposure to soil with mining-related contaminants above risk-based action levels from historical mining activities that would pose an unacceptable risk to human health with the reasonably anticipated future land use and traditional Navajo lifeways.
- Prevent exposure to soil with mining-related contaminants above risk-based action levels from historical mining activities that would pose an unacceptable risk to plants, animals, and other ecological receptors
- Prevent offsite migration of mining-related contaminants above risk-based action levels from historical mining activities to surface water, groundwater, or air that pose an unacceptable risk to human health.

3.2 Statutory Limits on Response Actions

Pursuant to CERCLA Section (§) 104(c)(1), the normal statutory limits for CERCLA actions of $2 million and 12 months do not apply, because the response action will be funded by a responsible party and not by the Superfund.

Once the Ruby Mines ASAOC and EE/CA are finalized, the design and implementation of the response action will fall under the CD in United States v. Cyprus Amax Minerals Co., No. 17-00140-PHX-DLR (D. Ariz.) (U.S. EPA, 2017d). Under the CD, the responsible parties' obligations to perform the required activities are subject to an annual spending cap of $25 million, adjusted for inflation as provided in the CD. The CD provides an annual planning process with review and comment by the NNEPA, whereby U.S. EPA determines which activities will be performed in the following 3 years.

3.3 Response Scope

The scope of the response action will be to address soil or other surficial contamination with mining-related COCs greater than cleanup goals at the Ruby Mines Site and for that to be the final action at the site. Post-removal-action site controls will be part of the analysis for any alternative that does not include complete removal of contaminants offsite.

3.4 Response Schedule

U.S. EPA's NTCRA Guidance (1993) requires public engagement in the form of community relations activities (including designating a Community Relations Spokesperson, conducting community interviews, preparing a Community Relations Plan, establishing an information repository, and providing Public Notice of the EE/CA's availability) and administrative record requirements. This includes establishing the administrative record file, publishing notice of the administrative record file's availability, holding a 30-day public comment period, and developing written responses to significant comments. In this way, Navajo Chapter and NNEPA input will be considered in selecting a preferred alternative. U.S. EPA will then publish an action memorandum to provide a written record of the decision to select an appropriate response action. U.S. EPA will notify the public of the schedule of the response action design and implementation upon issuance of the action memorandum.

4. Identification and Analysis of Response Action Alternatives

As part of the planning stage (nahat'á), all possible solutions are considered that may resolve the problem and its consequences. These possibilities are identified in this section and evaluated based on their effectiveness, feasibility, and cost, while balancing Navajo principles of balance and harmony, sustainability, and connectedness.

4.1 Development and Screening of Alternatives

U.S. EPA guidance (1993) for preparing EE/CAs advises identifying and assessing a focused number of alternatives that pass a prescreening for suitability. Table 4-1 presents the screening results for the plausible alternatives identified.

4.1.1 Treatment

CERCLA and the NCP express a preference for treatment that significantly and permanently reduce the toxicity, mobility, or volume of contaminants in selecting remedial actions, where such treatments are practicable. See CERCLA Section 121(b) and 40 CFR Section 300.430(a)(1)(iii). See also U.S. EPA Guidance on Principal Threat and Low-Level Threat Waste (1991 Guidance), describing how to identify wastes that may be appropriate for treatment. Principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health, or the environment should exposure occur.

U.S. EPA fully considered whether the Site contained any principal threat waste, whether the waste could safely be contained using engineering controls, and whether any treatment options may be practicable for the waste at the Site. As a result of its investigation and analysis, U.S. EPA concluded that although some individual samples at the Site contained higher levels of contaminants, the waste at the Site was variable and heterogeneous and U.S. EPA found no distinct areas of waste rock that were clearly distinguishable as meeting the definitions of principal threat waste in the 1991 Guidance. However, to be consistent with its preference for treatment, U.S. EPA did fully evaluate a complete range of treatment options.

The potential treatment options were evaluated based on site-specific criteria and included phytoremediation, soil washing, ablation, milling, acid extraction, stabilization, and solidification. Phytoremediation uses plants to remove contaminants. Soil washing, ablation, and milling employ physical means to remove contaminants. Acid extraction removes contaminants with an acetic solution that increases the contaminant's solubility. Stabilization is a process that reduces leaching in chemically bound material, and solidification is a process that encapsulates waste to form a solid material.

Each of the described treatment options were assessed based on their effectiveness and implementability on a site-specific basis. A technology or treatment option can be eliminated from further consideration if it does not meet the effectiveness or implementability criteria. Treatment options may be used alone or in combination to manage COCs throughout the site. Although some treatment options may address one or more COCs, unless COCs and the associated radioactivity can be treated and attenuated to achieve cleanup goals, the treatment option would be deemed impracticable because the treated waste would still require containment or disposal to shield the radioactivity. In fact, the total volume of waste requiring disposal for many options would either remain unchanged or increase because of the addition of water, binding agents, or chemicals.

The Ruby Mines are located in an arid region; water is a scarce resource on the Navajo Nation and must be either purchased and trucked in or extracted from a new 700- to 1,500-foot construction well, if allowed, by the Navajo Nation. Treatment methods requiring large quantities of water, such as soil washing, acid extraction, solidification, and stabilization, would place additional demand beyond what is already needed for construction dust suppression during waste excavation, loading, and stockpiling. The additional resource and cost impact is prohibitive. In addition, slurry and backfill of mine voids, while not a treatment option, would also require a significant volume of water. Wastewater generated from treatment processes would require additional treatment, and concentrates would require disposal; the additive cost of these treatments is impracticable.

With respect to particle size distribution, mine wastes generally consist of blasted sandstone bedrock, with particle sizes ranging from medium sand to gravels, which are significantly greater than clay and silt fines typical of sediments. Further, the uranium mineralization is located on the surface of the sand grains and not in fines or solution. An unpublished ablation bench scale treatability study conducted by DISA, Inc. for NNEPA demonstrated that fines comprise only 5% of total waste in the feed stock. As a result, uranium removal based solely on particle size separation (screening, sieving, flotation, and cyclone) is not a viable technological approach. Only in combination with ablation, which physically removes uranium mineral deposits from the surface of sand grains, would the cleanup goal be achieved. Ablation, as a standalone technology, is currently being evaluated in a pilot study.

The treatment evaluation concluded that no currently available treatment options are practicable at the Ruby Mines Site as follows:

- **Phytoremediation** is a treatment process that uses plants to absorb radionuclides and metals. This and similar alternative treatment methods were considered but screened out as infeasible for the site. Much of the contamination at the site is located in piles, and not all of the waste would be easily accessible by plant roots. Moreover, because radionuclides and metals cannot be biodegraded, plants used in phytoremediation must be harvested and sent for disposal as a radioactive waste, and prevention of human or animal consumption of the plants would be necessary. To use this treatment option, waste would have to be spread out over a very large area to achieve a workable depth, which would further contaminate additional areas. Phytoremediation has not been shown to reduce Ra-226 concentrations in mining waste to the extent needed to meet the cleanup goals. Because of the limited planting area, limited access, limited depth of root penetration, and harvested material handling requirements, phytoremediation was determined not to be practicable.
- **Soil washing** is a treatment process that involves washing the contaminated waste (with water) in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires that contaminants be readily soluble in water and sized sufficiently small so that dissolution can be achieved within a practical retention time. The most common forms of uranium oxides attached to sand particles in waste rock at the site have low solubility in water, rendering soil washing ineffective for removal to below cleanup goals. Solubility of other metals depends on the forms of the metals present in the waste and can range from highly soluble to insoluble. Insoluble metals in the waste would not be treated. Highly soluble metals in the wash solution are then precipitated as insoluble compounds, and the treated solids are dewatered. Additionally, the precipitates may form a sludge requiring additional treatment, such as dewatering or stabilization, before disposal. Dewatered precipitates and sludge must be disposed of at a mill, a Resource Conservation and Recovery Act facility, or a low-level radioactive waste facility because of the concentrating radionuclides. Because of the low concentrations of uranium in the waste rock and varying solubilities at different pH ranges for radionuclides and metals, soil washing likely would not meet cleanup goals and was determined not to be practicable.
- **Acid extraction** is similar to soil washing except an acidic solution instead of water is applied to the waste rock or other contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of metal constituents would be solubilized. A broader range of contaminants is expected to be acid soluble at ambient conditions with acid extraction than with soil washing. Acid extraction would dissolve a portion of the mineralized uranium attached to the sand particles; however, some percentage could remain bound in the sand particles. Dissolved contaminants are subsequently precipitated for additional treatment and disposal. According to the uranium mineralization on the surface of sand particles in the waste rock and varying solubilities of radionuclides and metals at different pH ranges, acid extraction likely would not decrease concentrations of all contaminants below cleanup goals and was determined not to be practicable. In particular, acid extraction would not remove Ra-226, which is a primary risk driver.

- **Ablation** is a treatment technology that can be applied to sandstone-hosted uranium mineralization, where the uranium minerals form a crust on the sand grains. The ablation process mixes water and waste rock into a slurry that is injected into impact tank modules. The opposing slurry streams impact one another, and collisions between the sandstone particles and fragments within each stream result in disassociation of fine-grained, intergranular, and mineralized material (uranium minerals) from coarser-grained sands. Ablation technology has potential for treating waste rock with surface uranium mineralization with some small commercial systems in operation. Pilot-scale studies began in summer 2022 to test the feasibility of the technology at three areas on the Navajo Nation, including Church Rock, Quivira, and Cove Transfer Station No. 2. Ablation technologies have not demonstrated sufficient throughput to address a large volume of waste rock. One of the goals of the pilot studies is to evaluate scale-up designs and economics. If ablation is determined to be successful and scalable after the pilot study, then a future draft of the EE/CA may incorporate it as an alternative.
- **Milling** is an offsite commercial process that removes uranium through a combination of several methods, including pulverization and acid extraction. Concentrations of uranium in the waste rock at the site are low, so any processing would therefore yield only a minimal amount of uranium. Additionally, milling does not remove radium, and the resulting mill waste is neither less toxic nor less mobile than the source material. Thus, milling was determined not to be practicable for treating uranium mine waste.
- **Solidification** is a process whereby uranium minerals and soluble radionuclides and metals in mine waste are physically encapsulated to form a solid material to reduce contaminant leachability and mobility. However, solidification does not address radiation concerns. Solidification involves mixing the waste with a binder material, such as cement, fly ash, clay, or geopolymers. The binder material would have to be hauled to the site, and a batch plant would need to be set up to mix the binder with waste. The mixing process requires a large quantity of water for binding to occur; therefore, a water source must be developed or water must be imported from offsite. Once the material is solidified, it may be placed into a repository or in aboveground mine workings as stackable blocks; however, the volume of waste requiring disposal greatly increases because of the addition of binding agents. Furthermore, unless placed in a disposal cell or repository, the solidified material may break apart when exposed to freeze-thaw and precipitation, potentially increasing leachability. On- or offsite disposal options are just as protective for the original volume of waste and use fewer resources. As a result, solidification was determined not to be practicable.
- **Stabilization** is a process whereby uranium minerals and soluble radionuclides and metals in mine waste are chemically altered to reduce contaminant leachability and to reduce toxicity. However, stabilization does not address radiation concerns. Surface area, porosity, and permeability of waste are reduced to limit leaching. Stabilization involves mixing waste with a neutralizing material such as lime or fly ash and pozzolan or cement. The neutralizing material would have to be hauled to the site, and a batch plant would need to be set up to mix the material with waste. The mixing process requires a large quantity of water for the reaction to occur; therefore, a water source must be developed or water must be imported from offsite. Once the material is stabilized, it may be placed into a repository or in aboveground mine workings as a gravel admixture; however, the volume of waste requiring disposal increases because of the addition of neutralizing agents. Furthermore, unless placed in a disposal cell or repository, the stabilized material may break apart when exposed to freeze-thaw and precipitation, potentially increasing leachability. Onsite or offsite disposal options are just as protective for the original volume of waste and use fewer resources. As a result, stabilization was determined not to be practicable.

Having considered treatment options and concluded that treatment was impracticable, there is no need for further analysis of toxicity, mobility, or the cleanup volume to determine whether they could conceptually be categorized as principal threat waste. If the treatments discussed previously or any other treatment methods are shown to be effective and feasible before selecting a remedy, U.S. EPA will amend this analysis and consider such treatments. This would not require a re-evaluation of the site cleanup volume categorization as principal threat waste, because the goal of evaluating and selecting a preferred treatment would be achieved.

4.1.2 Alternative Development Summary

Six response action alternatives passed the pre-screening process and were identified for further evaluation in accordance with the Final EE/CA Work Plan (CH2M 2017). The six alternatives analyzed in this EE/CA are as follows:

1. No Action
2. Consolidate and Repair Existing Caps
3. Consolidate and Cap at Each Site
4. Consolidate and Cap at One Site (Ruby No. 1)
5. Regional Repository
    a. Excavate and Manage at Black Jack No. 1
    b. Excavate and Manage at Mac No. 1
6. Excavation and Off-Navajo Disposal

These alternatives are detailed in Sections 4.2.1 through 4.2.7.

4.1.3 Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA requires response actions to comply with ARARs. The ARARs evaluation is a two-part process to determine where a given requirement is applicable and, if applicable, whether it is both relevant and appropriate.

ARARs cover federal, tribal, and state environmental requirements and are used to (1) evaluate the appropriate extent of a response action at the site, (2) develop and evaluate response action alternatives, and (3) guide the implementation and operation of a response action. Section 300.415(j) of the NCP requires that "actions pursuant to CERCLA Section 106, shall, to the extent practicable, considering the exigencies of the situation, attain ARARs under federal or state environmental or facility siting laws."

4.1.4 Terms and Definitions

Applicable requirements: Environmental protection statutes and regulations that legally apply and specifically address a hazardous substance, contaminant, response action, location, or other circumstance at a CERCLA site.

Relevant and appropriate requirements: Environmental protection regulation statutes that are not legally applicable but address problems or situations similar to those encountered at the CERCLA site.

To be considered (TBC) information: Unpromulgated or unenforceable criteria, advisories, guidance, or standards that may be used if no potential ARARs are identified covering a particular situation, or if potential ARARs are determined not to be protective.

CERCLA actions may have to comply with several different types of requirements. For this reason, ARARs and TBCs are typically divided into three categories, which are defined as follows:

1. **Chemical-specific ARARs and TBCs:** Regulatory health- or risk-associated numerical values that govern acceptable concentrations of a chemical in environmental conditions, such as soil, well water, or air. The most stringent chemical-specific standard should be used in the case of a chemical having more than one requirement, or in the case of a mixture of chemicals, several chemical-specific requirements.

2. **Action-specific ARARs and TBCs:** Determined according to the specific technologies or activities taking place under each alternative. Each alternative has an individual, distinct list of action-specific ARARs, depending on the technologies and activities being implemented.

3. **Location-specific ARARs and TBCs:** Determined according to site-related characteristics, such as geology, floodplains, wetlands, sensitive ecosystems and habitats, and historical places.

Identifying and evaluating ARARs and TBCs is an iterative process that continues throughout the response process. The list of ARARs and TBCs and their relevance to the response action may change. ARARs and TBCs for the site are summarized in Appendix D.

4.2 Description of Alternatives

This section provides a fully detailed description of each alternative to be evaluated in the EE/CA for the Ruby Mines Site. The following subsections will summarize common elements for the alternatives, including unavoidable impacts and associated costs. The selected alternatives are further described in the following subsections:

1. Alternative 1 – No Action
2. Alternative 2 – Consolidate and Repair Existing Caps
3. Alternative 3 – Consolidate and Cap at Each Site
4. Alternative 4 – Consolidate and Cap at One Site (Ruby No. 1)
5. Alternative 5 – Regional Repository
6. Alternative 6 – Excavate and Manage Off-Navajo Disposal

4.2.1 Summary and Common Elements

Comprehensive planning will need to occur to develop work plans and detailed engineering design documents necessary to implement the response alternative. The planning phase will also include procurement for services and materials. It is assumed that the following work elements, at a minimum, would need to be completed for each alternative (except for Alternative 1 – No Action):

- Access approvals
- Consideration of traditional life ways, including ceremonies or other cultural events
- Cultural and biological surveys and associated approvals
- Transportation/traffic planning (safety precautions, road improvements, and traffic management), based on the import of borrow to the sites and the export of waste along the potential haul routes presented on Figures 4-1a, 4-1b, and 4-1c
- Erosion and stormwater control plans
- Work scheduling
- Air monitoring plans
- Sampling and analysis plans
- Quality control/quality assurance plans
- Site safety, health, and environmental protection plans
- Dust management plan
- Coordination with other Navajo Nation authorities, based on action-specific ARARs, which may include Land Development, Water Management, Fish and Wildlife, Navajo Tribal Utility Authority, Department of Labor, Heritage & Historic Preservation Department, and others, as appropriate.

4.2.2 Cap Design Criteria

Several alternatives being evaluated in this EE/CA incorporate a cap as part of the response action. This section discusses the conceptual model used for these alternatives.

Standards applicable to cap design will be confirmed following the EE/CA's finalization and will include determination of the following:

- Design life for cap integrity, in terms of years
- Limit on average release rate of Radon-222, in terms of picocuries per square meter per second
- Cover thickness required to inhibit water infiltration from precipitation to protect the waste rock and reduce the potential for leachate development
- Measures to limit erosion and biointrusion (invasion of species of plants, burrowing mammals, and invertebrates through protective barriers), including establishing proper drainage patterns and erosion control, and biointrusion controls on plant and animal activity
- Maximum slope to complement the intended end use of animal grazing while optimizing long-term monitoring and maintenance requirements
- Revegetation goals that are consistent with the projected future land use but are not an integral component in the cap design to achieve protectiveness
  - Revegetation should attempt to emulate the structure, function, diversity, and dynamics of native plant communities in the area, and be sustainable under typical climate patterns. Fencing will be us, as appropriate, to prevent use until vegetation has been established.

Final design parameters will be determined by U.S. EPA in consultation with the Navajo Nation.

4.2.3 Occupational Safety and Health Administration

Occupational Safety and Health Administration (OSHA) has promulgated standards for protection of workers who may be exposed to hazardous substances at Resource Conservation and Recovery Act or CERCLA sites (29 CFR Parts 1910.120 and 1926.65). U.S. EPA requires compliance with OSHA standards in the NCP (40 CFR 300.150), but not through the ARAR process. Therefore, OSHA standards are not considered ARARs. Although the requirements, standards, and regulations of OSHA are not ARARs, they will be complied with during the response action.

4.2.4 Earth Moving on Navajo Nation

Most alternatives being evaluated involve some degree of earth moving. The Navajo Department of Labor Relations and the Navajo Nation Department of Natural Resources must be notified any time earth moving is to occur on the Navajo Nation.

4.2.5 Alternative 1: No Action

4.2.5.1 Alternative 1 Summary

Under Alternative 1, no treatment, containment, or response action would occur at the Ruby Mines Site. The NCP requires the response action alternative to remain in the EE/CA process for comparative purposes, where it is used as a baseline against which other alternatives are compared.

4.2.5.2 Site Work Activities

This alternative has no associated site work activities. The capped waste rock piles will be left in place along with any impacted soils remaining on haul roads, in work and step-out areas, drainage channels, or at nearby vents.

4.2.5.3 Site Controls and Security

Since there are no associated work activities, no site controls or security measures will be required.

4.2.6 Alternative 2: Consolidate and Repair Existing Caps

4.2.6.1 Alternative 2 Summary

Alternative 2 is the simplest response action presented and achieves the RAOs with the least amount of impact to the community from hauling and truck traffic. Alternative 2 involves full excavation of contaminated material above the cleanup goals from areas surrounding capped waste rock piles (haul roads, work and step-out areas, drainage channels, vents), consolidating them within the footprint of the existing waste rock piles, and repairing the existing caps at Ruby Mines Nos. 1 and 3. The caps would continue to function as a source control mechanism and would include evapotranspirative cover systems that support vegetative growth, storage and release of precipitation, and reduce potential infiltration. The scope of work for this alternative includes the following:

- Establishing temporary haul road(s) and installing temporary work facilities (such as field office, restroom, and storage) and traffic controls
  - Temporary haul roads will follow existing access roads to each site but may require grading to accommodate standard dump trucks and excavation equipment.
- Repairing land subsidence (settlement and sinkage) at Ruby Mines No. 3 adit (RUBY-003)
- Removing or plugging bat gates at Ruby Mines Nos. 1 and 3 adits and the drainage pipes at RUBY-002 and RUBY-017
- Excavating impacted soils from impacted areas surrounding each waste rock pile and the RUBY-002, RUBY-004, and RUBY-019 vents (not shown) and placing them within the existing footprint of the nearest capped waste rock pile
- Establishing a source(s) to borrow soil (borrow source) to cover the waste rock piles and stabilize drainages
  - Backfilling of areas outside of waste rock pile (haul roads, work and step-out areas, drainage channels, and vents) is not anticipated to be required. Instead, excavated areas will be regraded to match surroundings. Excavation in these areas may result in the disturbance of currently vegetated areas, which could require multiple years to reestablish.
- Identifying a water source for dust suppression activities during construction
  - Water for dust suppression is not available onsite and will be hauled from offsite. This will require obtaining a Water Use Permit from the Navajo Nation Water Code.
- Covering consolidated impacted soils and the existing capped waste rock piles with a 2-foot-thick cover composed of clean soil and grading the cover to match the contours of capped waste rock pile
- Regrading, where necessary, to eliminate erosion around the perimeter of existing caps
- Repairing the existing stormwater drainage channels and adding new channels for erosion control
- Removing temporary haul road(s) and temporary utilities
- Revegetating and restricting access to disturbed areas with fencing until vegetation is well established (vegetation could require 5 to 10 or more years to reestablish)
- Inspecting, repairing, and reporting completed work annually, to include inspection of physical hazards that were previously closed
- Administrative controls

4.2.6.2 Site Work Activities

Site preparation will include conducting utility surveys to identify existing utilities in areas where work will occur, placing of temporary work facilities and staging or laydown areas to support work for the project duration, and placing stormwater management and erosion control best management practices (BMPs). The existing land survey will be confirmed or revised as necessary to accurately delineate the existing footprint of the capped waste rock pile and areas in need of repair. Cultural resources identified at Ruby Mines No. 3 will be fenced so that they are not disturbed by site work activities. An archeologist will be onsite to monitor the work.

Work will be completed using existing local access dirt and two track roads. Existing roads will need improvement for vehicle access, including the former haul road from Wolf Canyon Road to the waste rock pile at Ruby Mines No. 1, the two track road from Ruby Mines No. 1 to the RUBY-002 and RUBY-004 vents, the dirt access road from Wolf Canyon Road to RUBY-019, and the former haul road from State Highway 371 to the waste rock pile at Ruby Mines No. 3.

The land subsidence at Ruby Mines No. 3 will be addressed by reopening the decline, placing PUF, and placing and compacting approximately 50 cy of earth fill. PUF is a foam material that is poured over the bulkhead, allowed to set, and covered with fill. PUF is a stable compound that adheres to the existing structure and, upon solidification, is resistant to decay or erosion when isolated from sunlight. The remaining opening would be backfilled manually or with small excavation equipment. The previously installed bat gates at Ruby Mines Nos. 1 and 3 will be removed or plugged, as well as the two drainage pipes at RUBY-002 and RUBY-017.

Drainage channel improvements will be completed over an approximate length of 450 feet at Ruby Mines No. 1, and 375 feet at Ruby Mines No. 3. Hydraulic controls will be implemented to dissipate energy from runoff, and limited quantities of rip rap will be placed in drainage channel reaches identified as being more susceptible to long-term erosion.

Impacted soils at both sites that contain Ra-226 and metals at concentrations greater than the cleanup goals will be excavated and placed within the footprint of each capped area. Impacted soil areas include portions of former haul roads, former work areas, step-out areas, and drainage channels. Soil will be excavated where sampling results demonstrate concentrations greater than the cleanup goals and include 37,500 cy of impacted soil from Ruby Mines No. 1; 500 cy of impacted soil from the RUBY-002, RUBY-004, and RUBY-019 vents; and 44,000 cy of impacted soil at Ruby Mines No. 3. Management of these volumes of impacted soils (approximately 5,000 truckloads, based on 16-cy dump trucks) will require local hauling only (less than 3 miles) from the areas of impact to the capped waste rock piles. This alternative will not involve hauling impacted soils along main roads or highways where people currently live. To the extent possible, existing vegetation in impacted areas will be preserved. Following excavation, confirmation testing of soils in each identified impacted soil area will be conducted. Confirmation soil testing is a method of analysis used to verify removal of soil with concentrations exceeding the cleanup goals.

The excavated soils will be placed within the existing footprint of the capped waste rock piles. Existingcapped waste rock piles will then be covered with clean soil as a vegetation growth medium that would function as an evapotranspirative cover system and graded to the contours of the waste rock cap. The thickness will be sufficient to reduce the radon release rate to less than an average of 20 pCi per square meter per second, as specified in CFR Title 40, Part 192.02. The soil cover thickness is also sufficient thickness to function as an evapotranspirative cover that will support native vegetation and reduce water infiltration from precipitation and thereafter reduce the potential for infiltration (U.S. EPA 2011).

Alternative 2 would require 14,700 cy of imported soil cover at Ruby Mines No. 1 and 20,000 cy at Ruby Mines No. 3. Approximately 2,200 truckloads (based on 16-cy dump trucks) of clean soil would be imported from a borrow source, assumed to be located in Gallup approximately 45 miles from the site, translating to 198,000 roundtrip truck-miles on interstate, county, and BIA roads and the former haul roads. It is assumed that trucks would operate 10 hours each day during this phase of work and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 28 to 36 days of continuous material hauling and up to 80 trucks per day. Engineering judgment suggests that 6,000 gallons of water (two 3,000-gallon tanker trucks) will be required per day during material hauling for dust suppression, resulting in the need for up to 216,000 gallons of water (delivered by 72 tanker trucks).

The waste rock caps at both sites will be graded and vegetated to restore each site to a stable, natural state suitable for traditional uses. Grading will be completed to blend work areas with undisturbed surrounding terrain and facilitate stormwater drainage that is free of depression storage. It is assumed that a backfill volume of 20% will be required to regrade excavated areas to match surroundings.

Execution of this response action, inclusive of excavation and consolidation of impacted materials and placement of capping materials, is estimated to require approximately 4 months. The schedule is subject to be extended based on weather, including inaccessibility of heavy trucks along existing dirt roads after heavy rainfall.

Revegetation efforts will focus on establishing a plant community similar to a surrounding reference area in structure, function, diversity, and dynamics. A seed mixture will be broadcast to encourage plant growth to maximize water removal and remain resilient when subjected to variable and unpredictable natural fluctuations and disturbances. Each capped waste rock pile will be fenced to prevent access until vegetation is reestablished, which could take up to 5 to 10 years.

Required plans will be completed. At a minimum, these will include surveys for biological and cultural resources (using existing information as applicable), stormwater pollution prevention plan (SWPPP), and spill prevention control and countermeasure plan (SPCC).

Post-construction monitoring and maintenance will consist of annual inspections to verify that erosion control measures remain effective and to document development of a stable vegetative cover over restored areas. This activity will extend over several years after construction.

4.2.6.3 Site Controls and Security

During repair and restoration activities, access will be restricted with temporary construction fencing to prevent people and domestic livestock from entering the construction area. Fugitive dust and general disturbance to the local community during restoration activities should be minimal; however, controls for managing fugitive dust will be implemented. Management of fugitive dust would be accomplished using water, which will require hauling to the site, resulting in additional truck traffic.

4.2.7 Alternative 3: Consolidate and Cap at Each Site

4.2.7.1 Alternative 3 Summary

Alternative 3 builds upon the response action presented in Alternative 2. It would achieve RAOs, reduce long-term monitoring and maintenance requirements, and involve a relatively low amount of hauling and truck traffic. Alternative 3 consists of full excavation of contaminated material above the cleanup goal from areas surrounding the waste rock piles (former haul roads, work and step-out areas, drainage channels, vents), and consolidating them within the existing waste rock cap areas, and placing an evapotranspirative cap over the piles. The cap would function as an evapotranspirative cover system that would support vegetative growth, store precipitation, reduce potential infiltration, and limit erosion. Figure 4-2 provides a cross-sectional view of the proposed conceptual design for the new waste rock cap. Refer to Figures 2-17 through 2-20 for location of haul roads, impacted soil areas to be excavated, drainage repairs, and capped area footprint.

The scope of work for this alternative includes the following:

- Establishing temporary haul road(s) and installing temporary work facilities and traffic controls
  - Temporary haul roads will follow existing access roads to each site but may require grading to accommodate standard dump trucks and excavation equipment.
- Repairing land subsidence (settlement/sinkage) at Ruby Mines No. 3 adit (RUBY-003)

- Removing or plugging bat gates at Ruby Mines Nos. 1 and 3 adits and the drainage pipes at RUBY-002 and RUBY-017
- Excavating impacted soils from impacted areas surrounding each waste rock pile and the RUBY-002, RUBY-004, and 019 vents (not shown) and placing within the footprint of the nearest capped waste rock pile
- Establishing a source(s) to borrow (borrow source) soil and rock fill (borrow material) to cap the waste rock piles and stabilize drainages
  - Backfilling of areas outside of waste rock piles (haul roads, work and step-out areas, drainage channels, and vents) is not anticipated to be required. Instead, excavated areas will be regraded to match surroundings. Excavation in these areas may result in the disturbance of currently vegetated areas, which could require three or more years to reestablish.
- Identifying a water source for dust suppression activities during construction
  - Water for dust suppression is not available onsite and will be hauled from offsite. This will require obtaining a Water Use Permit from the Navajo Nation Water Code.
- Capping the consolidated waste rock piles at each site with an evapotranspirative cover
- Regrading the excavated areas and capped waste rock piles to stabilize slopes, implementing hydraulic controls, and establishing appropriate stormwater drainage channels, including required erosion control measures
- Removing temporary haul road(s) and temporary utilities
- Revegetating and restricting access in disturbed areas with fencing (vegetation may take up to 5 to 10 or more years to reestablish)
- Inspecting, repairing, and reporting completed work annually, to include inspection of physical hazards that were previously closed
- Administrative controls

4.2.7.2 Site Work Activities

Site preparation will include conducting utility surveys to identify existing utilities in areas where work will occur, placing temporary work facilities and staging or laydown areas to support work for the duration of the project, and placing stormwater management and erosion control BMPs. The existing land survey will be confirmed or revised as necessary to accurately delineate the existing footprint of capped waste rock piles and areas in need of repair. Cultural resources identified at Ruby Mines No. 3 will be temporarily fenced so that they are not disturbed by site work activities. An archeologist will be onsite to monitor the work.

Work will be completed using existing local access dirt and two track roads. Existing roads will need improvement for vehicle access, including the former haul road from Wolf Canyon Road to the waste rock pile at Ruby Mines No. 1, the two track road from Ruby Mines No. 1 to the RUBY-002 and RUBY-004 vents, the dirt access road from Wolf Canyon Road to RUBY-019, and the former haul road from State Highway 371 to the waste rock pile at Ruby Mines No. 3.

The land subsidence at Ruby Mines No. 3 will be addressed by reopening the decline, placing PUF, and placing and compacting of approximately 50 cy of earth fill. The remaining opening would be backfilled manually or with small excavation equipment. The previously installed bat gates at Ruby Mines Nos. 1 and 3 will be removed or plugged, as will the two drainage pipes at RUBY-002 and RUBY-017.

Impacted soils at both sites that contain Ra-226 and metals at concentrations greater than the cleanup goals will be excavated and placed within the footprint of each capped area. Impacted soil areas include portions of the former haul roads, former work and step-out areas, and drainage channels. Soil will be excavated where sampling results demonstrate concentrations greater than the cleanup goals and include

37,500 cy of impacted soil from Ruby Mines No. 1; 500 cy of impacted soil from the RUBY-002, RUBY-004, and RUBY-019 vents; and 44,000 cy of impacted soil at Ruby Mines No. 3. Managing these volumes of impacted soils (approximately 5,000 truckloads, based on 16-cy dump trucks) will require local hauling only (less than 3 miles) from the area of impact to the capped waste rock piles. This alternative will not involve hauling impacted soils along main roads or highways where people currently live. To the extent possible, existing vegetation in impacted areas will be preserved. Following excavation, confirmation testing of soils in each identified impacted area will be conducted to verify removal of soil with concentrations exceeding the cleanup goals.

Following placement of soils from impacted areas, an evapotranspirative cap (assumed to be 3-feet thick for evaluation in this EE/CA) will be placed at each site (Figure 4-2). Each cap will include a layer of soil as a vegetation growth medium that would function as an evapotranspirative cover system. The soil cover is assumed to be sufficient to reduce the radon release rate to acceptable levels less than an average of 20 pCi per square meter per second, as specified in CFR Title 40, Part 192.02. The evapotranspirative cover thickness is also sufficient to support native vegetation and reduce the infiltration of water from precipitation and reduce the potential for infiltration.

Approximately 22,000 cy of fill material will be placed for the Ruby Mines No. 1 cap, and 30,000 cy for the Ruby Mines No. 3 cap. Soil material will be clean (having constituent levels at or less than the background threshold value) and will require minimal mechanical processing to be made suitable for use as cover material. Approximately 3,300 truckloads (based on 16-cy dump trucks) of clean soil will be imported from a borrow source, assumed to be located in Gallup approximately 45 miles from the site, translating to 297,000 roundtrip truck-miles on interstate, county, BIA, and the former haul roads. It is assumed that trucks would operate 10 hours each day during this phase of work and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 41 to 55 days of continuous material hauling and up to 80 trucks per day. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 330,000 gallons of water (delivered by 110 tanker trucks).

Drainage channels on the top of and around the perimeter of each newly constructed cap will be incorporated. Drainage channel improvements, including hydraulic controls, will be completed over an approximate length of 450 feet at Ruby Mines No. 1 and 375 feet at Ruby Mines No. 3. Rip rap will be placed in select drainage channel reaches that are more susceptible to long-term erosion.

The waste rock evapotranspirative caps at both sites will be finally graded and vegetated to restore each site to a stable, natural state suitable for traditional uses. Grading will be completed to blend work areas with undisturbed surrounding terrain and facilitate stormwater drainage that is free of depression storage. It is assumed that a backfill volume of 20% will be required to regrade excavated areas to match surroundings.

Execution of this response action, inclusive of excavating and consolidating impacted materials and placing capping materials, is estimated to require 7 months. The schedule is subject to be extended based on weather, including inaccessibility of heavy trucks along existing dirt roads after heavy rainfall.

Revegetation efforts will focus on establishing a plant community similar to the surrounding reference area in structure, function, diversity, and dynamics. A seed mixture will be broadcast to encourage plant growth to maximize water removal and remain resilient when subjected to variable and unpredictable natural fluctuations and disturbances. Each cap will be fenced to prevent access until vegetation is reestablished, which may require 5 to 10 years.

Required plans will be completed. At a minimum, these will include surveys for biological and cultural resources (using existing information as applicable), SWPPP, and SPCC.

Post-construction monitoring and maintenance will consist of annual inspections to verify that erosion control measures remain effective and to document development of a stable vegetative cover over restored areas. This activity will extend over several years after construction.

4.2.7.3 Site Controls and Security

During repair and restoration activities, access will be restricted with temporary construction fencing to prevent people and domestic livestock from entering the construction area. Fugitive dust and general disturbance to the local community during restoration activities should be minimal; however, controls for managing fugitive dust will be implemented. Fugitive dust management is accomplished using offsite water, which will require hauling to the site, resulting in additional truck traffic.

4.2.8 Alternative 4: Consolidate and Cap at One Site (Ruby No. 1)

4.2.8.1 Alternative 4 Summary

Alternative 4 includes removing waste rock and impacted soil from one site, hauling it to the other site, and constructing a cap at the other site comparable to Alternative 3. Alternative 4 achieves RAOs and reduces long-term monitoring and maintenance requirements; however, it will have a greater amount of hauling and truck traffic during implementation than Alternatives 2 or 3. Alternative 4 consists of consolidating waste rock from Ruby Mines No. 3 and fully excavating contaminated material above the cleanup goal from areas surrounding both capped waste rock piles (former haul roads, work and step-out areas, drainage channels, vents); consolidating within the existing waste rock pile at Ruby Mines No. 1; and placing a cap layer over the consolidated materials. The cap would function as an evapotranspirative cover system that would support vegetative growth, store precipitation, and reduce potential infiltration. Ruby Mines No. 1 is the preferred site for waste consolidation, based on its reduced aerial footprint, storage capacity, and constructability.

Figure 4-3 provides the footprint of the new capped waste rock pile at Ruby Mines No. 1. Refer to Figure 4-2 for a cross-sectional view of the proposed conceptual design for the new waste rock cap.

The scope of work for this alternative includes the following:

- Establishing temporary haul road(s) and installing temporary work facilities and traffic controls
  - Temporary haul roads will follow existing access roads to each site but may require grading to accommodate standard dump trucks and excavation equipment. Figure 4-1a presents potential haul roads from the Ruby Mines Sites, however, these are subject to change during the design phase
- Repairing land subsidence (settlement/sinkage) at Ruby Mines No. 3 adit (RUBY-003)
- Preparing Ruby Mines No. 1 to receive waste rock from Ruby Mines No. 3
- Removing or plugging bat gates at Ruby Mines Nos. 1 and 3 adits and the drainage pipes at RUBY-002 and RUBY-017
- Excavating waste rock from Ruby Mines No. 3 and impacted soils from areas surrounding each waste rock pile and the RUBY-002, RUBY-004, and RUBY-019 vents (not shown)
  - These excavated materials would be transported to Ruby Mines No. 1 and placed within the footprint of the existing impacted area (Figure 4-3).
- Establishing a borrow source(s) for soil and rock fill to cap Ruby Mines No. 1 and stabilizing drainages and backfill, as necessary, at Ruby Mines No. 3 to establish stable slopes and proper drainage
- Identifying a water source for dust suppression activities during construction
  - Water for dust suppression is not available onsite and will be hauled from offsite. This will require obtaining a Water Use Permit from the Navajo Nation Water Code.
- Backfilling areas outside of waste rock piles not anticipated

  - Excavated areas will be regraded to match surroundings. It is assumed that 26,000 cy of backfill (representing approximately 20 percent of the excavation volume of Ruby Mines No. 3) will be required to facilitate regrading.
- Capping the consolidated waste rock piles at Ruby Mines No. 1 with a cap that would consist of an evapotranspirative cover system
- Regrading the excavated areas (including the Ruby Mines No. 1 area) and capped waste rock piles to stabilize slopes and establishing proper stormwater drainage channels, including hydraulic controls and erosion control measures
- Removing temporary haul road(s) and temporary work facilities
- Revegetating and restricting access to disturbed areas with fencing
  - Vegetation could require 5 to 10 or more years to reestablish.
- Inspecting, repairing, and reporting completed work annually, to include inspection of physical hazards that were previously closed
- Administrative controls

4.2.8.2 Site Work Activities

Site preparation will include conducting utility surveys to identify existing utilities in areas where work will occur, placing temporary work facilities and staging or laydown areas to support work for the duration of the project, and placing stormwater management and erosion control BMPs. The existing land survey will be confirmed or revised as necessary to accurately delineate the existing footprint of capped waste rock piles and areas in need of repair. Cultural resources identified at Ruby Mines No. 3 will be fenced off so that they are not disturbed by site work activities. An archeologist will be onsite to monitor the work.

Work will be completed using existing local access dirt and two-track roads. Existing roads will need significant improvement to accommodate the increased traffic associated with moving waste from Ruby Mines No. 3 to Ruby Mines No. 1. Specifically, substantial improvements will be required for the former haul road from Wolf Canyon Road to the waste rock pile at Ruby Mines No. 1, the two-track road from Ruby Mines No. 1 to the RUBY-002 and RUBY-004 vents, the dirt access road from Wolf Canyon Road to RUBY-019, and the former haul road from State Highway 371 to the waste rock pile at Ruby Mines No. 3.

The land subsidence at Ruby Mines No. 3 will be addressed by reopening the decline, placing PUF, and placing and compacting approximately 50 cy of earth fill. The remaining opening would be backfilled manually or with small excavation equipment. The previously installed bat gates at Ruby Mines Nos. 1 and 3 will be removed or plugged, as will the two drainage pipes at RUBY-002 and RUBY-017.

Waste Rock at Ruby Mines No. 3 and impacted soils at Ruby Mines Nos. 1 and 3 sites that contain Ra-226 and metals at concentrations greater than the cleanup goals will be excavated and placed within the footprint of each capped area. Impacted soil areas include portions of the former haul roads, former work and step-out areas, and drainage channels. Soil will be excavated from areas where sampling results demonstrate concentrations greater than the cleanup goals and include 37,500 cy of Ruby Mines No. 1; 500 cy of soil from the RUBY-002, RUBY-004, and RUBY-019 vents; and waste rock and surrounding impacted soil from Ruby Mines No. 3 (174,000 cy). The waste rock and impacted soil would be transported to Ruby Mines No. 1. Loading of bulk-carriers for waste transport will take place in designated areas to avoid tracking materials offsite. To the extent possible, existing vegetation in impacted areas will be preserved during excavation. Following excavation, confirmation testing of soils will be conducted to verify removal of soil with concentrations exceeding the cleanup goals.

Unlike Alternatives 2 and 3, Alternative 4 requires the transport of waste rock and impacted soil from Ruby Mines No. 3 to Ruby Mines No. 1. Waste hauling will contribute to increased traffic on both local roads and public highways, and hauling impacted soils and waste rock along roads where people live. Transportation of waste rock and impacted soil is expected to require approximately 10,875 truckloads (based on 16-cy dump trucks) traveling along the 12-mile haul route, translating to 261,000 roundtrip truck-miles between Ruby Mines No. 3 and Ruby Mines No. 1 along dirt roads, State Highway 371, and BIA 49. It is assumed that trucks would operate 10 hours per day and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 136 to 181 days of continuous impacted material hauling and up to 80 trucks per day. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 1,086,000 gallons of water (delivered by 362 tanker trucks).

The extent of the consolidated waste rock pile at Ruby Mines No. 1 will generally be contained within the estimated limits of impacted soils (Figure 4-3). Following placement of waste rock and impacted soils, a cap will be placed at the new Ruby Mines No. 1 consolidated waste rock pile. The cap will include a sufficient thickness of soil as a vegetation growth medium (assumed to be 3 feet). The soil cover is assumed to be sufficient to reduce the radon release rate to acceptable levels less than an average of 20 pCi per square meter per second, as specified in CFR Title 40, Part 192.02. The soil cover thickness is also assumed to be sufficient to reduce the water infiltration from precipitation and reduce the potential for infiltration. That is, the cap will be designed as an evapotranspiration cover, which typically ranges from 2 to 10 feet in thickness (U.S. EPA 2011).

Approximately 72,600 cy of fill material will be placed for the consolidated Ruby Mines No. 1 cap. Following removal of waste rock, the Ruby Mines No. 3 site will be restored to match the natural and surrounding grade by placing and grading clean backfill to establish adequate drainage. An additional 26,000 cy of backfill will be required to backfill and regrade Ruby Mines No. 3. Soil borrow material will be clean (having constituent levels at or less than the background threshold value) and will require minimal mechanical processing to be made suitable for use as cover material. Approximately 6,200 truckloads (based on 16-cy dump trucks) of clean borrow material will be imported from a borrow source, assumed to be located in Gallup approximately 45 miles from the site, translating to 558,000 roundtrip truck-miles on interstate, county, BIA, and the former haul roads. It is assumed that trucks would operate 10 hours each day during this phase of work and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 78 to 103 days of continuous material hauling and up to 80 trucks per day. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 620,000 gallons of water (delivered by 206 tanker trucks).

Drainage channels on top of and around the perimeter of the newly constructed cap will be established, over a total length of approximately 4,000 feet. Hydraulic controls will be implemented to dissipate energy from runoff, and rip rap will be placed in select drainage channel reaches that are more susceptible to long-term erosion.

The consolidated and capped waste rock pile at Ruby Mines No. 1 will be regraded and vegetated to restore the site to a stable, natural state suitable for traditional uses. Grading will be completed to blend work areas with undisturbed surrounding terrain and to facilitate stormwater drainage that is free of depression storage. It is assumed that a backfill volume of 20% will be required to regrade excavated areas to match surroundings.

Execution of this response action, inclusive of excavation and consolidation of impacted materials and placement of capping materials, is estimated to require approximately 4 years to complete. During periods with snowfall (typically November through March), local roads and former haul roads may not be not passable. During this time, estimated to be approximately 4 months of the year, construction will be stopped and contractors will be demobilized. In the event of construction occurring over multiple field seasons, the site will be temporarily restored sufficiently to minimize exposure and potential migration while work is suspended. The schedule may also be extended based on weather, including inaccessibility of heavy trucks along existing dirt roads after heavy rainfall.

Revegetation efforts will focus on establishing a plant community similar to the surrounding reference area in structure, function, diversity, and dynamics. A seed mixture will be broadcast to encourage plant growth to maximize water removal and remain resilient when subjected to variable and unpredictable natural fluctuations and disturbances. Disturbed areas and the consolidated waste rock pile at Ruby Mines No. 1 will be fenced to prevent access until vegetation is reestablished, which may require 5 to 10 years.

Required plans will be completed. At a minimum, these will include surveys for biological and cultural resources, SWPPP, and SPCC.

Post-construction monitoring and maintenance will consist of annual inspections to verify that erosion control measures remain effective and to document development of a stable vegetative cover over restored areas. This activity will extend over several years after construction.

4.2.8.3 Site Controls and Security

During repair and restoration activities, access will be restricted with temporary construction fencing to prevent people and domestic livestock from entering the construction area. Fugitive dust and general disturbance to the local community during restoration activities should be minimal; however, controls for managing fugitive dust will be implemented. Management of fugitive dust is accomplished using offsite water, which will require hauling to the site, resulting in additional truck traffic.

4.2.9 Alternative 5: Regional Repository

4.2.9.1 Alternative 5 Summary

Alternative 5 includes the full excavation of contaminated material above the cleanup goal from both sites and hauling to one or more regional repositories located on the Navajo Nation lands, in cooperation with other mining site parties. Two regional repository alternatives are evaluated herein: (5a) two regional repositories and (5b) one regional repository for all mining waste sites in the area. For scenario 5a, it is assumed that two regional repositories will be established. The first will be located at Mac No. 1 and will include waste rock and impacted soils from Mac No. 1, Mac No. 2, Black Jack No. 2, and Mariano Lake. The second will be located at Black Jack 1 No. 1 to include waste rock and impacted soil from Black Jack No. 1, Ruby Mines No. 1, and Ruby Mines No.3. For scenario 5b, it is assumed that one 1,400,000-cy repository will be established at Mac No. 1 and will include waste rock and impacted soil from all of the mine sites (Mac No. 1, Mac No. 2, Black Jack No. 1, Black Jack No. 2, Mariano Lake, Ruby Mines No. 1 and Ruby Mines No. 2). For the purposes of this evaluation, Alternatives 5a and 5b are evaluated for disposal of waste rock and impacted soil only from the Ruby Mines Site. If a shared concept is selected, then additional information would be required to fully evaluate this alternative.

Alternative 5 achieves the RAOs and reduces long-term monitoring and maintenance requirements at the Site; however, long-term maintenance of the regional repository will be required. Alternative 5 requires a greater amount of hauling and truck traffic during implementation than Alternatives 2, 3, or 4.

Alternative 5 consists of excavating and hauling waste rock and impacted soils (areas surrounding capped waste rock piles [haul roads, work and step-out areas, drainage channels, vents] that have Ra-226 and metals concentrations above cleanup goals) to an on-Reservation regional repository. This alternative involves transporting waste on existing roads across 5 miles (from Ruby Mines No. 1) to 8 miles (from Ruby Mines No. 2) (average of 7 miles), one way, to Black Jack No. 1 (scenario 5a) or 3 miles (from Ruby Mines No. 1) to 15 miles (from Ruby Mines No. 2) (average of 9 miles), one way, to Mac No. 1 (scenario 5b). Following waste placement, a cap layer would be constructed over the consolidated materials. Similar to Alternatives 3 and 4, the cap would function as an evapotranspirative cover system that would support vegetative growth and store precipitation and reduce potential infiltration (Figure 4-2).

The scope of work for this alternative includes the following:

- Coordinating with other mining site parties to confirm siting of the new repository, in cooperation with Navajo Nation authorities
  - Complete site investigation of the proposed repository site(s)

  - Complete engineering design for the construction of the repository and addressing relevant environmental regulatory criteria and site access requirements
  - Complete site grading, excavating, drainage, and utility work for the new repository
- Establishing temporary haul road(s) and installing temporary work facilities and traffic controls
  - Temporary haul roads will follow existing access roads to each site but may require grading to accommodate standard dump trucks and excavation equipment. Figure 4-1b presents potential haul roads from the Ruby Mines Sites; however, these are subject to change during the design phase.
- Repairing land subsidence (settlement/sinkage) at the Ruby Mines No. 3 adit (RUBY-003)
- Removing or plugging bat gates at Ruby Mines Nos. 1 and 3 adits and the drainage pipes at RUBY-002 and RUBY-017
- Excavating 164,000 cy of waste rock and impacted soil from Ruby Mines No. 1; 174,000 cy of waste rock and impacted soil from Ruby Mines No. 3; and 500 cy of impacted soil from RUBY-002, RUBY-004, and RUBY-019 vents and hauling the excavated material to the repository
- Establishing a local borrow source(s) for soil for backfill, as needed, to establish stable slopes and proper drainage at Ruby Mines Nos. 1 and 3 following removal of waste rock and impacted soil
  - Backfilling areas outside of the waste rock piles (former haul roads, work and step-out areas, drainage channels, and vents) is not anticipated to be required. Instead, excavated areas will be regraded to match surroundings. It is assumed that 51,600 cy of backfill (representing approximately 20% of the excavation volume of Ruby Mines Nos. 1 and 3) will be required to facilitate regrading.
- Identifying a water source for dust suppression activities during construction
  - Water for dust suppression is not available onsite and will be hauled from offsite. This will require obtaining a Water Use Permit from the Navajo Nation Water Code.
- Placing and grading the waste rock and soils within the new repository
- Capping the repository with an evapotranspirative cover system
  - This work element may be postponed, as needed, depending on the schedule for receipt of waste from the other mine sites.
- Establishing proper stormwater drainage channels, including hydraulic controls and erosion control measures
- Removing temporary haul road(s) and temporary utilities
- Revegetating and restricting access to disturbed areas with fencing
  - Vegetation could require 5 to 10 or more years to reestablish.
- Inspecting, repairing, and reporting completed work annually, to include inspection of physical hazards that were previously closed
- Administrative controls

4.2.9.2 Site Work Activities

Site preparation will include conducting utility surveys to identify existing utilities in areas where work will occur, placing temporary work facilities and staging or laydown areas to support work for the duration of the project, and placing stormwater management and erosion control BMPs. The existing land survey will be confirmed or revised as necessary to accurately delineate the existing footprint of capped waste rock pile and areas in need of repair. Cultural resources identified at Ruby Mines No. 3 will be fenced so that they are not disturbed by site work activities. An archeologist will be onsite to monitor the work.

Removal of waste from Ruby Mines Nos. 1 and 3 will be completed using existing local access dirt and two-track roads. Existing roads will need significant improvement to accommodate the increased traffic associated with transporting waste rock and impacted soil to the repository and hauling clean material to restore the site. Specifically, substantial improvements will be required for the following:

- Former haul road from Wolf Canyon Road to the waste rock pile at Ruby Mines No. 1
- Two-track road from Ruby Mines No. 1 to the RUBY-002 and RUBY-004 vents
- Dirt access road from Wolf Canyon Road to RUBY-019
- Former haul road from State Highway 371 to the waste rock pile at Ruby Mines No. 3
- Haul roads from BIA Route 49 to Black Jack No. 1 (for scenario 5a)
- Haul roads from Wolf Canyon Road to Mac No. 1 (for scenario 5b)

The land subsidence at Ruby Mines No. 3 will be addressed by reopening the decline, placing PUF, and placing and compacting approximately 50 cy of earth fill. The remaining opening would be backfilled manually or with small excavation equipment. The previously installed bat gates at the Ruby Mines Nos. 1 and 3 adits will be removed or plugged, as will the two drainage pipes at RUBY-002 and RUBY-017.

Siting of the repository will include a hydrogeologic investigation to confirm the location's suitability. This investigation will consist of surficial geologic mapping, test pit excavation and logging, borehole drilling and lithologic logging, material properties testing, and aquifer hydraulic properties testing.

The engineering design of the repository will address general site grading and drainage, repository cell design, site access, and utilities. Regional site conditions and the nature of the waste and impacted soils precludes the need for the repository to be lined at the base. Ra-226 and metals are immobile, as evidenced by the lack of vertical migration observed at the Site. Further, the depth to groundwater is approximately 500 feet below ground surface near the Navajo Nation. COC leaching to groundwater has not been observed since mining operations ceased more than 30 years ago in 1985 and is not reasonably anticipated. Therefore, in consideration of the details presented in Table 4-1 and Appendix E, this EE/CA assumes that a liner system is not required.

Excavation activities will remove waste rock and impacted soil containing Ra-226 and metals at concentrations greater than the cleanup goals, including approximately 164,000 cy from Ruby Mines No. 1; 500 cy near the RUBY-002, RUBY-004, and RUBY-019 vents; and approximately 174,000 cy at Ruby Mines No. 3. Following excavation, confirmation soil testing will be conducted to verify removal of soil with concentrations exceeding the cleanup goals.

Alternative 5 includes transporting waste rock and impacted soil from the Ruby Mines Site to the regional repository. Waste hauling will substantially increase traffic on both local roads and public highways. Transportation of waste rock and impacted soil is expected to require approximately 21,160 truckloads (based on 16-cy dump trucks) traveling along the haul routes from Ruby Mines Nos. 1 and 3 to the repository at either Black Jack No. 1 (scenario 5a, an average of 7 miles away) or Mac No. 1 (scenario 5b, an average of 9 miles away), translating to 296,200 roundtrip truck-miles for scenario 5a or 380,800 roundtrip truck-miles for scenario 5b. It is assumed that trucks would operate 10 hours per day and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 264 to 353 days of continuous impacted material hauling and up to 80 trucks per day. Excavated waste rock and impacted soil will be transported to the repository in accordance with applicable U.S. Department of Transportation regulations in standard dump trucks on local dirt, county, BIA, and interstate roads. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 2,118,000 gallons of water (delivered by 706 tanker trucks).

Following placement of waste rock and impacted soils at the regional repository, a cap will be placed, similar to Alternatives 3 and 4. The cap will include soil as a vegetation growth medium (assumed to be 3 feet). The soil cover is assumed to be sufficient to reduce the radon release rate to acceptable levels that will not to exceed an average of 20 pCi per square meter per second, as specified in CFR Title 40, Part 192.02. The soil cover thickness is assumed to be sufficient to reduce the infiltration of water from precipitation and reduce the potential for infiltration. That is, the cap will be designed as an evapotranspirative cover, which typically ranges from 2 to 10 feet in thickness (U.S. EPA 2011). Additionally, following the removal of waste rock, the Ruby Mines Nos. 1 and 3 Sites will be restored to match the natural and surrounding grade by placing and grading clean backfill to establish adequate drainage. Approximately 124,200 cy of soil and rock are required to backfill Ruby Mines No. 1 and 3 and construct the cap at the regional repository. Approximately 7,800 truckloads (based on 16-cy dump trucks) of clean soil borrow material will be imported from a borrow source, assumed to be located in Gallup approximately 45 miles from the site, translating to 702,000 roundtrip truck-miles along public highways. It is assumed that trucks would operate 10 hours per day and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 98 to 130 days of continuous impacted material hauling and up to 80 trucks per day. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 780,000 gallons of water (delivered by 260 tanker trucks).

Drainage channels on top of and around the perimeter of the newly constructed cap will be established. Hydraulic controls will be implemented to dissipate energy from runoff, and rip rap will be placed in select drainage channel reaches that are more susceptible to long-term erosion. The newly constructed cap will be regraded and revegetated to restore the site to a stable, natural state suitable for traditional uses. Grading will be completed to blend work areas with undisturbed surrounding terrain and facilitate stormwater drainage that is free of depression storage.

Final grading at Ruby Mines Nos. 1 and 3 will be completed to blend the two excavated areas with undisturbed surrounding terrain and facilitate stormwater drainage that is free of depression storage. It is assumed that a backfill volume of 20% will be required to regrade excavated areas to match surroundings. Revegetation efforts will focus on establishing a plant community similar to the surrounding reference area in structure, diversity, and dynamics. A seed mixture will be broadcast to encourage plant growth to maximize water removal and remain resilient when subjected to variable and unpredictable natural fluctuations and disturbances. Disturbed areas will be fenced to prevent access until vegetation is reestablished, which may require 5 to 10 years.

Execution of this response action, inclusive of excavation, transport, and placement of capping materials, is estimated to require approximately 7 years to complete. During periods with snowfall (typically November through March), local roads and former haul roads may not be not passable. During this time, estimated to be approximately 4 months of the year, construction will be stopped, and contractors will be demobilized. In the event of construction occurring over multiple field seasons, the site will be temporarily restored sufficiently to minimize exposure and potential migration while work is suspended. The schedule may also be extended based on weather, including inaccessibility of heavy trucks along existing dirt roads after heavy rainfall.

Required plans will be completed. At a minimum, these will include surveys for biological and cultural resources (using existing information as applicable), SWPPP, and SPCC.

Post-construction monitoring and maintenance will consist of annual inspections to verify that erosion control measures remain effective and to document development of a stable vegetative cover over restored areas. This activity will extend over several years after construction.

4.2.9.3 Site Controls and Security

During repair and restoration activities, access will be restricted with temporary construction fencing to prevent people and domestic livestock from entering the construction area. Fugitive dust and general disturbance to the local community during restoration activities should be minimal; however, controls for managing fugitive dust will be implemented. Fugitive dust management is accomplished using offsite water, which will require hauling to the site, resulting in additional truck traffic.

4.2.10 Alternative 6: Excavate and Manage Off-Navajo Disposal

4.2.10.1 Alternative 6 Summary

Alternative 6 includes removing waste rock and impacted soil from both sites. Alternative 6 achieves RAOs and eliminates long-term monitoring and maintenance requirements, but it has the most significant impact of any of the alternatives because of the amount of hauling and truck traffic during implementation. Alternative 6 consists of fully excavating contaminated material above the cleanup goal (areas surrounding capped waste rock piles [haul roads, work and step-out areas, drainage channels, vents) and hauling the material to a licensed, off-Reservation repository. Three repositories were considered for offsite disposal, including U.S. Ecology in Grandview, Idaho (835 road miles from the site), Clean Harbors in Deer Trail, Colorado (575 road miles from the site), and Waste Control Specialists in Andrews, Texas (500 road miles from the site).

EPA Region 9 evaluated Energy Fuels' White Mesa Mill near Blanding, Utah as a possible offsite waste disposal facility for CERCLA waste under this EE/CA. In an Off-Site Rule Verification (OSR) of Continued Acceptability letter dated January 13, 2023, EPA Region 8 found six of White Mesa Mills' seven waste management units to be Acceptable to receive CERCLA waste. In that same correspondence, Region 8, found that Cell 4B remained unacceptable to receive CERCLA waste until it returns to compliance with 40 CFR § 62.252(b). Further, EPA Region 8 raised additional concerns related to compliance with the OSR based on increasing groundwater quality issues. Specifically, the letter states that recent groundwater data collected by the Mill demonstrate over 300 instances of Ground Water Compliance Limit (GWCL) permit exceedances in the Mill's Point of Compliance monitoring wells located throughout the facility, and notes that concentrations above GWCLs of multiple contaminants resulted in reported out of compliance status for 11 point of compliance wells during the 2021-Q2 2022 timeframe. Region 9 has concluded that current corrective actions implemented by Energy Fuels to control known releases appear to be ineffective based on this information. As a result, EPA Region 9 does not believe that disposal at the White Mesa Mill is a viable CERCLA waste disposal facility for this EE/CA. EPA Region 9 may reconsider White Mesa Mill as a potential disposal facility when additional data is available to support a finding that disposal at this facility would be effective and protective.

For the purposes of this evaluation, it is assumed that waste will be transported and disposed of at the Clean Harbors facility in Deer Trail, Colorado.

The scope of work for this alternative includes the following:

- Coordinating with appropriate authorities for waste transport on public roads
- Establishing temporary haul road(s) and installing temporary work facilities and traffic controls
  - Temporary haul roads will follow existing access roads to each site, but may require grading to accommodate standard dump trucks and excavation equipment. Figure 4-1c presents potential haul roads from the Ruby Mines Sites; however, these are subject to change during the design phase
- Repairing land subsidence (settlement or sinkage) at Ruby Mines No. 3 adit (RUBY-003)
- Removing or plugging bat gates at Ruby Mines Nos. 1 and 3 adits and the drainage pipes at RUBY-002 and RUBY-017
- Excavating 164,000 cy of waste rock and impacted soil from Ruby Mines No. 1; 174,000 cy of waste rock and impacted soil from Ruby Mines No. 3, and 500 cy of impacted soil from RUBY-002, RUBY-004, and RUBY-019 vents and hauling the excavated material to the repository
- Establishing a local borrow source(s) for soil for backfill, as needed, to establish stable slopes and proper drainage at Ruby Mines Nos. 1 and 3 following removal of waste rock and impacted soil.
  - Backfilling areas outside of waste rock pile (former haul roads, work and step-out areas, drainage channels, and vents) is not anticipated to be required. Instead, excavated areas will be regraded to

match surroundings. It is assumed that 51,600 cy of backfill (representing approximately 20% of the excavation volume of Ruby Mines Nos. 1 and 3) will be required to facilitate regrading.

- Identifying a water source for dust suppression activities during construction
  - Water for dust suppression is not available onsite and will be hauled from offsite. This will require obtaining a Water Use Permit from the Navajo Nation Water Code.
- Regrading disturbed areas to stable slopes and establishing proper stormwater drainage channels, including erosion control measures
- Removing temporary haul road(s) and temporary utilities
- Revegetating and restricting access to disturbed areas with fencing
  - Vegetation could require 5 to 10 or more years to reestablish.
- Administrative controls

4.2.10.2 Site Work Activities

Site preparation will include conducting utility surveys to identify existing utilities in areas where work will occur, placing temporary work facilities and staging or laydown areas to support work for the duration of the project, and placing stormwater management and erosion control BMPs. The existing land survey will be confirmed or revised as necessary to accurately delineate the existing footprint of capped waste rock piles and areas in need of repair. Cultural resources identified at Ruby Mines No. 3 will be fenced so that they are not disturbed by site work activities. An archeologist will be onsite to monitor the work.

Work will be completed using existing local access dirt and two-track roads. Existing roads will need significant improvement to accommodate the increased traffic associated with transporting waste rock and impacted soil to an offsite repository and hauling clean material to restore the site. Specifically, substantial improvements will be required for the following:

- Former haul road from Wolf Canyon Road to the waste rock pile at Ruby Mines No. 1
- Two-track roads from Ruby Mines No. 1 to the RUBY-002 and RUBY-004 vents
- Dirt access road from Wolf Canyon Road to RUBY-019
- Former haul road from State Highway 371 to the waste rock pile at Ruby Mines No. 3

The land subsidence at Ruby Mines No. 3 will be addressed by reopening the decline, placing PUF, and placing and compacting approximately 50 cy of earth fill. The remaining opening would be backfilled manually or with small excavation equipment. The previously installed bat gates at the Ruby Mines Nos. 1 and 3 adits will be removed or plugged, as will the two drainage pipes at RUBY-002 and RUBY-017.

Excavation activities will remove waste rock and impacted soil containing Ra-226 and metals at concentrations greater than the cleanup goals, including approximately 164,000 cy from Ruby Mines No. 1; 500 cy near the RUBY-002, RUBY-004, and RUBY-019 vents; and approximately 174,000 cy at Ruby Mines No. 3. Following excavation, confirmation soil testing will be conducted to verify removal of soil with concentrations exceeding the cleanup goals.

Alternative 6 includes transporting waste rock and impacted soil from the Ruby Mines Site to an offsite repository. Waste hauling will substantially increase traffic on both local roads and public highways. Transportation of waste rock and impacted soil is expected to require approximately 18,800 truckloads (based on 27-ton dump trucks, rated for highway use) traveling along the 575-mile haul route to the repository, translating to 21,600,000 roundtrip truck-miles along public highways. It is assumed that trucks would operate 10 hours per day and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 235 to 313 days of continuous impacted material hauling and up to 80 trucks per day. Excavated waste rock and impacted soil will be transported to the repository in accordance with applicable U.S. Department of Transportation regulations in standard dump trucks on local dirt, county, BIA, and interstate roads to Clean Harbors in Deer Trail, Colorado (575 miles, one-way) for disposal. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 1,878,000 gallons of water (delivered by 626 tanker trucks).

Approximately 51,600 cy of fill material will be required to backfill Ruby Mines No. 1 and 3 to match the surrounding grade. Fill material will be clean (having constituent levels at or less than the background threshold value) and will require minimal mechanical processing to be made suitable for use as cover material. Approximately 3,225 truckloads (based on 16-cy dump trucks) of clean soil borrow material will be imported from a borrow source, assumed to be located in Gallup approximately 45 miles from the site, translating to 290,250 roundtrip truck-miles on interstate, regional county, and BIA roads and the former haul roads. It is assumed that trucks would operate 10 hours each day during this phase of work and that approximately 6 to 8 truckloads would be processed per hour, yielding approximately 40 to 54 days of continuous material hauling and up to 80 trucks per day. Engineering judgment suggests that 6,000 gallons (two 3,000-gallon tanker trucks) of water will be required per day during material hauling for dust suppression, resulting in the need for up to 324,000 gallons of water (delivered by 108 tanker trucks).

Final grading will be completed to blend excavated areas at the Ruby Mines Site with undisturbed surrounding terrain and facilitate stormwater drainage that is free of depression storage. It is assumed that a backfill volume of 20% will be required to regrade excavated areas to match surroundings. Revegetation efforts will focus on establishing a plant community similar to the surrounding reference area in structure, function, diversity, and dynamics. A seed mixture will be broadcast to encourage plant growth to maximize water removal and remain resilient when subjected to variable and unpredictable natural fluctuations and disturbances. Disturbed areas will be fenced to prevent access until vegetation is reestablished, which may require 5 to 10 years.

During periods with snowfall (typically November through March), local roads and former haul roads are not passable. During this time, estimated to be approximately 4 months of the year, construction will be stopped, and contractors will be demobilized. These conditions will extend the timeframe until this response action can be completed. The duration of construction activities for this alternative could be 34 years or more, as discussed in Section 4.3.9.7. In the event of construction occurring over multiple field seasons, the site will be temporarily restored sufficiently to minimize exposure and potential migration while work is suspended.

Required plans will be completed. At a minimum, these will include surveys for biological and cultural resources (using existing information as applicable), SWPPP, and SPCC.

Post-construction monitoring and maintenance will consist of annual inspections to verify that erosion control measures remain effective and to document development of a stable vegetative cover over restored areas. This activity will extend over several years after construction.

4.2.10.3 Site Controls and Security

During repair and restoration activities, access will be restricted with temporary construction fencing to prevent people and domestic livestock from entering the construction area. Potential delays and temporary closure to construction areas may be needed to support field seasons and spending restrictions. Fugitive dust and general disturbance to the local community during restoration activities should be minimal; however, controls for managing fugitive dust will be implemented. Fugitive dust management is accomplished using offsite water, which will require hauling to the site, resulting in additional truck traffic.

4.3 Detailed Analysis of Alternatives

This section presents a detailed analysis of the six response action alternatives listed in Section 5. This phase of planning, nahat'a, is referred to as an alternative analysis.

The six alternatives analyzed in this EE/CA are as follows:

1. No Action
2. Consolidate and Repair Existing Caps
3. Consolidate and Cap at Each Site
4. Consolidate and Cap at One Site (Ruby No. 1)
5. Regional Repository
    a. Excavate and Manage at Black Jack No. 1
    b. Excavate and Manage at Mac No. 1
6. Excavate and Manage Off-Navajo Disposal

4.3.1 Alternative Analysis Approach

This analysis was completed in accordance with guidance provided by U.S. EPA for preparing EE/CA studies and other requirements referenced in the ASAOC, including the NCP and U.S. EPA's NTCRA Guidance (1993). Each alternative was evaluated based on effectiveness, implementability, acceptability, and cost. For the analysis, many questions were asked and answered, including those related to sacred elements and things that could get in the way of a good life, nayee (Figure 1-2). These questions were asked in a series of phases:

- Phase 1 – Is the alternative effective?
- Phase 2 – Is the alternative possible (implementable)?
- Phase 3 – What will the alternative cost?

Detailed evaluation criteria are described in the following subsections. A summary of the analysis is presented on Figure 4-4.

4.3.1.1 Effectiveness

Effectiveness refers to the ability of an alternative to meet the RAOs. The following criteria are used to evaluate effectiveness:

- Overall protection of human health and the environment at the level set with the RAOs
    - Describes how the action will reduce, control, or eliminate potential risks to human health and the environment using treatment, engineering, or institutional controls.
- Compliance with ARARs and other criteria, advisories, and guidance
    - Assesses an alternative in terms of its compliance with ARARs or, if a waiver is required, how it is justified.
- Long-term effectiveness and permanence
    - Magnitude of Risk: Evaluates the effectiveness of the alternative and assesses the risk remaining after site activities are complete.
    - Adequacy and Reliability of Controls: Evaluates the activities necessary to sustain the integrity (reliability) of the response action following its conclusion.
- Short-term effectiveness
    - Addresses the effects of the alternative during implementation, before the response objectives have been met. Specifically,
        - Protection of the community
        - Protection of the workers
        - Environmental impacts
        - Length of time until RAOs are achieved

- Considers green and sustainable practices throughout the response action, including resulting impacts to air, energy, water, and other natural and ecological resources resulting from a remediation objective of optimizing the net environmental benefit of cleanup actions. Evaluating and selecting remedial alternatives in terms of green and sustainable remediation (GSR) follows EPA guidance and considers energy requirements, air emissions, water requirements, along with the impacts the alternatives may have on water resources, land and ecosystems, material consumption and waste generation, and long-term stewardship.

