From: Bernice
To: Barnes, Cody, NMENV
Subject: [EXT] WQCC No. 18-05 (A) and GWB 19-24 (P)
Date: Wednesday, November 13, 2019 8:53:00 PM

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the
Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon.

In 1998, LANL said it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection to human health and the environment, including

- enhanced public participation;
- enhanced seismic requirements that address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers .

Please **deny** the draft permit and make a **recommendation** to the NMED Secretary that he require LANL to apply for a Hazardous Waste Act permit for the RLWTF.

Thank you for your careful consideration of my comments.

Sincerely,

Bernice J. Gutierrez
505-345-0311

November 13___, 2019

By email to: Cody.Barnes@state.nm.us
Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon.

In 1998, LANL said it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection to human health and the environment, including

- enhanced public participation;
- enhanced seismic requirements that address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers .

Please **deny** the draft permit and make a **recommendation** to the NMED Secretary that he require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Thank you for your careful consideration of my comments.

Sincerely,
Jean Stevens

From: dave mccoy
To: Barnes, Cody, NMENV
Subject: [EXT] LANL permit
Date: Thursday, November 14, 2019 5:31:47 AM

Dear Sir,
Citizen Action NM opposes the issuance of the discharge permit. The permit should be issued under the Hazardous Waste Act (RCRA). The prior corruption surrounding the permit should stop with this hearing by observance of the application of the appropriate law.
David McCoy
Citizen Action NM

November 14, 2019
By email to: Cody.Barnes@state.nm.us
Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:
I strongly oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon. This is an abomination and once poisons are in the ground they are very expensive to clean u.
In 1998, LANL said it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.
As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection to human health and the environment, including
 enhanced public participation;
 enhanced seismic requirements that address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
 protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers .
Please deny the draft permit and make a recommendation to the NMED Secretary that he require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Thank you for your careful consideration of my comments.

Sincerely,
Paul Pino, 68 Derek Rd, Sandia Park NM 87047

From:	mark devolder
To:	Barnes, Cody, NMENV
Subject:	[EXT] DP-1132 Permit for the RLWTF: Post-Hearing Comments
Date:	Friday, November 15, 2019 2:37:45 PM
Attachments:	RLWTF Post-Hearing Comments 111519 0a.docx

Fri 11-15-19 2:22 p.m.

Dear Mr. Barnes:

Attached are a portion of my post-hearing comments related to the DP-1132 Permit for the RLWTF. There are 71 comments related to the Solar Evaporation Tank (SET) only. The comments / questions primarily related to Engineered and Administrative Controls. I have attempted to be as truthful and accurate as possible given the limited information provided at the DP-1132 Public Hearing yesterday. Please consider the comments as preliminary as I have not had time to extensively research most issues.

I have not prepared comments as yet for either the MES, WMRM, or Reverse Osmosis potions of the over-all system, but they are forthcoming.

I have McAfee virus protection installed on my home computer.

Regards,

Mark DeVolder
P.O. Box 1155
Los Alamos, NM 87544
(505)-661-8799

To: Cody Barnes, NMED
From: Mark DeVolder, Public
Date: 11-15-19 1:51 p.m.
Subject: RLWTF Facility Post-Hearing Comments
Computer File: RLWTF Post-Hearing Comments / RLWTF Post-Hearing Comments 111519 0a

The following in information is provided as post-hearing comments to the DP-1132 Permit Hearing for the RLWTF (Thursday 11-14-19 9:00 a.m. to 5:00 p.m.). The content is preliminary and additional comments (or more detail) will be provided as research permits prior to COB 11-8-19.

Background on Mark DeVolder

BSChE University of New Mexico -1976
Cosden Oil and Chemical -1976 thru 1977
Stauffer Chemical-1977 thru 1979
Monsanto Chemical Intermediates-1980
LANL employee from 1980 thru 2017 (Retired)
LANL Group L-1, Target Fabrication for Nuclear Fusion Effort, 1980 thru 1981
LANL Group WX-1, Nuclear Weapons, 1981 thru 1989 (Work at Y-12 Plant, Rocky Flats Plant (RFP), Nevada Test Site, Q-Security Clearance, SIGMA-Level Security Access
LANL Group NMT-7 (Supervisor), Shipping and Receiving Nuclear Materials, Nuclear Material Blending Operations, Nuclear Material Vault Operations
NMT-8 (TA-55 Facilities Engineering Group), (Quality Assurance, Configuration Management)
NMT-8, ADWEM-AB, NMT-14 – TA-55 Facility Safety Analysis Report (1994), Hazard Analysis and Related Engineering work for TA-55, RLUOB, RFP, TA-55 recordkeeping, Design Standards for Integrating Processes into Gloveboxes (Copy to Merrick Engineers), Procedure: *Developing and Maintaining Equipment Data Books*, LANL Conference – Life-Cycle Engineering, Personal Security Assurance Program (PSAP)-Certified
ES-55, Recordkeeping for All TA-55 Systems / All RLUOB Systems / Some RLWTF Systems, System Engineering for 43 TA-55 Systems (Balance of Plant Systems), Project Engineering for TA-55 / RLUOB / RLWTF, Glovebox Design Standards, Close-out of Legacy Engineering Projects (DCPs), Derivative Classifier Certification

Solar Evaporation Tank (SET) Issues

Tank Configuration

1) The depth of the tank is unknown (Note: This becomes important if a person, animal, or airborne debris fall or migrate into the tank.)
2) The freeboard in the tank (that is, the height from maximum water level to the top of the tank) is unknown. (Note: This becomes important as various operating conditions and, emergency conditions potentially change the height of liquid in the tank. Precipitation such as rain and snow can add to the liquid level in the open-air tank. Wind can create

waves in the tank and potentially result in spillage outside the tank (perhaps during high-liquid-level situations encountered during emergency conditions. In addition, there may be seismically-induced wave issues / sloshing issues which could result in spillage of tank contents outside the tank.)

3) Why isn't the tank covered or mostly covered with vent holes to permit the release of evaporated water vapor to the environment?
4) Can vegetation blow into the tank because it is open to the environment?
5) Can vegetation be blown out of the tank and spread contamination to the environment?
6) Is any kind of fencing provided to keep vegetation out of the tank?
7) Is there any kind maintenance provided for weed control?
8) Can weed-control cuttings get into the tank?
9) Can animals (for example, rodents, deer, birds) get into the tank because it is open to the environment?
10) Can animals drown and remain in the tank?
11) Can burrowing or other types of animals get into the tank and then spread contamination outside of the tank to the environment?
12) Can a person fall into the tank and drown?
13) Is a two-person rule followed by all personnel visiting the tank when it is full of liquid? (Note: Because the depth of liquid in the tank is not known, it is not known if there is a requirement for personnel visiting the tank to know how to swim. It is not known if fall protection features need to be provided or a flotation device / life preserver needs to be worn by personnel.)
14) If a LANL employee or a contractor falls into the tank or reaches into the tank without appropriate Personal Protection Equipment (for example, gloves), what protective features are provided (for example, emergency response team / ERT personnel, first aid kit, telephone / cell phone / two-way radio, appropriate communications reception in all locations around the tank).
15) Can wind-borne debris (Styrofoam, paper, candy wrappers, etc.) get into the tank?
16) Can floating debris accumulated in the tank become airborne and be blown out of the tank spreading contamination outside the tank?
17) Is there any kind of netting to prevent wind-born debris from getting into or out of the tank?
18) Is there any kind of fencing in close proximity of the tank to exclude animals, vegetation, and wind-born debris while still allowing maintenance access (that is, tank / liner replacement repair? (Note: it is unknown how much room / space is necessary adjacent to the tank to permit liner replacement.)
19) Can birds get into the tank and then fly out of the tank spreading contamination to the environment?
20) Is the bottom of the tank sloped to permit complete drainage for maintenance purposes?
21) Is there some type of sump in the bottom of the tank?
22) How is the tank drained?
23) Is there a drain pipe at the bottom of the tank (gravity drain) or is there a suction line which extends down into the tank from grade level?

24) If a suction line is utilized is it provided with a suction screen to exclude debris?
25) If the suction line is provided with a suction screen, how is suction line inlet / screen cleaned if it becomes clogged with debris? (Note: Debris might include vegetation, weed-control cuttings, dead animals, cardboard, paper, rocks, soil, etc.)
26) Is a pump used to drain the tank?
27) Is secondary containment (spill pan) provided for a pump if a pump is used?
28) If a pump (and secondary containment) is used, are both properly secured (seismically secured)?
29) If a pump is serviced (for example, seal or part replacement), can contaminated water be released outside the tank?
30) Can the contents of a pump freeze and crack the pump?
31) Are spare parts available for the pump?
32) Are there provisions for a truck to pump out (suction out) the contents of the tank?
33) Can maintenance equipment (for example, a motor vehicle, truck, or crane) be inadvertently driven into the tank?
34) Are there bollards or other features which prevent a vehicle from inadvertently entering the tank.
35) How are floating / submerged debris removed from the tank (for example, nets with cables, nets on poles, etc.)?
36) Is there a concrete pad for removing and collecting debris from the tank?
37) How are debris (for example, foreign material like Styrofoam cups, paper, cardboard boxes, candy wrappers, plastic sheeting, CAUTION tape, vegetation, dead animals) handled after removal from the tank to prevent the spread of contamination to the environment.
38) What is the composition of the tank liners?
39) Is there any potential that the expansion strip material in the concrete tank basin could chemically react with the liner material (that is, a chemical incompatibility issue) and result in a leak to the environment? (Note: Polyvinyl Chloride can adversely react with asphaltic materials over time.)
40) Are both tank double-thickness tank liners (that is, primary containment and secondary containment) made of the same material?
41) If both liners are made from the same material, is there a potential for a common-cause failure? (Note: A common cause failure means that both the primary confinement and the secondary could fail in the same way and possibly at the same time. To avoid common-cause failures, different materials and/or engineered configurations with differing failure modes may be utilized).
42) What is the projected service life of the liners?
43) Was the vendor who provided the liner made aware of the complete spectrum of chemicals and radionuclides which would be present in the water contained by the tank liner?
44) Did the vendor who provided the liner provide any kind of warranty for the liner?

45) What type of quality assurance information is available on the integrity of the liner(s) (that is, material composition, liner thickness, sealing of seams, handling pre-cautions, installation requirements, rework or repair of the liner during construction)?
46) Is each liner a one-piece configuration or is each liner fabricated and sealed in place within the concrete basin (that is, a built-up assembly)?
47) Are there vendor requirements / procedures available governing the installation of the liners?
48) Can any kind of debris, sharp-edge machinery, sampling equipment, etc. result in a breach of the liner(s).
49) It is not known what security features have been provided (fences, locked access / egress locations, signs) to exclude the general LANL population from the tank area.
50) Could LANL employees or contractor personnel throw rocks or coins into the tank for fun (that is, horseplay)?
51) Could a disgruntled LANL employee, LANL employee not following procedures, or contractor personnel damage the tank liner and/or instrumentation monitoring system?
52) If the liner system is damaged and LANL has insufficient funding to make repairs due a budgetary shortfall, what happens (contingency plans)?
53) Given that the liners will be exposed to chemical and radioactive contamination (that is, an “undefined” current and future spectrum of both chemicals and radionuclides), will either the chemical or radioactive materials degrade the integrity of the liners over time?
54) Has or will LANL perform any advanced aging tests on samples of the liner materials to determine when a liner failure might occur?
55) What is the configuration of the interstitial leak monitoring system between the liners? (Note: It is not known if the interstitial monitoring system consists of continuous sensor features / sensor material in all locations between both liners or is a system of sensors distributed in a pre-determined number of locations.)
56) What are the failure modes for the monitoring instrumentation (for example, the pathway from the sensors to the instrumentation, cables, plugs connectors, the monitoring instrumentation, etc.)?
57) How are the tank liner monitoring instrumentation systems operated, calibrated, maintained, etc.
58) Is the monitoring instrumentation local or remote? (Note: If a failure occurs, is a local signal provided at the instrument monitoring location or is there a remote indication in the RLWTF Control Room?)
59) If a failure occurs in the liners as shown by the instrumentation, how long will it take to remedy the problem (that is, a failure of instrumentation sensor / cabling / instrumentation monitor or remote instrumentation interface in the RLWTF Control Room)?
60) How is the leak detection instrumentation protected (ruggedized instrumentation enclosure) from heat, cold, dust, moisture, wind, precipitation – rain and snow, rodents, and insects?
61) It is not known if there is level instrumentation (high level) provided for the tank.
62) The failure modes for any level instrumentation provided are not known.

63) It is not known how the setpoint on any level or high-level instrumentation would adjusted to accommodate changes in operating conditions or emergency situations.
64) The procedures governing the operation and maintenance of the SET were not discussed in any detail during the DP-1132. The extent of training for LANL employees and contractor employees (that is, operators, maintenance personnel, engineering personnel, supervisory personnel, visitors, etc.) working or visiting the SET were not discussed in any detail during the DP-1132 hearing. The efficacy of both the procedures and the training are unknown.
65) There may be a perception that the risks associated with the SET are low because of the low levels of chemical and radioactive contamination present in the contaminated water. However, appropriate precautions should be taken as they would be in any kind of nuclear facility. For example, are there signs around the perimeter of the tank which indicate CHEMICALLY / RADIOACTIVELY CONTMINATED WATER – NOT POTABLE WATER – DO NOT DRINK.
66) Is there a full set of Hazard Communication Information available (for example, Material Safety Data Sheets / MSDS's for all chemical constituents potentially present in the contaminated water and as well as information on radionuclides present?
67) Although general geotechnical information was provided during the DP-1132 hearing, there was a lack of specific report information provided on soil conditions found immediately below the concrete basin. For a sub-surface (below-grade) basin, soil must have required excavation, relocation and/or removal by heavy construction equipment. Prior to such work, soil surveys were most likely completed to establish integrity of the soil in and around the proposed construction site. During construction, any kind of soil anomaly (including unusual geological features, abandoned facility systems, pre-existing structural foundations or other buried materials) would typically be reported. Tuff which is present in areas around TA-35, TA-50, and TA-55 is by nature a brittle and porous material. Tuff formations may include fractures, crevices, sink holes and related features which might be uncovered during excavation and/or construction activities. Any issues would require some type of remediation during the construction effort and prior to any concrete placement. No such report information was provided during the DP-1132 hearing?
68) What quality assurance /integrity information is available on the concrete basin (for example, concrete mix information, data on the reinforcing bar used, thickness of the concrete, concrete strength, smoothness of concrete, any rework required, presence of sharp edges on concrete, data on expansion strip material, photographs, daily construction reports, etc.)
69) What is the composition and configuration of the expansion joints in the concrete basin?
70) The tank was tested with water which did not have any chemical and/or radiological content. This was a reasonable practice to prepare for introduction of chemically- and radiologically-contaminated water.
71) The Rocky Flats Plant also had contaminated liquid ponds. Those facilities leaked and contaminated downstream sources of drinking water utilized by nearby communities. This forced communities such as Broomfield to find other sources of drinking water.

From:	mark devolder
To:	Barnes, Cody, NMENV
Subject:	[EXT] DP-1132 Permit for RLWTF: Post Hearing Comments (MES)
Date:	Friday, November 15, 2019 10:40:30 PM
Attachments:	RLWTF Post-Hearing Comments MES 111519 0a.docx

Fri 11-15-19 10:39 p.m.

Dear Mr. Barnes:

Attached are a portion of my post-hearing comments related to the DP-1132 Permit for the RLWTF (second installment). There are 47 comments / questions related to the Mechanical Evaporator System (MES) only (and a few comments / questions related to the reverse osmosis system). The comments / questions are primarily related to Engineering and Administrative Controls. I have attempted to be as truthful and accurate as possible given the limited information provided at the DP-1132 Public Hearing yesterday. Please consider the comments as preliminary as I have not had time to extensively research most issues.

Unfortunately, the information provided for the evaporator during the DOP-1132 hearing was sketchy at best. You will note that I repeatedly indicate that information is unknown. However, I filled in the gaps as much as I was able based on my previous experience with evaporators (at Stauffer Chemical) and reverse osmosis systems (at Cosden Oil and Chemical), and natural gas-fired systems (at LANL). My intent is to make sure that any issues related to the MES which have not been completely addressed get some sort of attention.

I updated my background information slightly from the previous submission for the Post Hearing Comments on the SET.

I have not prepared comments as yet for either the WMRM.

I have virtually no information on the Reverse Osmosis system. This puts me in a position of addressing only theoretical operation and maintenance of a reverse osmosis system. I know very little about the separation membranes for reverse osmosis systems in nuclear applications.

I have McAfee virus protection installed on my home computer.

Regards,

Mark DeVolder
P.O. Box 1155
Los Alamos, NM 87544
(505)-661-8799

To: Cody Barnes, NMED
From: Mark DeVolder, Public
Date: 11-15-19 9:53 p.m.
Subject: RLWTF Facility Post-Hearing Comments (MES)
Computer File: RLWTF Post-Hearing Comments / RLWTF Post-Hearing Comments MES 111519 0a

The following information is provided as post-hearing comments to the DP-1132 Permit Hearing for the RLWTF (Thursday 11-14-19 9:00 a.m. to 5:00 p.m.). The content is preliminary for the MES and additional comments (or more detail) will be provided as research permits prior to COB 11-8-19.

Background on Mark DeVolder

BSChE University of New Mexico - 1976
Cosden Oil and Chemical - 1976 thru 1977
Stauffer Chemical - 1977 thru 1979
Monsanto Chemical Intermediates - 1980
LANL employee - 1980 thru 2017 (Retired)
LANL Group L-1, Target Fabrication - 1980 thru 1981
LANL Group WX-1, Weapons Engineering - 1981 thru 1989, Work at Y-12 Plant, Rocky Flats Plant / RFP, Nevada Test Site, Q-Security Clearance, SIGMA-Level Security Access
LANL Group NMT-7 - 1989 to 1992 (Supervisor / Recordkeeper), Shipping and Receiving Nuclear Materials, Nuclear Material Blending Operations, Nuclear Material Vault Operations, NMT-7 Personnel Training Records, Personal Security Assurance Program (PSAP)-Certified
LANL Group NMT-8 (TA-55 Facilities Engineering Group) - 1992 to 1993, (Quality Assurance, Configuration Management, NMT-8 Safety Committee)
LANL Groups NMT-8, ADWEM-AB (Authorization Basis), NMT-14 (Safety Basis) - 1993 to 2013, TA-55 Facility Safety Analysis Report (1994), Hazard Analysis and Related Engineering work for TA-55 / RLUOB / RFP, TA-55 Recordkeeping, Guideline: *Design Standards for Integrating Chemical, Metallurgical and Ceramic Processes into Gloveboxes* (Copy to Merrick Engineers), Procedure: *Developing and Maintaining Equipment Data Books*, LANL Conference on Life-Cycle Engineering, System Engineering for 43 TA-55 Systems (Balance of Plant Systems), Recordkeeping for All TA-55 Systems, Personal Security Assurance Program (PSAP)-Certified.
LANL Group ES-55, 2013 to 2017, Recordkeeping for All TA-55 Systems / All RLUOB Systems / Some RLWTF Systems, Project Engineering for TA-55 / RLUOB / RLWTF, Glovebox Design Standards, Close-out of Legacy Engineering Projects (DCPs), Derivative Classifier Certification.

Mechanical Evaporation System (MES) Issues

Evaporator Configuration

1) The type and configuration of the evaporator is unknown. It is not known if a single-effect / single-stage evaporator system or a multiple effect evaporator system will be

used. It is not known if the evaporator has a circulation pump or some type of natural gas-fired heat exchanger. It is not known if the evaporator is a thin-film type with mechanical wipers to remove accumulated solids.

2) It is not known how any solids might be separated from the evaporator effluent or how any separated solids might be handled further downstream.
3) A Process Flow Diagram (PFD) and/or Piping and Instrumentation Diagram (P&ID) was not provided during the DP-1132 hearing. A PFD typically contains information on inlet and outlet stream characteristics to / from the evaporator such as flow rate (minimum, average, and maximum) composition of stream (minimum, average, and maximum weight or concentration of various constituents), and temperature (minimum, average, and maximum). It is assumed that the evaporator operates at ambient pressure and is not provided with vacuum-type features. The characteristics of the product or effluent discharged from the evaporator are unknown. It is not known if the effluent stream contains evaporated solids, dissolved solids, etc. This makes any analysis of the evaporator system an exercise in speculation.
4) It is not known if any additional chemicals are added to the influent prior to being sent to the evaporator or reverse osmosis system (for example, addition of acid or caustic to adjust pH).
5) It is not known exactly which stream is being evaporated (the influent stream from the Waste Mitigation R____ M____ (WMRM) tanks, an accumulated stream from the reverse osmosis system, or a flush stream from the reverse osmosis unit.
6) A P&ID was not provided; therefore, any operating characteristics such as pressure or temperature are unknown. Any definition of instrumentation is also unknown. It may be assumed that evaporators may contain some type of temperature control and level control (high level / low level alarms).
7) The configuration of the evaporator is unknown. The size and capacity of the evaporator as well as the weight of evaporator components was not defined. The composition of the evaporator shell (perhaps stainless steel or some other alloy) is unknown. What is known is that the evaporator shell or evaporator heat exchanger (and pump if used) must be able to withstand temperatures created by a natural gas-fired heating system.
8) Evaporator systems which operate at elevated temperatures and contain acidic or caustic effluents or dissolved solid effluents are potentially subject corrosion, leakage, and external radioactive contamination. Fouling (solids accumulation) on internal evaporator surfaces (particularly heat exchanger surfaces) may occur. It is unknown how such surfaces are cleaned and maintained for reasonable evaporator operation / efficiency.
9) It is not known if evaporator instrumentation is subject to corrosion, fouling, etc. The accumulation of solids on thermowells (containers for temperature instrumentation) may result in erroneous operating temperature readings.
10) The natural-gas heating system was not defined during the DP-1132 hearing. Typically, natural gas systems are provided with a pressure regulator, an automatic shutoff valve, a tee in the line which permits external venting of natural gas venting to the atmosphere via an automatic vent valve, and another automatic vent valve (that is, a double block and bleed arrangement).

11) There was no discussion in the DP-1132 hearing about evaporator maintenance or equipment required for maintenance (for example, cranes or lifts).
12) No information was provided on the service life of evaporator equipment and what is required for evaporator equipment replacement.
13) In the event of a budgetary shortfall at LANL, no discussion was provided about operating evaporator equipment beyond its useful service life.
14) It is not known if the evaporator is provided with some type of entrainment separator, High Efficiency Particulate Air or HEPA filter, and a vent to the interior of the tent-like structure.

Secondary Containment

15) A photograph shown in Mr. Beers' DP-1132 hearing presentation showed a tent-like structure supported by a tubular metal frame. (Note: It is not known if tent-like structure is being used for secondary containment or there is some other type of secondary containment around the evaporator which could not be seen in the photograph.)
16) It is not known if the tent-like enclosure is considered a confined space.
17) It is not known where the evaporator (and any pumps, heat exchangers, instrumentation, etc.) are located within the tent-like structure.
18) It is not known if instrumentation inside the tent-like enclosure is monitored locally or remotely. Do personnel have to access the tent-like enclosure to monitor evaporator performance?
19) Tours (for NMED personnel) were provided of the RLWTF facilities, but no data on the configuration of the MES was forthcoming from any NMED personnel who went on those tours. It is not known if there were restrictions on dissemination of classified or UCNI-type information. Alternately, there may have been restrictions due to dissemination of confidential / propriety information protected by equipment vendors so that it could not be made available to the Public.
20) It is not known if the tent-like structure is simply an environmental boundary to protect workers from external environmental conditions.
21) It is not known if the tent-like structure serves as a chemical barrier (including Category I chemicals or suspected carcinogens) and / or radioactive contamination barrier.
22) It is not known if the tent-like structure is sealed.
23) It is not known if the tent-like structure is provided with an airlock.
24) It is not known if access to the tent-like structure requires the wearing of anti-contamination clothing (anti-c's) and where donning and doffing of such personal protective equipment (PPE) might be accomplished.
25) It is not known what kind of radiological monitoring equipment is provided or where it is located.
26) It is unknown why the MES was not located in a more robust structure equipped airlocks, facilities for with donning / doffing anti-contamination personal protective clothing (anti-c's) and other personal protective equipment (PPE) such as respirators and self-contained breathing apparatus (SCBA) units, and active ventilation features (that is, fans, high efficiency particulate air or HEPA filters, ventilation control instrumentation).

27) The tent-like structure is supported by a tubular frame. It would appear from the photograph in Mr. Beers' DP-1132 presentation that there are tabs which support the tent-like structure. It is not known if the tabs and tubular frame can support the 30 pound per square foot snow loading typically required for most LANL / DOE facilities.
28) The composition of the tent-like structure is not known.
29) It is not known if the tent-like structure is positioned on a concrete pad or an asphalt pad. (Note: If the tent-like structure is composed of polyvinyl chloride or PVC it could potentially react with asphaltic material and breach (chemical incompatibility). This could potentially result in the release airborne chemical and radioactive materials to the environment during either operation or maintenance activities.
30) It is not known if the tent-like structure is equipment with some type of integral filter to admit air to the natural gas-fired heating system.
31) It is not known if a filter on the tent-like structure could plug causing any of the following: depleted oxygen content which could have an adverse effect on workers, incomplete combustion of natural gas, decreased evaporator operating temperature, collapse and / or implosion of the tent-like structure, and / or tearing / leakage of the tent-like structure. (Note: A natural gas-fired system and operations / maintenance personnel may both compete for oxygen in the tent-like enclosure. If this is the case, SCBAs may be a requirement instead of respirators.)
32) It is unknown how the discharge of hot natural gas combustion gas out of the tent-like structure is accomplished or how any discharge feature is sealed.
33) It is not known how the natural gas supply line double block and bleed vent penetrates the tent-like structure or how that penetration is sealed. (Note: It is unknown if the entire double block and bleed system is located external to the tent-like structure.)
34) It is unknown if an external vent penetration is provided from the evaporator (entrainment separator or HEPA filter) to the outside of the tent-like structure.
35) It is unknown if an evaporator vent penetration in the tent-like structure is sealed.
36) The positioning of the evaporator, natural gas fired heating system, pump (if any) is not known. Therefore, it is not possible to determine if the evaporator system components could cause ignition of the tent-like structure due to radiant and / or convective heat transfer. (Note: I do not know if there is any kind of fire suppression system inside the tent-like structure. There is a new type of fire suppression system on the market which generates a water mist. The system is a vast improvement over Halon-type fire suppression systems or carbon dioxide fire suppression systems because the water mist does not degrade the oxygen concentration necessary for personnel to breath and permits personnel to evacuate from the scene of a fire. In this case, it would be the interior of the tent-like structure.)
37) It is not known if the evaporator vessel provided is with any kind of pressure relief valve, pressure safety valve / rupture disk.
38) It is not known if a discharge line from a pressure relief valve / pressure safety valve / rupture disk on the evaporator vents to the interior of the tent-like structure or exterior of the tent-like structure.
39) It is not known how a pressure relief valve / pressure safety valve / rupture disk discharge line which penetrates the tent-like structure is sealed.

40) It is not known if a pressurized release from a discharge line from a pressure relief valve / pressure safety valve / rupture disk discharge line could result in internal over-pressurization of the tent-like structure. (Note: This assumes that the discharge line vents within the tent-like structure.)
41) It is not known what the consequences will be if chemically- or radiologically-contaminated liquid from the evaporator is discharged from a pressure relief valve / pressure safety valve / rupture disk discharge line to the atmosphere. (Note: This assumes that the discharge line vents to the exterior of the tent-like structure.)
42) It is not known how the tent-like structure will withstand the combined effects of natural gas-fired heating inside of the structure, temperature cycling (hot and cold ambient temperatures outside the structure, and exposure to sunlight (ultraviolet light).
43) Surveillance of the tent-like structure for cracks, leaks, etc. was not defined.
44) No information was provided on soil conditions for the concrete pad / asphalt pad which supports the tent-like structure, evaporator, ancillary equipment, and secondary containment.
45) No quality assurance information (for example, design mix, reinforcing bar information, concrete strength, etc.) was provided the concrete pad which supports the tent-like structure. Alternately, no information was provided for the asphalt which supports the tent-like structure.
46) There was no discussion of how a hypothetical organic and inorganic waste stream would be processed through a reverse osmosis system and / or the evaporator.
47) There was no discussion about the potential for a hypothetical waste stream containing organics and inorganics flowing to the RLWTF and being concentrated in the evaporator.

From: Greg P
To: Barnes, Cody, NMENV
Subject: [EXT] Discharge permit for LANL
Date: Saturday, November 16, 2019 6:08:31 AM

Dear Cody Barnes,

I hope you are well and enjoying an optimistic outlook.

I am an acequia irrigator in Pojoaque Valley. I am emailing to say that I oppose the issuance of New Mexico Environment Department's "draft groundwater discharge permit" (DP-1132).

I think that discharges from the Radioactive Liquid Waste Treatment Facility ought to be regulated and managed under the New Mexico Hazardous Waste Act, as it provides better protection for us.

Thank you for your time.

Sincerely,
Gregory Corning
Pojoaque

November 16, 2019

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon.

In 1998, LANL stated it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection for human health and the environment, including

• enhanced public participation, such as a Class 3 permit modification process for the new low-level radioactive waste treatment facility;
• enhanced seismic requirements that would address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
• protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers .

Please deny the draft permit and make a recommendation to the NMED Secretary that he require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Thank you for your careful consideration of my comments.

Sincerely,

Alexa Jaramillo

November 16, 2019

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

This issue is complex, but vital. It affects all New Mexicans, but is most dangerous for the pueblos whose land was co-opted for making weapons of mass destruction. The US Government has no right to permanently pollute land that belongs to another sovereign nation, a nation that is trying to protect the environment that it rightfully considers its homeland. Because I want to express my concerns clearly, I am using arguments that others have put more clearly than I can. Please accept them with the understanding that, although they are not my words, they express my concern exactly.

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon, and through groundwater to the extensive spring system at the Rio Grande.

In 1998, LANL stated it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection for human health and the environment than the proposed groundwater discharge permit under the NM Water Quality Act, including

- enhanced public participation and oversight, such as a Class 3 permit modification process for the new, multi-million dollar low-level radioactive waste treatment facility;
- enhanced seismic requirements that would address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers.

Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

Cynthia Weehler

Cynthia Weehler
20 Descanso Rd., Santa Fe, 87508
cnthweehler@gmail.com
512-838-3351

From: Cletus
To: Barnes, Cody, NMENV
Subject: [EXT] waste
Date: Sunday, November 17, 2019 7:29:02 PM

November 17, 2019

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

Please know that I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon, and through groundwater to the extensive spring system at the Rio Grande. I'm surprised that in such a beautiful state you allow such environmental horrors to just be accepted. Do you have no morality?

In 1998, LANL stated it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection for human health and the environment than the proposed groundwater discharge permit under the NM Water Quality Act, including

- enhanced public participation and oversight, such as a Class 3 permit modification process for the new, multi-million dollar low-level radioactive waste treatment facility;
- enhancedseismic requirements that would address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers.

Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated. May God reward you according to your care for his world and his people!

Sincerely,

From:	Deborah Reade
To:	Barnes, Cody, NMENV
Subject:	[EXT] CARD"s Comments on DP-1132
Date:	Monday, November 18, 2019 4:34:31 PM
Attachments:	EJSCREEN-EPAFactSheet.pdf LANL-30mile.pdf Red_.Dust_.pdf CARDcomments_DP-1132_11-17-19.pdf

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Dear Mr. Barnes,

Attached, please find CARD's comments (written statement) on the DP-1132 Draft Permit. Please include this written statement in the Administrative Record for DP-1132 along with the three attachments, *Red Dust, EPA EJSCREEN Fact Sheet* and the *EJSCREEN ACS Report* using a 30-mile radius around LANL.

I will also send this through another email program as I've been having some problems with this program recently and want to make sure you receive all the documents. Please confirm receipt of the comments and the three attachments.

Thank you,
Deborah Reade
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117 Duran Street
Santa Fe NM 87501-1817
Phone/fax 505-986-9284
Reade@nets.com

November 17, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments by Citizens for Alternatives to Radioactive Dumping (CARD) on the DP-1132 discharge permit for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory (GWB 19-24 [P])

Dear Hearing Officer Virtue:

CARD opposes the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). These comments, or written statement, will look at both the permit and the RLWTF as well as at the public process for this discharge permit.

The Facility and the Discharge Permit

In 1998, LANL said it would transition the RLWTF to a zero discharge facility and in 2010, all discharges through Outfall 051 ceased. At that time, LANL began to use a mechanical evaporator system. Since then, all waste has been treated by evaporating the liquids and shipping any remaining hazardous, radioactive or mixed waste materials off-site for disposal. Despite NMED's recent release of non-contaminated water, true to NMED's statements in 1998 and 2010, no real discharge through Outfall 051 has occurred in almost ten years. Even the current fact sheet still describes the Solar Evaporative Tank (SET) as a zero-liquid-discharge unit.

Though the fact sheet claims the draft permit authorizes the discharge of treated water "via the Mechanical Evaporator System (MES) and the SET," in fact, the permit actually talks of discharges "to" these units instead of "via" them, as liquids are not coming out of them and haven't for ten years. The current "fake discharge" only points out that such a release is not part of any regular process currently being used at the Facility.

Thus, DP-1132 is also a "fake permit" because there is no discharge, hasn't been one in ten years and there are no plans to discharge ever again as part of any process currently going on at the Facility. The Facility, the so-called discharge, and the permit are all extremely

controversial and have been for two decades. As time passes though, trying to claim that there is a discharge from the RLWTF becomes less and less viable. Releasing water through Outfall 051 before the permit hearing, only shows how desperate NMED has become to try to prove this Facility shouldn't be permitted and regulated under the New Mexico Hazardous Waste Act. Yet, that is really the only viable alternative. This Facility must be regulated under the Resource Conservation and Recovery Act (RCRA) and the Hazardous Waste Act as this is, a treatment facility only; there is no discharge. The DP-1132 permit application must be denied and the NMED Secretary must require LANL to apply for a Hazardous Waste Act permit for the Facility instead.

The Public Process for DP-1132

Unfortunately, the public process for DP-1132 has suffered from many of the same ills as have been evident in other recent (and past) discharge permit processes in the GWQB. The PIP was inadequate, both public notices were defective and the fact sheet, though including some additional information, was more a fact sheet about what was required for permits in the regulations than about what important and vital information was actually in this particular permit.

The process has not identified all communities potentially affected by the proposed permit, nor has it accommodated the needs of those communities, statements in the PIP and the public notices notwithstanding.

Public Involvement Plan (PIP)

The PIP states on page 1 that it "implements the "elements set for in the *[Public Participation] Policy,*" but the lack of any public involvement in the Public Involvement Plan has resulted in a defective PIP and misunderstandings about where the affected communities are and those communities' needs and concerns. There is also no information for the general public on how to appeal or revise the PIP and no clear path to request corrections, make suggestions, or provide community-based, local input. Thus the public continues to be shut out of any meaningful involvement in the Public Involvement Plans, problems continue, and the PIPs, including this one, are of only limited use.

1. Improper use of EJSCREEN: The GWQB have arbitrarily and capriciously used a 4-mile radius in this PIP as the limits of where they will look to find the affected community. Use of such a radius has allowed the PIP to state that there are virtually only wealthy, highly educated, White people who speak English well in the affected community. Indeed, Los Alamos County is the wealthiest county in the entire country. At 4 miles the demographic percentages are:

Percentage minority population	27%
Percentage Hispanic population	17%

Percentage of American Indian population	1%
Percentage of persons speaking English "less than very well"	4%
Percentage of linguistically isolated households	3%
Percentage of households with $75,000+ income	69%
Percentage of households with less than $15,000 income	7%
Percentage with Bachelor's Degree or more	64%
Per capita income	$45,945.00

However, going out to a 30-mile radius shows quite different results

Percentage minority population	64%	237% increase
Percentage Hispanic population	53%	312% increase
Percentage of American Indian population	7%	700% increase
Percentage of persons speaking English "less than very well"	9%	225% increase
Percentage of linguistically isolated households	4%	133% increase
Percentage of households with $75,000+ income	37%	54% decrease
Percentage of households with less than $15,000 income	14%	200% increase
Percentage with Bachelor's Degree or more	38%	59% decrease
Per capita income	$33,408.00	73% decrease

Going out to just 30 miles massively increases both the Hispanic and Native American populations. The number of potentially affected pueblos increases from one (San Ildefonso) to around eleven and Native American percentages go up 700%. The Hispanic population goes up more than 300%, the percentage of persons speaking English less than very well more than doubles, the percentage of households earning less than $15,000 per year doubles and the percentage of people with a BA or more decreases by almost half. The actual affected population is heavily minority, speaks English less well, is less educated and most earn far less money than those living within the 4-mile radius.

The GWQB has given no justification for choosing only a 4-mile radius in their EJSCREEN calculations and indeed there is no justification. Did the Bureau even look to see what the situation was beyond 4 miles? The choice of such a limited radius is shocking since there are many people in the Bureau who have lived in the area for years and are completely aware of the demographic makeup of the population beyond the 4-mile radius..

In addition, the Bureau cannot argue that the discharge (if there were a discharge) from the

Facility could only affect people and the environment within the 4-mile radius. Agricultural land in Española worked by one of the Parties, Tewa Women United, and irrigated traditionally using Rio Grande water, has been highly contaminated because of discharges from LANL in the past. As the attached study, *Red Dust,* concludes in its 2013 abstract, "These findings indicate that LANL has polluted the lands inhabited by Indigenous communities. The nature and high levels of contaminants has also created an area in which health disparities are disproportionately high." There is even a suggestion in the study that dark leafy greens grown on this land with that water would be better used as soil remediation and then discarded in a hazardous waste dump than eaten. Clearly, discharge from the RLWTF could reach far beyond the 4-mile limit.

And one wonders if GWQB personnel have been properly trained in using EJSCREEN. EPA's *EJSCREEN Fact Sheet* (attached) describes how EJSCREEN can be used "...to identify areas that may have higher environmental burdens and vulnerable populations..." not to limit investigation only to the wealthiest county in the country. The *Fact Sheet* specifically states that EJSCREEN shouldn't be used **"[a]s the sole basis for ... making a determination** regarding the existence or absence of EJ concerns..." (emphasis added), and that EJSCREEN outputs should be supplemented "...with additional information and local knowledge..." Yet using it as the sole basis for making their determination is exactly what the GWQB have done. The *Fact Sheet* also states that there is "...substantial uncertainty in the EJSCREEN demographic and environmental data, particularly when looking at small geographic areas..." Surely, this is perfectly illustrated by the differences in data found at 4 miles and 30 miles.

By ignoring the large numbers of people of color in the affected communities, NMED and the GWQB can have no understanding of the needs and concerns of these communities nor can they create adequate planning for public outreach to the communities. The only public outreach NMED has done is the minimum required by the regulations—and there is some question if even this minimum outreach has been achieved.

Community needs and concerns, including health needs, have not been incorporated into the draft permit nor into the public participation process—indeed they have not been investigated at all even though NMED pledged that they would review community history, demographics, needs and concerns when they signed the Resolution Agreement three years ago. And though the PIP states it will include "a description of community/stakeholder groups..." again, they base this totally on the EJSCREEN preliminary results. And preliminary results have become final results. There are no community stakeholder groups described in the PIP other than various government entities. The GWQB have made no effort to identify stakeholders in the affected communities nor any effort to create partnerships with private and public entities or to share information with affected communities, with environmental and environmental justice organizations, religious institutions, public administration, environmental, law and health departments at colleges and universities and relevant community service organizations. as federal guidance and the Resolution Agreement describe.

2. Limitations on LEP and the Disabled: Though neither the *Public Participation Policy* nor the

Disability Policy put limits on what NMED is required to do to make it possible for people with disabilities to have "...the opportunity for full participation in its ... actions," Indeed, the *Disability Policy* states that "NMED will provide, **at no cost to the individual** appropriate auxiliary aids and services including, for example, qualified interpreters to individuals who are deaf or hard of hearing..." (emphasis added). Yet the PIP states on page 2 that "accommodations or services for persons with disabilities will be arranged to the extent possible."

Limitations are also put on language assistance for Low English Proficiency (LEP) speakers as the PIP allows language assistance only "...as resources allow." LEP hearing-impaired callers are not even told that they can use a Spanish version of TDD or TTY systems. Only public comment notices and hearing notices are planned to be translated into Spanish and then only because of LANL's statewide significance. Fortunately, NMED also translated the Fact Sheet. but this wasn't planned for in the PIP.

3. Notification: It is unclear if the notification process described on page 6 was carried out adequately for public comment as the description of who will be noticed and how is vague and incomplete. Were Tribes, Pueblos and Nations actually mailed notices? What about other government entities. Ditch associations are not even mentioned in the PIP though they are listed for notification in the regulations. This missed requirement is especially significant as one of the parties is a ditch associations, the New Mexico Acequia Association.

Public Notices

Unfortunately, both public notices are also defective since information required by either the PIP or the regulations themselves is missing and the public notice continues to make incorrect claims that all communities potentially affected by the permit have been identified and that public participation has been expanded to accommodate community needs.

1. PN-2 - missing & incomplete information: The PIP says there will be a statement on every public notice about the availability of language assistance , however, nothing at all about it has been incorporated into this public notice. And at 20.6.2.3108 (I) NMAC the regulations require that a description of the procedures to be followed by the Secretary in making a final determination be included in every PN-2, but that is completely missing also.

The description of the activities leading to the discharge, contact information, location of the discharge, depth to affected groundwater and TDS are all included in this public notice. However, the description of the quality of the discharge is lacking. Though we are told that the discharge could contain "...contaminants with concentrations above the standards of the regulations and that it may contain toxic pollutants, we are not given any list of the contaminants or even of the types of contaminants. That is necessary if the public is to understand fully what is involved in this discharge so they can evaluate if the permit will be able to protect our groundwater adequately.

2. Hearing Notice - missing, incorrect & incomplete information: Despite regulatory requirements to explain hearing procedures (20.6.2.3108 (L) NMAC), and further requirements to let the public know how to submit comments (20.6.2.3108 (F) NMAC), the public is only told they can submit oral or written statements at the permit hearing itself. In fact, written statements or statements of interest are accepted during the 30-day pre-hearing period and until the hearing is closed. However, we are not told how or to whom we can submit these statements. We are referred to the hearing procedure regulations at least twice but this is insufficient as LEP persons can't access them at all and even the general public must have excellent English, good computer skills and excellent online search skills to find this one small statement in the regulations. This is not okay, especially since the Bureau has been told, at length, about this problem during the WCS discharge permit process.

In addition, the hearing notice contradicts the PN-2 when it states on page 2 that the discharge "...will meet all numerical groundwater standards identified in 20.6.2. NMAC." In contrast, the PN-2 states that "the discharge may contain water contaminants with concentrations above the standards...and may contain toxic pollutants..." Which is correct?

The hearing notice includes good information on the location of the discharge and the activities that contribute to the discharge as well as good information on the volume, depth to groundwater, and TDS concentrations.

Finally, a partial list of contaminants is provided. However, again the GWQB has left off mentioning all the radionuclides that could be in the discharge. Though NMED claims they don't need to describe anything they don't regulate (like TRU radionuclides), there is no such prohibition anywhere in the regulations. Since TRU waste is a primary component of the waste treated at the Facility, it is inappropriate for NMED to eliminate this information from public notices. Without complete information on everything that could or will be in the waste, the public cannot properly evaluate whether or not the permit is adequately protective.

3. Hearing notice - inadequate assistance notification: The public notice only makes the barest mention that people can request language assistance. It doesn't copy the language of the PIP that describes the possibility of document translation so people don't even know that is a possibility. People requesting assistance are told to contact the permit contact. However, all phone voice mail is English-only. And though information is given about requesting disability assistance, TTY information is also English-only, as once again the notice follows the PIP and leaves out any mention of the TTY Spanish option mentioned in the PN-2.