SiteWise Version 3.1 (SiteWise), developed jointly by the Navy, United States Army Corps of Engineers, and Battelle, was used to quantify values for the GSR metrics for each alternative (NAVFAC 2015). SiteWise uses various emissions factors from governmental or nongovernmental research sources to delineate the environmental footprint of each activity. SiteWise uses a “cradle to grave” approach to quantify footprints. As a result, some activities, such as material production, create environmental burdens that do not directly occur onsite but contribute to the overall footprint of the response alternative. This is particularly true in the case of greenhouse gasses (GHGs), which contribute on a global, long-term scale.

The quantitative metrics calculated by the tool include the following:

1. GHGs reported as carbon dioxide equivalents, consisting of carbon dioxide, methane, and nitrous oxide
2. Energy usage (expressed as British thermal units)
3. Water usage (gallons of water)
4. Air emissions of criteria pollutants consisting of nitrogen oxides (NOx), sulfur oxides (SOx), and particulate matter less than 10 micrometers in aerodynamic diameter (PM10)
5. Accident risk (risk of injury and risk of fatality) based on generic accident statistics. Traffic accident statistics specific to the Navajo Nation are detailed further in Section 5.1.4.

The input parameters and results from SiteWise were associated with the assumptions linked with the alternative descriptions are included in Appendix F. For evaluation purposes, the term “footprint” will be used to describe the quantified emissions or quantities for each metric. To estimate the sustainability footprint for each alternative, three key elements possessing important sustainability impacts were identified and included in the assessment: (1) production of backfill, (2) transportation of backfill, and (3) residual handling. A lower footprint indicates lower deleterious impacts to environmental and social metrics, which collectively make up the SiteWise sustainability metrics. Conversely, a higher footprint indicates higher deleterious impacts associated with the SiteWise metrics.

Overall quantitative footprints for each alternative were calculated as part of the SiteWise analysis, along with relative impact of each alternative in each footprint. The relative impact is a qualitative assessment of the relative footprint of each alternative, and a rating of high, medium, or low is assigned to each alternative based on its performance against the other alternatives. The tool assigns a ranking of high to the highest footprint in each category and assigns the rankings of other alternatives based on the difference in data between alternatives. The ranking is based on a 30% difference; if the footprints of two alternatives are within 30% of each other, they were given the same ranking because there is minimal difference between the alternatives. This allows for some uncertainty inherent in life cycle impact assessments and the assumptions used in the model.

4.3.2 Implementability and Acceptability

Implementability addresses whether the alternative is possible or doable. For this analysis, the technical and administrative feasibility of implementing an alternative and availability of various required services and materials are evaluated. The following criteria are used to evaluate implementability:

- Technical feasibility
  - Includes detailing technical difficulties; evaluation of implementation factors, such as mobilizing needed equipment and materials at the site, staffing, and operating the alternative within the timeframes of the response schedule; the reliability of the technology; anticipated operational difficulties; and consideration of environmental conditions with respect to set-up, construction, and operation phases.
- Administrative feasibility
  - Includes the need for offsite permits, adherence to applicable nonenvironmental laws, and concerns of other regulatory agencies.
- Availability of services and materials
  - Evaluation of resources necessary to implement the alternative, including personnel (that is, experienced laborers); capacity of offsite treatment, storage, and disposal facilities to accept waste; and availability of adequate supplies and equipment for onsite activities.
- Acceptability
  - A stakeholder is defined as a person, people, or an organization interested in, affected by, or perceived as potentially being affected by a given action or decision. Acceptability is assessed by stakeholders during the EE/CA process. U.S. EPA will consider and respond to significant comments before making its decision on the EE/CA and its final selection of the response action in an Action Memorandum.

4.3.3 Cost

Direct and indirect capital costs are considered. These include costs for construction, equipment and materials, analytical services, engineering and design, permits and licenses, and long-term monitoring and maintenance.

Cost estimates were prepared for each alternative to compare the alternatives and support response action selection. Detailed cost estimates are presented in Table 5-1 and provided in Appendix G.

The scope and costs presented for the various alternatives are based on the best available information regarding current site conditions, estimates of quantities for each work element, and readily available information on the sources and unit costs for implementation. In preparing the cost estimates, conservative assumptions have been used, with an overall contingency of 25% added to each alternative to account for these uncertainties. Changes in the cost elements are likely as actual response action design is refined and implemented. The costs given should be considered as order-of-magnitude-type estimates, with an accuracy of minus 30% to plus 50%. Actual costs may vary from these estimates depending on variations in actual conditions from those estimated, such as weather conditions, inflation, actual fuel costs, actual insurance and bonding costs, the availability of materials, equipment, and labor, changes in regulatory requirements, and other factors that are difficult to estimate or control.

4.3.3.1 Technical and Logistical Concerns Applicable to Each Alternative

Each alternative response action requires the following activities (excluding Alternative 1: No Action):

- Stakeholder interface and communication
- Access approvals
- Cultural and biological surveys and associated approvals

- Engineering and design
- Transportation, traffic planning, and road improvements
- Site security and access controls
- Mine waste management
- Stormwater management
- Erosion control and maintenance
- Site restoration
- Post-construction monitoring, inspections of physical hazards closed during the RSE, and reporting

Each alternative will also have the following impacts (excluding Alternative 1: No Action):

- Inconvenience to the local population to include possible traffic control measures, and movement and operation of heavy equipment and bulk load carriers during the construction period
- Restriction of human, wildlife, and livestock access through fencing to response action areas during construction activities and for a period thereafter until vegetation is reestablished, which may require multiple years
- Potential minor changes to local stormwater drainage characteristics caused by modifications in site topography, replanting, and erosion controls

Each alternative response action will be limited by the presence of known or newly discovered cultural items. Cultural items will be avoided during the implementation of the response action through the installation of temporary fencing.

4.3.4 Analysis of Alternative 1: No Action

Implementation of Alternative 1, No Action, implies that no response work would be done. The No Action alternative is the baseline against which the other response action alternatives are compared. The areas would be left as they currently exist, leaving impacted soil in place. Under this alternative, no controls or removal technologies would be implemented. Therefore, this alternative does not meet the RAOs, including addressing or mitigating potential human health and ecological risks. Because Alternative 1 is not protective of human health and the environment, evaluation of effectiveness, feasibility, and cost are not applicable.

4.3.5 Analysis of Alternative 2: Consolidate, Repair, and Maintain Existing Caps

4.3.5.1 Protection of Human Health and the Environment

Alternative 2 will address each of the RAOs, including protection of human health and the environment, as impacted soils would be consolidated and covered, and the current capped waste rock piles would receive an improved soil cover. Consolidation of impacted soils, combined with replacement of the existing soil cover, will prevent direct contact between the waste rock and impacted soils and humans and the environment, as long as the cover is maintained. Once the cap is fully vegetated, the site would be restored to current land uses, such as livestock grazing, herding, and gathering firewood and pinon nuts. The original cap has been generally effective for the last 30 years since it was constructed in 1985, as evidenced by the limited extent of migration of COCs from the capped waste rock piles.

4.3.5.2 Compliance with ARARs

Alternative 2 would comply with chemical, location-, and action-specific ARARs identified in Appendix D.

An environmental protection plan would be developed for the work activities to address identified ARARs. The environmental protection plan is a document that outlines ARARs (see Appendix D), describes requirements identified through the ARAR review (for example, prevention of discharge to waters of the U.S. or protection of cultural areas), and summarizes what mitigation actions or BMPs will be undertaken to comply with ARARs (for example, completion of an SWPPP or archeological monitoring of cultural areas).

4.3.5.3 Effectiveness

4.3.5.3.1 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 2 depends on future maintenance activities, which would be driven by land use and utilization. For example, if the cap is grazed heavily, and vegetation is removed and soils become compacted, erosion potential could increase. However, given the performance history of the cover system in place currently and the climate of the site, Alternative 2 would be expected to maintain its integrity. Routine monitoring and maintenance of the cap will be required to maintain its integrity and compliance with RAOs. If properly maintained, the cap and associated stormwater controls will minimize water infiltration and erosion and maintain protectiveness.

4.3.5.3.2 Short-term Effectiveness

Potential impacts to the community during implementation of this alternative include transportation inconvenience from temporary traffic controls and access restrictions, potential noise, vehicle emissions and some dust during implementation, and pedestrian and traffic hazards associated with increased traffic. Since waste rock hauling would be restricted to the two mine sites and surrounding areas, heavy construction traffic on local roads and highways would be limited to mobilization and demobilization of equipment, and transportation of borrow material and water for dust suppression.

Implementation of Alternative 2 would present an economic opportunity to the community because local residents and contractors may be able to satisfy the requirement for experienced and inexperienced labor for the duration of construction and monitoring and maintenance periods. Protection of workers and nearby residents during implementation of Alternative 2 would be accomplished using standard safety protocols, use of fugitive dust controls (such as water for dust control and stopping work during high winds), and environmental monitoring. The work onsite would comply with applicable OSHA and tribal labor safety standards.

During excavation and consolidation of impacted materials, heavy equipment will mobilize to each site, but there will otherwise be limited traffic on the local roads and highways. During capping, truck traffic along local roads will increase for a period while cover materials and water for dust control are being delivered. Waste rock and impacted soils will not be transported on local roads or state highways while this alternative is being implemented. Work will be limited to times when roads are dry and passable so as to minimize road damage. BMPs (such as traffic signs, flaggers, traffic cones) will be implemented during construction activities.

With respect to GSR, Alternative 2 has the lowest footprint in all categories compared with other alternatives. Refer to Figures F-1 and F-2 and Tables F-2 and F-3. Processing of the backfill material accounted for the majority of the GHG, total energy, and criteria pollutant footprints (NO_x, SO_x, and PM_{10}). For Alternative 2, generic accident risk was highest because of transportation of backfill material to the site.

4.3.5.4 Implementability

4.3.5.4.1 Technical Feasibility

Alternative 2 is technically feasible; it would be implemented with conventional equipment and work approaches, and locally available materials and labor, as available. Work will be completed using existing public roadways and local dirt roads. Local dirt roads that access the Ruby Mines Site and vents (Ruby Mines No. 1 haul road and two-track roads) will need to be improved to accommodate heavy truck traffic needed for construction activities. Excavation of impacted soils would be scheduled and performed in a manner that optimizes material loading and transport. Conventional site access and environmental controls would be deployed. Current conceptual designs of a soil cover at the Ruby Mines No. 3 waste rock pile indicate that an adjacent restricted area would be avoided during construction activities; however, final design work may require separate consideration for waste rock and impacted soil that is located within the restricted area.

4.3.5.4.2 Administrative Feasibility

Alternative 2 is administratively feasible. The planning, design, and implementation of this alternative would be accomplished in accordance with well-defined, standard administrative requirements for projects of comparable scope. Access agreements with applicable grazing rights permit holders were secured as part of the RSE activities, and it is anticipated that they would be revised or renewed for this work. A Navajo Nation Heritage & Historic Preservation Department cultural compliance form and Navajo Nation Department of Fish and Wildlife (NNDFW) biological clearance were obtained for the RSE activities. Additional consultations would be undertaken with both agencies and the biological clearance and cultural compliance forms would be updated and revised to include construction activities. Administrative requirements, such as special permitting and coordination with regulatory agencies other than those identified in this EE/CA, are not anticipated.

4.3.5.5 Availability of Services and Materials

The excavation, hauling, and consolidation of impacted material, and placement of cap material would be accomplished using a variety of conventional equipment. Heavy equipment needed for this project, such as scrapers, excavators, dozers, loaders, compactors, and bulk carriers, are regionally available. Working space is available for establishing temporary construction laydown and staging areas, office facilities, and utilities. Temporary connections can be made to nearby permanent utilities, such as electrical power and telecommunications. Water for construction is not available onsite and will be hauled from offsite.

Borrow sources for the soil needed for cap fill and rip rap needed for erosion control are readily available, assumed to be located in Gallup approximately 45 miles from the site. Other materials, such as those needed for stormwater BMPs and seed mix for land restoration, are commercially available.

This alternative could potentially yield work assignments for experienced and unexperienced workers in the short term during the construction phase, including an estimated 5- to 10- person crew for 4 months, and long-term short-duration work during the monitoring and maintenance phase, including 1 person for 1 day for annual inspections and between 1 and 5 people for up to 10 days a year for repairs. Relevant training for workers, including needed certifications, is commercially available. Health and safety training to comply with OSHA requirements, including radiation and hazardous material handling training, is available.

4.3.5.6 Acceptability

Navajo Nation and community input will be solicited as part of the EE/CA review process and will be evaluated by U.S. EPA before selecting a response action. Factors associated with Alternative 2 to be considered include the following:

- Potential for job opportunities during construction and long-term monitoring and maintenance
- No transport of waste rock and impacted soil along roads where people live
- Some hauling of clean material and water for dust control along local roads and highways
- Disruption to surrounding communities for short duration of construction (4 months)

- Waste rock and impacted soil capped onsite
- Land available for herding, grazing, and gathering within approximately 5 to 10 years of construction completion
- Long-term monitoring and maintenance of each cap, which is required to maintain protectiveness

4.3.5.7 Cost

The estimated total cost for Alternative 2 is $6,033,000. The detailed cost estimate prepared for this alternative is included in Appendix G.

4.3.6 Analysis of Alternative 3: Consolidate and Cap at Each Site

4.3.6.1 Protection of Human Health and the Environment

Alternative 3 will address each of the RAOs, including protection of human health and the environment, because soils containing Ra-226 and metals at concentrations above cleanup goals would be consolidated within the footprint of the currently capped waste rock piles, which would then be covered with an evapotranspirative cap. Consolidation of impacted soils and installation of a cap will continue to prevent direct contact between the waste rock and impacted soils and humans and the environment. The evapotranspirative cover system would be less susceptible to erosion than Alternative 2, as long as the cover is maintained. Once the cap is fully vegetated, the site would be restored to current land uses, such as livestock grazing, herding, and gathering firewood and pinon nuts.

4.3.6.2 Compliance with ARARs

Alternative 3 would comply with chemical, location-, and action-specific ARARs identified in Appendix D.

An environmental protection plan would be developed for the work activities to address identified ARARs. The environmental protection plan is a document that outlines ARARs (see Appendix D), describes requirements identified through the ARAR review (for example, prevention of discharge to waters of the U.S. or protection of cultural areas), and summarizes what mitigation actions or BMPs will be undertaken to comply with ARARs (for example, completion of a SWPPP or archeological monitoring of cultural areas).

4.3.6.3 Effectiveness

4.3.6.3.1 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 3 depends on future maintenance activities, which would be driven by land use and utilization. This cap alternative may be less subject to erosion than Alternative 2 because the evapotranspirative cover system would be less susceptible to erosion if the land were over grazed and vegetation were absent. Routine inspection and maintenance of the cap would be required to maintain its integrity and compliance with RAOs. If properly maintained, the cap and associated stormwater controls would minimize water infiltration and erosion, and maintain protectiveness.

4.3.6.3.2 Short-term Effectiveness

Potential impacts to the community during implementation of this alternative include transportation inconvenience from temporary traffic controls and access restrictions, potential noise, vehicle emissions and some dust during implementation, and pedestrian and traffic hazards associated with increased traffic. Because waste hauling would be restricted to the two mine sites and surrounding areas, heavy construction traffic would be limited to equipment mobilization and demobilization, and transportation of borrow material and water for dust suppression.

Implementation of Alternative 3 would present an economic opportunity to the community because local residents and contractors may be able to satisfy the requirement for experienced and unexperienced labor for the duration of construction and monitoring and maintenance. Protection of workers and nearby residents during implementation of Alternative 3 would be accomplished using standard safety protocols, placement of fugitive dust controls (such as water for dust control and stopping work during high winds), and environmental monitoring. The work onsite would comply with applicable OSHA and tribal labor safety standards.

During excavation and consolidation of impacted materials, heavy equipment will mobilize to each site, but there will otherwise be limited traffic on the local roads and highways, similar to Alternative 2. During capping, truck traffic along local roads will increase incrementally more than Alternative 2 for a period while cover materials and water for dust control are being delivered. Waste rock and impacted soils will not be transported on local roads or state highways during implementation of this alternative. Work will be limited to times when dirt roads are dry and passable so as to minimize road damage. BMPs (such as traffic signs, flaggers, traffic cones) will be implemented during construction activities.

With respect to GSR, Alternative 3 has the second-lowest GHG emissions, total energy used, NOx, and accident risk compared with other alternatives. Refer to Figures F-1 and F-3 and Tables F-2 and F-3. Processing of the backfill material accounted for the majority of the GHG, total energy, and criteria pollutant footprints (NOx, SOx, and PM10). For Alternative 3, generic accident risk was highest because of transportation of backfill material to the site.

4.3.6.4 Implementability

4.3.6.4.1 Technical Feasibility

Alternative 3 is technically feasible; it would be implemented with conventional equipment and work approaches, and locally available materials and labor, as available. Work will be completed using existing public roadways and local dirt roads. Dirt roads that access the Ruby Mines Site and vents will need repair to accommodate heavy truck traffic needed for construction activities. Excavation of impacted soils would be scheduled and performed in a manner that optimizes material loading and transport. Conventional site access and environmental controls would be deployed. Current conceptual designs of a cover at the Ruby Mines No. 3 waste rock pile indicate that an adjacent restricted area would be avoided during construction activities; however, final design work may require separate consideration for waste rock and impacted soil that is located in the restricted area.

4.3.6.4.2 Administrative Feasibility

Alternative 3 is administratively feasible. The planning, design, and implementation of this alternative would be accomplished in accordance with well-defined, standard administrative requirements for projects of comparable scope. Access agreements with applicable grazing rights permit holders were secured as part of the RSE activities, and it is anticipated that they would be renewed for this work. A Navajo Nation Heritage & Historic Preservation Department cultural compliance form and NNDFW biological clearance were obtained for the RSE activities. Additional consultations would be undertaken with both agencies, and the biological clearance and cultural compliance forms would be updated and revised to include construction activities. Administrative requirements, such as special permitting and coordination with regulatory agencies other than those identified in this EE/CA, are not anticipated.

4.3.6.5 Availability of Services and Materials

The excavation, hauling, and consolidation of impacted material and construction of a cap would be accomplished using a variety of conventional equipment. Heavy equipment needed for this project, such as scrapers, excavators, dozers, loaders, compactors, and bulk carriers, are locally available. Working space is available for establishing temporary construction laydown and staging areas, office facilities, and utilities. Temporary connections can be made to nearby permanent utilities, such as electrical power and telecommunications. Water for construction is not available onsite and will be hauled from offsite.

Sources of soil and rock to construct the cap and rip rap needed for erosion control are readily available, assumed to be located in Gallup approximately 45 miles from the site. Other materials, such as those needed for stormwater BMPs and seed mix for land restoration, are commercially available.

This alternative could potentially yield work assignments for experienced and unexperienced workers in the short term during the construction phase, including an estimated 5- to 10-person crew for 7 months, and long-term short-duration work during the monitoring and maintenance phase, including 1 person for 1 day for annual inspections and 1 to 5 people for up to 5 days a year for repairs. Relevant training for workers, including needed certifications, is commercially available. Health and safety training to comply with OSHA requirements, including radiation and hazardous material handling training, is available.

4.3.6.6 Acceptability

Navajo Nation and community input will be solicited as part of the EE/CA review process and will be evaluated by U.S. EPA before selecting a response action. Factors associated with Alternative 3 to be considered include the following:

- Potential for job opportunities during construction and long-term monitoring and maintenance
- No transport of waste rock and impacted soil along roads where people live
- Additional hauling of clean materials and water for dust control along local roads and highways
- Disruption to surrounding communities for duration of construction (7 months)
- Waste rock and impacted soil capped onsite
- Land available for herding, grazing, and gathering within approximately 5 to 10 years of construction completion
- Long-term monitoring and maintenance of each cap required to maintain protectiveness

4.3.6.7 Cost

The estimated total cost for Alternative 3 is $8,076,000. The detailed cost estimate prepared for this alternative is included in Appendix G.

4.3.7 Analysis of Alternative 4: Consolidate and Cap at One Site

4.3.7.1 Protection of Human Health and the Environment

Alternative 4 will address each of the RAOs, including protection of human health and the environment, because waste rock and surrounding impacted soils from Ruby Mines No. 3 and impacted soils at Ruby Mines No. 1 would be consolidated at the Ruby Mines No. 1 waste rock pile, which would then be covered with a cap. Waste consolidation and cap installation will prevent direct contact between waste rock and impacted soils and humans and the environment. The evapotranspirative cover system would be less susceptible to erosion than Alternative 2, as long as the cover is maintained. Once the cap is fully vegetated, the site would be restored to current land uses, such as livestock grazing, herding, and gathering firewood and pinon nuts.

4.3.7.2 Compliance with ARARs

Alternative 4 would comply with chemical, location-, and action-specific ARARs identified in Appendix D.

An environmental protection plan would be developed for the work activities to address identified ARARs. The environmental protection plan is a document that outlines ARARs (see Appendix D), describes requirements identified through the ARAR review (for example, prevention of discharge to waters of the U.S. or protection of cultural areas), and summarizes what mitigation actions or BMPs will be undertaken to comply with ARARs (for example, completion of a SWPPP or archeological monitoring of cultural areas).

4.3.7.3 Effectiveness

4.3.7.3.1 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 4 depends on the cap's performance, future maintenance activities, and land use and utilization. This cap alternative may be less subject to erosion than Alternative 2 because the evapotranspirative cover system would be less susceptible to erosion than Alternative 2 if the land were over grazed and vegetation were absent. Routine inspection and maintenance of the cap would be required to maintain its integrity and compliance with RAOs. If properly maintained, the cap and associated stormwater controls would minimize water infiltration and erosion, and maintain protectiveness.

This alternative permanently mitigates potential risks to human health and the environment at Ruby Mines No. 3 without the need for further maintenance because waste rock and surrounding impacted soil will be removed.

4.3.7.3.2 Short-term Effectiveness

Potential impacts to the community during implementation of this alternative include transportation inconvenience from temporary traffic controls and access restrictions, potential noise, vehicle emissions, and some dust during implementation, and pedestrian and traffic hazards associated with increased traffic.

Implementation of Alternative 4 would present an economic opportunity to the community. Local residents and contractors may be able to satisfy the requirement for experienced labor for the duration of construction. Protection of workers and nearby residents during implementation of Alternative 4 would be accomplished using standard safety protocols, placement of fugitive dust controls (such as water for dust control and stopping work during high winds), and environmental monitoring. The work onsite would comply with applicable OSHA and tribal labor safety standards.

During excavation and consolidation of impacted materials, there will be a significant increase in truck traffic on local roads and highways as waste rock and impacted soils are hauled from Ruby Mines No. 3 to Ruby Mines No. 1. During capping, truck traffic along local roads will increase comparable to Alternatives 2 and 3 for a period while cover materials and water for dust control are being transported. Work will be limited to times when dirt roads are dry and passable so as to minimize road damage. BMPs (such as traffic signs, flaggers, traffic cones) will be implemented during construction activities.

With respect to GSR, Alternative 4 has a greater impact than Alternatives 2 and 3. Waste transportation and backfill material processing accounted for the majority of the GHG, total energy, and criteria pollutant footprints (NO_x, SO_x, and PM_{10}). For Alternative 4, generic accident risk was caused by transportation of backfill material to the site and residual handling. Refer to Figures F-1 and F-4 and Tables F-2 and F-3.

4.3.7.4 Implementability

4.3.7.4.1 Technical Feasibility

Alternative 4 is technically feasible; it would be implemented with conventional equipment and work approaches, and locally available materials and labor, as available. Work will be completed using existing public roadways and local dirt roads. Dirt roads that access the Ruby Mines Site and vents will need repair to accommodate heavy truck traffic needed for construction activities. Excavation of impacted soils would be scheduled and performed in a manner that optimizes material loading and transport. Conventional site access and environmental controls would be deployed. The current extent of impacted soil at the Ruby Mines No. 3 waste rock pile indicates that an adjacent restricted area would be avoided during removal activities; however, final design work and may require separate consideration for waste rock and impacted soil that is located in the restricted area.

4.3.7.4.2 Administrative Feasibility

Alternative 4 is administratively feasible. The planning, design, and implementation of this alternative would be accomplished in accordance with well-defined, standard administrative requirements for projects of comparable scope. Access agreements with applicable grazing rights permit holders were secured as part of the RSE activities, and it is anticipated that they would be renewed for this work. An NNHPD cultural compliance form and NNDFW biological clearance were obtained for the RSE activities. Additional consultations would be undertaken with both agencies, and the biological clearance and cultural compliance forms would be updated and revised to include construction activities. Administrative requirements, such as special permitting and coordination with regulatory agencies other than those identified in this EE/CA, are not anticipated.

4.3.7.5 Availability of Services and Materials

The excavation, hauling and consolidation of impacted material, and construction of a cap would be accomplished using a variety of conventional equipment. Heavy equipment needed for this project, such as scrapers, excavators, dozers, loaders, compactors, and bulk carriers, are locally available. Working space is available for establishing temporary construction laydown areas, office facilities, and utilities. Temporary connections can be made to nearby permanent utilities, such as electrical power and telecommunications. Water for construction is not available onsite and will be hauled in from offsite.

Sources of soil and rock to construct the cap and rip rap needed for erosion control are readily available, assumed to be located in Gallup approximately 45 miles from the site. Other materials, such as those needed for stormwater BMPs and seed mix for land restoration, are commercially available.

This alternative could potentially yield work assignments for experienced and unexperienced workers in the short term during the construction phase, including an estimated 5- to 10-person crew for approximately 4 years of intermittent construction work, and long-term short-duration work during the monitoring and maintenance phase, including 1 person for 1 day for annual inspections and 1 to 5 people for up to 5 days a year for repairs. Relevant training for workers, including needed certifications, is commercially available. Health and safety training to comply with OSHA requirements, including radiation and hazardous material handling training, is available. Transportation of waste rock between sites is likely to be limited to established and certified long-haul trucking companies.

4.3.7.6 Acceptability

Navajo Nation and community input will be solicited as part of the EE/CA review process and will be evaluated by U.S. EPA before selecting a response action. Factors associated with Alternative 4 to be considered include the following:

- Potential for job opportunities during construction and long-term monitoring and maintenance
  - However, off-Reservation resources may be required because of the volume of excavation and significant number of trucks required.
- Transport of waste rock and impacted soil along roads where people live
- Additional hauling of clean materials and water for dust control along local roads and highways
- Disruption to surrounding communities for duration of construction (4 years)
- Waste rock and impacted soil capped onsite
- Land available for herding, grazing, and gathering within approximately 5 to 10 years of construction completion
- Long-term monitoring and maintenance of each cap is required to maintain protectiveness

4.3.7.7 Cost

The estimated total cost for Alternative 4 is $18,139,000. The detailed cost estimate prepared for this alternative is included in Appendix G.

4.3.8 Analysis of Alternative 5: Excavate and Manage at Regional Repository

4.3.8.1 Protection of Human Health and the Environment

Alternative 5 will address each of the RAOs, including protection of human health and the environment, as waste rock and surrounding impacted soils containing Ra-226 and metal at levels above cleanup goals would be excavated from Ruby Mines No. 1 and 3, transported to a regional repository, and covered with a cap, preventing direct contact between waste rock and impacted soils and humans and the environment. The removal of waste rock and impacted soils from the Ruby Mines Site reduces risk by consolidating waste and minimizing exposure. Once fully vegetated, the sites could be suitable for residential use.

4.3.8.2 Compliance with ARARs

Alternative 5 would comply with chemical-, location-, and action-specific ARARs identified in Appendix D.

An environmental protection plan would be developed for the work activities to address identified ARARs. The environmental protection plan is a document that outlines ARARs (see Appendix D), describes requirements identified through ARAR review (for example, prevention of discharge to waters of the U.S. or protection of cultural areas), and summarizes what mitigation actions or BMPs will be undertaken to comply with ARARs (for example, completion of a SWPPP or archeological monitoring of cultural areas).

4.3.8.3 Effectiveness

4.3.8.3.1 Long-term Effectiveness and Permanence

Alternative 5 permanently mitigates potential risks to human health and the environment at Ruby Mines No. 1 and 3 without the need for further maintenance because waste rock and impacted soil would be removed and each site would be backfilled with clean soil.

The long-term effectiveness and permanence of the regional repository depends on proper design and construction of the repository and future maintenance activities. Routine inspection and maintenance of the repository would be required to maintain its integrity and compliance with RAOs. If properly maintained, the repository and associated stormwater controls would minimize water infiltration and erosion, and maintain protectiveness.

4.3.8.3.2 Short-term Effectiveness

Potential impacts to the community during implementation of this alternative include transportation inconvenience from traffic controls and access restrictions, potential noise, vehicle emissions, and dust during implementation, and pedestrian and traffic hazards associated with increased traffic. Heavy construction traffic would occur and require multiple mobilizations and demobilizations of equipment over a number of years, offsite hauling of waste rock and impacted soil along local roads and highways, and transportation of borrow material for backfill and water for dust suppression.

Implementation of Alternative 5 would present an economic opportunity to the community. Local residents and contractors may be able to satisfy the requirement for experienced labor for the duration of construction. Protection of workers and nearby residents during implementation of Alternative 5 would be accomplished using standard safety protocols, placement of fugitive dust controls (such as water for dust control and stopping work during high winds), and environmental monitoring. The work onsite would comply with applicable OSHA and tribal labor safety standards.

During excavation, backfill, and cap construction, there will be a significant increase in truck traffic on main roads and highways. Work will be limited to times when dirt roads are dry and passable so as to minimize road damage. BMPs (such as traffic signs, flaggers, and traffic cones) will be implemented during construction activities. Because waste rock and impacted soils will be transported offsite, this alternative will include extensive travel on local public roads and other tribal and interstate roads. These roads may be significantly impacted by the increased haul traffic for the duration of the construction project, by both wear and tear on the roadways and increased potential for traffic accidents.

With respect to GSR, the impacts from Alternatives 5a and 5b are comparable to each other and greater than Alternatives 2, 3, and 4. Waste transportation and backfill material processing accounted for the majority of the GHG, total energy, and criteria pollutant footprints (NOx, SOx, and PM10). For Alternatives 5a and 5b, generic accident risk was due to both transportation of backfill material to the site and residual handling. Refer to Figures F-1 and F-6 and Tables F-2 and F-3.

4.3.8.4 Implementability

4.3.8.4.1 Technical Feasibility

Alternative 5 is technically feasible; it would be implemented with conventional equipment and work approaches, and locally available materials and labor as available. Work will be completed using existing access public roadways and local dirt roads. Dirt roads that access the Ruby Mines Site and vents will need repairs to accommodate heavy truck traffic needed for construction activities. Excavation of waste rock and impacted soils would be scheduled and performed in a manner that optimizes material loading and transport. Conventional site access and environmental controls would be deployed. Current extent of impacted soil at the Ruby Mines No. 3 waste rock pile indicate that an adjacent restricted area would be avoided during removal activities; however, final design work may require separate consideration for waste rock and impacted soil that is located in restricted area.

4.3.8.4.2 Administrative Feasibility

Alternative 5 is administratively feasible. The planning, design, and implementation of this alternative would be accomplished in accordance with well-defined, standard administrative requirements for projects of comparable scope. Access agreements with applicable grazing rights permit holders were secured as part of the RSE activities at the Ruby Mines Site, and it is anticipated that they would be renewed for this work. An NNHPD cultural compliance form and NNDFW biological clearance were obtained for the RSE activities at the Ruby Mines Site. Additional consultations would be undertaken with both agencies, and the biological clearance and cultural compliance forms would be updated and revised to include construction activities. Siting and construction of a repository may require further administrative efforts. Administrative requirements, such as special permitting and coordination with regulatory agencies other than those identified in this EE/CA, are not anticipated.

4.3.8.5 Availability of Services and Materials

The excavation, hauling, and consolidation of impacted material and construction of a regional repository would be accomplished using a variety of conventional equipment. Heavy equipment needed for this project, such as scrapers, excavators, dozers, loaders, compactors, and bulk carriers, are locally available. Working space is available for establishing temporary construction laydown areas, office facilities, and utilities. Temporary connections can be made to nearby permanent utilities, such as electrical power and telecommunications. Water for construction is not available onsite and will be hauled in from offsite.

Sources of soil to construct the cap and rip rap needed for erosion control are readily available, assumed to be located in Gallup approximately 45 miles from the site. Other materials, such as those needed for stormwater BMPs and seed mix for land restoration, are commercially available.

This alternative could potentially yield work assignments for experienced and unexperienced workers in the short term during the construction phase, including an estimated 5- to 10-person crew for approximately 7 years of intermittent construction work, and long-term short-duration work during the monitoring and maintenance phase at the repository, including 1 person for 1 day for annual inspections and 1 to 5 people for up to 5 days a year for repairs. Relevant training for workers, including needed certifications, is commercially available. Health and safety training to comply with OSHA requirements, including radiation and hazardous material handling training, is available. Waste rock transportation to the regional repository is likely to be limited to established and certified long-haul trucking companies.

4.3.8.6 Acceptability

Navajo Nation and community input will be solicited as part of the EE/CA review process and will be evaluated by U.S. EPA before selecting a response action. Factors associated with Alternative 4 to be considered include the following:

- Potential for job opportunities during construction and long-term monitoring and maintenance
  - However, off-Reservation resources may be required because of the volume of excavation and significant number of trucks required.
- Transport of waste rock and impacted soil along roads where people live
- Additional hauling of clean materials and water for dust control along local roads and highways
- Disruption to surrounding communities for duration of construction (7 years)
- No waste rock or impacted soil remains at the Ruby Mines Site; however, waste remains on Reservation
- Land available for herding, grazing, and gathering within approximately 5 to 10 years of construction completion
- Long-term monitoring and maintenance of the repository is required to maintain protectiveness

4.3.8.7 Cost

The estimated cost for Alternative 5a is $27,171,000 (Black Jack No. 1). The estimated cost for Alternative 5b is $27,350,000 (Mac No. 1). The detailed cost estimates prepared for this alternative are included in Appendix G.

4.3.9 Analysis of Alternative 6: Excavate and Manage Off-Reservation

4.3.9.1 Protection of Human Health and the Environment

Alternative 6 will address the RAOs, including protection of human health and the environment, because all waste rock and soils containing Ra-226 and metals at levels above cleanup goals would be excavated from Ruby Mines No. 1 and 3 and transported to an offsite, licensed and permitted disposal facility, preventing direct contact between the waste rock and impacted soils and humans and the environment. Once the excavated area is fully vegetated, the site would be restored to current land uses, such as livestock grazing, herding, and gathering firewood and pinon nuts.

4.3.9.2 Compliance with ARARs

Alternative 6 would comply with chemical, location-, and action-specific ARARs identified in Appendix D.

An environmental protection plan would be developed for the work activities to address identified ARARs. The environmental protection plan is a document that outlines ARARs (see Appendix D), describes requirements identified through the ARAR review (for example, prevention of discharge to waters of the U.S. or protection of cultural areas), and summarizes what mitigation actions or BMPs will be undertaken to comply with ARARs (for example, completion of a SWPPP or archeological monitoring of cultural areas).

4.3.9.3 Effectiveness

4.3.9.3.1 Long-term Effectiveness and Permanence

Alternative 6 permanently mitigates potential risks to human health and the environment at Ruby Mines No. 1 and 3 without the need for further maintenance, because waste rock and impacted soil would be removed and each site would be backfilled with clean soil.

The long-term effectiveness and permanence of the off-Reservation disposal facility depends on proper design and construction and future maintenance activities, to be conducted by the owners of the disposal facility.

4.3.9.3.2 Short-term Effectiveness

Potential impacts to the community during implementation of this alternative include transportation inconvenience from traffic controls and access restrictions, potential noise, vehicle emissions, some dust during implementation, and pedestrian and traffic hazards associated increased traffic. Heavy construction traffic would occur and require multiple mobilizations and demobilizations of equipment over a number of years, offsite hauling of waste rock and impacted soil along local roads and highways, and transportation of borrow material for backfill and water for dust suppression.

Implementation of Alternative 6 would present a minimal economic opportunity to the local community, because most of the required labor force would be certified long-haul truck drivers. Protection of workers and nearby residents during implementation of Alternative 6 would be accomplished using standard safety protocols, placement of fugitive dust controls (such as water for dust control and stopping work during high winds), and environmental monitoring. All work onsite would comply with OSHA and tribal labor standards.

During excavation and consolidation of impacted materials, there will be a significant increase in truck traffic on main roads and highways as waste rock, impacted soils, and water for dust control are hauled offsite.

Because waste rock and impacted soils will be transported offsite, this alternative will include extensive travel on local public roads, including BIA Route 49 and State Highway 371, and other tribal and interstate roads. These roads may be significantly impacted by the increased haul truck traffic for the duration of the construction project, by both wear and tear on the roadways and increased potential for traffic accidents.

With respect to GSR, Alternative 6 has the highest GHG emissions, total energy used, NOx, and accident risk compared with other alternatives. Accidental risk is up to three orders of magnitude higher for Alternative 6 than the other alternatives as a result of the increased trucking needs. Refer to Figures F-1 and F-7 and Tables F-2 and F-3. Residual handling accounted for the majority of the GHG, total energy, and NOx emissions, and generic accident risk footprints. Backfill material processing accounted for the majority of the of remaining criteria pollutant footprints (SOx, and PM10).

4.3.9.4 Implementability

4.3.9.4.1 Technical Feasibility

Alternative 6 is technically feasible; it would be implemented with conventional equipment and work approaches, and some regionally available (off-Reservation) equipment and labor, because of the volume of excavation and the significant number of trucks that would be required. Local labor may be used for portions of the work; however, long-distance waste hauling will require many specialized contractors that are not known to exist on the Navajo Nation. Work will be completed using existing access public roadways and local dirt roads. Dirt roads that access the Ruby Mines Site and vents will need repair to accommodate the significant increase in heavy truck traffic needed for construction activities. Multiple mobilizations and demobilizations of heavy equipment contractors may be required based on the extended time frame of this alternative. The restricted area adjacent to the Ruby Mines No. 3 waste rock pile would be avoided during construction activities; however, final design work may require separate consideration for waste rock and impacted soil that is located within the restricted area.

The duration of work may be spread over a period of at least 32 years to accommodate spending cap limitations and seasonal limitations on accessibility to the sites. Under the CD, which will include the Ruby Mines Site following completion of this EE/CA, there is an annual spending cap. This spending cap is inclusive of the 94 legacy Cyprus Amax and WNI mine sites throughout the Navajo Nation. Selection of a response action for the Ruby Mines would need to balance the cost and duration of implementation at Ruby Mines with the need to address the other mine sites. Therefore, it is assumed that $10,000,000 would be allocated to the Ruby Mines Site response action per year.

4.3.9.4.2 Administrative Feasibility

Alternative 6 is administratively less feasible than other alternatives because of the transport of waste rock and impacted soil offsite for disposal. Administrative requirements, such as special permitting and coordination with regulatory agencies other than those identified in this EE/CA, may be required because waste would be transported to an offsite disposal facility. The planning, design, and implementation of this alternative would be accomplished in accordance with well-defined, standard, administrative requirements for projects of comparable scope. Access agreements with applicable grazing rights permit holders were secured as part of the RSE activities, and it is anticipated that they would be renewed for this work. An NNHPD cultural compliance form and NNDFW biological clearance were obtained for the RSE activities. Additional consultations would be undertaken with both agencies, and the biological clearance and cultural compliance forms would be updated and revised to include construction activities.

4.3.9.5 Availability of Services and Materials

The excavation and hauling of impacted material and transportation offsite for disposal would be accomplished using a variety of conventional equipment. Heavy equipment needed for this project, such as scrapers, excavators, dozers, loaders, compactors, and bulk carriers, are regionally available (off-Reservation). Working space is available for establishing temporary construction laydown areas, office facilities, and utilities. Temporary connections can be made to nearby permanent utilities, such as electrical power and telecommunications. Water for construction is not available onsite and will be hauled in from offsite. Sources of soil and rock to backfill each site and rip rap needed for erosion control are readily available, assumed to be located in Gallup approximately 45 miles from the site. Other materials, such as those needed for stormwater BMPs and seed mix for land restoration, are commercially available.

This alternative is anticipated to yield some local job opportunities. Experienced and unexperienced short-term work assignments may be available during excavation activities, including an estimated 5- to 10-person crew for the duration of construction. However, most of the labor force required to implement this alternative would be certified long-haul truck drivers.

4.3.9.6 Acceptability

Navajo Nation and community input will be solicited as part of the EE/CA process and will be evaluated by U.S. EPA before selecting a response action. Factors associated with Alternative 6 to be considered include the following:

- Potential for job opportunities during construction
  - However, off-Reservation resources may be required because of the volume of excavation and significant number of trucks required.
- Transport of waste rock and impacted soil along local roads, county roads, and interstate highways
- Hauling of clean materials along local roads and highways
- Disruption to surrounding communities for duration of construction

- No waste rock or impacted soil remains onsite
- Land available for herding, grazing, and gathering within approximately 5 to 10 years of construction completion
- No long-term monitoring and maintenance required to maintain protectiveness

4.3.9.7 Cost

The estimated total cost for Alternative 6 is $343,724,000. The detailed cost estimate prepared for this alternative is included in Appendix G. Once the Ruby Mines ASAOC and EE/CA are finalized, the design and implementation of the response action will fall under the CD in United States v. Cyprus Amax Minerals Co., No. 17-00140-PHX-DLR (D. Ariz.) (U.S. EPA, 2017d). Under the CD, there is an initial annual spending cap of $25,000,000. This spending cap covers work conducted at the 94 Cyprus Amax and WNI mine sites covered by the CD, including the response action implementation at the Ruby Mines Site.

Selection of a response action for the Ruby Mines would need to balance the cost and duration of implementation at Ruby Mines with the need to address the other mine sites. Therefore, it is assumed that $10,000,000 would be allocated to the Ruby Mines Site response action per year, resulting in at least a 34-year duration to complete the work.

5. Comparative Analysis of Alternatives

Section 4 provided an evaluation of the alternatives based on their effectiveness, feasibility, and cost, while balancing Navajo principles of balance and harmony, sustainability, and connectedness. In this section, the alternatives are directly compared with one another for each of these criteria. Alternative 1 – No Action is not evaluated further in this section because it represents no impact relative to current conditions. It does not meet RAOs, as defined in Section 4.

5.1 Effectiveness

5.1.1 Protection of Human Health and the Environment

Alternatives 2, 3, 4, 5, and 6 can achieve RAOs, including protection of human health and the environment. Alternatives 2, 3, and 4 would prevent direct contact between the waste rock and impacted soils and humans and the environment, as long as the cover is maintained, comparable to the current waste rock pile caps, which have been generally effective since 1985. Alternatives 5 and 6 provide protection of local human health and the environment because the waste rock and impacted soils are completely removed from the site and managed at a different location.

5.1.2 Compliance with ARARs

Alternatives 2, 3, 4, 5, and 6 would comply with the ARARs at the completion of implementation. Alternative 6, excavation and management offsite, will require additional compliance with U.S. Department of Transportation rules and regulations pertaining to the transport of waste materials on highways and interstate roads.

5.1.3 Long-term Effectiveness and Permanence

Alternative 2 will continue to prevent direct contact between the waste rock and impacted soils and humans and the environment, as long as the cover is maintained. Protection of human health and the environment has been maintained for most of the time period since the mine waste was capped in 1985, as evidenced by the limited extent of migration of COCs from the capped waste rock piles. The evapotranspirative cover system included in Alternatives 3 and 4 is less susceptible to erosion than Alternative 2 if the land were overgrazed and vegetation were absent. Alternative 5, management at a regional repository, is effective in the long term because waste rock and impacted soil are removed from the site; however, long-term monitoring and maintenance of the repository would be required. Alternative 6, excavation of waste rock and impacted soils with offsite disposal, is most effective in the long term, because this alternative results in the removal of waste rock and impacted soil, and eliminates the need for long-term cap monitoring and maintenance.

Each alternative will require post-construction monitoring and maintenance consisting of annual inspections to verify that erosion control measures remain effective and to document development of a stable vegetative cover over restored areas. It is anticipated that revegetation would take 5 to 10 years, during which time access to the sites will be limited (fenced).

5.1.4 Short-term Effectiveness

Alternatives 2 and 3 provide the greatest short-term effectiveness because waste is managed at each site, with only minimal, local transport of impacted soils at each site. Because handling and hauling of impacted material is minimized, these alternatives represent relatively minimal risks to the community, workers, and the environment during implementation. Import of clean fill material for cap construction and water for dust control, combined with construction vehicle traffic onsite, slightly increases risks to the community and site workers during construction. Alternatives 2 and 3 also have the shortest duration of work, resulting in the least amount time to achieve RAOs.

As the scope of the alternatives changes from Alternatives 2 to Alternative 6, hauling of significant quantities of impacted material will occur by residents who live along local roads and highways. Hauling of cover material and water for dust control will also be required, and project duration will increase. The increase in the magnitude of hauling and duration will increase the potential for impacts from fugitive dust, vehicle emissions, and noise, and increase potential pedestrian and traffic hazards.

A major component of short-term effectiveness is the impacts to surrounding communities, including traffic during construction. The total miles driven and construction duration increase with the higher numbered Alternatives. To summarize:

- Alternative 2 includes 4 months of construction and an estimated 198,000 total miles driven.
- Alternative 3 includes 7 months of construction and an estimated 297,000 total miles driven.
- Alternative 4 includes 4 years of construction and an estimated 819,000 total miles driven.
- Alternative 5 includes 7 years of construction and an estimated 998,000 to 1,083,000 total miles driven.
- Alternative 6 includes 34 years or more of construction and an estimated 21,917,000 miles driven.

Risks from increased traffic include wear and tear on roads from heavy equipment and the potential for increased traffic accidents. Because traffic safety is a large concern on the Navajo Nation, traffic statistics were reviewed for roads that would be impacted by construction activities (Navajo DOT 2018). Motor vehicle statistics were available for 2014, 2015, and 2016 for the Eastern Agency of the Navajo Nation, where the project site is located. The report only provided accident totals and did not provide information on total traffic flow or accident rates. Alternatives 2 through 5 would be limited to roads within the Eastern Agency. Alternative 6 would include roads in the Eastern and Northern Agency. A data review indicates the following:

- There is an average of 50 and 140 crashes in the Eastern and Northern Agencies each year, respectively.
- There is an average of 37 and 135 injury crashes in the Eastern and Northern Agencies each year, respectively.
- There is an average of 5 and 16 fatal crashes in the Eastern and Northern Agencies each year, respectively.
- The top four causes for traffic accidents are driver inattention, animal on road, driving under the influence, and speeding.

With respect to GSR, Alternatives 2, 3, 4, 5, and 6 were compared in terms of three major components: backfill production, transportation of backfill to the site, and residual handling. Of these three components, backfill production had the largest impact on SOx and PM10 footprints. Therefore, Alternatives 2, 3 and 6, with the least amount of backfill required, had the smallest SOx and PM10 footprints, whereas Alternatives 4 and 5 had the largest SOx and PM10 footprints. Residual handling had the largest impact on the remaining impact categories—GHG emissions, total energy used, NOx emissions, and accident risk when compared with other alternatives. Alternatives 2 and 3, with the least amount of residual handling, had the smallest impact in these categories, whereas Alternative 6, with the most residual handling, had the largest impact in these categories.

5.2 Implementability

5.2.1 Technical Feasibility

Alternatives 2, 3, 4, 5, and 6 are technically feasible. Alternatives 2 and 3 have the most flexibility in scope with respect to planning and design. They can be implemented with conventional equipment and work approaches as well as locally available materials and labor. Alternatives 4, 5, and 6 also represent conventional response actions, although each involves added scope as a result of increased requirements for loading and transport of impacted material and cap materials. If a shared regional repository concept is selected, then implementation of Alternative 5 may be complicated by coordination with other mine waste sites.

5.2.2 Administrative Feasibility

Alternatives 2 and 3 are the most administratively feasible alternative because waste is managed onsite; relatively low quantities of materials are being transported; and administrative requirements, such as special permitting and coordination with regulatory agencies other than those identified in this EE/CA, are not anticipated. Alternative 4 is comparable to Alternatives 2 and 3 in administrative feasibility, although additional material sources and transport would be required. If a shared regional repository concept is selected, Alternative 5 will require coordination with other mine waste sites. Alternative 6 involves significant transportation of waste rock and impacted soils offsite, which introduces additional administrative requirements. Alternative 6 also includes additional administrative obligations associated with a licensed repository. Therefore, Alternative 6 is ranked lowest for administrative feasibility.

5.2.3 Availability of Services and Material

Alternatives 2 and 3 rank highest of the alternatives for availability of services and materials because a relatively small-scale planning, design, and implementation effort and low volume of imported soil are required, and because conventional equipment and labor are locally available. Alternative 4 represents a greater challenge because of the additional excavation and hauling of waste rock and impacted soils, and greater volumes of import capping materials are needed. Alternatives 5 and 6 includes a significantly greater requirement for specialized long-haul contractors to transport waste offsite, which require the use of regional and potentially off-Reservation resources.

Each alternative could potentially yield short-term work for local, unexperienced workers. As the scope of the alternatives changes between Alternative 2 to Alternative 6, the need for unexperienced workers is reduced and the use of experienced or licensed workers increases.

5.2.4 Acceptability

Navajo Nation and community input will be solicited as part of the EE/CA process and will be evaluated by U.S. EPA before selecting a response action. Factors to be considered include the following:

- Potential for job opportunities during construction and long-term monitoring and maintenance (similar for Alternatives 2 and 3) based on duration and expected size of work force
  - Potential for job opportunities is slightly higher for Alternatives 4 and 5, based on the longer construction duration. Alternative 6 may create more job opportunities than the others overall; however, timing may be inconsistent.
- Transport of waste rock and impacted soil along local roads and highways (not applicable to Alternatives 2 and 3, significant for Alternatives 4 and 5, and most significant for Alternative 6)
- Transport of clean materials along local roads and highways (similar volumes of clean material required for Alternatives 2, 3, and 6, increased volume for Alternatives 4 and 5)
- Disruption to surrounding communities for duration of construction (increasing duration from Alternative 2 [4 months] through Alternative 6 [34 years or more])
- Waste rock and impacted soil remaining on the Ruby Mines Site (same for Alternatives 2 and 3, limited to one site for Alternative 4, and none for Alternatives 5 and 6)
- Alternatives 2 and 3 would allow waste rock pile areas to be used for herding, grazing, and gathering
  - Because Alternative 4 completely removes the waste rock pile from Ruby Mines No. 3, land could be used for future residential use at that location. Both Ruby Mines Nos. 1 and 3 could be used for future residential use under Alternatives 5 and 6, because waste rock and impacted soils would be removed. Land reuse is projected to be approximately 5 to 10 years following construction

completion (increasing duration from Alternative 2 [after 4 months of construction] through Alternative 6 [after at least 32 years of construction])

- Long-term monitoring and maintenance required at the site to maintain protectiveness for Alternatives 2, 3, and 4
  - Alternative 5 requires long-term monitoring and maintenance at the regional repository location. No long-term monitoring and maintenance is required after establishing vegetation for Alternative 6.

Recent conversations with some community members (Ruby Mines Site Status Meeting 2018) indicate that transportation of impacted materials by existing residences and impacts to local roads during construction are key concerns. See Section 5.1.4 for a comparison of alternatives based on traffic considerations.

5.3 Cost of Alternatives

The cost estimates for the alternatives are provided in Appendix G and summarized in Table 5-1.

Alternative 2 represents the lowest cost of implementation, estimated at $4,141,000 (capital cost), while providing protection of human health and the environment and the shortest amount of time (4 months for implementation and approximately 5 to 10 years for revegetation) to return the land to the community for current use.

Alternative 3 is comparable to Alternative 2 with respect to protectiveness and short-term effectiveness (7 months for implementation plus approximately 5 to 10 years for revegetation) and has an estimated capital cost ($6,183,000) that is slightly higher than Alternative 2.

Alternative 4 has an estimated capital cost ($16,247,000) that is nearly 4 times the cost of Alternative 2 and more than 2 times the cost of Alternative 3. It is equally protective but will require a longer time (4 years for implementation and an additional 5 to 10 years for revegetation) to restore the site for future use.

Alternative 5a has an estimated capital cost of $25,310,000 and Alternative 5b has a slightly higher estimated cost of $25,489,000 as a result of the mileage difference between the two regional repository locations. These costs are higher than Alternative 4. These alternatives provide more protection of human health and the environment and greater permanence at the Ruby Mines Site, but they pose additional short-term risks related to the magnitude of material that would be hauled offsite. For the purposes of this evaluation, Alternatives 5a and 5b are evaluated for disposal of waste rock and impacted soil only from the Ruby Mines Site. However, if a shared regional repository concept is selected to include wastes from other mine sites, then additional information would be required to fully evaluate this alternative and additional costs would be incorporated into this estimate, such as coordination with other stakeholders, increased material hauling, and repository cap maintenance.

Alternative 6 represents the highest cost of implementation at $343,623,000 (capital cost). This cost is more than 13 times greater and almost $320,000,000 higher than the next highest cost alternative. Although Alternative 6 offers the greatest protection of human health and the environment and greater permanence, it poses high short-term risks related to the magnitude of the material that would be hauled offsite on public roadways and volume of truck traffic over long-haul routes. Additionally, Alternative 6 would require many years to implement, prolonging the amount of time it would take to return the land to the community for use. Under the CD, which will include the Ruby Mines Site following completion of this EE/CA, there is an annual spending cap. This spending cap is inclusive of the 94 legacy Cyprus Amax and WNI mine sites throughout the Navajo Nation. Selection of a response action for the Ruby Mines would need to balance the cost and duration of implementation at Ruby Mines with the need to address the other mine sites. Therefore, it is assumed that $10,000,000 would be allocated to the Ruby Mines Site response action per year, resulting in at least a 34-year duration to complete the work.

6. Recommended Removal Alternative

Based on the evaluation presented herein, U.S. EPA has selected Alternative 3: Cap and Consolidate at Each Site as the recommended alternative.

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Tables

Table 1-1. Ruby Mine Sites Overview

Engineering Evaluation and Cost Analysis

Ruby Mines

Mine Site	Surface Area Acres (rounded)	Latitude (N)	Longitude (W)	Elevation ft amsl (estimated)	Years of Active Mining[b]	Tons of Ore Produced[b]	Year of Reclamation	COPCs identified in the RSE Investigation
Ruby Mines No. 1	25	35.518986	-108.222483	7480	1975-1981	495,360 tons (1976-1981)	1985	Ra-226, Arsenic, Molybdenum, Mercury, Selenium, Uranium, and Vanadium
Ruby Mines No. 2	NA	35.518986	-108.222483					
Ruby Mines No. 3	15	35.506703	-108.163614		1980-1985	295,000 tons		
Ruby Mines No. 4	NA	35.506703	-108.163614					

[a] The RSE Investigation area includes the mine site surface area, a 100-foot buffer, and inaccessible areas for the mine site.

[b] Information obtained from the U.S. EPA Atlas with Geospatial Data (U.S. EPA 2007).

Notes:

Only Ruby Mines Nos. 1 and 3 had surface operations

COPCs = contaminants of potential concern

ft amsl = feet above mean sea level

N = North

NA = Not Applicable

RSE = Removal Site Evaluation

W = West

Table 1-2. Ruby Mines Features and Dimensions

Engineering Evaluation and Cost Analysis

Ruby Mines

HMOSP Mine Feature Name[a]	Feature Description	Reclamation Status	Dimensions[b] Surface Area (SF) Surface Area (ft^2)	Observed During RSE? (Yes/No)
RUBY-001	Adit	Closed during Phase 1	16 feet by 20 feet wide	Yes
RUBY-002	Ruby Mine vent	Closed during Phase 1	10 feet by 12 feet at the collar and gradually decreases to a 6-foot-by-6-foot shaft that contains the bottom of a metal tank	Yes
RUBY-003	Adit	Closed during Phase 1	3-foot-by-3-foot opening that increases to an 8-foot-by-8-foot opening	Yes
RUBY-004/RUBY-013	Ruby Mine vent/Potential Vent Hole No. 8	Closed during Phase 1	6 feet by 6 feet	Yes
RUBY-005	Vent Hole No. 1	Closed during Phase 1	--	Yes
RUBY-007	Vent Hole No. 2	Closed during Phase 1	--	Yes
RUBY-008	Vent Hole No. 3	Closed during Phase 1	--	Yes
RUBY-009	Potential Vent Hole No. 4	--	--	No
RUBY-010	Potential Vent Hole No. 6	--	--	No
RUBY-011	Potential Vent Hole No. 5	Historically Closed	--	No
RUBY-012	Potential Vent Hole No. 7	--	--	No
RUBY-014	Ruby Mine vent	Closed	--	Yes
RUBY-015	Ruby Mine vent	Historically Closed	--	Yes
RUBY-016	Prospect	Closed during Phase 1	20 feet by 20 feet	Yes
RUBY-017	Shaft	Closed during Phase 1	1 foot by 2 feet	Yes
RUBY-018	Ruby mine vent	Closed during Phase 1	12 feet by 15 feet	Yes
RUBY-019	Ruby Mine vent	Historically Closed	--	Yes
RUBY-020	Prospect	Closed during Phase 1	7 feet by 7 feet	Yes
RUBY-021	Shaft	Closed during Phase 1	six inches in diameter	Yes
RUBY-022	Ruby Mine vent	Historically Closed	--	Yes
RUBY-023	Vent 23	Closed	--	Yes

[a] "RUBY-XXX" is a unique location identifier assigned by the Freeport-McMoRan Historic Mine Opening Safety Program (HMOSP).

[b] Dimensions were estimated by aerial figures.

[c] Area was calculated in GIS.

Notes:

Twenty-two features associated with the Ruby Mines were initially identified based on information contained in historical site documents, conversations with local residents during site visits, and observations by field personnel. Each of the features was an assigned unique identifier: RUBY-001 through RUBY-022. Of the 22 features, 9 features were excluded and 13 were carried through to site characterization. The 9 features excluded included 8 potential vent locations (RUBY-005, RUBY-007, RUBY-008, RUBY- 009, RUBY-010, RUBY-012, RUBY-013, and RUBY-014) that were shown on historical maps, but that could not be positively identified in the field. They may have been closed historically or not constructed as documented in historical plans. The other feature is a former dewatering well (RUBY-006), which is no longer operational.

No. = number

-- = information not available.

Table 2-1. Predominant Geology for Ruby Mines Features
Engineering Evaluation and Cost Analysis
Ruby Mines

Mine Feature Designation	Feature Description	Predominant Geology	Background Comparison Value (counts per minute)[a]
RUBY-001	Adit	Mancos Shale	11946
Ruby Mines No. 1	Capped waste rock pile	Colluvium	12404
	Drainages A, B, C	Colluvium	12404
	Exploratory borehole area	Dakota Sandstone	10318
	Former haul road to Wolf Canyon Road	Colluvium	12404
	Former haul road at Wolf Canyon Road - isolated location near BIA Route 49	Colluvium	12404
	Residences	Dakota Sandstone	10318
	Step out area	Colluvium	12404
	Work area	Colluvium	12404
RUBY-002	Ruby Mine vent	Dakota Sandstone	10318
RUBY-003	Adit	Mancos Shale	11946
Ruby Mines No. 3	Capped waste rock pile	Mancos Shale	11946
	Dewatering area	Mancos Shale	11946
	Drainages	Colluvium	12404
	Exploratory borehole area	Mancos Shale	11946
	Former haul road to New Mexico Highway 371	Mancos Shale	11946
	Residence	Mancos Shale	11946
	Work Area	Mancos Shale	11946
RUBY-004	Ruby Mine vent	Mancos Shale	11946
RUBY-011	Ruby Mine vent	Colluvium	12404
RUBY-015	Ruby Mine vent	Dakota Sandstone	10318
RUBY-016	Prospect	Mancos Shale	11946
RUBY-017	Shaft	Mancos Shale	11946
RUBY-018	Ruby mine vent	Colluvium	12404
RUBY-019	Ruby Mine vent	Colluvium	12404
RUBY-020	Prospect	Mancos Shale	11946
RUBY-021	Shaft	Dakota Sandstone	10318
RUBY-022	Ruby Mine vent	Dakota Sandstone	10318

[a] The background comparison value was calculated as the mean plus two standard deviations of the background sample concentrations collected in the background reference area for the given geologic unit.

Note:
No. = number

Table 2-2. Exposure Unit Summary

Engineering Evaluation and Cost Analysis

Ruby Mines

Exposure Unit	Geologic Formation	Area	Future Land Use[a]	Depth (inches bgs)	Surface Soil (0-12 inches bgs)	Surface Soil (12-18 inches bgs)	Total Number of Samples
1	Colluvium	Ruby Mines Site No. 1	Washes and Drainages	0-18	7	4	11
2	Colluvium	Ruby Mines Site No. 3	Washes and Drainages	0-18	13	6	19
3	Colluvium	Ruby Mines Site No. 1	Residential	0-18	42	17	59
4	Colluvium	Ruby Mines Site No. 3	Residential	0-18	29	5	34

[a] Residential use is assumed at each site outside of capped areas, with the exception of drainage/wash areas where residential use is not possible. The capped waste rock piles will be evaluated as a residential exposure unit for the risk assessment; however, future land use within the capped waste rock pile depends on the response action evaluated. If the capped waste rock pile remains in place after remedy implementation, then residential use would be unrestricted outside the cap and restricted in this area on the capped waste rock pile. If the waste rock pile is removed, then residential use would be unrestricted.

Note:

bgs = below ground surface

Table 2-3. Risk-Based Screening Levels, Background Threshold Values, and Cleanup Goals
Engineering Evaluation and Cost Analysis
Ruby Mines

EU 1- Ruby No. 1 - Washes and Drainages							
COC / COEC	Units	EPC	Human Health RBSL	Ecological RBSL	Eco PRG[a]	BTV	Cleanup Goal[b]
Near-Surface Soil (0-18 inches bgs)							
Radium-226	pCi/g	13	0.20	15	-	1.65	1.65
Selenium	mg/kg	17	153	1.0	5.1	1.5	5.1
Uranium	mg/kg	21	8.1	250	-	0.87	8.1
Vanadium	mg/kg	40	168	9.5	80	17	80
EU 2- Ruby No. 3 - Washes and Drainages							
COC / COEC	Units	EPC	Human Health RBSL	Ecological RBSL	Eco PRG[a]	BTV	Cleanup Goal[b]
Near-Surface Soil (0-18 inches bgs)							
Radium-226	pCi/g	28	0.20	15	-	1.65	1.65
Selenium	mg/kg	30	153	1.0	5.1	1.5	5.1
Uranium	mg/kg	64	8.1	250	-	0.87	8.1
Vanadium	mg/kg	97	168	9.5	80	17	80
EU 3- Ruby No. 1 - Residential							
COC / COEC	Units	EPC	Human Health RBSL	Ecological RBSL	Eco PRG[a]	BTV	Cleanup Goal[b]
Near-Surface Soil (0-18 inches bgs)							
Radium-226	pCi/g	366	0.05	15	-	1.65	1.65
Selenium	mg/kg	21	17	1.0	5.1	1.5	5.1
Uranium	mg/kg	804	3	250	-	0.87	2.8
Vanadium	mg/kg	153	65	9.5	80	17	65
EU 4- Ruby No. 3 - Residential							
COC / COEC	Units	EPC	Human Health RBSL	Ecological RBSL	Eco PRG[a]	BTV	Cleanup Goal[b]
Near-Surface Soil (0-18 inches bgs)							
Radium-226	pCi/g	418	0.05	15	-	1.65	1.65
Selenium	mg/kg	378	17	1.0	5.1	1.5	5.1
Uranium	mg/kg	357	3	250	-	0.87	2.8
Vanadium	mg/kg	101	65	9.5	80	17	65

[a] Because ecological RBSLs for selenium and vanadium are conservative screening values that are often below soil background concentrations in the U.S. and were not intended to be used as cleanup values, the lowest Published Los Alamos National Laboratory Ecological Preliminary Remediation Goals were used as the cleanup goals instead of Ecological RBSLs.

[b] The cleanup goal is the lesser of the human health or ecological RBSLs unless either RBSL is less than the BTV. If the BTV is higher than either RBSL, then the removal action goal is to address material that is distinguishable from background. For purposes of this EE/CA, the BTV is used to represent background for delineating contaminated areas.

Notes:
bgs = below ground surface
BTV = background threshold value
COC = contaminant of concern
COEC = contaminant of ecological concern
EPC = exposure point concentration
EU = exposure unit
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
PRG = preliminary remediation goals
Ra-226 = Radium-226
RBSL = risk-based screening level

Table 2-4. Cleanup Volume
Engineering Evaluation and Cost Analysis
Ruby Mines

Geologic Formation	Area	Acres	Cubic Yards
Colluvium	Ruby Mines Site No. 1	12	164,258
Colluvium	Ruby Mines Site No. 3	14	173,925
	Total	**26**	**338,183**

Table 2-5. Data Gaps

Engineering Evaluation and Cost Analysis

Ruby Mines

Area	Data Gaps
Ruby Mines Site No. 1	The vertical extent of media required for cleanup was not achieved at sample locations RM01-CWRP01, RM01-CWRP05, RM01-HR02, RM01-HR03, RM01-HR04, RM01-HR05, RM01-HR06, RM01-HR07, RM01-STEP01, RM01-STEP03, RM01-STEP05, RM01-WRK01, RM01-WRK02, RM01-WRK04, RM01-8MAY14-01, RM01-8MAY14-02, RM01-8MAY14-03, RM01-8MAY14-04, RM01-8MAY14-05, RM01-8MAY14-06, RM01-8MAY14-07, RM02-VENT02, RM02-VENT03, RM19-VENT02, RM19-VENT03, RM-COR18, RM-COR19, RM-COR20, RM-COR21, RM-COR23, RM-COR41, RM-COR42, RM-COR43, RM-COR45, RM-COR46, RM-COR47.
Ruby Mines Site No. 3	The vertical extent of media required for cleanup was not achieved at sample locations RM03-CWRP01, RM03-CWRP02, RM03-CWRP03, RM03-CWRP04, RM03-CWRP06, RM03-DRN02, RM03-DWTR01, RM03-DWTR02, RM04-VENT02, RM04-VENT03, RM03-8MAY14-02, RM03-8MAY14-03, RM03-8MAY14-04, RM03-8MAY14-05, RM03-8MAY14-06, RM03-8MAY14-07, RM03-8MAY14-08, RM03-8MAY14-09, RM-COR25, RM-COR26, RM-COR28, RM-COR29, RM-COR30, RM-COR31, RM-COR32, RM-COR33, RM-COR34, RM-COR36, RM-COR37, RM-COR38, RM-COR39, RM-COR40.

Table 4-1. Response Action Alternatives Identified
Engineering Evaluation and Cost Analysis
Ruby Mines

General Response Action	Process Options	Description	Retained for Further Evaluation?	Rationale
No Action	None	No treatment, no containment, or removal action will occur.	Yes	Required by the NCP for comparative purposes.
Engineering Controls (Containment)	Consolidate and Repair Existing Caps	Full excavation of contaminated material above the removal action goal from areas surrounding capped waste rock piles (haul roads, work and step-out areas, drainage channels, vents, etc.), consolidation within the footprint of the existing waste rock piles, and repair of the existing caps at Ruby Mines Nos. 1 and 3.	Yes	Process is implementable, effective, and can achieve RAOs.
Engineering Controls (Containment)	Consolidate and Cap at Each Site	Full excavation of contaminated material above the removal action goal from areas surrounding the waste rock piles (former haul roads, work and step-out areas, drainage channels, vents, etc.), consolidation within the existing waste rock piles, and placement of a cap over the piles. The cap would function as an evapotranspirative cover system that would support vegetative growth, store precipitation, reduce potential infiltration, and limit erosion.	Yes	Process is implementable, effective, and can achieve RAOs.
Engineering Controls (Containment)	Consolidate and Cap at One Site (Ruby No. 1)	Consolidating waste rock from Ruby Mines No. 3 and full excavation of contaminated material above the removal action goal from areas surrounding both capped waste rock piles (former haul roads, work and step-out areas, drainage channels, vents, etc.); consolidating within the existing waste rock pile at Ruby Mines No. 1; and placing a cap layer over the consolidated materials. The cap would function as an evapotranspirative cover system that would support vegetative growth and store precipitation and reduce potential infiltration. Ruby Mines No. 1 is the preferred site for consolidation of waste, based on its reduced aerial footprint, storage capacity, and constructability.	Yes	Process is implementable, effective, and can achieve RAOs.
Engineering Controls (Containment)	Excavate and Manage at a Regional Repository (Black Jack No. 1)	Full excavation of contaminated material above the cleanup goal from both sites and hauling to one or more regional repositories located on the Navajo Nation lands, in cooperation with other mining site parties. It is assumed that two regional repositories will be established. The first will be located at Mac No. 1 and will include waste rock and impacted soils from Mac No. 1, Mac No. 2, Black Jack No. 2, and Mariano Lake. The second will be located at Black Jack No. 1 to include waste rock and impacted soil from Black Jack No. 1, Ruby Mines No. 1, and Ruby Mines No. 3. The alternative includes the full excavation of contaminated material above the cleanup goals, hauling excavated material on existing roads across 5 miles (from Ruby Mines No. 1) to 8 miles (from Ruby Mines No. 2) (average of 7 miles), one way, to Black Jack No. 1, capping waste after placement in repository with an evapotranspirative cover system, and long-term operations and maintenance. The repositories on the Navajo Nation will require land use controls.	Yes	Process is implementable, effective, and can achieve RAOs.
Engineering Controls (Containment)	Excavate and Manage at a Regional Repository (Mac No. 1; combined waste from Homestake Mining Co., Western Nuclear and Chevron)	Full excavation of contaminated material above the cleanup goal from both sites and hauling to one on-Reservation repository that will be established at Mac No. 1 and will include waste rock and impacted soil from all of the mine sites (Mac No. 1, Mac No. 2, Black Jack No. 1, Black Jack No. 2, Mariano Lake, Ruby Mines No. 1 and Ruby Mines No. 2). The alternative includes the full excavation of contaminated material above the cleanup goals, hauling excavated material approximately 3 miles (from Ruby Mines No. 1) to 15 miles (from Ruby Mines No. 2) (average of 9 miles), one way, to Mac No. 1 , capping of waste after placement in repository with an evapotranspirative cover system, and long-term operations and maintenance. The repository on the Navajo Nation will require land use controls.	Yes	Process is implementable, effective, and can achieve RAOs.
Engineering Controls (Disposal)	Excavate and Manage Off-Navajo Disposal	The full excavation of contaminated material above the cleanup goals and transport off the Navajo Nation lands for disposal at an approved facility.	Yes	Process is implementable, effective, and can achieve RAOs.

Table 4-1. Response Action Alternatives Identified
Engineering Evaluation and Cost Analysis
Ruby Mines

General Response Action	Process Options	Description	Retained for Further Evaluation?	Rationale
Engineering Controls (Containment)	Construction of Caps with Liners (applicable for regional repositories)	The addition of a liner system to the regional repository alternatives. In this process, a bottom liner would be placed beneath the cap.	No	Waste rock piles and impacted soils are unlikely to produce leachate and impact groundwater. This is because (1) intervening geologic materials provide both hydraulic and geochemical barriers to leachate transport; (2) the depth to aquifers sufficient to supply drinking water is substantial, and recharge areas are not located near the site; and (3) there is a lack of leachate produced by the waste rock piles and impacted soils. The justification for these statements is detailed in the Ruby Mines Site Geology and Hydrogeology Summary Technical Memorandum (dated April 3, 2020), provided in Appendix E. It is unlikely that COCs would migrate from the rock piles and impacted soils to groundwater, based on these lines of evidence. Thus, further consideration of a liner system is unwarranted.
Engineering Controls (Containment)	Backfill Voids	Consists of returning waste rock and impacted soils to the underground mine workings.	No	The amount of waste rock that could be placed in mine voids cannot be reasonably determined. Waste rock currently located in the capped piles contains void space that was not present in the undisturbed, pre-mining rock formation. Eliminating this void space is unfeasible. The declines can only be accessed from the ground surface. Each decline (a sloped entrance shaft) is up to a half-mile in length, and mine workings are encountered at depths up to 500 feet below the ground surface. As a result, it is assumed that waste rock and soil placement would likely be limited to the upper, near surface portion of each decline; however, the exact location of the concrete wall reportedly installed in one of the declines is unknown, and the capacity of the shaft to receive waste rock and soil could be further limited. It is likely that even if the declines could be safely accessed to place waste rock, a significant volume of waste rock and impacted soils would remain that would require management similar to the other response actions presented. Given these uncertainties, an accurate scope of work and reliable cost estimate for this alternative cannot be developed.
Engineering Controls (Containment)	Encapsulation of Site (Concrete Cover)	A concrete cover is applied across the impacted area of the Mine Site.	No	Does not return the site to its pre-existing condition and is not conducive with current grazing and gathering land uses.

Table 4-1. Response Action Alternatives Identified
Engineering Evaluation and Cost Analysis
Ruby Mines

General Response Action	Process Options	Description	Retained for Further Evaluation?	Rationale
Engineering Controls (Containment)	Solidification	Uranium minerals and soluble radionuclides and metals in mine waste is physically encapsulated to form a solid material to reduce contaminant leachability and to reduce mobility. Solidification involves mixing waste with a binder material, such as cement, fly ash, clay, or geopolymers. The binder material would have to be hauled to the site, and a batch plant would need to be set up to mix the binder with waste. The mixing process requires a large quantity of water for binding to occur; therefore, a water source must be developed or water must be imported from offsite. Once the material is solidified, it may be placed into a repository or in aboveground mine workings as stackable blocks.	No	Solidification does not address radiation concerns. The volume of waste requiring disposal greatly increases because of the addition of binding agents. Furthermore, unless placed in a disposal cell or repository, the solidified material may break apart when exposed to freeze-thaw and precipitation, potentially increasing leachability. On- or offsite disposal options are just as protective for the original volume of waste and use fewer resources. As a result, solidification was determined not practicable.
Engineering Controls (Containment)	Stabilization	Uranium minerals and soluble radionuclides and metals in mine waste are chemically altered to reduce contaminant leachability and to reduce toxicity. Surface area, porosity, and permeability of waste are reduced to limit leaching. Stabilization involves the mixing of waste with a neutralizing material, such as lime/fly ash and pozzolan/cement. The neutralizing material would have to be hauled to the site, and a batch plant would need to be set up to mix the material with waste. The mixing process requires a large quantity of water for the reaction to occur; therefore, a water source must be developed or water must be imported from off site. Once the material is stabilized, it may be placed into a repository or in aboveground mine workings as a gravel admixture.	No	Stabilization does not address radiation concerns. The volume of waste requiring disposal increases because of the addition of neutralizing agents. Furthermore, unless placed in a disposal cell or repository, the stabilized material may break apart when exposed to freeze-thaw and precipitation, potentially increasing leachability. Onsite or offsite disposal options are just as protective for the original volume of waste and use fewer resources. As a result, stabilization was determined not practicable.
Engineering Controls (Disposal)	Disposal at Municipal Solid Waste Landfill	The full excavation of contaminated material above the cleanup goal and transportation off the Navajo Nation lands for disposal at a municipal solid waste landfill.	No	Disposal of radionuclide mine waste requires a facility that is licensed to accept such waste. Municipal Solid Waste Landfills are not licensed to accept radionuclide waste.
Treatment	Phytoremediation	Plants with the ability to absorb radionuclides and metals within their root system are planted within the cleanup extent of the Site.	No	Much of the contamination at the site is located in piles, and not all of the waste would be easily accessible by plant roots. Moreover, because radionuclides and metals cannot be biodegraded, plants used in phytoremediation must be harvested and sent for disposal as a radioactive waste, and prevention of human or animal consumption of the plants would be necessary. To use this treatment option, waste would have to be spread out over a very large area to achieve a workable depth, which would further contaminate additional areas. Phytoremediation has not been shown to reduce Ra-226 concentrations in mining waste to the extent needed to meet the removal action goals. Because of the limited planting area, limited access, limited depth of root penetration, and harvested material-handling requirements, phytoremediation was determined not practicable.
Treatment	Milling and Processing	An offsite commercial process that removes uranium by a combination of several methods, including pulverization and acid extraction.	No	Concentrations of uranium in the waste rock at the site are low, so any processing would therefore yield only a minimal amount of uranium. Additionally, milling does not remove radium, and the resulting mill waste is neither less toxic nor less mobile than the source material. Thus, milling was determined not practicable for treatment of uranium mine waste.

Table 4-1. Response Action Alternatives Identified
Engineering Evaluation and Cost Analysis
Ruby Mines

General Response Action	Process Options	Description	Retained for Further Evaluation?	Rationale
Treatment	Soil Washing	Involves washing the contaminated waste (with water) in a heap, vat, or agitated vessel to dissolve water-soluble contaminants. Soil washing requires that contaminants be readily soluble in water and sized sufficiently small so that dissolution can be achieved within a practical retention time.	No	The most common forms of uranium oxides attached to sand particles in waste rock at the site have low solubility in water, rendering soil washing ineffective for removal to below cleanup goals. Solubility of other metals depends on the forms of the metals present in the waste and can range from highly soluble to insoluble. Insoluble metals in the waste would not be treated. Highly soluble metals in the wash solution are then precipitated as insoluble compounds, and the treated solids are dewatered. Additionally, the precipitates may form a sludge requiring additional treatment, such as dewatering or stabilization, before disposal. Dewatered precipitates and sludge must be disposed of at a mill, RCRA C, or LLRW facility because of the concentrating of radionuclides. Because of the low concentrations of uranium in the waste rock and varying solubilities at different pH ranges for radionuclides and metals, soil washing likely would not meet cleanup goals and was determined not practicable.
Treatment	Acid Extraction	Similar to soil washing except an acidic solution instead of water is applied to the waste rock or other contaminated media in a heap, vat, or agitated vessel. Depending on temperature, pressure, and acid concentration, varying quantities of metal constituents would be solubilized. A broader range of contaminants are expected to be acid soluble at ambient conditions with acid extraction than with soil washing. Acid extraction would dissolve a portion of the mineralized uranium attached to the sand particles; however, some percentage could remain bound in the sand particles. Dissolved contaminants are subsequently precipitated for additional treatment and disposal.	No	Acid extraction likely would not decrease concentrations of all contaminants below cleanup goals, based on the uranium mineralization on the surface of sand particles in the waste rock and varying solubilities of radionuclides and metals at different pH ranges, and was determined not practicable. In particular, acid extraction would not remove Ra-226, which is a primary risk driver.
Treatment	Ablation	The ablation process mixes water and waste rock into a slurry that is injected into impact tank modules. The opposing slurry streams impact one another, and collisions between the sandstone particles and fragments within each stream result in disassociation of fine-grained, intergranular, and mineralized material (uranium minerals) from coarser-grained sands. Ablation technology has potential for treating waste rock with surface uranium mineralization with some small commercial systems in operation.	No	Pilot-scale studies began in summer 2022 to test the feasibility of the technology at three areas on the Navajo Nation, including Church Rock, Quivira, and the Cove Transfer Station No. 2. Ablation technologies have not demonstrated sufficient throughput to address a large volume of waste rock. One of the goals of the pilot studies is to evaluate scale-up designs and economics. If after the pilot study ablation is determined to be successful and scalable, then a future draft of the EE/CA may incorporate it as an alternative.

Notes:
COC = contaminant of concern
Gray = eliminated alternatives
NA = Not Applicable
NCP = National Contingency Plan
RAO = remedial action objective

Table 4-2. Summary of Alternative Metrics

Engineering Evaluation and Cost Analysis

Ruby Mines

Alternative	Volume of Backfill Material Transported to Site (cy)	Truckloads of Backfill Material Transported to Site	Volume of Waste Hauled Offsite (cy)	Mass of Waste Hauled Offsite (Tons)	Truckloads of Waste Hauled Offsite	Total Miles Driven	Water Use (gallons)	Approximate Project Duration[a]	Project Capital Cost
Alternative 2. Consolidate and Repair Existing Caps	34,700	2,200	0	0	0	198,000	216,000	4 months	$4,141,000
Alternative 3. Consolidate and Cap at Each Site	52,000	3,300	0	0	0	297,000	330,000	7 months	$6,183,000
Alternative 4. Consolidate and Cap at One Site	98,600	6,200	174,000	261,000	10,875	819,000	1,706,000	4 years	$16,247,000
Alternative 5a. Regional Repository (Black Jack No. 1)	124,200	7,800	338,500	507,750	21,156	998,188	2,898,000	7 years	$25,310,000
Alternative 5b Regional Repository (Mac No. 1)	124,200	7,800	338,500	507,750	21,156	1,082,813	2,898,000	7 years	$25,489,000
Alternative 6 Excavate and Manage Off-Reservation	51,600	3,225	338,500	507,750	18,806	21,916,639	2,190,000	≥ 34 years	$343,623,000

[a] During periods with snowfall, estimated to be approximately 4 months of the year, local roads and former haul roads may not be passable, and construction will be stopped.

Notes:

cy = cubic yards

Assumptions:

1. 1 cy of waste is equal to 1.5 tons.
2. Trucks have a 16 cy capacity.
3. Trucks used for off-Reservation transportation have a 27 ton capacity.
4. Round-trip travel from Gallup for backfill material is 90 miles.
5. Round-trip travel between Ruby Mines No. 1 and Ruby Mines No. 3 is 24 miles.
6. Round-trip travel between the Ruby Mines Site and Black Jack No. 1 is 14 miles (Alternative 5a).
7. Round-trip travel between the Ruby Mines Site and Mack No. 1 is 18 miles (Alternative 5b).
8. Round-trip travel between the Ruby Mines Site and the off-Reservation facility in Deer Trail Colorado is 1,150 miles.
9. 6,000 gallons of water will be required per day during material hauling for dust suppression.
10. Alternative 6 assumes a maximum spend of $10M per year based on prioritization of cleanup under the Consent Decree.

Table 5-1. Summary of Cost Estimates

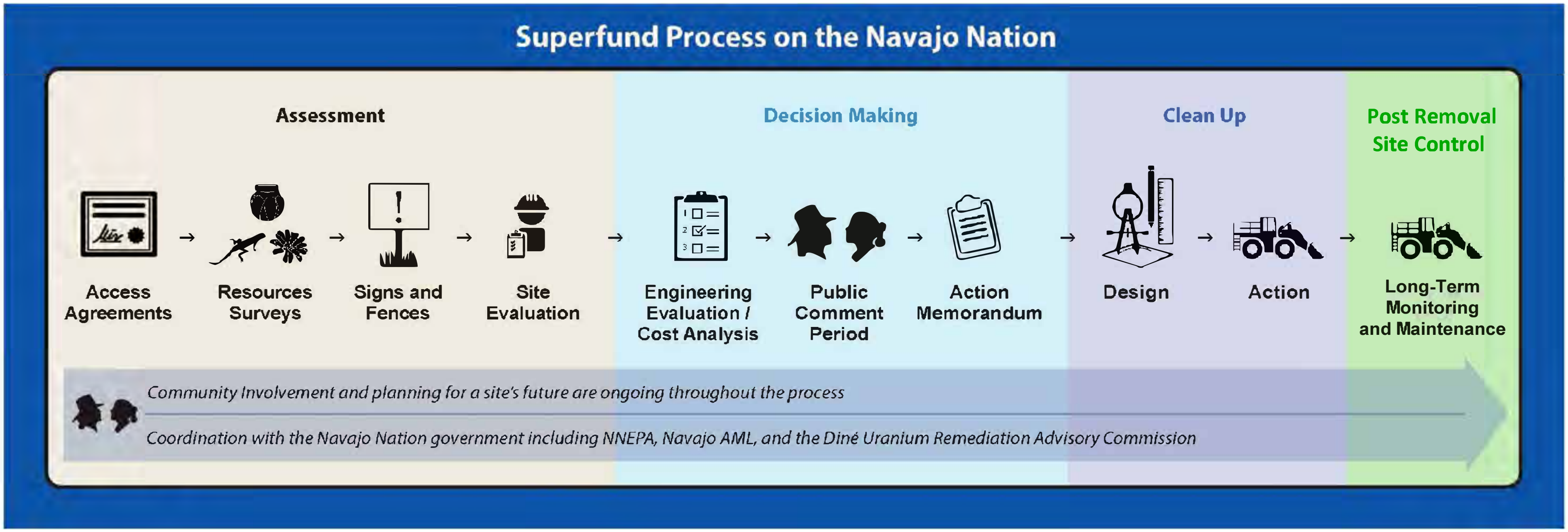
Engineering Evaluation and Cost Analysis

Ruby Mines

Alternative		Capital Cost	Long-term Monitoring and Maintenance Costs (Net Present Value)	-30% to +50% Range
Alternative 2	Consolidate and Repair Existing Caps	$4,141,000	$2,263,000	$4,483,000 to $9,605,000
Alternative 3	Consolidate and Cap at Each Site	$6,183,000	$2,263,000	$5,912,000 to $12,670,000
Alternative 4	Consolidate and Cap at One Site	$16,247,000	$2,263,000	$12,957,000 to $27,765,000
Alternative 5a	Regional Repository (Black Jack No. 1)	$25,310,000	$2,352,000	$19,363,000 to $41,493,000
Alternative 5b	Regional Repository (Mac No. 1)	$25,489,000	$2,352,000	$19,489,000 to $41,761,000
Alternative 6	Excavate and Manage Off-Reservation (U.S. Ecology)	$343,623,000	$102,000	$240,608,000 to $515,588,000

Note: Costs presented herein are for comparison purposes only and are not a guarantee of fixed costs for the specific alternative. The cost estimate is accurate to -30%/+50%.

Figures



Notes:
AML = Abandoned Mine Lands
NNEPA = Navajo Nation Environmental Protection Agency

Figure 1-1. Navajo Nation Superfund Process
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs

SLC \\DC1VS01\GISPROJ\F\FREEPORT\FCUP_NN\MAPFILES\SITESPECIFIC\COVE\RSE_REPORT_FIGURES\COVE_EECA_TENORM_VOL\COVE_EECA_TENORM_VOL.APRX TARROWOO 6/3/2022 10:53:16

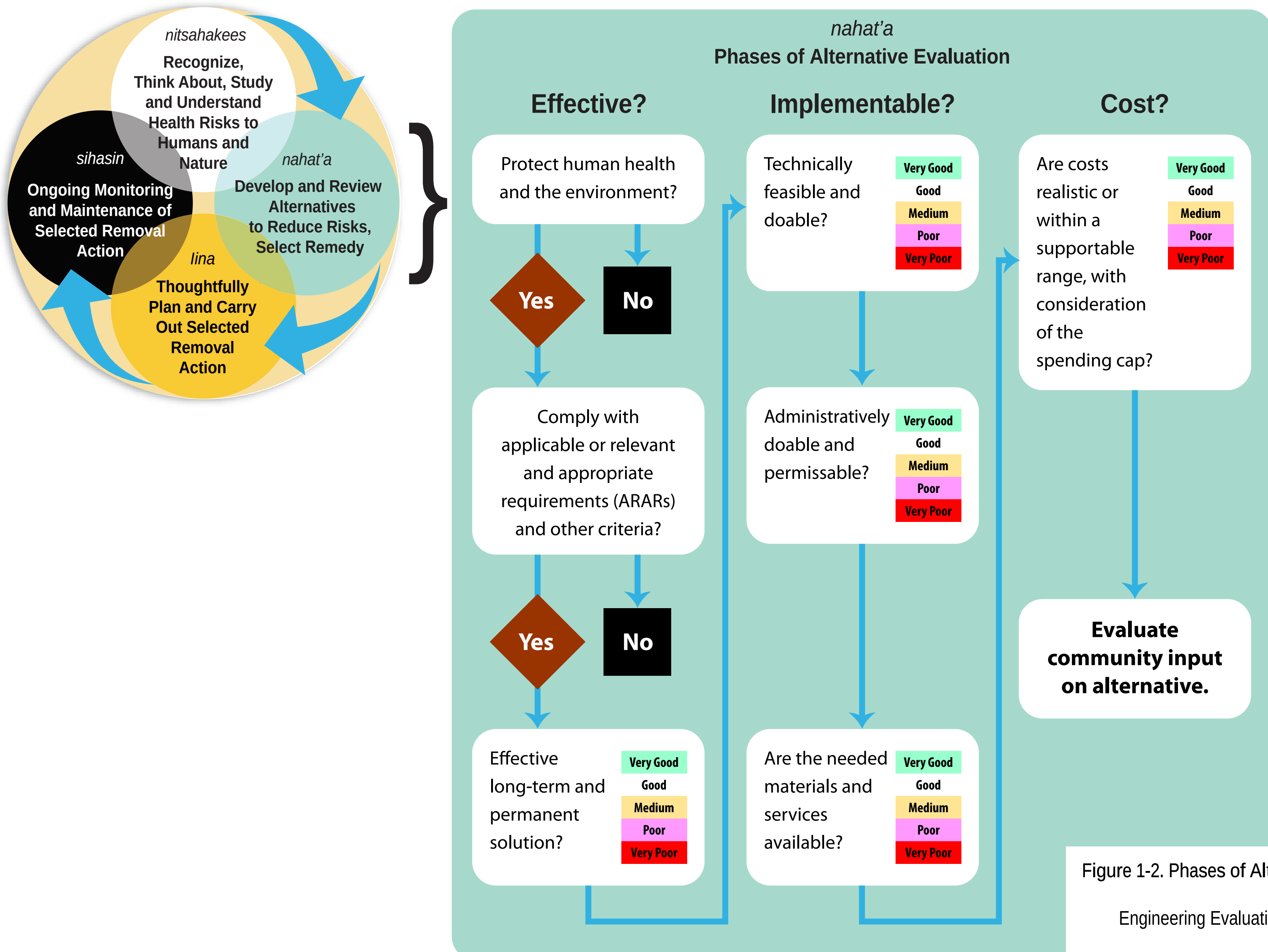
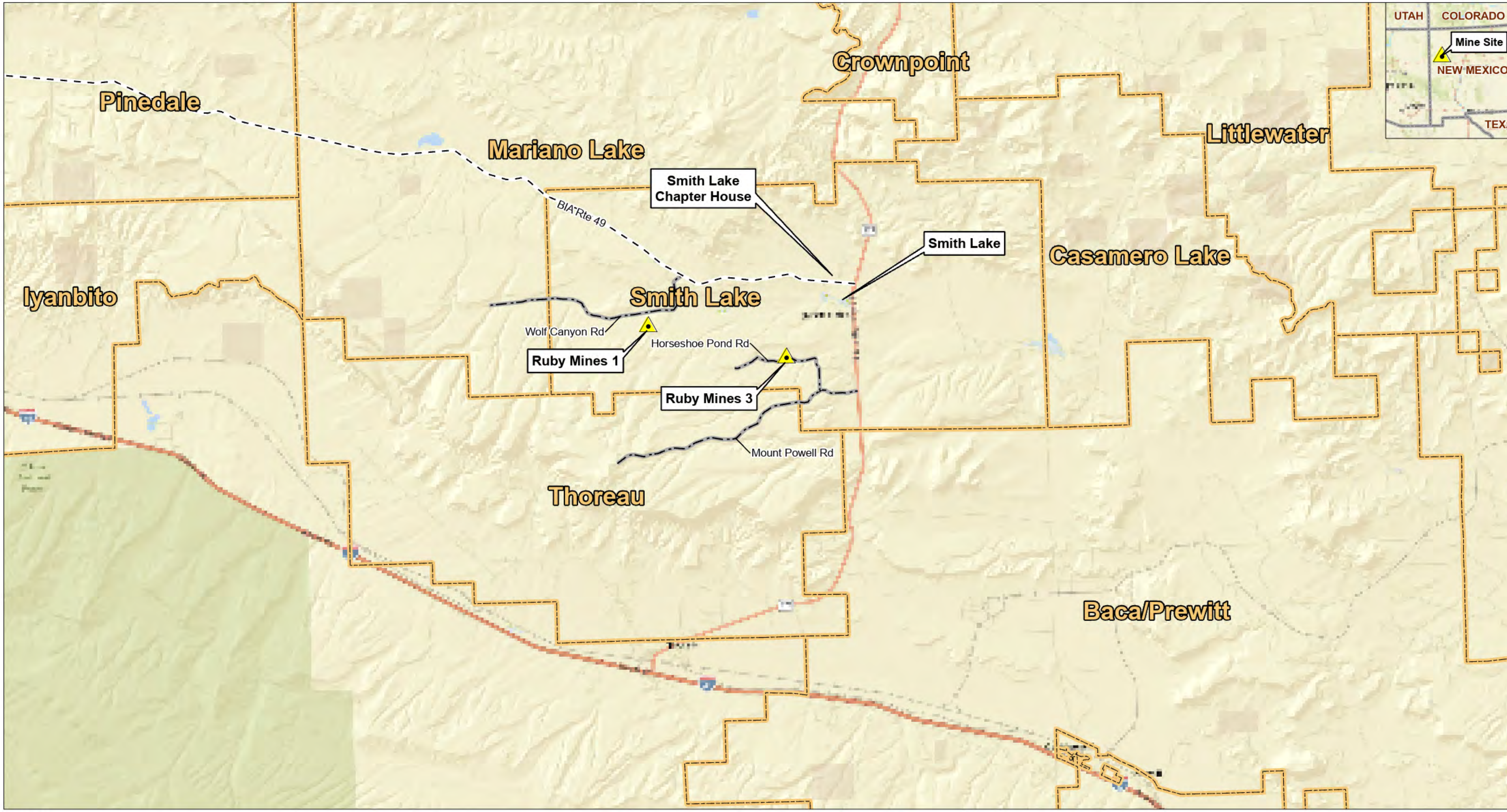


Figure 1-2. Phases of Alternative Evaluation

Ruby Mines

Engineering Evaluation and Cost Analysis

Jacobs



LEGEND

- Ruby Mines Location
- Major Road
- Maintained Gravel Road
- Navajo Nation Chapter 2015

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA_MAIN_OLD.APRX TARROWOO 11/2/2022 09:40:47

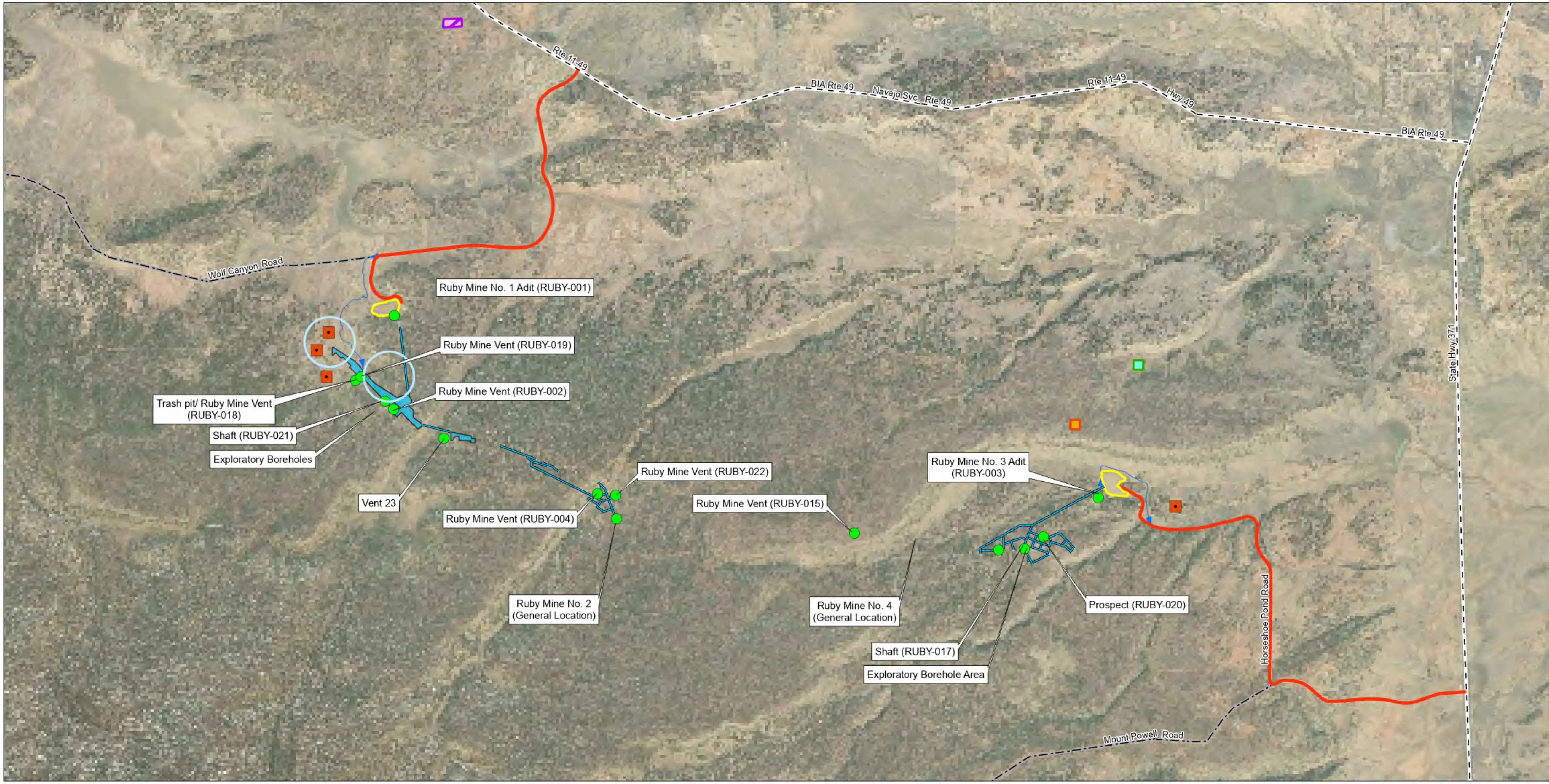
0 6,250 12,500 25,000
Feet

1:150,000 1:150,000

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Topographic Imagery: ESRI ArcGIS online

Figure 1-3. Ruby Mines General Location Map
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs



LEGEND

- Closed Mine Features
- Residences
- Shafts
- Former Haul Road
- Drainage
- Major Roads
- Maintained Gravel Road
- Underground Mine Workings
- Capped Waste Rock Pile
- Mancos Shale Background Reference Area
- Dakota Sandstone Background Reference Area
- Colluvial Backround Reference Area

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA_MAIN_OLD.APRX TARROWOO 11/2/2022 09:42:47

N

0 1,250 2,500 5,000

Feet

1:30,000 1 inch = 2,500 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 1-4. Ruby Mines Site Layout
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs

Cleanup Alternative and Description	Timing	Protective of Health and Environment	Potential Future Land Use	Waste Trucking Miles	Water Use During Implementation	Cost
2. Consolidate and Repair Existing Caps Excavate impacted soil, place within footprint of waste rock piles, and repair existing caps at each site	4 months	Protects humans and the environment	Suitable for herding, grazing, and gathering	No off-site waste trucking	>216,000 gallons	$
3. Consolidate and Cap in Place at Each Mine Site Excavate impacted soil, place within footprint of waste rock piles, and cover with evapotranspirative cap at each site	7 months	Protects humans and the environment	Suitable for herding, grazing, and gathering	No off-site waste trucking	>330,000 gallons	$$
4. Consolidate and Cap at a Local Repository Excavate waste rock pile from Ruby Mines No. 3 and impacted soil, place within footprint of waste rock pile at Ruby Mines No. 1, and cover with evapotranspirative cap.	4 years	Protects humans and the environment	Suitable for herding, grazing, gathering, and residential at Ruby Mines No. 3 only	>261,000 truck-miles between Ruby Mines No.3 and Ruby Mines No. 1	>1,706,000 gallons	$$$
5. Excavate and Manage at One or More Regional Repositories Excavate both waste rock piles and impacted soil, transport to an on-Reservation repository, and cover with evapotranspirative cap.	7 years	Protects humans and the environment	Suitable for herding, grazing, gathering, and residential	>380,000 truck-miles between Ruby Mines Site and On-Reservation Repository	>2,898,000 gallons	$$$$$
6. Excavate and Manage Off Reservation Excavate both waste rock piles and impacted soil, transport to off-Reservation disposal facility	34+ years*	Protects humans and the environment	Suitable for herding, grazing, gathering, and residential	>21,600,000 truck-miles between Ruby Mines Site and Off-Reservation Repository	>2,190,000 gallons	$$$$$$$$ $$$$$$$$ $$$$$$$$ $$$$$$$$ $$$$$$$$ $$$$$$$$ $$$$$$$$ $$$$$$$$ $$$$

*This assumes a maximum spend of $10M per year based on prioritization of cleanup under the Consent Decree

Figure 1-5. Overview of Alternative Comparison
Ruby Mines
Engineering Evaluation and Cost Analysis

LEGEND

- - - Former Haul Road
Drainage
Capped Waste Rock Pile

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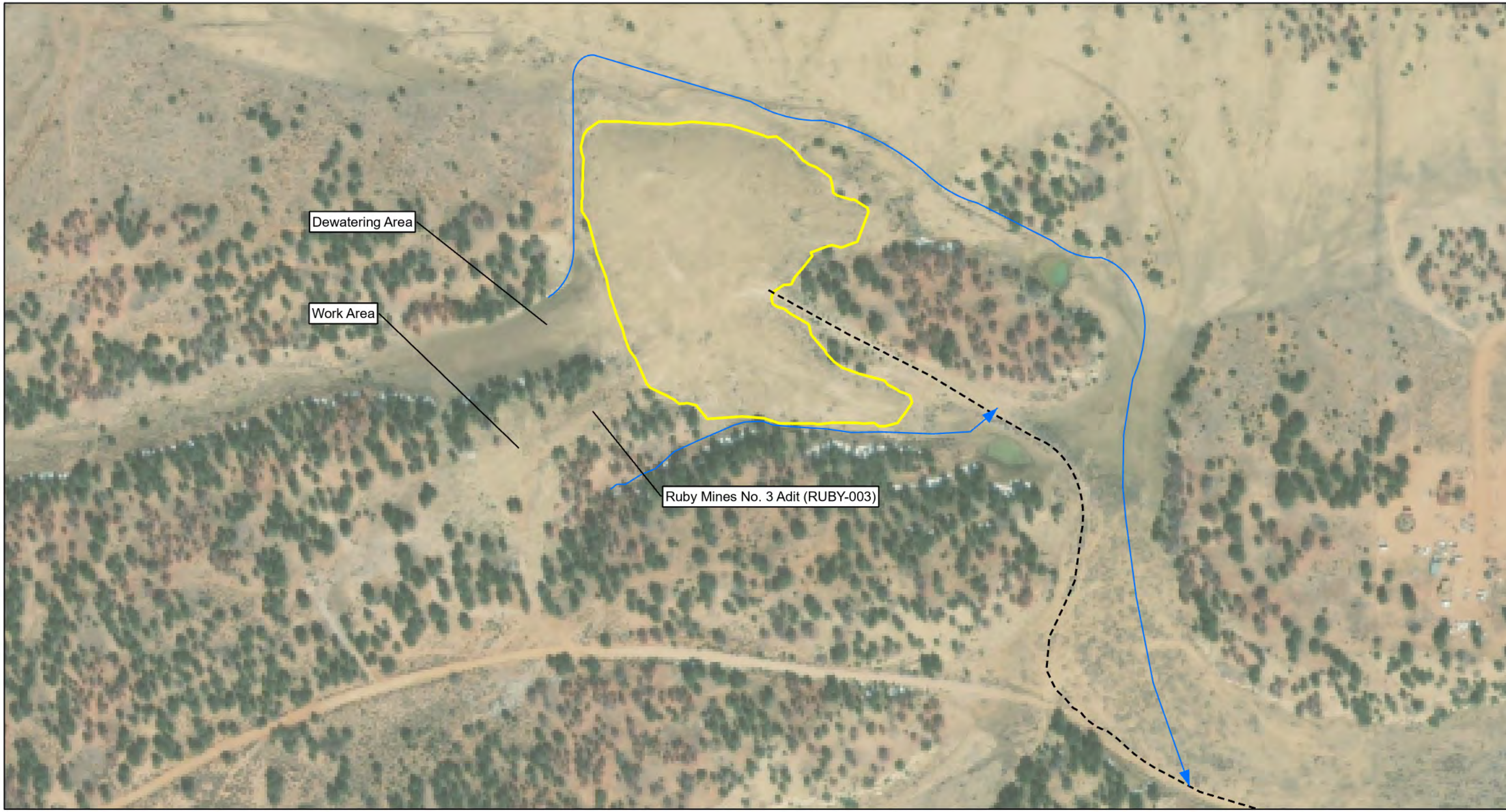
N

0 125 250 500
Feet
1:3,000 1 inch = 250 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-1. Ruby Mines No. 1 Features
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs



LEGEND

- Former Haul Road
- Drainage
- Capped Waste Rock Pile

N

0 100 200 400
Feet
1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-2. Ruby Mines No. 3 Features
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs

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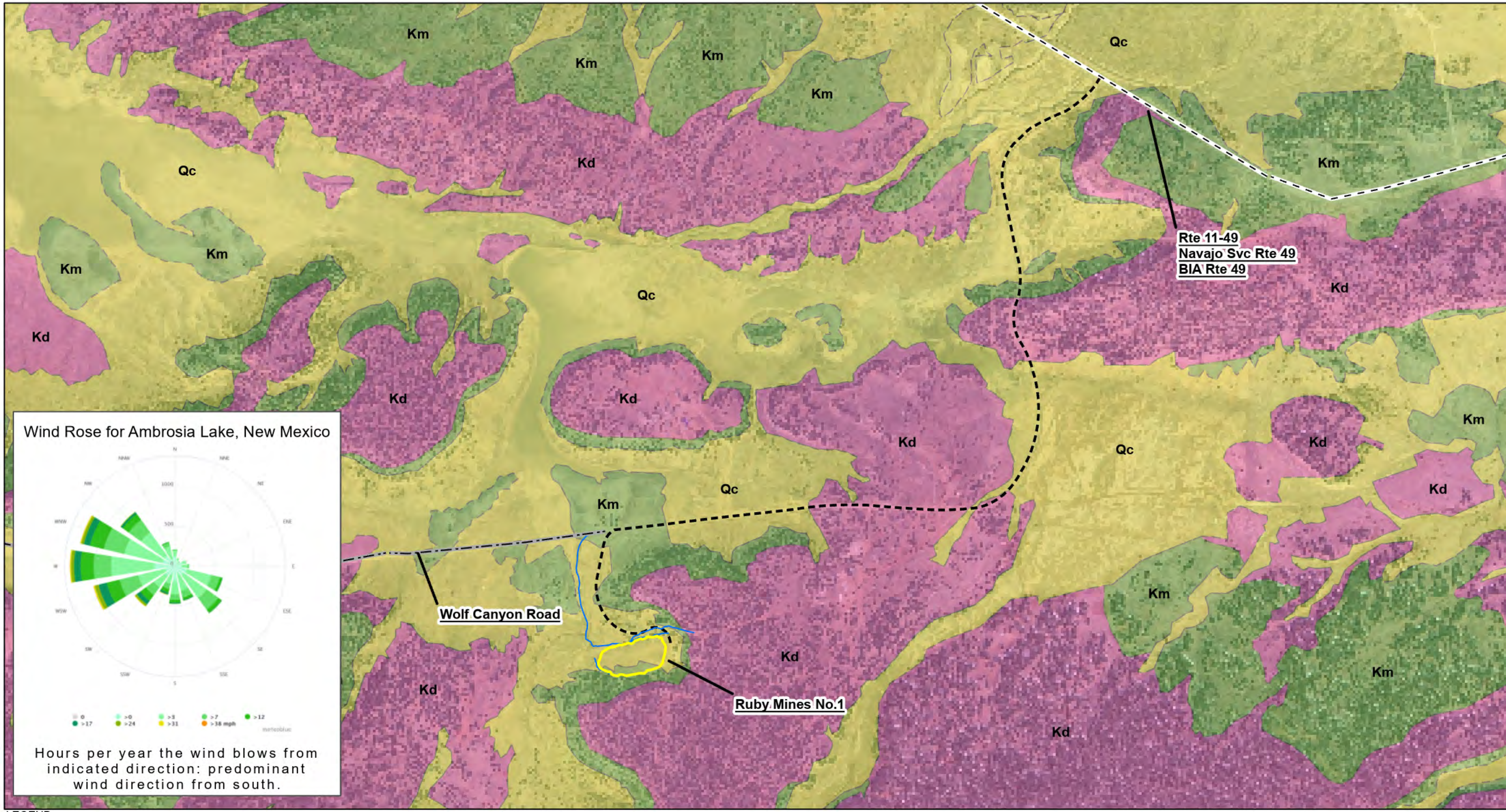

LEGEND

Capped Waste Rock Pile
Major Roads
Maintained Gravel Road
Former Haul Road
Drainage

SITE GEOLOGY

QUATERNARY

Qc: Qc: Colluvium, Grouped Colluvium, alluvial and eolian deposits

CRETACEOUS

Kd: Dakota Sandstone. Tan, brown and gray sandstone and conglomerates. Contains carbonaceous siltstone and coal lenses. Main Body and Twowells Tongue Member

Km: Mancos Shale. Dark grey to light grey, silty shale with interbedded limestone. Main Body and Whitewater Arroyo Tongue Member

Sources:
Wind Rose Source:
https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/ambrosia-lake_united-states_5455006

N

0 500 1,000 2,000
Feet
1:12,000 1 inch = 1,000 feet
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-3a. Geologic Map of Ruby Mines No. 1 Area with Wind Direction and Stormwater Drainage
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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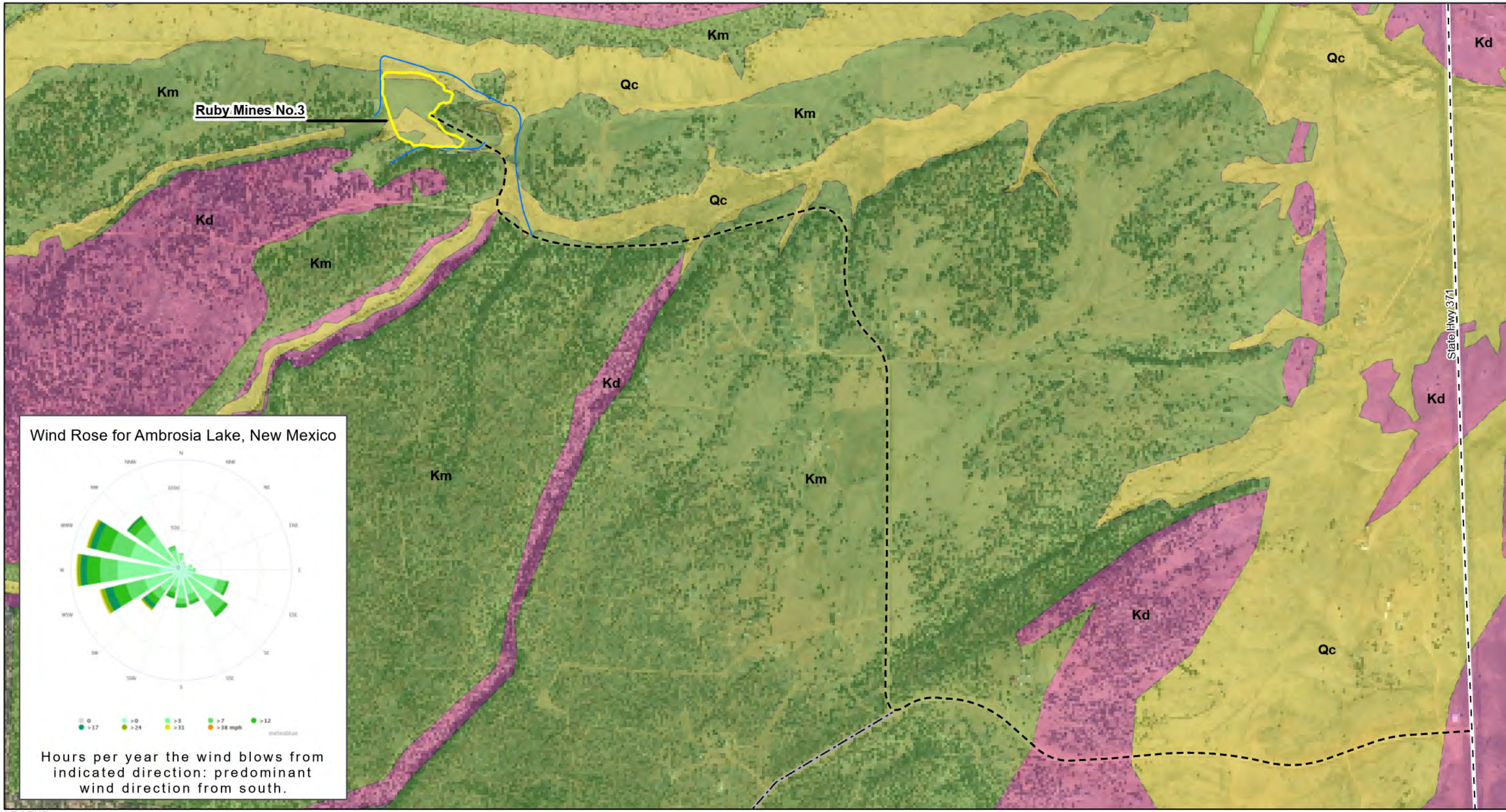

LEGEND

- Capped Waste Rock Pile
- Former Haul Road
- Major Roads
- Maintained Gravel Road
- Drainage

SITE GEOLOGY

QUATERNARY

Qc: Qc: Colluvium, Grouped Colluvium, alluvial and eolian deposits

CRETACEOUS

Kd: Dakota Sandstone. Tan, brown and gray sandstone and conglomerates. Contains carbonaceous siltstone and coal lenses. Main Body and Twowells Tongue Member

Km: Mancos Shale. Dark grey to light grey, silty shale with interbedded limestone. Main Body and Whitewater Arroyo Tongue Member

Sources:
Wind Rose Source:
https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/ambrosia-lake_united-states_5455006

N

0 500 1,000 2,000
Feet

1:12,000 1:12,000

Coordinate System: North American Datum 1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-3b. Geologic Map of Ruby Mines No. 3 Area with Wind Direction and Stormwater Drainage
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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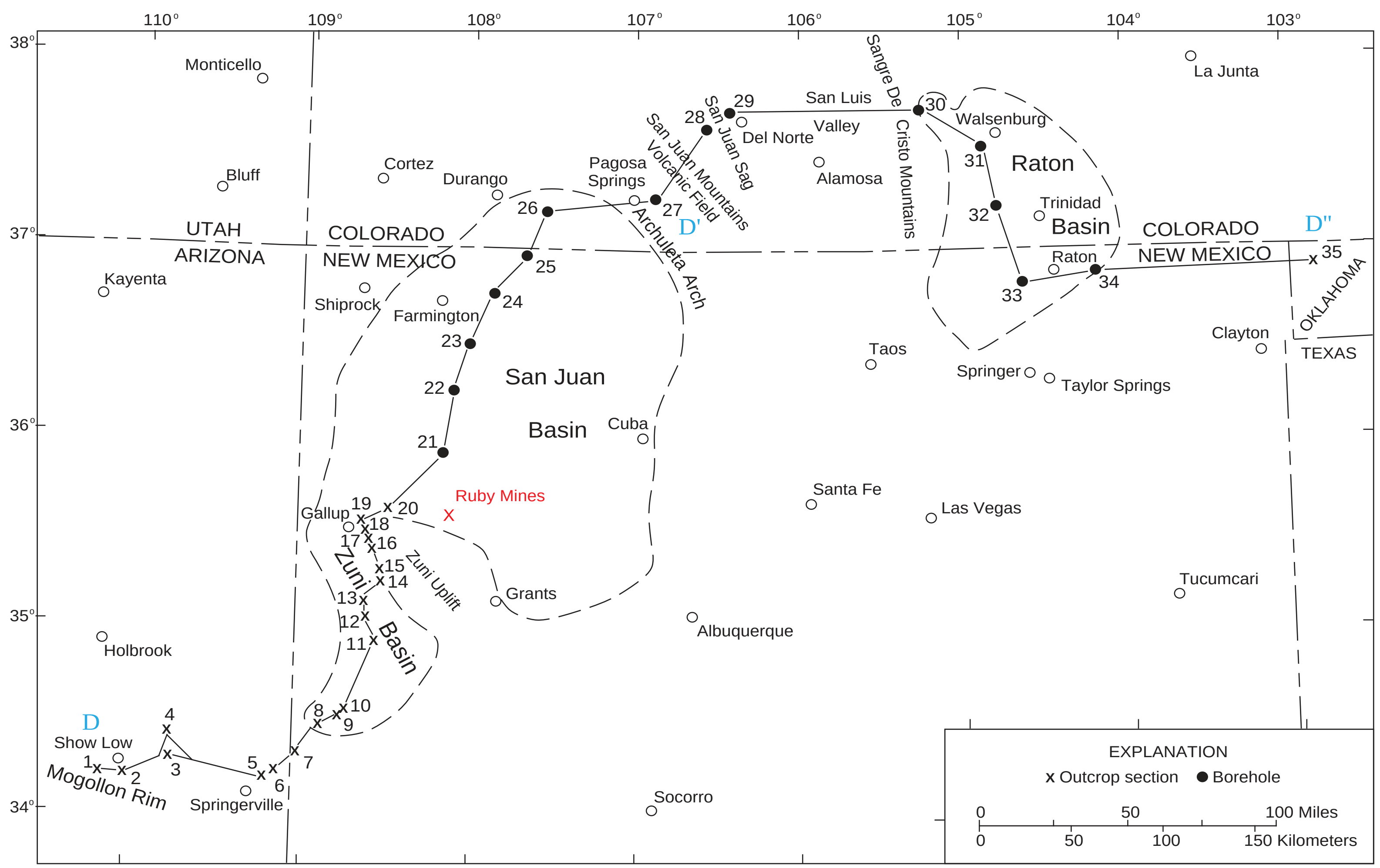
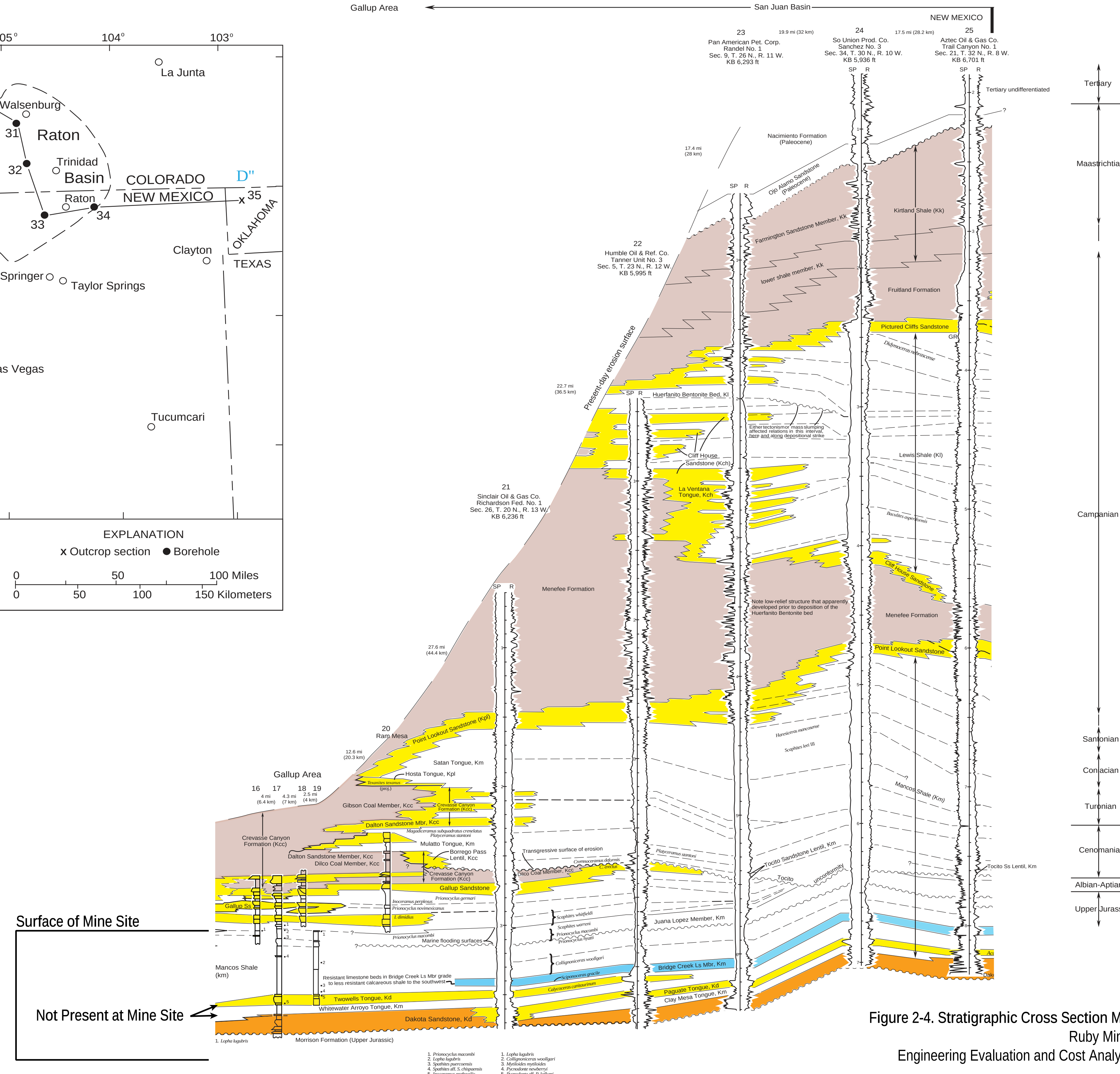


INDEX MAP SHOWING LOCATION OF CROSS SECTIONS

FACIES COLORS FOR CRETACEOUS ROCKS

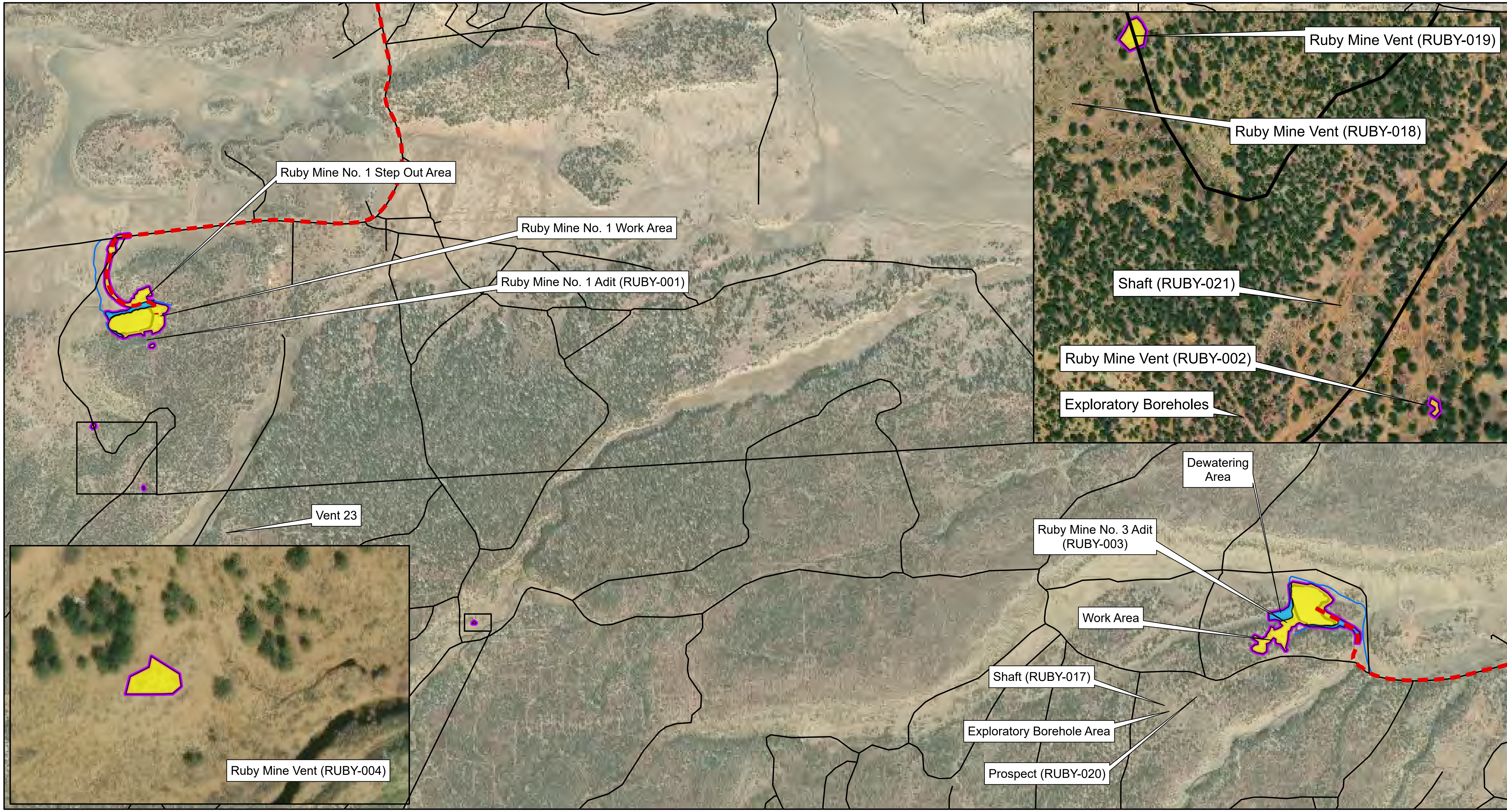
- Nonmarine strata (various formations)
- Marine and coastal sandstone
- Dominantly marine shale and siltstone (Mancos Shale)
- Greenhorn Limestone and Bridge Creek (Km) and Fort Hays (Km) Limestone Members
- Undivided nonmarine and marine strata (Dakota Sandstone)



(USGS. Regional Stratigraphic Cross Sections of Cretaceous Rocks From East-Central Arizona to the Oklahoman Panhandle. 2002)

Figure 2-4. Stratigraphic Cross Section Map
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs



LEGEND

Land Use Types

- Residential
- Drainage and Washes
- TENORM
- Former Haul Road
- Drainage
- Restricted Area
- Local Roads

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 6/26/2023 13:38:16

Notes:
The future land use of areas outside the TENROM boundary were not evaluated as part of the EE/CA, because it was not impacted by mining-related activities.

Future land use within the capped waste rock piles is dependent upon the response action evaluated. If the capped waste rock piles remain in place after remedy implementation, then residential use would be unrestricted outside the cap and restricted on the capped waste rock pile. If the waste rock pile is removed, then residential use would be unrestricted.

N

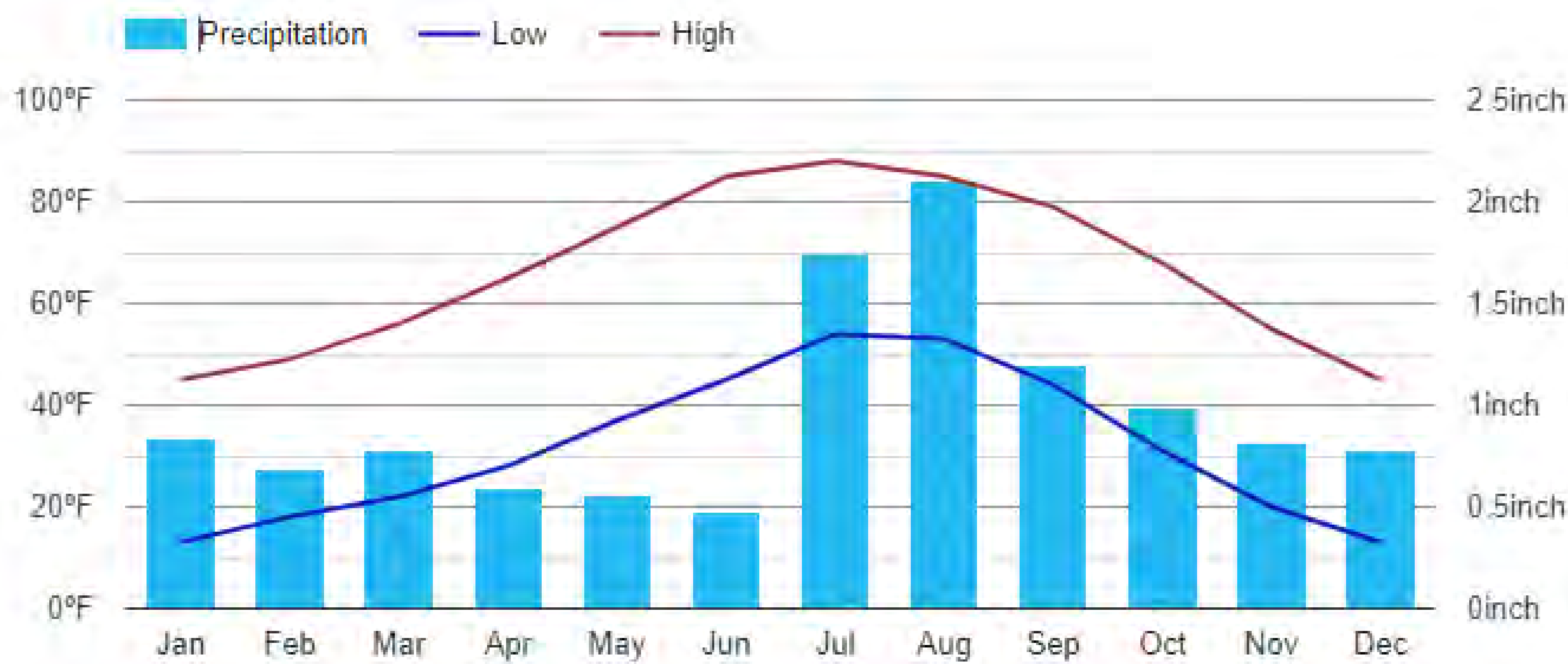
0 750 1,500 3,000
Feet

1:18,000 1 inch = 1,500 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-5. Ruby Mines Future Land Use
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs



Source: https://www.usclimatedata.com/climate/gallup/new mexico/united-states/usnm0121
Monthly data from 1981 to 2010.

Figure 2-6. Gallup Climate Graph
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs

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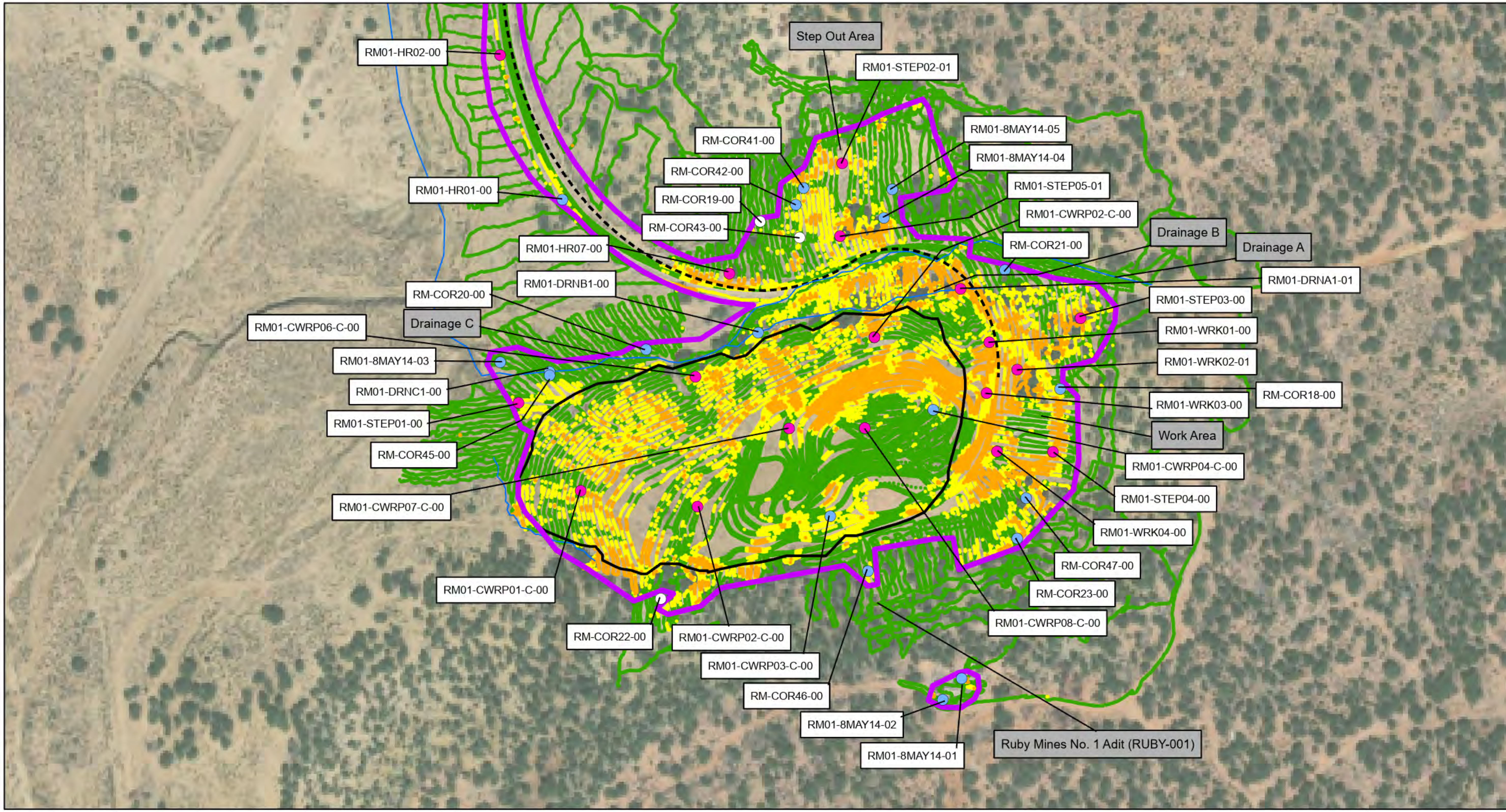


LEGEND
- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- TENORM

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 11/3/2022 16:34:00

Notes:
1. Data is shown for a Ra-226 exceedance of the PRG of 2.89 pCi/g or where one or more metals concentrations exceed the RSL/BTV value.
2. Metals concentrations that do not exceed the RSL are not shown.
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-001	RESIDENCES RUBY-021 RUBY-002 EXPLORATORY BOREHOLES	RUBY-019 RUBY-018 CAPPED WASTE ROCK PILE DRAINAGES FORMER HAUL ROAD WORK AREA STEP OUT AREA
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

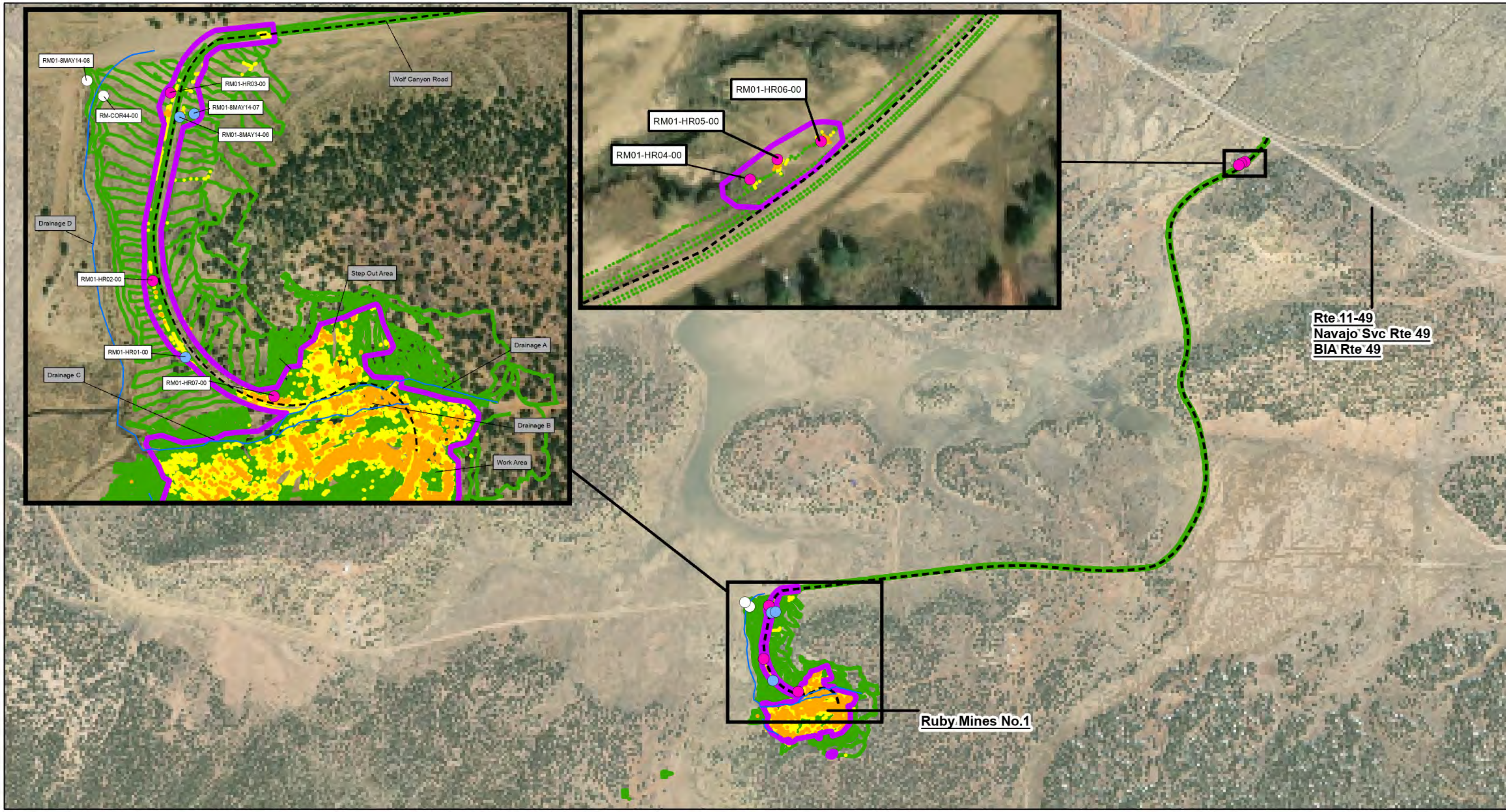
N

0 75 150 300
Feet
1:1,800 1 inch = 150 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-7. Ruby Mines No. 1 TENORM Extent and Summary of RSE Data
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs



LEGEND

- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- TENORM
- Former Haul Road
- Drainage

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 11/3/2022 16:40:36

Notes:
1. Data is shown for a Ra-226 exceedance of the PRG of 2.89 pCi/g or where one or more metals concentrations exceed the RSL/BTV value.
2. Metals concentrations that do not exceed the RSL are not shown.
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

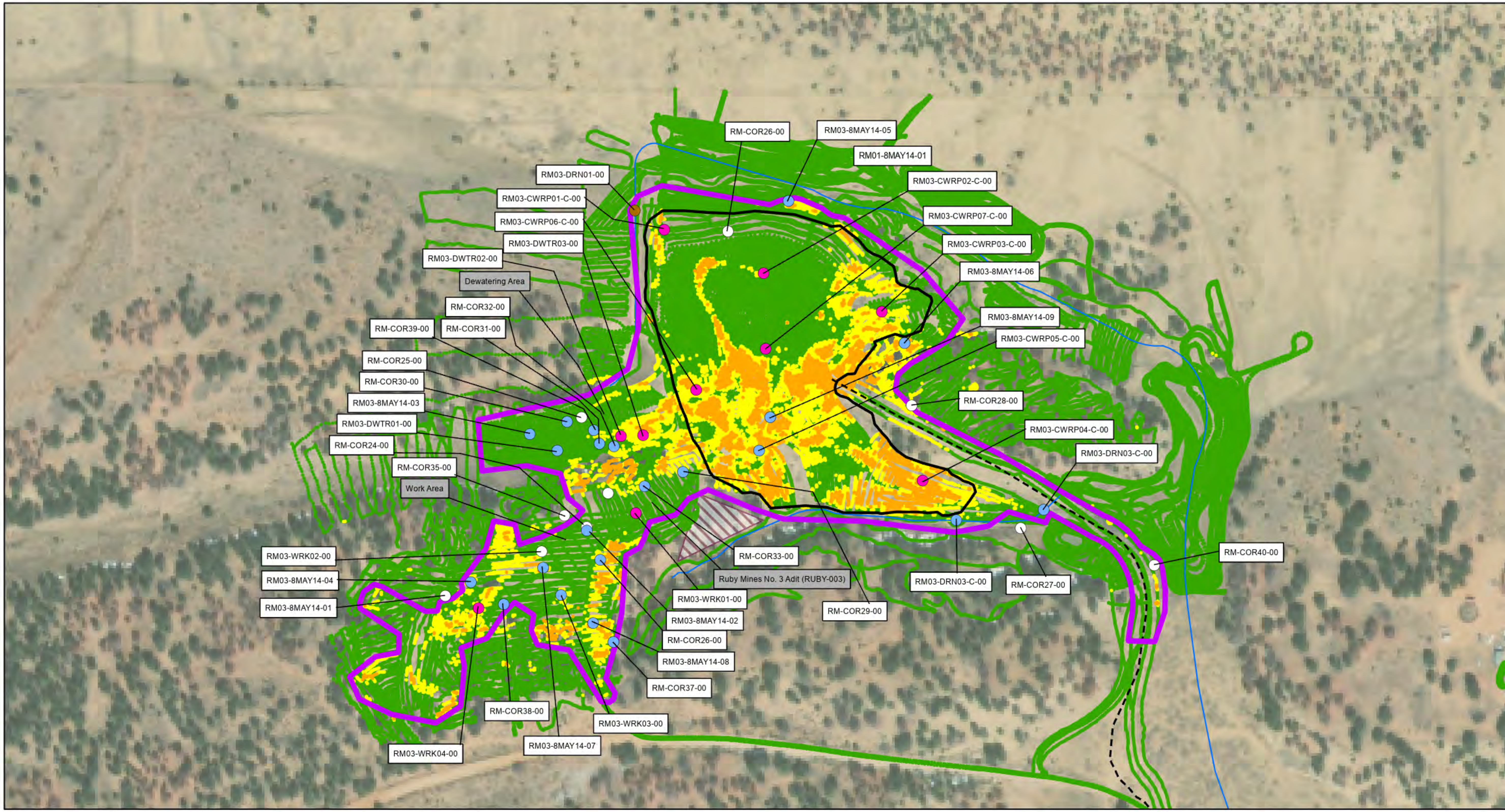
GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-001	RESIDENCES RUBY-021 RUBY-002 EXPLORATORY BOREHOLES	RUBY-019 RUBY-018 CAPPED WASTE ROCK PILE DRAINAGES FORMER HAUL ROAD WORK AREA STEP OUT AREA
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

N

0 500 1,000 2,000
Feet
1:12,000 1 inch = 1,000 feet
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-8. Ruby Mines No. 1 - Former Haul Road TENORM Extent and Summary of RSE Data
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs



LEGEND

- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Metals exceedance
- TENORM
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Restricted Area

Notes:
1. Data is shown for a Ra-226 exceedance of the PRG of 2.89 pCi/g or where one or more metals concentrations exceed the RSL/BTV value.
2. Metals concentrations that do not exceed the RSL are not shown.
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-003	NONE	DRAINAGES
	CAPPED WASTE ROCK PILE		
	DEWATERING AREA		
	WORK AREA		
	FORMER HAUL ROAD		
	RESIDENCE		
	RUBY-017		
	RUBY-020		
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

N

0 100 200 400
Feet
1:2,400 1 inch = 200 feet
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-9. Ruby Mines No. 3 TENORM Extent and Summary of RSE Data
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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LEGEND

- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- TENORM

\\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 11/3/2022 11:35:36

Notes:
1. Data is shown for a Ra-226 exceedance of the PRG of 2.89 pCi/g or where one or more metals concentrations exceed the RSL/BTV value.
2. Metals concentrations that do not exceed the RSL are not shown.
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-001	RESIDENCES RUBY-021 RUBY-002 EXPLORATORY BOREHOLES	RUBY-019 RUBY-018 CAPPED WASTE ROCK PILE DRAINAGES FORMER HAUL ROAD WORK AREA STEP OUT AREA
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

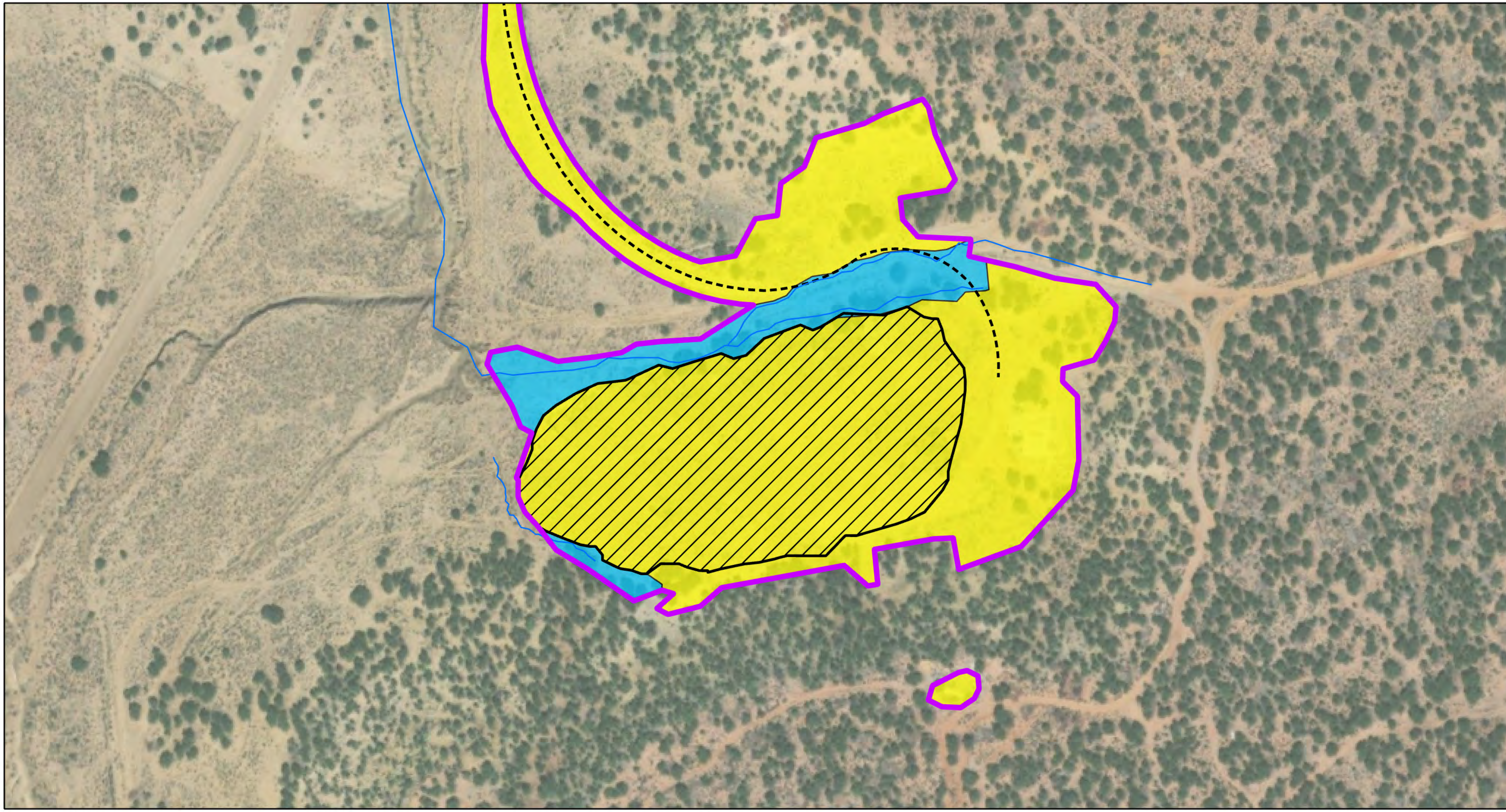
N

0 350 700 1,400
Feet
1:7,200 1 inch = 600 feet

Coordinate System: North American Datum 1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-10. Ruby-002, Ruby-004, and Ruby-019 TENORM Extent and Summary of RSE Data
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs



LEGEND

- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Future Land Use is Dependent on Alternative Selection
- TENORM
- Residential
- Drainage and Washes

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Notes:

Future land use within the capped waste rock piles is dependent upon the response action evaluated. If the capped waste rock piles remain in place after remedy implementation, then residential use would be unrestricted outside the cap and restricted on the capped waste rock pile. If the waste rock pile is removed, then residential use would be unrestricted.