The Fact Sheet

Like many of NMED's permit Fact Sheets, this one is greatly flawed. Most of the public who participate in the permitting process never read the permit or other documents beyond public notices and, if provided, a Fact Sheet. The Fact Sheet should summarize and supplement the permit and should contain all vital information in the permit. The permit is far too long to be translated in its entirety, even if NMED were willing to do so, and a good Fact Sheet is one of the best ways to involve the public whether it is the general public, the Minority public, or

those needing disability or language assistance. A translated fact sheet is, in fact, the only way to provide enough vital information to the LEP public for them to be able to participate fully and equally as the minimal information in even expanded public notices is inadequate for this. The English speaking public can always read the permit itself or the regulations. The LEP public cannot.

Unfortunately, this fact sheet's main problem is the lack of information provided. It is supposed to provide information about a permit that is over 100 pages long and yet it is only 7 pages long itself – quite a bit shorter than Fact Sheets meant to summarize permits only one fifth that size. Chunks of information on many conditions – many that are important – are just gone. The unusual practice of not numbering the permit conditions makes the information in the fact sheet appear vague and confusing. This allows many conditions to be completely ignored without the public knowing they are missing.

Equally troubling is the habit of stating that "requirements" or the "limitations" or "proscribed measures" in a section "meet" or "conform to" the regulations, without telling exactly how the conditions of this permit do that. This is more a fact sheet about the regulations and what's required in *any* permit than a fact sheet about this particular permit. Paragraph after paragraph state that the permit conditions conform to the regulations and seem to expect the public to agree without any supporting information from the actual permit.

Description of the Proposed Discharge, Facility, and Permit:
Information on the discharge and the facility in this section is good, but again, this section needs to be fleshed out as there is only a little more information than would appear in a public notice. A more complete description of the MES and the SET and of the discharge piping, pathways and system should have been included so the public could understand the influx and outflow and what's going where. Maps would have been helpful here as well.

And a more complete description of the quality of the discharge should have been included without NMED censoring information about the discharge and deciding what's appropriate and not appropriate for the public to understand. There is no list of contaminants in the Fact Sheet, though one was provided in the hearing notice. Such a list should be included here, as well.

Though corrective action plans are described in some detail in five or more places in the permit, none of these are described at all in the fact sheet. Because of problems with such "contingency plans" in the WCS permit, the public needs to have more detailed accurate information on each of these plans so they can evaluate if they are adequately protective or not.

Finally, there is no hydrological and geological information about the affected area in the fact sheet. In this, it mirrors the permit, but for the public to understand whether this permit is protective of ground and surface water, the public must be able to have at least a basic understanding of the affected geology and hydrology of the area including seismic issues.

These latter are many and serious and are not addressed at all in this permit.

The Regulatory Framework section is good and is one of the most complete sections in the fact sheet.

Operational Plan – Conditions
Conditions are the heart of any discharge permit but the fact sheet starts sketching them out and continues to do so throughout. And the fact sheet does not always copy the language or intent of the permit. Right away in the first paragraph, the permittees are "... required to post appropriate advisory signs at the Facility or at the discharge location." This does not conform to the language of the permit which only describes signs around the Facility. Expanding where the signs can be posted in the fact sheet makes it seem that the discharge location will be more protected than it actually will.

The second paragraph states what the section requires and says those requirements conform to the regulations without describing how they conform.

The third paragraph describes other requirements and says they conform to the regulations without describing how they conform.

The 4th paragraph describes effluent quality limits and limits for toxic pollutants and exemptions for contaminants. Tables and lists are mentioned but not included; they should be. the Corrective Action Plan for effluent exceedances is not even mentioned and, as described above, should be not only mentioned, but detailed.

The first paragraph on page 5 again states that there are effluent quality limits and says they conform to the regulations without describing how they conform. What area the limits? What's in the mentioned table of chemical constituent limits?

The second paragraph on page 5 refers to requirements in the installation and calibration of flow meters and says those requirements conform to the regulations without describing how they conform. No information is given on the location or number of flow meters. (There are four.)

Monitoring and Reporting Conditions
The second paragraph under Monitoring and Reporting describes what is required in the quarterly monitoring reports. However, this section is very sketchy indeed beyond the simple list. Number and locations of monitoring wells are missing (there are seven wells), along with frequency of sampling and analysis of wells, effluent/influent waste streams and a list of analytes. All of this is minimal information that should have been included. How can the public tell if the monitoring plan is sufficient without even knowing what is going to be monitored, where the monitoring points are and what the analytes are?

The next paragraph describes a moisture monitoring system to detect unauthorized releases

from the SET and to establish baseline conditions. But there is no description of what this system is (neutron moisture probes), how many there are, or where they are located exactly. Again, information on corrective action plans if there are exceedances are completely left out.

All information on waste stream tracking, personnel and emergency response is also completely missing.

Contingency Plan Conditions
This paragraph addresses spills and states that "standard contingency conditions address the exceedance of groundwater standards, contaminant discharge limits, etc. However, once again, we're told the conditions conform to the regulations without describing how they conform. No details about the corrective action plans are given.

Closure Conditions
Again, the first paragraph states that measures and timeframes for closure are desecribed and that if there is contamination, remediation will be required. But none of this is described. No information from the permit is included on closure requirements or corrective action plans for remediation.

The following paragraph mentions 6 specific "units" that will be shut down but doesn't say what they are (storage tanks). We're told that "upon cessation of operation of a unit" a stabilization work plan will be submitted. Actually, the time frame is 4 months for the plan.

The third paragraph mentions that there is an overall closure plan for the facility which is attached to the Permit. However, though 2 years of groundwater monitoring is mentioned, no complete summary of this closure plan is described and no link is given in the fact sheet to the closure plan online. This wouldn't help LEP persons, since the closure plan, like the permit itself, is English-only, but if there were a comprehensive and accurate summary of the vital information in the closure plan, that would have solved the information problem for everyone.

The last paragraph under this section states that certain corrective action must be performed under the Consent Order and not under this discharge permit. Again, there is no summary of the Consent Order and no links to it. There is no description of what Solid waste management units (SWMUs) and areas of concern (AOCs) are. In fact, this is the first time the Consent Order is mentioned in the fact sheet even though many aspects of this discharge permit must relate to it. There is no description of the criteria to determine what corrective action will fall under the discharge permit and what will fall under the Consent Order. The lack of information about the Consent Order and the relationship between it and the discharge permit is a major failure to include important information.

General Terms and Conditions
It is stated that "... these terms and conditions are standard in all discharge permits. Still, that is not an excuse simply to list them with no other information. The condition about complying with all other applicable laws is an important condition and should have been described in its

entirety.

In Summary
This is a very controversial discharge permit that shouldn't even exist. It hardly does exist as there is no real discharge to be regulated. The limited information available to the public in the public notices and especially in the fact sheet that is almost completely empty of actual information about the permit, obstructs public participation possibilities and especially so for the LEP public.

The lack of care to make sure the Public Involvement Plan actually captures the affected communities and the lack of investigation of any of the communities' concerns, needs and history, including health concerns, shows an amazing lack of interest to protect human health and the environment and an especial lack of interest in involving and protecting the People of Color who surround this DOE site with one of, if not the highest, concentrations of People of Color around it of any DOE site in the country. In a completely arbitrary way NMED was able to eliminate any attention to these people by eliminating them from attention even though at least some or many of them are already suffering from having been contaminated by past discharges from LANL. Since discharges aren't going to continue at the FLWTF under the current procedures, NMED must switch to a RCRA permit for this facility. Problems with the public process and permitting can be corrected then.

No matter what happens, NMED must look at what the effects will be on Minority residents and on the general public near permitted sites to make sure that effects are dealt. Some kind of formal public process to review and correct PIPs and fact sheets must incorporated into every permitting process in the future. Without such a review we end up with defective notices and fact sheets like those for this Facility and a lack of attention to the real needs of affected communities.

Please include these comments, along with the three attachments, in the Administrative Record for DP-1132. Attachments: *Red Dust, EPA EJSCREEN Fact Sheet, EJSCREEN ACS Report* (30-mile radius around LANL).

Sincerely,
Deborah Reade
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Red Dust

A Soil Scientist's Journey Through the Political Climate and Environmental Chemistry of Northern New Mexico

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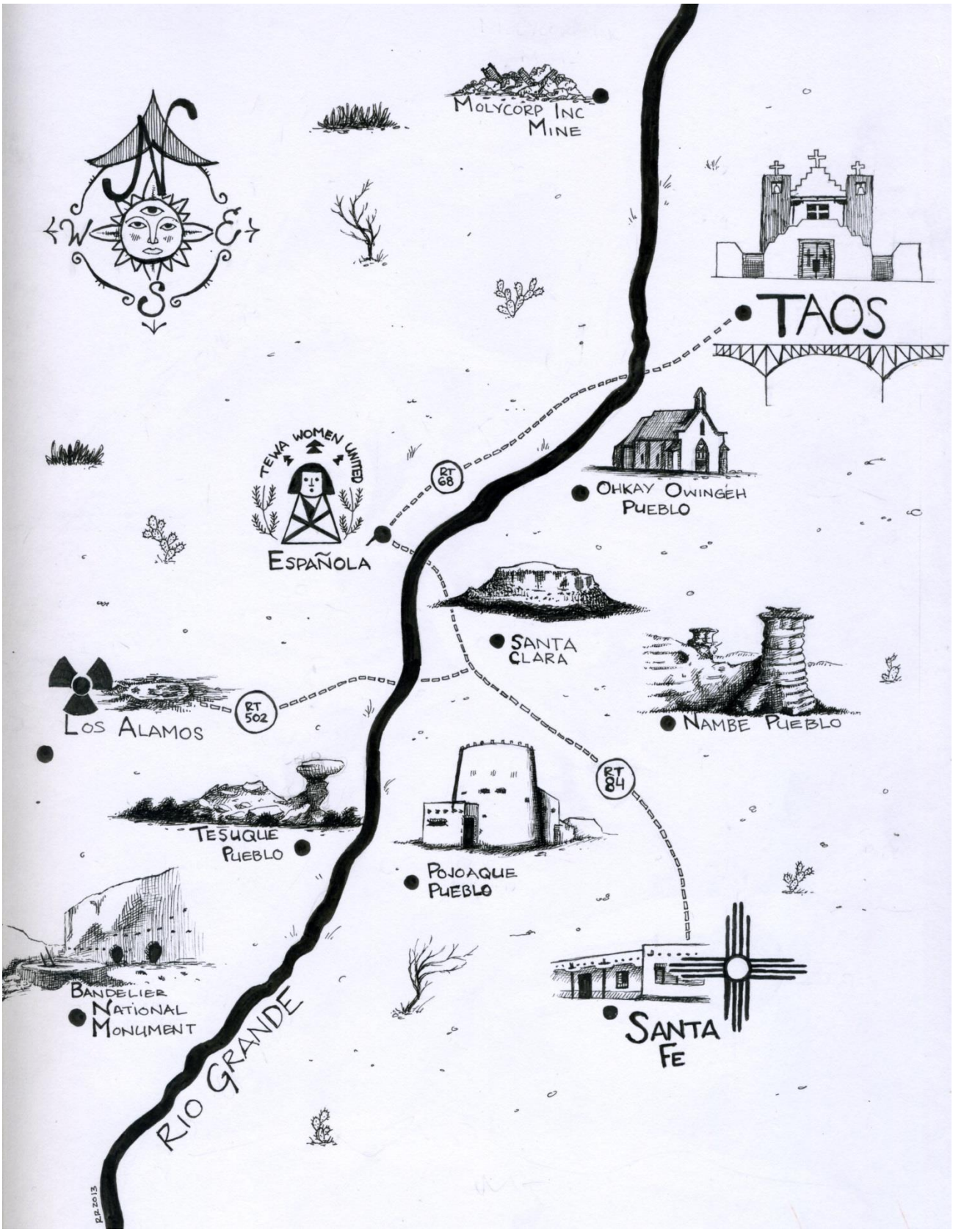
Red Dust

A Soil Scientist's Journey Through the Political Climate and Environmental Chemistry of Northern New Mexico

An NS Division III by Morgan Drewniany

Co-Chairs: Pamela Stone and Rayane Moriera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SANTA FE
RIO GRANDE
RP 2013

This work is dedicated to:

Everyone I worked with at Tewa Women United, and in the larger Rio Arriba Valley. You have framed my work for me and truly changed my thinking about health and environmental justice, and these experiences will lead me through my life and career.

The community of Los Alamos and my Starbucks family who welcomed me in as an outsider exploring issues that claimed the lab that sustains their livelihood on the hill was a source of suffering. Through work and play in the Atomic City, I saw firsthand that we cannot categorically point to a place and blame everyone in it- it's the few people at the top.

Don, Kelly, Lucy, Pip and Princess Sofie. You truly provided not just a house, but a home for me in New Mexico.

Pam and Rayane, my brilliant co-chairs and editors. Without you, this piece would still be a jumble of words, and I would still be a jumble of thoughts.

Sarah Steely. You were so imperative to my lab work, through setting up hundreds of tests, to looking at the pretty colors all my tests made.

My incredible friends at Hampshire and in Westfield. Rachel, your endless supply of jelly beans and your willingness to listen to my whining kept me going when I didn't know if I could. Your map is beautiful and adds an incredible amount to my work. Andrew, you have been here for me through it all, and I'm glad I've finally learned to take your advice; I wouldn't have found nearly as much drive without you nudging me along.

Mom and Dad. Thank you for your love, neverending support, and constant reminder that you are proud of me. There were days that you called that I needed nothing more than to hear from you.

A special thanks to the generous funding by : The Reproductive Rights Activist Service Corps at the Civil Liberties and Public Policy Program, Denice O'Neill Scholarship Fund, Samuel Morris Sustainability Endowment Fund, Tara Nelson Award, and Justine Salton Memorial Fund.

"Science loves order, simplicity, the manipulation of a single variable against a background of consistency. The tools of science do not work well when everything is changing at once."

- Steingraber, 1998

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Abstract

Experiments were performed to investigate the presence of health-threatening contamination in the soils of a food producing community garden in the Pueblos of Espanola, NM, downhill and downwind from Los Alamos National Labs (LANL). Soil samples were collected during an internship with the Indigenous women's group Tewa Women United in the Rio Arriba Valley of New Mexico. Over 100 samples were tested for arsenic, perchlorate, RDX, and hexavalent chromium using quantitative or semi-quantitative colorimetric methods. All four contaminants were found to be elevated, with levels above or closely approaching established health-protecting quality limits. It is clear that with levels this high, the health of those exposed is threatened as are the surrounding waterways. These findings indicate that LANL has polluted the lands inhabited by Indigenous communities. The nature and high levels of contaminants has also created an area in which health disparities are disproportionately high. Suggestions for bioremediation and behavioral change to protect public health and environmental justice while still utilizing the garden are recommended in the paper.

Introduction

Beyond the Ridge to the West

The drive from Los Alamos to Santa Fe is forty minutes long, down a highway that winds through towering mesas and long red stretches. It is just long enough to listen to *In the Reins* by Iron and Wine and Calexico, an album I found myself repeating throughout my summer. The initial descent from the secret city is steep and dangerous, 2000' in 10 minutes. As I departed Los Alamos and drove into the valley, houses became further and further apart and cars passed less frequently. After "Red Dust", the fourth track, drew to an end, I reached Pojoaque Pueblo with its scattered casinos and gas stations. From Pojoaque to Santa Fe, a gentle ascent is spread over the next three songs, where buildings and stores become more concentrated. Entering Santa Fe to the last chords of "Burn that Broken Bed," feels warm after the long ride through the country.

Santa Fe is lively and feels youthful, though it is one of the oldest cities in the United States. The separation between young and old is located somewhere between the shops hawking modern art and the local people of the pueblos with their crafts spread on wool blankets in the Plaza. Buildings crafted of adobe are nestled in with towering metal sculptures and vibrant murals. Greying women with turquoise jewelry bustle through crowds of laughing twenty-somethings waiting for the train to Albuquerque.

After a day of work, I would get into my Volvo once again to make the drive back to Los Alamos. Nothing stirred, the road was calm and straight, it was just me, the car and the road. No police waited with radar guns, no deer grazed on the side of the highway. A lonely sign explaining the Jemez Mountains was always a reminder that I was getting closer to the Atomic City. Driving back to Los Alamos after a day in Santa Fe, the beauty of the landscape is illuminated in as the sun sets over the Jemez mountain range. The mountains steal the climax of the show, shading the reds, purples and yellows of the sunset away from sight.

After crossing once again through Pojoaque, the wide open reservations housing the pueblos of Santa Clara and San Ildefonso are striking. I can feel that they have seen thousands of years. The ragged mesas that populate the land were sculpted by an ancient ocean that washed away rock and dirt incrementally to create ridges on their sides. Fossils of prehistoric sea creatures found in the mesas have been written about in petroglyphs and on old maps. Stretches of red land are scarred with the evidence of recent wildfire. All that remains on the majority of the land is scrub brush and tumbleweed, both quick growing and invasive, telling the story of these fires. Over the dry land spring dust devils creating tiny tornadoes of orange and brown on the sides of the highway. Small pockets of adobe homes, some crumbling back into the earth, follow rocky dirt roads.

Crossing the Rio Grande each day was also a cue of what the land has seen. The rapidly flowing river reminded me daily that water is precious in this place. It is thick with clay which gets washed up by the current. As monsoon season approached, the river often

became angry and unruly. Rain rushed down the sides of the surrounding mesas, stirring up the river and quickly creating rapids that seemed to disappear as quickly as they were made. More than once, the rain became so intense that the river overreached its banks, rushing into back yards, into kitchens and living rooms and devastating communities.

After the long drive each day, I would arrive back in Los Alamos, where I lived for the summer. Los Alamos today is a white-collar version of a factory town. One grocery store, three gas stations, two garages, a coffee shop and a handful of independently owned stores populate the plateau. A sole employer, the US Government, owns the majority of the community. Ashley Pond is a beautiful plot of land in the center of town across from the old communal lodge, land with plenty of well-manicured green Kentucky Bluegrass, and a reflective pond, both out of place in the dry Southwest. Though the view from the plateau contains a full New Mexican palette, the town itself feels like Anytown, USA.

The more time I spent in Northern New Mexico, the more I became aware of the divides between Los Alamos and Santa Fe, and the Espanola Valley. Not only was the land different, but the way of life was different in a way that I never would have realized had I not created relationships in both places. Social dynamics have sculpted Northern New Mexico just as much as the ancient seas and wildfires, and they have divided populations. Driving from place to place quickly changed from looking at landscapes to looking at people, and how they live.

I took the drive between Santa Fe and Los Alamos or Los Alamos and Espanola nearly every day, and it provided me a time in which I could reflect upon the work that I have done thus far in my academic career as well as where I wanted to go with that knowledge. I spent the majority of time in the car considering privilege, what it meant for me as a white person to be working with the Indigenous people in Northern New Mexico, and what it meant for me to be taking my experiences and writing about them as my Division III. During my time there, I discovered a love for understanding the community, their needs, and how I could do the work I want to do in a way that works *with* the people, not for them. My Division III stands as an attempt at bridging the gap between communities as well as those between environmental justice, social justice and science together.

My Division III

I began my journey in Northern New Mexico through a summer internship with Tewa Women United (TWU). Mine was an internship set up through a civil liberties organization I had worked for before, the Civil Liberties and Public Policy Program (CLPP), through a program called the Reproductive Rights Activist Service Corps (RRASC). I applied for the internship in hopes of gaining experience in an environmental justice setting. I met my supervisor at a conference the spring before I left and she was wonderful and inspiring; however, when I set out from Massachusetts to New Mexico in the summer, I had little knowledge of what to expect out of my time at TWU.

Tewa Women United is an organization whose mission is "to provide safe spaces for Indigenous women to uncover the power, strength and skills they possess to become positive forces for social change in their families and communities," (TWU, 2013). They were formed in 1989 as an indigenous women's support group, focusing on struggles women were experiencing in the community such as alcoholism, depression, and domestic and sexual violence. In 2001, Tewa Women United became an official nonprofit with 501c3 status and grew rapidly into a multi-departmental organization which still focuses on the community. They are located in the city of Espanola in the Rio Arriba Valley of Northern New Mexico. Rio Arriba is North of Santa Fe and Southeast of Los Alamos Counties. Programs at TWU include: Valuing Our Integrity with Courage, Empowerment, and Support (VOICES), a culturally appropriate response to sexual violence and trauma, the Indigenous Women's Health and Reproductive Justice Program, offering doula services in the Rio Arriba Valley, and the Environmental Justice (EJ) Program, addressing education and awareness of local environmental concerns. There are a number of other, smaller, programs within Tewa Women United which also aim to engage women in the communities as well.

All of the departments of Tewa Women United are interrelated and work closely together, and all of the employees are women from surrounding communities, mostly indigenous women from the Pueblos. The concerns of the community are the concerns of everyone who works in this small organization and I was embraced closely by the family of TWU throughout my time with them. Women in TWU come from all of the surrounding

Pueblos, but concentrate on serving women in the Tewa speaking Pueblos of Northern New Mexico: Nambe, Pojoaque, Santa Clara, San Ildefonso, Okeh Owingeh, and Tesuque (Edelman, 1986).

I worked in the environmental justice (EJ) department, which focuses more specifically on "taking care of our Mother Earth and all our relations," (TWU, 2013). The larger picture of Mother Earth is taken into account in the environmental justice department, but the EJ Program focuses mainly on local environmental risks. The great majority of work done in the EJ department is done regarding neighboring LANL, with the website stating that "LANL has been discharging its toxic and radioactive wastes onto Tewa ancestral land" (TWU, 2013). There are efforts through the EJ program to inform the community of happenings on the hill, such as the newly proposed Chemistry and Metallurgy Research Replacement (CMRR) Building, wastes at Area G or simply new reports coming out of the labs.

In my first few weeks of the internship, I worked on pre-existing projects such as working in the community garden, doing research on pesticide use in Espanola and the movement to raise funds for a terrace garden. Quickly, I realized that the thick, academic documents coming out of LANL outpaced the ability of TWU's EJ staff to digest the information by far. My privilege as a science student allowed me to delve into official documents and through the summer, I summarized over 1,000 pages of Department of Energy (DOE) and LANL reports for the community to access. The reports were written to

inform the community, but were not accessible in the least. I also attended official DOE and LANL meetings in Santa Fe and Albuquerque that were scheduled at times when the women leading the EJ department were with their families, and I made public statements in their respect. These experiences highlighted the class gap between people on the hill and people in the valley which played itself out over and over.

Parallel to my work in the Rio Arriba Valley with women from the surrounding Pueblos, I lived atop the Pajarito Plateau in Los Alamos because that was where I found housing. I lived with Don and Kelly, a couple who had worked in and around the labs for years. They gave me more than I could have ever asked for during my stay in Northern New Mexico. I also worked at a coffee shop atop the Plateau and met hundreds of the people who work in the labs. My experiences certainly framed the issues in Northern New Mexico for me in a way which they would have not been had I been an outsider in the Los Alamos community. I do not see the people who work at the labs as greedy or ill-intentioned. I believe that there are a few powerful people at the top who have made decisions at LANL that have caused devastating environmental results, but the poor decision making of a few does not reflect the vibrant community atop the Plateau.

The split of my time between the two places was nearly even. I had a full time job at Tewa Women United and spent time outside of work gardening, and going to special events like infant massage clinics or water blessing ceremonies before and after work in Espanola and the surrounding towns. Outside of that job, I worked around 10 hours a week in a coffee

shop in Los Alamos and spent time at "home" in Don and Kelly's house, as well as with friends I made in the Atomic City who were closer to my age than my coworkers at TWU. I could have, perhaps, used a bit more sleep some days but I feel like I took every opportunity that came to me.

Through my three months in New Mexico, I discovered a love for the history and current day Los Alamos and Rio Arriba Valley, and the communities in both places. My background lies in soil chemistry and environmental justice and putting all these pieces together, I unearthed my Division III. Throughout my DIII, I will give a layout of Northern New Mexico as it stands today, the history of the places I was in, environmental health in the region, and contaminant origins and movement in both the greater NNM area as well as the North Railroad Avenue garden in Espanola I focus on in my soil sampling. These sections serve as a lead-up to my independent experimental research.

For my own research, I collected around a hundred soil samples from a community garden overseen by the EJ department at TWU. It is located on North Railroad Avenue in Espanola and I tested the soil samples for arsenic, RDX, perchlorate, and hexavalent chromium. These are all contaminants discussed abundantly in the documents I reviewed during my work at TWU as health-threatening chemicals sourced from local industry. The garden is used for crops that are consumed by the local communities. Contamination of the garden soil by surrounding industry implies a larger contamination of Pueblo lands and the Rio Arriba Valley.

In my work, I concentrate a lot on the tenets of environmental justice, which I will later explore more deeply. The core of environmental justice, as defined by Tewa Women United, is "teach[ing] traditional Indigenous forms of healing medicines and foods to counteract the negative impacts that pollution and nuclear contamination ha[s] on our bodies, minds, spirits, lands, air, and water" (TWU, 2013). In a larger framework, I employ the definition Bullard uses to define EJ as "embracing the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations" (Wakefield et al., 2010: n.p.). The sources I have chosen to incorporate in my research rely heavily on the integration of environmental and social justice frameworks.

Through my experiences at Tewa Women United as well as the frameworks I have used to create my Division III, I aim to make my piece as accessible as possible. This accessibility is part of my journey to make science socially sensitive. The language I use is meant to be understandable by everyone, not just academics and scientists. My results are to be returned to the communities in the Rio Arriba Valley and therefore, I have tried to stray away from isolating rhetoric.

Chapter 1 introduces the New Mexico landscapes and first, aims to place the reader in the place. I use personal experiences from my time in Los Alamos and the Rio Arriba Valley. My narrative is important to paint a picture for the rest of the scenes I describe in the piece. I continue on to recount a short history of Northern New Mexico and how historical situations have informed the present, focusing on the Labs.

Chapter 2 explores environmental health in the region as it has been presented in local and regional studies, as well as the social dynamics between areas of Northern New Mexico. The chapter identifies where these two things meet and cause each other, as well as explaining why the environment informs health and sickness.

Chapter 3 looks at contaminant origins and movement in the larger region of Northern New Mexico. The specific geology and geochemistry of the region and possible sources/routes of contamination are presented. It wraps up with a focus on the largest polluter in the region: Los Alamos National Laboratory.

Chapter 4 presents contaminant information in the context of the gardens, and specifically, the North Railroad Avenue garden. It provides information as to why soil and agricultural science is important to Northern New Mexico and applies this information to my experimental research. It also details the choices I have made in contaminants to research in experimental analysis and their health implications.

Chapter 5 contains all of my personal experimental research, methods, data and analysis. This section provides information on the specific contaminants which were detected in the garden, where, and at what levels. The tone of this chapter shifts drastically from the rest of the Division III, due to the technical nature of the results provided, but I have tried to make this portion understandable and straight forward.

Three appendices are provided. The first, Appendix A, provides an index of all tables and figures provided throughout this paper. Appendix B provides detailed maps with scale in order to orient you, the reader, with the area. Appendix C contains all of my raw experimental data. In addition, there is a hand-drawn map in the very beginning of my Division III, before the Table of Contents, which has been lovingly provided in the hopes that it will help you find your place in my work as I found my place in Northern New Mexico.

As with all research, my work, and the sources I have chosen to integrate into my work, is informed by the experiences I have had in Northern New Mexico. The implications of the contaminants I have found in the soil of the community garden are huge, and can certainly be tied back to the history of Los Alamos and the Rio Arriba Valley, as well as where Northern New Mexico stands today.

Chapter 1: The Land of Enchantment

Through snapshots of the time I spent in the Rio Arriba Valley, Los Alamos and surrounding places, I aim to paint a picture of the region as it is today. An image of the area is important because my research depends so much upon the specific social and cultural dynamics of the area alongside the unique landscapes of Northern New Mexico. The people I met and the places I went shaped the direction of my research and I feel as though it is important to provide some of these stories in order to connect you, the reader, to this incredible setting.

1.1 New Mexico Today

Arriving in Los Alamos

My first day in Los Alamos began with a six hour drive from the Cactus Inn in McLean, Texas. The motel was cozy; overnight, cherry-sized hail fell from an impromptu thunderstorm. The sound of it falling on the rooftop concerned me, but was apparently "normal" in the southwest. My partner and best friend, Andrew, had accompanied me for the five-day drive from Massachusetts to New Mexico, after months of coaxing. He woke me at six in the morning so we could get a head start on our last day of travel. I let him drive and settled into the passenger seat with my pillow. Quickly, as the sun had not yet risen, I fell back to sleep against my seat belt. A couple hours later I woke up to the New Mexico state line, and a coffee, and took over in driving the remaining four hours.

Figure 1: View of the Jemez Mountain range from Route 502 between Santa Fe and Los Alamos. (Drewniany, 2013)

It took far longer than I expected to reach Los Alamos. Tension built in my body as we drove closer, not knowing what I should expect from the experience ahead. Countless possibilities existed in this new place. I fiddled with the radio, trying to find a station, trying to distract my mind from what was in front of me. Andrew sat next to me driving, trying to crack a joke in the silence between us while I drove up the hill to the Atomic City. Driving past the small airport, Ashley Pond, and the hospital, Andrew noticed my anxiety and exclaimed, "you're going to fucking love it here." I responded in my usual sarcasm, "how do you know?" He rebutted, explaining that he knew me as we pulled down Diamond Drive and drove closer to my home for the summer.

The population of Los Alamos today is far removed from general American society. The city feels like a small utopia atop the Pajarito Plateau. As you drive around you learn that the wealthy LANL staff live in beautiful neighborhoods with green lawns or extensive dry landscaping. Fruit trees abound in yards, offering up apricots, plums, and peaches all summer long. Traditional adobe styles are used to create "sustainable" "solar heated" spaces. On the parts of the plateau which have housed Los Alamosans for the longest, including the government-issue clapboard homes and dormitories, lower income housing gives college interns and low-paid LANL employees a place to live. These scenes differ immensely from those down the hill in the Pueblos.

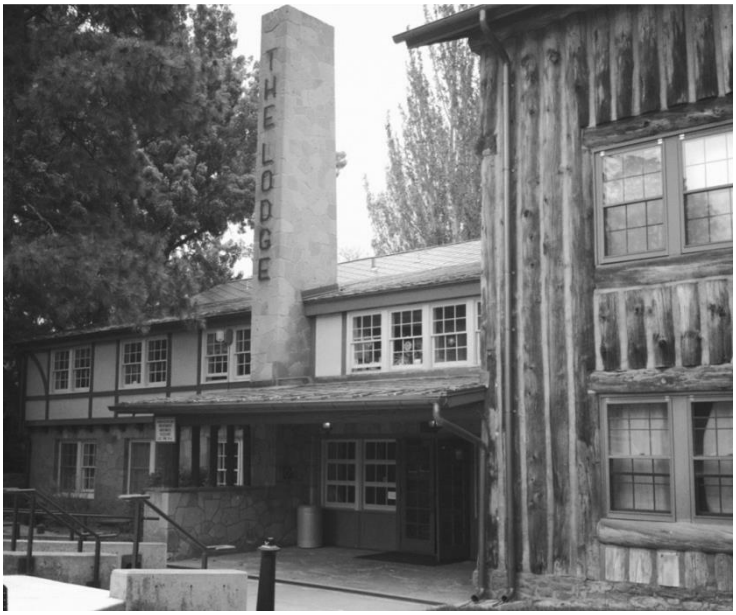


Figure 2: Fuller Lodge in Los Alamos, NM, the former home of the Los Alamos Ranch School and now, home to the Los Alamos Historical Museum. (Drewniany, 2013)

As I pulled into the driveway of one of the beautifully built adobe homes, Don waved and motioned for me to park in the corner of their driveway. I was lucky to make it up

through the tall stucco walls - designed for privacy but in practice, just a threat to car bumpers and mirrors. I shook his and Kelly's hands, unsure how to thank them for opening their house to me without even meeting me first. I looked at the Jemez mountain range visible from their deck, scorched and brown from the Las Conchas fire a year prior. They helped me unload my tightly-packed car and invited me to a beer festival later on in the day at Pajarito Mountain Ski Area just a bit further up the hill. Andrew reminded us that he needed to take a flight out of Santa Fe in a short two hours. We left the driveway as quickly as we had driven in.

Figure 3: Fire-scarred mountains of the Jemez Mountain Range from Don and Kelly's driveway.(Drewniany, 2013)

The drive back to Santa Fe felt all too short as I left the one person I knew in the lobby of the airport. I turned around to drive back to my summer home and tears welled up in my

eyes. I made it back up the steep stucco driveway once again, realizing I was home alone since Don and Kelly had gone to the festival. Not knowing quite what to do, I took a shower, trying to wash off the sharp feeling between my shoulders and the dry heat of the plateau. Rubbing my face hard with a towel after I stepped out, I realized I had a nosebleed from the drastic altitude change I was experiencing, with Los Alamos standing at an impressive 7,500' as compared to my sea level home in Massachusetts. I wiped it off, took a breath in and decided I needed to get out and go to the beer festival.

Figure 4: Route into Los Alamos on 502, with monsoon clouds rolling in. (Drewniany, 2013)

Pajarito Mountain is a ridge of the Pajarito plateau, and the access road leading up to it travels through the gates of Los Alamos National Labs. I stopped at the gates, thinking my car would be searched, and instead just got a glare from the guard inside. A winding road

through the national park led me to the summit. The forests, much like the ones I had seen from the deck at my summer home were badly burned with only stumps standing in some areas. All the blood rushed to my head, making me dizzy as I kept climbing. I reached the parking lot and took a deep breath of dry air before ascending the stairs to the ski lodge patio.

Music from a local ska band blasted from beneath the patio that held rows of local brewers. I'm a beer lover myself, but a huge and unexpected smile spread across my face as I scanned over how many people were there, dancing, laughing and talking about the brews. Even in my lightheadedness, I knew Andrew was right, that this place would be home to me. After some shuffling through the crowds, I found Don and Kelly. They introduced me to their friends, all outdoorspeople who told me their tales of hiking, kayaking and rock climbing in the Southwest. They welcomed me to the Pajarito Plateau with excitement.

That day I met the modern-day Los Alamos, which has a dynamic and diverse population. Over my next few months working in the Pueblos, visiting local museums, reading books and talking to the inhabitants of Los Alamos who worked in and lived near the labs, I learned so much. From all of my experiences, I gleaned that history at the labs is not always as it seems.

The Pueblos Today

Down the hill from Los Alamos lie several Pueblos including Santa Clara and San Ildefonso, which were where I spent most of my time. These communities lie on government-sanctioned reservation land now, but these communities have been in existence for thousands of years, practicing the same traditions and worshiping the same Mother Earth. I learned a lot about the people and culture in this area through my internship at Tewa Women United (TWU).

During my first week at TWU, I was invited to an event everyone at the office referred to simply as "feast." Still feeling uncomfortable in my new surroundings, I quickly accepted, excited to have somewhere to go on the weekend. Before gathering my things from the office, I walked to my supervisor's desk and timidly asked her if she could give me directions to the feast. She said we would be going to a coworker's aunt's house and she would gladly drive me there. We packed up, walked to the parking lot together and I began to follow behind her in my car from Espanola to Santa Clara Pueblo.

I had driven through a number of pueblos between Santa Fe and Los Alamos as well as from Los Alamos to Espanola, but had not been into the villages yet. Adobe homes of similar shapes were built off of narrow, dry dirt roads that engulfed my car in red dust. Spiky barbed wire lined the roads in some places and grates allowed me to cross a small, parched riverbed,

originally placed there to keep cattle in their pastures. Most Pueblos in the area follow the same design: off secluded dirt roads, surrounded by open, seemingly empty desert land.

The two Pueblos where I spent most of my time were San Ildefonso and Santa Clara. San Ildefonso is located 22 miles Northwest of Santa Fe and is known for its beautiful black glazed potteries (Edelman, 1986). Los Alamos National Labs (LANL) resides on traditional San Ildefonso land and the pueblo shares its boundaries with LANL to this day. San Ildefonso land is large and sprawling, containing the least amount of people per square mile of the six Tewa Pueblos in the area. All of the Pueblos are legally sovereign nations within the United States and have their own laws and regulations.

Riding through San Ildefonso on the way to Santa Fe from Espanola, I asked my work supervisor about a tall, dark mesa I drove by each day. Every morning my eyes would focus on it, approaching slowly as I descended into the Espanola valley from Los Alamos. It felt different from the other mesa tops, somehow more compelling. The red clay at the base of the mesa gradually became darker up and up the side, fading into a steel grey at the top where a handful of trees had planted their roots. She explained that it was Black Mesa, a mesa on which Natives from San Ildenfonso stood their ground against the Spanish and forced them out of the area in the Pueblo Revolt. Black Mesa stands for independence and the fight against colonization by the Spanish, something not often mentioned in the Spanish-strong and proud cities surrounding the mesa. Her short history lesson brought to my eyes

how connected the people on Northern New Mexican land still are to their history and how it has shaped their lives.

Figure 5: Black Mesa at Sunset, located in San Ildefonso Pueblo alongside the Rio Grande. (Drewniany, 2013)

Santa Clara is on the side of Black Mesa away from Los Alamos. The present village site is around four hundred years old and contains Puye Cliffs. Puye is home to astonishing cliff dwellings carved out of the stone on the side of the mesas of the Pajarito Mountains. The cliffside dwellings were home to the direct ancestors of Pueblo Indians that live in Northern New Mexico today. For the women who now live in the Pueblos, 28% have lived in the area their whole life and another 15% for more than twenty years (Berkowitz, 2010). The ties communities have to the land is long and enduring in Northern New Mexico. Roots in this

region are incredibly deep and it is uncommon for people to move out of the community (Berkowitz, 2010).

The feast I attended was in Santa Clara Pueblo and I had no idea what to expect walking in. I had been told there would be food and dancing performances in the commons, which seemed good enough to me, but I vastly underestimated the experience. As I parked my car on that day, I walked through rows and rows of vendors selling their art, the majority of which was intricate jewelry carved from local stones. I walked closer to the center of the village and heard the rhythmic beat of huge drums.

When the center came into my sight, I lost my breath. Around fifty people from the Pueblo of all ages were dancing together to the heartbeat of the drums. They wore beautiful costumes made of leather and feathers that I later learned were a gift from the Natives of the Midwestern United States. The dancers kept on for hours in the midday heat and sun, dancing, this time, for crops to grow. They moved from place to place, shaking shells on their ankles filled with pebbles that made a beautiful clink in time with the drums and rattles filled with corn. Sweat beaded on some dancers' foreheads, washing the paint from their faces while they kept on. Different traditional dances, with different steps, music and costumes are performed at each feast day to celebrate and show thanks.

Feast days are held in each Pueblo, often several each year. One large feast is held in each Pueblo on the day sacred to its Roman Catholic patron saint, brought in by influence of the Spanish in the 15th and 16th centuries. The saints were assigned to each Pueblo by the Spanish

missionaries so that each Pueblo's respective feast day would coincide with a traditional ceremony (Horgan, 1954).

I was led away from the center by co-workers to eat lunch in a Pueblo home. I sat down at the table inside and looked across the spread of food, not sure where to start, or even what most of the food was. Old dishes such as posole shared space with green-and-red-chile laden meats and fry bread to pile it all onto. The tradition of inviting people into the home and feeding them has been a long standing sign of thanks and celebration during feast days. It also provides a time in which the community bands together, which was important in the past when days were spent farming and hunting, but now is equally so to keep tradition alive.

Figure 6: The branching together of the Rio Grande, from Cochiti, NM. (Drewniany, 2013)

Through colonization and the change from a land-based economy, much of traditional Pueblo agriculture was abandoned; however, a modern movement back towards traditional agriculture is vibrant in the Rio Arriba valley. A farmer's market takes place twice a week in Espanola thanks to a few individuals' unrelenting work. I not only watched these markets, but bought amazing food at them each and every week. I bought pounds of blue corn masa and ground red chile to make recipes I learned throughout my time there. Farmers would back in their dust-covered pick-up trucks and unload the back onto a table. The parking lot which was empty when I arrived at 9 AM would transform quickly to rows and rows of tables, covered in baskets with crops changing from week-to-week like peas, cherries, squash blossoms and plums. Natural remedies like *cota*, a tea made from the greenthread plant promising to aid the kidneys in filtering were set alongside the other goods. In Espanola, the market is one of the only places to buy fresh foods. The farmers market, to me, truly represents community: specifically, a community weaving together for the well-being of each individual. The heart of the community, connection to the land and tradition are some of the things I would put forth to define the Pueblos, though it is something that cannot be described accurately in words.

During my time working at Tewa Women United, I spent a fair amount of time tending to the community garden in Espanola, which is connected to an *acequia*, a traditional irrigation system fed by the Rio Grande. The garden on North Railroad Avenue is part of the mission of the TWU EJ program, to bring people back to Mother Earth. Community

members are welcomed to come and participate in gardening and crops are distributed throughout the Tewa Women United staff and from there, their families and neighbors.

Figure 7: Rows of crops in the North Railroad Avenue Garden in Espanola, NM. This garden is tended to by community members and overseen by the Environmental Justice program through Tewa Women United. (Drewniany, 2013)

In the early morning, I would wake up and put on my wide brimmed hat and sunscreen to weed the garden before the sun got too hot in our plot. I tended to rows of crops that ranged from amaranth to arugula, as well as traditional corn, beans and squash which have

been planted for thousands of years, due to their resiliency through drought. These are the same gardens I collected soil from and tested in my Division III, and I ate from the plots nearly every day. The chemicals found in the soil the vegetable plants are growing in are extremely threatening to health, but in my embracing of the culture and community I was living in, it felt right to eat these crops. It is insulting that the vegetables that should be a source of health and well-being are the very sources of illness.

Figure 8: The main acequia in the garden, leading water to the individual rows of plants. Water does not flow into the garden unless the connection to the acequia madre is opened. As water flows into this main acequia in the garden, each row of the garden is watered

individually and then blocked off with a mound of clay. This allows water to reach each row without drowning plants. (Drewniany, 2013)

One day, after a rough time clearing the acequia of weeds to ensure a good flow of water the following morning, I sat down with a fellow gardener and talked for hours about the surrounding cultures, community and history. He brought a bag of cherries from his backyard and while spitting pits into the tall grass, we talked about the interwoven histories of people on these same lands that have shaped contemporary attitudes and actions.

1.2 History of Northern New Mexico

The history of Northern New Mexico is complex and multi-layered, but imperative to understand in order to frame my Division III. The land which a number of cultures have claimed as their own through history is vast and beautiful, with hot summers and cold, snowy winters, with a wet "monsoon" season between. Native Americans were the first people to have lived on the Pajarito Plateau and in the Rio Arriba Valley, followed by Spanish conquistadors, Anglo homesteaders and then the scientists of the atomic age. The stories of people throughout history will attempt to describe the situations that people of Northern New Mexico now face.

My reporting of the history and landscapes of the Pajarito Plateau and the Rio Arriba Valley, and events that occurred on them, are heavily informed by the histories published by Hal Rothman (1997) in his book, "On Rims and Ridges", Cold War anthropologist Joseph

Masco (2006) in his book "The Nuclear Borderlands: The Manhattan Project in Post-Cold War New Mexico," and Ruben Martinez (2012) in his narrative of experiences in Northern New Mexico, "Desert America." In addition to these texts, I rely on my own experiences in this region of the American Southwest and aim to paint a picture of the region, and offer a brief narrative of the history of places and people here.

History of Northern New Mexico

The Pajarito Plateau, home to Los Alamos, has a traceable human history that reaches back further then all of the cities in the United States, and certainly those in the Southwest. Signs of human occupation going back nearly ten-thousand years have been found here. The region is a section of the Eastern slope of the Jemez Mountain Range, which is located in a thirty-mile stretch between Santa Clara and Cochiti Pueblos. The Plateau stands out in the landscape and can be seen from most of the Northern Pueblos. Indigenous peoples throughout the Southwest have collected spring water, medicinal plants, minerals, and clay from the Jemez range for a long time. The plateau has spiritually important ruins, shrines, and powerful natural elements as well as sites of ancient mythohistorical emergence. Its soft, erodible surface created from volcanic ash spewed by the Valles Caldera gives way to a hard granite core underneath.