TENORM = Technologically Enhanced Naturally Occurring Radioactive Material

N

0 75 150 300

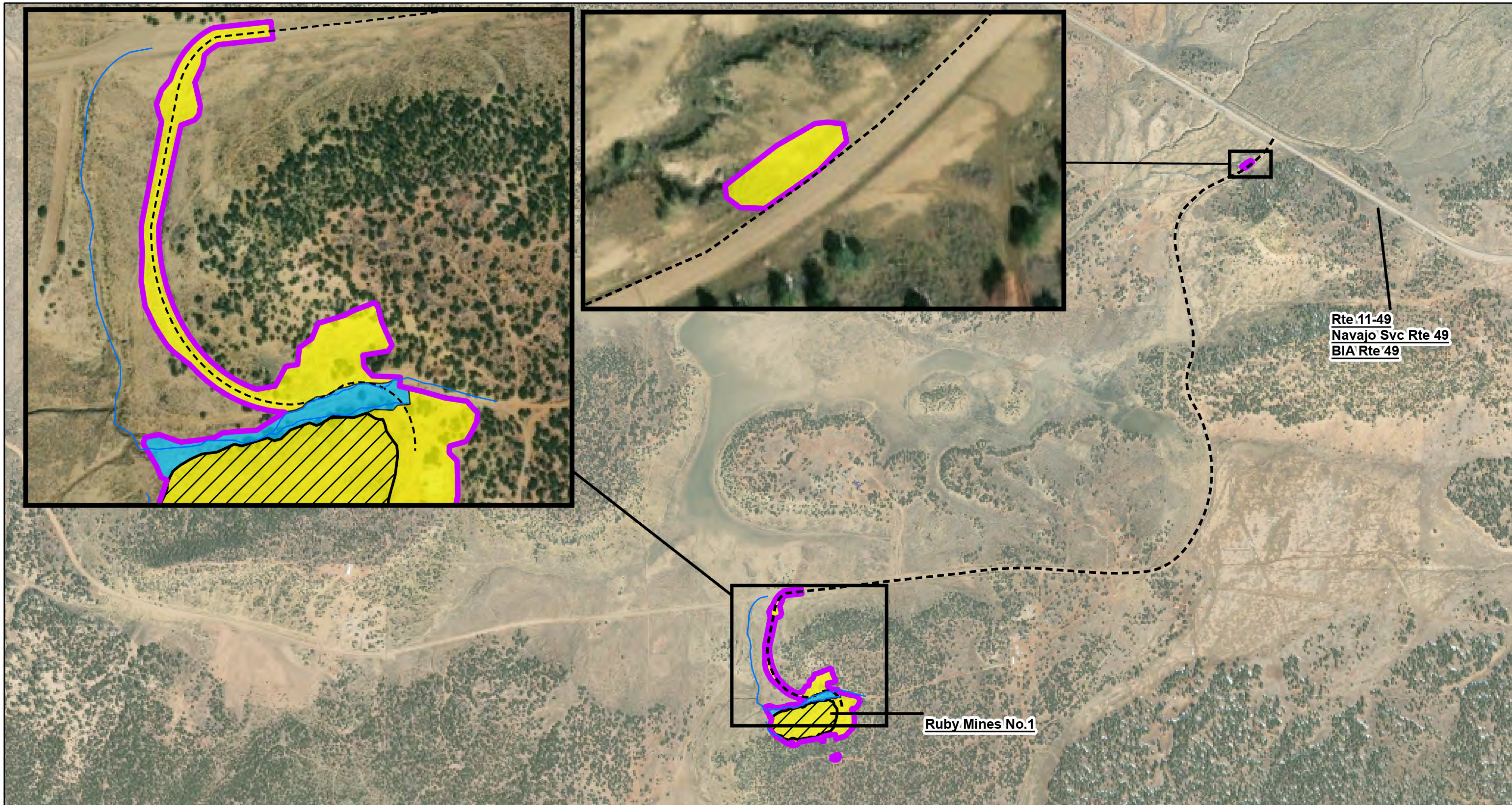
Feet

1:1,800 1 inch = 150 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-11. Ruby Mines No. 1
Exposure Unit Map
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs



LEGEND

- TENORM
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Future Land Use is Dependent on Alternative Selection
- Residential
- Drainage and Washes

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 5/19/2023 15:44:56

Notes:

Future land use within the capped waste rock piles is dependent upon the response action evaluated. If the capped waste rock piles remain in place after remedy implementation, then residential use would be unrestricted outside the cap and restricted on the capped waste rock pile. If the waste rock pile is removed, then residential use would be unrestricted.

TENORM = Technologically Enhanced Naturally Occurring Radioactive Material

N

0 500 1,000 2,000
Feet

1:12,000 1 inch = 1,000 feet

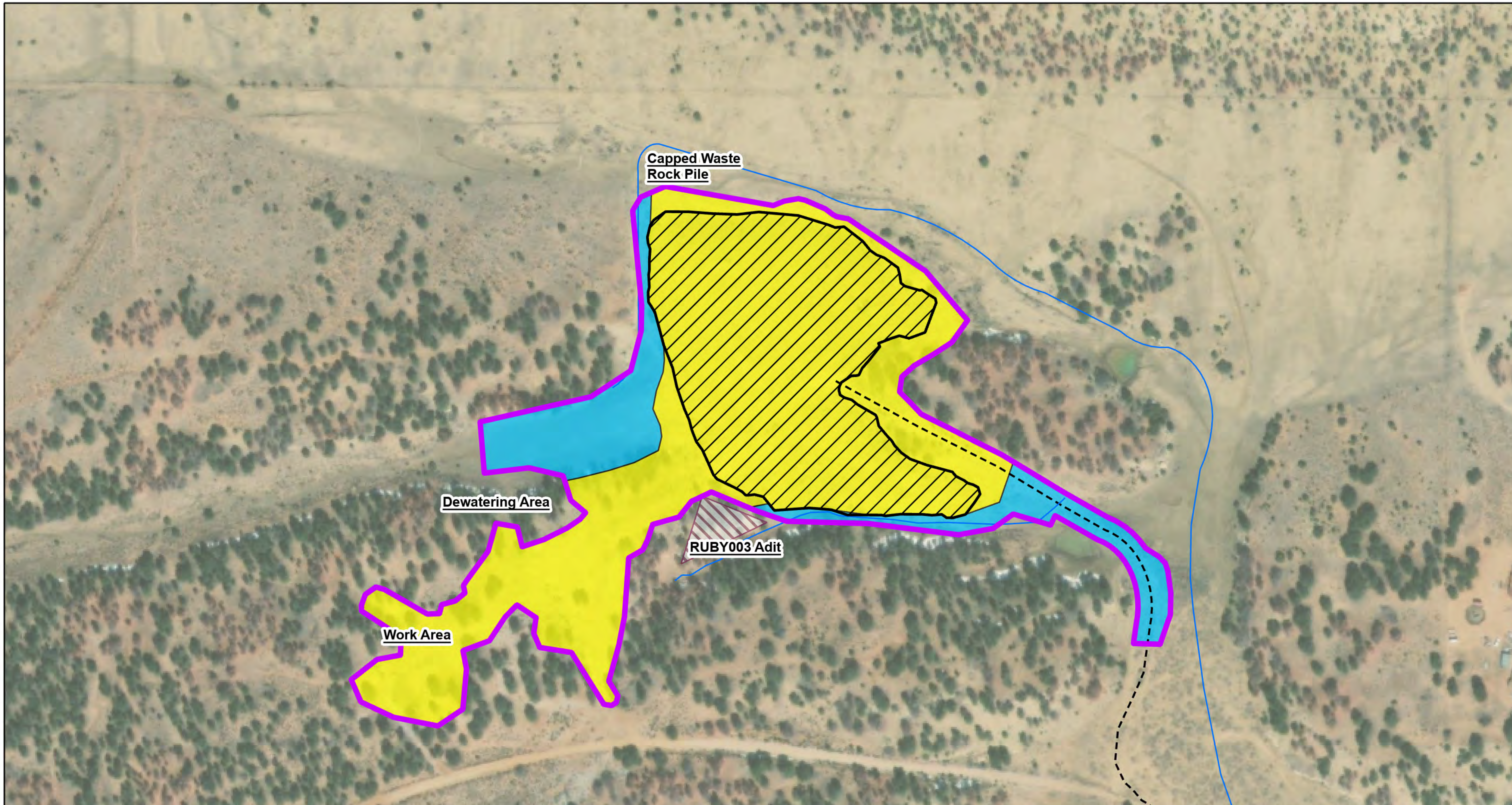
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-12. Ruby Mines No. 1 - Former Haul Road Exposure Unit Map

Engineering Evaluation and Cost Analysis

Ruby Mines

Jacobs



LEGEND
- TENORM
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Future Land Use is Dependent on Alternative Selection
- Restricted Area
- Residential
- Drainage and Washes

SLC \\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 5/25/2023 11:32:43

Notes:

Future land use within the capped waste rock piles is dependent upon the response action evaluated. If the capped waste rock piles remain in place after remedy implementation, then residential use would be unrestricted outside the cap and restricted on the capped waste rock pile. If the waste rock pile is removed, then residential use would be unrestricted.

TENORM = Technologically Enhanced Naturally Occurring Radioactive Material

N

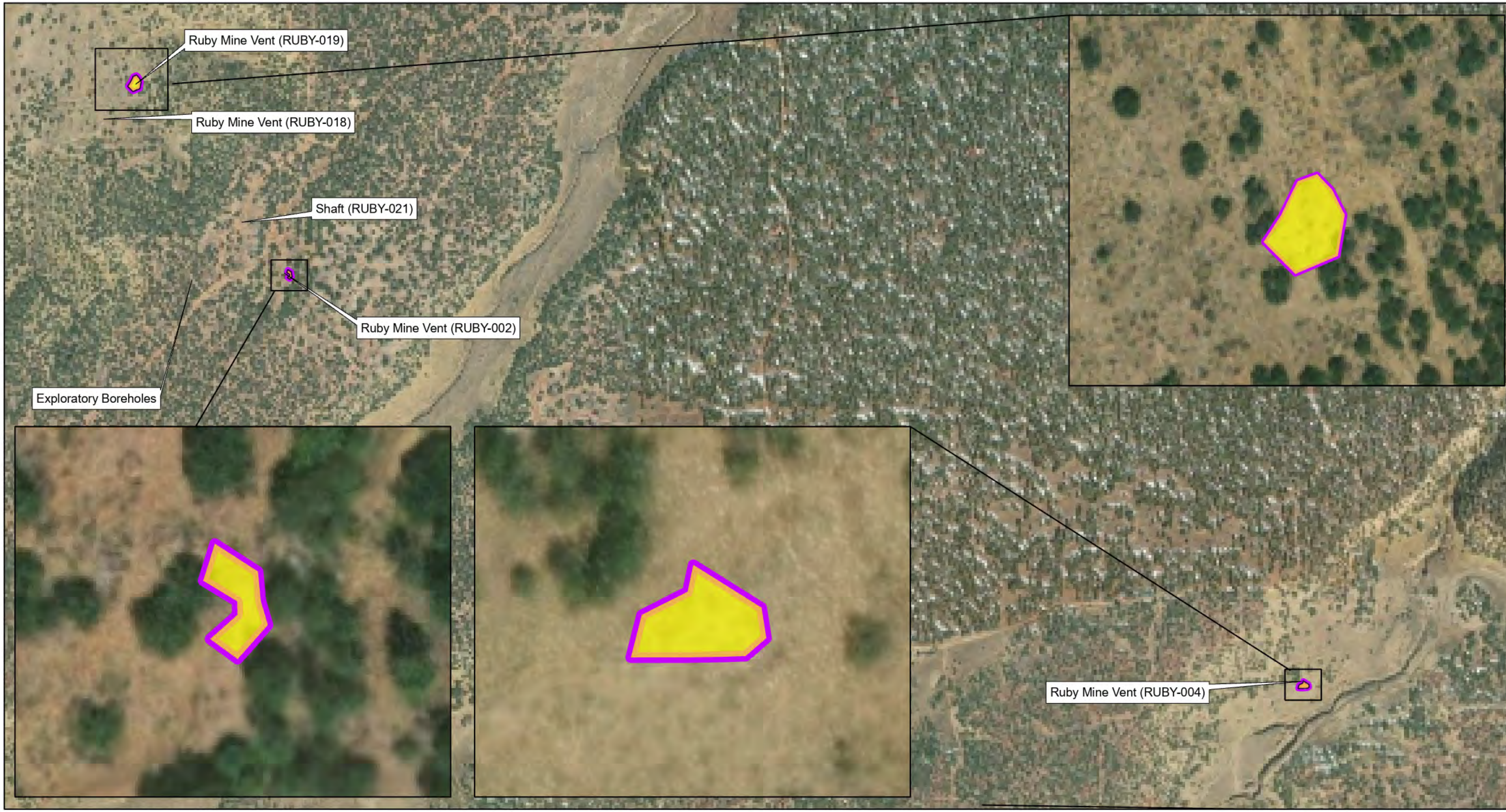
0 100 200 400
Feet

1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-13. Ruby Mines No. 3 Exposure Unit Map
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs



LEGEND

TENORM

Easy Access Open Space - Colluvium

TENORM = Technologically Enhanced Naturally Occurring Radioactive Material

N

0 300 600 1,200

Feet

1:7,200 1 inch = 600 feet

Coordinate System: North American Datum 1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-14. Ruby-002, Ruby-004, and Ruby-019, Exposure Unit Map

Ruby Mines

Engineering Evauation and Cost Analysis

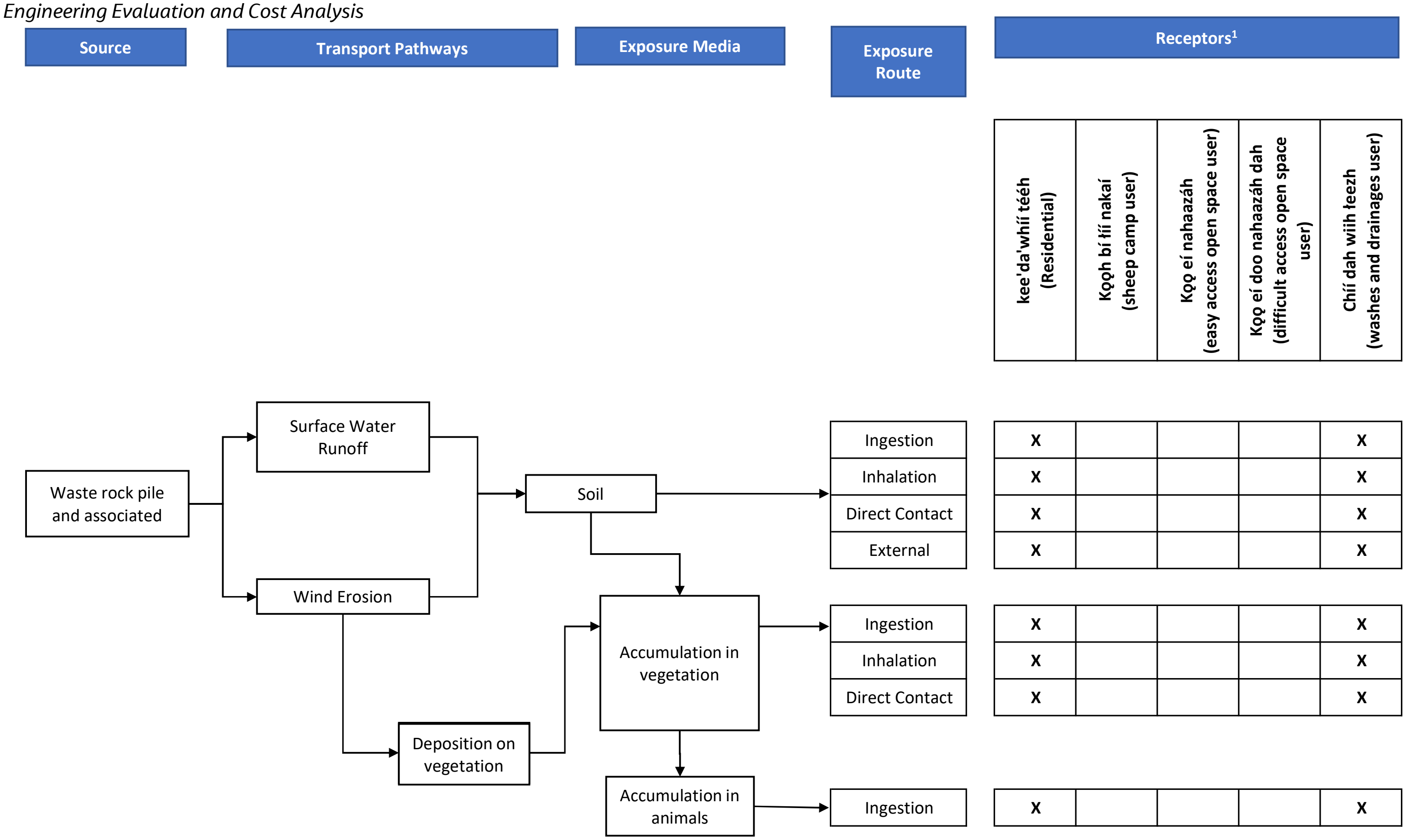
Jacobs

\\DC1VS01\GISPROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\RUBYMINEEECA.APRX TARROWOO 11/2/2022 11:08:57

Figure 2-15. Conceptual Model of Exposure Pathways - Human Health

Ruby Mines

Engineering Evaluation and Cost Analysis



X - Potentially complete exposure pathway.
Empty cell indicates an incomplete exposure pathway or pathway less conservative than those evaluated in the risk assessment.

HHRA = human health risk assessement

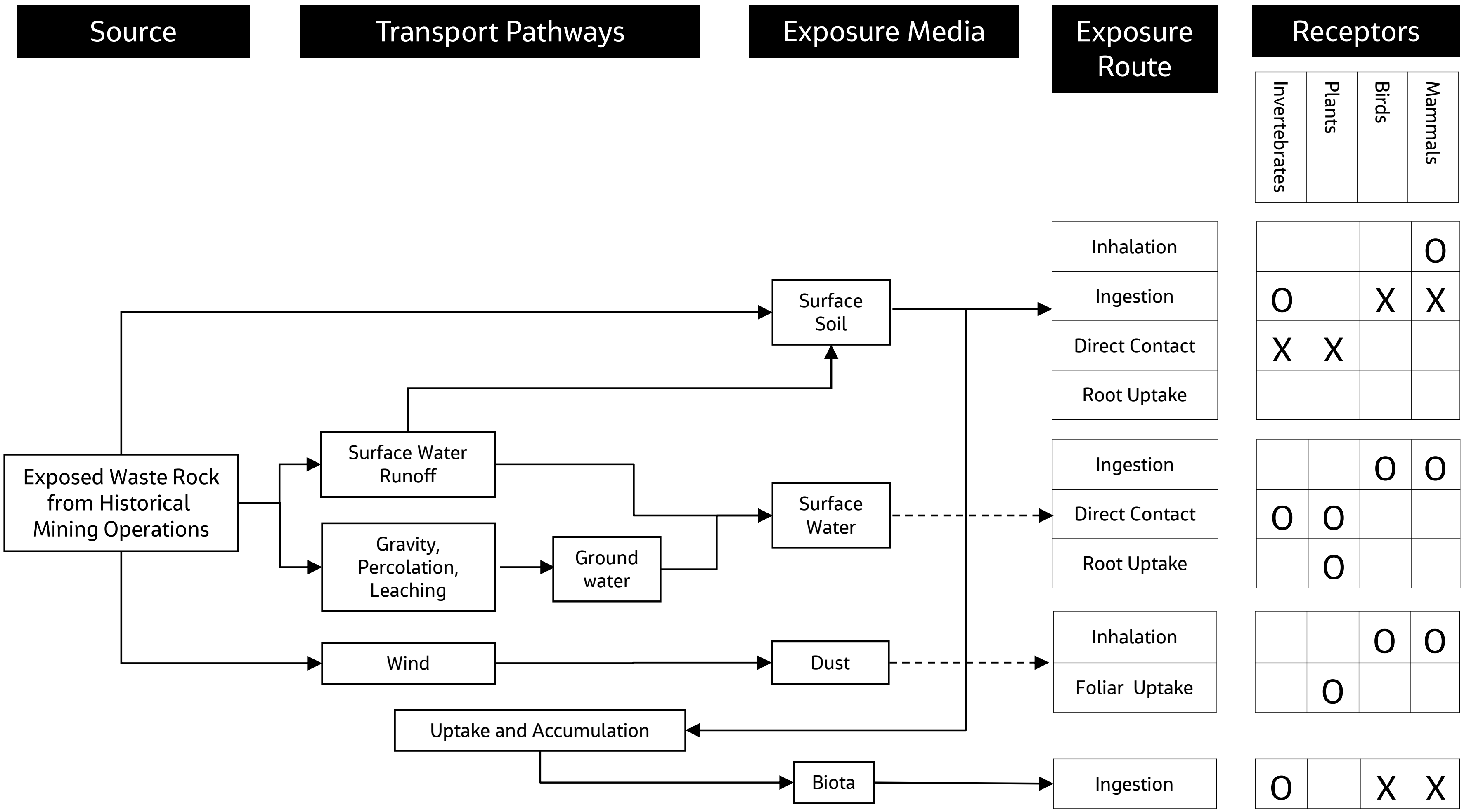
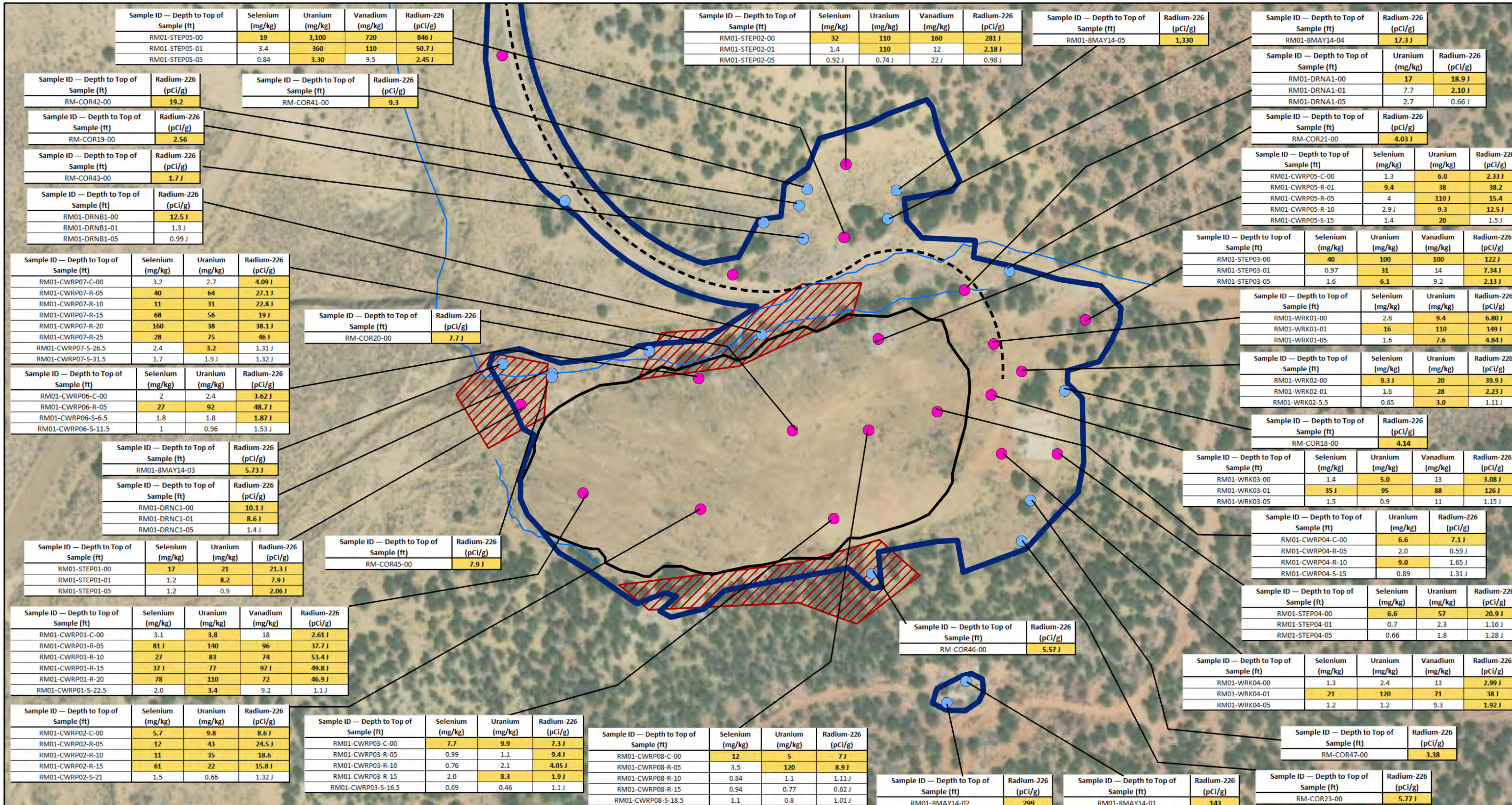


Figure 2-16. Ecological Conceptual Site Model and Screening Framework
Ruby Mines
Engineering Evaluation and Cost Analysis

X = Exposure route/receptor combination complete and evaluated in the screening level ecological risk assessment.
O = Exposure route/receptor combination potentially complete but insignificant or addressed in combination with other exposure pathways

Surface water exposure routes not evaluated due to lack of permanent water.

Solid line = Pathway complete and significant
Dashed line = Pathway complete but insignificant and not evaluated



Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP05-00	19	3,100	720	846 J
RM01-STEP05-01	3.4	360	110	50.7 J
RM01-STEP05-05	0.84	3.30	9.5	2.45 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR42-00	19.2

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR41-00	9.3

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR19-00	2.56

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR43-00	1.7 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-DRNB1-00	12.5 J
RM01-DRNB1-01	1.3 J
RM01-DRNB1-05	0.99 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP07-C-00	3.2	2.7	4.09 J
RM01-CWRP07-R-05	40	64	27.1 J
RM01-CWRP07-R-10	11	31	22.8 J
RM01-CWRP07-R-15	68	56	19 J
RM01-CWRP07-R-20	160	38	38.1 J
RM01-CWRP07-R-25	28	75	46 J
RM01-CWRP07-S-26.5	2.4	3.2	1.31 J
RM01-CWRP07-S-31.5	1.7	1.9 J	1.32 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR20-00	7.7 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP06-C-00	2	2.4	3.62 J
RM01-CWRP06-R-05	27	92	48.7 J
RM01-CWRP06-S-6.5	1.8	1.8	1.87 J
RM01-CWRP06-S-11.5	1	0.96	1.53 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-03	5.73 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-DRNC1-00	10.1 J
RM01-DRNC1-01	8.6 J
RM01-DRNC1-05	1.4 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP01-00	17	21	21.3 J
RM01-STEP01-01	1.2	8.2	7.9 J
RM01-STEP01-05	1.2	0.9	2.06 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR45-00	7.9 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP01-C-00	3.1	3.8	18	2.61 J
RM01-CWRP01-R-05	81 J	140	96	37.7 J
RM01-CWRP01-R-10	27	83	74	53.4 J
RM01-CWRP01-R-15	37 J	77	97 J	49.8 J
RM01-CWRP01-R-20	78	110	72	46.9 J
RM01-CWRP01-S-22.5	2.0	3.4	9.2	1.1 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP02-C-00	5.7	9.8	8.6 J
RM01-CWRP02-R-05	12	43	24.5 J
RM01-CWRP02-R-10	11	35	18.6
RM01-CWRP02-R-15	61	22	15.8 J
RM01-CWRP02-S-21	1.5	0.66	1.32 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP03-C-00	7.7	9.9	7.3 J
RM01-CWRP03-R-05	0.99	1.1	9.4 J
RM01-CWRP03-R-10	0.76	2.1	4.05 J
RM01-CWRP03-R-15	2.0	8.3	1.9 J
RM01-CWRP03-S-16.5	0.69	0.46	1.1 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP08-C-00	12	5	7 J
RM01-CWRP08-R-05	3.5	120	8.9 J
RM01-CWRP08-R-10	0.84	1.1	1.11 J
RM01-CWRP08-R-15	0.94	0.77	0.62 J
RM01-CWRP08-S-18.5	1.1	0.8	1.01 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP02-00	32	110	160	281 J
RM01-STEP02-01	1.4	110	12	2.18 J
RM01-STEP02-05	0.92 J	0.74 J	22 J	0.98 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-05	1,330

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-04	17.3 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-DRNA1-00	17	18.9 J
RM01-DRNA1-01	7.7	2.10 J
RM01-DRNA1-05	2.7	0.66 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR21-00	4.03 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP05-C-00	1.3	6.0	2.33 J
RM01-CWRP05-R-01	9.4	38	38.2
RM01-CWRP05-R-05	4	110 J	15.4
RM01-CWRP05-R-10	2.9 J	9.3	12.5 J
RM01-CWRP05-S-15	1.4	20	1.5 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP03-00	40	100	100	122 J
RM01-STEP03-01	0.97	31	14	7.34 J
RM01-STEP03-05	1.6	6.1	9.2	2.13 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK01-00	2.8	9.4	6.80 J
RM01-WRK01-01	16	110	149 J
RM01-WRK01-05	1.6	7.6	4.84 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK02-00	9.3 J	20	39.9 J
RM01-WRK02-01	1.6	28	2.23 J
RM01-WRK02-5.5	0.65	3.0	1.11 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR18-00	4.14

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK03-00	1.4	5.0	13	3.08 J
RM01-WRK03-01	35 J	95	88	126 J
RM01-WRK03-05	1.5	0.9	11	1.15 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP04-C-00	6.6	7.1 J
RM01-CWRP04-R-05	2.0	0.59 J
RM01-CWRP04-R-10	9.0	1.65 J
RM01-CWRP04-S-15	0.89	1.31 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP04-00	6.6	57	20.9 J
RM01-STEP04-01	0.7	2.3	1.16 J
RM01-STEP04-05	0.66	1.8	1.28 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR46-00	5.57 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK04-00	1.3	2.4	13	2.99 J
RM01-WRK04-01	21	120	71	38 J
RM01-WRK04-05	1.2	1.2	9.3	1.92 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR47-00	3.38

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-02	299

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-01	143

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR23-00	5.77 J

LEGEND
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Drainage Areas to be Addressed with Grading and Riprap

Notes:
1. Concentrations that are highlighted yellow exceed the following Residential Cleanup Goals:
Ra-226 = 1.65 pCi/g
Selenium = 5.1 mg/kg
Uranium = 2.8 mg/kg
Vanadium = 65 mg/kg

Notes continued:
2. Concentrations that are highlighted yellow exceed the following Washes and Drainages Cleanup Goals:
Ra-226 = 1.65 pCi/g
Selenium = 5.1 mg/kg
Uranium = 8.14 mg/kg
Vanadium = 80 mg/kg
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
Ra = Radium

N
0 75 150 300
Feet
1:1,800 1 inch = 150 feet
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-17. Ruby Mines No. 1 Cleanup Extent
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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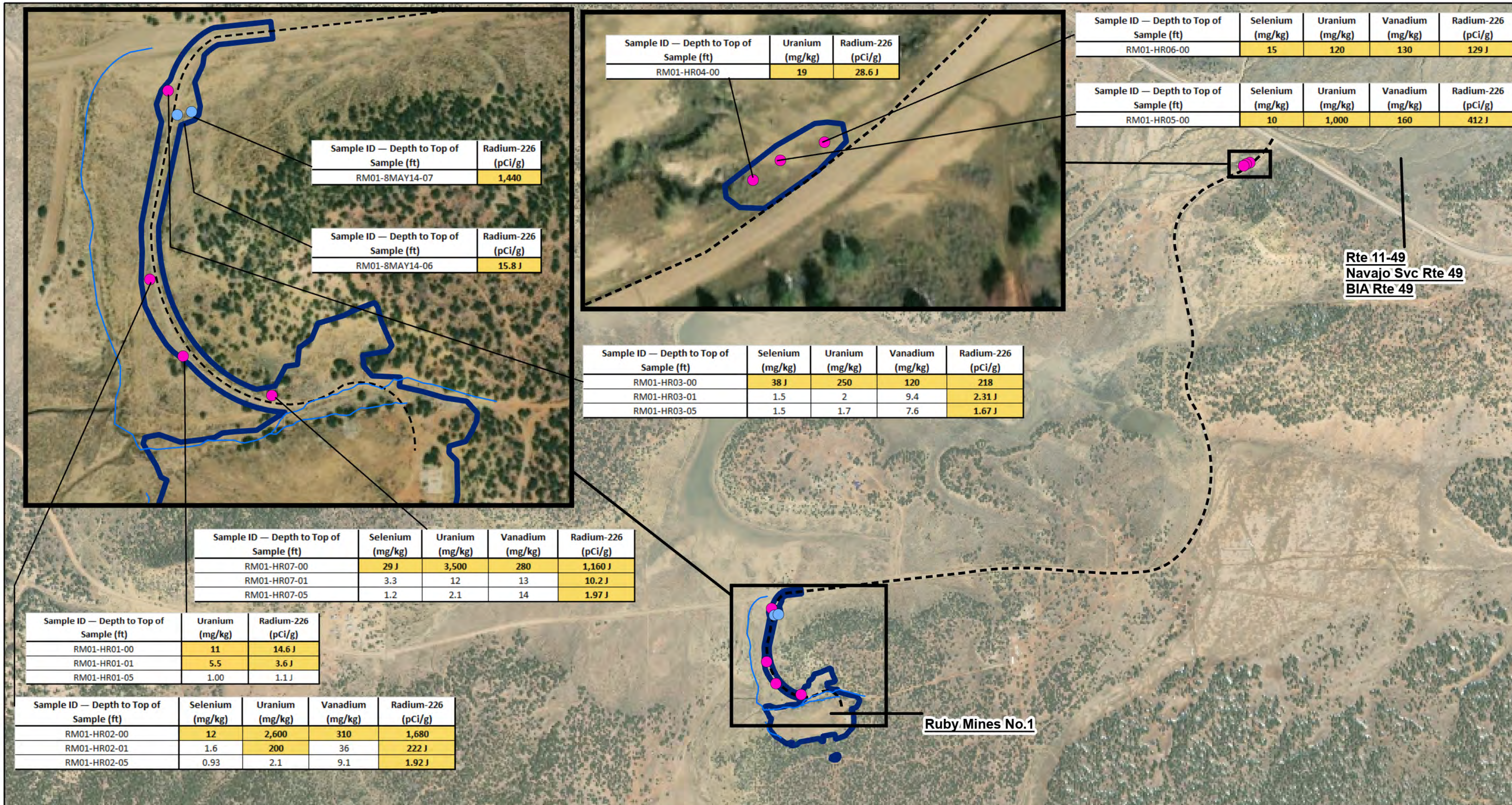

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-07	1,440

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-06	15.8 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR04-00	19	28.6 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-HR06-00	15	120	130	129 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-HR05-00	10	1,000	160	412 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-HR03-00	38 J	250	120	218
RM01-HR03-01	1.5	2	9.4	2.31 J
RM01-HR03-05	1.5	1.7	7.6	1.67 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-HR07-00	29 J	3,500	280	1,160 J
RM01-HR07-01	3.3	12	13	10.2 J
RM01-HR07-05	1.2	2.1	14	1.97 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR01-00	11	14.6 J
RM01-HR01-01	5.5	3.6 J
RM01-HR01-05	1.00	1.1 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-HR02-00	12	2,600	310	1,680
RM01-HR02-01	1.6	200	36	222 J
RM01-HR02-05	0.93	2.1	9.1	1.92 J

LEGEND

- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent
- Former Haul Road
- Drainage

Notes:
1. Concentrations that are highlighted yellow exceed the following Residential Cleanup Goals:
Ra-226 = 1.65 pCi/g
Selenium = 5.1 mg/kg
Uranium = 2.8 mg/kg
Vanadium = 65 mg/kg
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
Ra = Radium

N

0 500 1,000 2,000
Feet
1:12,000 1 inch = 1,000 feet
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-18. Ruby Mines No. 1 - Former Haul Road Cleanup Extent
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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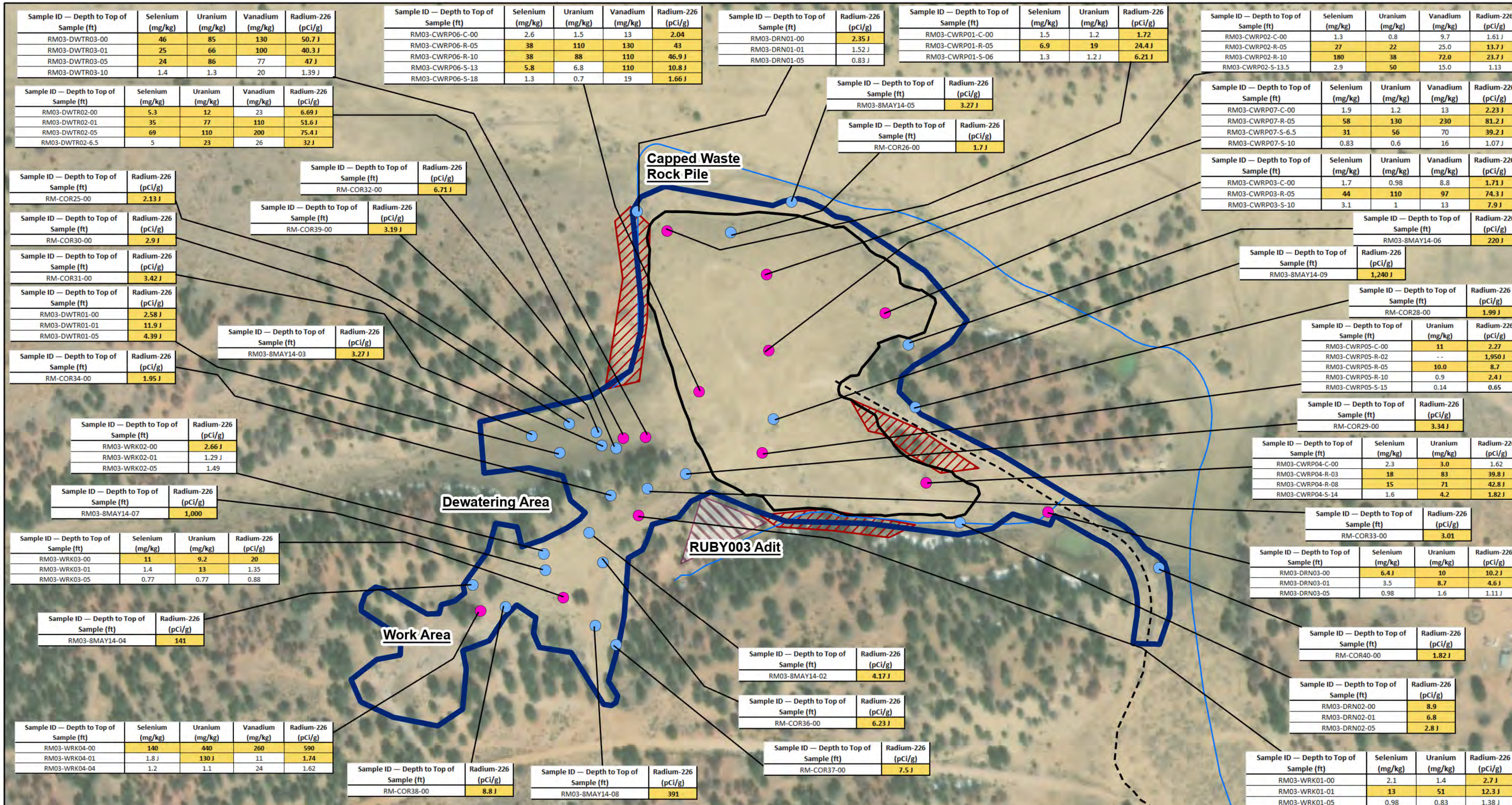

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-DWTR03-00	46	85	130	50.7 J
RM03-DWTR03-01	25	66	100	40.3 J
RM03-DWTR03-05	24	86	77	47 J
RM03-DWTR03-10	1.4	1.3	20	1.39 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-DWTR02-00	5.3	12	23	6.69 J
RM03-DWTR02-01	35	77	110	51.6 J
RM03-DWTR02-05	69	110	200	75.4 J
RM03-DWTR02-6.5	5	23	26	32 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP06-C-00	2.6	1.5	13	2.04
RM03-CWRP06-R-05	38	110	130	43
RM03-CWRP06-R-10	38	88	110	46.9 J
RM03-CWRP06-S-13	5.8	6.8	110	10.8 J
RM03-CWRP06-S-18	1.3	0.7	19	1.66 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-DRN01-00	2.35 J
RM03-DRN01-01	1.52 J
RM03-DRN01-05	0.83 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP01-C-00	1.5	1.2	1.72
RM03-CWRP01-R-05	6.9	19	24.4 J
RM03-CWRP01-S-06	1.3	1.2 J	6.21 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP02-C-00	1.3	0.8	9.7	1.61 J
RM03-CWRP02-R-05	27	22	25.0	13.7 J
RM03-CWRP02-R-10	180	38	72.0	23.7 J
RM03-CWRP02-S-13.5	2.9	50	15.0	1.13

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-05	3.27 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR26-00	1.7 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP07-C-00	1.9	1.2	13	2.23 J
RM03-CWRP07-R-05	58	130	230	81.2 J
RM03-CWRP07-S-6.5	31	56	70	39.2 J
RM03-CWRP07-S-10	0.83	0.6	16	1.07 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP03-C-00	1.7	0.98	8.8	1.71 J
RM03-CWRP03-R-05	44	110	97	74.3 J
RM03-CWRP03-S-10	3.1	1	13	7.9 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR25-00	2.13 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR32-00	6.71 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR39-00	3.19 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR30-00	2.9 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-06	220 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-09	1,240 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR31-00	3.42 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR28-00	1.99 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-DWTR01-00	2.58 J
RM03-DWTR01-01	11.9 J
RM03-DWTR01-05	4.39 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP05-C-00	11	2.27
RM03-CWRP05-R-02	- -	1,950 J
RM03-CWRP05-R-05	10.0	8.7
RM03-CWRP05-R-10	0.9	2.4 J
RM03-CWRP05-S-15	0.14	0.65

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-03	3.27 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR34-00	1.95 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR29-00	3.34 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-WRK02-00	2.66 J
RM03-WRK02-01	1.29 J
RM03-WRK02-05	1.49

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP04-C-00	2.3	3.0	1.62
RM03-CWRP04-R-03	18	83	39.8 J
RM03-CWRP04-R-08	15	71	42.8 J
RM03-CWRP04-S-14	1.6	4.2	1.82 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-07	1,000

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR33-00	3.01

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-WRK03-00	11	9.2	20
RM03-WRK03-01	1.4	13	1.35
RM03-WRK03-05	0.77	0.77	0.88

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-DRN03-00	6.4 J	10	10.2 J
RM03-DRN03-01	3.5	8.7	4.6 J
RM03-DRN03-05	0.98	1.6	1.11 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-04	141

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR40-00	1.82 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-02	4.17 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-DRN02-00	8.9
RM03-DRN02-01	6.8
RM03-DRN02-05	2.8 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR36-00	6.23 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM03-WRK04-00	140	440	260	590
RM03-WRK04-01	1.8 J	130 J	11	1.74
RM03-WRK04-04	1.2	1.1	24	1.62

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR37-00	7.5 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR38-00	8.8 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-08	391

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-WRK01-00	2.1	1.4	2.7 J
RM03-WRK01-01	13	51	12.3 J
RM03-WRK01-05	0.98	0.83	1.38 J

LEGEND

- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Restricted Area
- Drainage Areas to be Addressed with Grading and Riprap

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Notes:
1. Concentrations that are highlighted yellow exceed the following Residential Cleanup Goals:
Ra-226 = 1.65 pCi/g
Selenium = 5.1 mg/kg
Uranium = 2.8 mg/kg
Vanadium = 65 mg/kg

Notes continued:
2. Concentrations that are highlighted yellow exceed the following Washes and Drainages Cleanup Goals:
Ra-226 = 1.65 pCi/g
Selenium = 5.1 mg/kg
Uranium = 8.14 mg/kg
Vanadium = 60 mg/kg
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
Ra = Radium

N

0 100 200 400
Feet

1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-19. Ruby Mines No. 3 Cleanup Extent

Engineering Evaluation and Cost Analysis

Ruby Mines

Jacobs

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM19-VENT02-00	130	100	210	107 J
RM19-VENT02-01	5.0	76	20	8.4 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM19-VENT03-00	40.0	34	89	32.2 J
RM19-VENT03-01	4.1	7.5	21	4.24 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM02-VENT02-00	55	5.69 J
RM02-VENT02-01	48	1.36 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM02-VENT03-00	20.0	230	159 J
RM02-VENT03-01	4.3	110	10.3 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM04-VENT03-00	600	350	130	111
RM04-VENT03-02	81	56	25	24.3

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM04-VENT02-00	11.0	6.38 J
RM04-VENT02-01	2.1	2.38 J

LEGEND
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent

Notes:
1. Concentrations that are highlighted yellow exceed the following Residential Cleanup Goals:
Ra-226 = 1.65 pCi/g
Selenium = 5.1 mg/kg
Uranium = 2.8 mg/kg
Vanadium = 65 mg/kg
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
Ra = Radium

Coordinate System: North American Datum 1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-20. Ruby-002, Ruby-004, and Ruby-019, Cleanup Extent
Ruby Mines
Engineering Evauation and Cost Analysis

Jacobs

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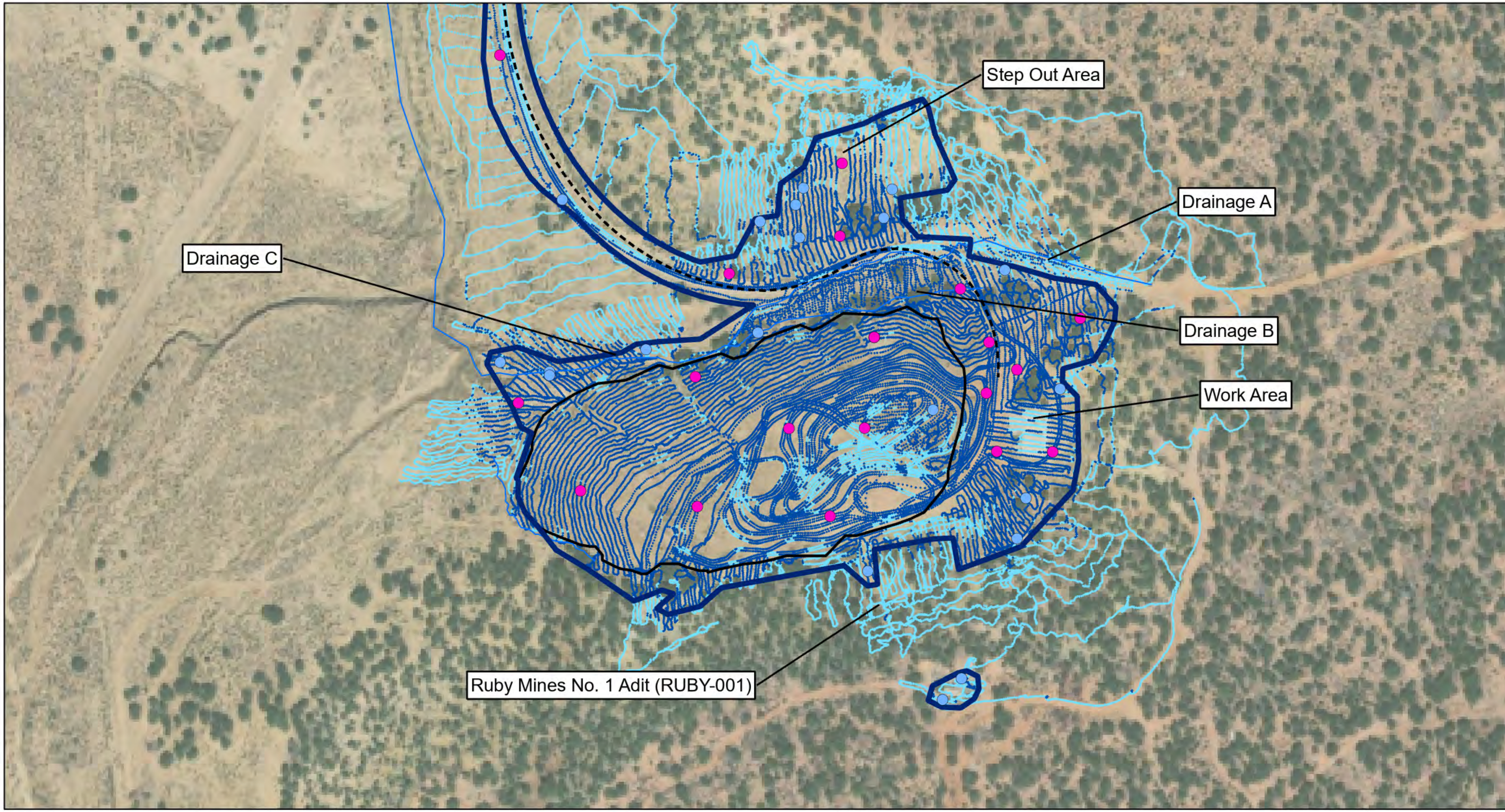

LEGEND

- pCi/g < 1.65
- pCi/g > 1.65
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Cleanup Extent

Notes:
1. Cleanup Goal for Ra-226 = 1.65 pCi/g
> = greater than
< = less than
pCi/g = picocuries per gram
Ra = Radium

N

0 75 150 300
Feet

1:1,800 1 inch = 150 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-21. Ruby Mines No. 1 - Calculated Radium-226 Concentrations in Surface Soil
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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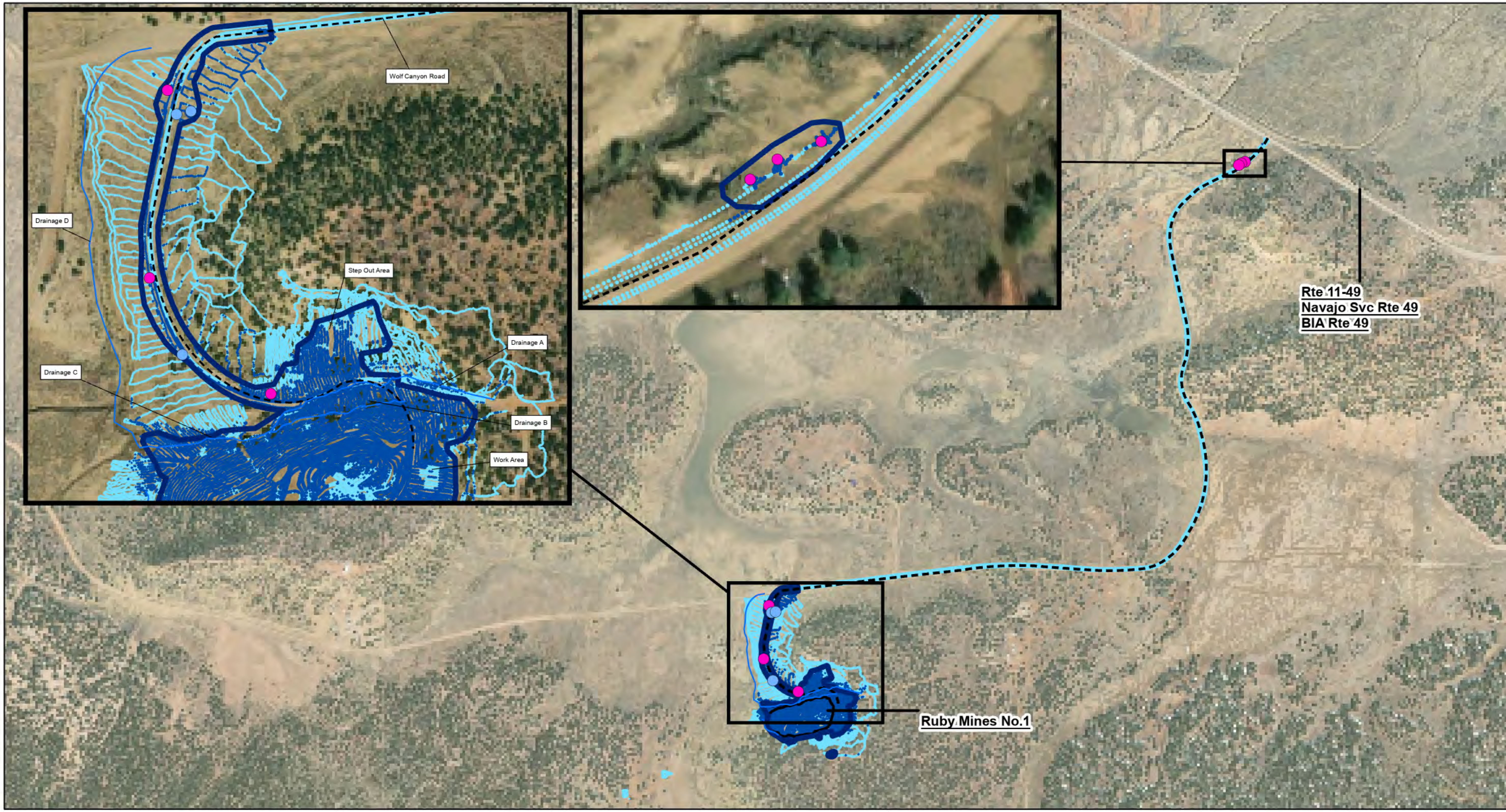

LEGEND

- pCi/g < 1.65
- pCi/g > 1.65
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent
- Former Haul Road
- Drainage

Notes:
1. Cleanup Goal for Ra-226 = 1.65 pCi/g
> = greater than
< = less than
pCi/g = picocuries per gram
Ra = Radium

N

0 500 1,000 2,000
Feet

1:12,000 1 inch = 1,000 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-22. Ruby Mines No. 1 - Former Haul Road - Calculated Radium-226 Concentrations in Surface Soil

Engineering Evaluation and Cost Analysis

Ruby Mines

Jacobs

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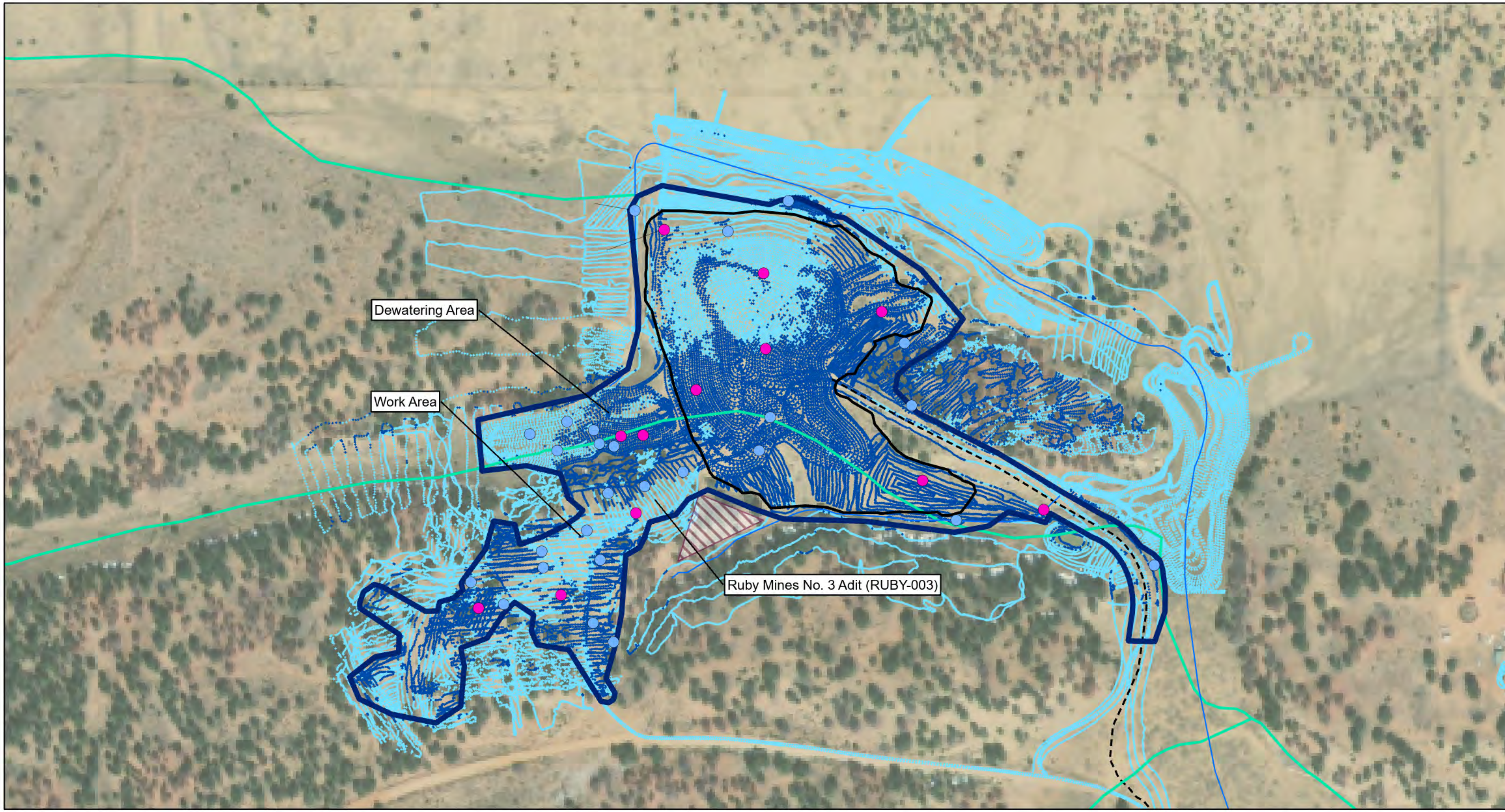

LEGEND

- pCi/g < 1.65
- pCi/g > 1.65
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent
- Former Haul Road
- Drainage
- NHD Drainage
- Capped Waste Rock Pile
- Restricted Area

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Notes:
1. Cleanup Goal for Ra-226 = 1.65 pCi/g
> = greater than
< = less than
pCi/g = picocuries per gram

N

0 100 200 400
Feet

1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-23. Ruby Mines No. 3 - Calculated Radium-226 Concentrations in Surface Soil
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

LEGEND

- pCi/g < 1.65
- pCi/g > 1.65
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Cleanup Extent

Notes:
1. Cleanup Goal for Ra-226 = 1.65 pCi/g
> = greater than
< = less than
pCi/g = picocuries per gram
Ra = Radium

N

0 350 700 1,400
Feet

1:7,200 1 inch = 600 feet

Coordinate System: North American Datum 1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 2-24. Ruby-002, Ruby-004, and Ruby-019, Calculated Radium-226 Concentrations in Surface Soil
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs

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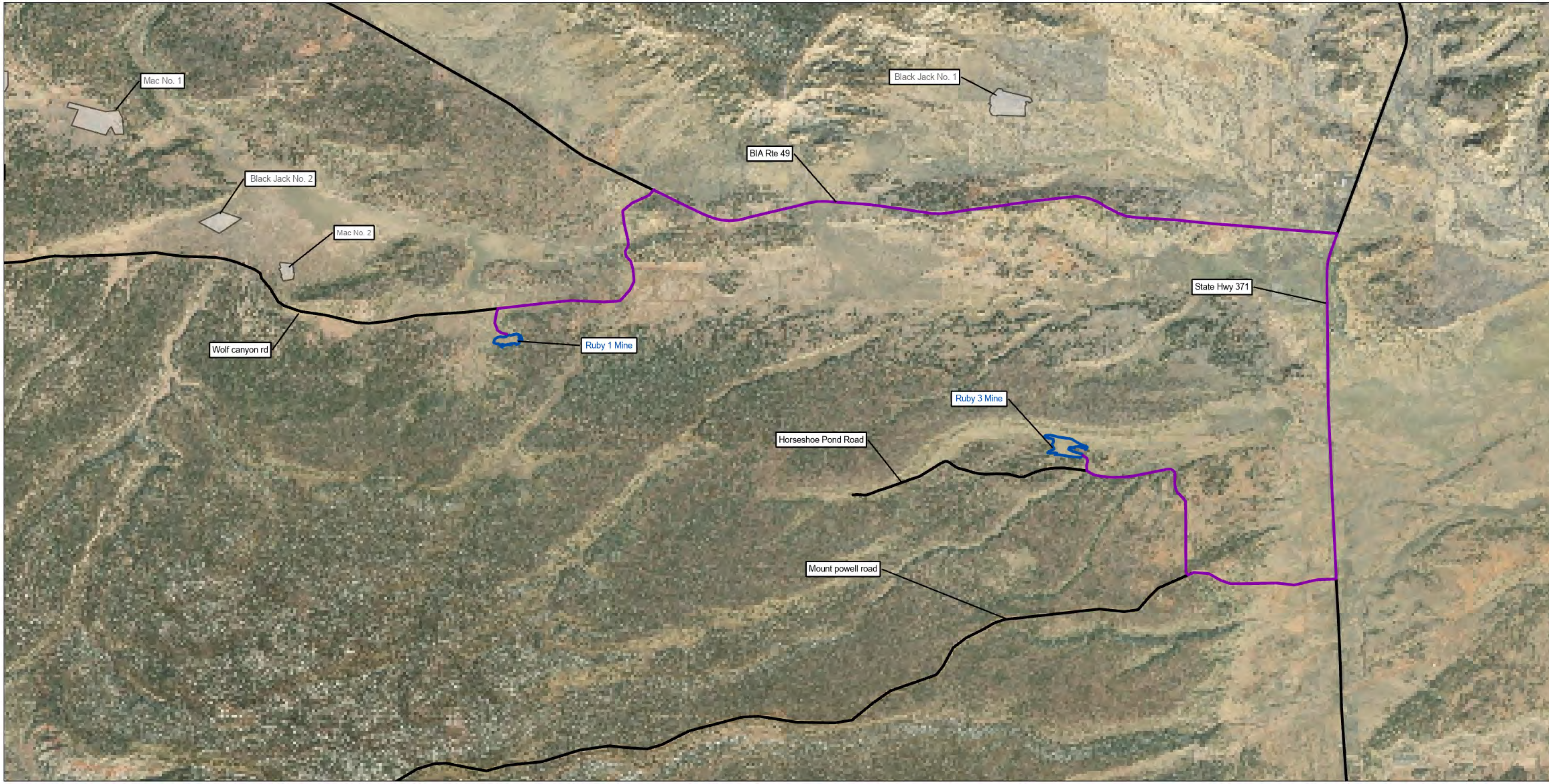

LEGEND

Alternative 4 Haul Route
Roads
Ruby Mines Site Boundary
Other Mine Boundary

Figure 4-1a. Potential Haul Route Alternative 4
Ruby Mines
Engineering Evaluation and Cost Analysis

0 2,000 4,000 8,000
Feet
1:48,000
1 inch = 4,000 miles
N
Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Aerial Imagery: ESRI ArcGIS online

Jacobs

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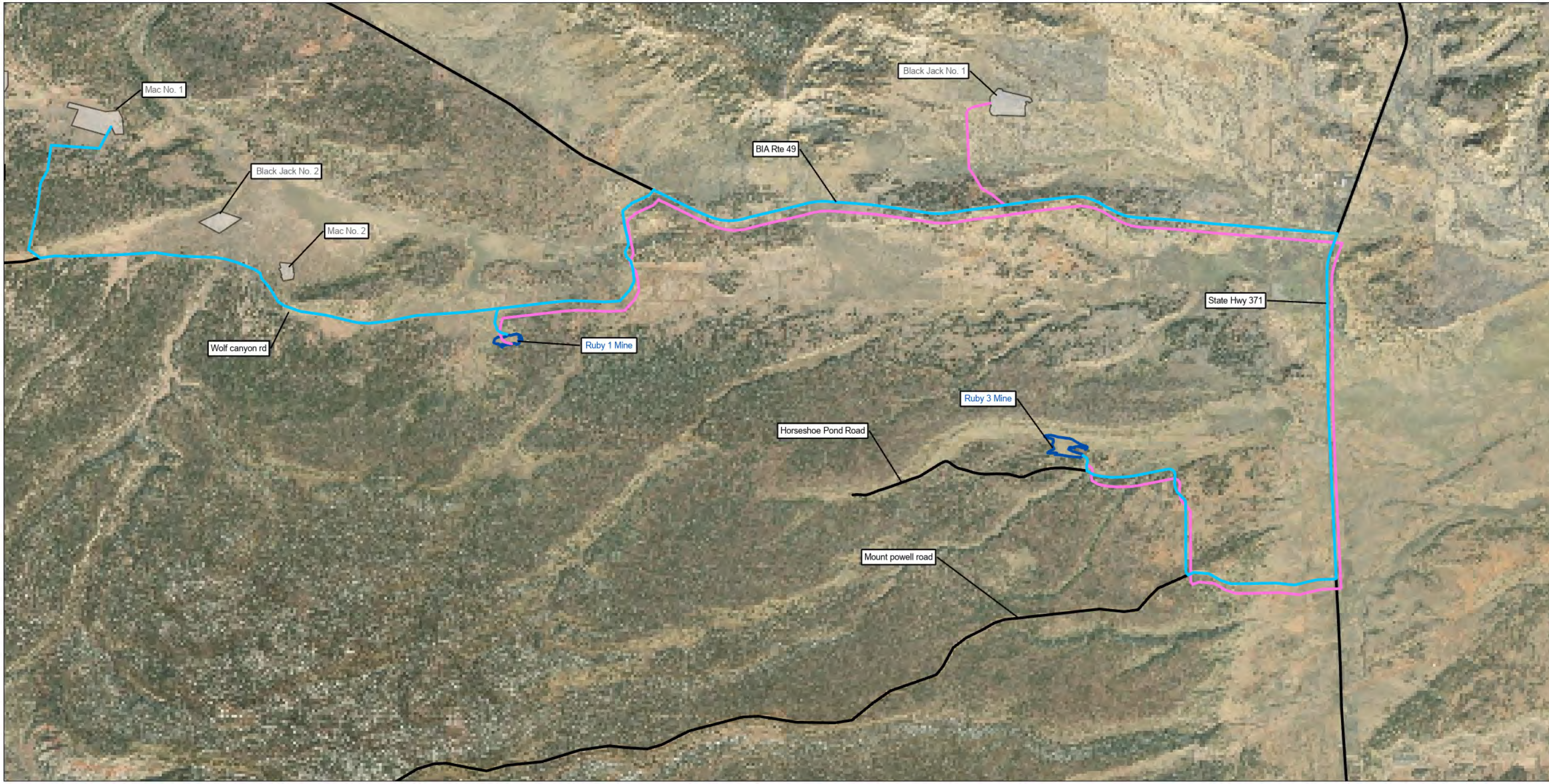

LEGEND

Alternative 5A Haul Route
Alternative 5B Haul Route
Roads
Ruby Mines Site Boundary
Other Mine Boundary

Figure 4-1b. Potential Haul Route Alternative 5a and 5b
Ruby Mines
Engineering Evaluation and Cost Analysis

N
0 2,000 4,000 8,000
Feet
1:48,000
1 inch = 4,000 miles
Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Aerial Imagery: ESRI ArcGIS online

Jacobs

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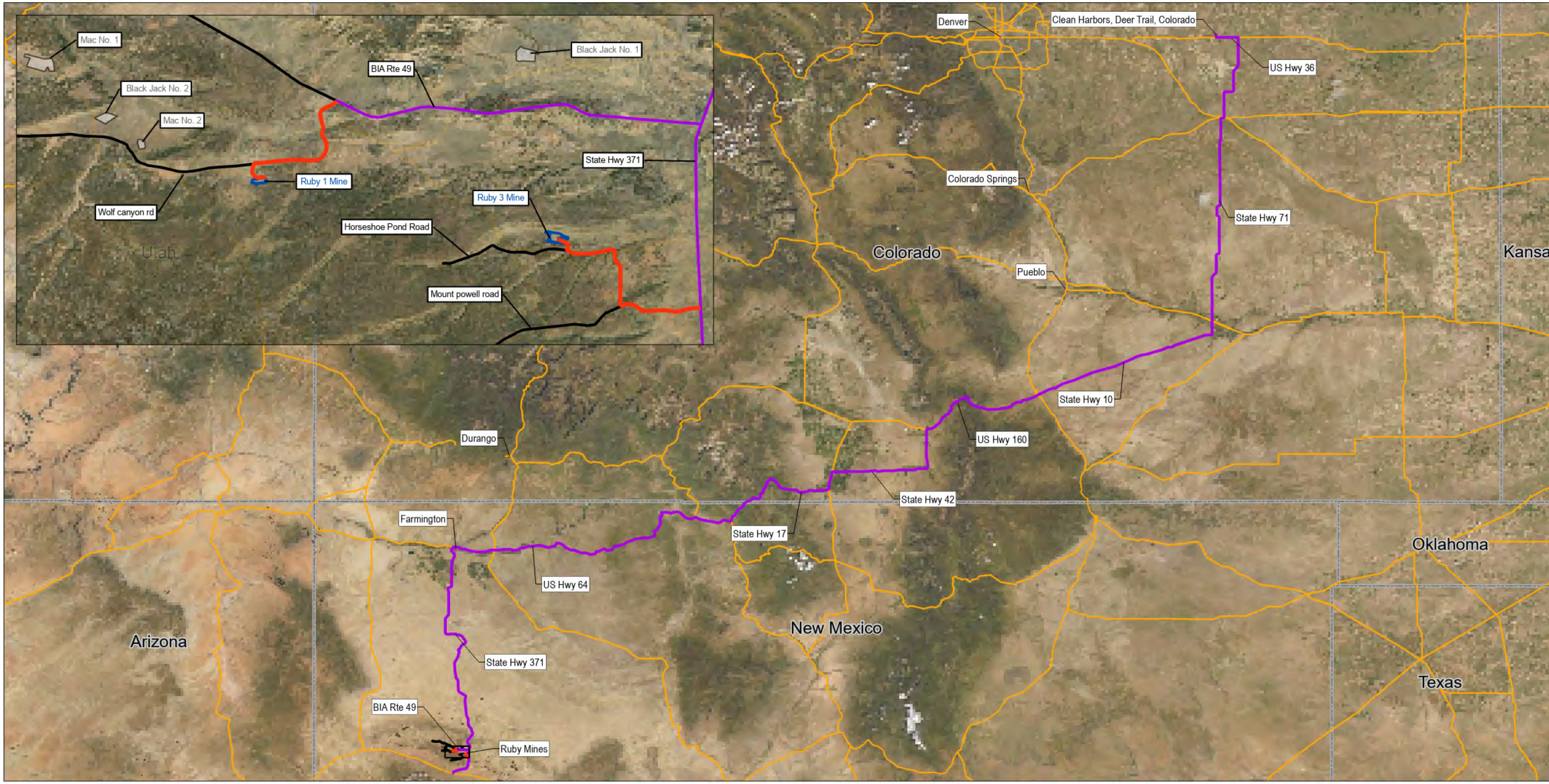

LEGEND

- Ruby Mines Site Boundary
- Other Mine Boundary
- Former Haul Road
- Potential Haul Route
- Roads
- US Interstates and Highways
- State Boundary

Figure 4-1c. Potential Haul Route Alternative 6 from Ruby Mines Site to Clean Harbors, Deer Trail, Colorado
Ruby Mines
Engineering Evaluation and Cost Analysis

N

0 12.5 25 50 75
Miles
1:2,600,000 1 inch = 41 miles

Coordinate System: World Geodetic System 1984;
Hydrolog, Transportation: United States Geological Survey 2014;
Aerial Imagery: ESRI ArcGIS online

Jacobs

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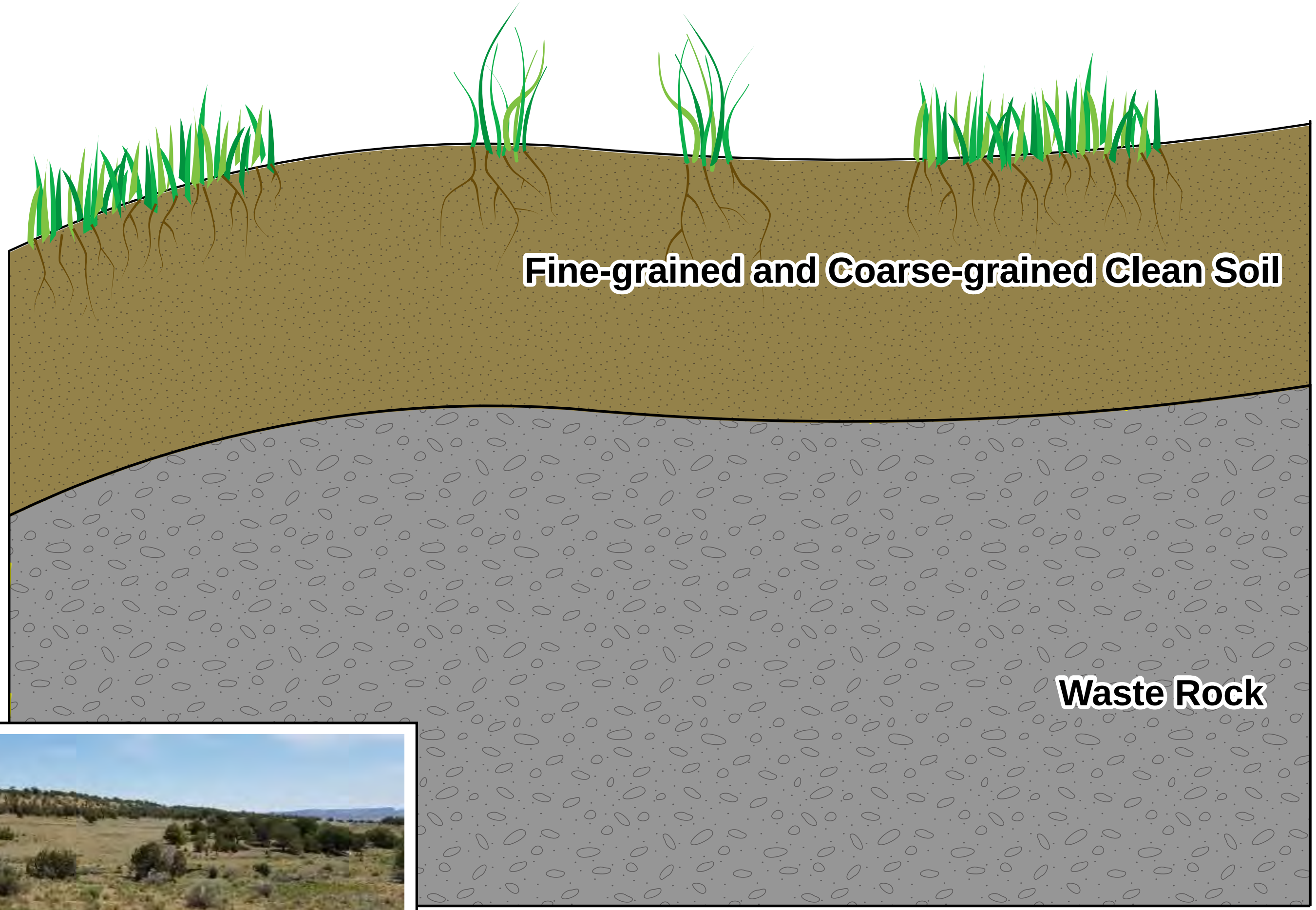
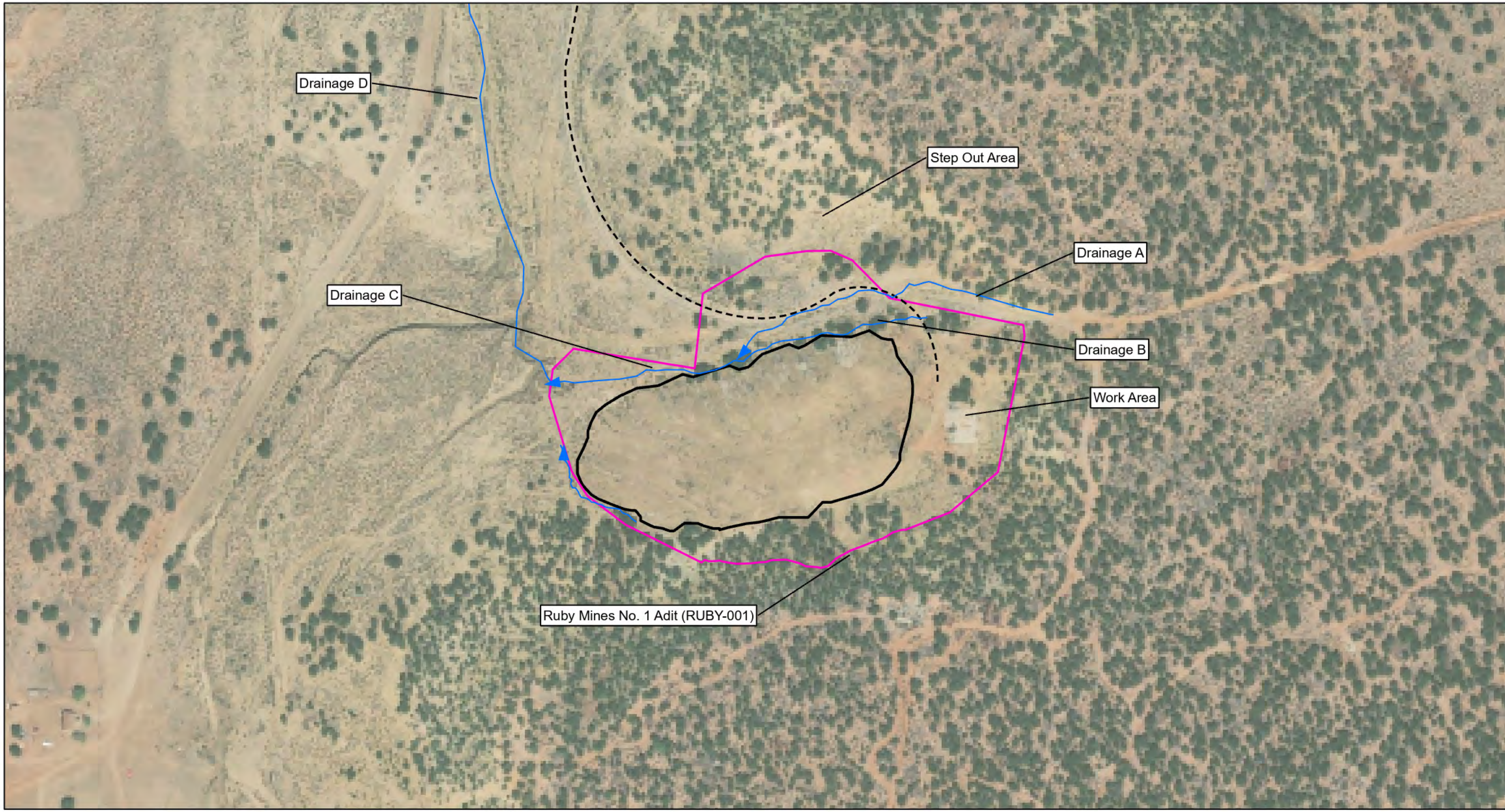


Revegetation will be focused on establishing a plant community similar to the surrounding reference area in structure, function, diversity, and dynamics.

Figure 4-2. Typical Cap Design
Ruby Mines
Engineering Evaluation and Cost Analysis



LEGEND

- Former Haul Road
- Drainage
- Existing Capped Waste Rock Pile
- Extent of Grading Cover System

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N

0 100 200 400
Feet
1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure 4-3. Combined Waste Rock Pile Footprint
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs

Figure 4-4. Alternative Comparison
Engineering Evaluation and Cost Analysis
Ruby Mines

Alternative	Threshold Criteria		Effectiveness		Implementability			Cost
	Protective of Human Health and the Environment	Compliance with ARARs	Short-Term (During Action)	Long-Term (After Action)	Technical Feasibility	Administrative Feasibility	Availability of Services and Materials	$$
1. No Further Action	Not applicable							
2. Consolidate and Repair Existing Caps	Yes	Yes	Good	Medium	Very Good	Good	Good	Very Good
3. Consolidate and Cap in Place at Each Mine Site	Yes	Yes	Good	Good	Very Good	Good	Good	Very Good
4. Consolidate and Cap at a Local Repository (in each Mine Area)	Yes	Yes	Medium	Good	Very Good	Good	Medium	Good
5. Excavate and Manage at One or More Regional Repositories	Yes	Yes	Poor	Good	Very Good	Medium	Medium	Medium
6. Excavate and Manage Off Reservation	Yes	Yes	Very Poor	Very Good	Very Good	Poor	Poor	Very Poor

Appendix A
RSE Data

Table A-1. Ruby Mine Site RSE Data

Sample Identification	Top of Sample Interval (feet)	Background Reference Area	Latitude[a]	Longitude[a]	Sample Date	Surface Radiation Readings Uncollimated (cpm)[b]	Collimated (cpm)[c]	Soil Radiation Readings Gamma/Total Core Screening (cpm)[d]	On-Contact Jar (cpm)[e]	RSL or PRG -->	Arsenic (mg/kg)[f] 12.2		Mercury (mg/kg)[6] 11		Molybdenum (mg/kg)[f] 390		Selenium (mg/kg)[f] 390		Uranium (mg/kg)[f] 16		Vanadium (mg/kg)[f] 390		Radium-226 (pCi/g)[f] 2.89	
RM01-CWRP01-C-00	0	Colluvium	35.51928012	-108.22403658	10/12/2014	27,214	9,124	13,600-13,800 / 100-200	- -		7.7		0.014		0.72		3.1		3.8		18.0		2.61	J
RM01-CWRP01-R-05	5	Colluvium	35.51928012	-108.22403658	10/12/2014			16,000-16,800 / 180-220	- -		8.1	J	0.0097		8.1	J	81	J	140		96		37.7	J
RM01-CWRP01-R-10	10	Colluvium	35.51928012	-108.22403658	10/12/2014			14,100-14,500 / 140-160	- -		4.3		0.009		2.1		27		83		74		53.4	J
RM01-CWRP01-R-15	15	Colluvium	35.51928012	-108.22403658	10/12/2014			15,800-16,000 / 100-140	- -		4.9	J	0.012		1.9	J	37	J	77		97	J	49.8	J
RM01-CWRP01-R-20	20	Colluvium	35.51928012	-108.22403658	10/12/2014			16,200-17,100 / 300-380	- -		5.2		0.012	U	1.7		78		110		72		46.9	J
RM01-CWRP01-S-22.5	22.5	Colluvium	35.51928012	-108.22403658	10/12/2014			13,400-13,700 / 100-140			7.3		0.017		0.52		2.0		3.4		9.2		1.1	J
RM01-CWRP02-C-00	0	Colluvium	35.51921340	-108.22343136	10/12/2014	25,779	8,558	16,900-17,600 / 90-160	- -		8.2		0.015		0.69		5.7		9.8		23.0		8.6	J
RM01-CWRP02-R-05	5	Colluvium	35.51921340	-108.22343136	10/12/2014			21,310-21,320 / 100-120	- -		3.3		0.01	U	0.85		12		43		60		24.5	J
RM01-CWRP02-R-10	10	Colluvium	35.51921340	-108.22343136	10/12/2014			19,340-20,090 / 140-180	- -		8.1		0.0096	U	1.1		11		35		29		18.6	
RM01-CWRP02-R-15	15	Colluvium	35.51921340	-108.22343136	10/12/2014			19,520-20,830 / 120-150	- -		3.4		0.011	U	0.48		61		22		8.6		15.8	J
RM01-CWRP02-S-21	21	Colluvium	35.51921340	-108.22343136	10/12/2014			18,970-19,120 / 90-110	- -		7.7		0.012	U	0.53		1.5		0.66		8.5		1.32	J
RM01-CWRP03-C-00	0	Mancos Shale	35.51917637	-108.22274675	10/12/2014	25,028	7,469	18,700-19,200 / 60-100	- -		10		0.013		1.4		7.7		9.9		14.0		7.30	J
RM01-CWRP03-R-05	5	Mancos Shale	35.51917637	-108.22274675	10/12/2014			16,700-17,200 / 120-140	- -		5.7		0.36		0.54		0.99		1.10		11.0		9.40	J
RM01-CWRP03-R-10	10	Mancos Shale	35.51917637	-108.22274675	10/12/2014			17,300-17,700 / 180-240	- -		3		0.011	U	0.77		0.76		2.10		10.0		4.05	J
RM01-CWRP03-R-15	15	Mancos Shale	35.51917637	-108.22274675	10/12/2014			16,300-16,600 / 80-120	- -		4.7		0.0099	U	1.6		2.0		8.3		13.0		1.9	J
RM01-CWRP03-S-16.5	16.5	Mancos Shale	35.51917637	-108.22274675	10/12/2014			18,400-19,100 / 80-100	- -		6.2		0.012	U	0.42		0.69		0.46		12.0		1.1	J
RM01-CWRP04-C-00	0	Colluvium	35.51962435	-108.22221811	10/12/2014	21,887	6,514	13,700-13,900 / 60-80	- -		8.5		0.026		0.68		3.2		6.6		21.0		7.1	J
RM01-CWRP04-R-05	5	Colluvium	35.51962435	-108.22221811	10/12/2014			12,900-13,200 / 80-100	- -		2.1		0.011	U	0.22		0.28		2.0		1.80		0.59	J
RM01-CWRP04-R-10	10	Colluvium	35.51962435	-108.22221811	10/12/2014			12,500-12,70 / 80-100	- -		1.2		0.011	U	0.31		0.82		9.0		14.0		1.65	J
RM01-CWRP04-S-15	15	Colluvium	35.51962435	-108.22221811	10/12/2014			12,700-13,000 / 80-100	- -		10		0.015		0.72		1.1		0.89		9.4		1.31	J
RM01-CWRP05-C-00	0	Colluvium	35.51993156	-108.22252387	10/12/2014	19,328	5,765	15,800-16,200 / 60-100	- -		6.0		0.011	U	0.64		1.3		6.0		17.0		2.33	J
RM01-CWRP05-R-01	1	Colluvium	35.51993156	-108.22252387	10/12/2014			16,500-16,700 / 100-140	- -		3.5		0.01	U	1.1		9.4		38.0		15.0		38.2	
RM01-CWRP05-R-05	5	Colluvium	35.51993156	-108.22252387	10/12/2014			19,600-20,100 / 60-100	- -		6		0.0099	U	4.6		4.0		110	J	9.4		15.4	
RM01-CWRP05-R-10	10	Colluvium	35.51993156	-108.22252387	10/12/2014			22,100-22,600 / 140-160	- -		2.9	J	0.01		2.4	J	2.9		9.3		11.0	J	12.5	J
RM01-CWRP05-S-15	15	Colluvium	35.51993156	-108.22252387	10/12/2014			17,400-17,800 / 60-100	- -		10		0.01	U	0.8		1.4		20.0		12.0		1.5	J
RM01-CWRP06-C-00	0	Colluvium	35.51976311	-108.22344545	10/13/2014	29,301	9,149	12,900-13,200 / 60-80	- -		7.8		0.017		0.61		2.0		2.4		14.0		3.62	J
RM01-CWRP06-R-05	5	Colluvium	35.51976311	-108.22344545	10/13/2014			15,700-16,000 / 100-140	- -		6.6		0.016		3.3		27.0		92		53.0		48.7	J
RM01-CWRP06-S-6.5	6.5	Colluvium	35.51976311	-108.22344545	10/13/2014			13,200-13,800 / 100-120	- -		9.4		0.015		0.66		1.8		1.8		10.0		1.87	J
RM01-CWRP06-S-11.5	11.5	Colluvium	35.51976311	-108.22344545	10/13/2014			13,100-13,400 / 80-120	- -		7.0		0.015		0.49	J	1.0		0.96		12.0		1.53	J
RM01-CWRP07-C-00	0	Colluvium	35.51954322	-108.22296825	10/12/2014	39,423	14,130	15,200-15,900 / 60-100	- -		7.1		0.014		0.52		3.2		2.7		14.0		4.09	J
RM01-CWRP07-R-05	5	Colluvium	35.51954322	-108.22296825	10/12/2014			15,600-15,900 / 80-120	- -		4.1		0.035		0.93		40		64		34.0		27.1	J
RM01-CWRP07-R-10	10	Colluvium	35.51954322	-108.22296825	10/12/2014			16,000-16,200 / 80-100	- -		4.2		0.011	U	0.87		11		31		26.0		22.8	J
RM01-CWRP07-R-15	15	Colluvium	35.51954322	-108.22296825	10/12/2014			16,400-16,800 / 120-160	- -		3.9		0.011	U	1.0		68		56		26.0		19.0	J
RM01-CWRP07-R-20	20	Colluvium	35.51954322	-108.22296825	10/12/2014			16,500-16,800 / 140-160	- -		2.4		0.0081	U	0.34		160		38		27.0		38.1	J
RM01-CWRP07-R-25	25	Colluvium	35.51954322	-108.22296825	10/12/2014			15,300-15,700 / 120-160	- -		4.9		0.01	U	1.0		28		75		19.0		46.0	J
RM01-CWRP07-S-26.5	26.5	Colluvium	35.51954322	-108.22296825	10/12/2014			15,300-15,700 / 100-140	- -		9.2		0.012	U	0.63		2.4		3.2		17.0		1.31	J
RM01-CWRP07-S-31.5	31.5	Colluvium	35.51954322	-108.22296825	10/12/2014			15,500-16,100 / 80-100	- -		7.7		0.0096		0.64		1.7		1.9		16.0		1.32	J
RM01-CWRP08-C-00	0	Colluvium	35.51953545	-108.22281929	10/12/2014	18,098	5,523	12,400-13,000 / 80-100	- -		6.5		0.016		0.55		12		5		27		7	J
RM01-CWRP08-R-05	5	Colluvium	35.51953545	-108.22281929	10/12/2014			12,600-12,900 / 100-140	- -		4.1		0.029		2.6		3.5		120		15.0		8.9	J
RM01-CWRP08-R-10	10	Colluvium	35.51953545	-108.22281929	10/12/2014			13,700-14,000 / 100-140	- -		3.3		0.012		0.92		0.84		1.10		6.30		1.11	J
RM01-CWRP08-R-15	15	Colluvium	35.51953545	-108.22281929	10/12/2014			13,700-14,200 / 60-100	- -		6		0.045		0.78		0.94		0.77		6.60		0.62	J
RM01-CWRP08-S-18.5	18.5	Colluvium	35.51953545	-108.22281929	10/12/2014			13,100-13,300 / 60-80	- -		9.9		0.016		0.66		1.1		0.8		14.0		1.01	J
RM01-DRNA1-00	0	Colluvium	35.52013463	-108.22208345	10/11/2014	30,924	8,365	10,900-11,300 / 80-120	- -		8.9		0.017		1.0		3.9		17.0		26.0		18.9	J
RM01-DRNA1-01	1	Colluvium	35.52013463	-108.22208345	10/11/2014			10,700-10,800 / 80-110	- -		9.5		0.0099	U	0.99		1.1		7.7		8.6		2.1	J
RM01-DRNA1-05	5	Colluvium	35.52013463	-108.22208345	10/11/2014			10,700-10,900 / 80-100	- -		4.1		0.011	U	0.43		0.59		2.70		5.60		0.66	J
RM01-DRNB1-00	0	Colluvium	35.51994811	-108.22312501	10/13/2014			13,700-14,000 / 80-100	- -		8		0.015		0.68		3.9		7.1		17.0		12.5	J
RM01-DRNB1-01	1	Colluvium	35.51994811	-108.22312501	10/13/2014			13,500-13,800 / 80-120	- -		11		0.013		0.9		1.1		2.0		9.9		1.3	J
RM01-DRNB1-05	5	Colluvium	35.51994811	-108.22312501	10/13/2014			14,600-15,200 / 80-100	- -		7.3		0.01	U	0.54		0.78		0.97		9.20		0.99	J
RM01-DRNC1-00	0	Colluvium	35.51982563	-108.22356640	10/12/2014	18,214	5,775	13,700-14,000 / 100-120	- -		6.5		0.012		0.6		4.5		5.9		16.0		10.1	J
RM01-DRNC1-01	1	Colluvium	35.51982563	-108.22356640	10/12/2014			13,500-13,800 / 60-90	- -		6.7		0.011		0.66		2.6		4.9		15.0		8.6	J
RM01-DRNC1-05	5	Colluvium	35.51982563	-108.22356640	10/12/2014			13,600-13,800 / 60-90	- -		9.4		0.012	U	0.79		1.4		1.3		16.0		1.4	J
RM01-HR01-00	0	Colluvium	35.52049169	-108.22413184	10/13/2014	25,600	9,665	9,200-9,400 / 100-140	- -		6.8		0.02		0.67		3.5		11.0		25.0		14.6	J
RM01-HR01-01	1	Colluvium	35.52049169	-108.22413184	10/13/2014			9,100-9,500 / 100-120	- -		8.2		0.015		0.51		1.1		5.5		11.0		3.6	J
RM01-HR01-05	5	Colluvium	35.52049169	-108.22413184	10/13/2014			8,800-9,100 / 60-100	- -		8.4		0.019		0.58		0.92		1.00		8.30		1.1	J
RM01-HR02-00	0	Mancos Shale	35.52111344	-108.22446822	10/13/2014	67,130	40,753	21,600-22,900 / 24,000-31,000	- -		35		0.23		15.0		12.0		2,600		310		1,680	
RM01-HR02-01	1	Mancos Shale	35.52111344	-108.22446822	10/13/2014			16,800-19,000 / 11,000-21,100	- -		11		0.04		5.0		1.6		200		36.0		222.0	J
RM01-HR02-05	5	Mancos Shale	35.52111344	-108.22446822	10/13/2014			10,200-10,400 / 80-100	- -		8.7		0.018		0.74		0.93		2.10		9.10		1.92	J
RM01-HR03-00	0	Mancos Shale	35.52261279	-108.22426613	10/13/2014	77,079	37,264	11,000-13,600 / 240-450	- -		8.6		0.021		3.8		38	J	250		120		218	
RM01-HR03-01	1	Mancos Shale	35.52261279	-108.22426613	10/13/2014			9,600-10,300 / 100-140	- -		10		0.048		0.94		1.5		2.0		9.4		2.31	J
RM01-HR03-05	5	Mancos Shale	35.52261279	-108.22426613	10/13/2014			10,300-10,600 / 100-120	- -		7.8		0.026		0.78		1.5		1.7		7.6		1.67	J
RM01-HR04-00	0	Colluvium	35.53505241	-108.20817575	10/10/2014	30,157	13,126	30,157 / - -	- -		6.9		0.022		0.87		3.2		19.0		31.0		28.6	J
RM01-HR05-00	0	Colluvium	35.53509467	-108.20810048	10/10/2014	89,648	33,068	89,648 / - -	- -		16		0.11		5.4		10		1,000		160		412	J
RM01-HR06-00	0	Colluvium	35.53514685	-108.20800107	10/10/2014	50,010	19,402	50,010 / - -	- -		14		0.036		15		15		120		130		129	J
RM01-HR07-00	0	Colluvium	35.52019176	-108.22327303	10/11/2014	176,269	72,600	13,400-14,000 / 140-200	- -		20	J	0.083		16	J	29	J	3,500		280		1,160	J
RM01-HR07-01	1	Colluvium	35.52019176	-108.22327303	10/11/2014			11,500-12,000 / 80-110	- -		9.3		0.018		2.6		3.3		12.0		13.0		10.2	J

Table A-1. Ruby Mine Site RSE Data

Sample Identification	Top of Sample Interval (feet)	Background Reference Area	Latitude[a]	Longitude[a]	Sample Date	Surface Radiation Readings Uncollimated (cpm)[b]	Collimated (cpm)[c]	Soil Radiation Readings Gamma/Total Core Screening (cpm)[d]	On-Contact Jar (cpm)[e]	RSL or PRG -->	Arsenic (mg/kg)[f] 12.2		Mercury (mg/kg)[6] 11		Molybdenum (mg/kg)[f] 390		Selenium (mg/kg)[f] 390		Uranium (mg/kg)[f] 16		Vanadium (mg/kg)[f] 390		Radium-226 (pCi/g)[f] 2.89	
RM01-HR07-05	5	Colluvium	35.52019176	-108.22327303	10/11/2014			10,800-11,000 / 60-100	- -		10		0.036		0.78		1.2		2.1		14.0		1.97	J
RM01-STEP01-00	0	Colluvium	35.51965026	-108.22435796	10/12/2014	24,593	8,403	11,970-12,150 / 90-110	- -		5.4		0.011	U	0.72		17		21		40		21.3	J
RM01-STEP01-01	1	Colluvium	35.51965026	-108.22435796	10/12/2014			11,860-12,100 / 90-110	- -		7.8		0.02		0.64		1.2		8.2		15.0		7.90	J
RM01-STEP01-05	5	Colluvium	35.51965026	-108.22435796	10/12/2014			11,970-12,200 / 90-110	- -		8		0.013		0.61		1.2		0.9		16.0		2.06	J
RM01-STEP02-00	0	Mancos Shale	35.52066313	-108.22269878	10/11/2014	97,827	40,360	15,000-16,500 / 100-220	- -		12		0.035		5.9		32		110		160		281	J
RM01-STEP02-01	1	Mancos Shale	35.52066313	-108.22269878	10/11/2014			13,100-14,100 / 100-120	- -		7.6		0.011	U	1.8		1.4		110		12.0		2.18	J
RM01-STEP02-05	5	Mancos Shale	35.52066313	-108.22269878	10/11/2014			12,100-12,300 / 60-80	- -		27	J	0.011	U	2.0	J	0.92		0.74	J	22	J	0.980	J
RM01-STEP03-00	0	Colluvium	35.52001544	-108.22144950	10/11/2014	59,471	21,694	13,200-13,700 / 100-120	- -		7		0.028		2.1		40		100		100		122	J
RM01-STEP03-01	1	Colluvium	35.52001544	-108.22144950	10/11/2014			12,400-13,100 / 100-100	- -		6.2		0.014		0.96		0.97		31.0		14.0		7.34	J
RM01-STEP03-05	5	Colluvium	35.52001544	-108.22144950	10/11/2014			12,500-12,100 / 80-100	- -		5.9		0.0092	U	0.88		1.6		6.1		9.2		2.13	J
RM01-STEP04-00	0	Colluvium	35.51946005	-108.22161970	10/12/2014	134,792	57,437	16,800-18,500 / 350-450	- -		7.8		0.018		1.3		6.6		57.0		22	J	20.9	J
RM01-STEP04-01	1	Colluvium	35.51946005	-108.22161970	10/12/2014			14,200-15,000 / 120-180	- -		9.9		0.029		0.77		0.70		2.3		7.5		1.16	J
RM01-STEP04-05	5	Colluvium	35.51946005	-108.22161970	10/12/2014			12,900-13,300 / 80-110	- -		7.3		0.017		0.64		0.66		1.80		6.50		1.28	J
RM01-STEP05-00	0	Colluvium	35.52035784	-108.22270497	10/11/2014	102,246	73,119	16,700-17,000/ 1,000-1,600	- -		20		0.026		6.6		19		3,100		720		846	J
RM01-STEP05-01	1	Colluvium	35.52035784	-108.22270497	10/11/2014			13,200-16,300 / 140-300	- -		8.5		0.018		1.2		3.4		360		110		50.7	J
RM01-STEP05-05	5	Colluvium	35.52035784	-108.22270497	10/11/2014			11,400-11,700 / 60-80	- -		11		0.019		1.0		0.84		3.30		9.50		2.45	J
RM01-WRK01-00	0	Colluvium	35.51991910	-108.22193262	10/11/2014	26,190	8,284	13,100-14,300 / 60-140	- -		3.9		0.014	J	0.42		2.8		9.4		15.0		6.80	J
RM01-WRK01-01	1	Colluvium	35.51991910	-108.22193262	10/11/2014			13,500-14,800 / 140-180	- -		7.9		0.018		2.3		16.0		110		45		149	J
RM01-WRK01-05	5	Colluvium	35.51991910	-108.22193262	10/11/2014			12,000-12,100 / 100-120	- -		8.1		0.019		0.64		1.6		7.6		10.0		4.84	J
RM01-WRK02-00	0	Colluvium	35.51979114	-108.22176407	10/11/2014	42,278	14,159	12,200-12,400 / 80-110	- -		6.8		0.023	J	0.9		9.3		20.0		31.0		39.9	J
RM01-WRK02-01	1	Colluvium	35.51979114	-108.22176407	10/11/2014			11,500-11,800 / 100-120	- -		9.2		0.016		1		1.6		28.0		12.0		2.23	J
RM01-WRK02-5.5	5.5	Colluvium	35.51979114	-108.22176407	10/11/2014			10,700-11,100 / 80-120	- -		6.9		0.026		0.44		0.65		3.00		8.40		1.11	J
RM01-WRK03-00	0	Colluvium	35.51968501	-108.22193452	10/11/2014	30,130	9,360	18,900-19,500 / 60-80	- -		3.7		0.012	J	0.34		1.4		5.0		13.0		3.08	J
RM01-WRK03-01	1	Colluvium	35.51968501	-108.22193452	10/12/2014			19,600-22,600 / 80-220	- -		9		0.022		2.9		35	J	95		88.0		126	J
RM01-WRK03-05	5	Colluvium	35.51968501	-108.22193452	10/12/2014			15,500-16,100 / 80-110	- -		10		0.022		0.7		1.5		0.9		11.0		1.15	J
RM01-WRK04-00	0	Colluvium	35.51943460	-108.22188727	10/12/2014	17,374	4,890	18,600-19,00 / 100-140	- -		4.0		0.017	J	0.35		1.3		2.4		13.0		2.99	J
RM01-WRK04-01	1	Colluvium	35.51943460	-108.22188727	10/12/2014			18,300-19,000 / 100-140	- -		7.8		0.038		2.7		21		120		71		38.0	J
RM01-WRK04-05	5	Colluvium	35.51943460	-108.22188727	10/12/2014			14,400-15,400 / 60-100	- -		9.3		0.048		0.71		1.2		1.2		9.3		1.92	J
RM02-VENT01-00	0	Dakota	35.51255708	-108.22251640	10/12/2014	9,167	3,164	see surface reading	- -		3.3		0.018		0.68		1.1		0.7		20.0		1.39	J
RM02-VENT01-01	1	Dakota	35.51255708	-108.22251640	10/12/2014			14,107 / - -	- -		3.5		0.01	U	0.43		0.93		0.79		19.00		0.94	J
RM02-VENT02-00	0	Dakota	35.51248804	-108.22252460	10/12/2014	30,995	12,495	see surface reading	- -		3.4		0.016		1.6		2.8		55.0		17.0		5.69	J
RM02-VENT02-01	1	Dakota	35.51248804	-108.22252460	10/12/2014			14,079 / - -	- -		2		0.011	U	2.1		1.4		48.0		11.0		1.36	J
RM02-VENT03-00	0	Dakota	35.51247430	-108.22252574	10/12/2014	113,882	47,869	see surface reading	- -		5.7		0.016		3.8		20.0		230		56.0		159	J
RM02-VENT03-01	1	Dakota	35.51247430	-108.22252574	10/12/2014			13,457 / - -	- -		2.8		0.016		2.8		4.3		110		15.0		10.3	J
RM03-CWRP01-C-00	0	Colluvium	35.50840798	-108.16320831	10/8/2014	15,909	5,297	10,600-11,100 / 100-110	- -		6.4		0.017		0.2		1.5		1.2		7.8		1.72	
RM03-CWRP01-R-05	5	Colluvium	35.50840798	-108.16320831	10/8/2014			12,000-12,200 / 80-110	- -		3.4		0.0092	U	0.77		6.9		19.0		17.0		24.4	J
RM03-CWRP01-S-06	6	Colluvium	35.50840798	-108.16320831	10/8/2014			11,600-11,800 / 80-100	- -		5.6		0.023	J	0.47		1.3		1.2	J	26	J	6.21	J
RM03-CWRP02-C-00	0	Mancos Shale	35.50816608	-108.16252582	10/9/2014	18,141	5,935	11,400-11,700 / 60-80	- -		6		0.016		0.19		1.3		0.8		9.7		1.61	J
RM03-CWRP02-R-05	5	Mancos Shale	35.50816608	-108.16252582	10/9/2014			11,500-12,000 / 100-140	- -		2.8		0.012	U	0.59		27		22.0		25.0		13.7	J
RM03-CWRP02-R-10	10	Mancos Shale	35.50816608	-108.16252582	10/9/2014			10,900-11,200 / 100-140	- -		6.2		0.022		2.1		180		38.0		72.0		23.7	J
RM03-CWRP02-S-13.5	13.5	Mancos Shale	35.50816608	-108.16252582	10/9/2014			12,000-13,400 / 80-100	- -		4.5		0.019		0.13		2.9		50.0		15.0		1.13	
RM03-CWRP03-C-00	0	Mancos Shale	35.50795564	-108.16171587	10/9/2014	19,634	7,124	18,700-19,200 / 60-100	- -		6.2		0.017		0.2		1.7		0.98		8.8		1.71	J
RM03-CWRP03-R-05	5	Mancos Shale	35.50795564	-108.16171587	10/9/2014			17,000-17,400 / 100-120	- -		6.9		0.022		2.2		44		110		97.0		74.3	J
RM03-CWRP03-S-10	10	Mancos Shale	35.50795564	-108.16171587	10/9/2014			17,300-17,700 / 180-240	- -		8.0		0.032		0.19		3.1		1.0		13.0		7.90	J
RM03-CWRP04-C-00	0	Colluvium	35.50700167	-108.16143713	10/8/2014	31,942	10,925	12,200-13,200 / 100-200	- -		7.2		0.018		0.6		2.3		3.0		12.0		1.62	
RM03-CWRP04-R-03	3	Colluvium	35.50700167	-108.16143713	10/8/2014			11,900-12,300 / 110-180	- -		4.4		0.015	J	2.0		18.0		83.0		61.0		39.8	J
RM03-CWRP04-R-08	8	Colluvium	35.50700167	-108.16143713	10/8/2014			12,900-13,800 / 140-180	- -		3.7		0.013		1.8		15.0		71.0		51.0		42.8	J
RM03-CWRP04-S-14	14	Colluvium	35.50700167	-108.16143713	10/8/2014			11,800-12,400 / 80-100	- -		6.5		0.016		0.55		1.6		4.2		11.0		1.82	J
RM03-CWRP05-C-00	0	Colluvium	35.50717090	-108.16254931	10/8/2014	24,347	8,078	10,900-11,300 / 60-80	- -		6.8		0.016	J	1.1		5.0		11	J	14	J	2.27	
RM03-CWRP05-R-02	2	Colluvium	35.50717090	-108.16254931	10/8/2014			10,400-11,000 / 120-180	- -		- -		- -		- -		- -		- -		- -		1,950	J
RM03-CWRP05-R-05	5	Colluvium	35.50717090	-108.16254931	10/8/2014			10,500-10,800 / 80-120	- -		1.4		0.016		0.46		4.4		10.0		10.0		8.7	
RM03-CWRP05-R-10	10	Colluvium	35.50717090	-108.16254931	10/8/2014			10,800-11,200 / 80-110	- -		9.0		0.018		1.5		1.1		0.9		8.7		2.4	J
RM03-CWRP05-S-15	15	Colluvium	35.50717090	-108.16254931	10/8/2014			9,000-10,400 / 60-80	- -		2.6		0.009	U	0.16		0.33		0.14		1.90		0.65	
RM03-CWRP06-C-00	0	Mancos Shale	35.50751233	-108.16297810	10/9/2014	31,320	10,834	12,100-12,600 / 120-180	- -		6.7		0.013		0.56		2.6		1.5		13.0		2.04	
RM03-CWRP06-R-05	5	Mancos Shale	35.50751233	-108.16297810	10/9/2014			13,600-13,800 / 120-180	- -		8.1		0.018		4.8		38.0		110		130		43.0	
RM03-CWRP06-R-10	10	Mancos Shale	35.50751233	-108.16297810	10/9/2014			12,100-12,400 / 100-140	- -		6.4		0.014		3.6		38.0		88.0		110		46.9	J
RM03-CWRP06-S-13	13	Mancos Shale	35.50751233	-108.16297810	10/9/2014			12,700-13,000 / 120-160	- -		2.6		0.012	U	0.98		5.8		6.8		110		10.8	J
RM03-CWRP06-S-18	18	Mancos Shale	35.50751233	-108.16297810	10/9/2014			12,300-12,600 / 80-100	- -		8.1		0.019		0.48		1.3		0.7		19.0		1.66	J
RM03-CWRP07-C-00	0	Mancos Shale	35.50773918	-108.16250762	10/9/2014	14,380	6,044	13,000-13,300 / 60-80	- -		7.2		0.018		0.53		1.9		1.2		13.0		2.23	J
RM03-CWRP07-R-05	5	Mancos Shale	35.50773918	-108.16250762	10/9/2014			11,300-11,500 / 120-160	- -		7.3		0.012		8.2		58.0		130		230		81.2	J
RM03-CWRP07-S-6.5	6.5	Mancos Shale	35.50773918	-108.16250762	10/9/2014			11,700-12,100 / 140-180	- -		5.8		0.011	U	3.0		31.0		56.0		70.0		39.2	J
RM03-CWRP07-S-10	10	Mancos Shale	35.50773918	-108.16250762	10/9/2014			10,500-10,800 / 80-100	- -		4.7		0.013		0.3		0.83		0.60		16.0		1.07	J
RM03-DRN01-00	0	Mancos Shale	35.50852907	-108.16340798	10/7/2014	13,376	4,182	10,800-11,300 / 80-100	- -		13		0.018		1.4		1.2		1.5		8.2		2.35	J
RM03-DRN01-01	1	Mancos Shale	35.50852907	-108.16340798	10/7/2014			9,700-11,100 / 80-110	- -		11		0.029		1.1		1.2		1.4		12.0		1.52	J
RM03-DRN01-05	5	Mancos Shale	35.50852907	-108.16340798	10/7/2014			8,500-9,100 / 60-80	- -		6.7		0.012		1.7		0.93		0.80		13.0		0.83	J

Table A-1. Ruby Mine Site RSE Data

Sample Identification	Top of Sample Interval (feet)	Background Reference Area	Latitude[a]	Longitude[a]	Sample Date	Surface Radiation Readings Uncollimated (cpm)[b]	Collimated (cpm)[c]	Soil Radiation Readings Gamma/Total Core Screening (cpm)[d]	On-Contact Jar (cpm)[e]	RSL or PRG -->	Arsenic (mg/kg)[f] 12.2		Mercury (mg/kg)[6] 11		Molybdenum (mg/kg)[f] 390		Selenium (mg/kg)[f] 390		Uranium (mg/kg)[f] 16		Vanadium (mg/kg)[f] 390		Radium-226 (pCi/g)[f] 2.89	
RM03-DRN02-00	0	Colluvium	35.50678115	-108.16119405	10/7/2014	19,784	5,626	10,900-11,800 / 60-80	- -		6.2		0.01	U	0.53		4.1		6.1		12.0		8.9	
RM03-DRN02-01	1	Colluvium	35.50678115	-108.16119405	10/7/2014			10,500-11,200 / 80-100	- -		6.6		0.021		0.48		2.2		6.3		13.0		6.8	
RM03-DRN02-05	5	Colluvium	35.50678115	-108.16119405	10/7/2014			10,700-11,300 / 60-80	- -		5.7		0.012		0.47		1.3		2.7		12.0		2.8	J
RM03-DRN03-00	0	Mancos Shale	35.50682375	-108.16058633	10/7/2014	16,378	5,635	12,500-13,200 / 60-80	- -		7	J	0.018	J	0.53		6.4		10.0		25.0		10.2	J
RM03-DRN03-01	1	Mancos Shale	35.50682375	-108.16058633	10/7/2014			10,500-11,200 / 80-110	- -		8.7		0.031		0.61		3.5		8.7		25.0		4.6	J
RM03-DRN03-05	5	Mancos Shale	35.50682375	-108.16058633	10/7/2014			10,600-11,300 / 80-110	- -		7		0.011		0.46		0.98		1.60		9.60		1.11	J
RM03-DWTR01-00	0	Mancos Shale	35.50725973	-108.16412418	10/7/2014	15,978	4,745	11,100-11,600 / 80-100	- -		9.4		0.033		0.53		1.7		2.2		20.0		2.58	J
RM03-DWTR01-01	1	Mancos Shale	35.50725973	-108.16412418	10/7/2014			11,700-12,500 / 80-100	- -		6.9		0.017		0.77		2.4		3.0		18.0		11.90	J
RM03-DWTR01-05	5	Mancos Shale	35.50725973	-108.16412418	10/7/2014			11,600-12,100 / 100-110	- -		6.6		0.015		0.5		2.4		2.8		17.0		4.39	J
RM03-DWTR02-00	0	Mancos Shale	35.50722708	-108.16350647	10/7/2014	24,524	8,178	13,200-13,700 / 80-100	- -		7		0.013		1.1		5.3		12.0		23.0		6.69	J
RM03-DWTR02-01	1	Mancos Shale	35.50722708	-108.16350647	10/7/2014			13,200-14,200 / 100-160	- -		7.9		0.019		3.9		35.0		77.0		110		51.6	J
RM03-DWTR02-05	5	Mancos Shale	35.50722708	-108.16350647	10/7/2014			14,800-16,200 / 160-180	- -		11		0.043		2.2		69.0		110		200		75.4	J
RM03-DWTR02-6.5	6.5	Mancos Shale	35.50722708	-108.16350647	10/7/2014			11,600-13,000 / 160-200	- -		8		0.023		1.1		5.0		23.0		26.0		32.0	J
RM03-DWTR03-00	0	Mancos Shale	35.50723849	-108.16335532	10/7/2014	41,483	14,453	14,200-15,800 / 100-120	- -		11		0.018		4.7		46.0		85.0		130		50.7	J
RM03-DWTR03-01	1	Mancos Shale	35.50723849	-108.16335532	10/7/2014			13,800-14,400 / 150-220	- -		11		0.017		3.5		25.0		66.0		100		40.3	J
RM03-DWTR03-05	5	Mancos Shale	35.50723849	-108.16335532	10/7/2014			12,700-14,000 / 250-300	- -		9.1		0.024		4.6		24.0		86.0		77.0		47.0	J
RM03-DWTR03-10	10	Mancos Shale	35.50723849	-108.16335532	10/7/2014			12,400-12,900 / 80-100	- -		8.4		0.013		1.1		1.4		1.3		20.0		1.39	J
RM03-WRK01-00	0	Mancos Shale	35.50680650	-108.16339085	10/8/2014	15,295	4,815	10,000-10,200 / 60-80	- -		6.6		0.015		0.48		2.1		1.4		18.0		2.7	J
RM03-WRK01-01	1	Mancos Shale	35.50680650	-108.16339085	10/8/2014			10,200-10,600 / 100-120	- -		8.5		0.018		2.6		13.0		51.0		53.0		12.3	J
RM03-WRK01-05	5	Mancos Shale	35.50680650	-108.16339085	10/8/2014			9,800-10,100 / 80-110	- -		6.3		0.012		0.42		0.98		0.83		13.00		1.38	J
RM03-WRK02-00	0	Mancos Shale	35.50659736	-108.16404576	10/8/2014	14,067	4,247	10,200-10,400 / 60-80	- -		6		0.014		0.43		1.8		1.9		13.0		2.66	J
RM03-WRK02-01	1	Mancos Shale	35.50659736	-108.16404576	10/8/2014			9,900-10,000 / 60-80	- -		8.2		0.025		0.50		0.95		0.66		15.0		1.29	J
RM03-WRK02-05	5	Mancos Shale	35.50659736	-108.16404576	10/8/2014			9,800-10,100 / 80-110	- -		3.4		0.0098	U	0.2		0.9		1.1		21.0		1.49	
RM03-WRK03-00	0	Mancos Shale	35.50634705	-108.16392051	10/8/2014	24,140	8,430	10,800-11,500 / 60-80	- -		6		0.014		0.76		11.0		9.2		31.0		20.0	
RM03-WRK03-01	1	Mancos Shale	35.50634705	-108.16392051	10/8/2014			10,800-11,200 / 60-100	- -		6.2		0.023		0.63		1.4		13.0		17.0		1.35	
RM03-WRK03-05	5	Mancos Shale	35.50634705	-108.16392051	10/8/2014			11,100-11,300 / 80-110	- -		1.9		0.011	U	0.45		0.77		0.77		10.0		0.88	
RM03-WRK04-00	0	Mancos Shale	35.50628205	-108.16448069	10/8/2014	104,266	40,982	104,266 / - -	- -		10		0.067		3.1		140		440		260		590	
RM03-WRK04-01	1	Mancos Shale	35.50628205	-108.16448069	10/8/2014			12,400-15,100 / 220-380	- -		4.3	J	0.0098	U	6.3		1.8		130	J	11.0		1.74	
RM03-WRK04-04	4	Mancos Shale	35.50628205	-108.16448069	10/8/2014			12,100-12,400 / 80-100	- -		8.2		0.017	J	0.52		1.2		1.1		24.0		1.62	
RM04-VENT01-00	0	Mancos Shale	35.5067822	-108.2055966	10/7/2014	13,279	4,256	see surface reading	- -		8.9		0.015		0.56		1.0		1.4		9.0		1.1	J
RM04-VENT01-01	1	Mancos Shale	35.5067822	-108.2055966	10/7/2014			11,081 / - -	- -		9.1		0.014		0.58		1.0		0.9		8.6		1.15	J
RM04-VENT02-00	0	Mancos Shale	35.5068450	-108.2055350	10/7/2014	23,252	8,397	see surface reading	- -		9.6		0.012		0.85		3.8		11.0		12.0		6.38	J
RM04-VENT02-01	1	Mancos Shale	35.5068450	-108.2055350	10/7/2014			11,117 / - -	- -		8.7		0.014		0.54		1.1		2.1		11.0		2.38	J
RM04-VENT03-00	0	Mancos Shale	35.5068284	-108.2054093	10/6/2014	97,183	43,463	see surface reading	- -		9.8		0.016		1.4		600		350		130		111	
RM04-VENT03-02	2	Mancos Shale	35.5068284	-108.2054093	10/6/2014			11,327 / - -	- -		9.6		0.016		1.1		81.0		56.0		25.0		24.3	
RM19-VENT01-00	0	Colluvium	35.5151521	-108.2251507	10/11/2014	12,716	3,889	see surface reading	- -		7.7		0.02		0.6		0.86		1.10		15.00		1.37	J
RM19-VENT01-01	1	Colluvium	35.5151521	-108.2251507	10/11/2014			11,327 / - -	- -		8.5		0.017		0.55		1.0		0.73		13.0		1.19	J
RM19-VENT02-00	0	Colluvium	35.5150691	-108.2250925	10/11/2014	77,944	31,787	see surface reading	- -		7.3		0.033		1.3		130		100		210		107	J
RM19-VENT02-01	1	Colluvium	35.5150691	-108.2250925	10/11/2014			13,000 / - -	- -		9.5		0.016		0.8		5.0		76.0		20.0		8.40	J
RM19-VENT03-00	0	Colluvium	35.5149550	-108.2251007	10/11/2014	33,329	12,254	see surface reading	- -		7.6		0.024		1.2		40.0		34.0		89.0		32.2	J
RM19-VENT03-01	1	Colluvium	35.5149550	-108.2251007	10/11/2014			13,000 / - -	- -		8.7		0.015		0.7		4.1		7.5		21.0		4.24	J
RM01-8MAY14-01	0	Dakota	35.5185001	-108.2220700	5/8/2014	38,876	11,774	see surface reading	11,776		NS		NS		NS		NS		NS		NS		143	
RM01-8MAY14-02	0	Dakota	35.5184085	-108.2221653	5/8/2014	79,193	35,235	see surface reading	14,687		NS		NS		NS		NS		NS		NS		299	
RM01-8MAY14-03	0	Colluvium	35.5198176	-108.2244555	5/8/2014	19,947	5,787	see surface reading	9,558		NS		NS		NS		NS		NS		NS		5.73	J
RM01-8MAY14-04	0	Colluvium	35.5204376	-108.2224782	5/8/2014	34,094	10,226	see surface reading	9,304		NS		NS		NS		NS		NS		NS		17.3	J
RM01-8MAY14-05	0	Colluvium	35.5205569	-108.2224392	5/8/2014	122,269	91,084	see surface reading	43,536		NS		NS		NS		NS		NS		NS		1,330	
RM01-8MAY14-06	0	Colluvium	35.5224196	-108.2241946	5/8/2014	26,512	8,423	see surface reading	10,331		NS		NS		NS		NS		NS		NS		15.8	J
RM01-8MAY14-07	0	Colluvium	35.5224421	-108.2240677	5/8/2014	268,857	112,974	see surface reading	40,655		NS		NS		NS		NS		NS		NS		1,440	
RM01-8MAY14-08	0	Colluvium	35.5227091	-108.2250849	5/8/2014	13,094	3,889	see surface reading	10,708		NS		NS		NS		NS		NS		NS		2.77	
RM03-8MAY14-01	0	Mancos Shale	35.5063502	-108.1647186	5/8/2014	12,877	3,804	see surface reading	8,508		NS		NS		NS		NS		NS		NS		1.19	
RM03-8MAY14-02	0	Mancos Shale	35.5067222	-108.1637377	5/8/2014	23,023	7,488	see surface reading	8,260		NS		NS		NS		NS		NS		NS		4.17	J
RM03-8MAY14-03	0	Mancos Shale	35.5071681	-108.1639460	5/8/2014	17,167	5,116	see surface reading	8,394		NS		NS		NS		NS		NS		NS		3.27	J
RM03-8MAY14-04	0	Mancos Shale	35.5064281	-108.1645422	5/8/2014	38,876	11,774	see surface reading	11,301		NS		NS		NS		NS		NS		NS		141	
RM03-8MAY14-05	0	Colluvium	35.5085730	-108.1623570	5/8/2014	30,597	10,838	see surface reading	7,956		NS		NS		NS		NS		NS		NS		3.27	J
RM03-8MAY14-06	0	Mancos Shale	35.5077736	-108.1615589	5/8/2014	47,897	18,852	see surface reading	9,320		NS		NS		NS		NS		NS		NS		220	J
RM03-8MAY14-07	0	Mancos Shale	35.5065111	-108.1640419	5/8/2014	109,898	41,707	see surface reading	28,208		NS		NS		NS		NS		NS		NS		1,000	
RM03-8MAY14-08	0	Mancos Shale	35.5062005	-108.1636982	5/8/2014	171,019	89,326	see surface reading	16,798		NS		NS		NS		NS		NS		NS		391	
RM03-8MAY14-09[g]	0	Colluvium	35.5073561	-108.1624775	5/8/2014	Max Meter[f] >999,999	313,782	see surface reading	44,070		NS		NS		NS		NS		NS		NS		1,240	J
RM-COR18-00	0	Colluvium	35.5197178	-108.2215697	10/8/2014	20,411	5,990	see surface reading	8,417		NS		NS		NS		NS		NS		NS		4.14	
RM-COR19-00	0	Colluvium	35.5204134	-108.2231135	10/8/2014	16,546	5,052	see surface reading	8,824		NS		NS		NS		NS		NS		NS		2.56	
RM-COR20-00	0	Colluvium	35.5198719	-108.2237010	10/8/2014	18,114	5,439	see surface reading	8,838		NS		NS		NS		NS		NS		NS		7.7	J
RM-COR21-00	0	Colluvium	35.5202168	-108.2218508	10/8/2014	17,964	5,074	see surface reading	8,400		NS		NS		NS		NS		NS		NS		4.03	J
RM-COR22-00	0	Mancos Shale	35.5188262	-108.2236257	10/8/2014	16,809	5,116	see surface reading	8,012		NS		NS		NS		NS		NS		NS		1.49	J
RM-COR23-00	0	Mancos Shale	35.5190879	-108.2217875	10/8/2014	20,456	6,117	see surface reading	8,319		NS		NS		NS		NS		NS		NS		5.77	J
RM-COR24-00	0	Mancos Shale	35.5067382	-108.1637461	10/8/2014	15,050	4,467	see surface reading	10,011		NS		NS		NS		NS		NS		NS		1.54	J

Table A-1. Ruby Mine Site RSE Data

Sample Identification	Top of Sample Interval (feet)	Background Reference Area	Latitude[a]	Longitude[a]	Sample Date	Surface Radiation Readings Uncollimated (cpm)[b]	Surface Radiation Readings Collimated (cpm)[c]	Soil Radiation Readings Gamma/Total Core Screening (cpm)[d]	On-Contact Jar (cpm)[e]	RSL or PRG -->	Arsenic (mg/kg)[f] 12.2	Mercury (mg/kg)[6] 11	Molybdenum (mg/kg)[f] 390	Selenium (mg/kg)[f] 390	Uranium (mg/kg)[f] 16	Vanadium (mg/kg)[f] 390	Radium-226 (pCi/g)[f] 2.89	
RM-COR25-00	0	Mancos Shale	35.5073522	-108.1637772	10/7/2014	17,355	5,326	see surface reading	11,625		NS	NS	NS	NS	NS	NS	2.13	J
RM-COR26-00	0	Colluvium	35.5084014	-108.1627698	10/8/2014	15,753	5,081	see surface reading	11,071		NS	NS	NS	NS	NS	NS	1.7	J
RM-COR27-00	0	Mancos Shale	35.5067331	-108.1607533	10/7/2014	13,996	3,505	see surface reading	12,319		NS	NS	NS	NS	NS	NS	1.38	J
RM-COR28-00	0	Mancos Shale	35.5074210	-108.1615060	10/7/2014	17,957	4,808	see surface reading	10,129		NS	NS	NS	NS	NS	NS	1.99	J
RM-COR29-00	0	Colluvium	35.5070483	-108.1630800	10/8/2014	18,719	5,456	see surface reading	10,559		NS	NS	NS	NS	NS	NS	3.34	J
RM-COR30-00	0	Mancos Shale	35.5073266	-108.1638812	10/7/2014	15,436	4,839	see surface reading	11,152		NS	NS	NS	NS	NS	NS	2.9	J
RM-COR31-00	0	Mancos Shale	35.5072085	-108.1636579	10/7/2014	17,341	4,884	see surface reading	11,914		NS	NS	NS	NS	NS	NS	3.42	J
RM-COR32-00	0	Mancos Shale	35.5071929	-108.1635577	10/7/2014	19,368	5,633	see surface reading	11,735		NS	NS	NS	NS	NS	NS	6.71	J
RM-COR33-00	0	Colluvium	35.5069660	-108.1633435	10/8/2014	20,175	6,084	see surface reading	10,196		NS	NS	NS	NS	NS	NS	3.01	
RM-COR34-00	0	Colluvium	35.5069288	-108.1635919	10/8/2014	17,119	4,937	see surface reading	10,459		NS	NS	NS	NS	NS	NS	1.95	J
RM-COR35-00	0	Mancos Shale	35.5068007	-108.1638891	10/8/2014	15,485	4,998	see surface reading	10,191		NS	NS	NS	NS	NS	NS	1.5	J
RM-COR36-00	0	Mancos Shale	35.5065530	-108.1636489	10/8/2014	20,280	6,344	see surface reading	10,159		NS	NS	NS	NS	NS	NS	6.23	J
RM-COR37-00	0	Mancos Shale	35.5060939	-108.1635526	10/8/2014	16,561	5,087	see surface reading	10,207		NS	NS	NS	NS	NS	NS	7.5	J
RM-COR38-00	0	Mancos Shale	35.5063058	-108.1643131	10/8/2014	18,409	5,955	see surface reading	10,242		NS	NS	NS	NS	NS	NS	8.8	J
RM-COR39-00	0	Mancos Shale	35.5072812	-108.1636952	10/7/2014	18,845	5,761	see surface reading	10,682		NS	NS	NS	NS	NS	NS	3.19	J
RM-COR40-00	0	Mancos Shale	35.5065268	-108.1598311	10/7/2014	14,482	4,310	see surface reading	11,173		NS	NS	NS	NS	NS	NS	1.82	J
RM-COR41-00	0	Colluvium	35.5205561	-108.2228955	10/8/2014	21,636	6,839	see surface reading	8,566		NS	NS	NS	NS	NS	NS	9.3	
RM-COR42-00	0	Colluvium	35.5204892	-108.2229318	10/8/2014	24,359	7,575	see surface reading	8,677		NS	NS	NS	NS	NS	NS	19.2	
RM-COR43-00	0	Colluvium	35.5203480	-108.2229117	10/8/2014	19,182	5,721	see surface reading	8,813		NS	NS	NS	NS	NS	NS	1.7	J
RM-COR44-00	0	Colluvium	35.5225850	-108.2249219	10/8/2014	13,437	4,292	see surface reading	8,252		NS	NS	NS	NS	NS	NS	1.5	J
RM-COR45-00	0	Colluvium	35.5197664	-108.2241976	10/8/2014	20,154	5,935	see surface reading	8,366		NS	NS	NS	NS	NS	NS	7.9	J
RM-COR46-00	0	Mancos Shale	35.5189433	-108.2225523	10/8/2014	20,369	6,292	see surface reading	8,309		NS	NS	NS	NS	NS	NS	5.57	J
RM-COR47-00	0	Colluvium	35.5192561	-108.2217416	10/8/2014	18,008	5,171	see surface reading	8,259		NS	NS	NS	NS	NS	NS	3.38	

[a] Location coordinates are in geographic coordinate system WGS 84, decimal degrees. West longitudes are designated as negative.

[b] Gamma radiation measurement from uncollimated 1 minute static reading from Ludlum 2221 2x2 NaI detector at 6 inches above ground prior to collection.

[c] Gamma radiation measurement from collimated 1 minute static reading from Ludlum 2221 2x2 NaI detector at 6 inches above ground prior to collection.

[d] Gamma radiation measurements from uncollimated screening reading with Ludlum 2221 2x2 NaI detector/Total radiation measurements with a Geiger Muller Ludlum 44-9 detector above core or sample prior to collection.

[e] Gamma radiation measurement from uncollimated 1 minute static reading from Ludlum 2221 2x2 NaI detector on contact from sample jar (ambient air ~9,000 counts per minute).