The land around the Pajarito Plateau is varied with low points filled with sage brush and hills of pinon and juniper rising out of it up as high as thirteen thousand feet.

Geologically, it looks like desert. The loamy soils, mesas, buttes, and long, snowy winters dispute the first impression of barrenness, providing a challenging but rewarding agricultural area that has been inhabited for thousands of years by some of the oldest tribes known to anthropologists in the United States, often referred to as the Pueblo Indians.

There is evidence in and around the Pajarito Plateau proving that people have inhabited the plateau and surrounding lands land in large-scale settlements since 900 AD. Populations grew and fell as communities learned to adapt to their lands and live in one area rather than roam. Cultural beliefs, along with climate change and drought, forced groups of Puebloan peoples to move throughout the region. By 1800, the lowland pueblos of San Ildefonso, Santa Clara, Pojoaque, and Cochiti were defined centers of Native American life in what is now Northern New Mexico.

Between the 1500s and 1880s, Pueblo life was relatively stable. Subsistence was the center of most activities, taking advantage of the fertility of the alluvial soils and the water available for irrigation from the Rio Grande. Some dry farming was also practiced, with beans, squash and corn (also known as maize) as the main crops. Livestock was kept on the land, and the plateau was used as a place to graze animals when the valley became uncomfortably hot in the summer.

The Pueblo Indians have not only one of the longest histories of land use in the United States, but also an unusually robust set of cosmological ritual and beliefs. Much of the knowledge of beliefs is protected within Pueblo societies, but some mythohistory is known.

The main story within the Pueblos is that of creation. It begins with the emergence from the earth, much like a plant seedling. Each of the tribes left a dark underworld, and with the help of supernatural and animal guides, pushed up toward the daylight to inhabit the surface of the earth. Each of the Northeastern Pueblos has a slightly different creation story that ties the people to the earth and ultimately creates a spiritual bond with a very specific geographic area. Some creation myths begin underwater, and they are led with different types of animals (Ortiz, 1969). Lakes, springs and caves become extremely sacred sites because they are all points of connection to the underworld as told in the creation story. The Puebloan people have elaborate systems of sacred shrines connected to creation spread throughout the landscape (Ortiz, 1969).

Often, Pueblo cosmologies also argue that the people are inseparable from the specific geographical space where their ancestors are buried and where the channels of power connecting the different levels of existence line up to focus life energy on their communities (Ortiz, 1969). The cosmology creates a culture where specific landmarks and places in the landscape are incredibly important, but are all interconnected. As Rita Swintzell of Santa Clara Pueblo explains:

> Differences among the elements of the life force are recognized and accepted, but essential characteristics are known to be the same. For example, a lump of clay is identical to that which determines human beings. The Tewa word "nung" is translated to mean "us" or "clay" depending on the context. There is direct cross-communication possible between all elements of nature – humans, plants, animals and even natural phenomena. (as cited by Masco, 2006: 103)

Tewa, the language which is spoken by some, shows the direct connection the communities have with their land. Tradition and beliefs are all tied to place in Pueblo culture.

Pueblo life and tradition is also set on a strict cyclical movement through a specific physical space; for example, the agricultural cycle. Rituals including dance are performed on a cyclical scale to focus cosmic energy: to grow crops or bring fertility and health, for example. Northeastern Pueblo people have lived on the same land, tended the same shrines and successfully reproduced the natural order for more than a millennium. They uphold a system that flawlessly connects space, ecology, power and action, placing humans within the center of an order in which every being has a specific role to play. The connectedness is exactly why pollution of land, water, and air is so very devastating to Pueblo populations to this day.

Cities of Gold

Again drawing on Martinez (2012), the region was first colonized by the Spaniards who arrived in what is now New Mexico in 1598, led by the myth of the Cities of Gold. The conquistadors blazed a trail into the area expecting bars of silver and gold to be scattered on the ground for the taking, a literal symbol of their colonial idea of wealth and power. As they arrived in the area the Spaniards quickly realized there was no treasure, only wide open valleys and tall mesas. After spending more time in the area, the Spaniards realized that maybe they had found a treasure after all. In meeting with the Natives, Spaniards realized

the land was good for farming, especially in the Espanola Valley, where the local communities kept vast stores of maize over the winter months. They began a culture of agriculture, but were challenged again when they realized that even though the land was rich, farming certainly wasn't effortless. Freezes stayed late into the spring and began early in the fall; rain was unpredictable at best, flooding occurred during monsoon season and gardens withered in long dry spells in the spring and summer.

But the Spaniards claimed more than agriculturally rich lands. Missionaries moved into the area to spread the word of their god. Towering church and mission structures were quickly put up, much larger than were needed (Swentzell, 2012). The Spanish buildings quickly became the dominant focal point of Pueblo landscapes as missionaries pressured Puebloan people away from their ideas of earth, sky, and water and towards a more Christian view of heaven (Swentzell, 2012).

To reward Spanish missionaries and other individuals who helped in the conquest of Northern New Mexican lands, the Mercedes Land Grants were founded in the sixteenth century. The grants pushed Puebloan people off their lands to give to the Spanish as rewards, which were then largely used for agriculture. The Spanish grants created buffers between communities of Natives and Hispanos and were often used as tools of colonization and conquest. Lands historically used by the Pueblos were taken for the grants as the Spanish's own and then granted to those who helped in the conquest; over five million acres for

farming and homesteading were given away. The Natives who no longer had a claim on the land were left with few resources, but ample anger towards the Spaniards.

To irrigate their newly-claimed lands and create more agricultural opportunities, the Spaniards brought acequia culture to Northern New Mexico. Acequias consisted of small waterways that moved water for miles from the main rivers through ground and wooden ditches accompanied by complicated systems of management through *mayordormos* (Swentzell, 2012). Mayordormos were community members in charge of looking over the acequia to ensure that no one farm was taking an unfair amount of water and leaving the farm down the ditch dry. The ditches required a fair amount of upkeep, being made of dirt and wood and constantly filled with water (Swentzell, 2012).

Each spring, the *acequia madre*, the "mother" acequia fed directly by the river, was cleared out by the Spanish in a big village ritual. Water rights became an integral part of land deals, because without water, there was no chance of subsistence living. Because the Rio Grande rises and falls with no outside control, acequias introduced a communal intimacy with the specific ecology of the valley that Hispanos had not connected to before.

Prior to Spanish intervention, Puebloan people used some irrigation from the Rio Grande, but mainly practiced "dry farming" with main crops consisting of corn, beans, and squash, none of which required irrigation. The communities talked with the clouds and used the water coming from the skies to nourish their plants (Swentzell, 2012). The introduction of acequias to Pueblo communities meant that yet another traditional practice, connecting

with the living watershed, was replaced with practices from the European system (Swentzell, 2012).

Land and Water

After eighty-two years of epidemic disease, loss of water rights, and unfair rule brought into Northern New Mexico by the Spanish, the Pueblo Indians fought back in the Pueblo Revolt of 1680. They banded together to force the Spanish South of the Rio Grande. The Revolt, celebrated to this day as an important point in Pueblo independence, resulted in twelve years without conflict between the Pueblos and Spaniards, an impressive length of peace during the Spanish colonial period.

In the time after the Revolt, Anglo homesteaders began to move into the area, with their own vision of the treasure New Mexico had to offer. They craved large lots of property with their name on the bill, for in their culture, land measured wealth. On the Pajarito Plateau, land was available and was claimed by Anglos who guarded it with all of their lives. They formed large ranches and farms where they could create their own prosperity.

Homesteaders were not part of an intricate social structure like their Hispano and Native neighbors and therefore lacked an overall sense of community. The land they owned was their home, but "home" did not mean the same generations of traditions on the plateau as it did for their neighbors. This connotation, that "home" meant success, contributed to the first significant divides within the region.

The Treaty of Guadalupe Hidalgo in 1848 integrated New Mexico into the Union. Old Spanish land grants were seen as obstacles to expansion, as they took up extensive plots of valuable land. In the favor of national expansion, Hispano land grants were taken away by the US government. This was an interesting imitation of the chain of events which occurred when the original conquistadors claimed Native lands. Without ownership of the acequias, many Hispanos found themselves with no livelihood. The reclamation of New Mexican lands was so extensive that only 300,000 acres of land belong to their "original" owners out of the whole state- 3/1,000 of the state's acreage.

As the traditional, land-based economy faded in favor of agriculture for profit, degradation of lands began along with the degradation of culture. Drought in a dry Southwestern place, along with overgrazing and monocropping, resulted in massive erosion. Some efforts were put in place in the 1930s by soil conservationists to restore eroded lands; including regulating grazing times, reseeding, and using vegetative cover to prevent future degradation by wind and heavy rains. People living off of the land were afraid of change because of the historical changing-of-hands of the land that had occurred throughout the previous 200 years, and therefore did not follow many of the soil conservation efforts. These events resulted in even further erosion that continuously degraded agricultural lands, resulting in areas today that have massive rifts or virtually no topsoil.

From the transition of Native American-dominant communities, through Spanish conquistadors and eventually Anglo homesteaders, there were many conflicts. However,

none were as severe as the arrival of Los Alamos National Labs, which changed the face of Northern New Mexico forever.

1.3 History of Los Alamos National Laboratory

Los Alamos National Laboratories is perhaps the most important complex in Northern New Mexico, providing jobs and security for the majority of people in the region. Its history begins in the 1940s and stretches to current day, eclipsing the history of Pueblos and conquistadors in the region. This history is important to consider because it shaped how the labs operate now and the historical practices of the labs have shaped health in the region. Information in this section relies on the histories written by Masco (2006) and Rothman (1997), as well as several personal experiences I had while in the Southwest and official reports from throughout the lab's history.

Siting the Labs

With the introduction of the Manhattan Project in 1939, the US Government became increasingly interested in formulating a nuclear weapon for military use. The project was a research and development program by the government to produce an atomic bomb, run by Robert Oppenheimer with Major General Leslie Groves as the director of the facility. With the project in place there was a search for a proper location for the laboratories creating the bomb. In 1942, Oppenheimer proposed Los Alamos and claimed that the area would inspire scientists working on the project and bring their work to fruition. Oppenheimer had spent

time at a boys' school in Northern New Mexico, and thanks to his experiences, the area represented freedom and a vigilant spirit to him that he hoped would also find the scientists. Major Groves was in favor of the location due to its seclusion; with only one road into and out of Los Alamos, the area could be secured without fences or barracks. In addition, a majority of the land proposed for the use of the labs was already owned by Federal agencies through the Park and Forest Services. However, there was still a great expanse of land known as home to many people at the site.

Los Alamos was home to the Los Alamos Ranch School in 1942 also. The Ranch School was similar to the one which Oppenheimer had attended himself. The school took up a small amount of space on the tablelike plateau, surrounded by land which was homesteaded by poor Hispano and Anglo farmers who had been there for years. Their ranches spread across the outer edges of the plateau, where their animals could graze freely. San Ildefonso Pueblo, which laid claim to the surrounding land for thousands of years, was located down the hill. In fact, most of present-day LANL resides on land historically belonging to San Ildefonso.

Very shortly after Oppenheimer's proposal the government decided that Los Alamos would be the official site, despite the land being occupied by farmers, ranchers, and local Puebloan people. Groundbreaking began in late 1942. The government seized the land from the Los Alamos Ranch School, as well as the poor homesteaders who didn't have legal rights to land protection. To this day, seizure of land is a sore point for many people who were

forced off their property in order for the labs to be built and never got what they were promised in return.

Once the ground was broken, the labs were built under a shroud of military secrecy. Mail was sent to all scientists on the plateau at PO Box 1663, regardless of their actual address in Los Alamos. The people who lived there generally called the city Los Alamos or "the mesa." People in Santa Fe referred to it as the Hill. In government and military speak, it was sometimes known as Site Y, or the Zia Project, neither of which caught on (Wilson and Serber, 1988).

Wilson and Serber (1988) recount through interviews with local women that the Los Alamos National Labs were actually formed as a group of laboratories focusing on different aspects of the formulation of an atomic weapon, with each specific laboratory known as a technical area, tech area, or more casually, tech. They were overseen in the beginning by Oppenheimer and a group of handpicked young and brilliant theoretical physicists. Special passes and badges were required for admission into the technical areas, which were manned by military guards.

A piece from Rothman's history (1997) of the Pajarito Plateau accurately captures the immediate shock Los Alamos National Labs brought to Northern New Mexico:

> Los Alamos had been dropped into a world to which it bore no relation. Not only were the physicists immersed in the realm of science… lonely and isolated in an aesthetically beautiful place, but they were also light years away from their predecessors in the way that they perceived institutions, in their reliance on the

> sociocultural infrastructure and in their level of integration into mainstream American society. (Rothman, 1997: 209)

The Pajarito Plateau, which had only been part of the industrial world for sixty years before the introduction of the labs, was dropped into a place of subservience to people who would ultimately shape the future of the world. The deep history of the plateau was quickly lost under the news about exciting new nuclear technologies and the scientists' interests.

After the War was Won

When World War II ended and Los Alamos National Labs was done celebrating, the encampment on the isolated Pajarito Plateau went into a brief period of decline. Oppenheimer, the brilliant young physicist who had opened the lab, was no longer director, having passed the torch to Norris Bradbury, who brought a new sense of urgency to weapons science at the labs. At this point in history, there was seemingly no more need for atomic science. Some thought the labs should shut down operations and abandon the installation high up on the plateau. LANL was rescued from this grim future by the uprising of the Cold War. In 1950, Bradbury explained his position on keeping the labs open, stating that the US truly "had, to put it bluntly, lousy bombs" (Fradkin, 1989, p 81) and that weapons science had a long way to go.

Bradbury (as cited by Fradkin, 1989) suggested that Los Alamos stay open to improve the reliability, versatility, size and weight of the weapons currently in the US stockpile. He insinuated to President Truman that there were actually no bombs in the current arsenal that were immediately usable. When the President received the news of ineffective bombs, he

immediately committed to expand the weapons program; by the following year, LANL had produced fifty more weapons for the stockpile. The decision to continue research and develop the hydrogen bomb in 1950 further increased nuclear science at LANL (Fradkin, 1989).

Shortly after this point, with the labs pumping out a seemingly endless supply of weapons, Bradbury realized what a monstrous new weapons laboratory he had created, stating in 1955:

> The future beyond [this] point looks somewhat unrewarding. Fissionable material will go on and on being made until the efficiency of atomic weapons will become of academic interest. Everyone will ultimately have all the weapons in all the variety wanted and the number will probably be more than the world can safely tolerate being used. (as cited in Fradkin, 1989: 81)

Bradbury's statement is shockingly accurate in regards to the US nuclear weapons arsenal today. The exact number of weapons in the stockpile is not publicly available, but is thought to be 5,113 warheads, in comparison to Russia with over 1,300 and France at around 300 (Arms Control Association, 2012). It can be stated, however, that the quantity of weapons globally is more than enough to validate Bradbury's foreshadowing of "more than the world can safely tolerate…" (Fradkin, 1989:81).

In 1963, the Nuclear Test Ban Treaty was passed by the United States, banning all above-ground testing of nuclear weapons. Underground testing was allowed, and was practiced as new technologies of weapons were released. The development of nuclear science was so rapid that a group of scientists would spend six to eight years creating a weapon that

they acknowledged would be replaced with new technology within ten years (Fradkin, 1989). In 1993, the world of nuclear science was shattered when the Comprehensive Test Ban Treaty was passed. No longer was any testing of nuclear weapons allowed, with surveillance by seismographs kept at all hours of the day to monitor violations.

The Labs Today

Fuller Lodge, the main building of the former Los Alamos Ranch School and the public hall of Los Alamos National Labs (Figure 2), now operates as the Los Alamos Historical Museum. The Bradbury Science Museum, located down the road from the Historical Museum, named after Norris Bradbury, is the public science museum related to LANL. Entering these museums on my second day in Los Alamos was a strange experience. Both museums glorify the short history the city has had in the past seventy years, with a scarce shred of history mentioned pre-1942. Fallout shelter signs in assorted colors line the walls next to plexiglass sheets protecting a small 1950s kitchen, complete with pastel toaster and replicas of atomic-era canned foods.

It seemed strange that a historical museum would concentrate so strongly on the present and future rather than the past. It seemed even stranger that the science museum glorified atomic weapons so single-mindedly and strongly, citing them as responsible for saving our society from violence and war. Both spaces gave the aura of containing the ultimate truth and refuting anyone who had an alternative story or opinion. Black and white photos and old

radiation badges boast how brave Los Alamosans had been, but ignore how many people had been hurt in the process. This was a theme that followed me throughout my time in the area: a lack of history in Los Alamos versus the deep, meaningful history that exists in the surrounding Pueblos.

The physical facilities of the labs are aging buildings reminiscent of the 1950s government style. Some new buildings have been constructed, but a huge budget is required to put up new laboratories with the required safety equipment. A map of the labs from above (see Appendix B) shows that the land is split up with atomic era names of "Technical Area (TA)" 1 through 74. The technical areas contain everything from shooting ranges to waste management to plutonium labs. Certain areas within TAs gain a letter as well, such as Technical Area 54 which contains the largest waste dump, more commonly known as Area G. Huge new scientific complexes are consistently proposed in order to further science in more modern settings.

Current day LANL is a different creature than it was in the past. The US still continues to spend over $6 billion a year at the three national laboratories (including LANL) on nuclear weapons science (Masco, 2006). This is actually a greater monetary total than during the Cold War, which averaged at $3.7 billion a year, adjusted for inflation (Masco, 2006). Unlike during the Cold War, the majority of LANL's money now is devoted to maintaining nuclear expertise, upgrading the nuclear arsenal and watching Cold War-era bombs age.

Other scientific ventures now occur at Los Alamos National Labs, and receive approximately 4% of the LANL budget (LANL, 2012). "National security," National Nuclear Security Administration (NNSA) Weapons Programs, NNSA Safeguards and Security, NNSA Nonproliferation and DOE Science receive the majority of the remaining budget (LANL, 2012). LANL's other areas of research occur in a multidisciplinary manner including space exploration, renewable energy, medicine, nanotechnology, and supercomputing, all upcoming fields of science. Non-nuclear fields of research have afforded LANL a respectable name in the larger scientific world.

LANL is still part of the Department of Energy, and therefore receives its budget through the DOE alongside the National Nuclear Security Adminstration (LANL, 2012). It also, from time to time, receives funding from the Department of Defense. Specific line budgets are not required to be passed through Congress, due to the military secrecy and national defense claims LANL boasts. The labs maintain a complex relationship with each branch of the US military as well as corporations and industrial suppliers because its work spans so many governmental concerns.

The money that is spent at Los Alamos National Labs today go into a program known as "stockpile stewardship," ushered in after the Comprehensive Test Ban Treaty (LANL, 2012). Stockpile Stewardship falls into two specific areas: the application of physics and engineering to the whole "cradle to grave" lifetime of a nuclear weapon and the use of

nuclear weapons in science and technology to support national objectives of a number of areas including environmental restoration and nonproliferation (Masco, 2006; LANL, 2012).

Stockpile stewardship is a program which covers most of the new buildings and administration of the laboratory. Taking care of aging bombs is proving to be more challenging to scientists than creating them. New engineering is being used in "bomb hospitals" to peer inside of the mechanisms of existing weapons to ensure their reliability and potency. So much pressure was put onto initially developing a weapon, and then creating exciting new technology that the microscopic, microsecond-by-microsecond phases atomic weapons go through were never studied. This is what nuclear scientists at LANL study now.

Stewardship is a controversial topic because billions and billions of dollars are poured into diagnostic technologies. Through the Cold War, as thousands of warheads were put together, safeguards were put into place to make sure that the bomb would not detonate if it fell into the wrong hands. Switches, locks and controls were put on each and every weapon in the name of protection.

These weapons, in their guarded state, are almost certainly inert, sitting on a shelf in a storage facility; this is why the billions of dollars poured into extensive testing of weapons are contested (Masco, 2006). All of the x-rays and diagnostic tools used to monitor aging bombs may realize a 10% decrease in power, but the weapon would still level an entire city (Masco, 2006). If the goal of stockpile stewardship is to ensure the well-being of the nuclear arsenal such that the weapons can be used in future wars, perhaps less intensive monitoring

is needed. The idea of complete nuclear non-proliferation also comes into play in the conversation. Activists claim that if the United States is committed to eliminating nuclear weapons, Stockpile Stewardship money should be spent on dismantling and recycling materials from the 5,113 weapon currently in the arsenal (LANL, 2012).

The histories of Northern New Mexico at large, including the Pueblos and the Spanish Conquest, land grants, and the Treaty of Guadalupe Hidalgo have created an area with profound roots in the specific geography of the region. Colonization and politics have shaped both land use practices and social dynamics to this day. Social dynamics exaggerated with the arrival of LANL have shaped communities in the area. The initial mission of the labs goes directly against the core beliefs of the Pueblos, as seen in their histories, and has ultimately led to a decline in spiritual, emotional and physical illness, as I will move on to explore.

Chapter 2: More Than the World Can Safely Tolerate

The split of cultures and wealth throughout Northern New Mexico is vast. It is a place in which the most exaggerated extremes of wealth and poverty are seen within an hour's drive. Los Alamos County, atop the Pajarito Plateau, has been rated as having the number one living conditions in the country, while Rio Arriba County down the hill, which holds both San Ildefonso and Santa Clara Pueblos, is rated 2,303 out of the 3,141 counties rated (Berkowitz, 2010). Santa Fe and Taos rate extremely high on the list as well, creating a nearly perfect triangle of living conditions on a map. The correlation of ethnicity to poverty is almost linear here. Los Alamos, the county with the highest rated living conditions is the most white. The relationship between ethnicity and poverty has created extreme social dynamics, which I will discuss leaning heavily on personal experience speaking and interacting with people across Northern New Mexico throughout my summer. These correlations side-by-side with health disparities prove the conditions of environmental injustice.

2.1 Pueblo/LANL Relations

Land

Los Alamos National Labs itself is located right on the foot of a volcano. Within Pueblo cosmology and beliefs, the caldera is a place of fire and one of the most sacred sites

that exists. It is not seen as coincidence that the place that released the "eternal fire" (Masco, 2006, p 107) is surrounded by volcanic sacred sites. In the beginning years of the labs when environmental impact statements weren't required, buildings and even dumps were put up quickly on sacred areas.

The Department of Energy (DOE) generally does not validate the sites which they have built upon as being sacred, claiming no important ruins existed on the land (Masco, 2006). What the DOE does not understand is what sacred truly means in a culture where mountains, caves, cliffs and even open swaths of land are sacred. "Sacred"ness of a place should never have to be defined. Dumps and buildings have, throughout the lab's history and even present-day, been constructed on sacred sites with little to no acknowledgement.

As the labs were built, the local people were not brought into the decision-making processes or planning due to "national security" and time concerns (Masco, 2006). The surrounding communities weren't told what type of industry was being forced into their homeland, but assumed the best of intentions. This was, perhaps, not the case, as Gregory Cajete of Santa Clara Pueblo states:

> As I was growing up, we used to talk and wonder about what was going on at Los Alamos. And we would reflect on how different the people from Los Alamos were, not only in terms of students and people that were up there but also the kinds of things that were part of the whole community, because largely Los Alamos kept to itself. It began as a scientific city, a secret city. There are so many stories as to why the lab was located at Los Alamos. One of them, of course, was because of its isolation… but I also think because of the fact that it was being put in a place where if something did indeed go wrong it wouldn't affect too many people. And the people it

> would affect, in a sense, in that time and place, were considered, I think, in some ways of thinking, almost expendable. (as cited by Masco, 2006: 132)

It is common discourse that the placement of the labs on the Pajarito Plateau was an intentional decision based on the "disposable" surrounding communities. Disposability is recognized more frequently when referred to as the "National Sacrifice Zone," a term coined in the WWII era to concrete that it was the citizen's duty in wartime to allow the government to do what was needed, in order to be a good patriot (Masco, 2006). This concept has caused millions of lives to be affected by ill-informed lab decisions during wars.

Much like the sacred spaces on the mesa top, Natives in the area were often seen not as people, but as part of the "national sacrifice zone" in the atomic age. They were, as Cajete says, expendable and without data and analysis to support his claim, the DOE would do what it thought was best. Natives were moved from their homes, and used as a low-paid workforce at the labs, cleaning up after the scientists and handling a great majority of the waste on the land.

Health and Sickness

LANL has contaminated millions of resources in the Rio Arriba valley, some of which are sacred and roped off, but most of which are contained within reservation land, water, and air. These are resources used by the general public, but under the guise of secrecy and national security, many of the contaminant releases by the labs are not made known to the general public, especially those from the past.

When the Cold War ended and the information flow was opened, many public forums were held by LANL to try and integrate itself into the communities as trustworthy. At the public meetings, the first concerns about health issues caused by the labs surfaced. In the early 1990s, San Ildefonso, located closest to the labs, announced they had determined increased rates of cancer going back to the founding of the Manhattan project (Masco, 2006). Pueblo members attended meetings pleading to know why they had so many cancers (Berkowitz, 2010).

Native Americans in New Mexico currently experience significantly higher rates of cancer than other ethnic groups (RACHC, 2008). The rise in illness is a starling change from the first decades of the 19th century, when prevalence of cancer in Natives was so low, they were thought to be "immune" to the disease (Masco, 2006, p 140). Some initial scientific studies have begun to correlate environmental releases of hazardous chemicals to elevated disease in New Mexico (see: Lemstra, 2009; Makhijani et al., 1995), but they are often overlooked or swept under the rug (Masco, 2006). Environmental contaminants and hazards through LANL are not known because they are not required to be published, or simply because the labs don't know the releases themselves due to poor past laboratory conduct. Contamination is unacceptable because pollutants likely have direct impacts on the health of surrounding communities.

The relationship between contamination of sacred land and sickness is often held as the common thread between Pueblos. Tewa Women United published on their Environmental Justice page:

> LANL has been dumping and discharging its toxic and radioactive wastes onto Tewa ancestral land. This land is revered as sacred to our people. LANL is surrounded by four pueblos; San Ildefonso and Santa Clara sit adjacent to LANL, both downwind and downstream. This contamination from dumping and discharging has been devastating to our land, water, air, food and the overall well-being of our people and ways of life. (TWU, 2011)

The labs have not only taken away sacred sites from Pueblo access, but have contaminated them with toxic chemicals. Taking away the places most sacred to the people and therefore, their spiritual connection causes even further physical strain as well in the form of stress and anxiety (Berkowitz, 2010).

2.2 Environmental Health

Health in Northern New Mexico is a contentious topic. Many of the women I worked with over the summer felt very strongly about the topic, attributing elevated rates of sickness, and more specifically, cancer, to the introduction of Los Alamos Laboratory in the 1940s. Many conversations I had which included local people, including members of the Pueblo communities, all reflected the fact that everyone knew someone who got sick from the labs. While most of the voiced concerns were focused on issues of radioactivity, the labs, and how they have impacted health here, it is the hazardous and toxic chemicals that I primarily focused on for my Division III. In fact is it non-radioactive chemicals which are

the sleeping dragon of the valley, slowly making their way into the water that is the lifeblood of these communities.

In this section I focus on first the role of environmental health and justice movements in defining health issues for economically stressed populations. I then incorporate health disparities in New Mexico, which include my observations and personal conversations with people from the region including Pueblo members as well as scientists up "on the hill." To further understand the complicated relationships of health, sickness, and the role of the labs in exacerbating issues Northern New Mexico, I will also utilize Maya Weiner Berkowitz's Division III from 2010. Her work explores issues of environmental justice, health and sickness in the Rio Arriba Valley through personal experience and independent research while also working with Tewa Women United. I also make extensive use of the environmental justice work by Nia Robinson (2008) and Robert Bullard (2010) and the environmental health work done by Sandra Steingraber in her book "Living Downstream" (1998).

Environmental Health and Justice

Environmental health is an important field of research which attempts to address public health as it relates to the environment a person is living in, whether it is a city street, down the road from a factory, or in the forest (Schapiro, 2007). More succinctly, it looks at the environment, both natural and built and how it affects the health of communities.

However, environmental justice (EJ) is separate from environmental health and in some circles is considered a branch of social justice where physical environmental degradation and social environmental arrangements are involved. Bullard, one of the leading voices in the EJ movement, is cited in Wakefield et al. (2010:n.p.) as defining environmental justice as something fundamental, "embracing the principle that all people and communities are entitled to equal protection of environmental and public health laws and regulations." Bullard's statement, of course, assumes that the state in question has environmental and health regulations in place.

An important part of the environmental health and environmental justice movements is that they both look at how multiple sources put people's health at risk (Wakefield et al., 2010). In areas like the American Southwest this is particularly important as many communities live on the margins. Compounded disadvantage is an environmental health term that takes into account several levels of health risk, adding environmental insults such as contaminants and stress which all result in elevated rates of disease (Schapiro, 2007). Compounding is an additionally important aspect to consider in Northern New Mexico as there are high rates of potential environmental exposures that put disadvantaged communities at risk.

The combination of health risks that are faced by communities may not be tied directly to specific, single, environmental contaminants and disease outcome (Wakefield et al., 2010). It is more probable that a slew of contaminants result in a "slow drip," that is more

likely to affect health, resulting in chronic and heavy bio-loads on the human system. Thus, the constant exposure to chemicals at low levels and in compounding amounts causes a great amount of scientific uncertainty as to what actually causes the diseases within a certain environment. Often the direct links of toxins in the environment to human health issues are confounded by other toxins as the result of widespread introduction of suspected chemical carcinogens; this is seen as a kind of uncontrolled experiment (Steingraber, 1998). The result of the experiment is complicated because each environment has different issues and chemicals which impact the specific area. A society which remains without any chemical exposure and would have a "natural" rate of disease no longer exists (Steingraber, 1998).

While there is no "control society," exposures to chemicals in the environment are unimpeded and multiple, as mentioned before (Steingraber, 1998). Chemicals are poured into the environment, exposing communities daily to small amounts through many different routes. For example, in the Southwest, a community member living in the desert may be exposed to arsenic through their water supply, through soil on their hands after gardening, as well as through inhalation of airborne dusts, all at small levels. This is in combination with hundreds of other single exposures throughout the day in the same and different exposure pathways. From a scientific point of view, such combinations are especially dangerous because they have the capacity to do immense harm while yielding meaningless data (Steingraber, 1998). The problem with the majority of contaminants is not longevity, but the

fact that we are continuously exposed to them through multiple routes (Steingraber, 1998). This is the case for all four chemicals I have investigated.

When we turn to the environmental justice movement after looking at the main issues of environmental health, they are framed differently. Environmental justice addresses the disparities that are often the result of racism, coined "environmental racism." Racism in the environmental sense manifests itself in unequal distribution of toxic wastes, wealth, resources and industrial sites (Cole and Foster, 2001). Furthermore, the framework of environmental justice recognizes that communities which bear heavier toxic burdens are often poor communities and as such bear the weight of pollutants from around the globe (Cole and Foster, 2001). Environmental racism is of particular interest here as my work covers reservation lands and regions where the local populations are some of the poorest in the United States.

These populations of Pueblo Indians are emblematic of issues of institutionalized racism in the United States, which is an "overarching institution of power that acts as a force for inertia, blocking progress…" (Hoerner and Robinson, 2008, p 42). These institutions have powerful hold and are now resulting in environmental legislation, including funding decisions on superfund cleanup sites, locations of government military installations and laboratories, as well as some threshold cleanup levels of contamination which all foster issues of racist ideology (Cole and Foster, 2001).

In the desert southwest, the locations of toxic sites such as incinerators, landfills, and chemical factories have been shown to increase in communities who have less political power; often poor communities of color who are then disproportionately affected (Hoerner and Robinson, 2008). In New Mexico, there are fifteen sovereign Indigenous nations within a fifty mile radius of Los Alamos National Labs (Masco, 2006). On the national scale, the disproportionate burden also been seen, with unequal distribution of toxic waste facilities targeting Indian land (Cole and Foster, 2001).

Indigenous Environmental Health

The Puebloan people have been on their lands for hundreds, if not thousands, of years, carrying on the same traditions, but they are now exposed to environmental contaminants through newly, disproportionally spread toxic sources. This is devastating to the health of communities which have deep traditions with the land and their bodies, as Tom Goldtooth, the leader of the Indigenous Environmental Network (IEN) stated:

> It's not as simple as telling… a mother not to breastfeed, because the original instructions are not man made. These are original instructions that are part of our spiritual being. (as cited by Cole and Foster, 2001, p 137)

Taking away the ability of Indigenous peoples to practice traditional living, including farming and water usage, as well as spiritually connecting to their ancestral lands, is environmental injustice. Forcing Pueblo communities away from their land and tradition due to widespread contamination not only affects health in the direct contaminant way, but also spiritually, contributing to stress and further sickness (Cole and Foster, 2001).

In the Rio Arriba Valley, water is what led people to settle. Now, the same water is contaminated and is seemingly responsible for significantly elevated rates of sickness in the community (Travers et al., 2009). Changes in the local environment as well as the severe lack of healthcare in the Rio Arriba Valley have vastly altered the life course and health of many community members (RACHC, 2008). No longer are many of the traditions, which have existed for hundreds of years, practiced, due to these changes. For example, the potteries created in the Pueblos: both black volcanic ash sand and red clay from the plains are collected in order to create the unique ceramic style of Santa Clara and San Ildefonso. They are traditionally combined with blessed water from a spring or river while reciting prayers or song. These potteries, once fired, are used for cooking and also for eating and drinking directly. If the soils are contaminated, then so are the potteries, and therefore there is a direct exposure from soil to mouth. Pottery has a very specific contamination route in the Pueblo community, but there are also many others which connect back to tradition.

Multiple routes of contamination were also a large part of the community I was working in and must be considered in the larger health picture. Water is used for drinking, cooking, showering, brushing teeth, and to water gardens, which produce crops that are then consumed. The soil, which those crops grow in, also is kicked up and inhaled in dust devils or during heavy monsoons. If the water is contaminated, this creates countless other ingestion routes. Even if a community member were to drink and brush their teeth with

only bottled water, but ate tomatoes from the community garden in an attempt to be healthy, they could be inadvertently ingesting the same amount of contaminants.

The "Most Sensitive Population"

Women are often the most sensitive to environmental toxins, and as such, one would think that women's health should be included in all public health evaluations, considering women make up 46% of the US public (Vahter et al., 2007). It is alarming to realize that in a survey of 1233 published epidemiologic studies on occupational cancer, only 7% concentrated on women, and only 1% on nonwhite women (Wakefield et al., 2010). The effects of sex have largely been overlooked in epidemiology and toxicology and therefore have not been incorporated into formation of public health standards (Vahter et al., 2007).

While much of the past research concerning epidemiology and environmental health has mainly involved occupationally exposed males who were considered to be representative of the population in general, recent research reveals that this is not so. The elderly, women, and children have significantly different health profiles (Vahter et al., 2007). However it is the studies on men which have determined maximum contamination levels (MCLs) in drinking water and other EPA limits in the US (Wakefield et al., 2010). A focus on men in formulation of MCLs has led to potentially dangerous limits which do not consider the biological factors which may influence the kinetics and toxicity of chemicals in the bodies of women differently than they do in men (Vahter et al., 2007). While research is still needed

on women's specific health, some differences seen are the result of larger muscle mass and body weight in men, differing hormones, and also potential exposure differences during menstruation (Vahter et al., 2007). Newly published health studies are moving towards including explicitly separate health assessments of women and men biologically, which is encouraging.

While biological factors are important, lifestyle can largely determine exposure to occupational and environmental chemicals, also adding to the disparities between the sexes, and for different age groups. Lifestyle factors include: smoking, dietary and nutritional inputs, physical activity, cosmetics and fashion as well as stress (Vahter et al., 2007). Exposure may increase exponentially between men and women in the case of some trace chemicals which are found in certain materials specific to daily activities (Wakefield et al., 2010). This also must be integrated into health studies in order to ensure true protection of health of all populations.

Alongside women, children are also ignored to a great degree in health studies, and if they are integrated, it is often as "small adults," (Wakefield et al., 2010). However, exposure to environmental toxicants early in life has completely different implications than adult exposure (Vahter et al., 2007). For example, endocrine (hormone) disrupting chemical exposure in childhood can devastate development both physically and mentally (Smith, 2006). Children have different behaviors and physiology from adults and thus "adult" levels of exposure throughout their growth and development results in higher bio-loads over the

course of a lifetime (Smith, 2006). The toxic exposures of children in the American Southwest have been seen to have hormonal influences on the brain (see: Vahter et al., 2007). These are pathways that add to total exposure and cannot be ignored.

Turning an eye to children and soil ingestion specifically, the factors change somewhat. Inhalation must still be taken into account, but so must ingestion through hand-mouth routes as well as play on the ground (Smith, 2006). Generally speaking, children ingest soil in ways that adults do not. The dust-hand-mouth pathway is one which is astoundingly common in many children who spend their time crawling on the ground or playing outdoors (Abrahams, 2002). The intakes through play are not insignificant amounts, with a mean ingestion amount of 184 mg per day of children aged 1 to 12 years old (Calabrese et al., 1994). Children 6-12 years old ingest only 25% the amount of soil a 1-6 year old does (Calabrese et al., 1994), which is alarming due to the important developmental stages in the ages of 1-6 years old. Exposure to endocrine disrupting chemicals at a young age may have devastating effects.

Additionally, 30% of indoor dust is made up of tracked-in soil from outdoors (Calabrese et al., 1994), which contains all contaminants that outdoor soils do. Children often play on floors, with their faces close to the ground, increasing risk of ingestion via mouth or inhalation (Smith, 2006). Play is a way in which contaminated soil may then affect children in a way that it does not affect adults.

Women and children have not been acknowledged in health studies and this is seen very clearly in Northern New Mexico, and the decisions which have been made there to protect citizens. Los Alamos National Labs, in their health assessments, specifically uses dose conversion factors for a 154 pound male, known as 'reference man,' because "dose conversion factors for populations other than adult workers have not been published by the DOE," (Smith, 2006). The use of a "reference man" is a sweeping generalization and may be putting thousands of people at risk for serious illness, because in some cases, protective drinking water limits are lowered by ten-fold in order to protect all women and children.

From here, in my discussions of health, I will concentrate largely on the effects of contaminants on women and children because they are truly the most sensitive population and have been ignored by Los Alamos National Labs health studies. I will also take into account the specific exposure routes that are experienced by Pueblo communities, because I believe an integrated approach is completely necessary to ensure health for all people. I believe that health is a human right and that the population of Rio Arriba Valley deserves nothing less than this treatment.

Regulatory Limits in the US

"Maximum contaminant levels," also known as MCLs, are limits set by the US Environmental Protection Agency (EPA) as the legal threshold limit of a certain contaminants that are allowed in drinking water. Threshold limits developed by the EPA are

done so in the name of protecting public health; however, MCLs are not simply a health based standard- they also take into account cost and the availability of technology to reduce contaminants to particular levels (Steingraber, 1998). Often the limits set by the EPA are further restricted by states, which set lower limits in order to protect the most sensitive populations: women and children. Lack of further restriction leaves citizens in states without more stringent guidelines in a potentially threatening situation.

In Maya Wiener-Berkowitz's Division III (2010), she talks about a woman at Tewa Women United who referred to MCLs as "allowable harm." Ideally, we want none of these contaminants in our bodies at all, and most of them do cause harm at trace levels, though the effects are often not known. The system put out by the EPA of regulating one contaminant at a time also brings back the question of how combinations of chemicals may act in concert to harm the body (Steingraber, 1998). Combinations of contaminants may cause more disease or completely different disease than are being predicted by EPA models.

In the research that I conducted on contaminants (see Chapter 5) I rely on established maximum contaminant levels. Previously established MCLs help to frame my analysis of the health effects of the contaminants I investigate and to tie my research into the current literature. However, I do not believe that EPA standards accurately reflect the real health risks and potential bio-loads that people are being confronted with. In addition, it is clear that the EPA system of evaluating contamination needs a lot of work; therefore I will also be

keeping a close eye on also integrating non-governmental research which looks at contamination with a more critical lens.

2.3 The Rio Arriba Valley and Health

As I have reviewed, specific health risks may be attributed to every community, especially those subject to an unequal burden of environmental toxicants such as Rio Arriba County. Rio Arriba is an extremely disadvantaged community and this, in combination with high risk, has created a situation of elevated sickness. Knowledge and understanding of local contamination is low due to access barriers, which in return creates more risk of sickness. It is important to understand and review these statistics and understand what creates risk in the valley to assess overall health.

Elevated Sickness in the Valley

Health studies published by LANL are generally predicated on a theoretical basis. Data is gathered from surrounding hospitals and clinics and condensed down into a general statement regarding health. This would be a relatively reliable manner of conducting health studies, if healthcare was reliable in the Valley (Berkowitz, 2010). There is a desperate lack of access and limited number of clinics in the area (Berkowitz, 2010). The main health service, provided to people living on the reservations, is known as Indian Health Services (IHS). But many Pueblo members do not trust IHS, especially in the context of accurately recording causes of death, which would give better statistics on health risks. Many claim that often

when people died of cancer, IHS lists other causes of death on their death certificate, which has skewed the official cancer rates (Masco, 2006). Furthermore, inaccurate recording may be affecting overall studies in the area, or hindering appropriate knowledge of health needs in these communities (Berkowitz, 2010). Outside the Pueblos, like in Espanola, Santa Fe and Los Alamos, clinics and hospitals are often too expensive, and thus there is an overwhelming lack of health care in the whole region (RACHC, 2004). Lack of health care results in a lack of studies of cancer rates and causes in the region, and as support relies on high levels of need, the statistical portraits drawn are irreconcilable with the small scale of communities in the Rio Arriba Valley (Masco, 2006).

Beyond the larger health support and reporting issues that populations in the area face, a lack of access to clinics, specifically to reproductive healthcare practitioners, has a direct impact on women's health. A gap in care may be contributing to the overall elevated cancer rates for women, which have been found to be twice the state average in breast and cervical cancer (Berkowtiz, 2010). Female reproductive cancers in Rio Arriba County are 75.03 for Native women, 32.04 for Hispanic and 31.19 for Anglo women per 100,000 (Berkowitz, 2010). This is a significant difference, and since there are no empirical or national health studies, the root causes of high rates of cancer in Native communities are not understood, but it is proposed it is due to toxic environmental exposure.

One study published in 2004 by the Rio Arriba Community Health Council (RACHC) about health in the Rio Arriba valley, involved surveys, focus groups, community meetings

and town hall forums to investigate health disparities in the region. It was found that the rates for general cancers in Rio Arriba County are elevated when viewed in contrast to New Mexico's average rates. It was found that for 191.1 per 100,000 people cancer was the cause of death in Rio Arriba County, versus the New Mexico rate of 159.2/100,000 (RACHC, 2004). Among males, the rate was 260.0/100,000 versus the state average of 188.5/100,000, with significantly higher rates of stomach, kidney and renal cancer. For women, the rate was 139.2/100,000 against the rate average of 137.3/100,000, with fairly similar rates of all cancers (RACHC, 2004).

It is hard to trace the root of elevated rates of cancer, because there are so many causes, including stress, exposure to industrial chemicals, and genetic factors (Fradkin, 1989). This is reality and is what the field of environmental health seeks to investigate. Environmental exposure and linkage to disease is hard to prove due to compounded disadvantage, which in Rio Arriba valley involves the lack of healthcare access as mentioned above, as well as stress from living in an economically depressed area in the shadow of an atomic laboratory. The causes of the cancer are somewhat unclear, but the numbers are straightforward. The valley is an area with high rates of cancer.

It is also clear that this situation is a direct example of environmental injustice. Rio Arriba Valley is a poor community of color which has been exposed to contaminants through many different sources over an extended period of time without their permission or knowledge. The figures on elevated cancer in Native American and Hispano communities as

well as elevated cancer in the Rio Arriba Valley as compared to Santa Fe are direct. If one can afford to leave the community to avoid potential contamination from the labs, or can afford to leave the community to receive better healthcare, they will most likely have less compounded disadvantage, but leaving isn't an option for many people in the community. The class dynamics, which were discussed earlier, have created a valley in which health is determined by social standings.

Access to Health and Science

Through my experiences in Northern New Mexico, working to look at health, I read through thousands of pages of LANL documents regarding contamination, possible chemical releases and health. Specifically, I reviewed the Final Supplemental Impact Statement for the Chemistry and Metallurgy Research Replacement Project at LANL, the Final Long Term Management and Storage of Elemental Mercury Environmental Impact Statement, Plans and Practices for Groundwater Protection at LANL, the Corrective Measures Evaluation for Material Disposal Area G at LANL and the Draft Environmental Impact Statement for the Disposal of Greater-Than-Class-C (GTCC) Low Level Radioactive Water and GTCC-like Waste at LANL. LANL and DOE documents are incredibly hard to read due to their thick, academic language. For every proposal for cleanup, new operations or new buildings, the labs are required to put out an environmental impact statement (EIS) which informs the public of all options being considered as well as the potential impacts those options will have on the surrounding flora and fauna, as well as social and cultural impacts. In total, the five

documents I summarized contained over 1,000 pages, with complicated graphs and charts, and took me the entire summer to review and consolidate in order to share with the community.

The EIS documents I reviewed were challenging to read and I found myself taking breaks every twenty minutes or so in order to clear my head. The women in my office told me that they had never been able to keep up with the documents and clearly understand what was being said, which is why I took on summarizing them with complete definitions as one of my main projects. EIS documents are released at least once a month through different departments at the labs, either summarizing the environmental impacts of a proposed building, reviewing environmental conditions or looking at citing waste disposal on the plateau. This rapid pace is the most challenging part of processing and understanding the documents coming out of the institutions.

LANL's impact statements and even the public notices announcing open forums are intended to include the public in decisions which use their tax money, but are not accessible in the least. Often times, they include no background information, history or appendices to aid the reader in understanding the data being presented. Some at the labs claim that the solution to fixing the problem of access is more science education, to provide knowledge. What I believe is more important is common language and open discourse.

It clicked that the thick language and constant release of official documents was a mechanism that was being used by the labs to further isolate themselves from the

surrounding communities. The labs are required to put out statements, but they are not required to release them in language that is accessible to non-scientists. As the Pueblo communities have become more frustrated with trying to understand institutional scientific language, they have stopped reading them as reliably; it's impossible to stand up to something you can't comprehend. Barriers to access have effectively achieved some apathy in communities surrounding LANL which feel that they are up against an unapproachable institution.

There have been several documents published by LANL and contractors working for LANL that look at contamination on the Pajarito Plateau and in the Rio Arriba Valley (see: EHC, 2007; Ferenbaugh et al., 1982; Hopkins, 2007). Official documents and reports have been incredibly important in my work, but they are not accessible to the communities I worked with due to their isolating language. Because of this the labs remain to be largely a mystery danger up on a hill. Knowledge is important, and having the knowledge of what contaminants are in their land could help Pueblo communities protect their health, or at the very least, inform them of the possible risks.

It is a common thread through environmental injustice- that the institutions causing health disparity put out what they refer to as "public" or "common" documents. This allows them to be able to claim that they gave communities a chance to voice their opinion. In communities with a lack of political power to begin with due to their class status, assuming understanding is an inherent mistake. The example of the interactions between LANL and

the Pueblo communities fits this mold perfectly. In order to honestly include the most disadvantaged, minority voices, LANL needs to step up and put out clear statements that cater to everyone, not just everyone who lives in academia.

Chapter 3: Toxic Origins and Movement in Northern New Mexico

The Rio Arriba Valley is a complicated space when it comes to looking at pollutants, due to numerous potential sources and unknown geochemistry of the landscape, that make up the mesas and canyons as they cut through by the Rio Grande. To predict and ultimately avoid health issues associated with contaminated water and soil, it is important to first understand the intricacies of the pathways contaminants may travel from sources into surrounding environment and subsequently impacting the local communities.

Northern New Mexico has a history of thousands of years of people living on the land with little impact (Rothman, 1997). As industry was introduced in the 1800s and then the atomic mission in the 1940s, waste was dumped into the rivers and mesa tops with no consideration of where it would go or who it would affect in the future (Masco, 2006). The disposal of toxic waste was in part due to a lack of knowledge of the impact it could have, and the result of a small group of people who held all of the power of decisions regarding waste disposal at Los Alamos National Labs (LANL). This chapter focuses mainly on toxic waste from LANL, what was done with it, and tracking where has gone and will continue to go. I rely heavily on the presentations I saw and conversations I had with Dr. Michael Barcelona from Western Michigan University about his research on accountable groundwater monitoring at Los Alamos National Laboratory, as well as two large watershed management plans by Environmental Health Consultants (EHS) and the National Research

Council (NRC). In addition, my personal experiences and conversations in the Rio Arriba Valley and Los Alamos have informed this chapter.

3.1 The Place and the Sources

Geochemistry and Geology

The geology of Northern New Mexico is impressive, with mesas flowing down into deep canyons and back up again. The mountains are truly towering, which I realized when I first drove into New Mexico and felt so small. Roads and riverbeds once filled with water weave into and out of canyons, now filled with red clays and rocks. Elevations range from 5,600 to a staggering 11,403 feet (Smith, 2006). These geological formations including mesas, rocks, and clays all contribute to contaminant pathways from the mesa tops and upstream sources to the Rio Arriba Valley. Different soil and rock types allow varying mobility of contaminants, ultimately resulting in differentiation of what gets to surrounding communities through the water and what stays planted in the ground.

The valleys in the area are cut into rocks which were deposited between approximately 1.8 billion and 3 million years ago, carved out by ancient streams (Smith, 2006) The rocks in this area are a mix of shale, sandstone and limestone with embedded shells, telling the story of an old ocean (Smith, 2006). The North-South mountain range has a granite core, generally flanked by the same sedimentary sandstones (Smith, 2006).

In contrast, most of the rocks that make up the Pajarito Plateau are volcanic rocks, and lie on top of the sedimentary rocks (Smith, 2006). This volcanic rock is known as tuff, which was a very important volcanic rock in the formation of the Pajarito Plateau. For years, tuff was believed to be impermeable and that it could block the flow of water (NRCS, 2008). We know now that tuff is made up of broken pieces of volcanic glass and sand fused together by the heat of magma released thousands of years ago (PEEC, 2012), and it is, in fact, not impermeable- dumps built atop tuff may be leaching into groundwater (Hopkins, 2007). This is very important in the discussion of toxic contaminants, especially in the context of LANL.

While the rock bases are complex, the topsoils in the area are mainly silty clay loam from 0-17 inches, clay loam down to 35 inches and cobbly clay loam beneath that (Austin, 1982). These clays have the capacity to bind to metals and ionic contaminant species due to their effective negative charge. The initially negatively charged clay layers will act like a magnet and attract positively charged ions, such as metals, then hold them in tightly to achieve a favored neutrally charged state. This means that the clay soil will hold on to the metals, not enabling contaminants to wash away with rainwater but often still allowing plant uptake. Clays, with a particle size of less than 2 micrometers, are not easily permeable- that is, they do not allow water to flow through them. Impermeability creates pools of surface water that sit on top of the soil, increasing exposure time to the clay resulting in more binding, and then eventually slow travel to groundwater. Clays that are more impermeable,

and have a more negative charge, result in the least amount of transfer of contaminants to groundwater, but the most contaminants bound to the soil.

The majority of the soil consisting of clays also means that the soils shrink and swell with moisture content (Austin, 1982). The presence of sand in the soils somewhat lessens the drastic effect because sand particles compact well, with a larger particle size of up to 1 millimeter. The following descriptions of specific clay types are important to understanding exactly how much of a contaminant and what types of contaminants are contained within the soil; however, the exact details of clay hydration and absorption are not necessary to understanding the overarching concept. I provide these details for enrichment and perhaps, further insight into soil science.

The clays found in Northern New Mexico are generally of the smectite family with a 2:1 structure (Manley, 1978). Clay minerals are fundamentally built of tetrahedral and octahedral oxide sheets which nestle on top of one another, held together by a total ionic charge. A 2:1 clay, such as smectite, is made up of one octahedral sheet sandwiched between two tetrahedral sheets. The interlayer between the sheets is hydrated, that is, it holds water, and may attract cations such as Mg^{2+} from solution outside of the clay, to be attached to the clay. It is through the mechanism of hydration that ionic contaminants may be bound to soils in the Southwest (Austin, 1982). These clays, which make up the majority of soils in Northern New Mexico, result in relatively high rates of contaminant retention (Manley, 1978).

In comparison, there are kaolinite clays available in the mountains close to the caldera. Kaolinites are 1:1 clays, with only one tetrahedral sheet for each octahedral sheet (Manley, 1978). In these clays, very little hydration is kept due to the lack of space between the two layers, which stack well. Kaolinite clays have been sought after for centuries, for potteries in the Pueblos. Because they contain very little moisture, when they are fired, they do so quickly and do not develop the cracks that 2:1 clays may when going through a rapid drying process (Austin, 1982). 1:1 clays are far more rare and do not represent the majority of soils in the region.

Average monthly precipitation ranges from 1.10 inches in June, the dry season, to 2.88 inches in August, during "monsoon" season. During this span of June-August, the average number of days with rainfall of 0.1 inches or more jumps from just 3 days to 7 days (NRCS, 2008). 0.1 inches may not appear to be a significant amount of rainfall over 24 hours, but the storms that appear in Rio Arriba Valley roll in and out within an extremely short period of time, releasing massive amounts of rainfall at once.

"Monsoon" season storms create large amounts of runoff water that can transport contaminants along the canyons, resulting in soil erosion that then enables more runoff during the next storm. The canyons off of the Pajarito Plateau all feed into the Rio Grande, whether it be directly or through another canyon. During large storm events on the flat mesa tops of the Pajarito Plateau, significant amounts of soil and debris are washed down into the

Rio Grande, smaller dry riverbeds and surrounding communities. This is an important route for contaminants making their way from the mesa top into the valley.

Groundwater under the Pajarito Plateau occurs in three forms: surface water in shallow rock beds in the canyons, sub-terrainian perched "pockets" of water and the main aquifer (EHC, 2007). Surface water, as well as the perched waters, flow through to the main aquifer at a very, very slow pace. The aquifer located in the Tesuque Formation 600-1,200 feet beneath Los Alamos provides the only municipal water for Los Alamos and White Rock (EHC, 2007). It discharges partially into the Rio Grande as well as neighboring aquifers that serve the Rio Arriba Valley (Travers et al., 2007).

Unfortunately, the exact details of geochemistry beneath the Pajarito Plateau are not understood. Los Alamos National Labs does not have good models to understand the pathways for transport of liquid and even fewer for solid contaminants that were buried over their years of operation (Hopkins, 2007). Several waste sites with unlined pits may be leaching into the various forms of groundwater all over the plateau. Pathway understanding is absolutely necessary for planning sampling well locations, sampling frequencies and analysis. For example, the presence or absence of perched groundwater under active waste sites may determine how quickly contaminants reach the main aquifer, if at all (Hopkins, 2007).

Fire

Fire in the Southwest has long been a natural process that cleared the forest of debris and activated new seeds to allow growth. As a natural, regular occurrence, historical fires burned at a low temperature, allowing a long smoldering of the forest floor (Rothman, 1997). Creation of and changes in fire policy in Northern New Mexico in the early 1900s with the development of National Parks allowed fire suppression causing the forests to become clogged with excess debris (Rothman, 1997). The result of this is that when fire did break out, it burned out of control and at a very high temperature. These fires in the 20th century burned so hot that they killed important microorganisms through the soil and indiscriminately took down stands of juniper, pinon and white pine (Rothman, 1997). In addition we are learning that the damage from these hot-burning fires may take more than one hundred years to heal, especially if the area is re-burned a short amount of time later (EHC, 2007).

The main problem that springs from the 20th century fires was explained to me in my pottery lessons in a simple allegory that links the ceramic traditions of the Pueblos to the natural occurrence of fires. Most of the soils in the area are comprised of clays, which are often used for pottery-making in the Pueblos. In the last step of processing, mugs and bowls are "fired" to close all of the micropores on the surface and make the piece suitable for holding liquids. As extremely hot fire spreads across the mesas, the same phenomenon occurs, and now the sides of the mesas are essentially glazed over. The glazing, with the lack

of trees after fire, makes water runoff into the canyons dangerous, and when large storm events move into fire-scarred areas, there is nothing to keep water from streaming down rapidly and all at once to the rivers and villages.

There were two major fires in Northern New Mexico over the past 15 years that have impacted the movement of contaminants. The first was the Cerro Grande fire of 2000, which burned hot and fast for nearly two months, and consumed a total of 48,000 acres of land, 27,000 of which were Los Alamos National Labs property (EHC, 2007). The area burned can be seen in Figure 9 below. The fire moved a lot of contaminated soil and mobilized contaminants as well as creating increased runoff towards the Rio Grande (CCNS, 2011). In fact, the impact of this fire resulted in flooding never seen before.

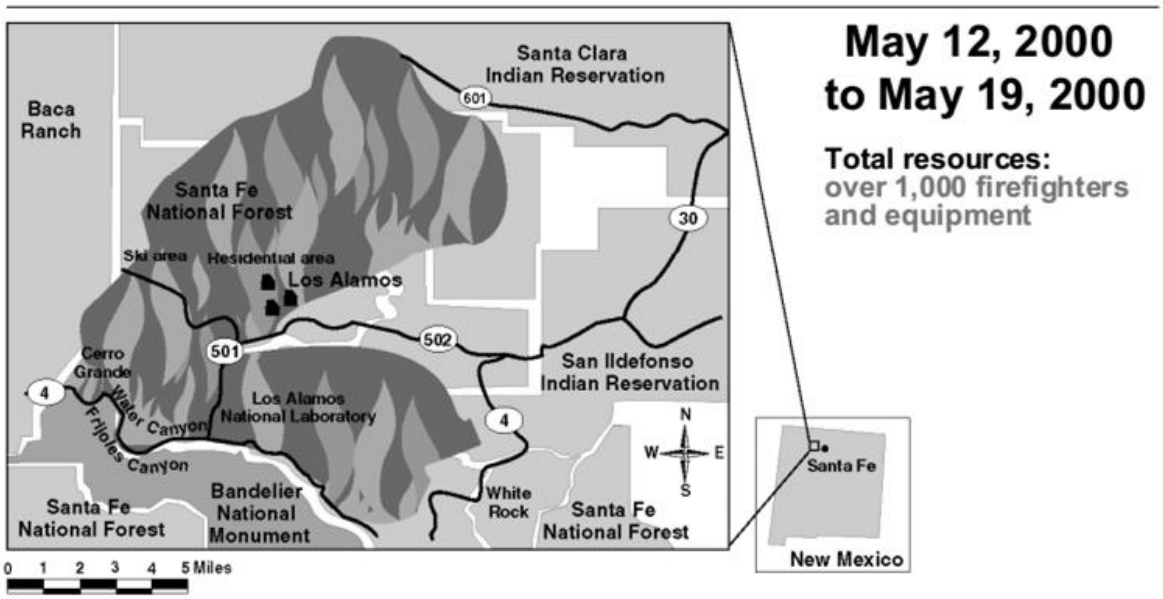


Figure 9: The land scorched in the Cerro Grande fire of 2000. Almost 48,000 acres of land were burned, about 280 homes were burned and 40 laboratory structures were damaged. From the fire, over 400 families were displaced and the overall damages were estimated at $1 billion (GAO, 2000).

The second major fire, the Los Conchas fire of 2011 was even more disastrous, burning 150,000 acres of land in about a month, as seen in Figure 10 below (LANL, 2011). It did not burn on LANL property, but re-burned several surrounding mesas in the Jemez range that had been previously scarred by the Cerro Grande fire. Sixteen thousand acres of Santa Clara land were burned, including several sacred sites. This process of re-burning and clearing of land under the mesas made effects from runoff from subsequent storm events even more drastic (CCNS, 2011).

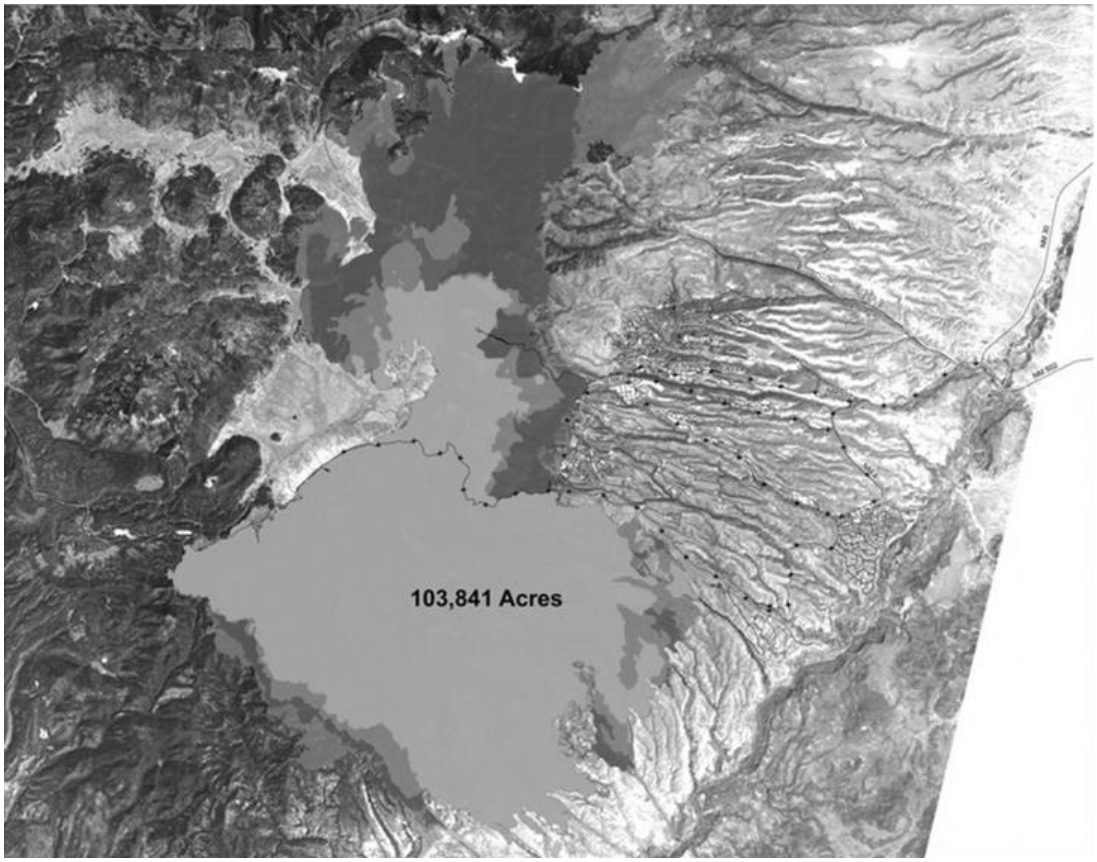


Figure 10: The area burned by the Los Conchas fire of 2011, which burned close to Los Alamos following the Cerro Grande fire of 2000. A great area of the same land was re-burned in this process, damaging forests deeply. This map shows where the fire started (light) out to where the fire was at its largest (dark) (LANL, 2011).

In the summer of 2012, massive flooding in Santa Clara Pueblo resulted in $3.7 million of property damage (Cabrero and Romero, 2012). The damage occurred after a fast-moving, high-volume storm on the Pajarito Plateau raced down the mesa sides and into small tributaries of the Rio Grande. A small dike put into place on one of the rivers broke completely, releasing millions of gallons of water into the community's homes, streets and businesses. The water from the broken dike was contaminated with potentially dangerous soil from the mesa tops and riverbeds (Cabrero and Romero, 2012). The combination of damages creating flooding proves that the "glazing over" resulting from massive fires is important.

Fires have contributed to contamination in the Rio Arriba Valley by creating pathways for water runoff to transport contaminants located in the soils of the mesas into the canyons, as well as through direct flooding. Fire-scarred land is one of many historical sources of contamination which have also affected the valley for hundreds of years, contributing to an area of intense concentration.

Sources of Contamination

There are several different routes by which pollution may enter the Rio Arriba Valley but it is industry that, in the past, used extremely hazardous chemicals in careless ways along these exposure routes. Industries include mining and agriculture across the Northern part of the state and science on top of the Pajarito Plateau. Potential sources of pollution need to be

explored in order to understand their impact on the communities in the Rio Arriba Valley as well as on top of the plateau.

While there are few natural inputs of contaminants threaten human health in Northern New Mexico, there is one notable exception: the Valles Caldera, a twelve mile wide volcanic caldera in the Jemez Mountains, one of only six known land-based supervolcanoes worldwide. The presence of a volcanic stand drastically increases the natural arsenic levels in the Rio Arriba Valley and on the Pajarito Plateau due to high arsenic levels in volcanic rock (EHC, 2007).

Although natural inputs of contamination are limited, industrial contamination sources have expanded since colonization of New Mexico. Industry was introduced into the area in the 1800s along with the railroad, and mining took a prominent role with many sites developed along the rivers which provided a good source of water for processing. Molycorps Inc., who now owns the largest developed mines in the area, located outside of Taos, has residual waste rock and tailings that have contributed heavy metals to the Red River, which merges with the Rio Grande (ASTDR, 2005). Molycorps actively mines molybdenum in an underground mine. Old Molycorps mines are listed as an EPA Superfund cleanup site (EPA, 2009). Tailings were used to backfill water lines in the municipal system in Taos developed in 1968. They contaminated the river and adjoining acequias, as well as the air as dust from the empty water lines was spread by the wind (ASTDR, 2005). Private wells around the mines have recorded elevated levels of arsenic, cadmium, iron, magnesium, manganese,

molybdenum, zinc, fluoride, and sulfate, all chemicals used industrially in the mines (ASTDR, 2005). While the impact of pollution from Molycorps' mines is still being explored, the tailings washed out into the Rio Grande may be settling in the riverbed, threatening future water use for drinking and agricultural use (ASTDR, 2005).

Agriculture has also been a huge focus of the communities of Northern New Mexico even farther back than mining and other industry (EHC, 2007). Large-scale agricultural farms built by homesteaders along the Rio Grande carelessly used the land, often discarding garbage and byproducts of farming such as manure or fertilizers directly into the river (EHC, 2007) in the name of moving towards the cash economy. Massive erosion due to monocropping and unregulated grazing on farmland also was commonplace on Northern New Mexican lands, and combined with unregulated dumping, contributed to pollution of the riverbeds and water (EHC, 2007).

Historical industries along the Rio Grande are more generally scattered across Northern New Mexico, and have created a dangerous mix of potential contaminants and routes to human health issues. But the largest single source of contamination, LANL, did not come into the picture until much later than agriculture and mining. In no way does their later emergence mean they have not had as much of an impact.

3.2 Contamination from the Los Alamos National Laboratories

As far as contaminant sources in Northern New Mexico go, Los Alamos National Labs is the main threat, because of the pure number of potential chemical releases and the nature of the contaminants as well as the general mystery surrounding what exists on the Pajarito Plateau. The records are loose, thinly recording the chemicals put into dumps in the past, making it complicated to track their releases. For example, reported in a study in 1993, a number of volatile organic compounds have been found under the labs including acetone, benzene, carbon disulfide, carbon tetrachloride, chloroform, chloromethane, 1,1-dichloroethane, 1,1-dichloroethene, methylene chloride, PCE, toluene, TCA, TCE, Freon 11, Freon 13 and xylene (as cited by Hopkins, 2007). Hexavalent chromium, nickel, high explosives, perchlorate, pentachloropenol, tritium, americium, cesium, nitrate, RDX and strontium-90 have also all been detected in local drinking water wells (CCNS, 2011). Understanding the vast number of waste outputs in scale and magnitude at LANL as well as the serious nature of the contaminants released is important to understanding potential health risks in communities surrounding the labs.

Solid Waste at Los Alamos National Labs

Waste disposal at Los Alamos has historically been unsystematic and without consideration of safety or permanence. Major canyons were used as waste release sites, connecting the top of the plateau to the Rio Grande (Travers et al., 2009). Waste, and the

way it has been handled at the labs, is a controversial topic. LANL has discharged waste on surrounding mesa tops and into canyons with little or no documentation (Masco, 2006). They had no consistent way of disposal in the past, due to lack of regulations, so the mountains became the dominant receptacle. Waste in the form of liquids, drums and cardboard boxes were released into the canyons or deposited into holes dug in the ground completely untreated; poor records were maintained about the volumes and activities of waste releases (Masco, 2006). A former LANL scientist stated that, "during the War years, partly because of ignorance, and partly because of the stress of wartime conditions, operations with plutonium were conducted with greater laxity than has ever been tolerated since." (Travers et al., 2009)

In the process of creating the atomic bomb, millions, perhaps billions, of gallons of waste in liquid form were produced, not to mention solid wastes. Between just 1944 and 1952, 2-3 million gallons of highly contaminated toxic radioactive waste was dumped into Acid Canyon, which leads directly to the Rio Grande (Masco, 2006). Solid waste such as contaminated instruments, gloves, jackets and equipment, and even spent nuclear fuel rods were buried in unlined pits and then covered with thin layers of soil (Masco, 2006). These sites have attracted some attention and have begun to be cleaned up (see: LANL, 2011; NRC, 2007).

For example, Area 21 is one of the most famously "mysterious" waste dumps from WWII that has been declassified and clean up begun (NRC, 2007). Area 21 is located across from the airport on the main road into Los Alamos, bordering Los Alamos Canyon. Since the

soil is regularly exposed to local citizens and visitors, it was a priority for cleanup. LANL documents show photos of scientists cleaning up the forty-year old landfill to uncover things they never expected, like an old truck with its trunk full of cardboard boxes packed with contaminated lab gear. Cleanup of LANL's scattered dumps is taking place slowly, and is complicated by the very limited records of what the sites contain (Masco, 2006). The consolidated wastes from various sites being cleaned up on the plateau are documented and moved to material disposal areas (MDAs).

Another site, known as Material Disposal Area G, is the most well-documented and largest MDA at LANL currently, expected to receive 54,000 drums worth of waste each year to be placed in permanent pits and shafts covered with dirt (Hopkins, 2007). Area G is located on a fingerlike mesa with its sides draining into Canada del Buey and Pajarito Canyon, directly into the Pueblo de San Ildefonso (LASG, 2011), covering a total area of 63 acres and containing 334 active and inactive waste management units (Hopkins, 2007).

During active operations while waste is received, pits and trenches at Area G have been open to the atmosphere, allowing dust and debris to be kicked up. Pits and shafts that are covered only by soil allow for infiltration by water and leaching of contaminants to groundwater (Hopkins, 2007). The groundwater chemistry under MDA G is not known, but it is possible that the groundwater, which is in layers of granite beneath the site, has the potential to push contaminants into the regional aquifer, which is used for drinking water (Hopkins, 2007).

In addition, channel soils beneath Area G have measurable amounts of beryllium, cadmium, cobalt, mercury and silver, all considered chemicals of potential concern due to their status as man-made only chemicals and their hazard to human health (Hopkins, 2007). While these are not the only chemicals of concern; they are simply the chemicals that can be traced back directly to Area G (Hopkins, 2007). All of the chemicals mentioned in this chapter as detected in groundwater may possibly be from Area G, but tracing chemicals to their origin is difficult due to the lack of geochemistry knowledge and documentation of waste.

In other areas the materials are documented and different from Area 21 and Area G, but this does not mean they don't have the potential for problematic impact on the environment and the communities in the region. Material disposal area S contains mostly explosives and it is currently being used for an active study on how weather and sediment affect the decomposition of explosives and therefore, is not being actively contained (Travers et al., 2009). Material disposal area H contains an even larger amount of high explosives; an estimated 50,000 pounds were disposed in it each year it was open from 1960 to 1986. Technical area 16 is estimated to have burned 96,300 pounds of explosives waste each year since it was opened, as reported by a 1981 LANL memo (as cited by Travers et al., 2009).

Material disposal area B is one of the oldest on the plateau and needs a more modern cleanup. It consists of several unlined disposal trenches, 90% of which are estimated to be holding contaminated laboratory debris in cardboard boxes sealed with nothing but masking tape. It also contains at least one truck which was buried after contamination resulting from

exposure at the Trinity test. In its current state, MDA B has a high probability of pollutant mobilization and release to surrounding groundwater (Travers et al., 2009; LASG, 2011).

In total, 1,405 solid waste dumps located on the Pajarito Plateau are considered hazardous by the New Mexico Environmental Department (NMED) (EHC, 2007). LANL considers 9,125 total individual sites to have the capability to contaminate groundwater (EHC, 2007). Some of the sites are contained within the dumps, or material disposal areas, while some are scattered and stand alone across the landscape. The number of sites gives some perspective on the massive scale at which waste was generated at LANL as well as the gravity of contamination. Even if a massive cleanup effort were undertaken immediately, it would take years to unearth and consolidate waste in individual sites, which would still have contaminated soils and likely irreversible groundwater contamination.

Liquid Waste

Liquid discharges are direct waste streams that travel from the labs in rivers down canyons. Discharges traveled out of the labs completely untreated in the past, bathing local canyons with radiation that is still detected in soils and plants (Travers et al., 2009). Disposal has changed somewhat since water treatment plants were installed at the labs, cleaning up the wastewater before releasing it into discharges (NRC, 2005). Between 1993 and 2006, LANL decreased the number of active discharges from 141 to 17, with only two considered contamination sources by the New Mexico Environmental Department (NRC, 2005). The release of such volumes of liquid is concerning because the liquid is dumped into canyons

that feed directly into the Rio Grande. Water from release sites may also act as a liquid driver, pushing contaminants present in soil or in solid form closer to the Rio Grande or into the groundwater. The liquids are treated before release, following strict DOE guidelines which regulate some chemicals more strictly than EPA drinking water limits (see: Del Signore, 2011), however, only a handful of heavy metals and radionuclides are regulated (EHC, 2007).

Equally concerning are the explosions that have occurred in the surrounding mountains. Between 1944 and 1962, 254 nuclear explosives tests were completed in the Bayo Canyon site (TA-10), 3 miles from LANL (Ferenbaugh, 1982). Procedures were set up so that the wind had to be blowing north east, away from Los Alamos and instead towards the Pueblos (Ferenbaugh, 1982). The test assemblies in Bayo Canyon explosions usually included components made from natural or depleted uranium and a radiation source for tracking the efficiency of the bomb (Ferenbaugh, 1982). Detonation of these bombs resulted in a wide spreading of radioactive materials as well as nonradioactive materials in the form of aerosols and solid debris. Explosives wastes not only traveled through the air towards local pueblos but settled into the soils to remain for decades to come (Ferenbaugh, 1982).

Total fallout from the Bayo Canyon tests is unknown, but suspected to be some of the highest accumulated fallout in the country when compared to other testing sites (Ferenbaugh, 1982). Hundreds of other explosives tests, including non-nuclear tests, happened after the Bayo Canyon tests, as cited by local citizens. In fact, I heard many stories of people from San Ildefonso, White Rock and Santa Clara, who were woken in the morning

or startled during an afternoon walk by the echoes of bombs off of the mountains as late as the early 1990s, when the Comprehensive Test Ban Treaty was passed.

Monitoring of Contaminants

LANL has installed a series of monitoring wells along their boundaries, near the Rio Grande and in the land surrounding the plateau due to requests by the community as well as requirements by the New Mexico Environmental Department (NMED) and US Environmental Protection Agency (EPA) to ensure that no contaminants are leaching from waste dumps. Unfortunately both the placement of the wells as well as the methods used for drilling and sampling do not provide for the most accurate representation of pollution in the region.

Many assumptions have been made in the drilling of the wells, most importantly, the direction of the flow of groundwater under the labs. Wells have been installed on one side of Area G, but not the other (Barcelona, 2012). If the flow of groundwater is towards the wells, as LANL assumes it to be, the monitoring wells will read accurate levels of contamination, but if the flow of groundwater is perpendicular, the wells will read as having no contamination, risking health of surrounding inhabitants. The alternative flow of water under Area G is likely (Barcelona, 2012) and without more intensive geological investigation, it will not be known.

Placement of the testing wells both up and downwind is lacking (EHC, 2007). The communities located here have been potentially exposed to LANL contaminants since its

inception and have been requesting information on possible contaminants since the labs became public (Masco, 2006). Testing wells on the surrounding lands are placed in seemingly random locations, with little representation of the communities close by (EHC, 2007). A reconsideration of location as well as an increase in number of testing wells in surrounding communities is needed before the monitoring sites may be considered representative of overall contamination.

Bentonite clays as drilling muds have also been used in the creation of the monitoring wells in and around the labs (EHC, 2007). Use of additives in the drilling of wells has been condemned by many leading scientists, as they bind to metals that could be present as active contaminants in the groundwater supply. Bentonite clays will bind to and mask the presence of numerous contaminants and once they are introduced, the contaminants will continue to be covered up (EHC, 2007). Wells drilled with additives are almost definitely ruined and must be re-drilled to ensure complete accuracy in testing (CCNS, 2011).

Poor sampling and analysis of well readings as well as inefficient reporting of monitoring information to the public also prove that LANL's groundwater well network is inefficient and not representative of current contamination in the aquifer (CCNS, 2011). Accurate sampling and reliable reporting to the public are basic scientific tenets that the lab must follow to protect health and instill confidence in their capabilities to monitor contaminants they have released. It is probable at this point that millions of gallons of waste have leached to surrounding communities without their knowledge (Masco, 2006), due to a deficient groundwater testing network and across-the-board lack of documentation of

contaminant location and migration. Without accurate readings, the unsustainable pattern of waste disposal at LANL could continue on and pollute surrounding lands, affecting health in all of Northern New Mexico.

Chapter 4: Contamination in the Gardens

As I have established, chemical contaminants are widespread in Los Alamos and the Rio Arriba Valley from historical and ongoing surrounding industry. I reviewed the range of chemicals which have been detected in drinking water and otherwise in the area, and for my experimental research, chose to narrow the breadth of contaminants to four chemicals to achieve a greater depth of understanding as to what is actually in the soils, and in the gardens. In this chapter, I will discuss the specific chemical characteristics, toxicity and remediation possibilities of four main chemicals: arsenic, RDX, perchlorate, and hexavalent chromium. I rely on many different sources of background information, but have made a conscious effort to use scientific case studies which take into account women and children in their health assessments.

I have chosen to examine arsenic, RDX, perchlorate, and hexavalent chromium specifically because of their differences; however, they all carry a common thread of high toxicity. These are all contaminants which have been detected in and around the Rio Arriba Valley (EHC, 2007; NRC, 2005), but have never been determined to be present in community gardens because there has never been testing such as my own. Perchlorate and RDX are both explosives which would have been used in open-air testing at LANL, and could easily be leaching out of waste dumps on the hill into surrounding canyons and groundwater (Hopkins, 2009). Arsenic is a naturally found element, but is also used in many different

industries and could be associated with historical mining, polluting the river, or coming from waste buried in Los Alamos with a toxic slew of chemicals (EHC, 2007). Hexavalent chromium is most probably leaching from legacy waste at the labs as well, and is frequently known for its mobility in water from industrial sites (EHC, 2007).

4.1 Soil and its Importance

Soil is absolutely fundamental in looking at the world of all living and non-living things. It is a complex mixture of inorganic and organic matter, air, water, and living organisms. Most essential nutrients for life are provided through soil and interactions that take place in soil (Kang, 2002). In short, soil perpetuates life. The productivity of soil in determining plant growth is fundamental in providing food resources (Kang, 2002).

Soil as a Route of Exposure

Because soil has many different uses and contains a delicate balance of many components, pollution and contamination of soil is frequent. Soil is the ultimate and most important sink of contamination in the environment (Adriano, 1986). Plants buffer human exposure somewhat through the plant-soil system in which plants take up trace elements which exceed soil capacity (Adriano, 1986). Uptake varies plant-to-plant and depends on the element. With the drastic increase in anthropogenic (human-made) pollutants due to industry, severe soil pollution has occurred, resulting in barren areas (Kang, 2002). These are

areas in which the levels of contamination are so high that all surrounding plants die, leaving empty patches of soil which are then exposed to humans (Kang, 2002).

Soil is often overlooked in the field of public health; however, it is imperative to include soil in health assessments because soils reflect all of the activities that have taken place in the course of their existence (Mielke et al., 1999). For example, this includes all the historical contamination as well as the human activities that rely on the soils from gardening to pottery. The soils literally make up the land. While ownership of land and lifestyles has been renegotiated over the past centuries, the effects of contaminants present in the area are on a multi-century trajectory due to their presence in the soil and water (Masco, 2006).

The transfer from soil to human is for many elements an important and indirect route for people to consider in health assessment (Mielke et al., 1999). Inhalation is the first exposure, and when gusts blow the dry desert soils up outdoors, mineral dusts are inhaled by humans, trapped in their lungs and sinuses and subsequently ingested, passing through the gastro-intestinal tract (Abrahams, 2002). Ingestion rates are often determined by degree of grass cover because without sufficient grass cover, soil is exposed to the open air and more likely to be blown up (Calabrese et al., 1994). In the Rio Arriba Valley, there is massive erosion due to overgrazing, monocropping, and fire (Masco, 2006). Erosion results in a high level of direct ingestion through suspended dusts.

There have not been many studies on soils or in gardens in general, despite their obvious importance in communities on the margins and in particular in the Northern New

Mexican communities I worked with. The uptake of crops in Los Alamos have been the subject of a single study, after much request from the surrounding communities (Masco, 2006). There was a study that undertook very limited testing on the soil, fruits, stems, and leaves of pinto beans, squash and sweet corn. Each was planted and then analyzed for tritium, cesium, strontium, plutonium and total uranium (Fresquez et al., 1998). All plants were found to contain radionuclides, well under the official permissible dose limit of 100 mrem/year within an assumed maximum ingestion rate (Fresquez et al., 1998). No hazardous chemicals were analyzed, but the insistence of the community on completing the study in Los Alamos shows the interest in knowledge, as well as the value placed on gardens and food.

3.2 Contaminants Being Tested

In this section I will lay out the basic chemical structures, properties, bioavailability in different types of soils and plants, health effects and potential remediation techniques. These will inform my research on the four chemicals of concern and why they are important in the context of the communities I have discussed.

Arsenic

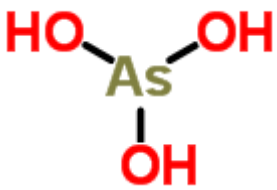
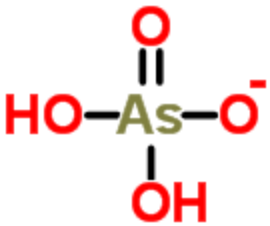
	Arsenite – As^{+3} as $As(OH)_3^0$	Arsenate – As^{+5} as $H_2AsO_4^-$
	 (ChemSpider, 2013)	 (ChemSpider, 2013)
Solubility	3.7g/100 mL H_20 at 20C (ChemSpider, 2013)	.0059 mg/L H_20 at 20C (ChemSpider, 2013)
Mobility	More mobile (Sengupa et al., 2008)	Less mobile (Sengupta et al., 2008)
Behavior in Soils	Present in anoxic soils (Fayiga et al., 2007) Much less prevalent (Martinez-Sanchez et al., 2011)	Present in aerobic/oxic soils (Fayiga et al., 2007) Sorbed to clays (Fayiga et al., 2007) Forms stable surface complex (Nagajyoti et al., 2010)
Water Quality Limits	10 ug/L (EPA, 2012)	
Regional Screening Level	0.39 mg/kg (EPA, 2012)	
RFD_0	$3.0x10^{-3}$ mg/kg.day (EPA, 2012)	
SFO	1.5 $(mg/kg.day)^{-1}$ (EPA, 2012)	

Table 1: Arsenic properties

Arsenic (As) is an element which has been studied over hundreds of years to understand its toxicity. It is a heavy metal found commonly in soils and plants at low levels; however, as the industrial age came about, its prevalence in soil and water rose quickly. Arsenic is used in many chemical processing industries as well as mining and electroplating

(Nagajyoti et al., 2010). It is now known to cause a broad spectrum of health effects known overall as arsenicosis, which is linked to Bowen's disease, squamous cell carcinoma and basal cell epithelioma, all ailments of the skin (Sengupta et al., 2008). Some cancers of the liver, lung, bladder and kidney have also been hypothesized to be linked to arsenic poisoning (Chen et al., 1992). Chronic exposure to arsenic has also been seen to have adverse obstetrical outcomes in women such as miscarriage and premature birth (Ahmad et al., 2001).

Arsenic can find its way into food systems through agriculture, as the soils that are most affected by its natural occurrence are found in the desert southwest of the United States such as New Mexico, Utah, Nevada and California. The reason this region is a natural ground for arsenic is that geologically, there were alkaline brines trapped in closed basins. The result is that the rocks in this region are naturally high in As and contact with alkaline waters results in soil contamination around 10 ug/L, the current defined EPA drinking water limit (Tollestrup et al., 2005; Longmire et al., n.d.). Unfortunately, As also makes its way into soils from mining companies and chemical industries along rivers such as those located along the Rio Grande upstream of Los Alamos. The As does not immediately bind to soils and may make its way down the river until it is used to water a farm, where it may build up with repeated watering, also known as "compounding."

In the environment, arsenic is found in two forms: trivalent arsenite and pentavalent arsenate. Arsenite causes the most immediate medical effects but is somewhat less prevalent

than arsenate in soils and plants. Arsenate is still very toxic to biota and is found widely. Generally arsenic is consumed in arsenate in food and water (Sengupta et al., 2008).

In soils with high levels of organic matter (OM), mobile or available As is lowest in both of its forms. The lack of mobility is due to the high cation exchange capacity and metal sequestering ability of OM. The same type of restriction in mobility is seen in high clay areas due to clay's similar ability to bind As. Clay carries an effective negative charge between sheets which easily attracts As with a positive 3/5 charge. pH is also negatively correlated with total As (Martinez-Sanchez et al., 2011). High pH soils with a high sand content are found to be the highest in bioavailable As. Presence of iron, aluminum and manganese also affect available As in the soil. These are metals highly competitive for binding sites on organic matter and clay and as other metals increase in the soil, more mobile arsenic may occur (Fayiga et al., 2007).

Absorption by plants is restricted by how much As is mobile in the soil, but also by several other factors. Arsenate is the main form taken up by plants, due to its prevalence in the environment (Martinez-Sanchez et al., 2011). Arsenate is an analog of phosphate and carries the same charge. It competes for the same uptake carriers in the roots of plants where it is taken up and translocated throughout the plant. (Nagajyoti et al., 2010). Uptake of arsenic is a much studied mechanism and has been confirmed in a number of studies and it is shown Figure 11 below from Zhao (2010).