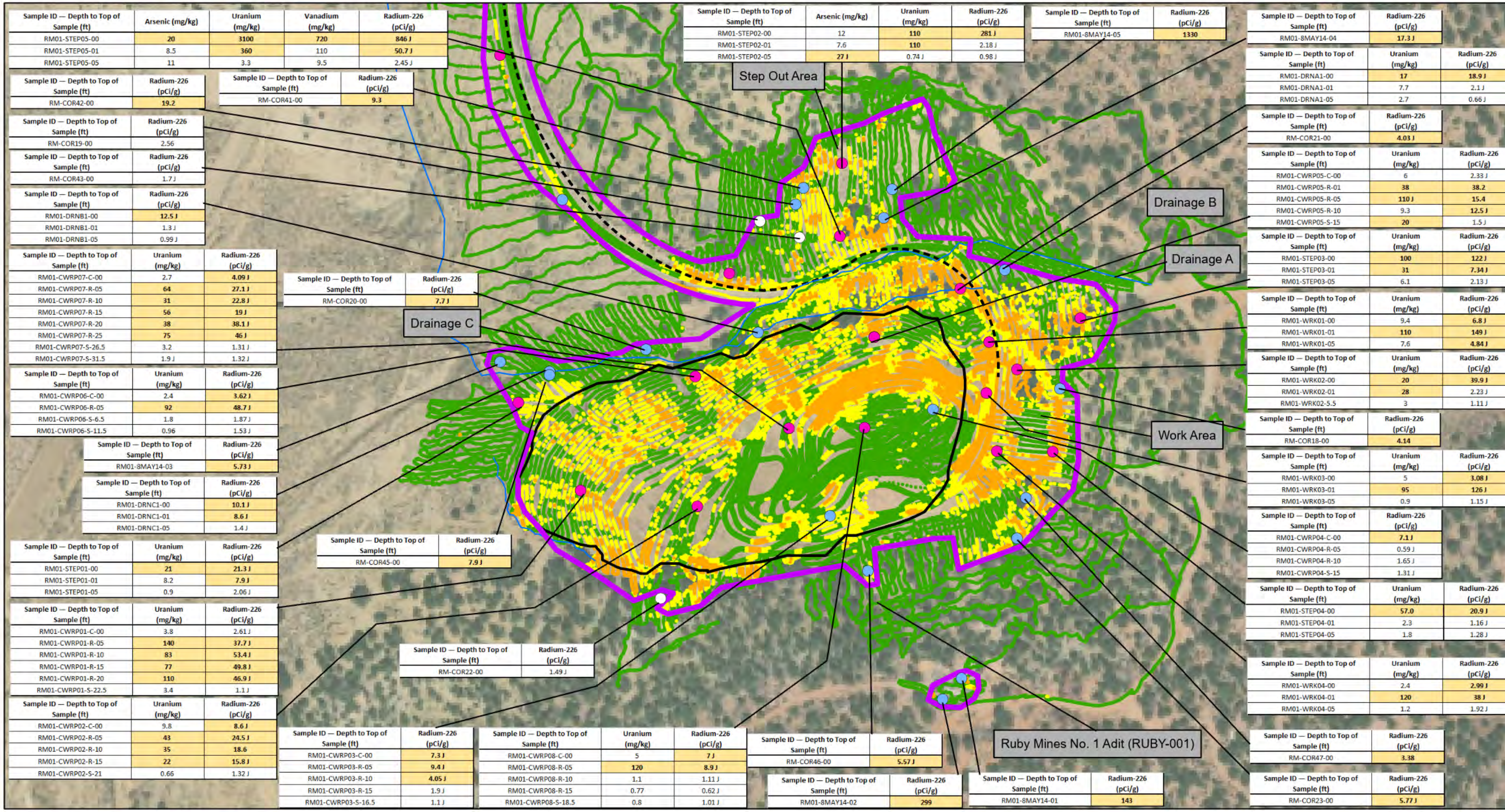
[f] Laboratory analytical method SW846 6020 was used to analyze samples for metals arsenic, molybdenum, selenium, uranium, and vanadium. Method SW846 7471A was used for mercury analysis. Method EPA 901.1 was used for radium-226 analysis.

[g] Sample from cap material is not applicable for correlation of radium-226 with detector readings because the material could be waste rock, not mine affected soil. The data is provided for information only.

Notes:

- - = Not analyzed
Bold Grey Data = Analytical detections exceeding the RSL or PRG
COPC = constituent(s) of potential concern
cpm = counts per minute
EPA = U.S. Environmental Protection Agency mg/kg = milligrams per kilogram
J = Estimated. This qualifier indicates that the analyte was detected, but should be considered estimated.
NaI = sodium iodide

NS = not sampled
pCi/g = picocurie(s) per gram
PRG = Preliminary Remediation Goal
RSL = USEPA Regional Screening Levels are based on a Hazard Quotient of 1.0 and a residential exposure scenario
U = The analyte was not detected above the indicated method detection limit.
UJ = The analyte was not detected above the indicated estimated method detection limit.



Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP05-00	20	3100	720	846 J
RM01-STEP05-01	8.5	360	110	50.7 J
RM01-STEP05-05	11	3.3	9.5	2.45 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR42-00	19.2

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR41-00	9.3

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR19-00	2.56

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR43-00	1.7 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-DRNB1-00	12.5 J
RM01-DRNB1-01	1.3 J
RM01-DRNB1-05	0.99 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP07-C-00	2.7	4.09 J
RM01-CWRP07-R-05	64	27.1 J
RM01-CWRP07-R-10	31	22.8 J
RM01-CWRP07-R-15	56	19 J
RM01-CWRP07-R-20	38	38.1 J
RM01-CWRP07-R-25	75	46 J
RM01-CWRP07-S-26.5	3.2	1.31 J
RM01-CWRP07-S-31.5	1.9 J	1.32 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR20-00	7.7 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP06-C-00	2.4	3.62 J
RM01-CWRP06-R-05	92	48.7 J
RM01-CWRP06-S-6.5	1.8	1.87 J
RM01-CWRP06-S-11.5	0.96	1.53 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-03	5.73 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-DRNC1-00	10.1 J
RM01-DRNC1-01	8.6 J
RM01-DRNC1-05	1.4 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP01-00	21	21.3 J
RM01-STEP01-01	8.2	7.9 J
RM01-STEP01-05	0.9	2.06 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR45-00	7.9 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP01-C-00	3.8	2.61 J
RM01-CWRP01-R-05	140	37.7 J
RM01-CWRP01-R-10	83	53.4 J
RM01-CWRP01-R-15	77	49.8 J
RM01-CWRP01-R-20	110	46.9 J
RM01-CWRP01-S-22.5	3.4	1.1 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR22-00	1.49 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP02-C-00	9.8	8.6 J
RM01-CWRP02-R-05	43	24.5 J
RM01-CWRP02-R-10	35	18.6
RM01-CWRP02-R-15	22	15.8 J
RM01-CWRP02-S-21	0.66	1.32 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-CWRP03-C-00	7.3 J
RM01-CWRP03-R-05	9.4 J
RM01-CWRP03-R-10	4.05 J
RM01-CWRP03-R-15	1.9 J
RM01-CWRP03-S-16.5	1.1 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP08-C-00	5	7 J
RM01-CWRP08-R-05	120	8.9 J
RM01-CWRP08-R-10	1.1	1.11 J
RM01-CWRP08-R-15	0.77	0.62 J
RM01-CWRP08-S-18.5	0.8	1.01 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR46-00	5.57 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-02	299

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-01	143

Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP02-00	12	110	281 J
RM01-STEP02-01	7.6	110	2.18 J
RM01-STEP02-05	27 J	0.74 J	0.98 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-05	1330

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-04	17.3 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-DRNA1-00	17	18.9 J
RM01-DRNA1-01	7.7	2.1 J
RM01-DRNA1-05	2.7	0.66 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR21-00	4.03 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-CWRP05-C-00	6	2.33 J
RM01-CWRP05-R-01	38	38.2
RM01-CWRP05-R-05	110 J	15.4
RM01-CWRP05-R-10	9.3	12.5 J
RM01-CWRP05-S-15	20	1.5 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP03-00	100	122 J
RM01-STEP03-01	31	7.34 J
RM01-STEP03-05	6.1	2.13 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK01-00	9.4	6.8 J
RM01-WRK01-01	110	149 J
RM01-WRK01-05	7.6	4.84 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK02-00	20	39.9 J
RM01-WRK02-01	28	2.23 J
RM01-WRK02-5.5	3	1.11 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR18-00	4.14

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK03-00	5	3.08 J
RM01-WRK03-01	95	126 J
RM01-WRK03-05	0.9	1.15 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-CWRP04-C-00	7.1 J
RM01-CWRP04-R-05	0.59 J
RM01-CWRP04-R-10	1.65 J
RM01-CWRP04-S-15	1.31 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-STEP04-00	57.0	20.9 J
RM01-STEP04-01	2.3	1.16 J
RM01-STEP04-05	1.8	1.28 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-WRK04-00	2.4	2.99 J
RM01-WRK04-01	120	38 J
RM01-WRK04-05	1.2	1.92 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR47-00	3.38

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR23-00	5.77 J

LEGEND

- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- TENORM

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Notes:
1. Concentrations that are highlighted yellow exceed the preliminary remediation goal for Ra-226 (2.89 pCi/g) and Metals (BTV or RSL).
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-001	RESIDENCES RUBY-021 RUBY-002 EXPLORATORY BOREHOLES	RUBY-019 RUBY-018 CAPPED WASTE ROCK PILE DRAINAGES FORMER HAUL ROAD WORK AREA STEP OUT AREA
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

N

0 75 150 300
Feet
1:1,800 1 inch = 150 feet

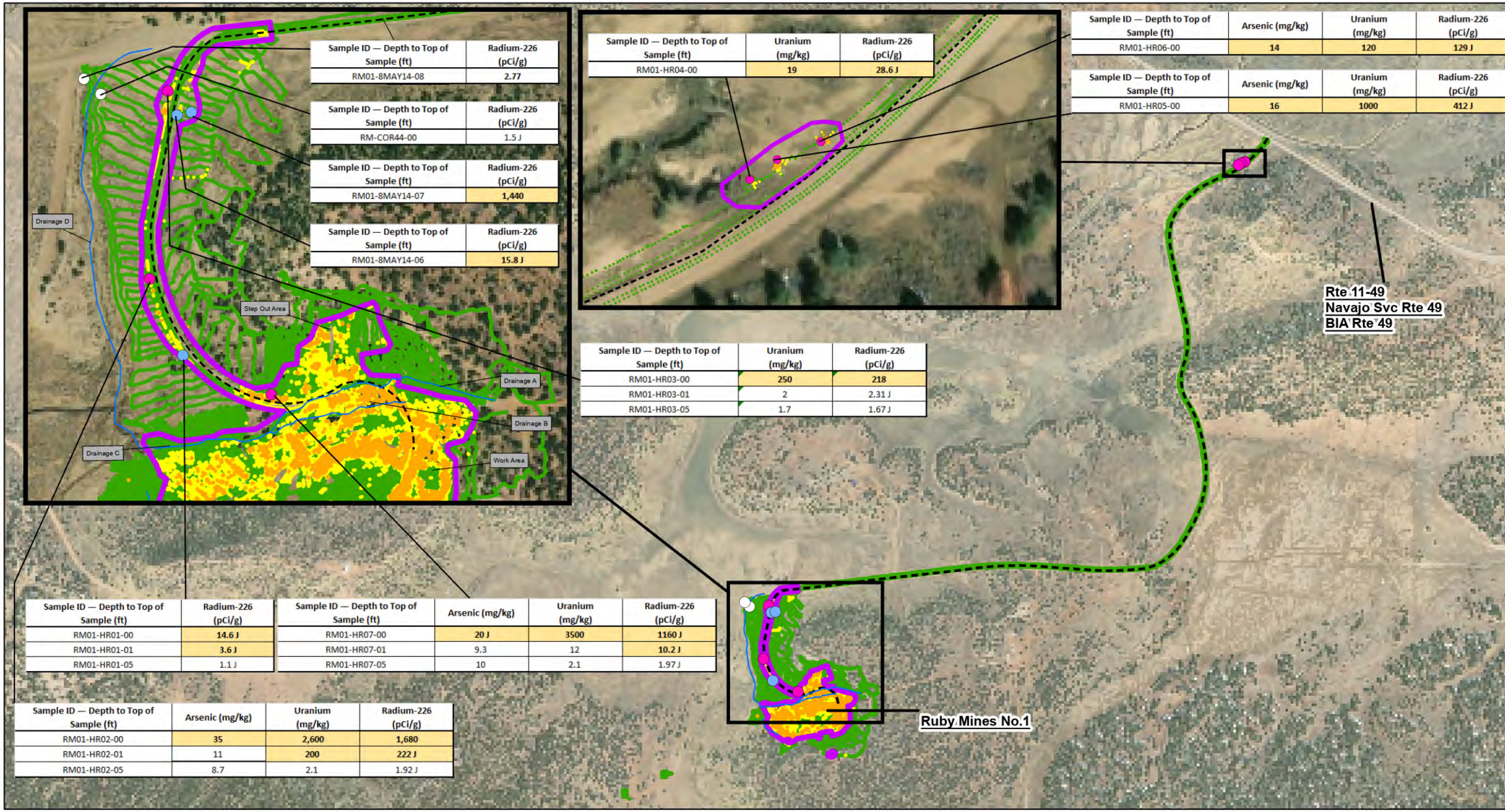
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure A-1. Ruby Mines No. 1 Radium-226 Results in Soil and Gamma Radiation Survey

Engineering Evaluation and Cost Analysis

Ruby Mines

Jacobs



Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-08	2.77

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR44-00	1.5 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-07	1,440

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-8MAY14-06	15.8 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR04-00	19	28.6 J

Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR06-00	14	120	129 J

Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR05-00	16	1000	412 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR03-00	250	218
RM01-HR03-01	2	2.31 J
RM01-HR03-05	1.7	1.67 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM01-HR01-00	14.6 J
RM01-HR01-01	3.6 J
RM01-HR01-05	1.1 J

Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR07-00	20 J	3500	1160 J
RM01-HR07-01	9.3	12	10.2 J
RM01-HR07-05	10	2.1	1.97 J

Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM01-HR02-00	35	2,600	1,680
RM01-HR02-01	11	200	222 J
RM01-HR02-05	8.7	2.1	1.92 J

LEGEND
- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- TENORM
- Former Haul Road
- Drainage

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Notes:
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> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

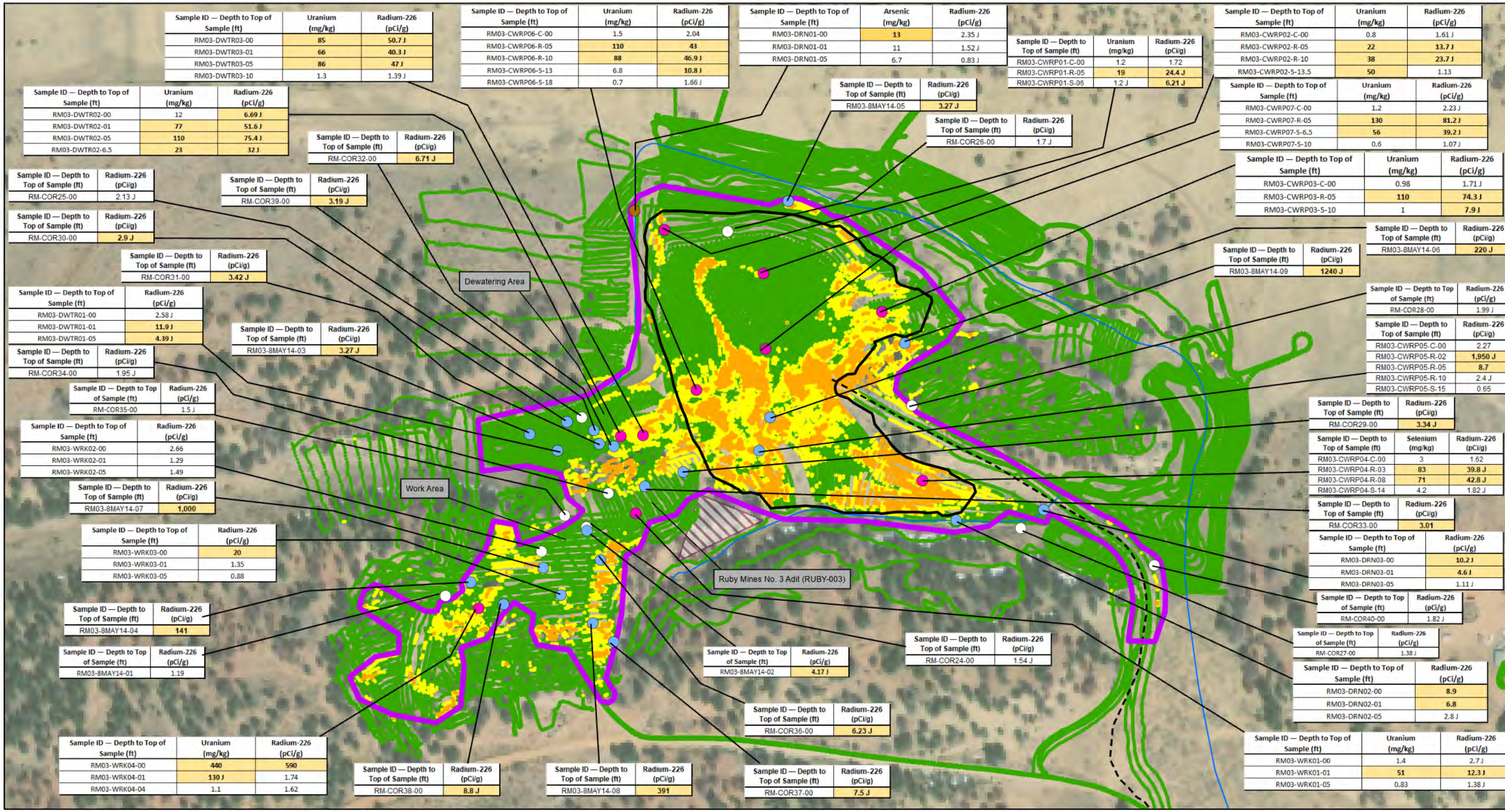
GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-001	RESIDENCES RUBY-021 RUBY-002 EXPLORATORY BOREHOLES	RUBY-019 RUBY-018 CAPPED WASTE ROCK PILE DRAINAGES FORMER HAUL ROAD WORK AREA STEP OUT AREA
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

N

0 500 1,000 2,000
Feet
1:12,000 1 inch = 1,000 feet
Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure A-2. Ruby Mines No. 1 - Former Haul Road Radium-226 Results in Soil
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs



Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-DWTR03-00	85	50.7 J
RM03-DWTR03-01	66	40.3 J
RM03-DWTR03-05	86	47 J
RM03-DWTR03-10	1.3	1.39 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP06-C-00	1.5	2.04
RM03-CWRP06-R-05	110	43
RM03-CWRP06-R-10	88	46.9 J
RM03-CWRP06-S-13	6.8	10.8 J
RM03-CWRP06-S-18	0.7	1.66 J

Sample ID — Depth to Top of Sample (ft)	Arsenic (mg/kg)	Radium-226 (pCi/g)
RM03-DRN01-00	13	2.35 J
RM03-DRN01-01	11	1.52 J
RM03-DRN01-05	6.7	0.83 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP01-C-00	1.2	1.72
RM03-CWRP01-R-05	19	24.4 J
RM03-CWRP01-S-06	1.2 J	6.21 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP02-C-00	0.8	1.61 J
RM03-CWRP02-R-05	22	13.7 J
RM03-CWRP02-R-10	38	23.7 J
RM03-CWRP02-S-13.5	50	1.13

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-DWTR02-00	12	6.69 J
RM03-DWTR02-01	77	51.6 J
RM03-DWTR02-05	110	75.4 J
RM03-DWTR02-6.5	23	32 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-05	3.27 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR26-00	1.7 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP07-C-00	1.2	2.23 J
RM03-CWRP07-R-05	130	81.2 J
RM03-CWRP07-S-6.5	56	39.2 J
RM03-CWRP07-S-10	0.6	1.07 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR32-00	6.71 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP03-C-00	0.98	1.71 J
RM03-CWRP03-R-05	110	74.3 J
RM03-CWRP03-S-10	1	7.9 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR25-00	2.13 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR39-00	3.19 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR30-00	2.9 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-06	220 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-09	1240 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR31-00	3.42 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-DWTR01-00	2.58 J
RM03-DWTR01-01	11.9 J
RM03-DWTR01-05	4.39 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR28-00	1.99 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-03	3.27 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-CWRP05-C-00	2.27
RM03-CWRP05-R-02	1,950 J
RM03-CWRP05-R-05	8.7
RM03-CWRP05-R-10	2.4 J
RM03-CWRP05-S-15	0.65

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR34-00	1.95 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR35-00	1.5 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR29-00	3.34 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-WRK02-00	2.66
RM03-WRK02-01	1.29
RM03-WRK02-05	1.49

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Radium-226 (pCi/g)
RM03-CWRP04-C-00	3	1.62
RM03-CWRP04-R-03	83	39.8 J
RM03-CWRP04-R-08	71	42.8 J
RM03-CWRP04-S-14	4.2	1.82 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-07	1,000

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR33-00	3.01

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-WRK03-00	20
RM03-WRK03-01	1.35
RM03-WRK03-05	0.88

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-DRN03-00	10.2 J
RM03-DRN03-01	4.6 J
RM03-DRN03-05	1.11 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-04	141

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR40-00	1.82 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-01	1.19

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-02	4.17 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR24-00	1.54 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR27-00	1.38 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-DRN02-00	8.9
RM03-DRN02-01	6.8
RM03-DRN02-05	2.8 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR36-00	6.23 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-WRK01-00	1.4	2.7 J
RM03-WRK01-01	51	12.3 J
RM03-WRK01-05	0.83	1.38 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM03-WRK04-00	440	590
RM03-WRK04-01	130 J	1.74
RM03-WRK04-04	1.1	1.62

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR38-00	8.8 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM03-8MAY14-08	391

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM-COR37-00	7.5 J

LEGEND

- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- Metals exceedance
- TENORM
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Restricted Area

Notes:
1. Concentrations that are highlighted yellow exceed the preliminary remediation goal for Ra-226 (2.89 pCi/g) and Metals (BTV or RSL).
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-003 CAPPED WASTE ROCK PILE DEWATERING AREA WORK AREA FORMER HAUL ROAD RESIDENCE RUBY-017 RUBY-020	NONE	DRAINAGES
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

N

0 100 200 400
Feet

1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure A-3. Ruby Mines No. 3
Radium-226 Results in Surface Soil
Engineering Evaluation and Cost Analysis
Ruby Mines

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Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM19-VENT01-00	1.37 J
RM19-VENT01-01	1.19 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM19-VENT02-00	100	107 J
RM19-VENT02-01	76	8.4 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM19-VENT03-00	34	32.2 J
RM19-VENT03-01	7.5	4.24 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM02-VENT02-00	55	5.69 J
RM02-VENT02-01	48	1.36 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM02-VENT01-00	1.39 J
RM02-VENT01-01	0.94 J

Sample ID — Depth to Top of Sample (ft)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM02-VENT03-00	230	159 J
RM02-VENT03-01	110	10.3 J

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM04-VENT02-00	6.38 J
RM04-VENT02-01	2.38 J

Sample ID — Depth to Top of Sample (ft)	Selenium (mg/kg)	Uranium (mg/kg)	Radium-226 (pCi/g)
RM04-VENT03-00	600	350	111
RM04-VENT03-02	81	56	24.3

Sample ID — Depth to Top of Sample (ft)	Radium-226 (pCi/g)
RM04-VENT01-00	1.1 J
RM04-VENT01-01	1.15 J

LEGEND

- > 3x Background
- 2x Background - 3x Background
- < 2x Background
- No exceedance
- Ra-226 and Metals exceedance
- Ra-226 exceedance
- TENORM

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Notes:
1. Concentrations that are highlighted yellow exceed the preliminary remediation goal for Ra-226 (2.89 pCi/g) and Metals (BTV or RSL).
> = greater than
< = less than
BTV = background threshold value
CPM = counts per minute
J = Analyte was detected, but the given concentration should be considered estimated.
mg/kg = milligrams per kilogram
pCi/g = picocuries per gram
PRG = preliminary remediation goal
Ra = Radium
RSL = regional screening level
TENORM = Technologically-Enhanced Naturally-Occurring Radioactive Material

GEOLOGY	MANCOS SHALE	DAKOTA SANDSTONE	COLLUVIUM
FEATURE	RUBY-001	RESIDENCES RUBY-021 RUBY-002 EXPLORATORY BOREHOLES	RUBY-019 RUBY-018 CAPPED WASTE ROCK PILE DRAINAGES FORMER HAUL ROAD WORK AREA STEP OUT AREA
< 2X	< 23892	< 20636 CPM	< 24808 CPM
2 - 3	23892 - 35838 CPM	20636 - 30954 CPM	24808 - 37212 CPM
> 3X	> 35838	> 30954 CPM	> 37212

N

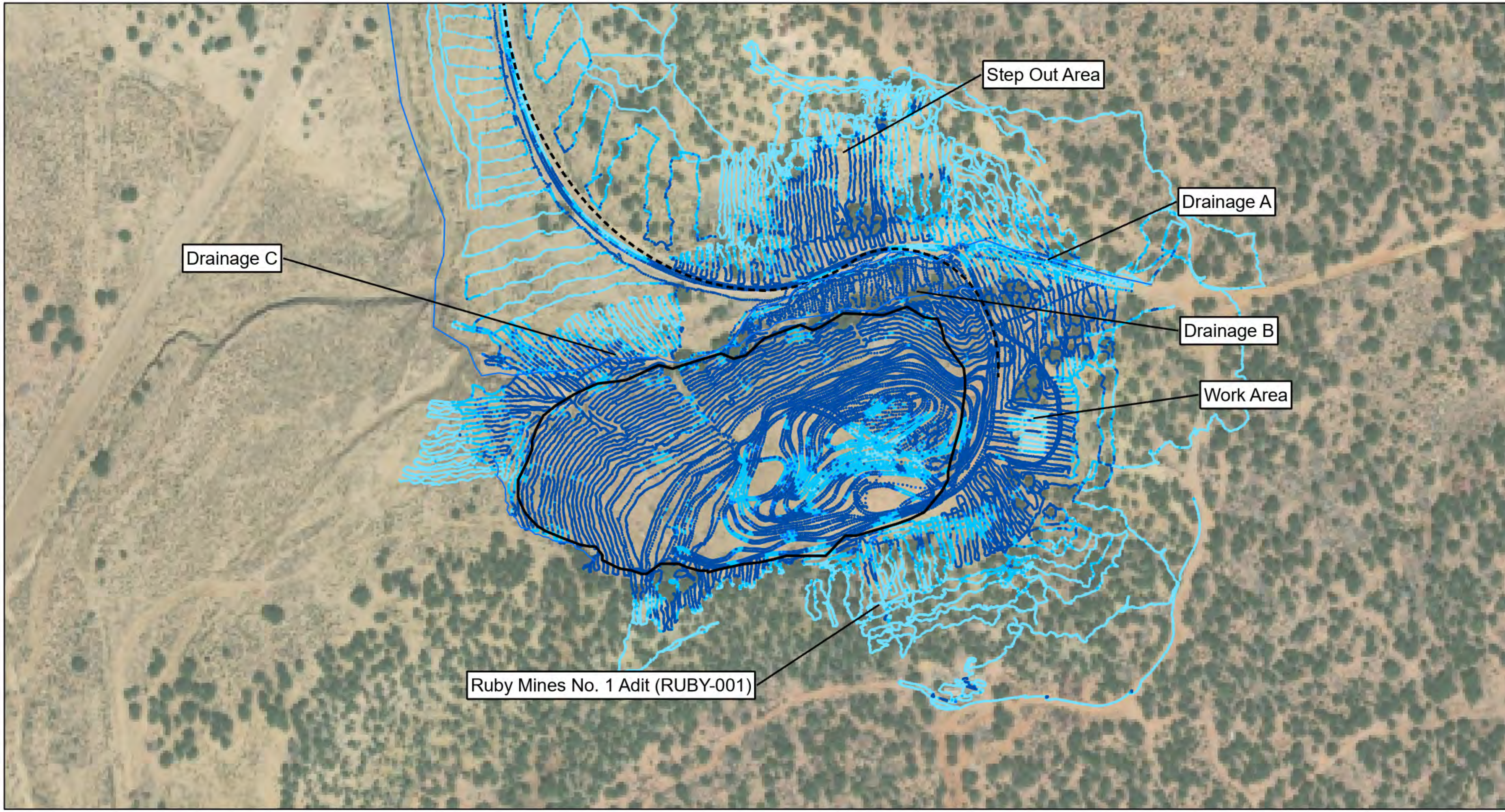
0 350 700 1,400
Feet

1:7,200 1 inch = 600 feet

Coordinate System: North American Datum 1983
New Mexico State PlaneWest Federal Information Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure A-4. Ruby-002, Ruby-004, and Ruby-019, Gamma Radiation Survey and Sampling Results
Ruby Mines
Engineering Evaluation and Cost Analysis

Jacobs



LEGEND

- < PRG
- PRG - 2xPRG
- 2xPRG - 3xPRG
- > 3xPRG
- Former Haul Road
- Drainage
- Capped Waste Rock Pile

Notes:
1. PRG for Ra-226 = 2.89 pCi/g
> = greater than
< = less than
pCi/g = picocuries per gram
PRG = preliminary remediation goal

N

0 75 150 300
Feet
1:1,800 1 inch = 150 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure A-5. Ruby Mines No. 1 - Calculated Radium-226 Concentrations in Surface Soil
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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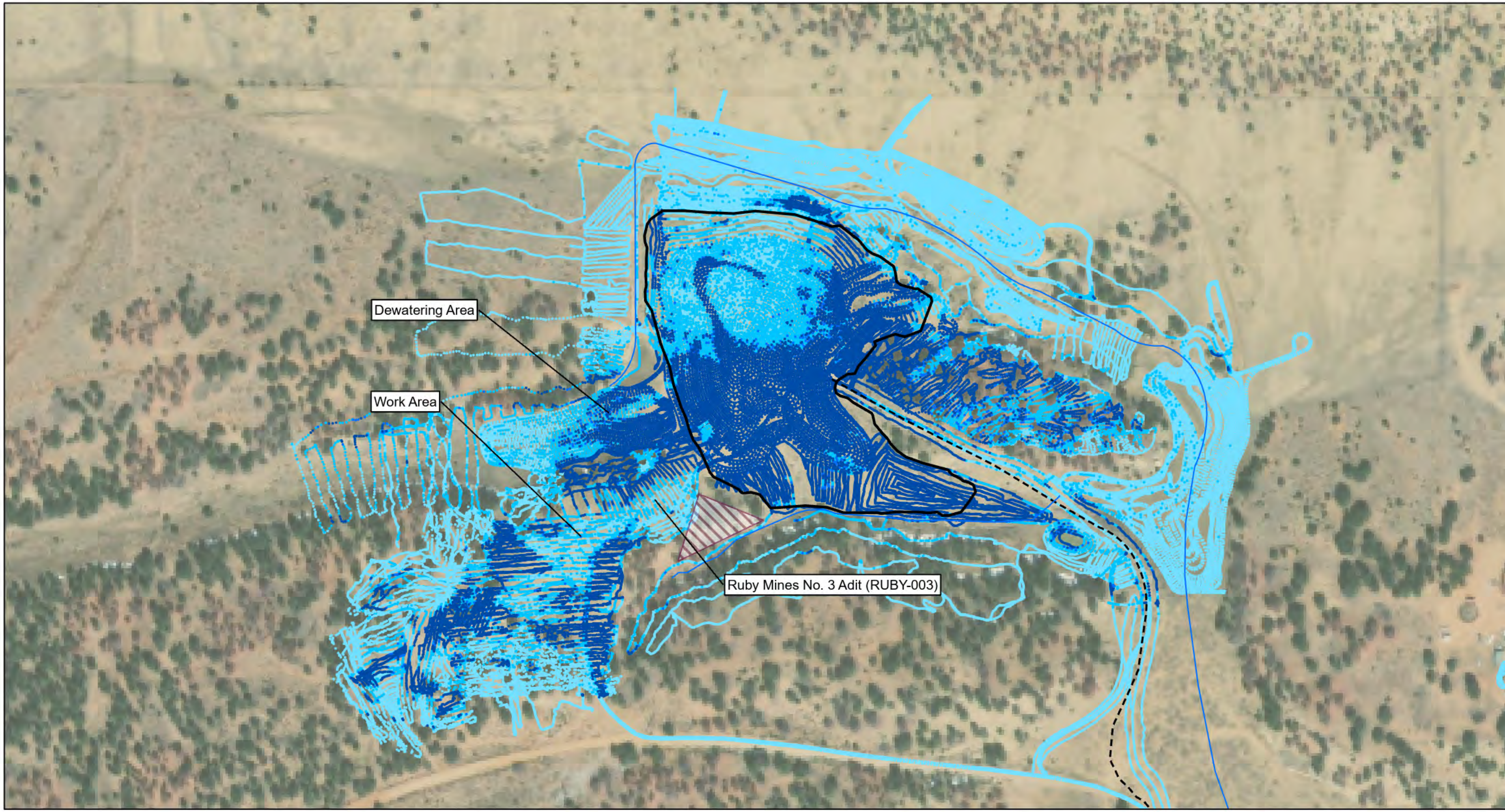

LEGEND

- < PRG
- PRG - 2xPRG
- 2xPRG - 3xPRG
- > 3xPRG
- Former Haul Road
- Drainage
- Capped Waste Rock Pile
- Restricted Area

Notes:
1. PRG for Ra-226 = 2.89 pCi/g
> = greater than
< = less than
pCi/g = picocuries per gram
PRG = preliminary remediation goal

N

0 100 200 400
Feet

1:2,400 1 inch = 200 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Aerial Imagery: ESRI ArcGIS online

Figure A-6. Ruby Mines No. 3 - Calculated Radium-226 Concentrations in Surface Soil
Engineering Evaluation and Cost Analysis
Ruby Mines

Jacobs

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Appendix B
Photograph Log

Project Title:	**Ruby Mines Site**
Location:	Smith Lake Chapter of the Navajo Nation, New Mexico
Date:	October 17, 2018

Engineering Evaluation and Cost Analysis — Ruby Mines Site Photolog

Photograph 1: Ruby Mine No. 1 capped waste rock pile (side view from bottom of slope facing south)

Photograph 2: Ruby Mines No. 1 (view from top of capped waste rock pile facing west)

Photograph 3: Ruby Mines No. 1, bat gate

Photograph 4: Ruby Mines No. 1, area around bat gate.

Photograph 5: Ruby Mines No. 1, erosion channel on slope (side view)

Photograph 6: Ruby Mines No. 1, erosion channel on slope

Photograph 7: Ruby Mines No. 1, erosion channel downstream of capped waste rock pile

Photograph 8: Ruby Mines No. 1, view of waste rock pile from bottom of slope

Photograph 9: Ruby Mines No. 3, capped waste rock pile

Photograph 10: Ruby Mines No. 3, capped waste rock pile (from side)

Photograph 11: Ruby Mines No. 3, capped waste rock pile (from top)

Photograph 12: Ruby Mines No. 3, capped waste rock pile

Photograph 13: Ruby Mines No. 3, haul road

Photograph 14: Haul Road at Ruby Mines No. 3

Appendix C
Risk Assessment Tables

Table C-1. Risk-Based Soil Screening Levels for Human Health and Ecological Receptors

Engineering Evaluation and Cost Analysis

Ruby Mines

Human Receptors [a,b]									
Receptor	Toxic Effect	Radium-226 (pCi/g)	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)
Chíí dah wiih łeezh (washes and drainages)	Cancer	0.196	5.06	--	--	--	NA	--	--
	Noncancer	--	11.6	8.72	33.8	153	NA	8.14	168
Kee'da'whíí tééh (full-time Navajo residential)	Cancer	0.0523	2.31	--	--	--	NA	--	--
	Noncancer	--	4.52	3.04	12.1	17	NA	2.82	64.6

Ecological Receptors [c]								
Receptor	Radium-226 (pCi/g)	Arsenic (mg/kg)	Mercury (mg/kg)	Molybdenum (mg/kg)	Selenium (mg/kg)	Thorium (mg/kg)	Uranium (mg/kg)	Vanadium (mg/kg)
Soil Receptors								
Plant	540	91	64	NA	3	NA	250	80
Soil Invertebrates	15	68	0.5	NA	41	NA	NA	NA
Avian Herbivore	340	340	0.67	180	1.9	NA	15,000	13
Avian Ground Insectivore	82	150	0.13	150	1.4	NA	11,000	9.5
Avian Intermediate Carnivore	610	1,000	0.58	900	7.5	NA	140,000	110
Mammalian Herbivore	3,400	180	230	NA	3.4	NA	2,600	1,500
Mammalian Ground Insectivore	5,100	31	17	NA	1.0	NA	1,200	610
Mammalian Carnivore	3,700	1,300	760	NA	130	NA	12,000	6,900

Reference:

Newport News Nuclear BWXT-Los Alamos, LLC. 2020. “ECORISK Database (Release 4.2).” Document EM2020-0575, Los Alamos, New Mexico. N3B 2020, 701067. November.

Navajo Nation Environmental Protection Agency (NNEPA). 2022. "v1.00 Navajo Risk Calculator.xlsm" Excel Workbook. August.

[a] The human health RBSLs were calculated using the Navajo risk-based remediation goal calculator (NNEPA, 2022). The screening levels were calculated using exposure parameter inputs recommended by the Navajo Nation Environmental Protection Agency and include external radiation exposure, soil ingestion, dermal contact (metals only), soil (or dust) inhalation, consumption of homegrown produce and gathered wild plants, consumption of homegrown animal products (meat, eggs, and milk), and consumption of hunted animals (meat only). The scenarios also include use of plants for medicinal and ceremonial purposes.

[b] The target cancer risk used in the RBSLs is one in ten thousand (1E-04) and the target noncancer hazard is 1.

[c] Ecological RBSLs are LOECs based on Los Alamos National Laboratory ECORISK database low-effect level environmental screening levels (Newport News Nuclear BWXT-Los Alamos, LLC. 2020). Screening levels for birds and mammals are low effect values for avian herbivores (American robin), avian ground insectivores (American robin), avian intermediate carnivores (American kestrel), mammalian herbivores (mountain cottontail), mammalian ground insectivores (montane shrew), and mammalian top carnivores (gray fox).

Notes:

-- = not applicable
LOEC = lowest observed effect concentration
mg/kg = milligram per kilogram
NA = not available
pCi/g = picocurie per gram
RBSL = risk-based screening level

Table C-2. Human Health Risk and Hazard Summary

Engineering Evaluation and Cost Analysis

Ruby Mines

EU 1 - Colluvium, Ruby No. 1				
COPC [a]	Units	Exposure Point Concentration	Cancer Risk [b]	Noncancer Hazard [b]
Near-Surface Soil (0-18 inches bgs)				
Radionuclides				
Radium-226	pCi/g	13	**6.6E-03**	--
		Radionuclide Total	**7E-03**	--
Metals				
Arsenic	mg/kg	11	**2.2E-04**	0.95
Mercury	mg/kg	0.020	--	0.0023
Molybdenum	mg/kg	1.0	--	0.030
Selenium	mg/kg	17	--	0.11
Uranium	mg/kg	21	--	**2.6**
Vanadium	mg/kg	40	--	0.24
		Metal Total	**2E-04**	**4**
		Grand Total	**7E-03**	**4**

EU 2 - Colluvium, Ruby No. 3				
COPC [a]	Units	Exposure Point Concentration	Cancer Risk [b]	Noncancer Hazard [b]
Near-Surface Soil (0-18 inches bgs)				
Radionuclides				
Radium-226	pCi/g	28	**1.4E-02**	--
		Radionuclide Total	**1E-02**	--
Metals				
Arsenic	mg/kg	10	**2.0E-04**	0.86
Mercury	mg/kg	0.025	--	0.0029
Molybdenum	mg/kg	2.8	--	0.084
Selenium	mg/kg	30	--	0.20
Uranium	mg/kg	64	--	**7.8**
Vanadium	mg/kg	97	--	0.58
		Metal Total	**2E-04**	**10**
		Grand Total	**1E-02**	**10**

EU 3 - Colluvium, Ruby No. 1				
COPC [a]	Units	Exposure Point Concentration	Cancer Risk [b]	Noncancer Hazard [b]
Near-Surface Soil (0-18 inches bgs)				
Radionuclides				
Radium-226	pCi/g	366	**5.0E-01**	--
		Radionuclide Total	**5E-01**	--
Metals				
Arsenic	mg/kg	10	**4.4E-04**	**2.3**
Mercury	mg/kg	0.052	--	0.017
Molybdenum	mg/kg	3.6	--	0.29
Selenium	mg/kg	21	--	1.2
Uranium	mg/kg	804	--	**285**
Vanadium	mg/kg	153	--	**2.4**
		Metal Total	**4E-04**	**291**
		Grand Total	**5E-01**	**291**

Table C-2. Human Health Risk and Hazard Summary

EU 4 - Colluvium, Ruby No. 3				
COPC [a]	Units	Exposure Point Concentration	Cancer Risk [b]	Noncancer Hazard [b]
Near-Surface Soil (0-18 inches bgs)				
Radionuclides				
Radium-226	pCi/g	418	**5.5E-01**	--
		Radionuclide Total	**6E-01**	--
Metals				
Arsenic	mg/kg	7.9	**3.4E-04**	**1.7**
Mercury	mg/kg	0.025	--	0.0081
Molybdenum	mg/kg	2.0	--	0.16
Selenium	mg/kg	378	--	**22**
Uranium	mg/kg	357	--	**126**
Vanadium	mg/kg	101	--	**1.6**
		Metal Total	**3E-04**	**152**
		Grand Total	**6E-01**	**152**

Reference:

Navajo Nation Environmental Protection Agency (NNEPA). 2022. "v1.00 Navajo Risk Calculator.xlsm" Excel Workbook.

[a] **Bolded** COPCs are selected as risk-based contaminants of concern because cancer risk is greater than 1E-04 or noncancer hazard is greater than 1.

[b] **Bolded** values are values greater than the target cancer risk of 1E-04 or noncancer target hazard of 1. In practice, values can be slightly higher than the stated cutoff but still be considered equal to the cutoff because of rounding. Cancer risk is calculated using the one-hit equation of high carcinogenic risk levels (i.e., greater than 1E-02; RAGS Part A). The methodology for calculating the risks and hazards, and the inputs for cancer and noncancer equations are provided in the US and Navajo Nation's Environmental Protection Agency's Navajo Risk Calculator v1.00 (NNEPA, 2022).

Notes:

-- = not applicable
bgs = below ground surface
COPC = contaminant of potential concern
EPC = exposure point concentration
EU = exposure unit
IRIS = Integrated Risk Information System
mg/kg = milligram per kilogram
pCi/g = picocurie per gram
RBSL = risk-based screening level

Table C-3. Human Health Risk-Based Contaminants of Concern Compared to Risk-Based Screening Levels and Background Threshold Values

Engineering Evaluation and Cost Analysis

Ruby Mines

EU 1 - Colluvium, Ruby No. 1					
COC	Units	EPC [a]	Human Health RBSL [b]	BTV	Is EPC > RBSL and BTV? [c]
Near-Surface Soil (0-18 inches bgs)					
Radium-226	pCi/g	13	0.20	1.7	**Yes**
Arsenic	mg/kg	11	5.1	12	**No**
Uranium	mg/kg	21	8.1	0.87	**Yes**

EU 2 - Colluvium, Ruby No. 3					
COC	Units	EPC [a]	Human Health RBSL [b]	BTV	Is EPC > RBSL and BTV? [c]
Near-Surface Soil (0-18 inches bgs)					
Radium-226	pCi/g	28	0.20	1.7	**Yes**
Arsenic	mg/kg	10	5.1	12	**No**
Uranium	mg/kg	64	8.1	0.87	**Yes**

EU 3 - Colluvium, Ruby No. 1					
COC	Units	EPC [a]	Human Health RBSL [b]	BTV	Is EPC > RBSL and BTV? [c]
Near-Surface Soil (0-18 inches bgs)					
Radium-226	pCi/g	366	0.052	1.7	**Yes**
Arsenic	mg/kg	10	2.3	12	**No**
Uranium	mg/kg	804	2.8	0.87	**Yes**
Vanadium	mg/kg	153	65	17	**Yes**

EU 4 - Colluvium, Ruby No. 3					
COC	Units	EPC [a]	Human Health RBSL [b]	BTV	Is EPC > RBSL and BTV? [c]
Near-Surface Soil (0-18 inches bgs)					
Radium-226	pCi/g	418	0.052	1.7	**Yes**
Arsenic	mg/kg	7.9	2.3	12	**No**
Selenium	mg/kg	378	17	1.5	**Yes**
Uranium	mg/kg	357	2.8	0.87	**Yes**
Vanadium	mg/kg	101	65	17	**Yes**

Notes:

[a] EPCs are provided on Table C-2.

[b] The human health RBSLs are provided on Table C-2. The human health RBSL is based on the receptor assumed at each geologic unit.

[c] If **Yes**, the contaminant of concern should be considered for response action. If **No**, the contaminant of concern is not recommended for response action based on the available data.

bgs = below ground surface
BTV = background threshold value
COC = contaminant of concern
EPC = exposure point concentration
EU = exposure unit
mg/kg = milligram per kilogram
pCi/g = picocurie per gram
RBSL = risk-based screening level

Table C-4. Ecological Risk Hazard Quotients
Engineering Evaluation and Cost Analysis
Ruby Mines

EU 1 - Colluvium, Ruby No. 1											
COPEC [a]	Units	Exposure Point Concentration	Plant HQ	Soil Invertebrates HQ	Avian Herbivore HQ	Avian Ground Insectivore HQ	Avian Carnivore HQ	Mammalian Herbivore HQ	Mammalian Ground Insectivore HQ	Mammalian Carnivore HQ	Maximum HQ
Near Surface Soil (0-18 inches bgs) [b]											
Radionuclides											
Radium-226	pCi/g	13	0.02	0.9	0.04	0.2	0.02	0.004	0.003	0.003	0.9
Metals											
Arsenic	mg/kg	11	0.1	0.2	0.03	0.07	0.01	0.06	0.4	0.008	0.4
Mercury	mg/kg	0.020	0.0003	0.04	0.03	0.2	0.03	0.00009	0.001	0.00003	0.2
Molybdenum	mg/kg	1.0	--	--	0.006	0.007	0.001	--	--	--	0.01
Selenium	mg/kg	17	**6**	0.4	**9**	**12**	**2**	**5**	**17**	0.1	**17**
Uranium	mg/kg	21	0.08	--	0.001	0.002	0.0002	0.008	0.02	0.002	0.08
Vanadium	mg/kg	40	0.5	--	**3**	**4**	0.4	0.03	0.07	0.006	**4**

EU 2 - Colluvium, Ruby No. 3											
COPEC [a]	Units	Exposure Point Concentration	Plant HQ	Soil Invertebrates HQ	Avian Herbivore HQ	Avian Ground Insectivore HQ	Avian Carnivore HQ	Mammalian Herbivore HQ	Mammalian Ground Insectivore HQ	Mammalian Carnivore HQ	Maximum HQ
Near Surface Soil (0-18 inches bgs) [b]											
Radionuclides											
Radium-226	pCi/g	28	0.05	**2**	0.08	0.3	0.05	0.008	0.005	0.008	**2**
Metals											
Arsenic	mg/kg	10	0.1	0.1	0.03	0.07	0.01	0.06	0.3	0.008	0.3
Mercury	mg/kg	0.025	0.0004	0.05	0.04	0.2	0.04	0.0001	0.001	0.00003	0.2
Molybdenum	mg/kg	2.8	--	--	0.02	0.02	0.003	--	--	--	0.02
Selenium	mg/kg	30	**10**	0.7	**16**	**22**	**4**	**9**	**30**	0.2	**30**
Uranium	mg/kg	64	0.3	--	0.004	0.006	0.0005	0.02	0.05	0.005	0.3
Vanadium	mg/kg	97	1	--	**7**	**10**	0.9	0.06	0.2	0.01	**10**

EU 3 - Colluvium, Ruby No. 1											
COPEC [a]	Units	Exposure Point Concentration	Plant HQ	Soil Invertebrates HQ	Avian Herbivore HQ	Avian Ground Insectivore HQ	Avian Carnivore HQ	Mammalian Herbivore HQ	Mammalian Ground Insectivore HQ	Mammalian Carnivore HQ	Maximum HQ
Near Surface Soil (0-18 inches bgs) [b]											
Radionuclides											
Radium-226	pCi/g	366	0.7	**24**	1	**4**	0.6	0.1	0.07	0.1	**24**
Metals											
Arsenic	mg/kg	10	0.1	0.2	0.03	0.07	0.01	0.06	0.3	0.008	0.3
Mercury	mg/kg	0.052	0.0008	0.1	0.08	0.4	0.09	0.0002	0.003	0.00007	0.4
Molybdenum	mg/kg	3.6	--	--	0.02	0.02	0.004	--	--	--	0.02
Selenium	mg/kg	21	**7**	0.5	**11**	**15**	**3**	**6**	**21**	0.2	**21**
Uranium	mg/kg	804	**3**	--	0.05	0.07	0.006	0.3	0.7	0.07	**3**
Vanadium	mg/kg	153	**2**	--	**12**	**16**	1	0.1	0.3	0.02	**16**

Table C-4. Ecological Risk Hazard Quotients

EU 4 - Colluvium, Ruby No. 3											
COPEC [a]	Units	Exposure Point Concentration	Plant HQ	Soil Invertebrates HQ	Avian Herbivore HQ	Avian Ground Insectivore HQ	Avian Carnivore HQ	Mammalian Herbivore HQ	Mammalian Ground Insectivore HQ	Mammalian Carnivore HQ	Maximum HQ
Near Surface Soil (0-18 inches bgs) [b]											
Radionuclides											
Radium-226	pCi/g	418	0.8	**28**	1	**5**	0.7	0.1	0.08	0.1	**28**
Metals											
Arsenic	mg/kg	7.9	0.09	0.1	0.02	0.05	0.008	0.04	0.3	0.006	0.3
Mercury	mg/kg	0.025	0.0004	0.05	0.04	0.2	0.04	0.0001	0.001	0.00003	0.2
Molybdenum	mg/kg	2.0	--	--	0.01	0.01	0.002	--	--	--	0.01
Selenium	mg/kg	378	**126**	**9**	**199**	**270**	**50**	**111**	**378**	**3**	**378**
Uranium	mg/kg	357	1	--	0.02	0.03	0.003	0.1	0.3	0.03	1
Vanadium	mg/kg	101	1	--	**8**	**11**	0.9	0.07	0.2	0.01	**11**

Reference:

Newport News Nuclear BWXT-Los Alamos, LLC. 2020. "ECORISK Database (Release 4.2)." Document EM2020-0575, Los Alamos, New Mexico. N3B 2020, 701067. November.

[a] **Bolded** COPECs have a HQ greater than 1.

[b] Near Surface Soil (0-18 inches bgs) was used to represent exposure for all ecological receptors.

Notes:

HQ is calculated by dividing the EPC by the ecological RBSL. **Bolded** HQ values indicate HQs greater than 1.

Ecological RBSLs are LOECs based on Los Alamos National Laboratory ECORISK database low effect level environmental screening levels (Newport News Nuclear BWXT Los Alamos, LLC. 2020).

Screening levels for birds and mammals are low effect values for avian herbivore (American robin), avian insectivore (American robin), avian intermediate carnivore (American kestrel), mammalian herbivore (mountain cottontail), mammalian insectivore (montane shrew), and mammalian top carnivore (gray fox).

-- = no screening level
bgs = below ground surface
COPEC = contaminant of potential ecological concern
EU = exposure unit
HQ = hazard quotient
LOEC = lowest observed effect concentration
mg/kg = milligram per kilogram
pCi/g = picocurie per gram
RBSL = risk-based screening level

Appendix D
ARARs

Attachment D to the EE/CA for the Ruby Mines Site

Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Materials for Engineering Evaluation/Cost Analysis (EE/CA)

Introduction to ARARs and TBC Tables

Tables D-1 and D-2 below list the federal and Navajo location- and action-specific ARARs and TBC materials, respectively, that have been identified for all the alternative response actions described in the draft EE/CA for the Ruby Mines Site (Site). EPA did not identify chemical specific ARARs or TBCs because potential chemical-specific ARARs were not as conservative as the risk based cleanup standards developed for this action. Chemical related requirements tied to an action such as cap design were included in the action-specific table. Following Tables D-1 and D-2 is a list of federal and Navajo ARARs that must be attained if certain conditions are present at the Site. Identification and evaluation of ARARs is an iterative process that continues throughout the response process. As a better understanding is gained of Site conditions, contaminants, and response alternatives, the lists of ARARs, TBCs and their relevance to the removal action may change. ARARs and TBCs are finalized in the Action Memo for the selected response action.

Cleanup standards were derived through the EPA risk assessment process, in accordance with the following EPA guidance.

Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-18, Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (August 1997).

Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-23, Clarification of the Role of Applicable, or Relevant and Appropriate Requirements in Establishing Preliminary Remediation Goals under CERCLA (August 1997).

Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-25, Use of Soil Cleanup Criteria in 40 CFR Part 192 as Remediation Goals for CERCLA Sites (February 1998).

Office of Solid Waste and Emergency Response (OSWER) Directive No. 9200.4-40, Radiation Risk Assessment at CERCLA Sites: Q&A (May 2014).

The following Navajo Nation laws, regulations and guidances are not considered ARARs or TBCs for the response actions anticipated by this EE/CA; however, they are listed here because situations may arise during implementation of the alternatives discussed in the EE/CA, or during future actions at the Site, where these requirements may be applicable.

Navajo Nation CERCLA, 4 N.N.C. §§2101-2805 – The NNCERCLA requirements must be complied with during implementation of the response action if petroleum contamination is discovered at the Site, because NNCERCLA § 2104.Q includes petroleum in the definition of hazardous substance. Based on Site investigations thus far, petroleum contamination is not anticipated.

Navajo Nation Underground and Aboveground Storage Tank Act of 2012, 4 N.N.C. §§ 1501-1577 (NNSTA) – If any permanent storage tanks are found at a site, including both USTs and ASTs and tanks holding not only petroleum but any hazardous substances, NNSTA §1542(C)(1) requires their removal. (The guidance for temporary/mobile storage tanks brought on site is included in Table A-2 below as a TBC because that situation is anticipated to arise.)

Navajo Nation Business Opportunity Act, 5 N.N.C. §§201-214, and the Navajo Preference in Employment Act, 15 N.N.C §§ 601-619 – While these are not environmental regulations and therefore, not ARARs, these regulations give preference to Navajo Nation businesses and individuals when hiring employees and contractors to perform the response actions contemplated by this EE/CA.

Navajo Nation Dine Radioactive Materials Transportation Act, 18 N.N.C. §§1304-1307 ("RMTA") – The RMTA is not applicable to onsite activities; however, its requirements may be applicable to transportation on public roads on the Navajo Nation between sites that are subject to a combined action pursuant to CERCLA § 104(d)(4), as well as for shipment of radioactive materials through the Navajo Nation generally. RMTA § 1307 includes specific requirements that are not found in federal law, including advance notice of the transportation of radioactive and related substances, equipment, vehicles, persons, and materials over and across Navajo Nation lands, as well as license fees, bonding requirements, route restrictions and curfews.

The EE/CAs for which the ARARs tables were prepared do not address groundwater, and therefore ARARs for groundwater are not included. If any groundwater contamination is found at the Site, the related ARARs for the Site will be addressed at that time.

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Cultural Resources	FEDERAL **The Native American Graves Protection and Repatriation Act** **25 USC §§ 3002(c) and (d)** 43 CFR §§ 10.3(b)-(c) and 10.4(b)-(e)	Protects Native American cultural items from unpermitted removal and excavation and requires the protection of such items in the event of inadvertent discovery. Excavation or removal of cultural items must be done under procedures required by this Act and the Archaeological Resources Protection Act (Sec. 3 (c)(1)).	**Applicable** Substantive requirements are applicable if cultural items (meaning human remains and associated or unassociated funerary objects, sacred objects, or cultural patrimony), are inadvertently discovered or are intentionally excavated or removed within area to be disturbed. If cultural items are discovered, on-going activity in the area of discovery must stop, the relevant Indian tribe official must be notified immediately, and reasonable effort must be made to protect such cultural items.
Cultural Resources	FEDERAL **National Historic Preservation Act** **54 USC §§ 306101(a), 306102, 306107, and 306108** 36 CFR §§ 800.3(a) and (c); 800.4(a)-(c); 800.5(a)-(b); 800.6(a)-(b); 800.10(a); 800.13(b)-(d) 36 CFR §§ 60.9(a); 63.2(a) and (c)	Federal agencies are required to consider the effects of federally funded (in whole or in part) activity on any historic property, minimize harm to any National Historic Landmark, and nominate qualifying historic property for inclusion on the National Register. Federal agencies may be required to identify historic properties, determine whether proposed activity will have an adverse effect on historic properties, and develop alternatives or modifications to the proposed action that could avoid, minimize, or mitigate adverse effects, through NHPA's section 106 process.	**Applicable** Substantive requirements are applicable if federally funded activity could adversely affect historic property (meaning a prehistoric or historic district, site, building, structure, or object) included on, or eligible for inclusion on, the National Register of Historic Places.

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Cultural Resources	FEDERAL **Preservation of Historical and Archaeological Data 54 USC §§ 312502(a) and 312503**	Protects significant scientific, prehistorical, historical, and archaeological data. When a federal agency action may cause irreparable loss or destruction of significant data, the agency must notify DOI and either recover, protect, and preserve the data itself, or request DOI to do so.	**Applicable** Substantive requirements are applicable if federal agency action may cause irreparable loss or destruction to significant scientific, prehistorical, historical, or archaeological data.
Cultural Resources	FEDERAL **Archaeological Resources Protection Act of 1979** **16 USC §§ 470cc(a)-(c) and 470ee(a)** 43 CFR §§ 7.4(a), 7.5(a), 7.7, 7.8(a), 7.9(c), and 7.35	Prohibits the excavation, removal, damage, or alteration or defacement of archaeological resources on public or Indian lands, unless by permit or exception.	**Applicable** Substantive requirements are applicable if eligible archaeological resources are located within the area to be disturbed.
Cultural Resources	FEDERAL **American Indian Religious Freedom Act** **42 USC § 1996**	Policy of the United States to protect access to and the use of religious, ceremonial, and burial sites and sacred objects by Native American groups.	**TBC** Policy should be followed if Native American sacred sites are identified within area to be disturbed.

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Biological Resources	FEDERAL **Migratory Bird Treaty Act** **16 USC § 703(a)** 50 CFR §§ 10.13 and 21.10	Prohibits the killing, capturing, taking and incidental taking of protected migratory bird species, their parts, nests and eggs, without DOI's prior approval. The species of protected migratory birds are listed at 50 CFR § 10.13.	**Applicable** Substantive requirements are applicable if migratory birds, or their nests, are present at or near the site.
Biological Resources	FEDERAL **Bald and Golden Eagle Protection Act** **16 USC §§ 668(a)** 50 CFR §§ 22.10; 22.80(a), (c)-(f); 22.85(a)-(b) and (d)-(e) 50 CFR § 13.21(b)	Prohibits the unpermitted taking, including the killing, disturbing, or incidental taking, of bald and golden eagles, their parts, nests, and eggs.	**Applicable** Substantive requirements applicable if bald or golden eagles, or their nests, are identified at or near the site.

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Biological Resources	FEDERAL **Endangered Species Act** **16 USC §§ 1531(c); 1536(a)(2), (c)-(d), (g)-(h), and (l); 1538(a) and (g); 1539(a)** 50 CFR §§ 17.21(a)-(c);17.22(b); 17.31(a) and (c);17.32(b); 17.82; and 17.94(a) 50 CFR §§ 402.09; 402.12 (a)-(b) and (i); 402.14(a); 402.15(a)	Federal agencies must ensure that any activities funded, carried out, or authorized by them do not jeopardize the continued existence of any threatened or endangered species, nor result in the destruction or alteration of such species' habitats. List of endangered and threatened species can be found at 50 CFR Part 17, Subpart B.	**Applicable** Substantive requirements applicable if endangered or threatened species are identified at the site.
Cultural Resources	NAVAJO NATION **Navajo Nation Cultural Resources Protection Act (NNCRPA)** **11 N.N.C. §§ 1003(S); 1021; and 1031**	Prohibits alteration, damage, excavation, defacement, destruction, or removal of cultural properties.	**Applicable** Substantive requirements applicable to activities at the AUM sites where cultural resources may be encountered.

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Cultural Resources	NAVAJO NATION **Navajo Nation Policy for the Disposition of Cultural Resources Collections Sections 2 and 6.1 These sections would trigger other provisions in the policy.**	Establishes procedures and guidelines to be followed for excavation (as a last resort) and disposition of cultural resources recovered on Navajo Nation Lands, including handling of inadvertent discovery.	**TBC** TBC for activities on AUMs where cultural resources may be encountered.
Cultural Resources	NAVAJO NATION **Navajo Nation Guidelines for the Treatment of Discovery Situations**	Establish procedures and guidelines to be followed in any situation involving the discovery of cultural or historic property, including historical and prehistoric archaeological sites and traditional cultural properties and human remains, whether or not previously identified.	**TBC** The Navajo Nation Historic Preservation Dept. (NN HPD) performs these functions pursuant to a contract with the BIA, under which the NN HPD serves as the BIA's agent.

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Cultural Resources	NAVAJO NATION **Navajo Nation Policy for the Protection of Jishchaá: Gravesites, Human Remains, and Funerary Items**	Establishes principles for locating and handling of gravesites, human remains, and associated artifacts and soil in the area to be disturbed by AUM removal activities. See in particular Section IV (Traditional Concerns), which contains requirements if the AUM activity comes into contact with gravesites, human remains, or funerary items. It imposes specific requirements for how to navigate around, prepare for, and respond to burial grounds and uncovered remains. See also Section V (Encountering Gravesites, Human Remains, and Funerary Items), which specifies the procedures when an inadvertent discovery is made. Sections VI and VII contain additional requirements in that event.	**TBC**

Table D-1 Location-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Biological Resources	NAVAJO NATION **Navajo Nation Endangered Species Act (NNESA)** **17 N.N.C. §§ 500-508** **Navajo Nation Endangered Species List –** Resource Committee Resolution RCAU-103-05	NNESA § 507 makes it unlawful for any person to "take, possess, transport, export, process, sell or offer for sale or ship any species or subspecies of wildlife" listed as endangered or threatened on federal or Navajo Nation lists, which also protect those species' critical habitat. NNESA §§ 500-504 and 506-508 also protect, to various extents, game fish, game birds, songbirds, game animals, fur-bearing animals (all defined under § 500), and hawks, vultures, and owls from being taken. The Navajo Nation Endangered Species List includes species that are not on the federal list. It also provides broader criteria for when species would be listed, based on their prospects of survival or recruitment within the Navajo Nation. (See Categories "G2" and "G3"). Category G4 provides a means for the Navajo Nation Department of Fish and Wildlife to include additional species (or exclude species), making it possible for the list to change during the course of work.	Applicable Substantive requirements applicable if protected species or habitat are identified within area to be disturbed on AUM sites.

Table D-2 Action-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Air	FEDERAL **Clean Air Act** **42 U.S.C. §§ 7401, *et seq.*** 40 CFR § 61.92	Emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.	**Relevant and appropriate** This standard is applicable to a DOE facility. The Site is not a DOE facility; therefore, this standard is not applicable. However, this standard has been determined to be relevant and appropriate during removal action activities because of potential emissions of radionuclides during excavation of the waste and movement of the waste.
Air	FEDERAL **Clean Air Act** **42 U.S.C. §§ 7401, *et seq.*** 40 CFR §§ 61.222(a)	Radon-222 emissions to the ambient air from a uranium mill tailings pile that is no longer operational shall not exceed 20 pCi/m^2-sec.	**Relevant and appropriate** These requirements are applicable to non-operational uranium mill tailings piles. The Site's waste to be disposed of, is not uranium mill tailings. These requirements have been determined to be relevant and appropriate to the design of the engineered cover to be constructed in Alternative (fill in Alt. #), which consists of onsite containment of the contaminated soil and uranium waste rock.
Water	FEDERAL **Clean Water Act** **33 USC § 1342(p)(3)(A)** NPDES – Stormwater Discharges 40 CFR §§ 122.41(d) and (e)	Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards. All reasonable steps must be taken to minimize or prevent discharges which have a reasonable likelihood of causing adverse impacts on surface water.	**Applicable** if there are discharges to WOTUS. **Relevant and appropriate** if there are discharges to Navajo Nation Surface Waters (as defined in Table 206.1, *see* https://www.epa.gov/sites/default/files/2014-12/documents/navajo-tribe.pdf (Waters of the NN)).
Water	FEDERAL **Clean Water Act** **33 USC § 1342(p)(3)(A)** NPDES – Stormwater Discharges 40 CFR § 450.21	Requires BMPs to abate discharges of pollutants from stormwater discharges, including erosion and sediment control BMPs. All treatment and control systems and facilities will be properly operated and maintained.	**Applicable** if there are discharges to WOTUS. **Relevant and appropriate** if there are discharges to Navajo Nation Surface Waters (as defined in Table 206.1, *see* https://www.epa.gov/sites/default/files/2014-12/documents/navajo-tribe.pdf (Waters of the NN)).

Table D-2 Action-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Water	FEDERAL **Clean Water Act** **33 USC § 1342(p)** NPDES 2022 Construction General Permit (CGP) for Stormwater Discharges from Construction Activities Part 2. Technology-Based Effluent Limitations. Section 2.2. Erosion and Sediment Control Requirements, Subsection 2.2.1.	"2.2 EROSION AND SEDIMENT CONTROL REQUIREMENTS You must implement erosion and sediment controls in accordance with the following requirements to minimize the discharge of pollutants in stormwater from construction activities. 2.2.1 Provide and maintain natural buffers and/or equivalent erosion and sediment controls for discharges to any receiving waters that is located within 50 feet of the site's earth disturbances. a. Compliance Alternatives. For any discharges to receiving waters located within 50 feet of your site's earth disturbances, you must comply with one of the following alternatives: i. Provide and maintain a 50-foot undisturbed natural buffer; or ii. Provide and maintain an undisturbed natural buffer that is less than 50 feet and is supplemented by erosion and sediment controls that achieve, in combination, the sediment load reduction equivalent to a 50-foot undisturbed natural buffer; or iii. If infeasible to provide and maintain an undisturbed natural buffer of any size, implement erosion and sediment controls to achieve the sediment load reduction equivalent to a 50-foot undisturbed natural buffer. See Appendix F, Part F.2 for additional conditions applicable to each compliance alternative. b. Exceptions. See Appendix F, Part F.2 for exceptions to the compliance alternatives."	**Applicable** for operators of construction activities if weather events necessitating stormwater runoff controls occur during on-site excavation, waste consolidation, and repository construction.

Table D-2 Action-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Repository	FEDERAL **Uranium Mill Tailings Radiation Control Act 42 USC §§ 7918 and 2022** 40 CFR §§192.02(a) and (d)	Requires design of uranium mill tailings disposal sites to provide for control of residual radioactive materials for up to 1,000 years to the extent reasonably achievable and, in any case, for at least 200 years. The uranium mill tailings disposal site must also be designed and stabilized in a manner that minimizes the need for future maintenance.	**Relevant and Appropriate** These standards are applicable to UMTRCA Title I sites. The Site is not a Title I Site; therefore, these requirements are not applicable. These requirements have been determined to be relevant and appropriate to the design of the engineered cover to be constructed under Alternative (insert #), which consists of onsite containment of the contaminated soil and uranium waste rock.
Repository	FEDERAL **Uranium Mill Tailings Radiation Control Act 42 USC §§ 7918 and 2022** 10 CFR Part 40, Appendix A. Criterions 1, 4, 6(1), 6(3), 6(5) and 6(7)	In selecting and designing uranium mill tailings disposal sites, certain criteria must be considered, including remoteness, hydrologic and topographic features, potential for erosion and vegetation. Disposal sites must be covered by an earthen cap, or approved alterative, that meets certain control requirements, including limiting the release of radon 222 to the atmosphere. When the final radon barrier is placed in phases, verification of the radon-222 release rate must be completed for each portion of the final radon barrier as it is emplaced. Waste or rock with elevated levels of radium must not be placed near the surface of disposal sites. Disposal sites must be closed in a manner that, to the extent necessary, controls, minimizes, or eliminates post closure escape of non-radiological hazardous constituents, leachate, contaminated rainwater, or waste decomposition products to the ground or surface waters or atmosphere.	**Relevant and Appropriate** These standards are applicable to UMTRCA Title I sites. The Site is not a Title I sites; therefore, these requirements are not applicable. These requirements have been determined to be relevant and appropriate to the design of the engineered cover to be constructed in Alternative (insert #), which consists of onsite containment for the contaminated soil and uranium waste rock.

Table D-2 Action-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
Repository	FEDERAL **NRC Regulations Protection of the General Population from Releases of Radioactivity** 10 CFR § 61.41	"Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable."	**Relevant and Appropriate** This standard is applicable to NRC sites. The Site is not an NRC site; therefore, this requirement is not applicable. This standard was found to be relevant and appropriate to the design of the engineered cover to be constructed in Alternative (insert #) for the onsite containment of contaminated soil and uranium waste rock.
All	NAVAJO NATION **Navajo Nation Fundamental Law 1 N.N.C. §§ 201-206** Navajo Nation Guidance on the Uniform Application of Fundamental Law to AUM Cleanup Activities (2022)	The Navajo people have an obligation under the Diné Fundamental Law to listen to elders and medicine people and respect, preserve and protect Mother Earth as stewards and guardians for the benefit of future generations. The 2020 Guidance explains the principles of Fundamental Law and how they would be applied at the various stages of AUM cleanup.	**TBC** Navajo Nation Fundamental Law and the 2022 Guidance will be TBCs to the extent that they do not conflict with US CERCLA, the National Contingency Plan, 40 CFR Part 300, or other federal requirements.
Soil and Water	NAVAJO NATION **Navajo Nation Underground and Aboveground Storage Tank Act of 2012 – 4 N.N.C. §§ 1501-1577, as amended** NNEPA Storage Tank Program Guidance No. 3 (ASTs at Construction Sites) – Section III	The Act regulates storage of petroleum and other regulated substances in underground and aboveground storage tanks. This guidance clarifies that the NNSTA applies to ASTs that are temporarily placed at construction sites within the Navajo Nation. It requires such ASTs to file tank information forms with NNEPA, locate the tank within a secondary containment area, secure the tank to prevent movement on the containment surface or mount it on metal skids (not on an elevated stilt rack), and contact the Navajo Nation Storage Tank Program for an inspection of the AST to check for evidence of soil	**TBC** Guidance should be followed for AUM response activities requiring ASTs to be brought to sites, for example for fuel needed for equipment and vehicles.

Table D-2 Action-Specific ARARs and TBC Information			
Media	**Requirement**	**Requirement Synopsis**	**Prerequisites, Status and Rationale**
	(Operating Guidelines)	contamination both prior to the first deposit of a regulated substance and when the AST is removed from the site.	