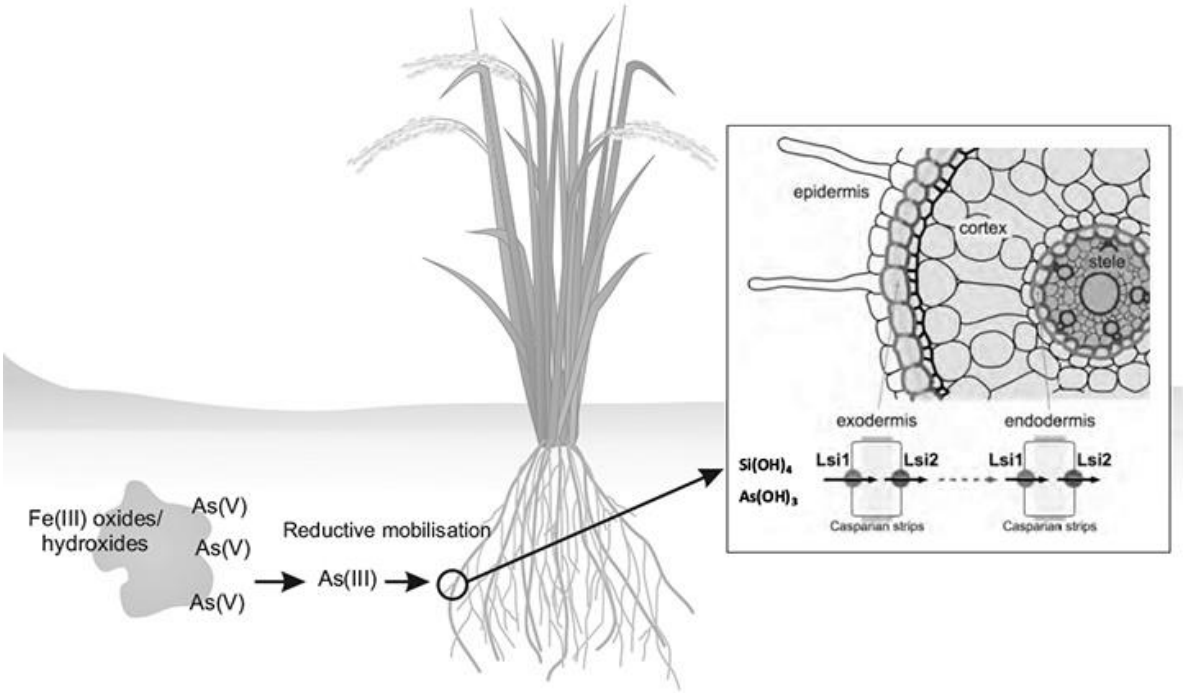


Figure 11: Uptake of As in plants. Arsenate (As^{+5}) is the prevalent form of arsenic found in the soil. Arsenate is readily taken up by phosphate transporters and translocated to shoots. In reducing environments, arsenite in the predominant form of arsenic found. A number of the aquaporin nodulin26-like intrinsic proteins (NIPs) in the root are also able to transport arsenite through the highly efficient silicon (Si) pathway of entry to root cells and move towards the xylem. (Zhao et al., 2010)

Health effects from arsenic are also a very well-studied field that has shown a wide variety of connected disorders and disease. Arsenicosis, which is noted as a disease linked to arsenic, may take 2-20 years to develop depending upon exposure rate as well as physiology (Ahmad, 2004) such as the physical differences discussed between men and women. With a time frame this large, it has often been seen that patients are unaware of any relevant causal exposure (Watson et al., 2004). Large-scale arsenicosis has been seen in Japan, India, Chile and Vietnam; however, it is also a significant problem in the United States. As many as 1/8 of dermatologists in the Southwest see at least one patient with arsenical skin problems in a one

year period, a number which doubles over a 10 year period to ¼ of dermatologists. This figure may even be low, due to the poor healthcare in parts of the US Southwest (Tollestrup et al., 2005).

As mentioned above, arsenate is the most commonly consumed form of arsenic, while arsenite is more toxic. When ingested through food or water, arsenate is slowly reduced to arsenite by glutathione, an antioxidant tripeptide in the body, seen in Figure 12 (Sengupta et al., 2008). The transformation mechanism of arsenic somewhat lessens the importance of speciation taken in to the body.

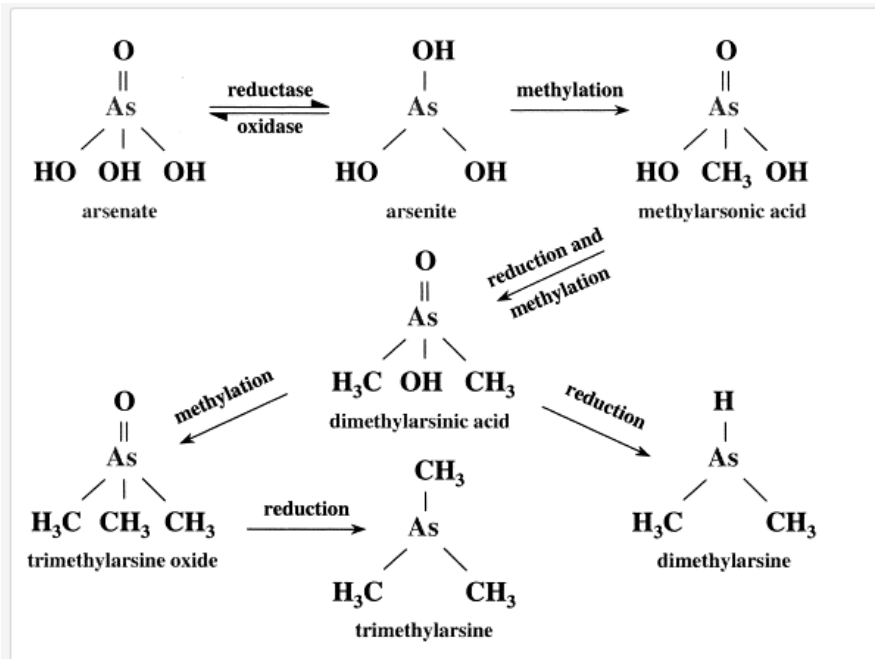


Figure 12: Arsenic is known to sorb to mineral phases, which can impact its environmental mobility. Arsenite, on the other hand, sorbs less strongly to some key mineral phases. This might result in the mobilization of the more mobile arsenite, also more toxic than arsenate. (Mukhopadhyay et al., 2002)

It has been shown that arsenite will widely distribute throughout the body, concentrating in the skin, hair, nails, stomach and small intestine by binding to sulfhydryl

groups in keratin filament and other essential compounds (Sengupta et al., 2008). When it binds with a functional group, it inactivates that group. In this way, arsenic inhibits DNA repair process and alters tumor suppressor gene p53 by DNA methylation (Hasnet et al., 2005). Methylation of DNA is essential to organisms because it helps cells remember where they have been and what they have done in the past. Hypermethylation of DNA, which is induced by arsenic, inactivates tumor suppression genes involved in repairing DNA, leading to uncontrolled cell proliferation. (Sengupta et al., 2008). The uncontrolled proliferation may lead to cancer. Diets low in protein have been hypothesized to increase As toxicity due to lower methylation capacity (Smith et al., 1992). This connection is important for poor communities who may not have proper access to nutritionally rich foods.

Arsenic is excreted mainly through urine, passing through the kidneys as a mixture of inorganic, monomethylated, and dimethylated forms (ASTDR, 2007), all of which can be seen in Figure 12 with the transition between the three. Arsenic is rapidly removed from the blood and may be normal even when urine levels remain elevated; most arsenic is cleared through urinary excretion within 2 days (ASTDR, 2007). Excretory mechanisms point to acute and high levels of repeated exposures as the most important in health studies.

Arsenicosis is linked to skin cancers including Bowen's disease, squamous cell carcinoma, and basal cell epithelioma, which are often first seen as keratotic lesions on the palms and soles or hyperpigmentation scattered across the body (Sengupta et al., 2008). Skin cancers may also arise with no early indication at all (Watson et al., 2004). Populations in

Taiwan, Mexico, India, and Chile that consumed drinking water with high levels of As had high rates of skin cancer, up to 25%, in areas with drinking water levels between 10 and 50 ug/L (Sengupta et al., 2008). The lifetime risks of skin cancer from As has been calculated with be 1.3/1000 in males and 0.6/1000 in females per microgram of As per day. Thus, in an area with a drinking water level of 50 ug/L, lifetime risk of dying from arsenicosis is 21/1000 on average, as compared to a lifetime cancer risk of 10/1000 for a smoker (Smith et al., 1992).

In addition to skin cancer, significant dose-response relationship has been observed between ingested As level and mortality from cancer of the liver, lung, bladder, and kidney in most age groups (Chen et al., 1992, Smith et al., 1992, Sengupta et al., 2008). As age increased, mortality rates significantly increased (Chen et al., 1992), most likely due to As binding with metallothionen, a metal sequestering protein which shuttles metals to the kidney, liver and bladder for excretion (Hasnat et al., 2005).

Adverse obstetrical outcomes are somewhat less studied in the field of arsenic poisoning, but are still fairly well understood. Outcomes include increased stillbirth occurrence, increased spontaneous abortion and preterm births. In women of childbearing age exposed to drinking water 0.1 ppm or higher (as compared to the EPA drinking water limit of 0.01 ppm), all three outcomes were significantly higher than the control group (Ahmad et al., 2001). Risk of miscarriage and stillbirth increased exponentially as drinking water levels of As increased (Hasnat et al., 2005). Transplacental transfer of As is therefore, a major concern. It has been seen that As concentration is the same in maternal and cord

blood, indicating free transfer across the placenta (Sengupta et al., 2008). Maternal toxicity due to sequestering of As in the liver that redistributes zinc has been seen in pregnant rats exposed to arsenate (Hasnat et al., 2005). The relationship between arsenic and zinc is not well studied and should be a point of future research. Currently, the US EPA maximum contaminant level (MCL) is 0.01 ppm, however, 8% of public water supplies in the US exceed the MCL (Tollestrup et al., 2005) and considering the serious implications of arsenic poisoning, the "safe" level may not be protecting everyone.

Some promise for phyotoremediation of As has been seen with a number of plants. High As tolerance has been seen in a number of species including grasses due to their ability to suppress a high affinity P system and take up As instead, as seen in Figure 11 above. This suppression reduces As influx to a level where a plant can easily detoxify by constructive mechanisms (Nagajyoti et al., 2010). *Pteris vittata*, the Chinese Brake Fern, is a strong bioaccumulator of As. After 8 weeks of growth in a study, it took up 24.4 mg As out of a 131 mg As/kg soil contaminated field. The control only took up 6.7-19.3 mg As in the same amount of time (Fayiga et al., 2007). Since the fern is a small species that grows quickly, phytoremediaton in this manner would require little commitment time to cleanup and may be suitable for small fields.

RDX

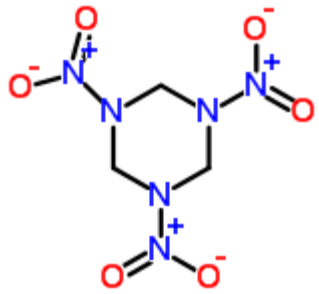
	RDX – cyclo-1,3,5-trimethylene-2,4,6-trinitramine, $C_3H_6N_6O_6$  (ChemSpider, 2013)
Solubility	$1x10^{-6}$ mg/L at 25C (ChemSpider, 2013)
Mobility	Mobile (Falone et al., 2007)
Behavior in Soils	Adsorbs to clays (Townsend et al., 1996) Will leach to groundwater if not taken up by plants (Chen et al., 2011) Will not break down in soil (Chen et al., 2011)
Water Quality Limits	0.1mg/L for one day (EPA, 2012), 0.002 mg/L lifetime (EPA, 2012)
Regional Screening Level	5.6 mg/kg (EPA, 2012)
RFD_0	$3.0x10^{-3}$ mg/kg.day (EPA, 2012)
SFO	$1.1x10^{-1}$ $(mg/kg.day)^{-1}$ (EPA, 2012)
Adsorption Coefficient	24.88 – moderate adsorption, will leach (Falone et al., 2007)

Table 2: RDX Properties

Cyclo-1,3,5-trimethylene-2,4,6-trinitramine, more commonly known as RDX (research department explosive), or C4, is a chemical with widespread application in munitions (Chen et al., 2011). It is used as a component in propellants, detonators, bombs, grenades and a wide variety of other military ordinance (Murnyak, 2011). The first widespread use of RDX was during World War II. In this time, open air testing at military

bases was commonplace, as well as packing of explosives outdoors (Hundal et al., 1997). Consequently, accidental environmental contamination of soils and groundwater has occurred at military bases and the surrounding communities. It is estimated by the US Defense Science Board that more than 15 million acres of closed sites containing RDX and other explosives contamination exist (Ryloh et al., 2008) where concentrations can exceed thousands of milligrams per kilogram of soil (Zhang et al., 2009). It has been known for a long time that RDX is neurotoxic, and it is classified by a possible carcinogen by the US EPA due to early animal studies (Zhang et al., 2009). Cleanup is required in communities where RDX levels are high because it is toxic not only to humans, but to aquatic and terrestrial organisms as well (Hundal et al., 1997).

RDX is especially concerning as a military waste because it is mobile in soil and therefore poses a risk of groundwater contamination when present at high levels. In fields where TNT and RDX are present together, RDX is comparatively much more mobile and is taken up into plants much more easily. It also degrades at a much slower rate than TNT (Chen et al., 2011; Ryloh et al., 2008). Knowledge of the soil binding properties and plant metabolism of RDX is limited. It is a concern that high levels of RDX in the environment may enter the food chain through accumulation in plants.

Though studies on RDX in soil are sparse, some information is known around its behavior in groundwater systems. Sorption studies with RDX have indicated it has low affinity for soil surfaces and is significantly mobile (Lewis et al., 2004; Townsend et al., 1996).

Sorption varies with soil types, and adsorption coefficients of 24.88 (Falone et al., 2007) indicate that RDX is only ever moderately adsorbed to soil and may leach to groundwater (Chen et al., 2011). Sorption values on bentonite clay are similar to sorption values on natural sediment, indicating clay content is important to sorption of RDX. Areas with high clay content will sequester more RDX than a sandy or loamy field because sand and loam do not provide a charged surface for RDX to adsorb to (Townsend et al., 1996). RDX sequestered by soils does not degrade appreciably until it reaches groundwater or air where it degrades at a more rapid rate (ASTDR, 2011). In addition, RDX is resistant to microbial degradation in soils and its structure will remain stable in that medium (Chen et al., 2011). In soil, the half-life of RDX is 2,100 days in winter conditions and 465 days in summer conditions, as compared to 9-13 hours in water (ASTDR, 2011).

As stated above, not much is known about the specific metabolism of RDX in plants either. Roots readily take up RDX and translocate it to aerial organs. The roots-shoots mechanism happens quickly; RDX has been found at high levels in the youngest plant organs (Best et al., 1999). In several studies, it has been seen that total concentration of RDX per unit of plant tissue is always higher than that in the soil, showing an impressively high uptake rate of RDX (Chen et al., 2011). The accumulation of RDX in plant tissue is concentration-dependent, with plants such as maize taking up 3,267 ug RDX from soil in 4 weeks in a pot containing 100 mg/kg RDX in soil (Chen et al., 2011). Wheat was able to take up 2,800 ug per gram dry biomass (Chen et al., 2011).

Despite high uptake rates, plants have a low ability to degrade RDX and accumulation may occur. RDX is returned back into the food chain through the soil as plants die or leaf drop occurs or through animals eating the plants (Ryloh et al., 2008). Some plants are capable of transforming RDX into polar compounds such as formaldehyde and methanol within 1-7 days of incubation (Best et al., 1999). Transformation is promising for in-situ bioremediation prospects, though formaldehyde and methanol are both very toxic as well. Plants would need to be removed completely from the site after remediation for offsite disposal.

RDX has been proven relatively toxic to all plants at both high and low levels (Chen et al., 2011). Brown tips of leaves, browning lesions, necrotic spots and defoliation are the most common symptoms of RDX toxicity, increasing with increasing concentration. Dry biomass of plants affected by RDX toxicity have been found to be comparatively lower than that of control plants, but RDX does not halt reasonable growth in any plants (Chen et al., 2011). It begins to stunt growth as low as 100 mg/kg and halts growth at 500 mg/kg RDX (Rylott et al., 2008).

Acute health effects of RDX have been known for a very long time, involving the central nervous system (CNS), gastro-intestinal system (GI), and renal system. Acute effects include hyperirritability, nausea, vomiting, generalized seizures, and prolonged amnesia. All of the health effects were first seen in men working on military bases or in the field with explosives, and were considered to all be reversible (Etnier, 1989). A very clear causal relationship between RDX and seizures was drawn, eventually linking RDX to neurotoxicity

in the cases of inhalation, oral or dermal exposure (Zhang et al., 2009). The following Figure 13 summarizes existing health studies and shows how many gaps exist.

Longer term studies on chronic low-level RDX exposure are less available than acute studies, due to the military limiting information on the explosive during wartime. RDX is slowly absorbed in the GI after ingestion and does not accumulate appreciably. In rat studies (Etnier, 1989) over 2 years with dosages ranging from 1 to 25 mg/kg, long-term effects of RDX exposure include anemia with secondary splenic lesions, hepatotoxicity, cataracts, and urogenital lesions. No developmental or reproductive toxicity has been found (Etnier, 1989). No studies including children or mothers have been carried out, but it is assumed that children are more susceptible to the effects of RDX than adults due to their developing systems as well as smaller size and weight. In rat studies, RDX passed through the placenta and into breast milk. No birth defects were seen in animal studies, but babies of a smaller weight and length were recorded (ASTDR, 2011).

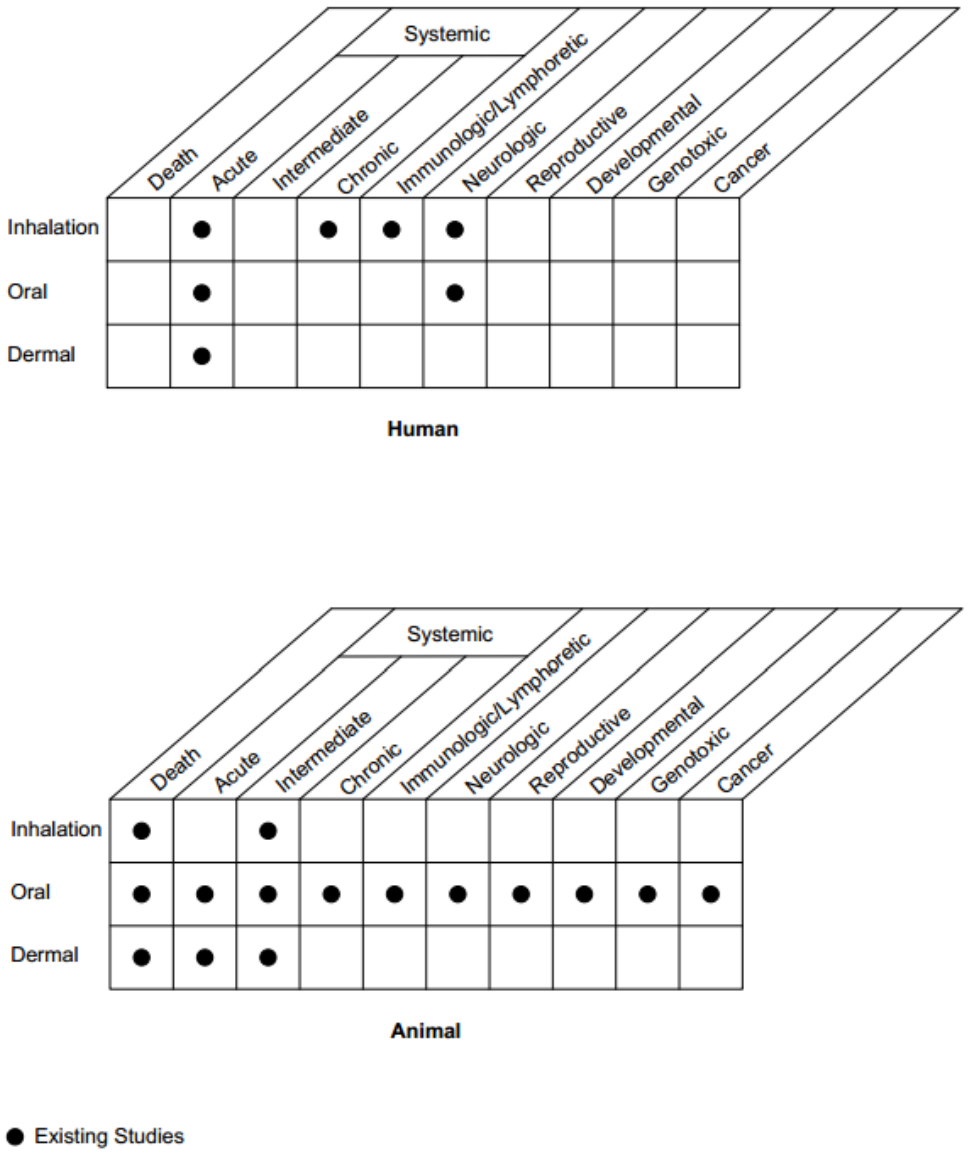


Figure 13: Existing Information on Health Effects of RDX (ASTDR, 2012). Case studies are available regarding systemic effects in humans following acute exposures to RDX via all three routes. One study in the workplace provides information on immunological and neurological effects following inhalation exposure for chronic periods (Hathaway and Buck 1977). Neurological effects have also been described following acute oral exposures to RDX (Hollander and Colbach 1969; Kasuske et al. 2009; Ketel and Hughes 1972; Küçükardalĭ et al. 2003; Merrill 1968; Stone et al. 1969; Woody et al. 1986). Animal data on inhalation exposure is limited to one study. Oral animal data are available for all exposure durations and for all end points. Dermal data on death and systemic effects are available for animals exposed to RDX for acute and intermediate exposure periods. (ASTDR, 2012)

Exposure to RDX has significantly altered miRNA expression profiles in the brain and liver in mice, suggesting carcinogenicity and toxicity. The aberrant expression of miRNA in the brain was greater. In both cases, many cancer-related miRNAs were significantly affected by RDX, suggesting a potential cause of RDX carcinogenicity. The miRNA-206 targets the BDNF gene, which is one of the most important members of neuronal function. Decreasing BDNF levels have been linked with Alzheimer's and Parkinson's diseases. This may be the mechanism in which RDX is neurotoxic, but more studies are required in both cases to confirm carcinogenicity and toxicity though miRNAs (Zhang et al., 2009). Following is a proposed model of the miRNA/RDX mechanism from the Zhang et al. 2009 study (Figure 14).

Currently the US EPA's water quality criterion "for protection of human health and sensitive population through drinking water and aquatic foodstuffs" is 105 ug/L RDX. The water quality limit is based on toxicity data that, as discussed above, are far from complete. The level also does not take into account any RDX exposure through foods or through airborne particulate. No health information is known specifically for pregnant women or children, and therefore the EPA protective level may not truly be protecting the most sensitive population.

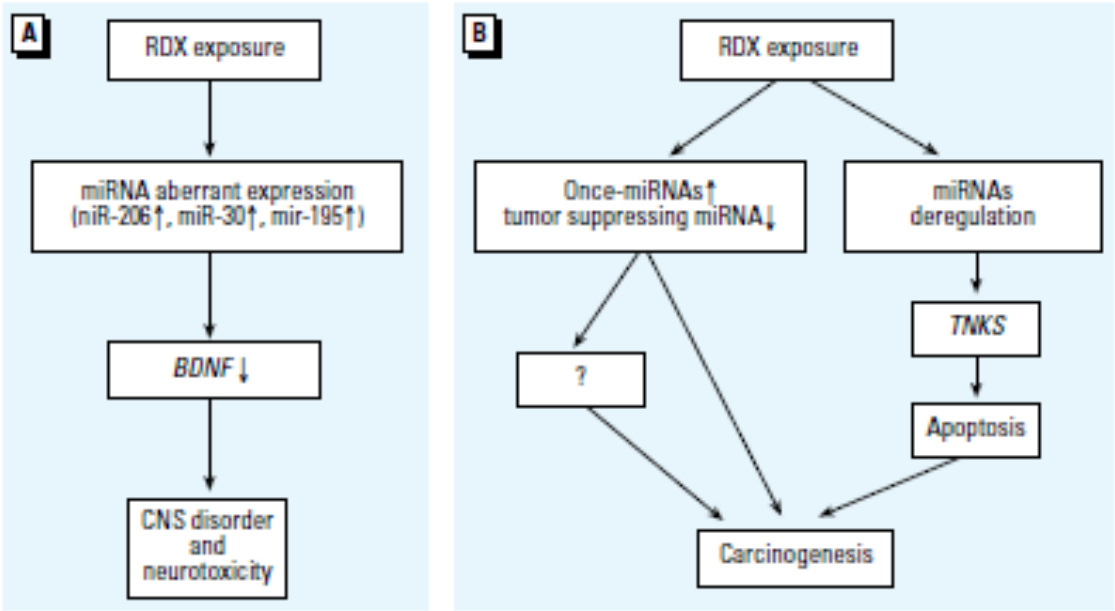


Figure 14: A proposed model showing the mechanisms of RDX-induced CNS disorder and carcinogenesis. RDX exposure caused abberant expressions of many miRNAs. Some of them, as shown (miR-16, miR-20 and miR-195) target BDNF, one of the most important members of the neurotrophin family in mammals. RDX-induced overexpression of these miRNAs inhibits the expression of BDNF, leading to neurotoxicity and CNS disorder. RDX also induced aberrant expressions of tumor suppressing miRNAs which would lead to tumor pathogenesis or target genes related to cell cycles which regulate cell apoptosis. These proposed molecular changes eventually cause RDX induced carcinogenesis and CNS disorder. (Zhang et al., 2009)

Phytoremediation of RDX has seen a lot of attempts, since the majority of RDX contaminated fields are wide, open spaces. Most plants take up RDX in extremely significant amounts at a rapid pace, as reviewed before, which is promising for phytoremediation. If leaves are cut off of large plants before leaf drop, RDX may be removed from soil at a steady pace. If the plants are left to be and leaf drop occurs, RDX will simply be returned to the environment in a more concentrated form (Chen et al., 2011). Few plants have been identified as being capable of degrading RDX, however, they do exist (Best et al., 1999). RDX

is taken up in these plants and reduced to MNX and DNX. Subsequent mineralization of the heterocyclic ring occurs with the aid of light, yielding methanol and formaldehyde, both benign products (Ryloh et al., 2008). Phytoremediation is certainly possible in a short timeframe if care and time is taken to carry it out properly. The exact mechanism of the biodegradation of RDX in order to clean up land follows in Figure 15, showing the transformation of RDX all the way to methanol.

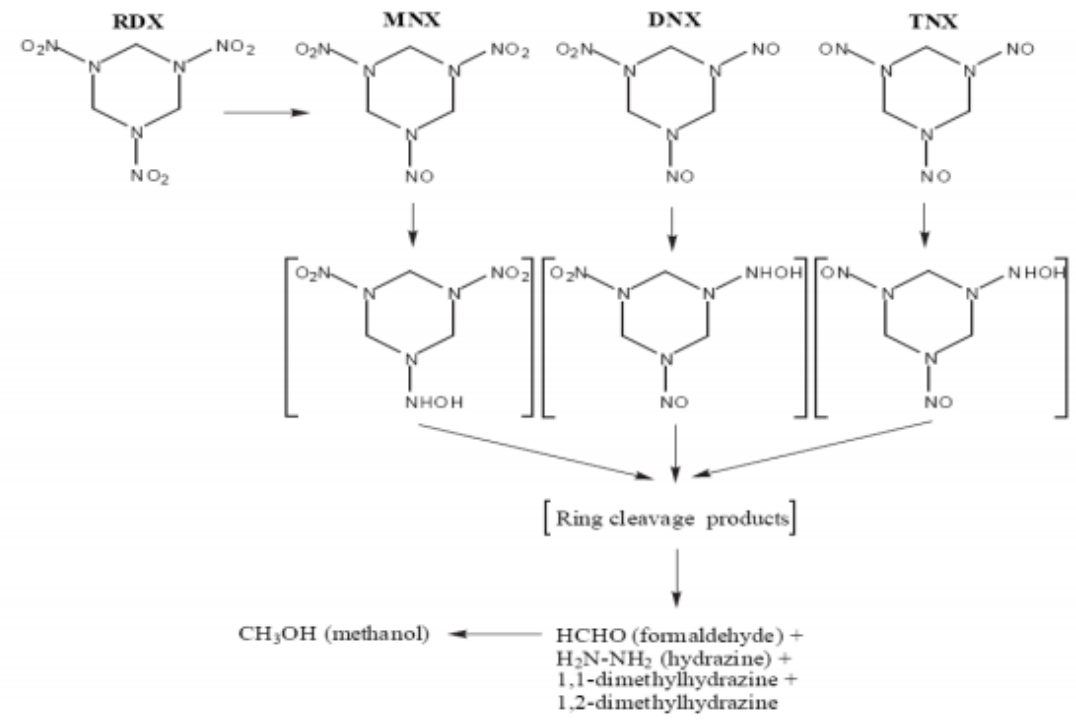


Figure 15: Mechanism of biodegradation of RDX within plants (Sanka, 2009). One pathway of RDX biodegradation in plants involves the production of mono, di, and tri nitroso intermediates from RDX, through sequential reductions of the nitrogroups. Another proposed mechanism of RDX degradation occurs with cleavage of the ring and further break down to formaldehyde and nitramine (NO2-NH2). These are finally converted to carbon dioxide, methane (CH4) and nitrous oxide by microorganisms in the soil (Sanka, 2009).

Perchlorate

	Perchlorate – ClO_4^- (ChemSpider, 2013)
Solubility	1.5g/100 mL H_20 at 25C (ChemSpider, 2013)
Mobility	Very mobile in soils through water (Ting et al., 2006)
Behavior in Soils	10% perchlorate will attach to clay layers (Brown and Urbansky, 2003)
Water Quality Limits	No EPA limit, 2 ug/L (MA DEP), 18 ug/L (CA DHS) 24.5 ug/L (NAS)
Regional Screening Level	550 mg/kg (EPA, 2012)
RFD_0	$7.0x10^{-4}$ mg/kg.day (EPA, 2012)
SFO	none

Table 3: Perchlorate Properties

Perchlorate is an anion derived from perchloric acid ($HClO_4$) and found commonly in groundwater as a result of military contamination. Due to its unique combination of solubility, stability and mobility, it has a huge potential for localized contamination and high compounded concentrations (Crawford-Brown et al., 2006). Perchlorate also has a similar ionic radius and charge to iodide, a necessary thyroidal signaler, giving it the ability to block iodide in the thyroidal system (Irizarry et al., 2011). Iodide blocking may lead to disruption of hormones and thyroidal problems. Fetuses and newborns are the most susceptible to

hormonal problems, as the only source of iodide in utero and during infancy is from the mother, and iodide is crucial during development (Irizarry et al., 2011).

Perchlorate is formed naturally by unspecified heterogeneous photochemical reactions in the atmosphere (MADEP, 2006). High concentrations of perchlorate are used industrially in systems that require a rapid exothermic release of oxygen, such as fireworks or solid rocket fuel (Crawford-Brown et al, 2006). Perchlorate is highly water soluble and stable at ambient temperature and pressure, making it extremely likely to contaminate waters when disposed of improperly (Ting et al., 2006). Military contamination is generally the main point of concern in perchlorate contamination. Perchlorate salts and perchloric acid are used in over 250 types of munitions at military bases. The structure of perchlorate, as discussed above, allows it to easily contaminate water supplies near military bases (MADEP, 2006).

The transfer of perchlorate to soil is relatively low, at around 10% (Brown and Urbansky, 2003). Perchlorate's transfer properties mean that highly contaminated water sources which may be used to irrigate agricultural fields will transfer 10% of the perchlorate to clay layers. When considering highly contaminated waters not treated to any drinking water standard, this is a concern (Brown and Urbansky, 2003).

Uptake of perchlorate by plants in contaminated soil has not been deeply studied. It has been determined that perchlorate uptake is highly variable plant-to-plant due to individual traits (Yu et al., 2004). Uptake is also limited by the presence of external nutrients in the soil. If plants are well-fed, they take up significantly less perchlorate (Yu et al., 2004).

Ion transport is the route by which perchlorate enters plants, passing from soil solution into xylem. A diagram of the mechanism of plant uptake is provided below in Figure 16.

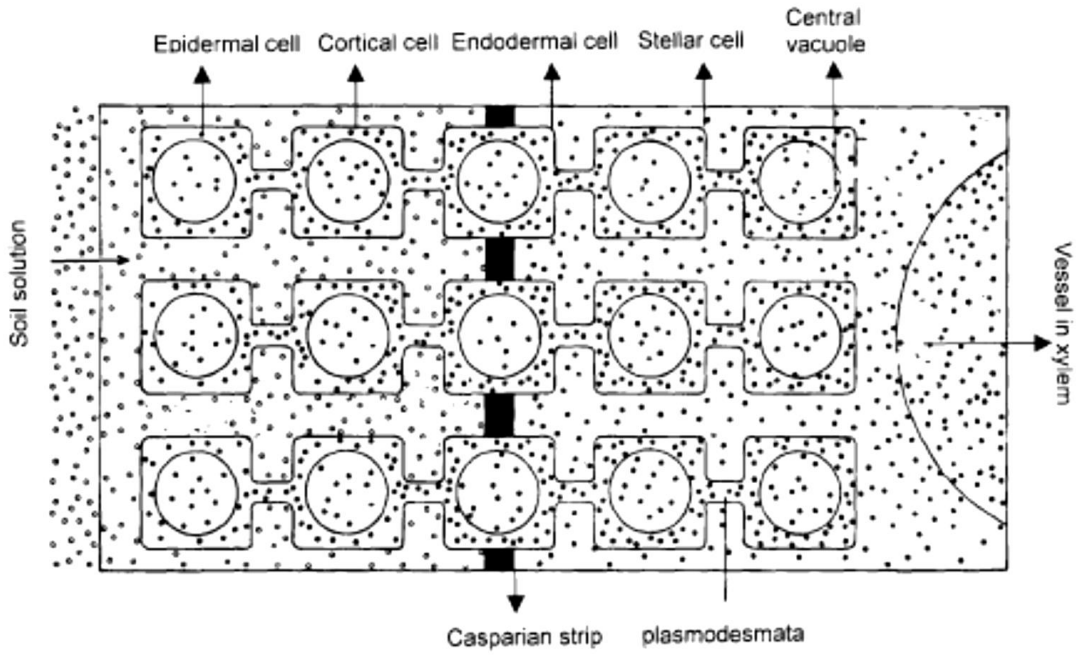


Figure 16: Ion transport model of perchlorate from soil water into the vessels of the root (Yu et al., 2004). The perchlorate enters the root through soil solution, trapped in the pockets between particles of soil. Perchlorate is more likely to exist in solution than in soil, making this pathway particularly important. The exact mechanism of perchlorate uptake is not established, but it is hypothesized that perchlorates are taken up by the root system as an ion in solution, transported up the stem via the xylem and into the leaves and stem (Yu et al., 2004).

Perchlorate contaminated waters are a public health issue because perchlorate attacks the thyroid gland, reducing uptake of iodine (Zewdie et al., 2010). It competes with iodide at the thyroid and can reduce or completely block uptake of iodide into thyroid, and synthesis and secretion of hormones can be impaired due to the blockage of iodide. Perchlorate is very readily absorbed from the gastro-intestinal (GI) tract and distributed systemically with total

body water (Ting et al., 2006). Iodide is a key component of thyroid hormones including thyroxine (T3) and triiodothyrodine (T4), both used to regulate cell replacement, energy production and growth and maturation of body tissues. The half-life of T4 is 5-7 days and the half-life of T3 is about 1 day in adults with no thyroidal issues. This requires a fairly high and regular turnover of thyroidal hormones to keep the hormone supply regular (Irizarry et al., 2010). Role of T3 and T4 in the thyroid is seen in the following diagram, Figure 17.

The simplest mode of action for perchlorate in thyroid involves inhibition of iodide transport into the thyroid by substitution. Substitution is possible due to perchlorate's similar ionic radius and charge. Without competition, perchlorate may then transport into the thyroid follicle and thyroid lumen against a concentration gradient where it again blocks iodide from entering into the thyroid. Here, normal thyroidal hormone production is affected. From the thyroid, perchlorate diffuses back into the bloodstream and is excreted from the body (Clewell et al, 2004).

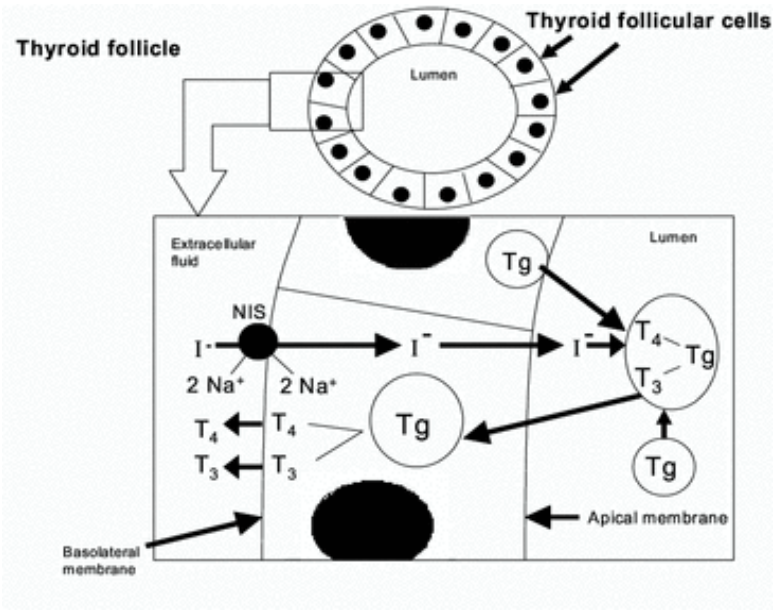


Figure 17: Role of T3 and T4 in the thyroid (NRC, 2005). Thyroid hormones (T4 and T3) are produced by the follicular cells of the thyroid gland and are regulated by TSH made by the thyrotropes of the anterior pituitary gland. The effects of T4 are mediated via T3 (T4 is converted to T3 in target tissues). T3 is 3- to 5- fold more active than T4. T4 is produced by follicular cells of the thyroid gland. It is produced as the precursor thyroglobulin (Tg) which is cleaved by enzymes to produce active T4 (NRC, 2005).

When thyroid hormones in the system are low because of impaired production, the hypothalamus reacts, promoting more hormone production (Zewdie et al., 2010). Prolonged hormone deficiency and hypothalamus stimulation can cause thyroid enlargement. This condition causes a large growth in the neck (known as a goiter), making breathing and swallowing difficult. If left untreated, the patient may not only go through significant pain, but may have to undergo hormone therapy to reverse the problem. If the source of the problem is not removed from the patient's life, the problem will only return regardless of treatment (Ting et al., 2006).

Iodine deficiency disorders (IDDs) were considered a public health concern in the past, but as iodine supplements, such as iodide-supplemented salts, increased in the US, the public health issue dissipated. As environmental perchlorate levels are beginning to rise and affect iodine absorption, IDDs are once again becoming a concern. (Crawford-Brown, 2006)

Although adults are clearly affected by perchlorate, they are not the most sensitive population to be considered. The Ting et al. study (2006) determined that pregnant women and their fetuses are the most sensitive cohort, especially babies in utero and infants. In utero, babies are extremely sensitive because perchlorate exposure limits iodide transport into the womb as well as later on, in breast milk, the only source the infant will have of iodide. Gestation can be a vulnerable period in regards to perchlorate exposure because the mother has increased nutritional demands for iodide. If iodide levels are depressed due to overexposure to perchlorate, thyroid hormones will not be produced at high enough levels. These thyroid hormones are critically important for fetal brain development. Therefore, at low levels, the fetus is at risk.

In utero, the fetal brain undergoes many stages supported by maternal T4 (Clewell et al., 2004). The mother is the only source of thyroid hormone during the first trimester, and the hormone is critically important during the first trimester when the brain first begins to form. If T4 is not supplied in high enough levels, brain development in neonates is significantly retarded, varying within populations due to a number of different factors (Zewdie et al., 2010; Ting et al., 2006). The majority of the supply of T4 comes from the mother's breast milk and therefore, the mothers supply needs to be abundant. The mother's

production of T4 is completely dependent upon her iodide supply in the thyroid. If her production is slowed or halted by perchlorate competition, T4 levels can easily be compromised (Ginsberg et al., 2005).

Perchlorate may also impair iodine excretion into breast milk in humans, suggested by data showing an inverse correlation between perchlorate and iodide concentration in breast milk in a small number of US samples that contained greater than 10 μg/L perchlorate. Iodide limitation in breast milk harms the baby in the way that any thyroid production it may have is not completed because of low iodide levels (Zewdie et al., 2010).

Both iodide levels and T4 levels have been correlated to lower IQ scores later in life. In the same study discussed above, carried out by Zewdie et al. (2010), it was shown that children born to iodine-deficient mothers have IQ levels 5-13 points lower than their iodine-sufficient peers. Iodide deficiency was associated with a four-fold increase in a risk of a low IQ. In an area with known low to moderate iodide uptake in the gestational and infant period, significantly lower IQ levels were recorded (Zewdie et al., 2010).

The main route for perchlorate intake in humans is through drinking water and currently, the United States Environmental Protection Agency (USEPA) recommends a perchlorate drinking water limit of 23.5 μg/mL (Mwegoha et al., 2007), adopted from the National Academy of Sciences (NAS) recommendation. The current EPA limit is not an enforceable limit under the Safe Drinking Water Act and is therefore not required to be reported to communities. The recommended level was determined by a number of studies monitoring hormonal levels and changes through a large population. However, there are

many other methods of determining the safe drinking water level to protect even the most sensitive subpopulation of pregnant women and their fetuses. The USEPA health advisory level prior to the NAS study was 15 μg/mL.

In areas where perchlorate levels in bodies of water are elevated, the soil which is used for agriculture is often polluted as well, requiring cleanup to protect health (Mwehoga et al., 2007). Native species can often be used to remediate perchlorate, such as the *Salix* genus. Phytoremediation has been the most successful method of in-situ bioremediation for perchlorate thus far. *Salix* is planted into the contaminated area and then takes up the perchlorate. Uptake has been seen at greater than 95% in humic soils (Mwegoha et al., 2007).

Animal manure extract can be injected through the soil into the groundwater alongside *Salix* to reach the root location and location of remediation to enhance the conversion of perchlorate to chlorite as much as possible. Dissolved organic carbon (DOC) is often a limiting factor in the breaking down of perchlorate by *Salix* and addition of animal manure speeds the removal rate. Since the DOC is being added by an organic source, it is completely safe to add to areas with groundwater (Mwegoha et al., 2007). After uptake, the plants must be removed and disposed of elsewhere.

Remediation by phytodegration could reduce the amount of perchlorate in the area, and it would not be cost efficient whilst preserving the natural environment. It is a public health concern that perchlorate must be reduced. If perchlorate is not reduced in the environment, adults are at risk for thyroid problems and children are at risk for impeded brain development and future mental issues.

Hexavalent Chromium

	Hexavalent Chromium ($Cr^{+6,}$ as chromate, CrO_4^{2-}) (ChemSpider, 2013)
Solubility	2298 mg/L at 25C (ChemSpider, 2013)
Mobility	Relatively mobile
Behavior in Soils	Weakly sorbed to soils, easily displaced by other ions (Balistrieri and Chao, 1987) Sorption decreases with pH (Bartlett, 1991) Reduces to CrIII in presence of high OM levels (Bloomfield and Pruden, 1980)
Water Quality Limits	0.05 mg/L (EPA, 2012)
Regional Screening Level	550 mg/kg (EPA, 2012)
RFD_0	$3.0x10^{-3}$ mg/kg.day (EPA, 2012)
SFO	$5.0x10^{-1}$ $(mg/kg.day)^{-1}$ (EPA, 2012)
Adsorption Coefficient	52 L/kg, will desorb easily (Stollenwek and Grove, 1985)

Table 4: Hexavalent Chromium Properties

Chromium VI (Cr VI) is a well-documented human carcinogen, first suspected in the 1800s as a group of Scottish pigment workers were found with an abnormally high incidence of lung cancer (Finley et al., 1997). It is commonly seen as a contaminant related to occupational cancer and is also the second most prevalent cause of contact dermatitis in the United States (Kimbrough et al., 1999). Naturally occurring chromates are very rare and found only in highly oxidizing environments; their presence in soils and water is almost

always the result of human activities such as electroplating and other industrial activities (Finley et al., 1997).

Chromium can travel from industrial sites to be deposited elsewhere by either wet deposition or dry deposition, alongside transport by water and dumping in soils. Chromium emitted into the atmosphere can be particle bound or dissolved in droplets, staying airborne for 7-10 days, allowing long distance transport by wind and in dry deposition, these particles settle and are captured by soil or surface waters (Kimbrough et al., 1999). Wet deposition involves the particles becoming entrained within atmospheric moisture like snow and rain, then falling to earth where it settles on soil and surface waters (Kimbrough et al., 1999). After settling down, chromium can also be introduced or reintroduced into the environment via wind resuspention of chromium-contaminated soil particles.