List of ARARs to be Included in EE/CA ARARs Tables to Address Certain Site Conditions if Encountered

Media	Requirement	Requirement Synopsis	Prerequisites, Status and Rationale
Soil and Water	NAVAJO NATION **Navajo Nation Leaking Storage Tank Soil and Water Cleanup Standards 2012 –** Resolution of the Navajo Nation Council CAP-47-95	Establish cleanup standards for soil and water contaminated by leaking underground and aboveground storage tanks. More stringent than federal requirements, which consist of screening levels for contaminated soils and not standards. Also, Cleanup Standards § VI provides that the point of compliance is at the source of the release and not at the nearby receptor, i.e., drinking water well. Cleanup Standards § IX provides that "NNEPA will not consider Monitoring Natural Attenuation as an acceptable cleanup method unless contamination levels are within 10% of the values of the relevant cleanup standard."	**Applicable** Applicable if there is a leak from a temporary tank that is brought to a site, for example for fuel needed for equipment and vehicles. Also applicable to response activities resulting from releases of petroleum or other regulated substances from tanks, if there are any, at AUMs.
Surface Water	NAVAJO NATION **Navajo Nation Clean Water Act (NNCWA) 4 N.N.C. § 1302(43)** Navajo Nation	The surface water quality standards apply to all "waters of the Navajo Nation" pursuant to the NNCWA. They are intended to protect, maintain, and improve the quality of Navajo Nation surface waters for public and private drinking water supplies and other domestic uses, and for fish, wildlife, cultural, agricultural, and recreational uses of water. 4 N.N.C. § 1302(43) defines waters	**Applicable or Relevant and Appropriate** Applicable to discharges into Navajo Nation Surface Waters (as defined in Table 206.1, *see* https://www.epa.gov/sites/default/files/2014-12/documents/navajo-tribe.pdf (Waters of the NN)) on AUM sites and relevant and appropriate if there may be discharges into such Waters as a result of removal activities. Relevant and appropriate as clean-up standards for Waters of the Navajo Nation contaminated by AUM sites.

	Surface Water Quality Standards (NNWQS) Table 207.1, Table 206.1 See the August 16, 2018 Atlas of Navajo Nation Surface Waters for maps of all NN surface waters.	of the Navajo Nation more broadly than the federal definition of waters of the U.S. Therefore, the provisions of the NNCWA are more broadly applicable than those of the federal CWA. All Navajo Nation surface waters are listed in Table 206.1 and depicted in the 2018 Atlas. There are no federal WQS, only federal criteria, so only the NNSWQS would be applicable although the federal criteria would be relevant and appropriate. The NNSWQS are more stringent in that they cover more waters than would be covered under the federal CWA due to the broader definition of waters of the Navajo Nation under the NNCWA, 4 NNC § 1302(43). The NNSWQS also are more stringent because they apply to more designated uses. The federal criteria cover 4 uses/scenarios: Aquatic habitat acute and chronic, domestic consumption of organisms (fish) plus water, and domestic consumption of fish. The NNSWQS also include primary and secondary human contact, agricultural watering, and livestock watering. See NNWQS Table 206.1. The following COPCs for the site are included in the NNSWQS and have numeric standards, see Table 207.1: (1) molybdenum for agricultural water supply; (2) vanadium for agricultural and livestock watering; and (3) selenium for both domestic consumption and fish consumption. Also, Navajo Nation uses the MCL for Radium 226/228 for its WQS for domestic water supply,	

		agricultural water supply, and livestock watering, so it would be applicable for these uses. USEPA would use the MCL as relevant and appropriate, rather than applicable. Similarly, Navajo Nation uses the MCL for uranium for its WQS for all uses. Finally Navajo Nation uses the arsenic MCL for all uses, and that would be more stringent than the water quality criteria for primary and secondary human contact, agricultural use, and livestock watering.	
Water	FEDERAL **Clean Water Act** **33 USC § 1344** CWA § 404(b) Guidelines 40 CFR §§230.10; 230.61, and 230.71-76	Prohibits the unpermitted discharge of dredge or fill material into waters of the U.S., other than incidental fallback. Should dredge and fill material be discharged to a water of the U.S., the chemical, biological and physical impacts to the WOTUS must be tested and evaluated. Any adverse effects shall be minimized by treating the material prior to discharge, limiting the mobility of the discharge materials, and avoiding or limiting impacts to WOTUS that serve as wildlife habitat, recreational space or other use by humans.	**Applicable** if there are discharges to WOTUS. **Relevant and Appropriate** if there are discharges to Navajo Nation Surface Waters (as defined in NNCWA § 1302(43) and listed in NNSWQS Table 206.1, *see* https://www.epa.gov/sites/default/files/2014-12/documents/navajo-tribe.pdf) (Waters of the NN)).
Water	FEDERAL **Clean Water Act** **33 USC § 1344 (CWA § 404)** 33 CFR §323.3(a), 323.4(a)(6), (b), (c)	The construction of temporary roads that result in a discharge of dredge or fill material to a water of the U.S. does not require a permit unless the materials contain toxic pollutants, or the discharge will alter the flow of the WOTUS.	**Applicable** if there are discharges to WOTUS. **Relevant and Appropriate** if there are discharges to Navajo Nation Surface Waters (as defined in NNCWA § 1302(43) and listed in NNSWQS Table 206.1, *see* https://www.epa.gov/sites/default/files/2014-12/documents/navajo-tribe.pdf (Waters of the NN)).
Water	FEDERAL **Clean Water Act** **33 USC § 1344 (CWA §**	On-site CERCLA actions conducted by a federal agency that involve the discharge of dredged or fill material into waters of the United States must	**Applicable** if there are discharges to WOTUS. **Relevant and Appropriate** if there are discharges to Navajo Nation Surface Waters

	404) Nationwide Permit 38 – Clean Up of Hazardous and Toxic Waste	comply with the substantive requirements of the NWP 38 General Conditions, as appropriate, and any regional or case-specific conditions recommended by the Corps District Engineer, after consultation.	(as defined in NNCWA § 1302(43) and listed in NNSWQS Table 206.1, *see* https://www.epa.gov/sites/default/files/2014-12/documents/navajo-tribe.pdf (Waters of the NN)).

Appendix E
Ruby Mines Site Geology and Hydrogeology Summary Technical Memorandum

Jacobs

Memorandum

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Subject:	**Ruby Mines Site Geology and Hydrogeology Summary Technical Memorandum**
To:	Western Nuclear, Inc.
From:	Monica Fulkerson/CLT
Date:	April 3, 2020

Introduction

Two waste rock piles at the Ruby Mines Site (Site), located within the Smith Lake Chapter of the Navajo Nation near Thoreau, New Mexico (Figure 1), were capped during reclamation of the Site in 1985. As part of the review of the draft engineering evaluation/cost analysis (EE/CA) (Jacobs 2019) prepared for the Site, the U.S. Environmental Protection Agency (U.S. EPA) questioned whether leachate from the two waste rock piles and impacted soils could potentially impact groundwater at the Site. To address that question, this technical memorandum identifies and explains the conditions at the Site that make it unlikely for contaminants of potential concern (COPCs) associated with the waste rock and impacted soils to migrate to and adversely impact groundwater beneath the Site, including the following conditions: (1) the intervening geologic materials provide both hydraulic and geochemical barriers to transport of leachate; (2) the substantial depth to aquifers sufficient to supply drinking water and the absence of recharge areas located near the Site; and (3) the lack of leachate produced by the two waste rock piles and impacted soils.

1. Hydraulic and Geochemical Barriers

The geologic materials at the Site provide hydraulic and geochemical barriers that prevent the transport of leachate from the two waste rock piles and impacted soils to groundwater.

1.1 Geology

The Site is underlain by a sequence of Cretaceous and Late Jurassic sandstone and shale, mudstone, and siltstone of the Mancos Shale and Dakota and Morrison Formations (USGS 1990) (Figure 2).

The Mancos Shale is the shallowest bedrock at the Site. The Manco Shale is up to 100 feet thick and primarily consists of shale, mudstone and siltstone with minor layers of limestone, and sandstone. The main body of the Mancos Shale functions as a regional aquitard over the Dakota Formation (Cooley et al. 1969).

The Dakota Formation generally underlies the Mancos Shale and primarily consists of sandstone with interbedded siltstone and shale. The Dakota Formation at the Site is approximately 140 to 190 feet thick (USGS 1990). The base of the Dakota Formation is approximately 300 feet below ground surface (bgs) at the Site (Robertson 1990). Historical bailing tests indicate that wells in the Dakota Formation produce

0.02 to 0.4 gallons per minute (gpm) per foot of drawdown, suggesting that the formation has low permeability (Cooley et al. 1969).

The upper units of the Morrison are the Brushy Basin Member, a massive sandy mudstone up to 160 feet thick, which underlies the Dakota Formation. Below the Brushy Basin Member lies the Westwater Canyon Member, a 120- to 220-foot thick sandstone with few claystone and conglomerate deposits. The Brushy Basin Member acts as an aquitard. Historical bailing tests indicate that that wells in the upper Morrison Formation produce 0.02 to 2.2 gpm per foot of drawdown, suggesting that this formation also has low permeability (Cooley et al. 1969).

Historical mining activities targeted sandstones in the lower part of the Brushy Basin Member of the Upper Jurassic Morrison Formation (Figure 3) (Ristorcelli 1980), identified as "Jmbs" on Figure 2 and Figure 4 (Robertson 1990).

Figures 3 and 4 show that at Smith Lake (three miles northwest of the Site), the Brushy Basin Member is approximately 180 to 200 feet below the ground surface.

Prior to mine dewatering, water levels in the Dakota Sandstone may have been more than 200 feet higher than in the underlying Morrison Formation (Stone et al. 1983). The persistence of hydraulic-head differences in the Dakota and Morrison is an indication that a relatively low vertical permeability exists in the confining layer between the two formations (Stone et al. 1983), which also indicates that vertical migration of contaminants is unlikely.

1.2 Contaminant Transport

The sandstone, siltstone, and mudstones of Mancos Shale and Dakota Formation contain organic carbon, clays, and iron-bearing minerals with significant capacity to attenuate and immobilize COPCs, including uranium and radium. The Mancos Shale contains clay minerals including illite, smectite, and swelling-clays such as montmorillonite (bentonite) that can limit water movement through the shale bed. In addition, pyrites in the shale oxidize to form iron hydroxide minerals (four to six percent by weight [wt. %]) (Brookins 1979; U.S. DOE 2011). The Dakota formation contains limonitic sandstone (oxidized iron minerals imparting an orange color to the sandstone) up to four wt. % with significant clay content as well (Brookins 1979). Radionuclides and other COPCs will sorb to iron minerals in clays and oxidized iron mineral phases in sandstones, limiting migration through these geologic units (Ames et al. 1983; Waite et al. 1994, Peak and Sparks 2002).

2. Depth to Usable Aquifers and Groundwater Recharge

COPCs are unlikely to migrate from the two waste rock piles and impacted soils to groundwater due to the substantial depth to aquifers sufficient to supply drinking water and the absence of recharge areas located near the Site.

2.1 Depth to Usable Aquifers

Groundwater underlying the Site has a variety of naturally occurring geochemical qualities that affect its usability and results in certain specific geologic formations being targeted for drinking water production. The lower beds of the Mancos Shale are known to yield adequate supplies of water; however, the water quality is naturally poor because of high concentrations of dissolved solids (particularly sulfate). The Dakota Sandstone can also produce substantial quantities of groundwater when it is below the water table. The water quality in the Dakota Sandstone also is typically unsuitable for domestic use because of the naturally high concentrations of dissolved solids. Deeper wells, completed in the Westwater Canyon Member of the Morrison Formation, Cow Springs Sandstone, Entrada Sandstone, and San Andres and Glorieta Sandstone, provide water of better chemical quality (Cooper and John 1968) (Figure 2).

Groundwater within the Navajo Nation is used for domestic, subsistence agriculture, and livestock purposes. Groundwater wells near the Site are primarily deep residential supply wells and are identified in the Navajo Nation Well Database (2019), which are listed in Table 1 and shown on Figure 5. Key takeaways include:

- Well depths range from 679 feet to 3,170 feet bgs, which indicates that water resources with water quality sufficient for domestic use are hundreds of feet below the Site. Therefore, any potential groundwater contamination would need to migrate this distance to impact the usable groundwater resources.
- The measured static water levels are far above the aquifers, indicating that the aquifers supplying the wells are confined, and thus are likely recharged far from the location of the wellheads.
- The database does not indicate the depth or geologic formation in which the shallowest or first water is encountered, but the static water levels observed in wells screened in the Dakota (the shallowest formation with wells) suggest that there is more than 300 feet of unsaturated soils between the two waste rock piles and the water table.

The absence of shallow wells at or near the Site prevents the exact measurement of the depth to shallow groundwater potentially present in the Mancos Shale and overlying alluvial sediments. And while the potentiometric head measured in wells screened in confined aquifers (for example, 355 feet to 475 feet bgs in wells screened in the Dakota) does not exactly correspond to the depth to the shallowest groundwater, it can be used to provide a rough estimate of the depth to shallow groundwater at the Site.

2.2 Precipitation and Groundwater Recharge

The mean annual precipitation averages approximately 11 inches, based on data collected between 1929 and 2015 (Western Regional Climate Center 2015), and in some years may be as little as three inches (Cooley 1969). Sporadic high-intensity summer thunderstorms (that is, monsoons) result in locally concentrated precipitation. Winter precipitation generally is distributed more evenly. Estimated annual evaporation is 75 to 80 inches (Roca Honda 2009), which far exceeds annual precipitation and indicates that groundwater is not recharged by direct infiltration of precipitation across the area. Rather, groundwater is recharged by infiltration of stormwater runoff at spatially limited areas where major drainage features cross or align with surface outcrops, approximately four to eight miles south and southwest of the Site and at fault traces (Cooper and John 1968). Because the two waste rock piles and impacted soils are not located in those spatially limited recharge areas, it is unlikely that they have impacted groundwater.

3. Leachate Production

Multiple lines of evidence, including leachate production at a nearby location and analytical results from the dewatering area and haul roads at the Site, indicate that minimal leachate has been produced from the two waste rock piles and impacted soils and, therefore, is unlikely to migrate to groundwater.

3.1 Waste Rock Piles

The two waste rock piles at the Site contain either waste rock that was excavated to access the ore bodies at the Site or ore that was of such low grade that it was not economical to send off the Site for processing. When the Site was closed, previously reserved topsoil was used to cap the two waste rock piles and it was vegetated with perennial grasses (MMD 1995).

3.2 Dewatering Area

Groundwater produced during mine dewatering efforts was discharged to the ground into the "Dewatering Area". While not leachate, this discharge can be considered a proxy for leachate production and infiltration at the two waste rock piles and would be a worst-case example because of the following issues:

1) Produced water had equilibrated with the ore material over a significantly longer period of time than leachate from the two waste rock piles would have equilibrated, and the ore body had higher concentrations of uranium than the waste rock; therefore, it is inferred that produced water would likely have contained higher concentrations of COPCs than leachate from the two waste rock piles.
2) The quantity of produced water discharged to the Dewatering Area is assumed to be significantly more than the amount from local precipitation. This resulted in (a) a larger hydraulic driving force that resulted in deeper transport of COPCs, and (b) greater total mass of COCs deposited on the Dewatering Area.

As part of the Site's removal site evaluation (RSE), surface and subsurface soil samples were collected from the Dewatering Area and analyzed for radium-226 (Ra-226) (CH2M HILL 2015[1]). The extreme mass loading in the Dewatering Area resulted in shallow soils having detections of Ra-226 at concentrations exceeding the risk-based action level (RBAL); however, Ra-226 was only detected to a maximum depth of 6.5 feet. This suggests that even under extreme mass loading conditions, COPCs in leachate from the two waste rock piles were not transported deep enough to adversely impact groundwater beneath the Site, which is hundreds of feet below the ground surface.

3.3 Former Mine Haul Roads

Evaluation of impacts along the former mine haul roads also indicate limited vertical transport of contaminants at the Site. The former mine haul roads near the two waste rock piles are not maintained. Surface and subsurface soils along these roads were sampled as part of the RSE and analyzed for metals and Ra-226. The presence of analytes decreased with depth and exceedances of the RBAL were limited to surface and near surface (less than 5 feet bgs) soils (CH2M HILL 2015). This shows that vertical transport of COPCs is unlikely at the Site, even where no cap is present.

3.4 Leachate Production at NAML Test Cell

In 2012, Navajo Abandoned Mine Lands (AML) Agency constructed a leachate test cell at the Plot 6 Mine Site, which is located in the Teec Nos Pos Chapter of the Navajo Nation. The Plot 6 Mine Site is located approximately 113 miles northwest of the Ruby Mines Site. This area has similar hydrogeologic conditions as the Ruby Mines Site, with respect to depths to aquifers and aquitards. In this area, several local aquifers and three regional aquifers lie in the Little Colorado River Plateau Basin, which is similar to the San Juan Basin to the east. The aquifers consist of sedimentary formations of sandstone and limestone that are stacked on top of one another and generally separated by impermeable shales and siltstones. Similar to the San Juan Basin, each aquifer has a large areal extent within the basin, but there is little vertical hydrologic connection between them. Precipitation rates in the Teec Nos Pos Chapter are similar to the precipitation rates at the Ruby Mines Site and it is assumed that evapotranspiration rates are comparable. The objective of the NAML leachate test cell was to evaluate a construction method for encapsulating waste rock that would be protective of migration to underlying geologic strata. The leachate test cell was constructed with a liner composed of a geomembrane between two geotextiles to separate mine waste

[1] On December 15, 2017, CH2M HILL Companies Ltd. and its subsidiaries including CH2M HILL, Inc. (CH2M) became part of Jacobs Engineering Group Inc. (Jacobs). CH2M performed the RSE work and prepared the RSE Report. Jacobs prepared the EE/CA. Jacobs and CH2M are referred to collectively as Jacobs.

and native soils. However, the leachate collection pipe is located above the liner system; therefore, the leachate collected represents the volume that would be discharged to native soils in an unlined cell (Attachment 1). Monitoring data for the test cell has not been made available by Navajo AML. On June 15, 2018, Jacobs attempted to collect a leachate sample from the test cell; however, there was insufficient fluid present in the system to sample (Attachment 1), which indicates that the cell continues to operate as designed and produce minimal leachate.

4. Conclusion

In summary, the two waste rock piles and impacted soils at the Site are unlikely to produce leachate and impact groundwater because: (1) intervening geologic materials provide both hydraulic and geochemical barriers to leachate transport; (2) the depth to aquifers sufficient to supply drinking water is substantial and recharge areas are not located near the Site, and (3) the lack of leachate produced by the two waste rock piles and impacted soils. Based on these lines of evidence, it is unlikely that COPCs associated with the two waste rock piles and impacted soils would migrate to groundwater beneath the Site.

5. References

This memorandum relies on previously published information about the regional geology, groundwater, climate, and relevant site-specific experiences, as listed below. The findings are not based on site-specific field work intended to support the evaluation. This technical memorandum should be read in full, with no excerpts to be representative of the findings. The conclusions of this memorandum should be reevaluated if and/or when site-specific data become available. The findings in the memorandum are excluded from any warranty/guarantee (expressed or implied) to the extent permitted by law. This technical memorandum was prepared exclusively for Western Nuclear, Inc. and no liability is accepted for any use or reliance on the report by third parties.

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Table

Table 1. Groundwater Wells near Ruby Mines Site, Listed in Stratigraphic Order and by Well Depth.

Well Identifier	Total Depth of Well (feet)	Static Water Level (feet) in Well	Use	Aquifer Code[C]	Approximate Distance to Ruby Mines Site
Smith Lake 01 Smith Lake Mission	679	355	Domestic/Livestock	211 DKOT	4 miles east northeast
16K-325	696	399	Domestic	211 DKOT	4 miles northeast
16K-327 Old Smith Lake Chpt Well	701	399	Municipal	211 DKOT	4 miles northeast
Smith Lake 02 Smith Lake Trading Post	1,100	9[b]	Domestic	211 DKOT	4 miles east northeast
16T-597 Smith Lake #2	1,939	475	Municipal	211 DKOT	5 miles east northeast
16T-594 Smith Lake #1	2,024	407	Municipal	211 DKOT	5 miles east northeast
Smith Lake 03 Smith Lake T.P. Test Well	1,100	600	Not found/Other	221 WSRC	4 miles east northeast
16K-525	1,221	Unknown	Livestock	221 WSRC	4 miles northeast
16T-325 Smith Lake Chpt Hse Well	1,800	610	Not found- Livestock/Municipal	221 WSRC 221 CSPG	4 miles northeast
16T-519	1,275	502	Livestock	221 CSPG	1 mile northwest
16T-591 Smith Lake #2	1,400	562	Domestic	221 CSPG	1 mile north
16-unk-0002 15N 13W 21 14	1,308	676	Industrial-Mine Dewatering	221 ENRD	1/2 mile northwest
16T-593 Smith Lake MUT HELP HSG	1,620	462	Domestic	221 ENRD	4 miles northeast
16-unk-0005 15N 12W 17 11111	3,170	670	Municipal	221 ENRD	4 miles northeast
16-unk-0006 15N 13W 25 1423	3,102	550	Industrial-Mine Dewatering	313 SADG	1 mile east
16-649	Unknown	Unknown	Industrial-Mine Dewatering	unknown	1/2 mile northwest
16-41[a] Leo House (developed spring)	0	0	Not found/Abandoned Domestic/ Livestock	unknown	1 mile north
Leo House Leo House Family Well	1355	712	Livestock	unknown	1 mile north
16-31[a] Ruby Well (developed spring)	10	0	Not reported	unknown	Onsite

Source: https://www.arcgis.com/home/webmap/viewer.html?useExisting=1&layers=0aaf3464feba46b7ae6041a8d0a67372

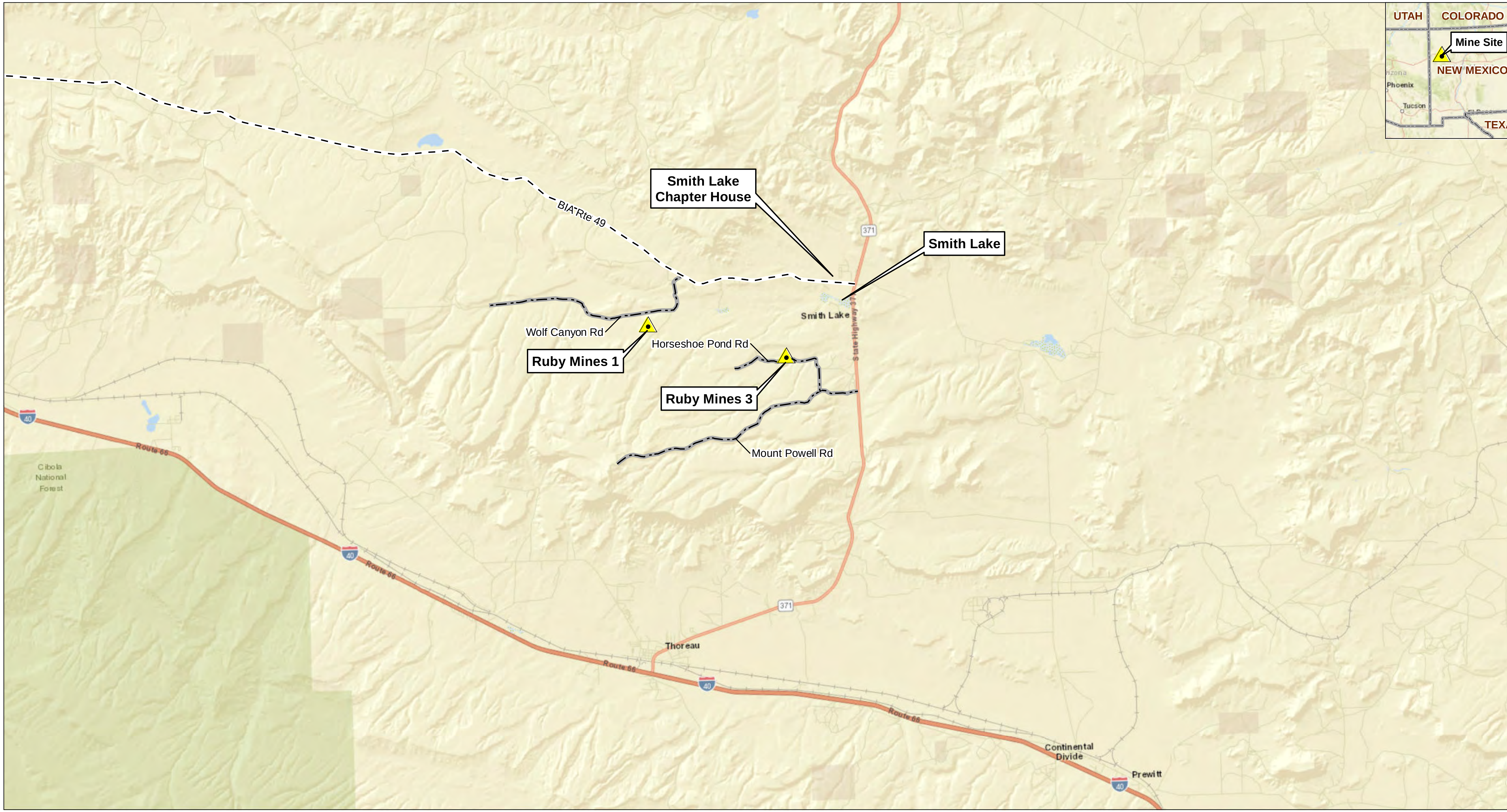
Notes

[a] Review of recent aerial imagery (Google Earth 2020) shows no surface evidence of groundwater discharge (dark or reflective areas suggestive of wet soil or standing water, green deciduous vegetation suggestive of shallow groundwater, or stock tanks and residences indicating the use of water) at these locations. Site visits conducted during the RSE (Jacobs 2015) revealed that well 16-31 is abandoned and no longer used.

[b] The depth to water reported for the Smith Lake 02 wells is considered an anomaly because this well has approximately the same location and exactly the depth as the Smith Lake 03 well which has a substantially deeper static water level, which is consistent with other nearby wells.

[C] USGS Aquifer Codes: DKOT=Dakota, WSRC=Westwater Canyon Sandstone, CSPG=Cow Springs Sandstone, ENRD=Entrada Sandstone, SADG=San Andres Limestone and Glorietta Sandstone

Figures



LEGEND

- Ruby Mines Location
- Major Road
- Maintained Gravel Road

N

0 6,250 12,500 25,000
Feet
1:150,000 1 inch = 12,500 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Topographic Imagery: ESRI ArcGIS online

Figure 1. Ruby Mines General Location Map

Jacobs

SLC \\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\FIGURE 1-2_RM GENERAL LOCATION MAP.MXD AESPEJO 12/13/2018 12:26:00

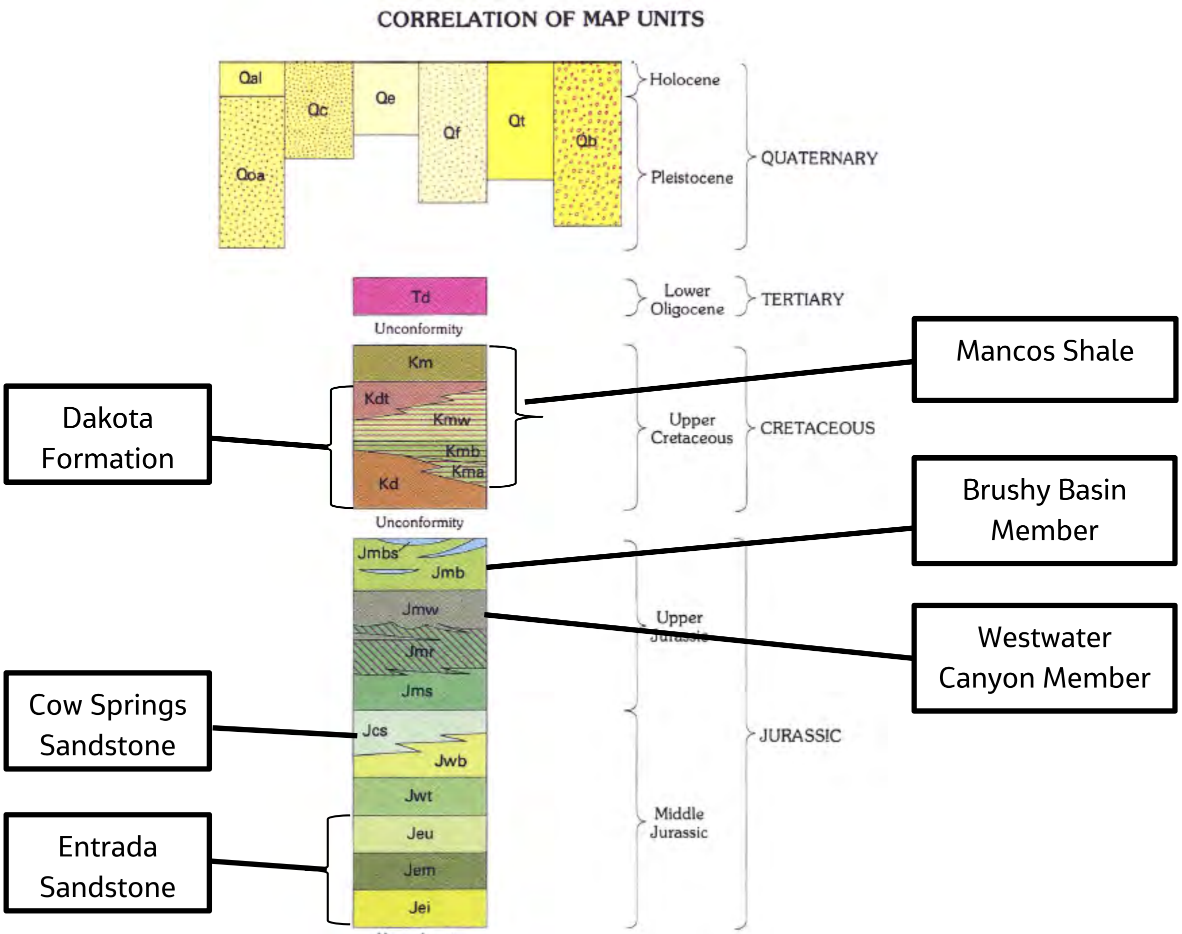


Figure 2. Geologic Stratigraphy of the Thoreau Northeast Quadrange.

Note: The Cretaceous Mancos (Km) and Dakota Formations (Kd, Kdt) overly the ore bearing Brushy Basin Member (Jmb and Jmbs) of the Jurassic Morrison Formation. Drinking water is typically extracted from the Dakota Formation (Kd, Kdt), Westwater Canyon (Jmw) member of the Morrison Formation, Cow Springs Sandstone (Jcs), and the Entrada Sandstone (Jeu, Jem, Jei).

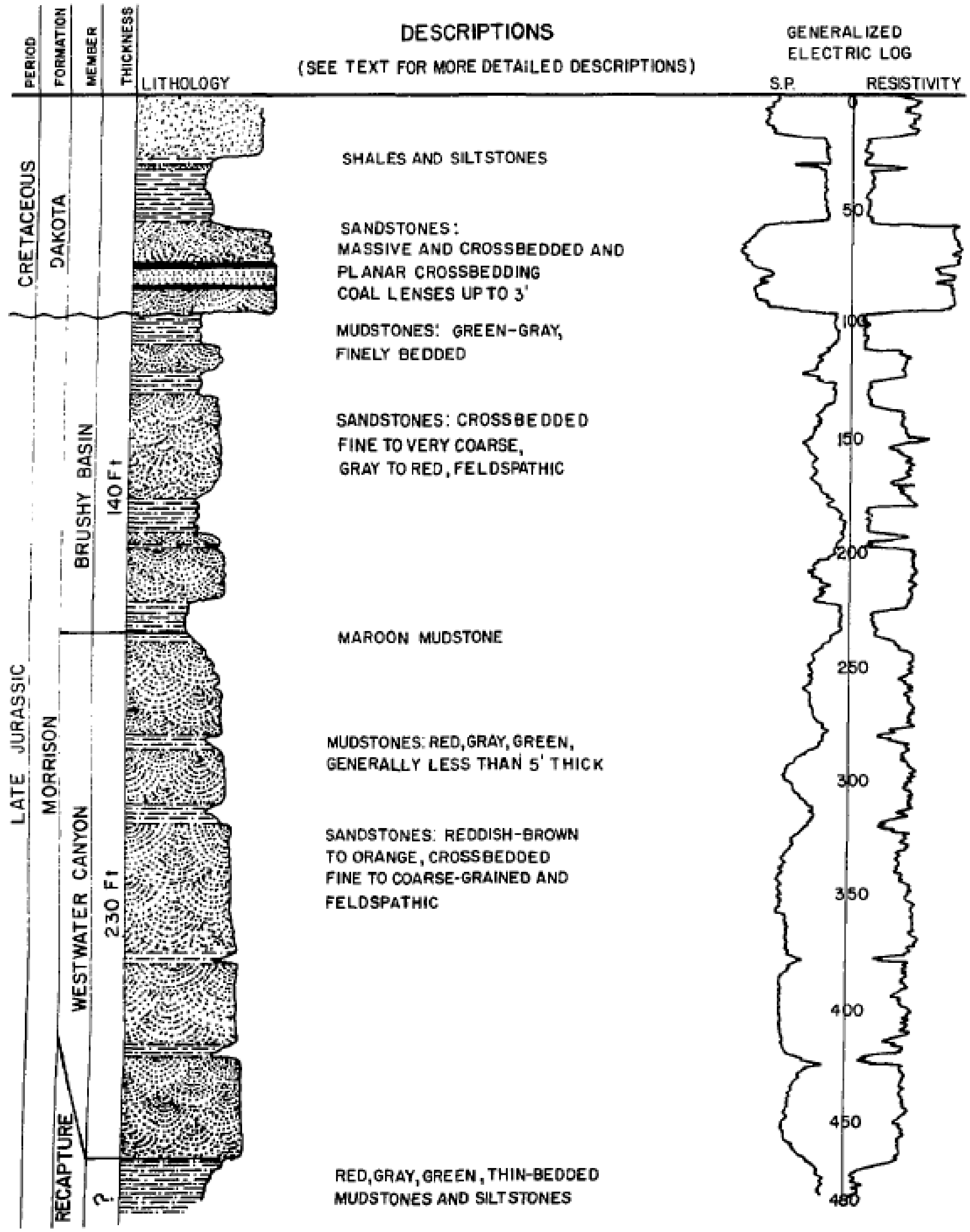


Figure 3. Generalized Stratigraphic Section and Electric Log of the Morrison Formation at Smith Lake (Ristorcelli 1980)

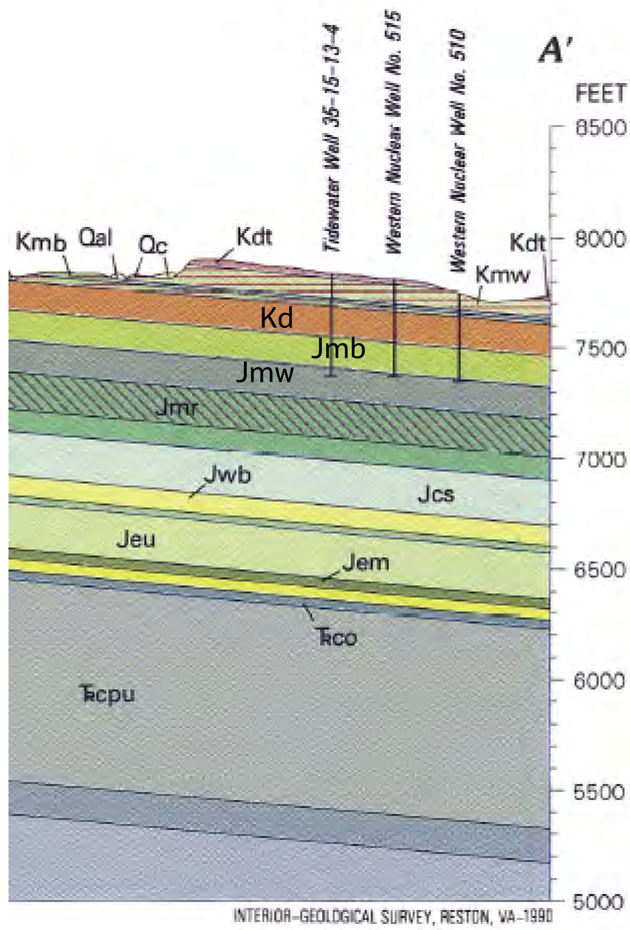


Figure 4. Geologic Stratigraphic Cross-section Near the Ruby Mine

LEGEND

- Ruby Mines Location
- Water Well
- Developed Spring
- Major Road
- Maintained Gravel Road

N

0 1,500 3,000 6,000

Feet

1:36,000 1 inch = 3,000 feet

Coordinate System: North American Datum1983
New Mexico State PlaneWest Federal Information
Processing Standards 3003;
Mine Locations CH2M Hill Engineers, Inc. 2014;
Topographic Imagery: ESRI ArcGIS online

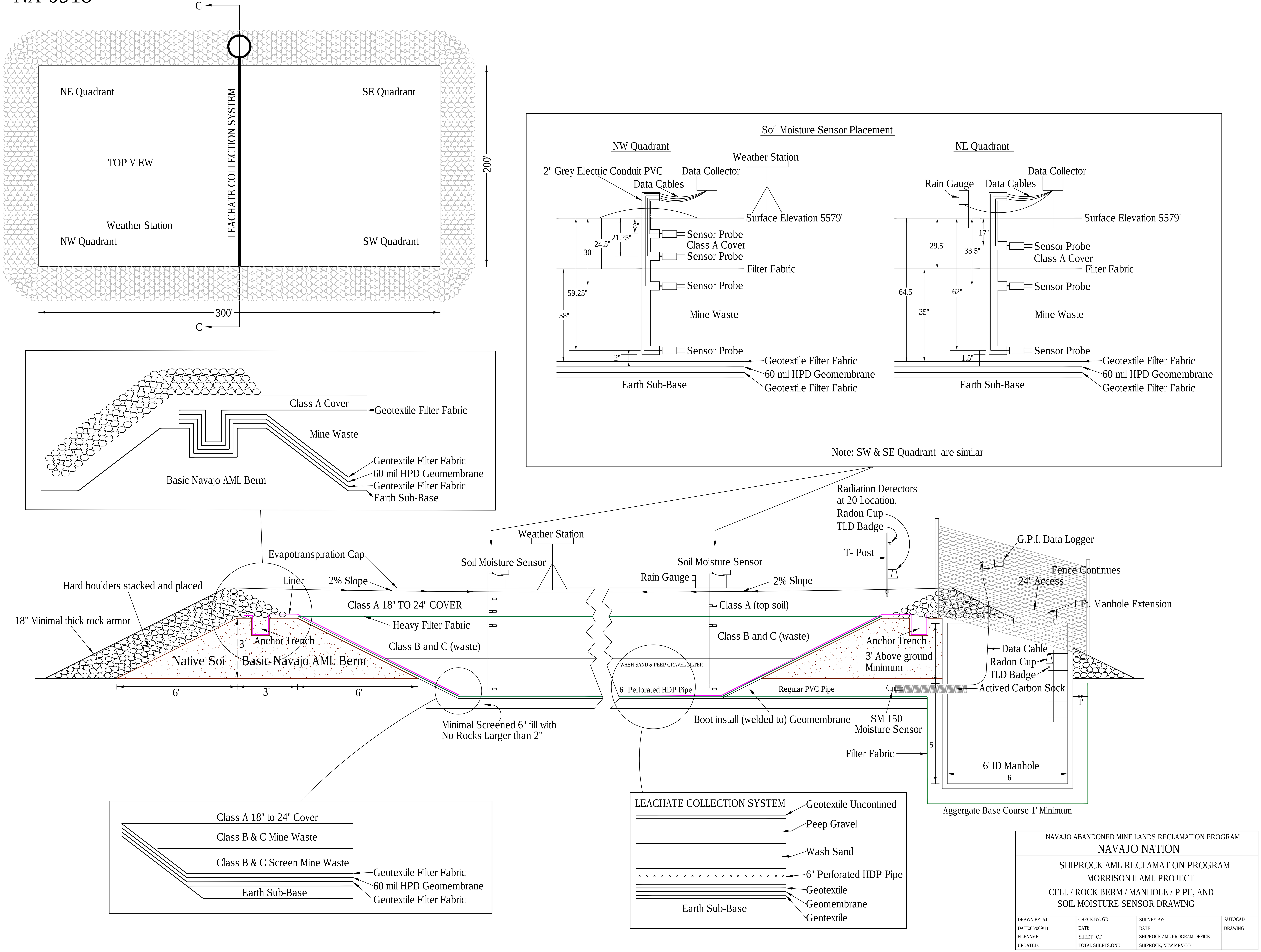
Figure 5. Groundwater Wells Near Ruby Mines Site

SLC \\BROOKSIDEFILES\GIS_SHARE\ENBG\00_PROJ\F\FREEPORT\RUBYMINE\MAPFILES\EECA\FIGURE 5_GW WELLS NEAR RUBY MINES SITE.MXD AESPEJO 4/3/2020 08:23:32

Jacobs

Attachment 1. Additional Information

DIAGRAM 9
NA-0918



JACOBS

Water Sampling Log

Log Date:	6/15/2018	**Time:**	13:11
Name:	Josh Yount	**Project:**	FCUP Navajo Nation

MINE INFORMATION

Mine Area:	Tse Tah
Mine Area Abbreviation:	TT
Sample Location:	Well Water
Sample Number:	001
Sample ID:	**TT-WW-001-06152018**
	☐ Split Sample Provided to U.S. EPA?
Comments:	No sample collected due to not enough water present.
Location ID:	Plot 6 cell leachate

SAMPLE INFORMATION

Sample Depth:	0 ***(ft)***
Initial Depth to Water:	0 ***(ft)***
Sample Crew's Initials:	JL, JY
Comments (Odor, Cementation, etc.)	No water present, estimated 1-in of wet slushy sediment in bottom of leachate collection manhole. Not enough water to sample. No sample collected.
Sample Collection Method:	
If Other, Describe:	

GPS LOCATION

latitude	36.90024094	**altitude**	1686
longitude	-109.2691511	**velocity**	0
timestamp	Jun 15, 2018 01:16:01 PM	**accuracy**	16.687

WATER PARAMETERS

Time	DTW (ft)	Flow Rate (0.3-0.5 ml/min)	Turbidity (NTU)	Temp (C)	SC (mS/cm)	DO (%)	DO (mg/L)	pH
	0	0	0	0	0	0	0	0

Source: WaterSample_TT-WW-001-06152018_2018-06-15T17_26_57.xml

PHOTOS

Photo of Sample in Jar

Photo of Area where Sample was Taken

Source: *WaterSample_TT-WW-001-06152018_2018-06-15T17_26_57.xml*

** SAMPLE QA/QC - Verify in Office against COC **

QA/QC Sample Taken?:	No
QA/QC Sample Type:	
QA/QC Sample ID:	
QA/QC Sample Time:	
QA/QC Sample Type:	
QA/QC Sample ID:	
QA/QC Sample Time:	
QA/QC Sample Type:	
QA/QC Sample ID:	
QA/QC Sample Time:	
QA/QC Sample Type:	
QA/QC Sample ID:	
QA/QC Sample Time:	

Field QC Check Name:	Natalie Dowdy
In-office QC Check Name:	Gavin Wagoner

Appendix F
SiteWise Analysis

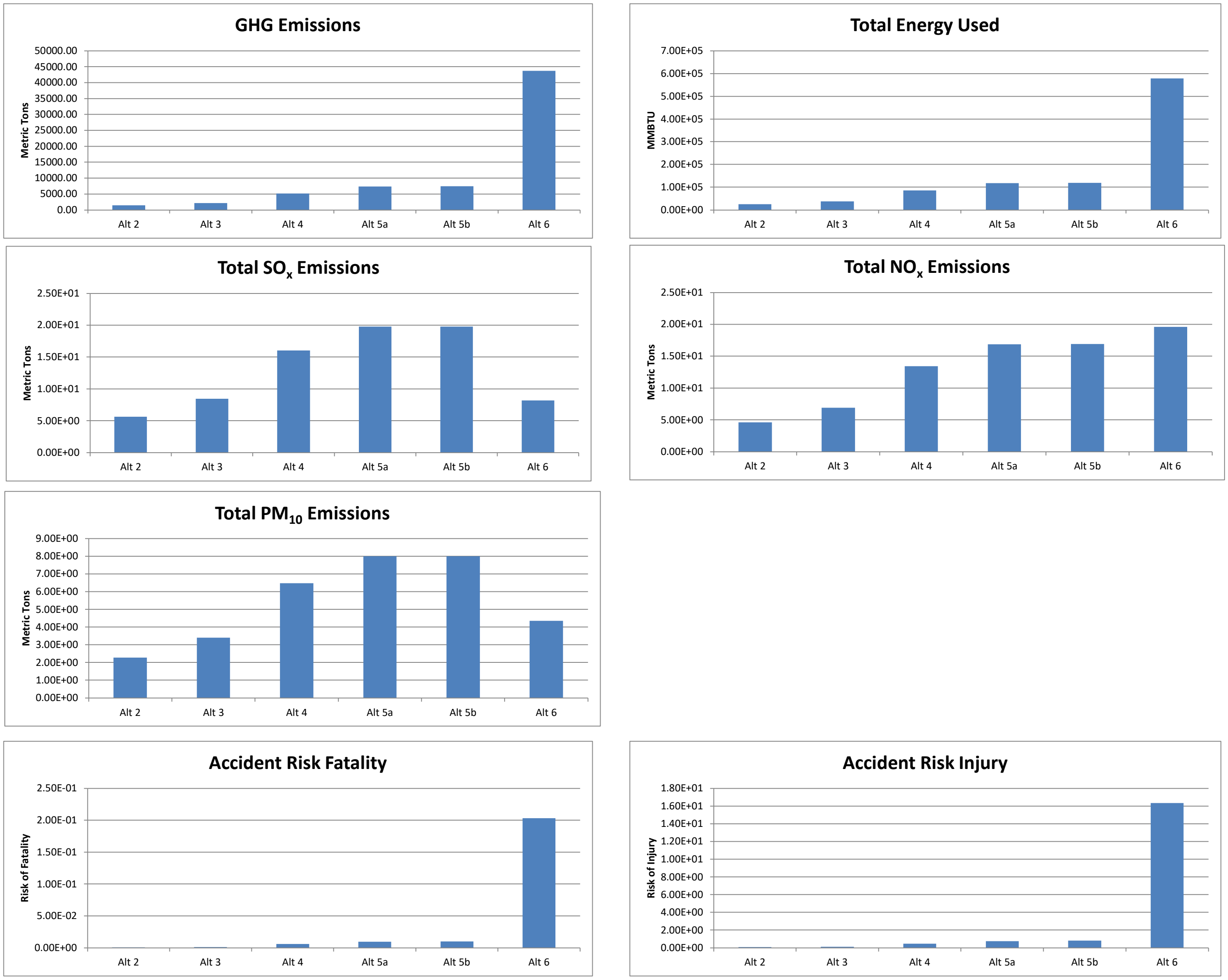
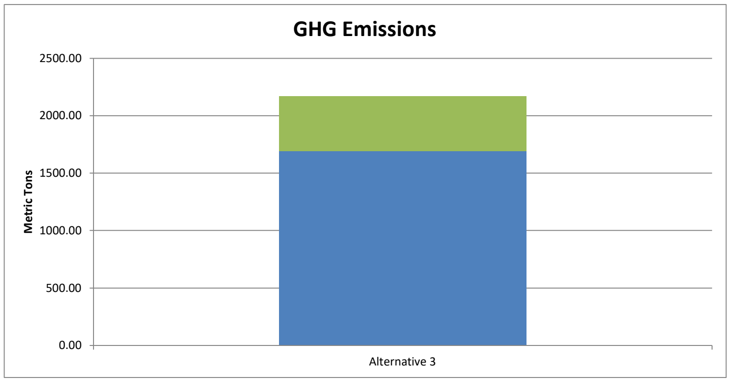
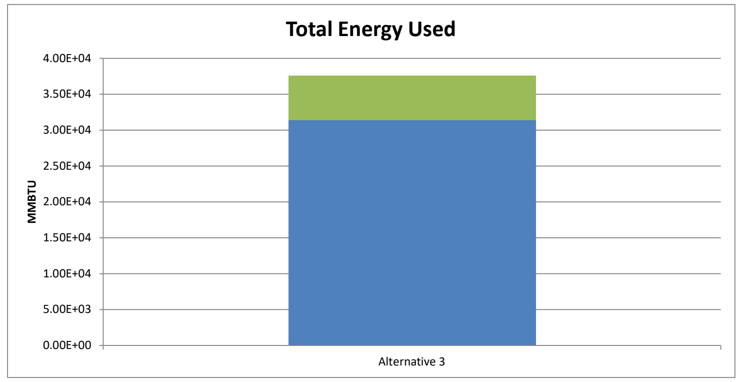


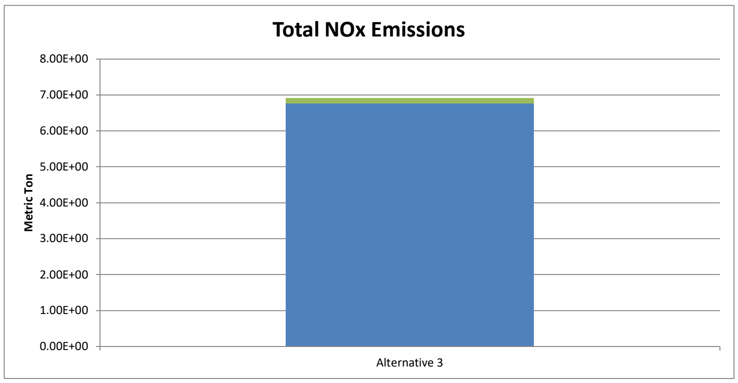
FIGURE F-1
Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

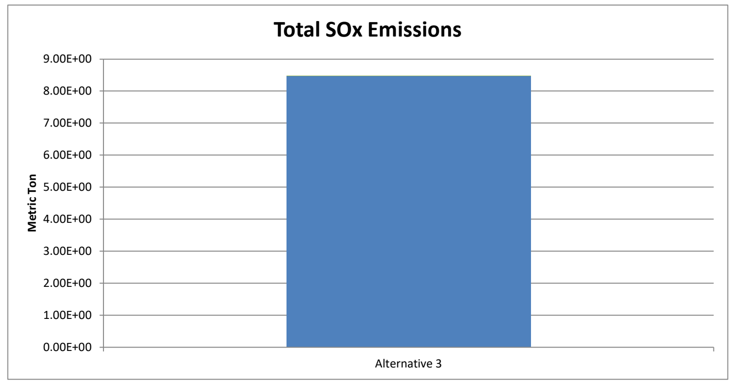
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

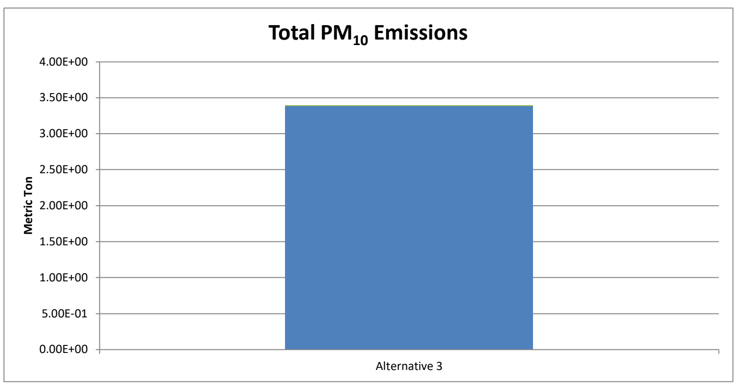
FIGURE F-2
Alternative 2 - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

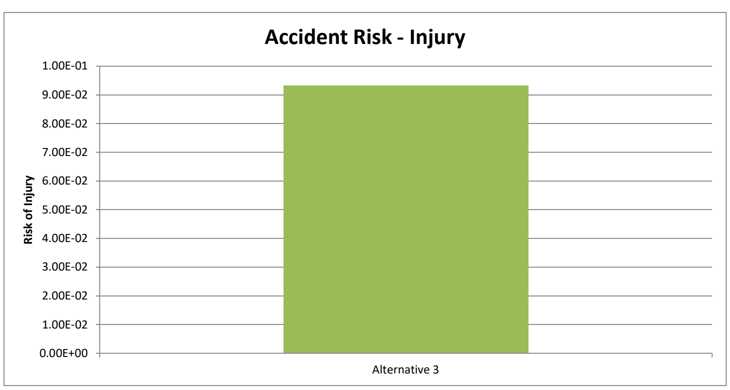






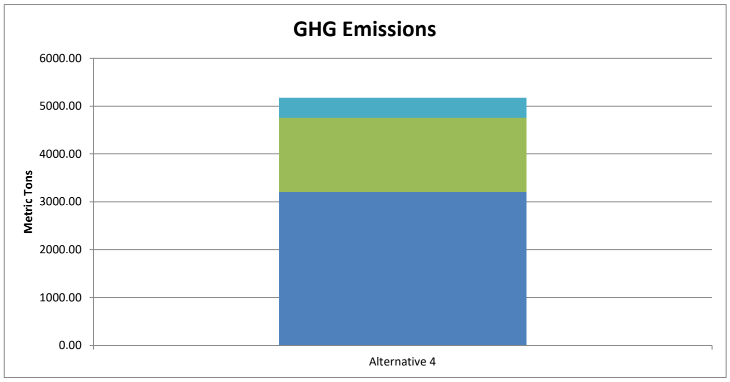


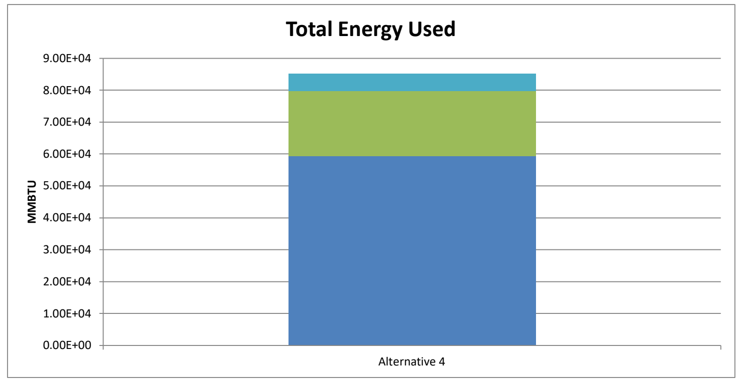


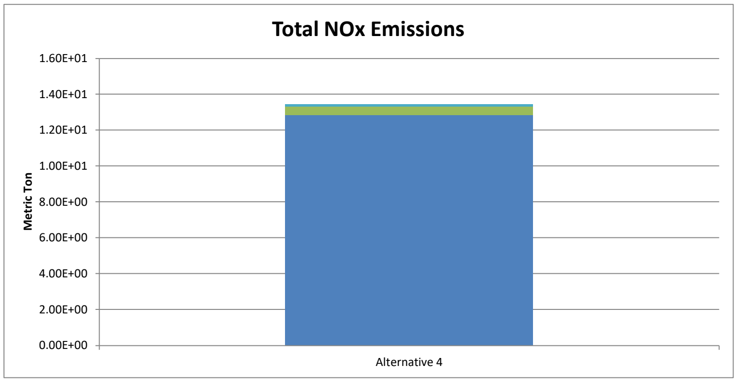


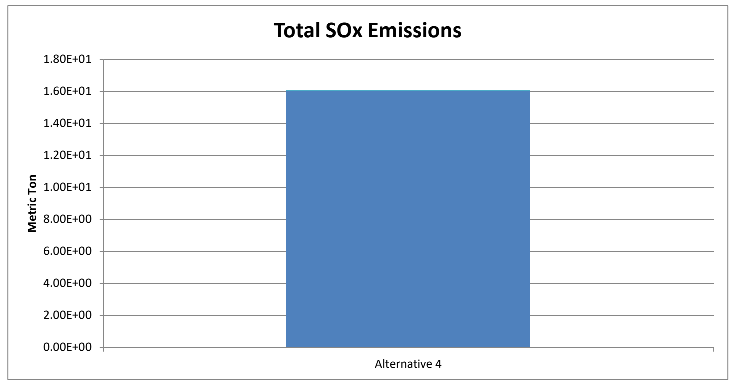
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

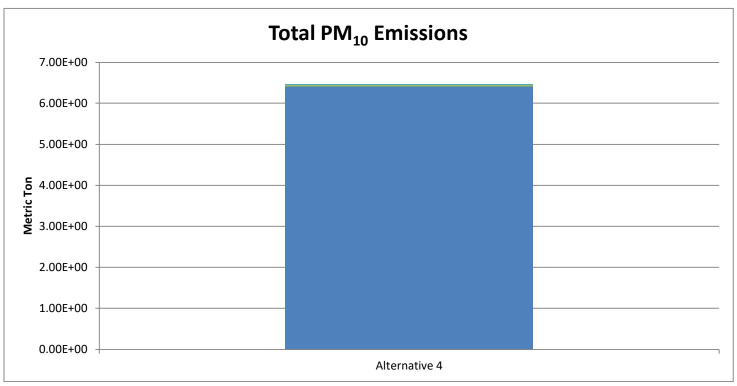
FIGURE F-3
Alternative 3 - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

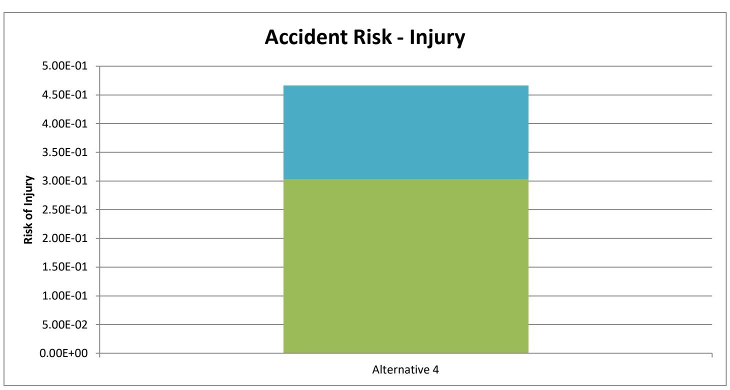


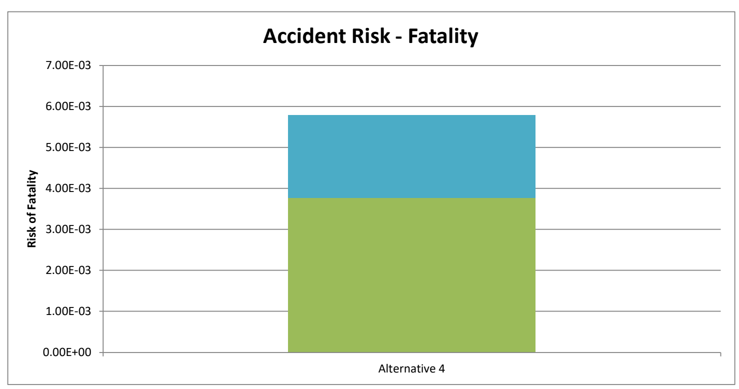












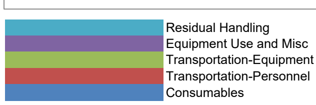
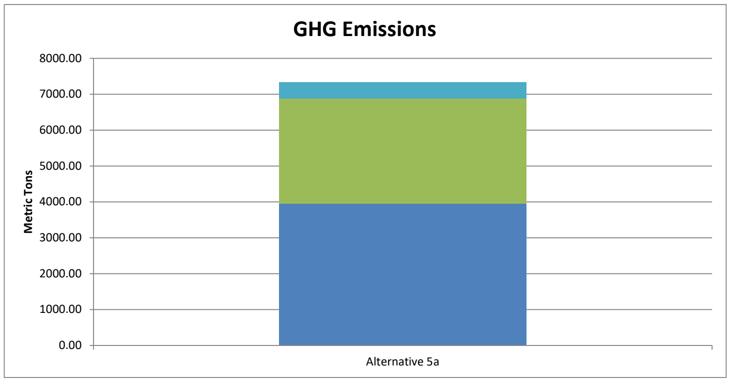
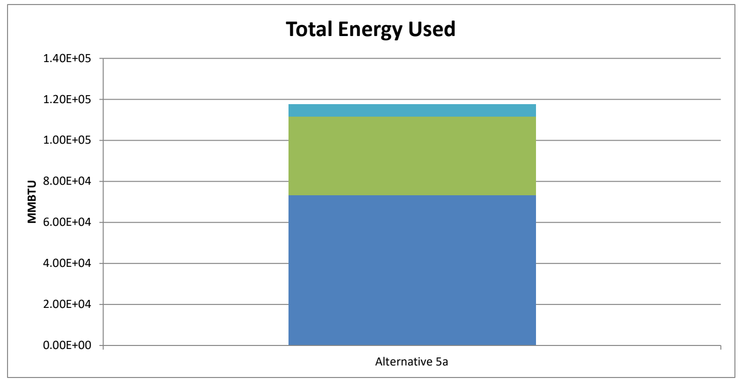
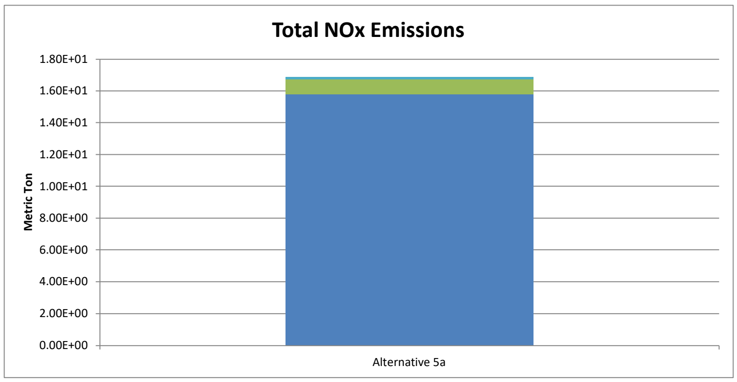
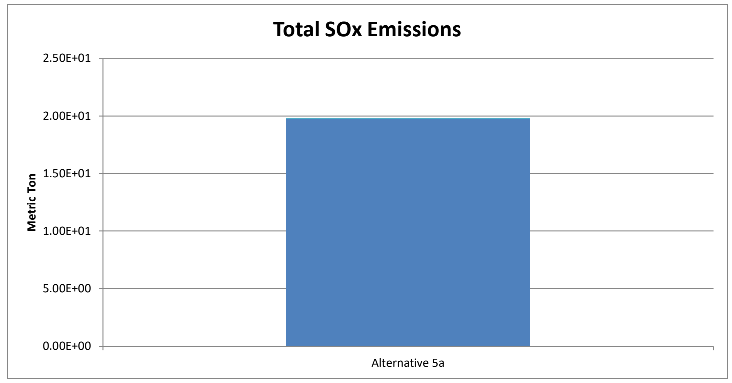


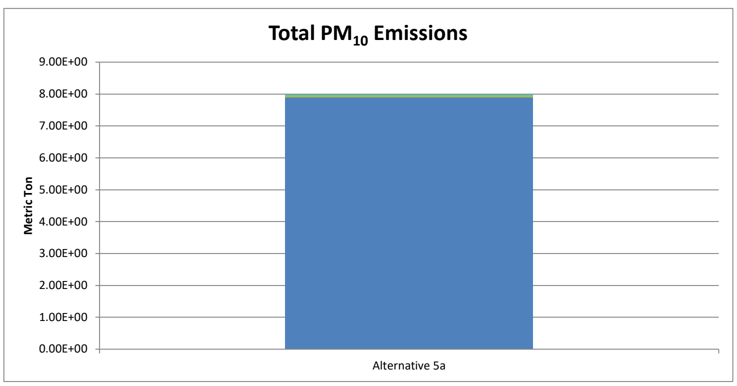
FIGURE F-4
Alternative 4 - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

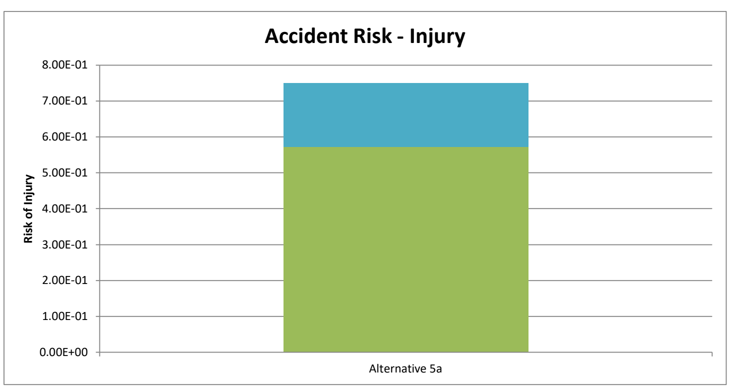


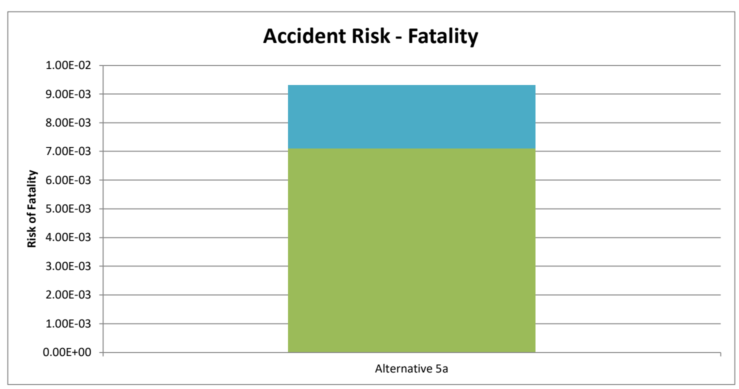






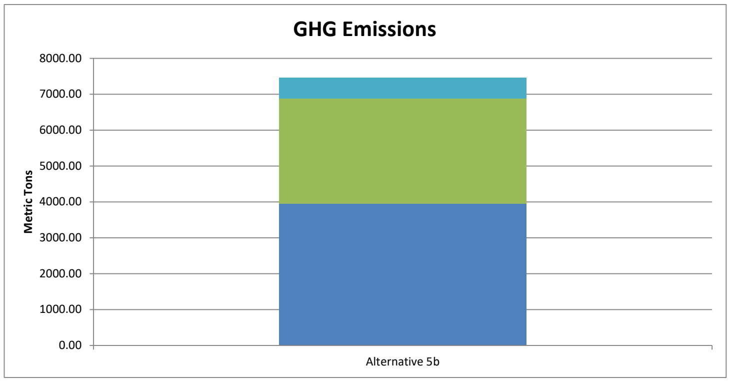


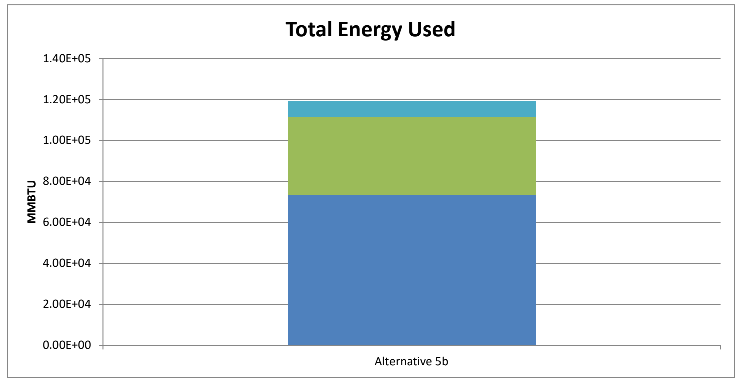


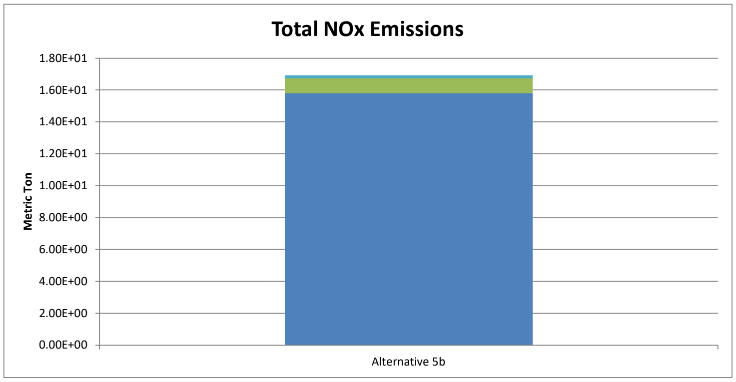


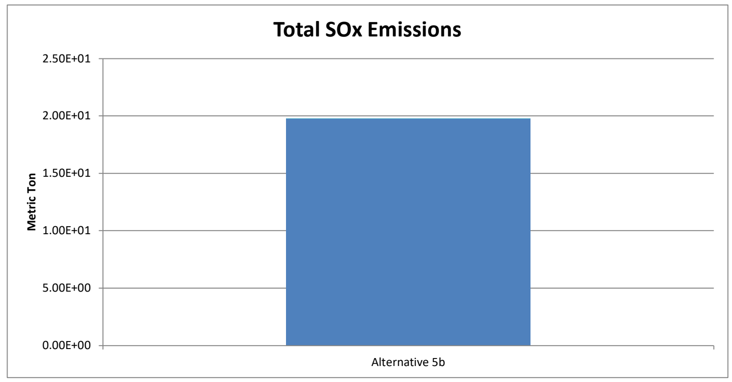
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

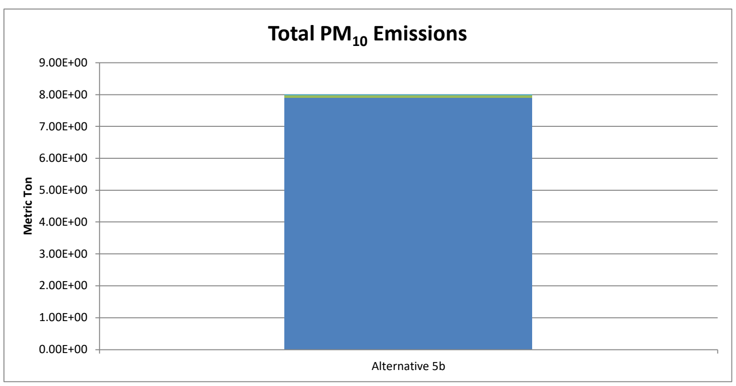
FIGURE F-5
Alternative 5a - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

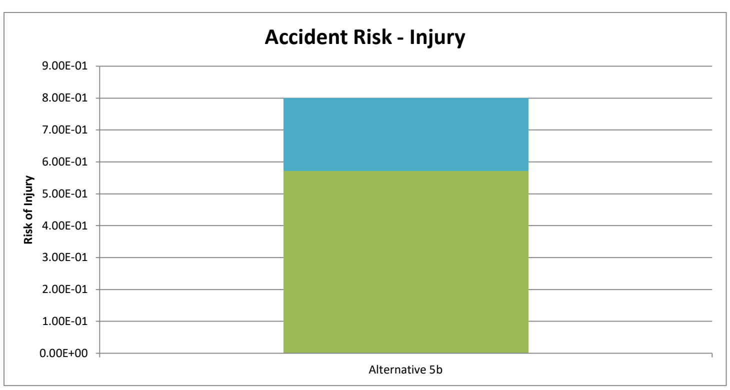


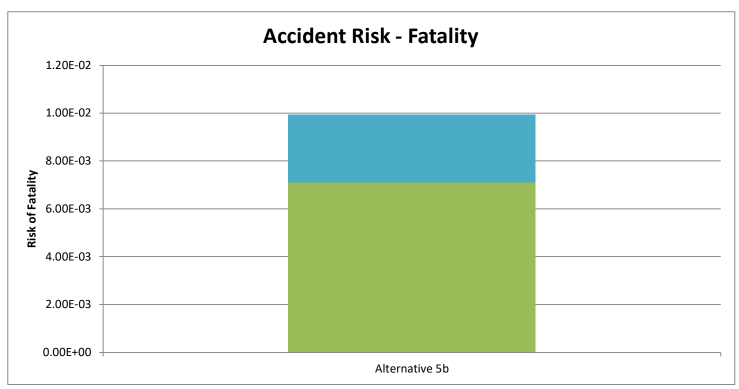






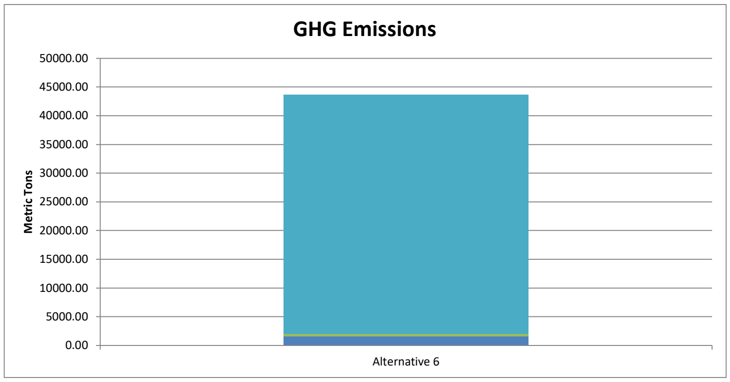


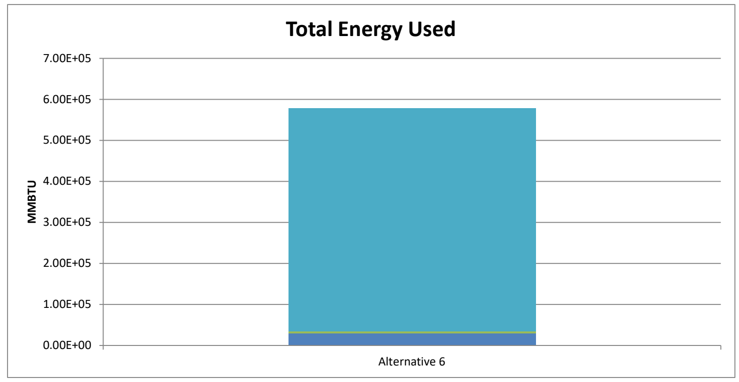


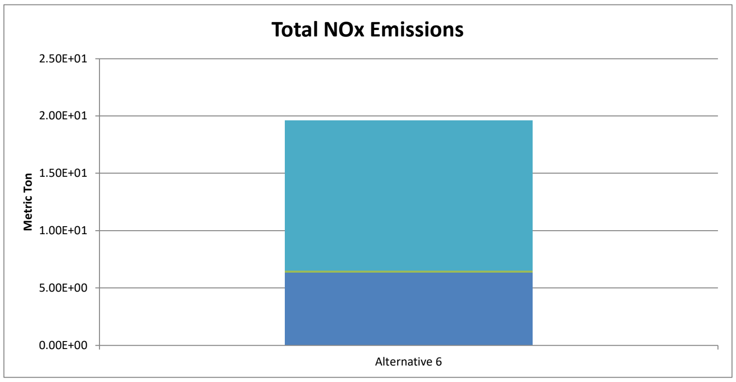


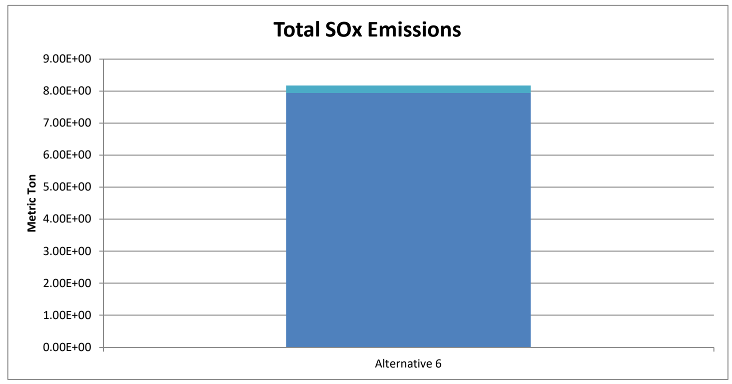
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

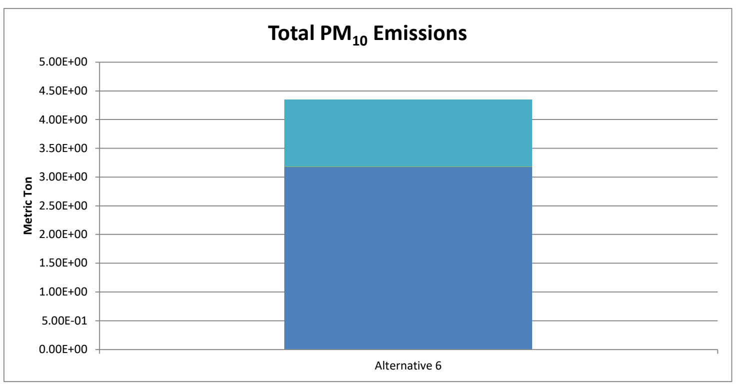
FIGURE F-6
Alternative 5b - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

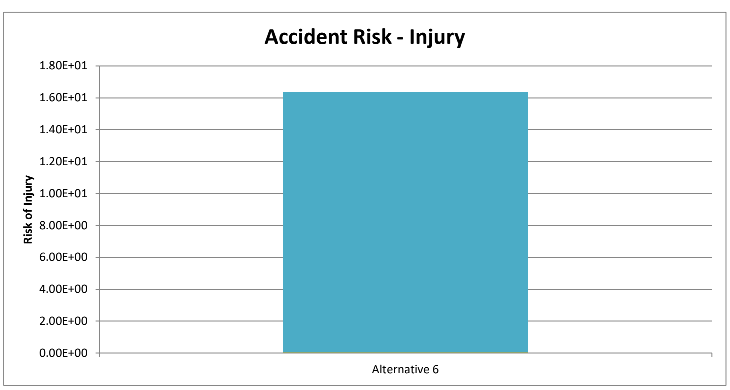


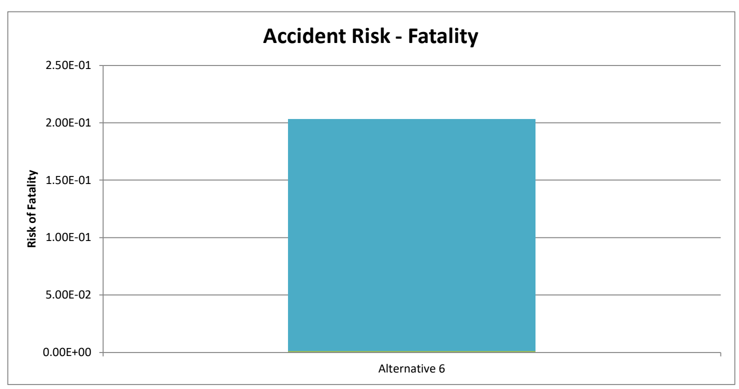












Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

FIGURE F-7
Alternative 6 - Sustainability Analysis Summary
Engineering Evaluation and Cost Analysis
Ruby Mines Site

Appendix G
Cost Estimates

Table G-1. Summary

Engineering Evaluation and Cost Analysis

Ruby Mines

Ruby Mines Site EE/CA						
Cost Type	Alternative 2 Consolidate and Repair Existing Caps	Alternative 3 Consolidate and Cap at Each Site	Alternative 4 Consolidate and Cap at One Site (Ruby 1)	Alternative 5a Excavate and Manage at Regional Repository (Black Jack No. 1)	Alternative 5b Excavate and Manage at Regional Repository (Mac No. 1)	Alternative 6 Excavate and Manage at off-Reservation
Total Estimated Present Worth Costs						
Capital Cost	$4,140,678	$6,183,394	$16,246,745	$25,309,728	$25,488,750	$343,622,857
O&M Cost	$1,784,400	$1,784,400	$1,784,400	$1,873,620	$1,873,620	$89,220
Periodic Cost	$478,560	$478,560	$478,560	$478,560	$478,560	$13,262
Total Estimated Costs	$6,403,638	$8,446,354	$18,509,705	$27,661,908	$27,840,930	$343,725,339
Net Present Value	$6,033,021	$8,075,736	$18,139,088	$27,171,274	$27,350,296	$343,723,689
Estimated Range of Costs	From	From	From	From	From	From
-30%	$4,482,547	$5,912,448	$12,956,794	$19,363,335	$19,488,651	$240,607,737
	To	To	To	To	To	To
+50%	$9,605,458	$12,669,531	$27,764,558	$41,492,862	$41,761,395	$515,588,008

Table G-2. Alternative 2: Consolidate and Repair Existing Caps

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost
Part 1: Ruby Mines No. 1						
1	1.1	Consolidate material from impacted soils (for example, haul roads, work areas, drainages,) within existing capped waste rock pile	37,500	yd^3	$ 7.12	$ 266,991.75
2	1.2	Excavate and consolidate material from vents	500	yd^3	$ 8.87	$ 4,436.00
3	1.3	Regrade waste rock pile as necessary to create uniform, stable slopes	198,000	ft^2	$ 0.83	$ 164,686.50
4	1.4	Supply and place 2-foot-thick soil cap from Schumacher Pit in Thoreau	14,700	yd^3	$ 16.65	$ 244,697.52
5	1.5	Realign/regrade perimeter surface water drainage channels to stable	450	ft.	$ 16.83	$ 7,575.58
6	1.6	Revegetate cap and excavated areas	12	acre	$ 3,327.00	$ 39,924.00
7	1.7	Post-excavation status survey sampling	1	l.s.	$ 277,250.00	$ 277,250.00
Part 2: Ruby Mines No. 3						
8	2.1	Consolidate material from impacted soils (for example, haul roads, work areas, drainages,) within existing capped waste rock pile	42,000	yd^3	$ 7.12	$ 299,030.76
9	2.2	Regrade waste rock pile as necessary to create uniform, stable slopes	270,000	ft^2	$ 0.83	$ 224,572.50
10	2.3	Supply and place 2-foot-thick soil cap from Schumacher Pit in Thoreau	20,000	yd^3	$ 16.65	$ 332,921.80
11	2.4	Realign/regrade perimeter surface water drainage channels to stable	375	ft	$ 16.83	$ 6,312.98
12	2.5	Fill Ruby Mines No. 3 Adit subsidence with material from Schumacher Pit in Thoreau	50	yd^3	$ 23.68	$ 1,183.86
13	2.6	Revegetate cap and excavated areas	14	acre	$ 3,327.00	$ 46,578.00
14	2.7	Post-excavation status survey sampling	1	l.s.	$ 277,250.00	$ 277,250.00
Part 3: Site Planning and Permitting						
15	3.1	Environmental Permitting	1	l.s.	$ 55,450.00	$ 55,450.00
	Estimate Total Excluding Taxes (Combined Sections 1 and 2)					**$ 2,193,411.25**
	Estimate Total Excluding Taxes (Combined Section 3)					**$ 55,450.00**
					Navajo Nation Gross Receipts Taxes (6%)	**$ 131,604.68**
					Mobilization/Demobilization (10%)	**$ 219,341.13**
					Engineering (15%)	**$ 361,912.86**
					Construction Management (15%)	**$ 361,912.86**
					Contingency (25%)	**$ 817,045.69**
SUBTOTAL CAPITAL COST						**$ 4,140,678.46**

Part 4: Long-term Monitoring and Maintenance Total Estimated Costs			
See Alternative 2 Net Present Value Worksheet			
16	4.1	Annual-Inspection, Maintenance, and Reporting; 5 yr Review and Maintenance	$ 2,262,960.00
		Total Estimated Costs	**$ 6,403,638.46**
		Net Present Value	**$ 6,033,021.04**
		Total Estimated Costs Lower Range (-30%)	$ 4,482,546.92
		Total Estimated Costs Upper Range (+50%)	$ 9,605,457.69

Notes:

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered "order-of-magnitude" estimates, with an expected accuracy of -30% to +50%

All volumes are in place volumes

% = percent

$ = U.S. dollar

\+ = plus

\- = minus

ft. = foot (feet)

ft^3 = cubic foot (feet)

ft^2 = square foot (feet)

l.s. = lump sum

yd^3 = cubic yard

Table G-3. NPV Alternative 2

Engineering Evaluation and Cost Analysis

Ruby Mines

Annual O&M Cost					
Description	**Years**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Annual Inspection and Reporting	100	100	EA	$ 17,844.00	$ 1,784,400
				100 YR Total	**$1,784,400**

Periodic Costs					
Description	**Year**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Maintenance - Fix Erosion and Revegetate (Every 5 Year)	0-100	20	EA	$ 10,666.00	$ 213,320.00
5 Year Review	0-100	20	EA	$ 13,262.00	$ 265,240.00
			Total Periodic Costs		$ 478,560.00
				Total Annual and Periodic Costs	**$ 2,262,960.00**

Present Value Analysis

Discount Rate =	0.5%	For Federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of OMB Circular A-94 (OMB 2020). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. Because the Federal government has a different "cost of capital" than the private sector, these rates are appropriate to use for adjusting future year expenditures in a present value calculation for Federal facility remediation projects. Annual & periodic costs should be constant in this analysis. Source: U.S. EPA 2000.

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Capital Cost	0	$ 4,140,678	$ 4,140,678	1.00	$ 4,140,678.46
Annual O&M Cost	1 to 100		$ 17,844	78.54	$ 1,401,514.95
Periodic Cost	1			1.00	$ -
Periodic Cost	2			0.99	$ -
Periodic Cost	3		$ 10,666	0.99	$ 10,507.60
Periodic Cost	4			0.98	$ -
Periodic Cost	5		$ 13,262	0.98	$ 12,935.37
Periodic Cost	6		$ 10,666	0.97	$ 10,351.55
Periodic Cost	7			0.97	$ -
Periodic Cost	8			0.96	$ -
Periodic Cost	9		$ 10,666	0.96	$ 10,197.81
Periodic Cost	10		$ 13,262	0.95	$ 12,616.78
Periodic Cost	11			0.95	$ -
Periodic Cost	12		$ 10,666	0.94	$ 10,046.36
Periodic Cost	13			0.94	$ -
Periodic Cost	14			0.93	$ -

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	15		$ 23,928	0.93	$ 22,203.20
Periodic Cost	16			0.92	$ -
Periodic Cost	17			0.92	$ -
Periodic Cost	18		$ 10,666	0.91	$ 9,750.18
Periodic Cost	19			0.91	$ -
Periodic Cost	20		$ 13,262	0.91	$ 12,002.94
Periodic Cost	21		$ 10,666	0.90	$ 9,605.37
Periodic Cost	22			0.90	$ -
Periodic Cost	23			0.89	$ -
Periodic Cost	24		$ 10,666	0.89	$ 9,462.72
Periodic Cost	25		$ 13,262	0.88	$ 11,707.32
Periodic Cost	26			0.88	$ -
Periodic Cost	27		$ 10,666	0.87	$ 9,322.19
Periodic Cost	28			0.87	$ -
Periodic Cost	29			0.87	$ -
Periodic Cost	30		$ 23,928	0.86	$ 20,602.72
Periodic Cost	31			0.86	$ -
Periodic Cost	32			0.85	$ -
Periodic Cost	33		$ 10,666	0.85	$ 9,047.35
Periodic Cost	34			0.84	$ -
Periodic Cost	35		$ 13,262	0.84	$ 11,137.73
Periodic Cost	36		$ 10,666	0.84	$ 8,912.99
Periodic Cost	37			0.83	$ 8,868.65
Periodic Cost	38			0.83	$ -
Periodic Cost	39		$ 10,666	0.82	$ 8,780.62
Periodic Cost	40		$ 13,262	0.82	$ 10,863.42
Periodic Cost	41			0.82	$ -
Periodic Cost	42		$ 10,666	0.81	$ 8,650.22
Periodic Cost	43			0.81	$ -
Periodic Cost	44			0.80	$ -
Periodic Cost	45		$ 23,928	0.80	$ 19,117.61
Periodic Cost	46			0.79	$ -
Periodic Cost	47			0.79	$ -
Periodic Cost	48		$ 10,666	0.79	$ 8,395.19
Periodic Cost	49			0.78	$ -
Periodic Cost	50		$ 13,262	0.78	$ 10,334.89
Periodic Cost	51		$ 10,666	0.78	$ 8,270.51
Periodic Cost	52			0.77	$ -

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	53			0.77	$ -
Periodic Cost	54		$ 10,666	0.76	$ 8,147.69
Periodic Cost	55		$ 13,262	0.76	$ 10,080.35
Periodic Cost	56			0.76	$ -
Periodic Cost	57		$ 10,666	0.75	$ 8,026.68
Periodic Cost	58			0.75	$ -
Periodic Cost	59			0.75	$ -
Periodic Cost	60		$ 23,928	0.74	$ 17,739.55
Periodic Cost	61			0.74	$ -
Periodic Cost	62			0.73	$ -
Periodic Cost	63		$ 10,666	0.73	$ 7,790.04
Periodic Cost	64			0.73	$ -
Periodic Cost	65		$ 13,262	0.72	$ 9,589.92
Periodic Cost	66		$ 10,666	0.72	$ 7,674.35
Periodic Cost	67			0.72	$ -
Periodic Cost	68			0.71	$ -
Periodic Cost	69		$ 10,666	0.71	$ 7,560.37
Periodic Cost	70		$ 13,262	0.71	$ 9,353.73
Periodic Cost	71			0.70	$ -
Periodic Cost	72		$ 10,666	0.70	$ 7,448.09
Periodic Cost	73			0.69	$ -
Periodic Cost	74			0.69	$ -
Periodic Cost	75		$ 23,928	0.69	$ 16,460.83
Periodic Cost	76			0.68	$ -
Periodic Cost	77			0.68	$ -
Periodic Cost	78		$ 10,666	0.68	$ 7,228.51
Periodic Cost	79			0.67	$ -
Periodic Cost	80		$ 13,262	0.67	$ 8,898.65
Periodic Cost	81		$ 10,666	0.67	$ 7,121.16
Periodic Cost	82			0.66	$ -
Periodic Cost	83			0.66	$ -
Periodic Cost	84		$ 10,666	0.66	$ 7,015.40
Periodic Cost	85		$ 13,262	0.65	$ 8,679.48
Periodic Cost	86			0.65	$ -
Periodic Cost	87		$ 10,666	0.65	$ 6,911.21
Periodic Cost	88			0.64	$ -
Periodic Cost	89			0.64	$ -
Periodic Cost	90		$ 23,928	0.64	$ 15,274.28

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	91			0.64	$ -
Periodic Cost	92			0.63	$ -
Periodic Cost	93		$ 10,666	0.63	$ 6,707.46
Periodic Cost	94			0.63	$ -
Periodic Cost	95		$ 13,262	0.62	$ 8,257.21
Periodic Cost	96		$ 10,666	0.62	$ 6,607.84
Periodic Cost	97			0.62	$ -
Periodic Cost	98			0.61	$ -
Periodic Cost	99		$ 10,666	0.61	$ 6,509.71
Periodic Cost	100		$ 13,262	0.61	$ 8,053.84
					$ 6,033,021.04
Total Present Value					**$ 6,033,021.04**

Table G-4. Alternative 3: Consolidate and Cap at Each Site

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost
Part 1: Ruby Mines No. 1						
1	1.1	Consolidate material from impacted soils (for example, haul roads, work areas, drainages,) within existing capped waste rock pile	37,500	yd^3	$ 7.12	$ 266,991.75
2	1.2	Excavate and consolidate material from vents	500	yd^3	$ 7.12	$ 3,559.89
3	1.3	Regrade waste rock pile as necessary to create uniform, stable slopes	198,000	ft^2	$ 0.83	$ 164,686.50
4	1.4	Supply and place 3-foot-thick soil cap from Schumacher Pit in Thoreau	22,000	yd^3	$ 16.65	$ 366,213.98
5	1.5	Supply and place erosion control blankets over the regraded cap	198,000	ft^2	$ 1.73	$ 342,547.92
6	1.6	Realign/regrade perimeter surface water drainage channels to stable configurations (riprap where necessary).	450	ft.	$ 16.83	$ 7,575.58
7	1.7	Revegetate cap and excavated areas	12	acre	$ 3,327.00	$ 39,924.00
8	1.8	Post-excavation status survey sampling	1	l.s.	$ 277,250.00	$ 277,250.00
Part 2: Ruby Mines No. 3						
9	2.1	Consolidate material from surficial soil hotspots (for example, haul roads, work areas, drainages, vents) within existing capped waste rock pile	42,000	yd^3	$ 7.12	$ 299,030.76
10	2.2	Regrade waste rock pile as necessary to create uniform, stable slopes	270,000	ft^2	$ 0.83	$ 224,572.50
11	2.3	Supply and place 3-foot-thick soil cap from Schumacher Pit in Thoreau	30,000	yd^3	$ 16.65	$ 499,382.70
12	2.4	Supply and place erosion control blankets over the regraded cap	270,000	ft^2	$ 1.73	$ 467,110.80
13	2.5	Realign and regrade perimeter surface water drainage channels to stable	375	ft.	$ 16.83	$ 6,312.98
14	2.6	Fill Ruby Mines No. 3 Adit subsidence with material from Schumacher Pit in Thoreau	50	yd^3	$ 23.68	$ 1,183.86
15	2.7	Revegetate cap and excavated areas	14	acre	$ 3,327.00	$ 46,578.00
16	2.8	Post-excavation status survey sampling	1	l.s.	$ 277,250.00	$ 277,250.00
Part 3: Site Planning and Permitting						
17	3.1	Environmental Permitting	1	l.s.	$ 55,450.00	$ 55,450.00
	Estimate Total Excluding Taxes (Combined Sections 1 and 2)					**$ 3,290,171.22**
	Estimate Total Excluding Taxes (Combined Section 3)					**$ 55,450.00**
					Navajo Nation Gross Receipts Taxes (6%)	**$ 197,410.27**
					Mobilization/Demobilization (10%)	**$ 329,017.12**
					Engineering (15%)	**$ 542,878.25**
					Construction Management (15%)	**$ 542,878.25**
					Contingency (25%)	**$ 1,225,588.78**
SUBTOTAL CAPITAL COST						**$ 6,183,393.90**

Table G-4. Alternative 3: Consolidate and Cap at Each Site

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost	
Part 4: Long-term Monitoring and Maintenance Total Estimated Costs							
See Alternative 3 Net Present Value Worksheet							
18	4.1	Annual-Inspection, Maintenance, and Reporting; 5 yr Review and Maintenance				$	2,262,960.00
					Total Estimated Costs	**$**	**8,446,353.90**
					Net Present Value	**$**	**8,075,736.48**
					Total Estimated Costs Lower Range (-30%)	$	5,912,447.73
					Total Estimated Costs Upper Range (+50%)	$	12,669,530.84

Notes:

+50%

All volumes are in place volumes

% = percent

$ = U.S. dollar

+ = plus

- = minus

ft. = foot (feet)

ft3 = cubic foot (feet)

ft2 = square foot (feet)

l.s. = lump sum

yd^3 = cubic yard

Table G-5. NPV Alternative 3

Engineering Evaluation and Cost Analysis

Ruby Mines

Annual O&M Cost					
Description	**Years**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Annual Inspection and Reporting	100	100	EA	$ 17,844.00	$ 1,784,400
				100 YR Total	**$1,784,400**

Periodic Costs					
Description	**Year**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Maintenance - Fix Erosion and Revegetate (Every 5 Year)	0-100	20	EA	$ 10,666.00	$ 213,320.00
5 Year Review	0-100	20	EA	$ 13,262.00	$ 265,240.00
			Total Periodic Costs		$ 478,560.00
			Total Annual and Periodic Costs		**$ 2,262,960.00**

Present Value Analysis

Discount Rate = 0.5%

For Federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of OMB Circular A-94 (OMB 2020). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. Because the Federal government has a different "cost of capital" than the private sector, these rates are appropriate to use for adjusting future year expenditures in a present value calculation for Federal facility remediation projects. Annual & periodic costs should be constant in this analysis. Source: USEPA 2000.

Capital Cost	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Capital Cost	0	$ 6,183,394	$ 6,183,394	1.00	$ 6,183,393.90
Annual O&M Cost	1 to 100		$ 17,844	78.54	$ 1,401,514.95
Periodic Cost	1			1.00	$ -
Periodic Cost	2			0.99	$ -
Periodic Cost	3		$ 10,666	0.99	$ 10,507.60
Periodic Cost	4			0.98	$ -
Periodic Cost	5		$ 13,262	0.98	$ 12,935.37
Periodic Cost	6		$ 10,666	0.97	$ 10,351.55
Periodic Cost	7			0.97	$ -
Periodic Cost	8			0.96	$ -
Periodic Cost	9		$ 10,666	0.96	$ 10,197.81
Periodic Cost	10		$ 13,262	0.95	$ 12,616.78
Periodic Cost	11			0.95	$ -
Periodic Cost	12		$ 10,666	0.94	$ 10,046.36
Periodic Cost	13			0.94	$ -
Periodic Cost	14			0.93	$ -

Capital Cost	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	15		$ 23,928	0.93	$ 22,203.20
Periodic Cost	16			0.92	$ -
Periodic Cost	17			0.92	$ -
Periodic Cost	18		$ 10,666	0.91	$ 9,750.18
Periodic Cost	19			0.91	$ -
Periodic Cost	20		$ 13,262	0.91	$ 12,002.94
Periodic Cost	21		$ 10,666	0.90	$ 9,605.37
Periodic Cost	22			0.90	$ -
Periodic Cost	23			0.89	$ -
Periodic Cost	24		$ 10,666	0.89	$ 9,462.72
Periodic Cost	25		$ 13,262	0.88	$ 11,707.32
Periodic Cost	26			0.88	$ -
Periodic Cost	27		$ 10,666	0.87	$ 9,322.19
Periodic Cost	28			0.87	$ -
Periodic Cost	29			0.87	$ -
Periodic Cost	30		$ 23,928	0.86	$ 20,602.72
Periodic Cost	31			0.86	$ -
Periodic Cost	32			0.85	$ -
Periodic Cost	33		$ 10,666	0.85	$ 9,047.35
Periodic Cost	34			0.84	$ -
Periodic Cost	35		$ 13,262	0.84	$ 11,137.73
Periodic Cost	36		$ 10,666	0.84	$ 8,912.99
Periodic Cost	37			0.83	$ 8,868.65
Periodic Cost	38			0.83	$ -
Periodic Cost	39		$ 10,666	0.82	$ 8,780.62
Periodic Cost	40		$ 13,262	0.82	$ 10,863.42
Periodic Cost	41			0.82	$ -
Periodic Cost	42		$ 10,666	0.81	$ 8,650.22
Periodic Cost	43			0.81	$ -
Periodic Cost	44			0.80	$ -
Periodic Cost	45		$ 23,928	0.80	$ 19,117.61
Periodic Cost	46			0.79	$ -
Periodic Cost	47			0.79	$ -
Periodic Cost	48		$ 10,666	0.79	$ 8,395.19
Periodic Cost	49			0.78	$ -
Periodic Cost	50		$ 13,262	0.78	$ 10,334.89
Periodic Cost	51		$ 10,666	0.78	$ 8,270.51
Periodic Cost	52			0.77	$ -

Capital Cost	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	53			0.77	$ -
Periodic Cost	54		$ 10,666	0.76	$ 8,147.69
Periodic Cost	55		$ 13,262	0.76	$ 10,080.35
Periodic Cost	56			0.76	$ -
Periodic Cost	57		$ 10,666	0.75	$ 8,026.68
Periodic Cost	58			0.75	$ -
Periodic Cost	59			0.75	$ -
Periodic Cost	60		$ 23,928	0.74	$ 17,739.55
Periodic Cost	61			0.74	$ -
Periodic Cost	62			0.73	$ -
Periodic Cost	63		$ 10,666	0.73	$ 7,790.04
Periodic Cost	64			0.73	$ -
Periodic Cost	65		$ 13,262	0.72	$ 9,589.92
Periodic Cost	66		$ 10,666	0.72	$ 7,674.35
Periodic Cost	67			0.72	$ -
Periodic Cost	68			0.71	$ -
Periodic Cost	69		$ 10,666	0.71	$ 7,560.37
Periodic Cost	70		$ 13,262	0.71	$ 9,353.73
Periodic Cost	71			0.70	$ -
Periodic Cost	72		$ 10,666	0.70	$ 7,448.09
Periodic Cost	73			0.69	$ -
Periodic Cost	74			0.69	$ -
Periodic Cost	75		$ 23,928	0.69	$ 16,460.83
Periodic Cost	76			0.68	$ -
Periodic Cost	77			0.68	$ -
Periodic Cost	78		$ 10,666	0.68	$ 7,228.51
Periodic Cost	79			0.67	$ -
Periodic Cost	80		$ 13,262	0.67	$ 8,898.65
Periodic Cost	81		$ 10,666	0.67	$ 7,121.16
Periodic Cost	82			0.66	$ -
Periodic Cost	83			0.66	$ -
Periodic Cost	84		$ 10,666	0.66	$ 7,015.40
Periodic Cost	85		$ 13,262	0.65	$ 8,679.48
Periodic Cost	86			0.65	$ -
Periodic Cost	87		$ 10,666	0.65	$ 6,911.21
Periodic Cost	88			0.64	$ -
Periodic Cost	89			0.64	$ -
Periodic Cost	90		$ 23,928	0.64	$ 15,274.28

Capital Cost	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	91			0.64	$ -
Periodic Cost	92			0.63	$ -
Periodic Cost	93		$ 10,666	0.63	$ 6,707.46
Periodic Cost	94			0.63	$ -
Periodic Cost	95		$ 13,262	0.62	$ 8,257.21
Periodic Cost	96		$ 10,666	0.62	$ 6,607.84
Periodic Cost	97			0.62	$ -
Periodic Cost	98			0.61	$ -
Periodic Cost	99		$ 10,666	0.61	$ 6,509.71
Periodic Cost	100		$ 13,262	0.61	$ 8,053.84
					$ 8,075,736.48
Total Present Value					**$ 8,075,736.48**

Table G-6. Alternative 4: Consolidate and Cap at One Site (Ruby 1)

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate		Item Cost	
Part 1: Ruby Mines No. 3								
1	1.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks and haul to Ruby Mine No. 1 for consolidation in that	42,000	yd^3	$	22.57	$	947,862.30
2	1.2	Excavate material from waste rock stockpile, load into trucks and haul to Ruby Mine No. 1 for consolidation in that location	132,000	yd^3	$	20.35	$	2,686,200.00
3	1.3	Fill Ruby Mines No. 3 Adit subsidence with material from Schumacher Pit in Thoreau	50	yd^3	$	15.01	$	750.50
4	1.4	Regrade excavated areas where impacted soils have been removed	270,000	ft^2	$	0.83	$	224,572.50
5	1.5	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	26,400	yd^3	$	21.35	$	563,640.00
6	1.6	Revegetate backfilled waste rock pile and excavated areas	14	acre	$	3,327.00	$	46,578.00
7	1.7	Post-excavation status survey sampling	1	l.s.	$	277,250.00	$	277,250.00
Part 2: Ruby Mines No. 1								
8	2.1	Consolidate material from impacted soils (for example, haul roads, work areas, drainages) within existing capped waste rock pile	37,500	yd^3	$	7.12	$	266,991.75
9	2.2	Excavate and consolidate material from vents	500	yd3	$	22.57	$	10,175.00
10	2.3	Consolidate and grade material imported from Ruby Mine No. 3 within extended	174,000	yd^3	$	5.38	$	935,885.10
11	2.4	Supply and place 3-foot-thick soil cap from Schumacher Pit in Thoreau	72,600	yd^3	$	16.65	$	1,208,506.13
12	2.5	Supply and place erosion control blankets over the regraded cap	653,400	ft^2	$	1.73	$	1,130,408.14
13	2.6	Realign and regrade perimeter surface water drainage channels to stable	4,000	ft	$	16.83	$	67,338.48
14	2.7	Revegetate cap and excavated areas	15	acre	$	3,327.00	$	49,905.00
15	2.80	Post-excavation status survey sampling	1	l.s.	$	277,250.00	$	277,250.00
Part 3: Site Planning and Permitting								
16	3.1	Environmental Permitting	1	l.s.	$	55,450.00	$	55,450.00
	Estimate Total Excluding Taxes (Combined Sections 1 and 2)						**$**	**8,693,312.90**
	Estimate Total Excluding Taxes (Combined Section 3)						**$**	**55,450.00**
						Navajo Nation Gross Receipts Taxes (6%)	**$**	**521,598.77**
						Mobilization/Demobilization (10%)	**$**	**869,331.29**
						Engineering (15%)	**$**	**1,434,396.63**
						Construction Management (15%)	**$**	**1,434,396.63**
						Contingency (25%)	**$**	**3,238,259.06**
SUBTOTAL CAPITAL COST							**$**	**16,246,745.28**

Table G-6. Alternative 4: Consolidate and Cap at One Site (Ruby 1)

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost	
Part 4: Long-term Monitoring and Maintenance Total Estimated Costs							
See Alternative 4 Net Present Value Worksheet							
17	4.1	Annual-Inspection, Maintenance, and Reporting; 5 yr Review and Maintenance				$	2,262,960
					Total Estimated Costs	**$**	**18,509,705**
					Net Present Value	**$**	**18,139,088**
					Total Estimated Costs Lower Range (-30%)	$	12,956,794
					Total Estimated Costs Upper Range (+50%)	$	27,764,558

Notes:

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered “order-of-magnitude” estimates, with an expected accuracy of -30% to +50%

All volumes are in place volumes

% = percent

$ = U.S. dollar

+ = plus

- = minus

ft. = foot (feet)

ft^3 = cubic foot (feet)

ft^2 = square foot (feet)

l.s. = lump sum

yd^3 = cubic yard

Table G-7. NPV Alternative 4

Engineering Evaluation and Cost Analysis

Ruby Mines

Annual O&M Cost					
Description	**Years**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Annual Inspection and Reporting	100	100	EA	$ 17,844.00	$ 1,784,400
				100 YR Total	**$1,784,400**
Periodic Costs					
Description	**Year**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Maintenance - Fix Erosion and Revegetate (Every 5 Year)	0-100	20	EA	$ 10,666.00	$ 213,320.00
5 Year Review	0-100	20	EA	$ 13,262.00	$ 265,240.00
			Total Periodic Costs		$ 478,560.00
				Total Annual and Periodic Costs	**$ 2,262,960.00**
Present Value Analysis					
Discount Rate =	0.5%	For Federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of OMB Circular A-94 (OMB 2020). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. Because the Federal government has a different "cost of capital" than the private sector, these rates are appropriate to use for adjusting future year expenditures in a present value calculation for Federal facility remediation projects. Annual & periodic costs should be constant in this analysis.			
Cost Type	**Year**	**Total Cost**	**Total Cost per**	**Discoutn Factor**	**Present Value**
Capital Cost	0	$ 16,246,745	$ 16,246,745	1.00	$ 16,246,745.28
Annual O&M Cost	1 to 100		$ 17,844	78.54	$ 1,401,514.95
Periodic Cost	1			1.00	$ -
Periodic Cost	2			0.99	$ -
Periodic Cost	3		$ 10,666	0.99	$ 10,507.60
Periodic Cost	4			0.98	$ -
Periodic Cost	5		$ 13,262	0.98	$ 12,935.37
Periodic Cost	6		$ 10,666	0.97	$ 10,351.55
Periodic Cost	7			0.97	$ -
Periodic Cost	8			0.96	$ -
Periodic Cost	9		$ 10,666	0.96	$ 10,197.81
Periodic Cost	10		$ 13,262	0.95	$ 12,616.78
Periodic Cost	11			0.95	$ -
Periodic Cost	12		$ 10,666	0.94	$ 10,046.36
Periodic Cost	13			0.94	$ -

Cost Type	Year	Total Cost	Total Cost per	Discoutn Factor	Present Value
Periodic Cost	14			0.93	$ -
Periodic Cost	15		$ 23,928	0.93	$ 22,203.20
Periodic Cost	16			0.92	$ -
Periodic Cost	17			0.92	$ -
Periodic Cost	18		$ 10,666	0.91	$ 9,750.18
Periodic Cost	19			0.91	$ -
Periodic Cost	20		$ 13,262	0.91	$ 12,002.94
Periodic Cost	21		$ 10,666	0.90	$ 9,605.37
Periodic Cost	22			0.90	$ -
Periodic Cost	23			0.89	$ -
Periodic Cost	24		$ 10,666	0.89	$ 9,462.72
Periodic Cost	25		$ 13,262	0.88	$ 11,707.32
Periodic Cost	26			0.88	$ -
Periodic Cost	27		$ 10,666	0.87	$ 9,322.19
Periodic Cost	28			0.87	$ -
Periodic Cost	29			0.87	$ -
Periodic Cost	30		$ 23,928	0.86	$ 20,602.72
Periodic Cost	31			0.86	$ -
Periodic Cost	32			0.85	$ -
Periodic Cost	33		$ 10,666	0.85	$ 9,047.35
Periodic Cost	34			0.84	$ -
Periodic Cost	35		$ 13,262	0.84	$ 11,137.73
Periodic Cost	36		$ 10,666	0.84	$ 8,912.99
Periodic Cost	37			0.83	$ 8,868.65
Periodic Cost	38			0.83	$ -
Periodic Cost	39		$ 10,666	0.82	$ 8,780.62
Periodic Cost	40		$ 13,262	0.82	$ 10,863.42
Periodic Cost	41			0.82	$ -
Periodic Cost	42		$ 10,666	0.81	$ 8,650.22
Periodic Cost	43			0.81	$ -
Periodic Cost	44			0.80	$ -
Periodic Cost	45		$ 23,928	0.80	$ 19,117.61
Periodic Cost	46			0.79	$ -
Periodic Cost	47			0.79	$ -
Periodic Cost	48		$ 10,666	0.79	$ 8,395.19
Periodic Cost	49			0.78	$ -
Periodic Cost	50		$ 13,262	0.78	$ 10,334.89
Periodic Cost	51		$ 10,666	0.78	$ 8,270.51

Cost Type	Year	Total Cost	Total Cost per	Discoutn Factor	Present Value
Periodic Cost	52			0.77	$ -
Periodic Cost	53			0.77	$ -
Periodic Cost	54		$ 10,666	0.76	$ 8,147.69
Periodic Cost	55		$ 13,262	0.76	$ 10,080.35
Periodic Cost	56			0.76	$ -
Periodic Cost	57		$ 10,666	0.75	$ 8,026.68
Periodic Cost	58			0.75	$ -
Periodic Cost	59			0.75	$ -
Periodic Cost	60		$ 23,928	0.74	$ 17,739.55
Periodic Cost	61			0.74	$ -
Periodic Cost	62			0.73	$ -
Periodic Cost	63		$ 10,666	0.73	$ 7,790.04
Periodic Cost	64			0.73	$ -
Periodic Cost	65		$ 13,262	0.72	$ 9,589.92
Periodic Cost	66		$ 10,666	0.72	$ 7,674.35
Periodic Cost	67			0.72	$ -
Periodic Cost	68			0.71	$ -
Periodic Cost	69		$ 10,666	0.71	$ 7,560.37
Periodic Cost	70		$ 13,262	0.71	$ 9,353.73
Periodic Cost	71			0.70	$ -
Periodic Cost	72		$ 10,666	0.70	$ 7,448.09
Periodic Cost	73			0.69	$ -
Periodic Cost	74			0.69	$ -
Periodic Cost	75		$ 23,928	0.69	$ 16,460.83
Periodic Cost	76			0.68	$ -
Periodic Cost	77			0.68	$ -
Periodic Cost	78		$ 10,666	0.68	$ 7,228.51
Periodic Cost	79			0.67	$ -
Periodic Cost	80		$ 13,262	0.67	$ 8,898.65
Periodic Cost	81		$ 10,666	0.67	$ 7,121.16
Periodic Cost	82			0.66	$ -
Periodic Cost	83			0.66	$ -
Periodic Cost	84		$ 10,666	0.66	$ 7,015.40
Periodic Cost	85		$ 13,262	0.65	$ 8,679.48
Periodic Cost	86			0.65	$ -
Periodic Cost	87		$ 10,666	0.65	$ 6,911.21
Periodic Cost	88			0.64	$ -
Periodic Cost	89			0.64	$ -

Cost Type	Year	Total Cost	Total Cost per	Discoutn Factor	Present Value
Periodic Cost	90		$ 23,928	0.64	$ 15,274.28
Periodic Cost	91			0.64	$ -
Periodic Cost	92			0.63	$ -
Periodic Cost	93		$ 10,666	0.63	$ 6,707.46
Periodic Cost	94			0.63	$ -
Periodic Cost	95		$ 13,262	0.62	$ 8,257.21
Periodic Cost	96		$ 10,666	0.62	$ 6,607.84
Periodic Cost	97			0.62	$ -
Periodic Cost	98			0.61	$ -
Periodic Cost	99		$ 10,666	0.61	$ 6,509.71
Periodic Cost	100		$ 13,262	0.61	$ 8,053.84
					$ 18,139,087.86
Total Present Value					**$ 18,139,087.86**

Table G-8. Alternative 5a: Excavate and Manage at Regional Repository (Black Jack No. 1)

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate		Item Cost	
Part 1: Ruby Mines No. 1								
1	1.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks and haul to repository	37,500	yd^3	$	22.57	$	846,305.63
2	1.2	Excavate and consolidate material from vents, load into trucks and haul to repository	500	yd^3	$	24.82	$	12,412.48
3	1.3	Excavate material from waste rock stockpile, load into trucks and haul to repository	126,000	yd^3	$	22.34	$	2,815,151.03
4	1.4	Regrade excavated areas where impacted soils have been removed	523,000	ft^2	$	0.83	$	435,005.25
5	1.5	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	25,200	yd^3	$	16.65	$	419,481.47
6	1.6	Revegetate backfilled waste rock pile and excavated areas	12	acre	$	3,327.00	$	39,924.00
7	1.7	Post-excavation status survey sampling	1	l.s.	$	277,250.00	$	277,250.00
Part 2: Ruby Mines No. 3								
8	2.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks and haul to onsite repository	42,000	yd^3	$	18.91	$	794,154.90
9	2.2	Excavate material from waste rock stockpile, load into trucks and haul to onsite repository	132,000	yd^3	$	18.91	$	2,495,915.40
10	2.3	Regrade excavated areas where impacted soils have been removed	344,000	ft^2	$	0.83	$	286,122.00
11	2.4	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	26,400	yd^3	$	16.65	$	439,456.78
12	2.5	Fill Ruby Mines No. 3 Adit subsidence with material from Schumacher Pit in Thoreau	50	yd^3	$	23.68	$	1,183.86
13	2.6	Revegetate backfilled waste rock pile and excavated areas	14	acre	$	3,327.00	$	46,578.00
14	2.7	Post-excavation status survey sampling	1	l.s.	$	277,250.00	$	277,250.00
Part 3: Construct Receiving Repository and Receive Waste								
15	3.1	Establish traffic control and maintain access roads	1	l. s.	$	166,350.00	$	166,350.00
16	3.2	Place and grade waste from Ruby Mine Nos. 1 and 3	338,000	yd^3	$	5.38	$	1,817,983.70
17	3.3	Supply and place 3-foot-thick soil cap from Schumacher Pit in Thoreau	72,600	yd^3	$	16.65	$	1,208,506.13
18	3.4	Supply and place erosion control blankets over the regraded cap	653,400	ft^2	$	1.73	$	1,130,408.14
19	3.5	Revegetate cap and excavated areas	15	acre	$	3,327.00	$	49,905.00

Table G-8. Alternative 5a: Excavate and Manage at Regional Repository (Black Jack No. 1)

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost
Part 4: Site Planning and Permitting						
20	4.1	Environmental Permitting	1	l.s.	$ 55,450.00	$ 55,450.00
	Estimate Total Excluding Taxes (Combined Sections 1 and 2)					**$ 13,559,343.76**
	Estimate Total Excluding Taxes (Combined Section 3)					**$ 55,450.00**
		Navajo Nation Gross Receipts Taxes (6%)				**$ 813,560.63**
		Mobilization/Demobilization (10%)				**$ 1,355,934.38**
		Engineering (15%)				**$ 2,237,291.72**
		Construction Management (15%)				**$ 2,237,291.72**
		Contingency (25%)				**$ 5,050,855.55**
SUBTOTAL CAPITAL COST						**$ 25,309,727.75**
Part 4: Long-term Monitoring and Maintenance Total Estimated Costs						
See Alternative 5 Net Present Value Worksheet						
21	5.1	Repository 100 yr (Annual-Inspection, Maintenance, and Reporting; 5 yr Review and Maintenance), Mine Site 5 yr (Annual Inspection and				$ 2,352,180.00
		Grand Total				**$ 27,661,907.75**
		Net Present Value				$ 27,171,273.56
		Total Estimated Costs Lower Range (-30%)				$ 19,363,335.43
		Total Estimated Costs Upper Range (+50%)				$ 41,492,861.63

Notes:

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered “order-of-magnitude” estimates, with an expected accuracy of -30% to +50%

All volumes are in place volumes

% = percent

$ = U.S. dollar

+ = plus

- = minus

ft. = foot (feet)

ft^3 = cubic foot (feet)

ft^2 = square foot (feet)

l.s. = lump sum

yd^3 = cubic yard

Table G-9. NPV Alternative 5a

Engineering Evaluation and Cost Analysis

Ruby Mines

Annual O&M Cost					
Description	**Years**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Repository Annual Inspection and Reporting	100	100	EA	$ 17,844.00	$ 1,784,400.00
Mine Site Annual Inspection and Reporting	5	5	EA	$ 17,844.00	$ 89,220.00
				100 YR Total	**$1,873,620**
Periodic Costs - Repository					
Description	**Year**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Maintenance - Fix Erosion and Revegetate (Every 5	0-100	20	EA	$ 10,666.00	$ 213,320.00
5 Year Review	0-100	20	EA	$ 13,262.00	$ 265,240.00
			Total Periodic Costs		$ 478,560.00
				Total Annual and Periodic Costs	**$ 2,352,180.00**
Present Value Analysis					
Discount Rate =	0.5%	For Federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of OMB Circular A-94 (OMB 2020). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. Because the Federal government has a different “cost of capital” than the private sector, these rates are appropriate to use for adjusting future year expenditures in a present value calculation for Federal facility remediation projects. Annual & periodic costs should be constant in this analysis. Source: USEPA 2000.			
Cost Type	**Year**	**Total Cost**	**Total Cost per**	**Discount Factor**	**Present Value**
Capital Cost	0	$ 25,309,728	$ 25,309,728	1.00	$ 25,309,727.75
Annual O&M Cost Repository	1 to 100		$ 17,844	78.54	$ 1,401,514.95
Annual O&M Cost Mine Sites	1 to 5		$ 17,844	4.93	$ 87,897.16
Periodic Cost	1			1.00	$ -
Periodic Cost	2			0.99	$ -
Periodic Cost	3			0.99	$ -
Periodic Cost	4			0.98	$ -
Periodic Cost	5		$ 23,928	0.98	$ 23,338.67
Periodic Cost	6			0.97	$ -
Periodic Cost	7			0.97	$ -
Periodic Cost	8			0.96	$ -
Periodic Cost	9			0.96	$ -
Periodic Cost	10		$ 23,928	0.95	$ 22,763.85
Periodic Cost	11			0.95	$ -
Periodic Cost	12			0.94	$ -

Cost Type	Year	Total Cost	Total Cost per	Discount Factor	Present Value
Periodic Cost	13			0.94	$ -
Periodic Cost	14			0.93	$ -
Periodic Cost	15		$ 23,928	0.93	$ 22,203.20
Periodic Cost	16			0.92	$ -
Periodic Cost	17			0.92	$ -
Periodic Cost	18			0.91	$ -
Periodic Cost	19			0.91	$ -
Periodic Cost	20		$ 23,928	0.91	$ 21,656.35
Periodic Cost	21			0.90	$ -
Periodic Cost	22			0.90	$ -
Periodic Cost	23			0.89	$ -
Periodic Cost	24			0.89	$ -
Periodic Cost	25		$ 23,928	0.88	$ 21,122.96
Periodic Cost	26			0.88	$ -
Periodic Cost	27			0.87	$ -
Periodic Cost	28			0.87	$ -
Periodic Cost	29			0.87	$ -
Periodic Cost	30		$ 23,928	0.86	$ 20,602.72
Periodic Cost	31			0.86	$ -
Periodic Cost	32			0.85	$ -
Periodic Cost	33			0.85	$ -
Periodic Cost	34			0.84	$ -
Periodic Cost	35		$ 23,928	0.84	$ 20,095.29
Periodic Cost	36			0.84	$ -
Periodic Cost	37			0.83	$ -
Periodic Cost	38			0.83	$ -
Periodic Cost	39			0.82	$ -
Periodic Cost	40		$ 23,928	0.82	$ 19,600.35
Periodic Cost	41			0.82	$ -
Periodic Cost	42			0.81	$ -
Periodic Cost	43			0.81	$ -
Periodic Cost	44			0.80	$ -
Periodic Cost	45		$ 23,928	0.80	$ 19,117.61
Periodic Cost	46			0.79	$ -
Periodic Cost	47			0.79	$ -
Periodic Cost	48			0.79	$ -
Periodic Cost	49			0.78	$ -
Periodic Cost	50		$ 23,928	0.78	$ 18,646.76

Cost Type	Year	Total Cost	Total Cost per	Discount Factor	Present Value
Periodic Cost	51			0.78	$ -
Periodic Cost	52			0.77	$ -
Periodic Cost	53			0.77	$ -
Periodic Cost	54			0.76	$ -
Periodic Cost	55		$ 23,928	0.76	$ 18,187.50
Periodic Cost	56			0.76	$ -
Periodic Cost	57			0.75	$ -
Periodic Cost	58			0.75	$ -
Periodic Cost	59			0.75	$ -
Periodic Cost	60		$ 23,928	0.74	$ 17,739.55
Periodic Cost	61			0.74	$ -
Periodic Cost	62			0.73	$ -
Periodic Cost	63			0.73	$ -
Periodic Cost	64			0.73	$ -
Periodic Cost	65		$ 23,928	0.72	$ 17,302.64
Periodic Cost	66			0.72	$ -
Periodic Cost	67			0.72	$ -
Periodic Cost	68			0.71	$ -
Periodic Cost	69			0.71	$ -
Periodic Cost	70		$ 23,928	0.71	$ 16,876.49
Periodic Cost	71			0.70	$ -
Periodic Cost	72			0.70	$ -
Periodic Cost	73			0.69	$ -
Periodic Cost	74			0.69	$ -
Periodic Cost	75		$ 23,928	0.69	$ 16,460.83
Periodic Cost	76			0.68	$ -
Periodic Cost	77			0.68	$ -
Periodic Cost	78			0.68	$ -
Periodic Cost	79			0.67	$ -
Periodic Cost	80		$ 23,928	0.67	$ 16,055.41
Periodic Cost	81			0.67	$ -
Periodic Cost	82			0.66	$ -
Periodic Cost	83			0.66	$ -
Periodic Cost	84			0.66	$ -
Periodic Cost	85		$ 23,928	0.65	$ 15,659.98
Periodic Cost	86			0.65	$ -
Periodic Cost	87			0.65	$ -
Periodic Cost	88			0.64	$ -

Cost Type	Year	Total Cost	Total Cost per	Discount Factor	Present Value
Periodic Cost	89			0.64	$ -
Periodic Cost	90		$ 23,928	0.64	$ 15,274.28
Periodic Cost	91			0.64	$ -
Periodic Cost	92			0.63	$ -
Periodic Cost	93			0.63	$ -
Periodic Cost	94			0.63	$ -
Periodic Cost	95		$ 23,928	0.62	$ 14,898.09
Periodic Cost	96			0.62	$ -
Periodic Cost	97			0.62	$ -
Periodic Cost	98			0.61	$ -
Periodic Cost	99			0.61	$ -
Periodic Cost	100		$ 23,928	0.61	$ 14,531.16
					$ 27,171,273.56
Total Present Value					**$ 27,171,273.56**

Table G-10. Alternative 5b: Excavate and Manage at Regional Repository (Mac No. 1)

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost
Part 1: Ruby Mines No. 1						
1	1.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks and haul to repository	37,500	yd^3	$ 22.57	$ 846,305.63
2	1.2	Excavate and consolidate material from vents, load into trucks and haul to repository	500	yd^3	$ 24.82	$ 12,412.48
3	1.3	Excavate material from waste rock stockpile, load into trucks and haul to repository	126,000	yd^3	$ 22.34	$ 2,815,151.03
4	1.4	Regrade excavated areas where impacted soils have been removed	523,000	ft^2	$ 0.83	$ 435,005.25
5	1.5	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	22,800	yd^3	$ 16.65	$ 379,530.85
6	1.6	Revegetate backfilled waste rock pile and excavated areas	12	acre	$ 3,327.00	$ 39,924.00
7	1.7	Post-excavation status survey sampling	1	l.s.	$ 277,250.00	$ 277,250.00
Part 2: Ruby Mines No. 3						
8	2.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks and haul to onsite repository	42,000	yd^3	$ 21.35	$ 896,626.50
9	2.2	Excavate material from waste rock stockpile, load into trucks and haul to onsite repository	132,000	yd^3	$ 19.21	$ 2,536,172.10
10	2.3	Regrade excavated areas where impacted soils have been removed	344,000	ft^2	$ 0.83	$ 286,122.00
11	2.4	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	26,000	yd^3	$ 16.65	$ 432,798.34
12	2.5	Fill Ruby Mines No. 3 Adit subsidence with material from Schumacher Pit in Thoreau	50	yd^3	$ 23.68	$ 1,184.00
13	2.6	Revegetate backfilled waste rock pile and excavated areas	14	acre	$ 3,327.00	$ 46,578.00
14	2.7	Post-excavation status survey sampling	1	l.s.	$ 277,250.00	$ 277,250.00
Part 3: Construct Receiving Repository and Receive Waste						
15	3.1	Establish traffic control and maintain access roads	1	l. s.	$ 166,350.00	$ 166,350.00
16	3.2	Place and grade waste from Ruby Mine Nos. 1 and 3	338,000	yd^3	$ 5.38	$ 1,817,983.70
17	3.3	Supply and place 3-foot-thick soil cap from Schumacher Pit in Thoreau	72,600	yd^3	$ 16.65	$ 1,208,506.13
18	3.4	Supply and place erosion control blankets over the regraded cap	653,400	ft^2	$ 1.73	$ 1,130,408.14
19	3.5	Revegetate cap and excavated areas	15	acre	$ 3,327.00	$ 49,905.00

Table G-10. Alternative 5b: Excavate and Manage at Regional Repository (Mac No. 1)

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate	Item Cost
Part 4: Site Planning and Permitting						
20	4.1	Environmental Permitting	1	l.s.	$ 55,450.00	$ 55,450.00
	Estimate Total Excluding Taxes (Combined Sections 1, 2 and 3)					**$13,655,463.15**
	Estimate Total Excluding Taxes (Combined Section 4)					**$ 55,450.00**
					Navajo Nation Gross Receipts Taxes (6%)	**$ 819,327.79**
					Mobilization/Demobilization (10%)	**$ 1,365,546.32**
					Engineering (15%)	**$ 2,253,151.42**
					Construction Management (15%)	**$ 2,253,151.42**
					Contingency (25%)	**$ 5,086,660.02**
SUBTOTAL CAPITAL COST						**$25,488,750.12**
Part 4: Long-term Monitoring and Maintenance Total Estimated Costs						
See Alternative 5 Net Present Value Worksheet						
21	5.1	Repository 100 yr (Annual-Inspection, Maintenance, and Reporting; 5-yr Review and Maintenance), Mine Site 5 yr (Annual Inspection and				$ 2,352,180.00
					Grand Total	**$27,840,930.12**
					Net Present Value	$27,350,295.92
					Total Estimated Costs Lower Range (-30%)	$19,488,651.08
					Total Estimated Costs Upper Range (+50%)	$41,761,395.18

Notes:

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered “order-of-magnitude” estimates, with an expected accuracy of -30% to +50%

All volumes are in place volumes

% = percent

$ = U.S. dollar

+ = plus

- = minus

ft. = foot (feet)

ft^3 = cubic foot (feet)

ft^2 = square foot (feet)

l.s. = lump sum

yd^3 = cubic yard

Table G-11. NPV Alternative 5b

Engineering Evaluation and Cost Analysis

Ruby Mines

Annual O&M Cost					
Description	**Years**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Repository Annual Inspection and Reporting	100	100	EA	$ 17,844.00	$ 1,784,400.00
Mine Site Annual Inspection and Reporting	5	5	EA	$ 17,844.00	$ 89,220.00
				100 YR Total	**$1,873,620**
Periodic Costs - Repository					
Description	**Year**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Maintenance - Fix Erosion and Revegetate (Every 5 Year)	0-100	20	EA	$ 10,666.00	$ 213,320.00
5 Year Review	0-100	20	EA	$ 13,262.00	$ 265,240.00
			Total Periodic Costs		$ 478,560.00
				Total Annual and Periodic Costs	**$ 2,352,180.00**

Present Value Analysis

Discount Rate = 0.5%

For Federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of OMB Circular A-94 (OMB 2020). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. Because the Federal government has a different “cost of capital” than the private sector, these rates are appropriate to use for adjusting future year expenditures in a present value calculation for Federal facility remediation projects. Annual & periodic costs should be constant in this analysis. Source: USEPA 2000.

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Capital Cost	0	$ 25,488,750	$ 25,488,750	1.00	$ 25,488,750.12
Annual O&M Cost Repository	1 to 100		$ 17,844	78.54	$ 1,401,514.95
Annual O&M Cost Mine Sites	1 to 5		$ 17,844	4.93	$ 87,897.16
Periodic Cost	1			1.00	$ -
Periodic Cost	2			0.99	$ -
Periodic Cost	3			0.99	$ -
Periodic Cost	4			0.98	$ -
Periodic Cost	5		$ 23,928	0.98	$ 23,338.67
Periodic Cost	6			0.97	$ -
Periodic Cost	7			0.97	$ -
Periodic Cost	8			0.96	$ -
Periodic Cost	9			0.96	$ -
Periodic Cost	10		$ 23,928	0.95	$ 22,763.85
Periodic Cost	11			0.95	$ -

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	12			0.94	$ -
Periodic Cost	13			0.94	$ -
Periodic Cost	14			0.93	$ -
Periodic Cost	15		$ 23,928	0.93	$ 22,203.20
Periodic Cost	16			0.92	$ -
Periodic Cost	17			0.92	$ -
Periodic Cost	18			0.91	$ -
Periodic Cost	19			0.91	$ -
Periodic Cost	20		$ 23,928	0.91	$ 21,656.35
Periodic Cost	21			0.90	$ -
Periodic Cost	22			0.90	$ -
Periodic Cost	23			0.89	$ -
Periodic Cost	24			0.89	$ -
Periodic Cost	25		$ 23,928	0.88	$ 21,122.96
Periodic Cost	26			0.88	$ -
Periodic Cost	27			0.87	$ -
Periodic Cost	28			0.87	$ -
Periodic Cost	29			0.87	$ -
Periodic Cost	30		$ 23,928	0.86	$ 20,602.72
Periodic Cost	31			0.86	$ -
Periodic Cost	32			0.85	$ -
Periodic Cost	33			0.85	$ -
Periodic Cost	34			0.84	$ -
Periodic Cost	35		$ 23,928	0.84	$ 20,095.29
Periodic Cost	36			0.84	$ -
Periodic Cost	37			0.83	$ -
Periodic Cost	38			0.83	$ -
Periodic Cost	39			0.82	$ -
Periodic Cost	40		$ 23,928	0.82	$ 19,600.35
Periodic Cost	41			0.82	$ -
Periodic Cost	42			0.81	$ -
Periodic Cost	43			0.81	$ -
Periodic Cost	44			0.80	$ -
Periodic Cost	45		$ 23,928	0.80	$ 19,117.61
Periodic Cost	46			0.79	$ -
Periodic Cost	47			0.79	$ -
Periodic Cost	48			0.79	$ -
Periodic Cost	49			0.78	$ -

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	50		$ 23,928	0.78	$ 18,646.76
Periodic Cost	51			0.78	$ -
Periodic Cost	52			0.77	$ -
Periodic Cost	53			0.77	$ -
Periodic Cost	54			0.76	$ -
Periodic Cost	55		$ 23,928	0.76	$ 18,187.50
Periodic Cost	56			0.76	$ -
Periodic Cost	57			0.75	$ -
Periodic Cost	58			0.75	$ -
Periodic Cost	59			0.75	$ -
Periodic Cost	60		$ 23,928	0.74	$ 17,739.55
Periodic Cost	61			0.74	$ -
Periodic Cost	62			0.73	$ -
Periodic Cost	63			0.73	$ -
Periodic Cost	64			0.73	$ -
Periodic Cost	65		$ 23,928	0.72	$ 17,302.64
Periodic Cost	66			0.72	$ -
Periodic Cost	67			0.72	$ -
Periodic Cost	68			0.71	$ -
Periodic Cost	69			0.71	$ -
Periodic Cost	70		$ 23,928	0.71	$ 16,876.49
Periodic Cost	71			0.70	$ -
Periodic Cost	72			0.70	$ -
Periodic Cost	73			0.69	$ -
Periodic Cost	74			0.69	$ -
Periodic Cost	75		$ 23,928	0.69	$ 16,460.83
Periodic Cost	76			0.68	$ -
Periodic Cost	77			0.68	$ -
Periodic Cost	78			0.68	$ -
Periodic Cost	79			0.67	$ -
Periodic Cost	80		$ 23,928	0.67	$ 16,055.41
Periodic Cost	81			0.67	$ -
Periodic Cost	82			0.66	$ -
Periodic Cost	83			0.66	$ -
Periodic Cost	84			0.66	$ -
Periodic Cost	85		$ 23,928	0.65	$ 15,659.98
Periodic Cost	86			0.65	$ -
Periodic Cost	87			0.65	$ -

Cost Type	Year	Total Cost	Total Cost per Year	Discount Factor	Present Value
Periodic Cost	88			0.64	$ -
Periodic Cost	89			0.64	$ -
Periodic Cost	90		$ 23,928	0.64	$ 15,274.28
Periodic Cost	91			0.64	$ -
Periodic Cost	92			0.63	$ -
Periodic Cost	93			0.63	$ -
Periodic Cost	94			0.63	$ -
Periodic Cost	95		$ 23,928	0.62	$ 14,898.09
Periodic Cost	96			0.62	$ -
Periodic Cost	97			0.62	$ -
Periodic Cost	98			0.61	$ -
Periodic Cost	99			0.61	$ -
Periodic Cost	100		$ 23,928	0.61	$ 14,531.16
					$ 27,350,295.92
Total Present Value					**$ 27,350,295.92**

Table G-12. Alternative 6: Excavate and Manage Off-Reservation

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate		Item Cost	
Part 1: Ruby Mines No. 1								
1	1.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks	56,250	ton	$	25.78	$	1,450,364.06
2	1.2	Excavate and consolidate material from vents, load into trucks	750	ton	$	21.63	$	16,219.13
3	1.3	Excavate material from waste rock stockpile, load into trucks	189,000	ton	$	15.80	$	2,986,814.25
4	1.4	Haul waste from site to off-Reservation Repository	9,111	Load	$	4,678.29	$	42,624,459.36
5	1.5	Disposal at Off-Reservation Repository	246,000	ton	$	200.00	$	49,200,000.00
6	1.6	Regrade excavated areas where impacted soils have been removed	523,000	ft^2	$	0.83	$	435,005.25
7	1.7	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	25,200	yd^3	$	16.65	$	419,481.47
8	1.8	Revegetate backfilled waste rock pile and excavated areas	12	acre	$	3,327.00	$	39,924.00
9	1.9	Post-excavation status survey sampling	1	l.s.	$	277,250.00	$	277,250.00
Part 2: Ruby Mines No. 3								
10	2.1	Excavate material from impacted soils (for example, haul roads, work areas, drainages), load into trucks	63,000	ton	$	19.13	$	1,205,205.75
11	2.2	Excavate material from waste rock stockpile, load into trucks	198,000	ton	$	15.80	$	3,129,043.50
12	2.3	Haul waste from site to off-Reservation Repository	9,667	Load	$	4,678.29	$	45,223,511.76
13	2.4	Disposal at Off-Reservation Repository	261,000	ton	$	200.00	$	52,200,000.00
14	2.5	Regrade excavated areas where impacted soils have been removed	344,000	ft^2	$	0.83	$	286,122.00
15	2.6	Backfill waste rock excavation with fill from Schumacher Pit in Thoreau	26,400	yd^3	$	16.65	$	439,456.78
16	2.7	Fill Ruby Mines No. 3 Adit subsidence with material from Schumacher Pit in Thoreau	50	yd^3	$	23.68	$	1,183.86
17	2.8	Revegetate backfilled waste rock pile and excavated areas	14	acre	$	3,327.00	$	46,578.00
18	2.9	Post-excavation status survey sampling	1	l.s.	$	277,250.00	$	277,250.00

Table G-12. Alternative 6: Excavate and Manage Off-Reservation

Engineering Evaluation and Cost Analysis

Ruby Mines

Item		Item Description	Quantity	Unit	Unit Rate		Item Cost	
Part 3: Site Planning and Permitting								
19	3.1	Environmental Permitting	1	l.s.	$	55,450.00	$	55,450.00
	Estimate Total Excluding Taxes (Combined Sections 1 and 2)						**$**	**200,257,869.16**
	Estimate Total Excluding Taxes Sections 3						**$**	**55,450.00**
						Navajo Nation Gross Receipts Taxes (6%)	**$**	**12,015,472.15**
						Mobilization/Demobilization (5%)	**$**	**10,012,893.46**
						Engineering (10%)	**$**	**21,027,076.26**
						Construction Management (15%)	**$**	**31,540,614.39**
						Contingency (25%)	**$**	**68,713,481.36**
SUBTOTAL CAPITAL COST							**$**	**343,622,856.78**
Part 4: Long-term Monitoring and Maintenance Total Estimated Costs								
See Alternative 6 Net Present Value Worksheet								
20	4.1	Postconstruction Inspection and Maintenance (5 yr) and 5 yr Review					$	102,482.13
						Grand Total	**$**	**343,725,338.91**
						Net Present Value	$	343,723,689.43
						Total Estimated Costs Lower Range (-30%)	$	240,607,737.23
						Total Estimated Costs Upper Range (+50%)	$	515,588,008.36

Notes:

This estimate is not intended to function as guarantee of fixed costs for field implementation. Costs are considered “order-of-magnitude” estimates, with an expected accuracy of -30% to

All volumes are in place volumes

% = percent

$ = U.S. dollar

+ = plus

- = minus

ft. = foot (feet)

ft^3 = cubic foot (feet)

ft^2 = square foot (feet)

l.s. = lump sum

yd^3 = cubic yard

Table G-13. NPV Alternative 6

Engineering Evaluation and Cost Analysis

Ruby Mines

Annual O7M Cost					
Description	**Years**	**Quantity**	**Unit**	**Unit Cost**	**Total**
Mine Site Annual Inspection and Reporting	5	5	EA	$ 17,844.04	$ 89,220.21
				100 YR Total	**$89,220**

Periodic Costs					
Description	**Year**	**Quantity**	**Unit**	**Unit Cost**	**Total**
5 Year Review	0-100	1	EA	$ 13,261.92	$ 13,261.92
			Total Periodic Costs		$ 13,261.92
				Total Annual and Periodic Costs	**$102,482**

Present Value Analysis					
Discount Rate =	0.5%	For Federal facility sites, it is generally appropriate to apply the "real" discount rates found in Appendix C of OMB Circular A-94 (OMB 2020). This rate represents the "real" discount rate that approximates the marginal pretax rate of return on an average investment and has been adjusted to eliminate the effect of expected inflation. Because the Federal government has a different "cost of capital" than the private sector, these rates are appropriate to use for adjusting future year expenditures in a present value calculation for Federal facility remediation projects. Annual & periodic costs should be constant in this analysis. Source: USEPA 2000.			
Cost Type	**Year**	**Total Cost**	**Total Cost per Year**	**Discount Factor**	**Present Value**
Capital Cost	0	$ 343,622,857	$ 343,622,857	1.00	$ 343,622,856.78
Annual O&M Cost Repository	1 to 100			78.54	$ -
Annual O&M Cost Mine Sites	1 to 5		$ 17,844	4.93	$ 87,897.37
Periodic Cost	1			1.00	$ -
Periodic Cost	2			0.99	$ -
Periodic Cost	3			0.99	$ -
Periodic Cost	4			0.98	$ -
Periodic Cost	5		$ 13,262	0.98	$ 12,935.29
					$ 343,723,689.43
Total Present Value					**$ 343,723,689.43**