CrVI is seen as a dangerous carcinogen, but its trivalent form, CrIII, is not nearly as toxic for a number of reasons. These are the two stable forms of chromium and are interchangeable under different reducing and oxidizing environments. CrVI usually occurs with oxygen as CrO_4^{2-} or $Cr_2O_7^{2-}$ in the environment. Which oxyanion exists depends strongly on pH and concentration with CrO_4^{2-} predominating (Urbano et al., 2012). CrIII is less mobile and is mainly bound to organic matter in soil and aquatic environments (Shanker et al., 2005). Unike CrVI, CrIII forms positively charged compounds like $[Cr(OH)]^{2+}$which absorb easily to negatively charged layers of clay and organic matter in soil. It is much less

bioavailable than CrVI also due to this sequestration and its lower water solubility (Urbano et al., 2012).

CrVI in soils poses a risk not only of contact dermatitis and inhalation of particles, but also ingestion of CrVI through agricultural crops. As mentioned above, both CrVI and CrIII may be found in agricultural soils, but CrVI is a much more concerning species. CrVI sorption in soil is limited to the number of available positive surface exchange sites. Sites quickly disappear at increasing pH in soils, but at acidic and neutral pH, Fe and Al2O3 sites easily absorb CrVI in either anionic form (Saha et al., 2011). Soil has a limited reducing capacity to change CrVI to CrIII, which will bind to available organic matter. High concentrations of CrVI introduced quickly may exhaust the reducing capacity of that soil and excess CrVI may persist for years. The reducing capacity of soil has been seen to increase with decreasing pH (Kimbrough et al., 1999). A neutral to acidic soil is best for sequestering CrVI, while basic soils generally have more available Cr.

It is unknown whether or not chromium is a necessary compound to plant growth and well-being, however, CrVI uptake in plants is a metabolically meditated process. It is absorbed through the roots via the sulfate pathway, which is ionically similar (Saha et al., 2011). It is then transmitted throughout the plant, concentrating in roots. Small amounts have been seen in above ground portions of plants, with leaves containing more CrVI than grains (Kinbrough et al., 1999). CrVI competes with Ca, K, Mg, P, B and Cu for transport binding and decreases these nutrients in the final plant, as seen in soybean trials. CrIII, on

the other hand, is passively taken up and retained in cation exchange sites. It can enter the plant system if organically complexed at this point and transported in (Shanker et al., 2005).

Both forms of chromium are highly toxic to plants at high levels as well. Toxicity is seen at multiple levels, from reduced yield, through effects on leaf and root growth, to inhibition of enzymatic activities. Chromium toxicity is hypothesized to be due partially due to the competition that blocks out necessary elements from entering the plant at the root. Uptake of chromium is not seen to be particularly high in any plant due to its toxicity (Shanker et al., 2005).

As mentioned above, chromium VI is a known carcinogen. Cancer from chromium shows mainly in the lungs, but it is also a possible oral, intestinal and stomach carcinogen as well (Holmes et al., 2008). The difference in toxicity of CrVI and CrIII has been rationalized due to their geometries. CrVI has a tetrahedral structure that resembles phosphate and sulfate ions. This tetrahedral complex may enter cells via nonspecific anion exchangers that are generally used for uptake of phosphate/sulfate. CrIII is octahedral and cannot enter through nonspecific exchangers in the same manner. They are toxic only by nonspecific mechanisms when administered close to solubility in aqueous solution (Urbano et al., 2012). CrIII may enter cellular membranes, but at a rate exponentially slower than CrVI (Kimbrough et al., 1999).

The mechanism that causes carcinogenicity of chromium is relatively well studied, but not certain, as seen in Figure 18. It is hypothesized that as CrVI centers a cell by

nonspecific anion exchangers, it is reduced quickly to CrIII. Gluthathione reacts with CrVI, leading to the stepwise reduction to CrIII through one electron transfer. During the one electron transfer steps, different free radicals are generated (Saha et al., 2011). These free radicals cause DNA double strand breaks, misrepair of breaks, neoplastic transformation and cancer (Holmes et al., 2008).

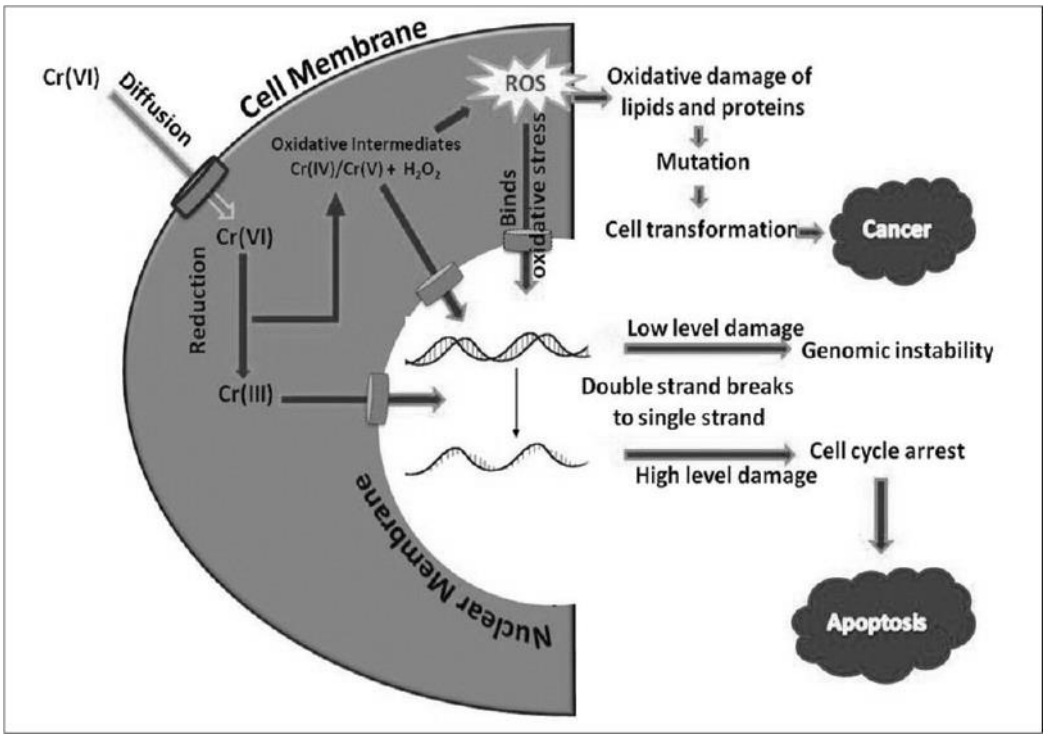


Figure 18: Possible mechanism of hexavalent chromium carcinogenicity (Das and Singh, 2011). Hexavalent chromium is transported into cells via the sulfate transport mechanisms, taking advantage of the similarity of sulfate and chromate's structure and charge. Inside the cell, Cr(VI) is reduced first to pentavalent chromium (Cr(V)), then to trivalent chromium (Cr(III)). The damage and therefore, the cancer, is caused by hydroxyl radicals, produced during reoxidation of pentavalent chromium by hydrogen peroxide molecules present in the cell. (Das and Singh, 2011)

Ingested chromium is reduced most often in the stomach, where the pH is around 1. Reduction happens up until 10 mg/L (Finley et al., 1997). After this point, CrVI continues to

the intestine where it is readily absorbed and then reduced. Heightened levels of stomach and intestinal cancer have been seen in chromium exposed populations, but more research is needed to conclusively determine the carcinogenicity (Kimbrough et al., 1999). Liver and kidney damage from chronic chromium is also commonly seen. Damage is not due to the reduction mechanism, but simply due to the fact that these are the excreters of chromium in the human body (Kimbrough et al., 1999). Recent research has also shown that oral and intestinal cancers are seen in populations exposed to CrVI, and that ingestion may pose a more serious risk than previously thought (Holmes et al., 2008). Additionally, in recent research, an increase in mental, psychoneurotic and personality disorders among all race groups has been seen related to chromium exposure in rodents. This raises the possibility that CrVI is also neurotoxic (Urbano et al., 2012).

The US EPA's maximum contaminant level for chromium VI is 0.05 mg/L and 2 mg/L for chromium III. At these "safe" doses under environmental conditions such as ingestion by tapwater, measureable increases in excreted chromium are seen as opposed to controls (Finley et al., 1997). These levels do not take into account women, children, or people who may be exposed to chromium through sources other than tapwater.

Phytoremediation has been relatively unsuccessful in cases of chromium due to the toxicity is has on plants. Translocation from roots to shoots is also extremely slow, or nonexistent, in some species, limiting how much chromium could be taken into a plant. In species where leaves or branches with concentrated contaminant may be cut off, the

remediation capacity is much higher (Shanker et al., 2005). Most successfully seen is a remediation technique capitalizing on oxidized manganese-rich soils. Addition of organic matter to these Mn-rich soils results in unstable Mn III compounds that temporarily prevent Cr III oxidation to Cr VI and promote reduction of CrVI to CrIII (Kimbrough et al., 1999).

Chapter 5: Experimental Determination of Contaminant Levels in a Food Producing Community Garden

This chapter aims to explain the details and results of soil analyses I conducted and the procedures I used to test the soil of the North Railroad Avenue Community Garden in Espanola, NM for: arsenic, perchlorate, RDX, and hexavalent chromium. I was most interested in these chemicals, which not only seriously threaten public health, but have been detected as being released by industrial or military activity in Northern New Mexico.

The soil was collected from the community garden in Espanola, NM on North Railroad Avenue with the permission of garden leaders. I then tested these soils at Hampshire College in Amherst, Massachusetts. The goals of the soil testing were as follows:

1. To determine presence and levels of contaminants in the soil in the gardens
2. To determine the health risk of contaminant constituents in the gardens
3. To determine methods of reducing contaminant risk that take into account specific soil conditions

From the garden, soil samples were collected on a grid system aligned to both edges of the field to assess places where levels of contaminants were highest and lowest. They were then assessed for measures of soil quality including pH, conductivity and redox potential, which all indicate availability, interaction and fate of contaminants in the soil and soil solution. Colorimetric methods were utilized in order to test for arsenic, perchlorate, RDX, and hexavalent chromium due to restrictions on laboratory equipment. An in-depth literature

study was taken on in order to find the most reliable and well-tested colorimetric methods which could be completed using the materials available.

5.1 Experimental Results and Discussion

All experiments were performed in the laboratories at Hampshire College in the 2012-2013 academic year by Morgan Drewniany, with the assistance and guidance of Rayane Moreira, Assistant Professor of Organic Chemistry, Sarah Steely, Laboratory Technician, and the staff of the Natural Science department. Throughout this section, samples will be referred to by their position in the garden, (column#, row#). A table of all results with average, standard deviation, minimum and maximum values may be seen in Table 5. All experimental methods with details are available following this results section for the interested scientist, but are not necessary to understand the results and meaning of the results.

The levels of RDX do not have a label due to the inability to test quantitatively. RDX is not commercially available as a standard solution, and therefore, a standard curve to match up against the measured amounts was not obtainable. The amounts given in the table are relative levels seen in the field. One sample, which is seen as “4”, was the absolute highest recorded due to instrumental limits. The samples which did not test positive in the first spot test read as “0”. This gave information on where RDX was spatially located in relative amounts. A regression to get exact values for remaining samples was not completed due to lack of information on the correlation.

	ORP (mV)	pH	Conductivity (uS/cm)	RDX (qualitative – to scale)	Arsenic (ppm)	Perchlorate (ppm)	Cr(VI) (ppm)
Average	203.4	6.086	101.3		0.0277	6.961	0.219
Standard Dev	0.0273	0.2164	29.20	0.7797	0.010	3.124	0.0117
Max	209.2	6.5	158.7	"4" (see justification)	0.05	15.28	0.2418
Min	199.4	5.44	41.1	0	0.005	1.571	0.199
MCL (ppm)				105	0.01	0.02	0.05
RSL (mg/kg soil)				5.6	0.39	550	0.29
RFD_0 (mg/kg.day)				0.003	0.0003	0.0007	0.003
SFO $(mg/kg.day)^{-1}$				0.11	1.5	None	0.5

Table 5: Average, standard deviation, maximum and minimum values for all contaminants tested. The measurements of RDX are not quantitative like the rest, but qualitative and therefore there is no measurable average value. Average measured values, water quality limits and toxicity threshold limits for all measured contaminants are also listed. All information from EPA, 2012.

For the garden, average contaminant concentrations are compared to relevant "health protecting" standards set by the EPA. These are guidelines used across the United States and should cover the contamination in the Railroad Avenue garden, especially since it is used for crops which are eaten and pregnant women and their children are exposed to these soils. Water quality limits (MCL) are given with the assumption that soil leaches to groundwater, and levels appearing in soil solution will exist in groundwater. Regional screening levels (RSL) are soil cleanup benchmarks used in EPA Superfund sites, all given at the 'residential' level, which aim to protect citizens using soil for average residential purposes such as gardening and outdoor play. The reference dose (RFD_0) is "an estimate… of a daily oral exposure (including sensitive subgroups) that is likely to be without an appreciable risk of

deleterious effects during a lifetime" (EPA, 2012). This is the most general health-protecting standard the EPA puts out and is assumed to be the dose below which no adverse carcinogenic health effects should occur. A high reference dose indicates a contaminant which is of less concern. Oral slope factors (SFO) define the cancer risk due to ingestion, and are given due to the nature of contaminants in soil. An SFO of 1.5, such is for arsenic, represents 1.5 "extra" cases of cancer per person ingesting 1 mg of a chemical per kilogram of body mass per day. Both the MCL and the RSL take RFD_0 and SFO into account in their assessments of risk. All averages given are in the form of parts per million (ppm), which also may be interpreted as milligrams contaminant per kilogram of soil.

It may be easily seen that all four contaminants exceed the water quality limits defined by the EPA. Hexavalent chromium closely approaches the RSL limit, indicating that there is an immediate health risk resulting from the presence of these contaminants. This trend may be seen in Figures 19-22 below.

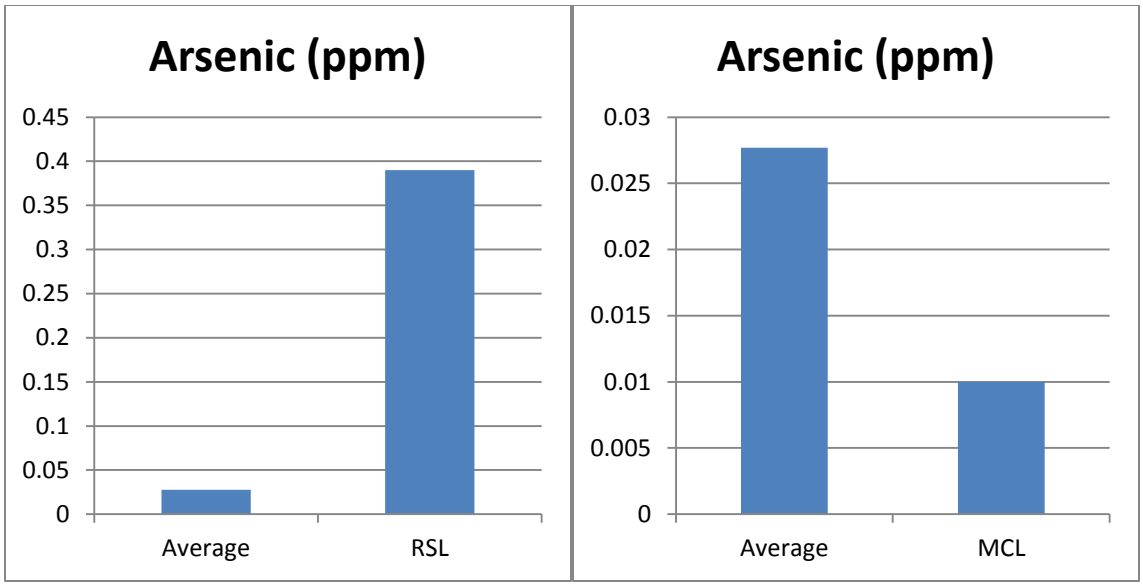


Figure 19: Arsenic Average found versus EPA RSL, MCL

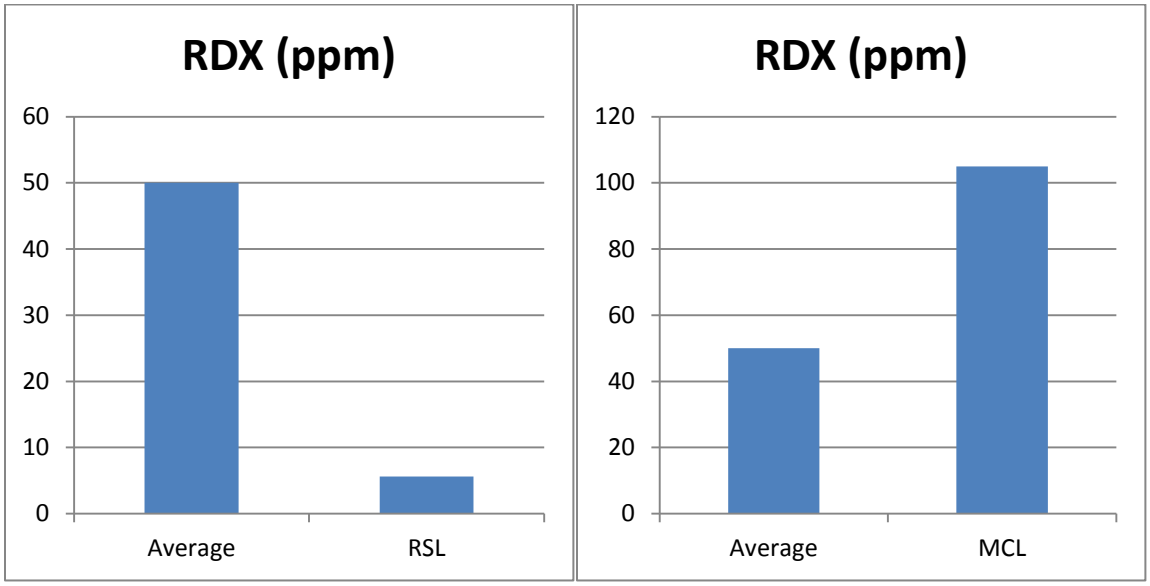


Figure 20: RDX average found versus EPA RSL, MCL

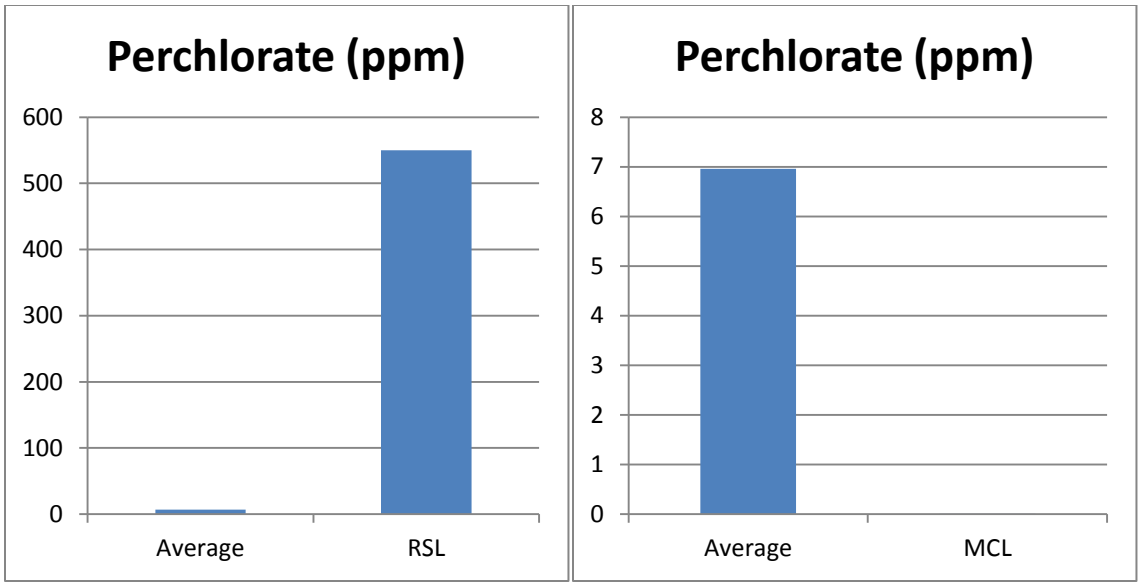


Figure 21: Perchlorate average found versus EPA RSL, MCL

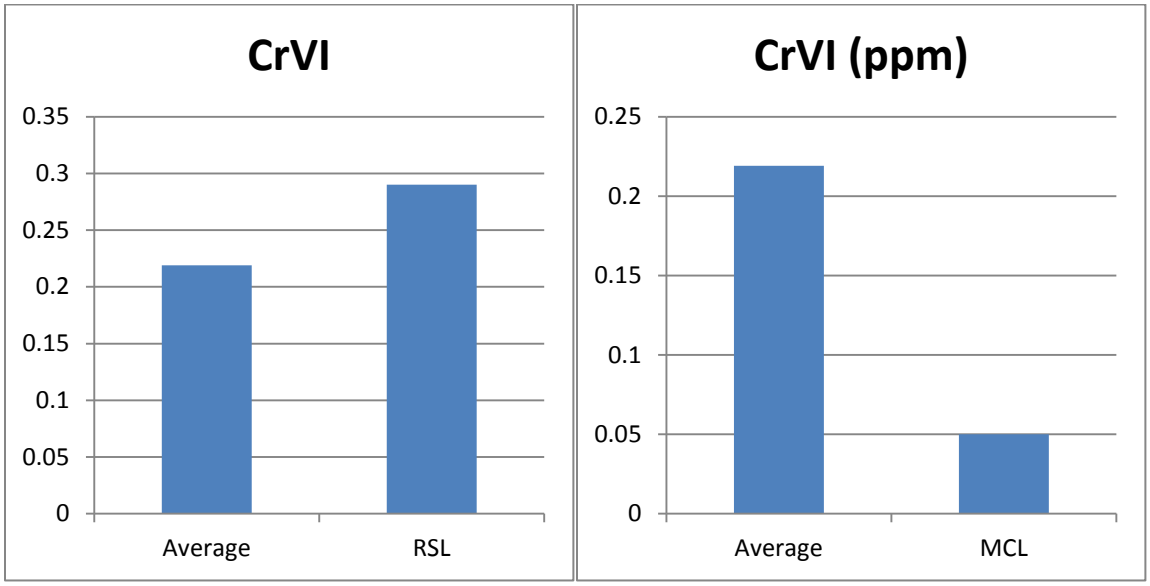


Figure 22: CrVI average found versus EPA RSL, MCL

Soil Electrochemical Properties

The soil pH, conductivity and redox potential were all measured using a water quality meter. These are important measures of the availability, interaction, and fate of elements in the soil and soil solution. pH determines both plant growth and mobility of contaminants,

conductivity determines the flow of electrons in a solution and therefore the amount of ion activity, and redox potential which determines mobility of contaminants.

In these samples, it can be seen that pH and ORP have low standard deviations, indicating a relatively stable average throughout the field. Conductivity, on the other hand, varies drastically, with the highest levels laying along row 1 and decreasing in columns 4 and 5, where water is least likely to pool.

The average pH levels ranged from 5.44 to 6.5, with an average of 6.09. This is in the range of 5.5-7.5, the range which indicates dominance and presence of hydroxyl-aluminum ions, which buffer soil acidity (Thomas, 1996). At this pH range macronutrients in the soil like metals are at their highest availability. Also within this pH range, toxic trace ions with a positive charge, such as arsenite (3+) and arsenate (5+) are least mobile and therefore, less available to plants. Because of this, human exposure through eating produce from the gardens is less likely, but exposure through dust and ion transport into water is still likely.

The redox potential (ORP) in the garden ranged from 199.4 mV to 209.2 mV, with an average of 203.4 mV. At these levels, with an average pH around 6, arsenite, AsO_4^{3-}, with As^{3+}, is more soluble and mobile in soils than arsenate, As^{5+}. Overall, the samples were slightly reduced (ORP=~200 mV) and slightly acidic (pH=~6), which are favorable soil conditions for low trace metal solubility, and therefore contaminants will bind well to the soil.

Contaminants: RDX, Perchlorate, Hexavalent Chromium and Arsenic

Garden soil contaminant concentrations were determined for arsenic, RDX, hexavalent chromium and perchlorate. There was no acceptable control sample readily available in Northern New Mexico, and therefore, the levels of contaminants found were compared to EPA recommended limits due to the high exposure the garden causes to local communities.

The levels of RDX, perchlorate, hexavalent chromium and arsenic found were elevated to possible risk levels. Arsenic levels in the Southwest, and in New Mexico specifically, are naturally elevated due to the soil types and in this specific instance, a nearby caldera, as discussed in chapter 3. This distribution may be seen in the USGS soil arsenic map below (Figure 23). It is difficult to tell how much arsenic is coming from man-made sources as opposed to naturally high levels. Despite this, the total level of arsenic must be considered in order to protect health. RDX and perchlorate are both man-made explosive chemicals, and therefore, they have no naturally occurring levels and are not assumed to be present except in the case of external input. The amounts found are all assumed to be enhanced by surrounding human activities.

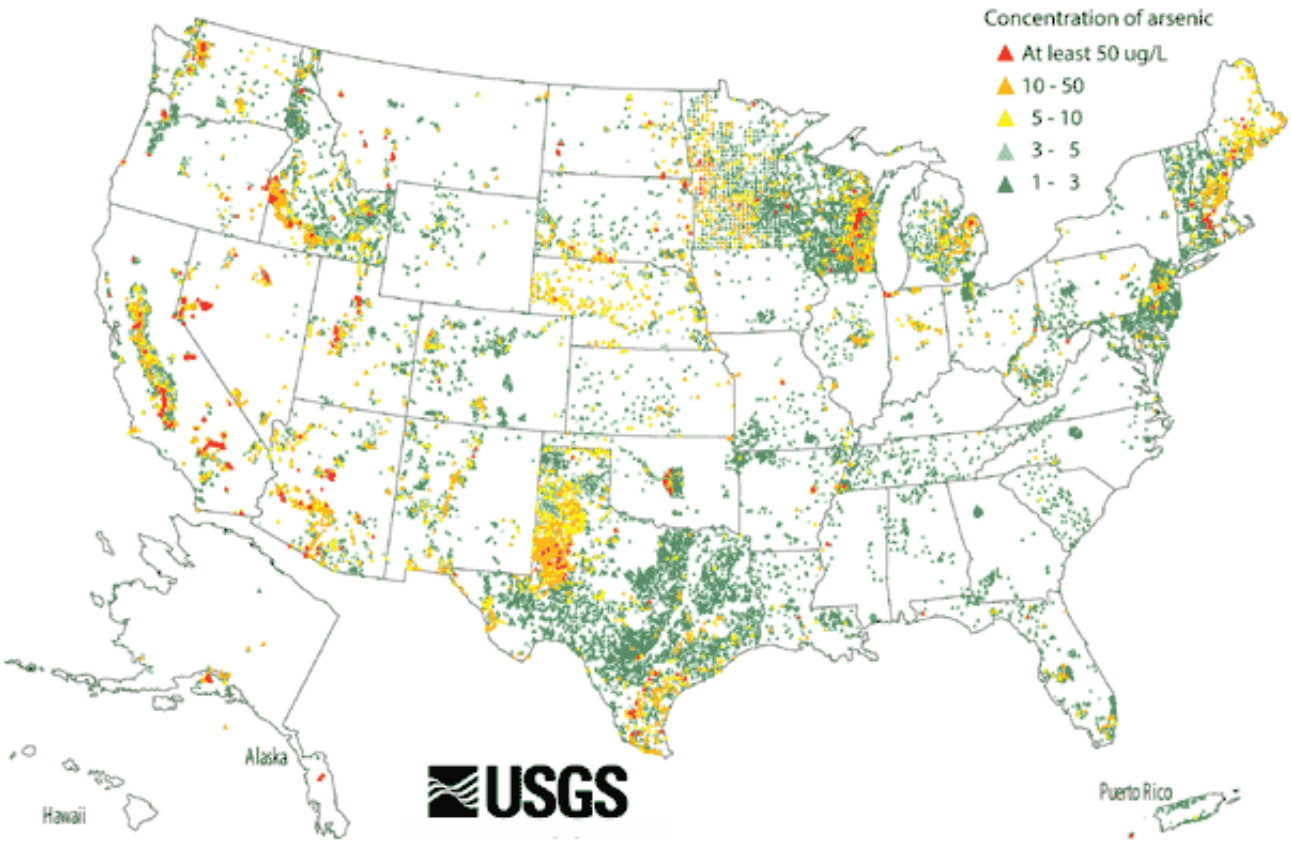


Figure 23: Map of the US by arsenic distribution in soil. Northern New Mexico can be seen on this map to have high points near the Pajarito Plateau, spiking at "at least 50 ug/L." This is listed as the US Drinking Water upper limit. (USGS, 2012)

The distribution of RDX, perchlorate, hexavalent chromium and arsenic were analyzed by placing the rows and columns on a 3D scale (Figures 24-27). This aids in visualizing where the highest concentrations of each contaminant lies.

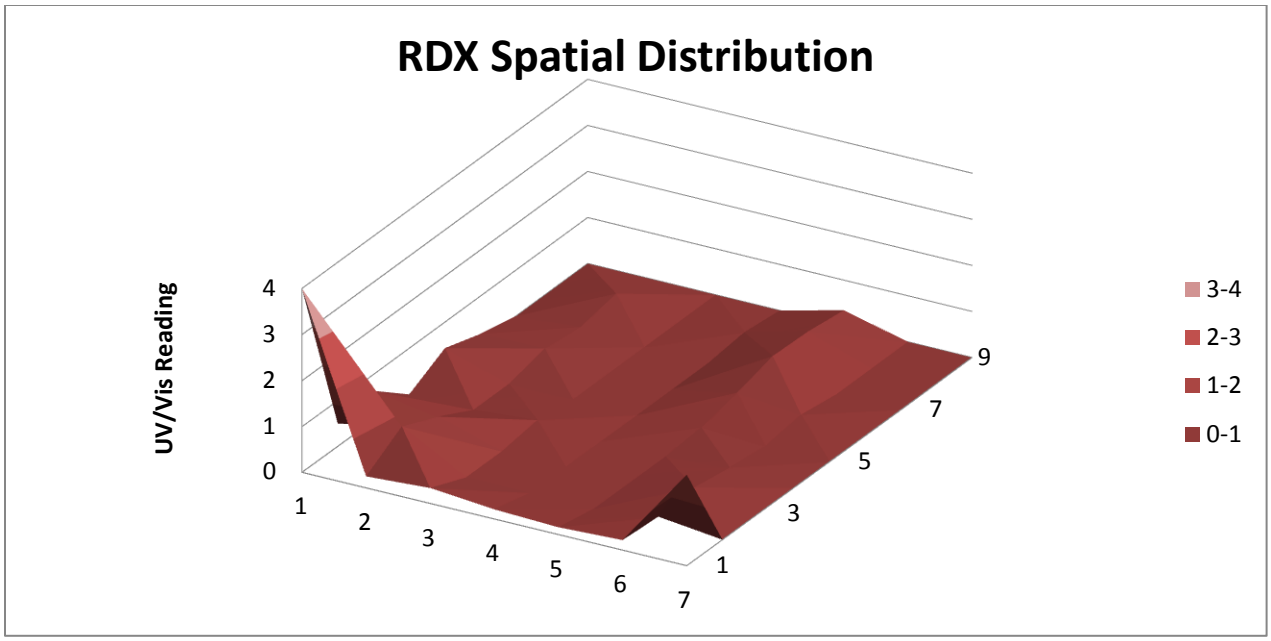


Figure 24: Distribution of RDX within the North Railroad Avenue garden. The high point, listed as "4" is estimated to be 50 ppm and "0" values are 0 ppm.

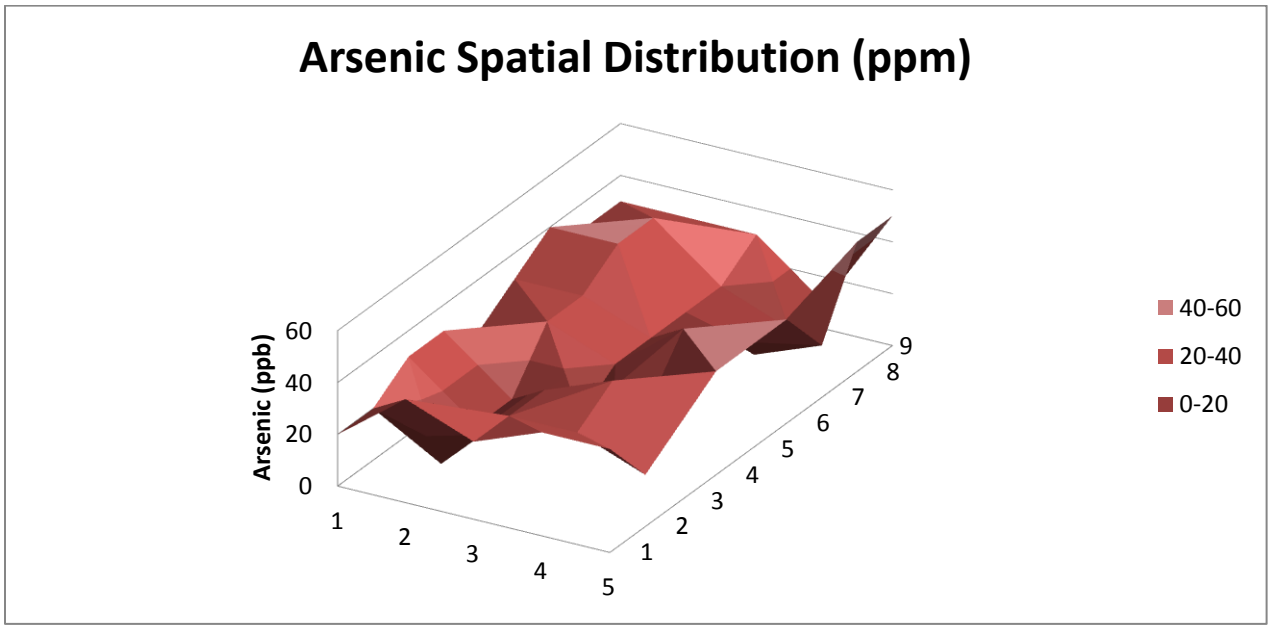


Figure 25: Distribution of Arsenic within the North Railroad Avenue garden.

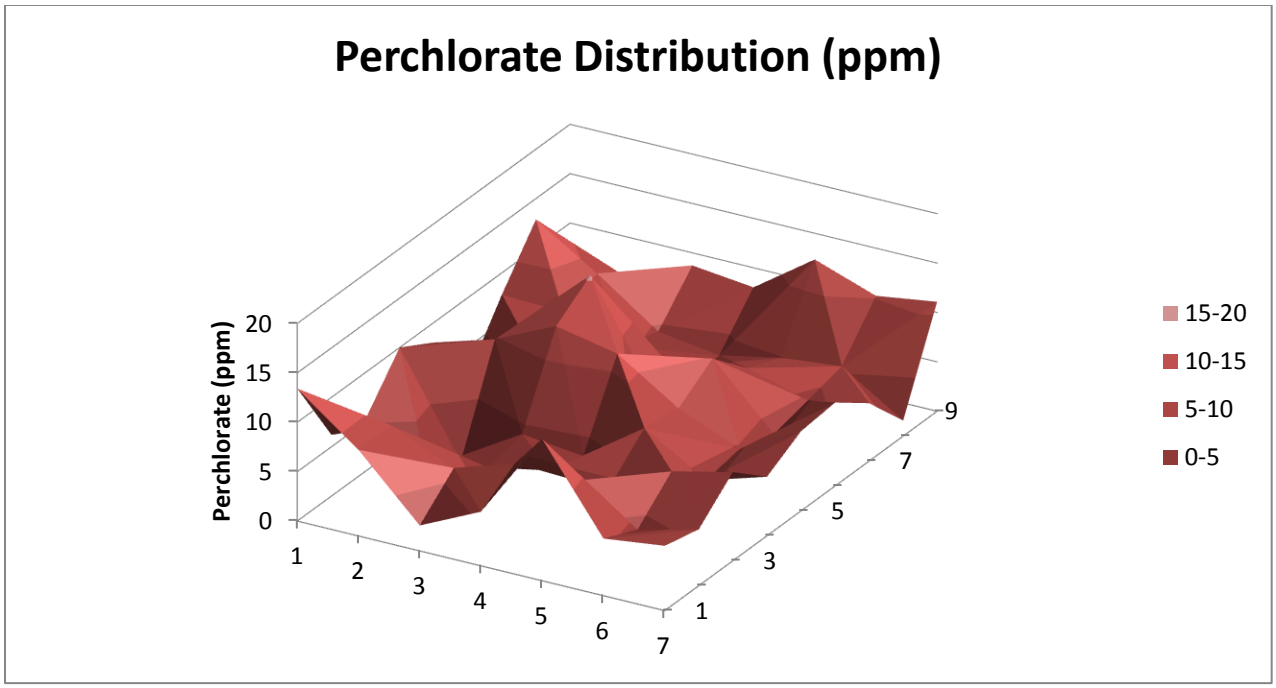


Figure 26: Distribution of Perchlorate within the North Railroad Avenue garden.

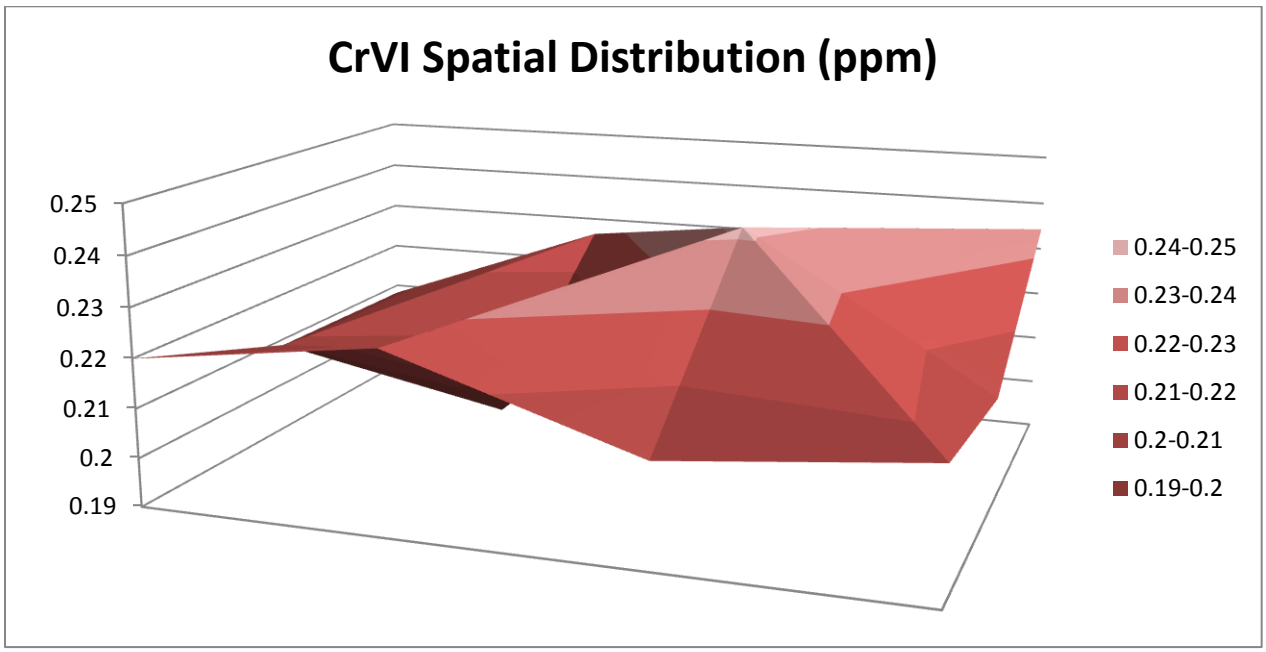


Figure 27: Distribution of CrVI within the North Railroad Avenue garden.

It can be seen that the distribution of RDX is very clear, with highest levels pooling at the inflow of water and the end of the irrigation ditch, where water often sits for extended periods of time. Its solubility of $1x10^{-6}$ mg/L (ChemSpider, 2013) explains this behavior, as does its' tendency to adsorb to clays (Townsend et al., 1996). With this combination of RDX behaviors, the contaminant, which travels easily with water, will accumulate in places where water pools, then attach to the clays in these areas. It is likely that the highest levels of RDX seen in the soil proves the presence of RDX in the waterways, and is approaching the groundwater if it is not yet there.

The distribution of arsenic is varied throughout the field, most likely due to natural variation. Soil was crushed and then analyzed, but the variation seen is most likely due to small "clobs" of soil with varying levels of arsenic. Arsenic is naturally high in this area due to a neighboring caldera, so this variation is not unexpected. The arsenic that is in this soil is not likely to leach significantly to groundwater, but due to the overall high levels found, it is possible for it to accumulate in groundwater in appreciable amounts.

Perchlorate levels also pool at the inflow of water and the end of the irrigation ditch, as well as the end of the columns where water also pools at the end of watering days. This shows that much like RDX, it is concentrating where water most often sits. Perchlorate is also mobile, with a solubility of 150 mg/L (ChemSpider, 2013), and sorbs around 10% to clay layers (Brown and Urbansky, 2010). This explains the relative high spots at the ends of the rows and columns, as well as the high spots in the middle of the field. The ends of the rows

and columns are likely due to the mechanism that RDX utilizes, in which the contaminant builds up with pooling of water. The spots in the middle which contain high levels of perchlorate are most likely due to points with more organic matter which attracts perchlorate much like a magnet. Much like RDX, perchlorate is also likely present in high levels in waterways and approaching the water table. Looking at the figure that 10% of perchlorate in the groundwater sorbs to clay, we may assume that the levels of perchlorate in local waterways is approximately 90% higher than the elevated levels already found in the soil. This is alarming because the soil levels of perchlorate already exceed water quality limits.

The distribution of CrVI found in the soil is not very clear. There is a high point of 0.241ppm, but this is not a drastic difference when compared to the minimum value found of 0.199 ppm. It appears as though the distribution throughout the field is consistent when looking at the average, maximum, and minimum values found. It is likely that the source of hexavalent chromium is through the waterway, but this cannot be confirmed with the data available.

The quantities of each contaminant were also plotted against pH to investigate any relationship which could be solved by adjusting the pH of the soil. There was no correlation found.

Uptake by Plants and Total Exposures

The plant uptake mechanisms for perchlorate and RDX are not well-understood enough to extrapolate the amounts of which each contaminant may be contributing to the diet of the community through the garden. It is known that the uptake mechanisms are highly variable from plant-to-plant (Best et al., 1999; Yu et al., 2004). It is known, however, that plants take up a very significant amount of RDX at a rapid pace, and do not degrade RDX at all (Chen et al., 2011). This creates an environment in which plants accumulate RDX, and from these plants, the RDX is taken up by the plants and eaten by the community, or recycled back into the soil as the plants compost in the fall (Chen et al., 2011). It may easily be assumed that a significant amount of RDX is being ingested through fruit and vegetables from the garden alongside inhalation of soil particulate and the groundwater, which invariably contains some RDX, as is seen in the soil. As stated before, perchlorate uptake by plants is a gap in the field and requires further research, but at the levels found in the soil, is likely a risk through the aforementioned pathways.

The uptake of arsenic by plants is limited to the type of arsenic available in the soil (Martinez-Sanchez et al., 2011), which was not measured in this study. It is known that in both forms, it readily translocates to the fruit of the plant, which is the portion that is eaten. In this specific garden, it may be assumed that a large amount of the average 0.0277 ppm measured is taken up by the plants, especially if the arsenic is coming in through the water and they are bathed with it twice a week. Again, along with the inhalation of soil particles

and intake of arsenic through high measured drinking water levels, this poses a large health risk.

Plant uptake of CrVI is through established sulfate pathways. These are pathways the plant uses to take up a nutrient it needs, and arsenic "tricks" the plant to be absorbed through this route. CrVI has been found to be extremely toxic to plants at low levels. Roots-shoots mechanisms are slow to nonexistent due to the extreme toxicity of the contaminant (Kimbrough et al., 1999). It is likely that before the plant becomes a very serious threat to health, that plants suffer reduced yield and slowed leaf and root growth (Shanker et al., 2005).

Experimental Methods

This section aims to inform the interested scientist of my methodology in soil testing through colorimetric means. It is not necessary to understand the larger piece, and stands simply as a testament to the work I completed in the lab.

Soil Sample Collection

Soil samples were collected at the North Railroad Avenue community garden following all protocol laid out in the US Environmental Protection Agency's (US EPA) surface soil guidelines (US EPA, 2000). The number of samples that were taken followed the guidelines set forth in the Environmental Monitoring and Support Laboratory's "Preparation

of Soil Sampling Protocols: Techniques and Strategies" (Mason, 1983). Samples were taken at regular intervals on a grid system aligned to the edges of the garden to avoid bias in collection. These procedures for sampling the lots take into account the variation in the material itself by sampling the entire site (Van Ee, 1990). In this experiment, soil was be taken from horizon A, the surface soil, avoiding soil that is in immediate contact with the air and sunlight. Tools were rinsed in the field but complete decontamination of tools was not a concern due to the nature of the contaminants being investigated. The grid system set up included taking a sample in each 10 m^2 at both sites. This layout is shown in Figure 33. A marked tape measure was used to lay out the exact grid system.

Figure 33: The North Railroad Avenue Garden. This middle section of the field (480 ft^2) was the plot gardened by Tewa Women United in the summer of 2013.

1 cell in grid = 10 ft x 10 ft, 1 sample taken in each cell = 48 samples total

At each square, the top layer of soil and debris was first removed to 1/2" with a spade rinsed with DI water. Using a pre-cleaned scoop, a generous amount of soil was placed into one pre-labelled zip lock bag. The container was closed tightly and placed aside. This routine was repeated until all samples were collected. All labeled samples were then transported to a cool, dry, dark place to rest until procedures were completed.

Soil Electrochemical Properties

To prepare for pH, ORP and conductivity testing, samples were first removed from storage. 2.000 g of crushed soil chosen randomly from the bag, to avoid bias, was measured out on an accurate scale. Exact weight was noted in a logbook. The 2.000 g sample was transferred to a 20 mL plastic test tube, then 10 mL of distilled deionized water was added, a cap was screwed on, and the sample was vortexed to mix thoroughly. The sample was allowed ample time for settling. After settling, the clear liquid was poured off of the samples into new, labeled 20 mL plastic tubes. This procedure was completed for each sample for these three tests.

pH, DO and ORP testing was completed with a water quality meter. The water quality meter was turned on and warmed up for approximately 30 minutes. Using prepared 4, 7 and 10 pH standards, the meter was calibrated under the pH setting. One sample at a time, pH was measured and recorded, rinsing with DI water between samples until all samples were complete. Next, the meter was set to the DO setting. One sample at a time, DO

was measured and recorded, rinsing with DI water between samples until all samples were complete. Finally, the meter was set to the conductivity setting. One sample at a time, conductivity was measured and recorded, rinsing with DI water between samples until all samples were complete. All tests were done in the same day to avoid bias and variation between samples.

Arsenic Testing

To test for arsenic, all samples were measured to 2.000 g with an accurate scale, placed into a 50 mL plastic tube and vortexed with 20 mL DI water. The samples were allowed ample time to settle. All tests were carried out following explicit instructions from the Hach Arsenic Low-Range Test kit. Two samples were analyzed at a time and recorded in a logbook. Between tests, the test vessels were cleaned vigorously to avoid contamination. Samples were randomly re-tested to ensure accurate readings.

RDX Testing

To test for RDX levels, a quantitative test was first completed, followed by a qualitative test for samples which showed positive results for RDX. All tests were completed according to the procedures laid out in Haas et al (1990) "Conception for the Investigation of Contaminated Munition Plants." An oxidation/reduction step is utilized through use of diphenylamine, which produces dark blue N,N'diphenylene-diphenoquinone-diimene in the presence of nitramenes such as RDX (Haas et al., 1990).

For the rapid quantitative test, a few milligrams of dry, crushed soil were placed in a clean, labeled test tube. A drop of prepared 1% diphenylamine in 88% sulfuric acid was added. In the presence of RDX, the sample will turn dark blue. In the absence, the sample will turn black. This was repeated for each sample and results were recorded.

All positive samples were then prepared for qualitative assessment of RDX. 2.5000 g of soil were measured into a clean, labeled test tube. 6.25 mL of concentrated acetone was added, and the sample was vortexed. After ample time for settling, the sample was filtered through filter paper into a flask, fed only by gravity, leaving soil behind. The filter and soil were disposed of. 2.5 mL of the filtered acetone solution were pipetted into a new, labeled test tube. The filter, flask and pipette were then rinsed. This procedure was repeated for all positive samples. After all samples were filtered and in new test tubes, all tubes were uncapped and left in the hood overnight to allow drying, until all acetone was evaporated. In the morning, the residue in each tube was dissolved in 2 mL of the 1% diphenylamine in 88% sulfuric acid solution. The reaction was allowed to proceed for 5 minutes, then the sample was measured with a spectrometer in a 5 mm quartz cuvette at 596 nm. All samples were measured and the results were recorded.

Perchlorate Testing

To test for levels of perchlorate, samples were first measured to 2.000 g with an accurate scale, placed in a 50 mL plastic tube and vortexed with 20 mL DI water. The samples

were allowed ample time to settle. The clear solution was poured off into new, labeled, 20 mL plastic tubes. All tests were carried out according to the procedures laid out in The US Army Corps of Engineers "Field Screening Method for Perchlorate in Water and Soil." This method separates the chlorate from perchlorate in soil solution through use of a solid phase extraction manifold conditioned with a perchlorate-specific ion-pair reagent. An ion pairing dye is then added. The dye pair is extracted with xylene and then the positive pink xylene layer is measured by spectrophotometry (Thorne, 2004).

A solution of 2.5 mM DTAB in 15% acetone was prepared by placing 0.3854 g DTAB into 75 mL acetone and 425 mL DI in a 500 mL Erlenmeyer flask. A solution of 25 mM DTAB was prepared by placing 3.854 g DTAB into 500 mL DI in a 500 mL Erlenmeyer flask. 1500 mg/L BG stock in 95% acetone/water was prepared by placing 15 mg BG into 9.5 mL acetone/0.5 mL water in a 25 mL Erlenmeyer. Calibration curve standards for perchlorate were created using a 1000 ug/mL perchlorate stock. A blank, 1 ug/mL, 2 ug/mL, 5 ug/mL, 10 ug/mL and 20 ug/mL were all created in clean test tubes with DI from the 1000 ug/mL stock. All solutions were refrigerated until use.

3 mL Phenomenex STRATA X styrene/divenylbenzene (SDVB) solid phase extraction (SPE) cartridges were set up on a manifold and conditioned with 1 mL of the 25 mM DTAB solution into a waste container. The waste container was replaced with a clean test tube. 4 mL of prepared soil solution sample was fed into the conditioned SPE cartridge, which was then rinsed with 2 mL 2.5 mM DTAB solution into the clean test tube to elute any retained

chlorate ions. The SPE cartridge was then rinsed with 1 mL acetone to pick up any residue into the clean test tube. A separate new test tube was prepared with 2 drops of BG solution. 1 mL of water was added to the BG solution to reconstitute the BG. 2 mL of the sample fed through the SPE cartridge was added. 1 mL of xylenes was added to the BG/sample solution and shaken vigorously to mix. Five drops of acetone was added to clear cloudiness. 1 mL of the sample from the xylene layer was absorbed at 640 nm in a spectrophotometer using a 5 mm quartz cuvette. This procedure was repeated for all samples into clean, labeled test tubes and all amounts were recorded.

Hexavalent Chromium Testing

To test for levels of hexavalent chromium in the soil, the US Air Force IERA Hexavalent Chromium (CrVI) Field Analytical Method for Bioenvironmental Engineers (1999) was followed. This method takes advantage of a strong anion solid extraction (SPE) apparatus to first separate CrIII from CrVI. The SPE traps the CrVI which CrIII is eluted and removed. A strong buffer solution of ammonium hydroxide and ammonium sulfate is used to elute CrVI. Before spectrophotometric analysis at 540 nm, HCl and diphenylcarbazide solution were added and complexed with CrVI to produce a measurable pink color (US IERA, 1999).

Soil samples were prepared by measuring 2.000 g soil from each of 12 “blocks” consisting of 4 single points in the field, to reduce number of samples. These samples were

placed in clean, labeled test tubes and vortexed with 20 mL DI water. Solutions to be used in the experiment were then prepared. First, a strong buffer solution of 0.5M ammonium sulfate/0.1M ammonium hydroxide was mixed. A complexation reaction solution of diphenylcarbazide (DPC) was mixed in amber glass and dissolved in acetonitrile. CrVI stock was mixed to create calibration solutions at 0, 0.1, 1.0, 2.0, and 3.0 ppm, all with HCl, strong buffer, and DPC solution to imitate the conditions samples would be measured under.

Phenomenex X-A anion SPE tubes were set up on a manifold and 3 mL of samples were fed through to elute CrIII, into a waste container. Each tube was then rinsed with DI water to elute any residual CrIII. 3 mL of strong buffer was fed through each tube three times into clean, labeled test tubes to then elute CrVI. Before measurement, 0.1 mL HCl and 2 mL DPC solution were added to each labeled tube and allowed to react for 10 minutes to produce the quantifiable pink color. After creating a calibration curve with the calibration solutions, all the samples were absorbed at 540 nm in a spectrophotometer in a 5mm quartz cuvette. This was repeated until all samples were measured and recorded.

Conclusions

The Rio Arriba Valley and the Pueblos it contains are communities I care deeply about. From my first day driving through the dry, red land between Santa Fe and Los Alamos, to the day I left with tears in my eyes and turquoise around my neck, I felt connected to the land and people who welcomed me as family. I collected my soil samples for analysis in a sundress, wide-brimmed hat, and bare feet, feeling the clay between my toes, and ate vegetables from the community garden all summer long. The implications of this work are personal, and I intend to make them accessible and give not simply information, but hope for remediation, back to the community.

The average levels of RDX, perchlorate, arsenic, and hexavalent chromium found in the soils of the Railroad Avenue Community Garden in Espanola, NM, were all found to be significantly higher than institutionally-set public health standards. The locations of the contaminants indicate that perchlorate and RDX are travelling into the garden through the water and concentrating in areas where irrigation water pools. These levels are assumed to be anthropogenically enhanced due to their status as a man-made contaminant, and are likely sourced from explosives at Los Alamos National Labs. The presence of arsenic may be due to either natural or man-made sources, but are regardless at a high enough level to warrant concern for public health. CrVI is nearly always anthropogenically enhanced in the environment, where found. At the levels which have been found, it is certainly threatening

to health. When considering exposure to these contaminants through regular soil exposure pathways (inhalation, direct ingestion) as well as intake through food grown in the gardens, the levels ingested may be very significant and a risk to the community.

Outcomes of Soil Testing

Arsenic

Health risks posed by arsenic at the levels found include arsenicosis, which commonly leads to skin cancer, as well as cancers of the liver, lung, bladder, and kidney (Chen et al., 1992). In women, chronic exposure to arsenic, as is most likely occurring in the Rio Arriba Valley community, leads to adverse obstetrical outcomes including stillbirths and miscarriages (Ahmad et al., 2001). Arsenic also readily transfers across the placenta, putting unborn children at risk if mothers are exposed to high levels (Sengupta et al., 2008). These effects have already been seen in the Southwest, which is known to be an area with high natural arsenic levels in groundwater (Tollestrup et al., 2005), but Northern New Mexico has not been a center of focus. The levels found are certainly concerning, and are causing a direct risk to the community eating from and working in the area.

As mentioned above, it is difficult to differentiate if the high arsenic levels in the soil are natural or anthropogenically enhanced. It is most likely that the arsenic levels in the soil of the garden are elevated due to the close-by caldera. Though these levels are extremely elevated as compared to the average soil in the United States, they are not unusually elevated

as compared to other soils in the Southwest (Tollestrup et al., 2005). It is possible that some anthropogenic sources of arsenic are located upstream in the old mines or abandoned industrial sites, but the proximity of the caldera is the largest source.

Since the arsenic found is a natural non-point source, cleanup or containment will be extremely difficult, or close to impossible. There are several options for bioremediation with plants that are well studied and proven to work (see: Fayiga et al., 2007; Nagajyoti et al., 2010), but if the soil continues to be exposed to the arsenic through water, it will continue to be contaminated. The most effective cleanup method would require ongoing work. In a study completed by Fayiga (2007) brake ferns were planted across a field contaminated with arsenic and took up a significant amount of the contaminant. Brake ferns are a small species which grow quickly and could easily be integrated into the community garden, between rows or even between plants. However, commitment to cleanup would be necessary, because if plants were left to take up arsenic, then composted back into the field, it would simply concentrate into the topsoil and create a more threatening environment because the fern does not degrade arsenic into a less threatening chemical species.

RDX

Risks posed by the presence of RDX are far less studied than arsenic, but some information is known due to military studies. RDX is a man-made chemical used widely in munitions, and pre-World War II, was used abundantly in open-air testing of explosives

(Hundal et al., 1997). Looking at the surrounding area, it is clear that Los Alamos National Laboratory, where many munitions were produced before World War II and open air testing was common practice, is most likely the source of RDX. It is not a chemical commonly used in other industry.

Chronic exposure to RDX has been seen to cause neurotoxicity, CNS disorders, hepatotoxicity, and brain and liver cancers (Etnier, 1989). It is officially classified as a "possible human carcinogen" by the EPA. No studies have been specifically completed on mothers and children, however, in rat studies, RDX has been seen to pass easily through the placenta and into breast milk. No direct birth defects were seen in these studies, but smaller babies were recorded (ASTDR, 2011). The levels at which RDX is assumed to be present at in these fields certainly contribute to chronic exposure symptoms and may be casing an unacceptable health risk, especially since plants take up a very significant amount of RDX.

Fortunately, there are a handful of plants which are known to not only take up RDX appreciably, but also break it down into benign products and eventually methanol (Ryloh et al., 2008). These are small plants which could be easily incorporated into the community garden and with care, phytoremediation is possible. The problem with remediation through biodegradation is similar to that of arsenic, even if RDX is cleared out of the garden, the source is the incoming water as seen by distribution of RDX in the field, and thus, the soil will continue to be contaminated.

Perchlorate

Perchlorate, much like RDX, is also a man-made chemical which has commonly been found in groundwater around the United States as a result of military contamination. It is used as an industrial additive in systems that require quick exothermic releases of oxygen, such as munitions (Crawford-Brown et al., 2006). It has been seen to have contaminated hundreds, if not thousands, of military bases across the United States which practiced explosives testing (MADEP, 2006). Looking at these facts, it is also likely that perchlorate is coming from LANL's legacy waste dumps and abandoned explosives testing sites, washing down "glazed" canyonsides during storm events, or from old explosives testing particulate.

The risks of perchlorate exposure are largely connected to perchlorate's tendency to reduce iodide uptake at the thyroid (Irizarry et al., 2010). Iodide reduction leads to hormone deficiency and thyroid enlargement in adults, but more serious developmental effects in children (Ting et al., 2006). Babies exposed to perchlorate in the womb and then through breastmilk in their infancy will not have sufficient hormones and fetal brain development is at risk (Ting et al., 2006). Perchlorate exposure has been seen to cause retardation in brain development and later on in life, low IQ (Zewdie et al., 2010).

Phytoremediation is possible in the case of perchlorate. Plants have been found which reduce perchlorate to a far less threatening produce, chlorate. In-situ remediation has been extremely successful in these studies, but most of the plants which reduce perchlorate grow

slowly and take years to reduce a significant amount of the contaminant (Mwehoga et al., 2007). Once again, though perchlorate may be able to be reduced and removed from the soils in the Railroad Avenue garden, it will still remain due to the constant input of the contaminant.

Hexavalent Chromium

The risks put forth by hexavalent chromium are very well known in the public health sphere as it is one of the most studied anthropogenic and industrial contaminants. It clearly causes carcinogenicity, but mechanisms are still being figured out. Through this route of exposure, risk of possible oral, intestinal, and stomach cancer is elevated highly (Holmes et al., 2008). Ingested chromium is reduced in the stomach and in exposed populations, and causes these cancers (Kimbrough et al., 1999).

Unfortunately, phytoremediation is not feasible for CrVI due to the low level of tolerance plants have for the contaminant. However, because roots-shoots translocation is extremely slow in the case of CrVI (Shanker et al., 2005), edible non-root vegetables pose lower risk. Addition of organic matter to soils has been seen to promote the reduction of CrVI to CrIII, a more benign species, and gives the most promise for in situ remediation (Kimbrough et al., 1999).

How to Begin to Think About Cleanup and Justice

Looking at the overarching implications of my study, it is clear that there are at least three dangerous chemicals coming into the community of Espanola from Los Alamos National Labs and contaminating the soil. Contamination is unacceptable, especially coming from a community of wealth into a community with a population which consists of low-income, Native peoples. The unequal burden of health risks to the Rio Arriba Community seen in my study is a picture of environmental injustice.

The contaminants which are present in the garden are more likely than not leaching to the groundwater, especially when considering the high mobilities of perchlorate and RDX, as well as their tendency not to accumulate in soils. The fact that they were detected in such high levels in the soil implies that the amount of both contaminants in the water flowing into the garden is significantly higher, as much as 90% in the case of perchlorate. More research is needed specifically in the Rio Arriba Valley, especially on exactly what contaminants are leaching to the communities surrounding LANL, not just in Los Alamos. The contamination also begs the conclusion that better testing wells in more locations are needed to monitor water quality in the area to protect all health. If contaminants are present at this time, there is certainly more on its way, because the legacy waste from LANL is just beginning to surface in water sources.

Some phytoremediation can be put into place in the gardens and more widely, surrounding the Rio Arriba Valley, but proposals of bioremediation are not enough. Regardless of cleanup in the garden, contaminants will continue to accumulate due to their presence in the water, which is necessary for repeated irrigation. Cleanup at LANL to remove the sources of these contaminants is imperative for the ongoing health of communities downhill and downstream from the labs, as is trustworthy and transparent testing and monitoring of water and soil so risks are assessed and understood. I highly recommend further testing of the garden. Though I will put forth a recommendation, and believe that the plants are probably safe, testing and more data on measured levels in the plants, not just the soil, should be collected first.

Though the garden soil has been found to be contaminated, I do not believe it is advisable to stop eating vegetables from the garden entirely. I think, because of the deep-rooted traditions in the Pueblo communities in agriculture and of cultivating Mother Earth at large, it is beneficial overall to continue eating from the garden. I ate from this very garden, understanding my risk due to my interest in sampling from the garden. This being said, I do believe that intake of certain vegetables should be limited. Leafy green vegetables generally contain the highest concentration of contaminants, which tend to translocate to plant leaves (Fayiga et al., 2007). Intake of these plants specifically should be very limited. As stated in my study, specific uptakes of perchlorate and RDX are not known for many plants, but it does vary species-to-species. Because of species variation, intake of each individual

vegetable should be limited. A variety of plants should be eaten rather than just a few to limit exposure. The process of limitation not only will protect physical health, but nourish emotional and spiritual health as well.

The fact that there are chemicals which have been detected in the soil of the North Railroad Avenue community garden and traced back to the labs concretes the historical trauma which has taken place on this land. Communities in the Pueblos de San Ildefonso and Santa Clara have been on the land of Northern New Mexico for hundreds, if not thousands of years, respecting and taking care of their Mother Earth. As the Spanish conquistadors moved in, the Pueblos got pushed aside, and when the labs came in, so went the last threads of the traditional land-based economy. These are peoples who still live and thrive on the lands and the labs absolutely need to clean up land that is not theirs to begin with, regardless of whether they intend to continue using the land. Contamination in the garden not only resurfaces historical trauma, but perpetuates harm to communities in the Rio Arriba Valley and deserves further research, monitoring and remediation to right what has been wrong and protect health in the highest order.

This garden is a testament to the brilliant movement back to traditional methods of living. The ruby red beets and kale that shines in the dewy morning should be a source of health, as they have been for thousands of years. Tomatoes, peas, and squash should not be seen as an increase in cancer risk, yet this is the point at which we are standing. Each person I weeded the garden with has a passion for the well-being of their community, rightfully so,

and I hope that this Division III will aid in their journey to feed and nourish people. The stunning red landscapes of Northern New Mexico have weathered many times through conquest and contamination, and I have the utmost hope that the people, who depend on this land, including those on the hill in Los Alamos, will protect the wealth it contains and best serve environmental justice.

Appendix A: Maps

Figure 28: Regional Map of Espanola, NM. Red boxed area indicates N. Railroad Avenue Community Garden surveyed, and its relative distance to the Rio Grande (~1,000').

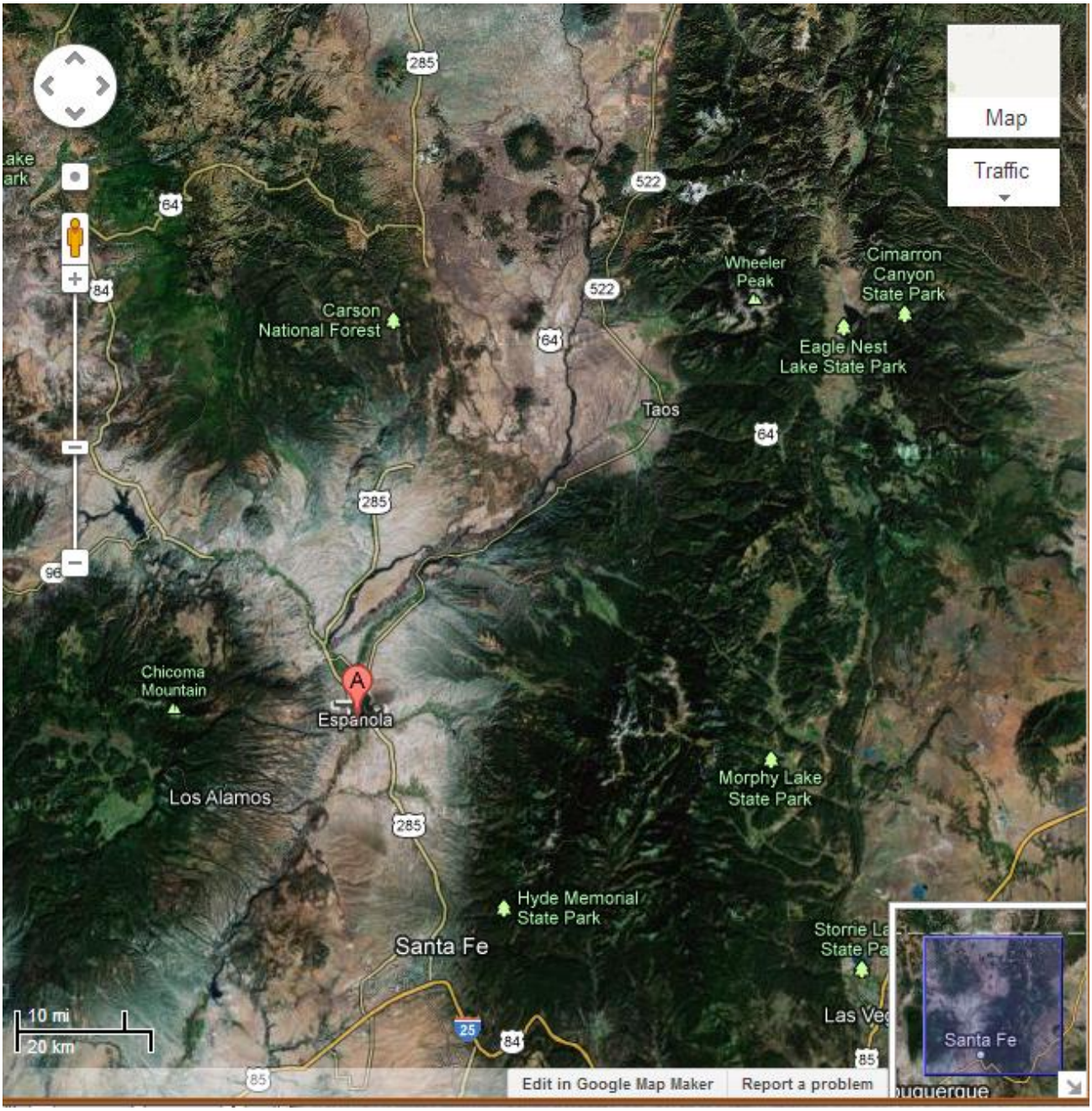


Figure 29: Regional map to show orientation and geological structures between Santa Fe, Los Alamos, Espanola, and Taos, NM. The Rio Grande may be seen travelling from west of Taos, into Espanola, and east of Los Alamos.

Figure 30: State map of New Mexico. The Rio Grande may be seen travelling through the center of the state. Los Alamos is seen as green due to the surrounding national parks, as is the outskirts of Santa Fe into Taos.

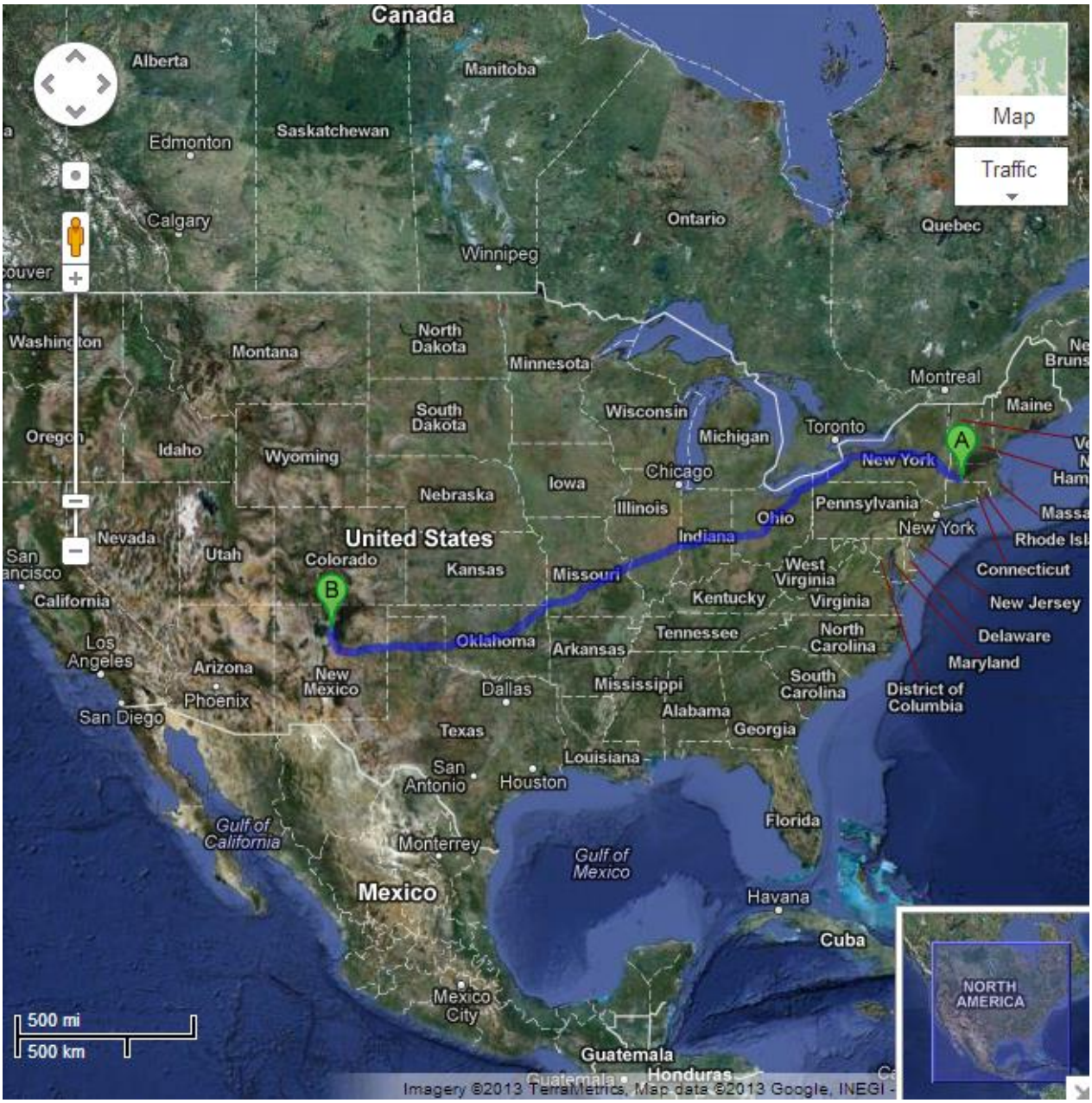


Figure 31: National map showing the route from Amherst, Massachusetts to Espanola, NM.

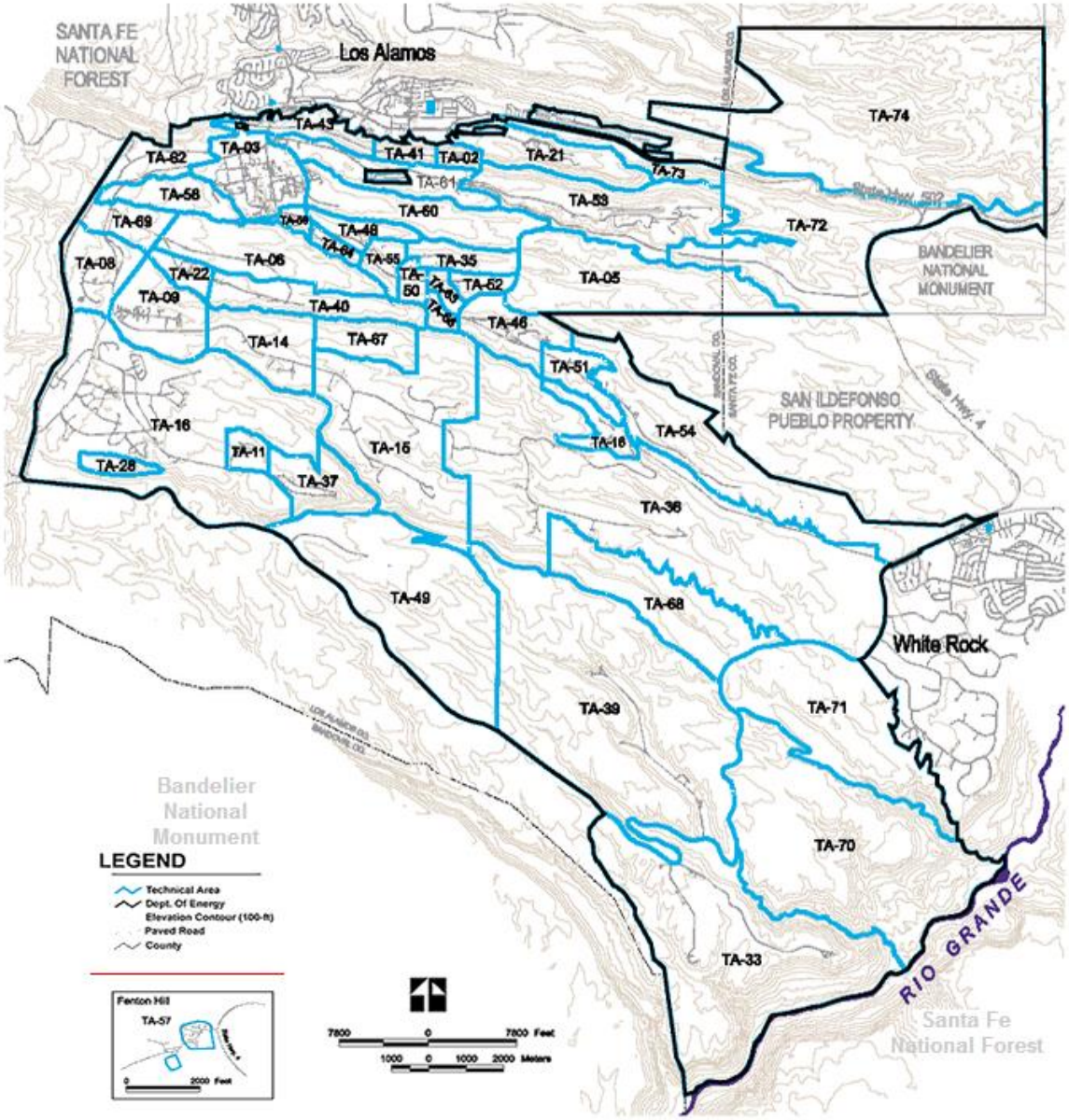


Figure 32: Technical Areas at Los Alamos National Labs. (LASG, 2004).

Appendix B: Raw Experimental Data

	ORP	pH	Conductivity	RDX (quant)	Arsenic (ppb)	Perchlorate ppm
BLANK		6.78	79	0.002		-1.60452
11	2.038	6.11	150.8	4	40	13.42344
12	2.071	6.2	158.7	0.5		6.216288
13	2.036	5.91	130.8	0.644	30	5.292152
14	2.083	5.86	122.7	0	30	10.00691
15	2.06	5.66	131	0.436	30	7.985077
16	2.068	5.65	134	0.179	20	2.14517
17	1.997	5.61	124	0	20	7.803581
18	2.023	5.44	128.5	0	30	12.88927
19	2.023	6.21	112.3	0	5	3.266667
21	2.002	6.04	117.4	0.251	30	8.73914
22	2.028	5.85	126.1	0.778	30	8.624912
23	2.029	5.76	136.6	0.421	40	1.854999
25	2.075	6	122.5	0	30	9.829542
26	2.088	6.09	124.6	0.201	30	6.753159
27	2.02	5.94	111.9	0.0993	30	7.538477
28	1.995	5.92	116.3	0.257	30	8.926506
29	2.011	5.96	120.4	0	10	5.724949
31	2.049	5.92	117.4	0.338	20	2.575112
32	2.002	5.86	120.2	0	20	5.880267
33	2.025	6.4	115.6	0	30	3.418178
34	2.044	6.48	106.9	0.12	30	4.267273
35	2.092	6.43	102.3	0	20	12.6524
36	2.04	6.25	102.1	0	30	15.27758
37	2.052	6.12	110.7	0	40	5.567727
38	2.058	6.1	105.8	0	30	4.553636
39	1.994	5.92	121.1	0	30	8.72502
41	2.007	6.12	98.3	0.21	40	5.481738
42	2.04	6.15	98.4	0	5	7.864979
43	2.07	6.18	88.5	0	10	4.611384
44	2.011	5.97	100.7	0	10	3.545098
45	2.019	5.93	104.5	0	30	11.38891
46	2.037	6.42	91.1	0	30	5.381789

47	2.038	6.5	68.8	0	40	3.425476
48	2.031	6.39	79	0.0933	40	3.652821
49	2.045	6.08	97.6	0	30	8.016965
51	2.007	6.09	83.1	0.159	30	14.36852
52	2.06	6.16	72.4	0	30	7.626052
53	2.016	6.2	86.3	0	30	4.609639
54	2.08	6.47	56.9	0	10	7.890363
55	2.076	6.35	63.3	0.0706	20	7.364121
56	2.026	6.26	58.3	0.259	20	9.880468
57	2.019	6.07	60	0.487	20	6.399687
58	2.013	5.93	65.2	0.456	20	4.931381
59	1.999	5.96	60.3	0.347	30	12.34716
61	2.005	6.15	61.9	0.219	40	5.789202
62	2.012	6.11	59.3	0.163	30	4.175731
63	2.071	6.17	48.6	0.235	40	7.552438
64	2	5.94	50.4	0.102	20	4.114334
65	2.067	5.99	41.1	0	40	4.768289
66	2.065	6.24	43.2	0.122	30	3.755944
67	2.016	6.44	41.1	0	10	4.64835
68	2.008	6.11	130.3	0	10	5.567727
69	2.022	6.05	131.2	0	10	10.17921
71	2.002	6.01	122.2	1.99	40	6.569125
72	1.998	6.01	114.7	0	20	5.708766
73	1.999	6.06	117.6	0	30	8.985048
74	2.057	6.19	123.9	0	40	5.985928
75	2.067	6.24	126.6	0	40	8.070906
76	2.036	6.26	123.5	0	40	8.448335
77	2.055	6.25	113.8	0	20	5.864243
78	2.005	6.09	108.6	0	50	1.571016
79	2.029	6.15	118.4	0	50	11.07828
Average	2.03405	6.0868	101.2870968	0.21189032	27.70491803	6.960594
Standard Dev	0.0274	0.2164	29.19616901	0.56830983	10.73426299	3.124206
Max	2.092	6.5	158.7	4	50	15.27758
Min	1.994	5.44	41.1	0	5	1.571016
	ORP	pH	Conductivity	RDX (quant)	Arsenic (ppb in 10% sol'n)	Perchlorate ppm

CrVI		
	UV/Vis	ppm
block 1	0.12016	0.216171
block 2	0.083681	0.210958
block 3	0.19324	0.226614
block 4	0.14738	0.220061
block 5	0.088339	0.211624
block 6	0.29973	0.241831
block 7	0	0.199
block 8	0.067815	0.208691
block 9	0.24685	0.234275
block 10	0.18237	0.225061
block 11	0.19167	0.22639
block 12	0.064316	0.208191
	Average	0.219072
	Standard Dev	0.011744
	Max	0.241831
	Min	0.199

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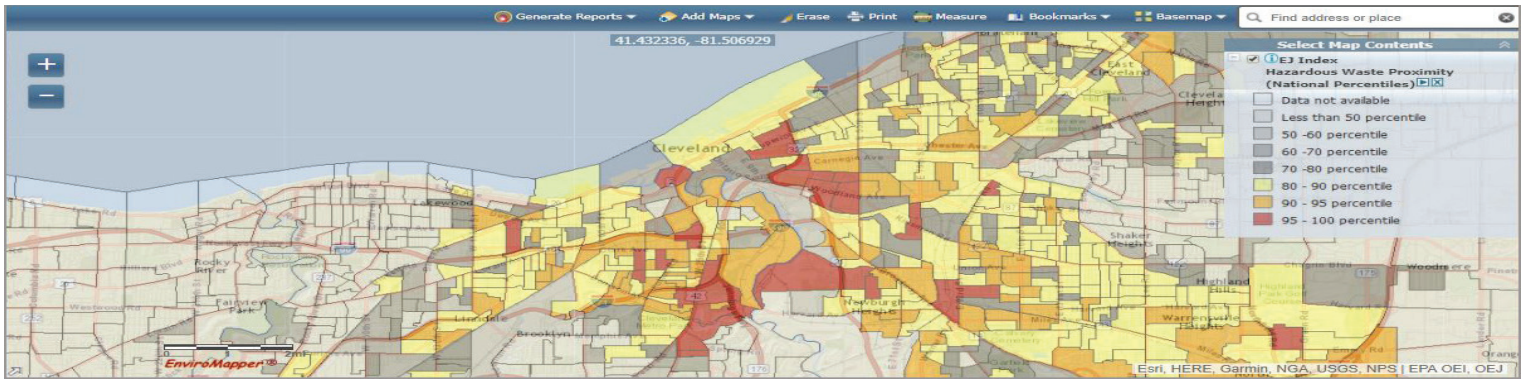
United States Environmental Protection Agency

EJSCREEN Fact Sheet



How does EPA use EJSCREEN?

EPA uses EJSCREEN to identify areas that may have higher environmental burdens and vulnerable populations as the Agency develops programs, policies and activities that may affect communities. A few examples of what EJSCREEN supports across the Agency include:

- Informing outreach and engagement practices;
- As an initial screen for voluntary programs, enhanced outreach in permitting, and prioritizing enforcement work;
- Developing retrospective reports of EPA work; and
- Enhancing place-based activities.

EJSCREEN is not used by EPA staff for any of the following:

- As a means to identify or label an area as an "EJ community;"
- To quantify specific risk values for a selected area; or
- As the sole basis for EPA decision-making or making a determination regarding the existence or absence of EJ concerns.

Additionally, note that EPA is not requiring state, local, or tribal partners to use EJSCREEN in any context.

What is Environmental Justice?

EPA defines environmental justice (EJ) as, "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies." EPA's goal is to provide an environment where all people enjoy the same degree of protection from environmental and health hazards and equal access to the decision-making process to maintain a healthy environment in which to live, learn, and work.

What is EJSCREEN?

An important first step to ensuring environmental justice for all people in this country is to identify the areas where people are most vulnerable or likely to be exposed to different types of pollution. For this reason, EPA developed EJSCREEN to help aid in efforts to ensure programs, policies, and resources are appropriately inclusive and consider the needs of communities most burdened by pollution.

Proximity to traffic is one of the 11 environmental indicators.

EJSCREEN is an environmental justice screening and mapping tool that utilizes standard and nationally-consistent data to highlight places that may have higher environmental burdens and vulnerable populations. The tool provides both summary and detailed information at a high geographic resolution for both demographic and environmental indicators.

EJSCREEN also provides 11 EJ Indexes, which combine demographic information with a single environmental indicator (such as proximity to traffic) that can help identify communities that may have a high combination of environmental burdens and vulnerable populations. The tool displays this information in color-coded maps, bar charts, and standard reports on an easy to use web interface. All of this information can be used to assist efforts by stakeholders and advocates to protect human health and the environment in communities affected by pollution.

How can EJSCREEN be accessed?

EJSCREEN will be available as part of EPA's GeoPlatform that helps coordinate mapping activities, applications, and data across the Agency. It will be available through the EPA website, and will not require any downloads to use the tool.

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What are the limitations of the tool?

For EPA's purposes, EJSCREEN will be used as an initial step in highlighting locations that may be candidates for further review. But EPA recognizes that screening level results have significant limitations and are not intended or designed to provide a risk assessment. For example, EJSCREEN does not provide data on every environmental impact and demographic indicator that may be relevant to a particular location, and data may be several years old. Thus, EPA will supplement EJSCREEN outputs with additional information and local knowledge before making any decisions about potential environmental justice issues.

Users of this tool should also be aware that screening tools are subject to substantial uncertainty in their demographic and environmental data, particularly when looking at small geographic areas like a census block group. Lastly, while the use of percentiles provides useful perspective by putting the 11 environmental indicators in common units, it simply means those two scores are equally common (or equally rare) in the United States. It does not mean the risks are equal or comparable.

How can the public use EJSCREEN?

EJSCREEN can be a useful tool to help communities and others identify areas with higher environmental and economic burdens in order to participate meaningfully in decision-making processes that impact their health and environment.

The public will be able to use EJSCREEN to access high-resolution environmental and demographic information for communities in the United States. The tool may help users identify areas with minority and/or low-income populations, potential air and water quality issues, and other factors that may be of interest. EJSCREEN may also be used to support educational programs, grant writing, community awareness efforts, and other purposes.

What kind of data does EJSCREEN use?

Because EJSCREEN is intended as a national tool, environmental and demographic data selected for the tool must be nationally available at the Census tract or block group level. EPA uses demographic data from the U.S. Census Bureau American Community 5-year Summary Survey (ACS), which include demographic indicators for race/ethnicity, poverty, age, educational level and language barriers.

Demographic Indicator	**Description** (Source: 2012 - 2016 ACS Estimates)
Low-Income	Percentage of block group population at or below twice the federal "poverty level"
Minority	All people other than non-Hispanic white-alone individuals
Less than high school education	Percentage of people age 25 or older without a high school diploma
Linguistic isolation	Percentage of people in household in which all members over age 14 years speak English less than "very well"
Individuals under age 5	Percentage of people under the age of 5
Individuals over age 64	Percentage of people over the age of 64

EJSCREEN puts each indicator or index value in perspective by reporting the value as a percentile. For example, the lead paint indicator may show 60% of housing in an area was built prior to 1960. It may not be obvious whether this is a relatively high or low value, compared to the rest of the nation or state. Therefore, EJSCREEN also reports that 60% pre-1960 puts the area at the 80th percentile. For a place at the 80th percentile nationwide, that means 20% of the US population has a higher value.

The 11 environmental indicators are based on information developed from direct measurements, proxy estimates of pollution exposure, and facility location information. Environmental and proximity indicators are screening-level proxies for exposure or risk – not actual exposure or risk.

Environmental Indicator	**Year of Data**
Particulate Matter (PM 2.5)	2014
Ozone	2014
NATA Diesel Particulate Matter	2011
NATA Air Toxics Cancer Risk	2011
NATA Respiratory Hazard Index	2011
Lead Paint Indicator	2012-2016
Traffic Proximity	2014
Proximity to Superfund (NPL) Sites	2018
Proximity to Risk Management Plan (RMP) Facilities	2018
Proximity to Hazardous Waste Facilities	2018
Wastewater Discharger Indicator	2017

EPA

For More Information

To find more detailed information about EJSCREEN visit: https://www.epa.gov/ejscreen
For questions, requests, feedback, and issues using EJSCREEN, e-mail enviromail_group@epa.gov.

EJSCREEN Report (Version 2018)

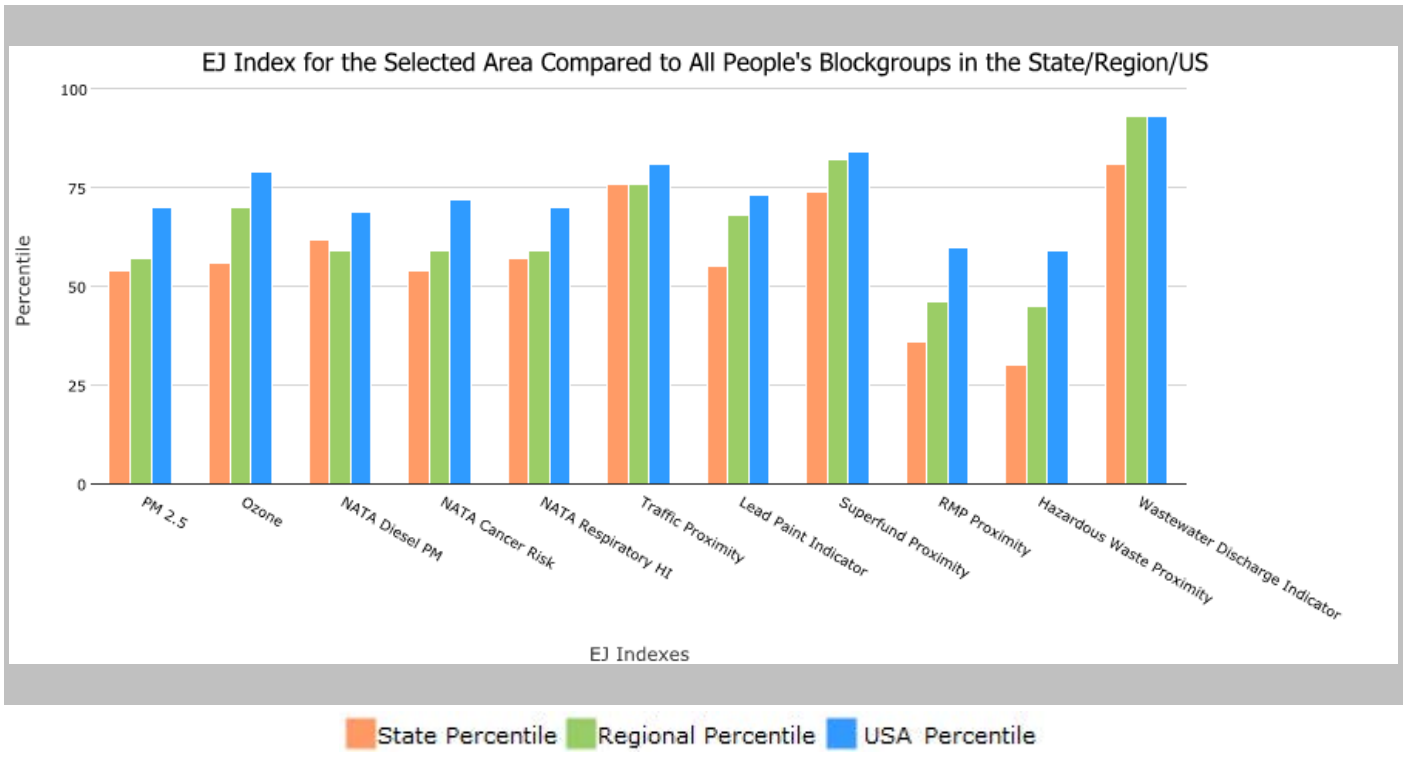
30 mile Ring Centered at 35.876850,-106.325220, NEW MEXICO, EPA Region 6

Approximate Population: 179,383

Input Area (sq. miles): 2827.03

(The study area contains 1 blockgroup(s) with zero population.)

Selected Variables	State Percentile	EPA Region Percentile	USA Percentile
EJ Indexes			
EJ Index for PM2.5	54	57	70
EJ Index for Ozone	56	70	79
EJ Index for NATA* Diesel PM	62	59	69
EJ Index for NATA* Air Toxics Cancer Risk	54	59	72
EJ Index for NATA* Respiratory Hazard Index	57	59	70
EJ Index for Traffic Proximity and Volume	76	76	81
EJ Index for Lead Paint Indicator	55	68	73
EJ Index for Superfund Proximity	74	82	84
EJ Index for RMP Proximity	36	46	60
EJ Index for Hazardous Waste Proximity	30	45	59
EJ Index for Wastewater Discharge Indicator	81	93	93



This report shows the values for environmental and demographic indicators and EJSCREEN indexes. It shows environmental and demographic raw data (e.g., the estimated concentration of ozone in the air), and also shows what percentile each raw data value represents. These percentiles provide perspective on how the selected block group or buffer area compares to the entire state, EPA region, or nation. For example, if a given location is at the 95th percentile nationwide, this means that only 5 percent of the US population has a higher block group value than the average person in the location being analyzed. The years for which the data are available, and the methods used, vary across these indicators. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports.

EJSCREEN Report (Version 2018)

30 mile Ring Centered at 35.876850,-106.325220, NEW MEXICO, EPA Region 6

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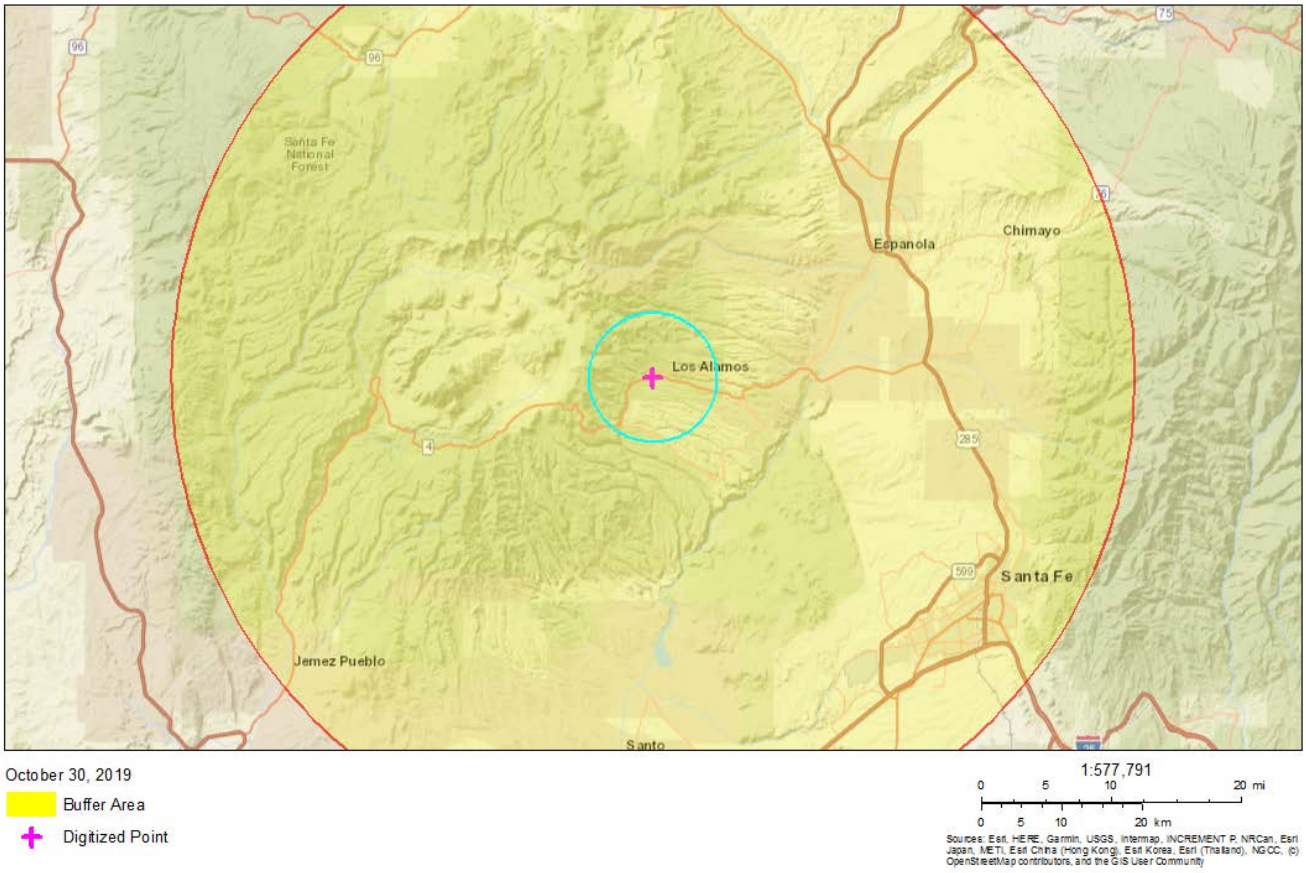

Sites reporting to EPA	
Superfund NPL	1
Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)	1

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Selected Variables	Value	State Avg.	%ile in State	EPA Region Avg.	%ile in EPA Region	USA Avg.	%ile in USA
Environmental Indicators							
Particulate Matter (PM 2.5 in µg/m^3)	5.42	6.25	17	9.55	0	9.53	1
Ozone (ppb)	50.1	49.7	41	40.4	97	42.5	90
NATA* Diesel PM (µg/m^3)	0.281	0.473	42	0.721	<50th	0.938	<50th
NATA* Cancer Risk (lifetime risk per million)	27	32	29	42	<50th	40	<50th
NATA* Respiratory Hazard Index	1.1	1.4	43	1.8	<50th	1.8	<50th
Traffic Proximity and Volume (daily traffic count/distance to road)	270	290	71	320	72	600	67
Lead Paint Indicator (% Pre-1960 Housing)	0.18	0.19	65	0.18	69	0.29	49
Superfund Proximity (site count/km distance)	0.079	0.13	66	0.07	79	0.12	65
RMP Proximity (facility count/km distance)	0.011	0.22	11	0.8	0	0.72	0
Hazardous Waste Proximity (facility count/km distance)	0.043	0.39	34	0.86	14	4.3	11
Wastewater Discharge Indicator (toxicity-weighted concentration/m distance)	0.017	2.1	71	0.38	88	30	83
Demographic Indicators							
Demographic Index	50%	52%	49	44%	61	36%	74
Minority Population	64%	61%	53	51%	64	38%	76
Low Income Population	37%	43%	41	38%	51	34%	60
Linguistically Isolated Population	4%	5%	58	6%	61	4%	69
Population With Less Than High School Education	13%	15%	48	17%	47	13%	60
Population Under 5 years of age	5%	6%	44	7%	37	6%	46
Population over 64 years of age	18%	15%	69	13%	79	14%	73

* The National-Scale Air Toxics Assessment (NATA) is EPA's ongoing, comprehensive evaluation of air toxics in the United States. EPA developed the NATA to prioritize air toxics, emission sources, and locations of interest for further study. It is important to remember that NATA provides broad estimates of health risks over geographic areas of the country, not definitive risks to specific individuals or locations. More information on the NATA analysis can be found at: https://www.epa.gov/national-air-toxics-assessment.

For additional information, see: www.epa.gov/environmentaljustice

EJSCREEN is a screening tool for pre-decisional use only. It can help identify areas that may warrant additional consideration, analysis, or outreach. It does not provide a basis for decision-making, but it may help identify potential areas of EJ concern. Users should keep in mind that screening tools are subject to substantial uncertainty in their demographic and environmental data, particularly when looking at small geographic areas. Important caveats and uncertainties apply to this screening-level information, so it is essential to understand the limitations on appropriate interpretations and applications of these indicators. Please see EJSCREEN documentation for discussion of these issues before using reports. This screening tool does not provide data on every environmental impact and demographic factor that may be relevant to a particular location. EJSCREEN outputs should be supplemented with additional information and local knowledge before taking any action to address potential EJ concerns.

From:	Paula Garcia
To:	Barnes, Cody, NMENV
Subject:	[EXT] Public Comments about draft Groundwater Discharge Permit (DP-1132) WQCC No. 18-05 (A) and GWB 19-24 (P)
Date:	Monday, November 18, 2019 9:11:57 AM
Attachments:	DP-1132 public comment NMAA 11-13-19.pdf LANL-PAJARITO-FAULT-SYSTEM-FIGURES.pdf

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Dear Mr. Barnes,

Please see the attached comments on DP-1132. Thank you for your consideration.

Paula Garcia
Executive Director
New Mexico Acequia Association
805 Early Street, Suite 203B
Santa Fe, NM 87505
(505) 995-9644
www.lasacequias.org

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November 14, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

The New Mexico Acequia Association (NMAA) opposes the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, a tributary of Mortandad Canyon, which discharges into the Rio Grande. NMAA represents numerous acequia irrigators and farmers in the Pojoaque and Española Valley who rely on clean air and water to grow healthy food for their families and to support their livelihoods.

We are concerned that the Water Quality Act is not adequate to regulate the RLWTF. The RLWTF is a key facility for treating liquid radioactive and hazardous wastes from the production of plutonium pits (the triggers for nuclear weapons). The NM

Hazardous Waste Act is more protective of human health and the environment than the NM Water Quality Act for several reasons including seismic considerations.

The RLWTF storage and treatment operations rely on tanks and ancillary equipment, such as sumps, pumps and pipes. For new tank systems, the Hazardous Waste Act regulations require a Professional Engineer (P.E.) to review and certify that the tank system has sufficient structural integrity for storing and treating hazardous waste. These include a requirement that the design ensure that the tank system will not be dislodged if it is place in a seismic fault zone. This is a factor in Los Alamos.

Because of the type of waste that is handled by the RLWTF, we maintain that the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection to human health and the environment, including

- enhanced public participation;
- enhanced seismic requirements that address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers.

In 1998, LANL said it would transition the RLWTF to a zero discharge facility. NMED must do a careful review of the best regulatory framework to protect the health, safety, and welfare of the people of New Mexico from the potential adverse impacts from this highly complicated facility that carries many risks to the environment. Please **deny** the draft permit and make a **recommendation** to the NMED Secretary that he require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Thank you for your careful consideration of our comments.

Sincerely,

Paula Garcia
Executive Director, New Mexico Acequia Association
805 Early Street Bld. B, Suite 203
Santa Fe, NM 87505
paula@lasacequias.org

Figure 1. Map of the Pajarito Fault System and Embudo Fault System – Southwestern Section in Northern New Mexico. **Source:** Figure 5-4 in LANL 2007 PSHA Report.

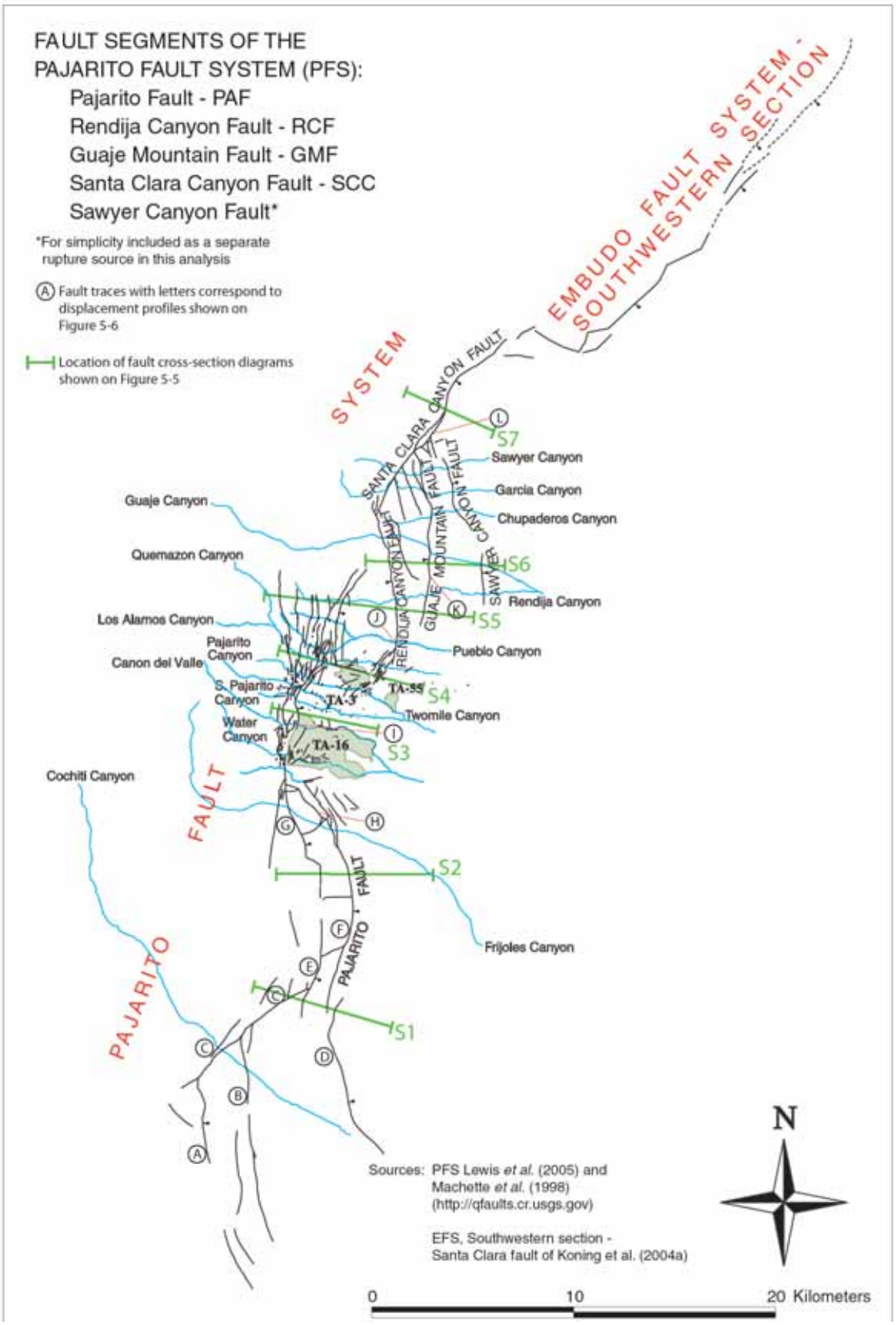
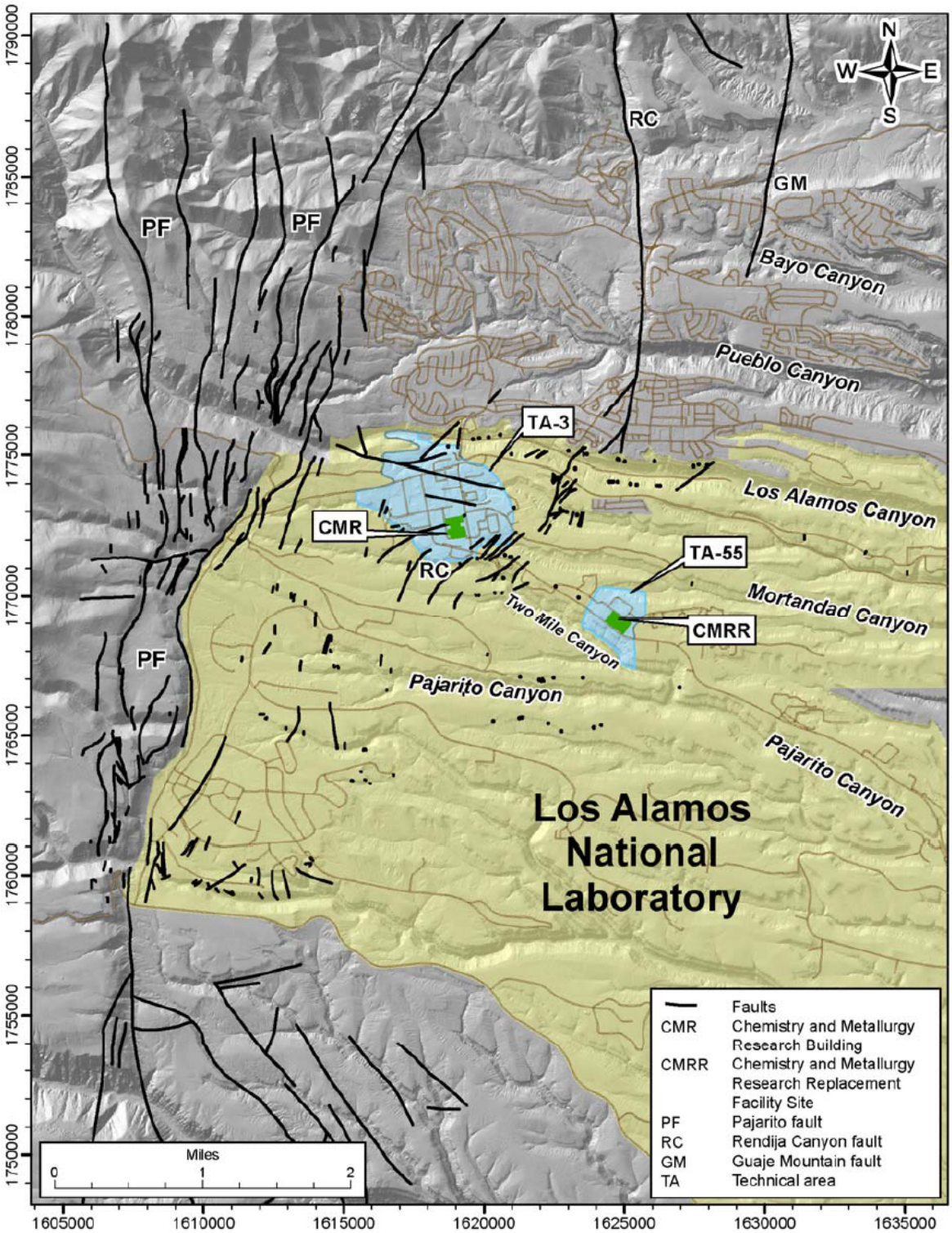


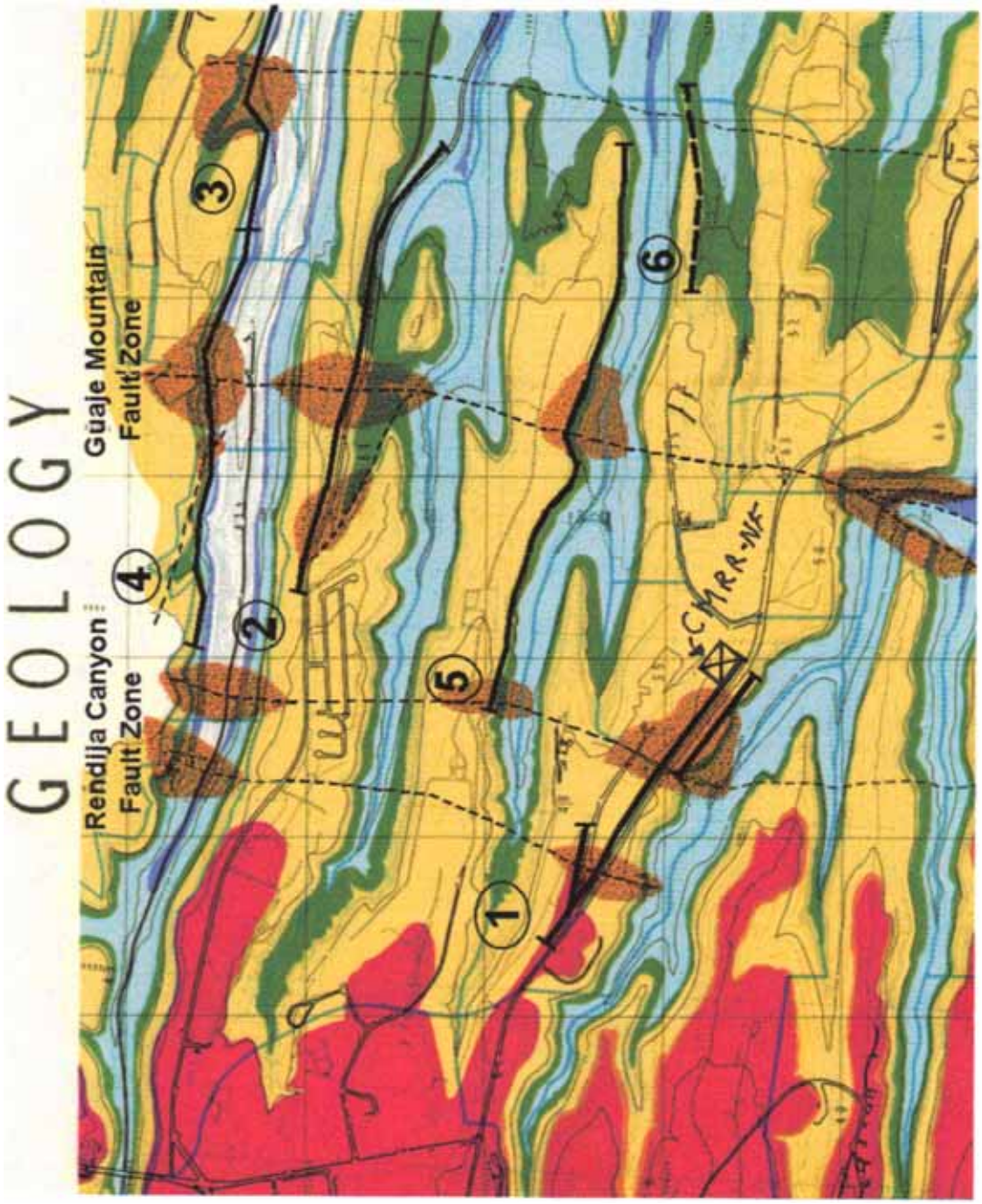
Figure 2. Mapped Faults in the Los Alamos National Laboratory Area.

Please Note. The detailed mapping to determine the southward extent of the GM Fault (Guaje Mountain Fault) toward and possibly close to the location of the proposed CMRR Nuclear Weapons Facility has not been performed.



Source: Figure 3-5 in the DOE 2011 SEIS

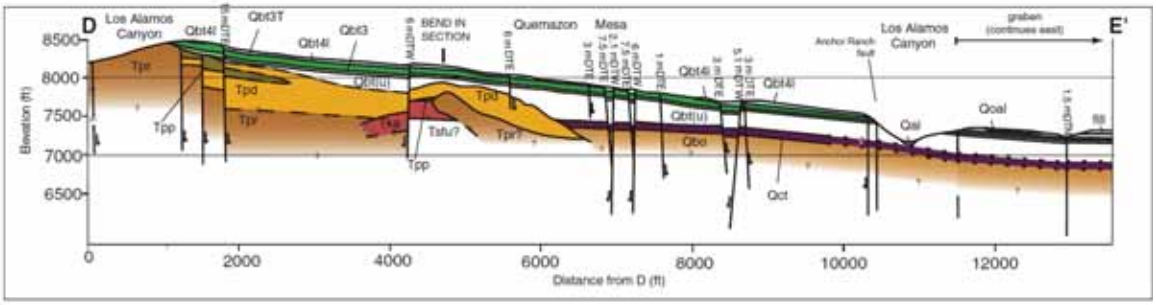
Figure 3. Map in 2004 LANL Report by Wohletz showing proposed location of Rendija Canyon Fault along the western boundary of LANL TA-55 and Guaje Mountain Fault 2500 feet east of the eastern boundary of TA-55.
Source: Figure 14 in Wohletz, 2004 (LA-UR-04-8337)

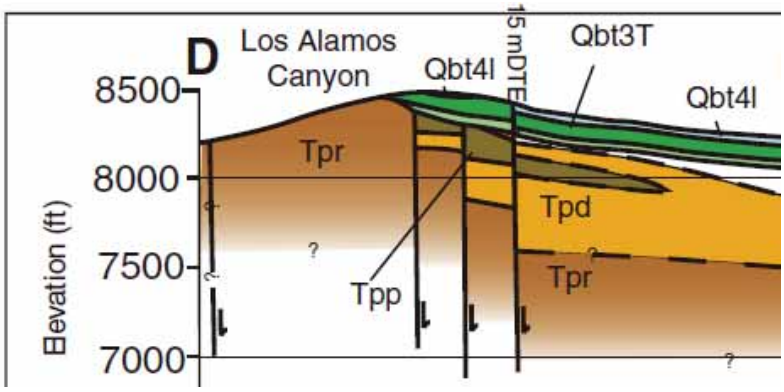


Scale 0----------1950 feet

- **Black X inside rectangle is location of proposed CMRR-NF**
- **Dashed black lines show trend of inferred faults - - - - - - - - -**
- **Brown patches along dashed black lines are zones of intense fractures**
- **Circled numbers 1 to 6 have no relation to intense fracture zones.**

Figure 4. West to East Cross-Section D-E' on page 263 in Lewis et al., 2009.





Note. The vertical arrows show the side of the discrete faults where displacement is downward. 15mDTE means the vertical displacement is 15 meters (49 feet) downward to the east.

An additional important factor is that the youthful PFS is currently at a growth stage where the interaction between the primary Pajarito Fault (PF or PAF) and the subsidiary Rendija Canyon Fault (RCF) and Guaje Mountain Fault (GMF) often results in multiple ground-breaking ruptures from two of the three faults (Lewis et al., 2009). The powerful multiple surface-rupturing earthquakes are described on page 3-25 in the DOE 2011 draft SEIS as follows:

> New paleoseismic data argue for three Holocene (past 11,000 years) surface-rupturing earthquakes, including an earthquake on the Pajarito Fault, approximately 1,400 years ago; an earthquake on the Pajarito Fault approximately 5,000 to 6,000 years ago, which is consistent with an event during the same general time frame on the Guaje Mountain Fault; and a third earthquake on both the Pajarito and the Rendija Canyon Faults, approximately 9,000 years ago. This paleoseismic event chronology demonstrates that the Pajarito Fault often ruptures alone, but sometimes ruptures either with the Rendija Canyon Fault or Guaje Mountain Fault. When this occurs, the resultant seismic moment and, therefore, the earthquake magnitude are larger than when the main Pajarito Fault ruptures alone. Given the evidence for youthful movement on the Pajarito Fault system, future ruptures should be expected.

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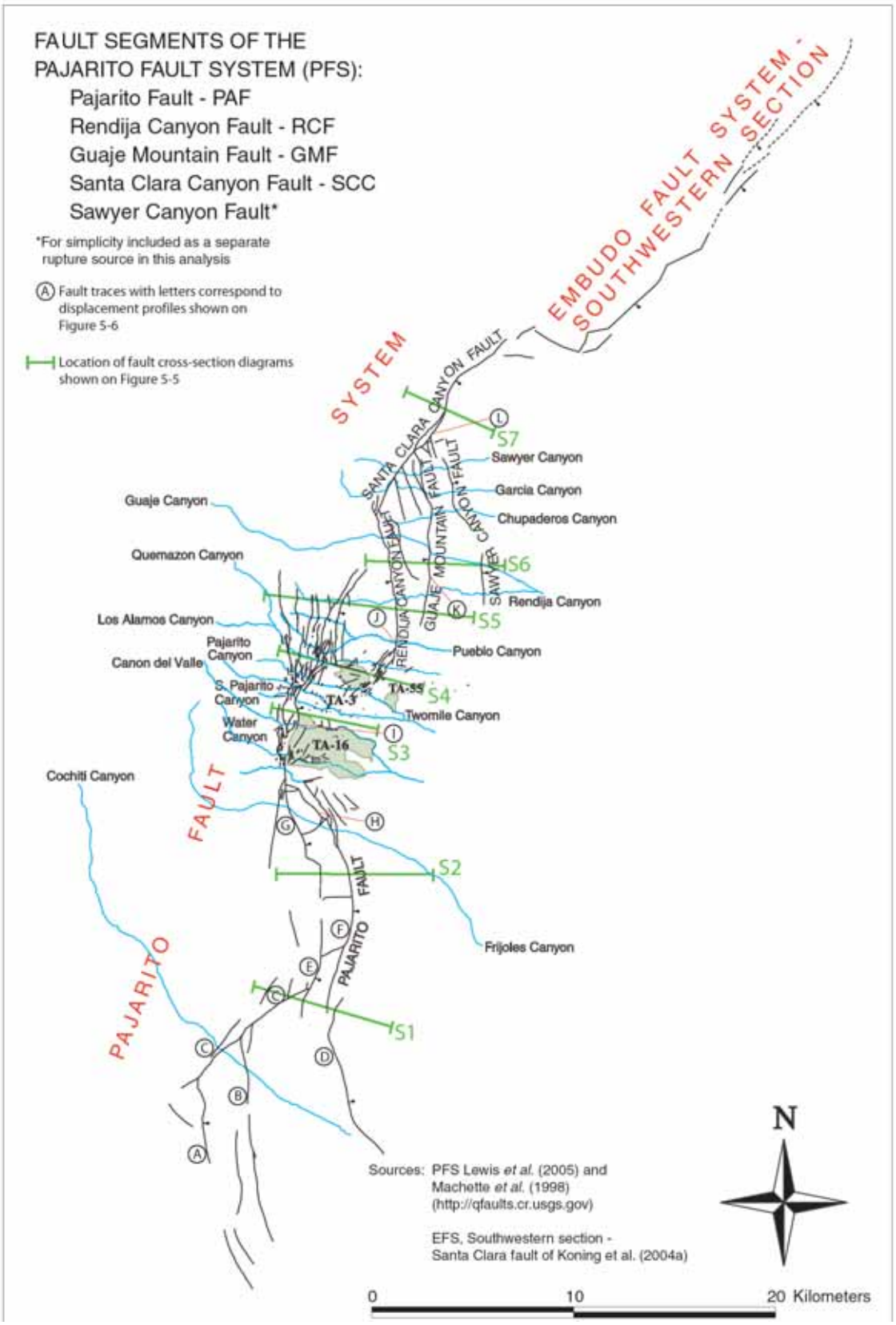

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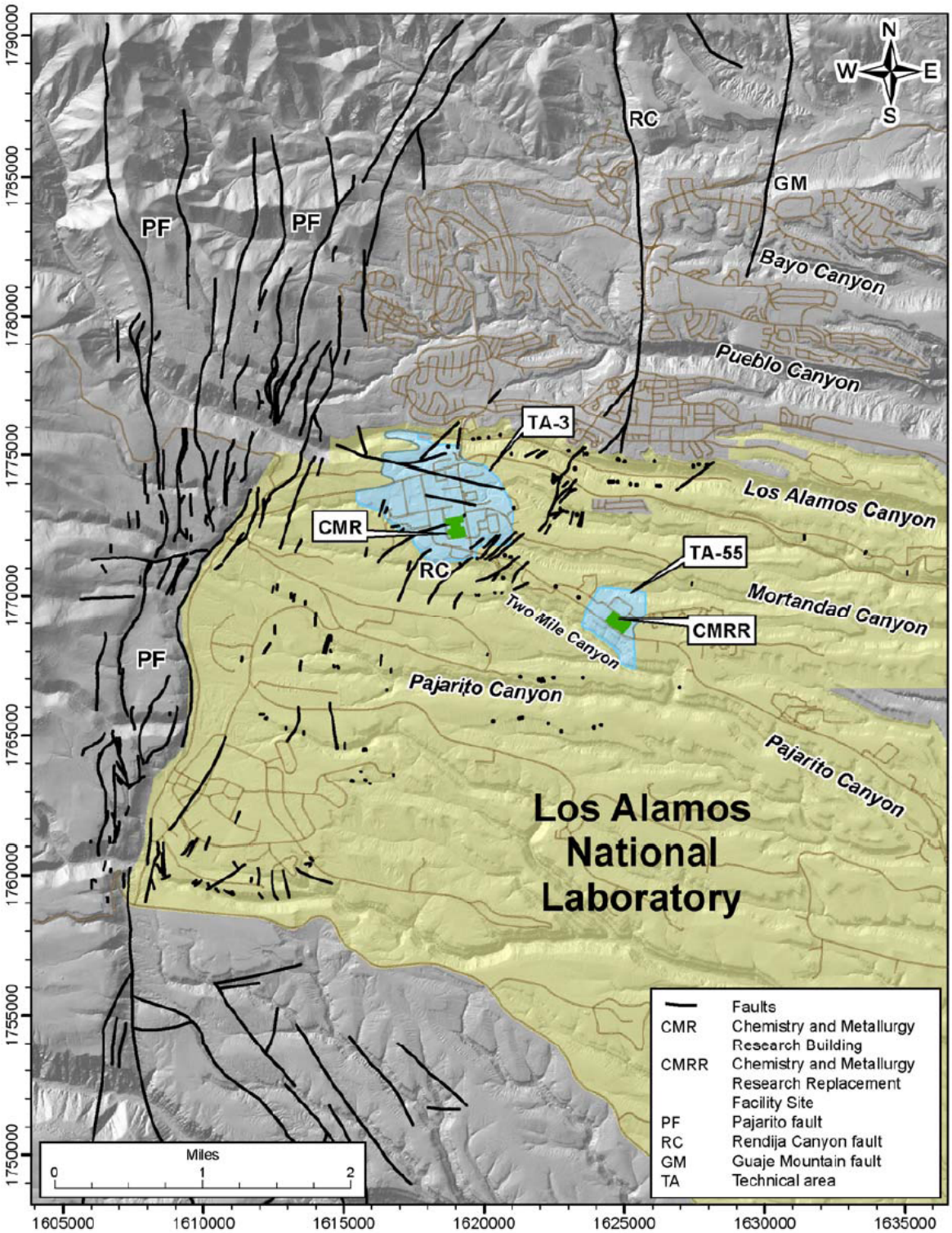

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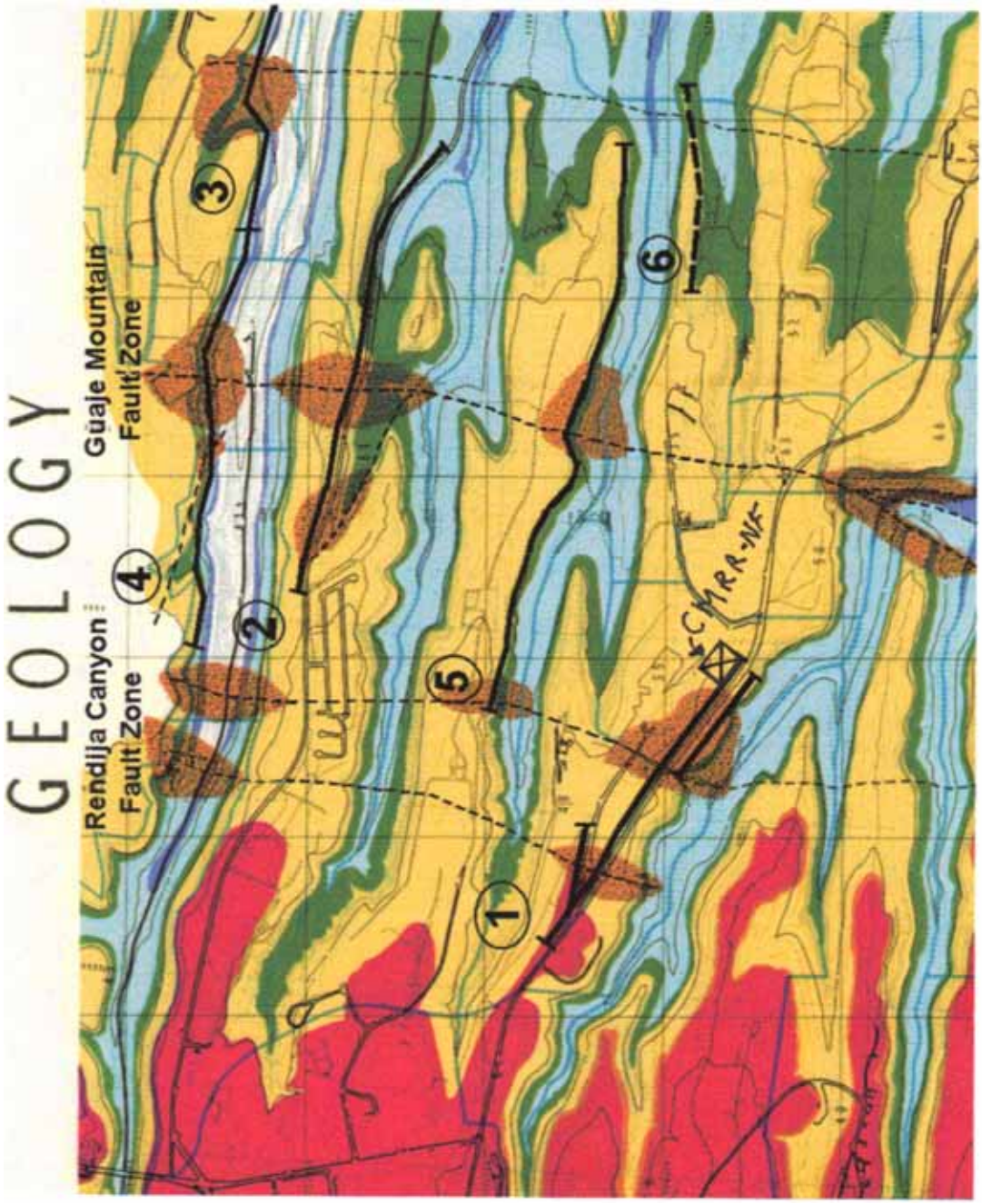

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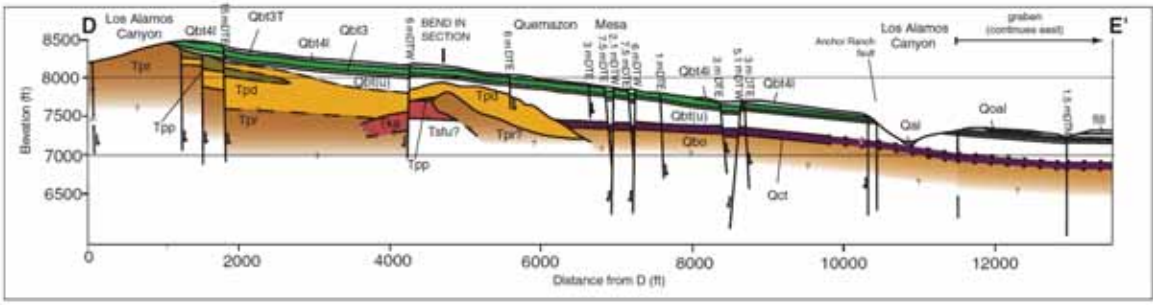

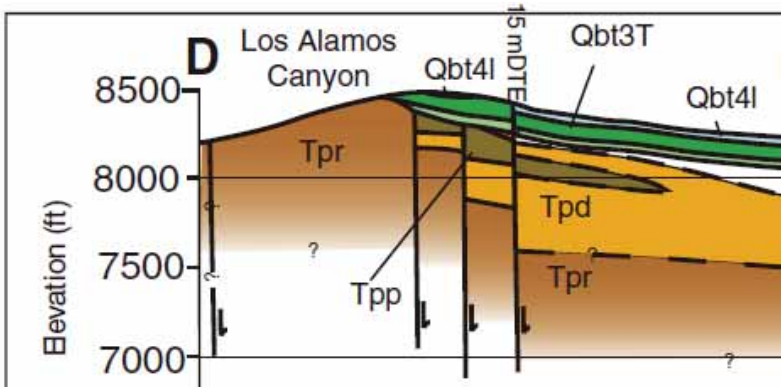

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November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon, and through groundwater to the extensive spring system at the Rio Grande.

In 1998, LANL stated it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection for human health and the environment than the proposed groundwater discharge permit under the NM Water Quality Act, including

- enhanced public participation and oversight, such as a Class 3 permit modification process for the new, multi-million dollar low-level radioactive waste treatment facility;
- enhanced seismic requirements that would address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers.

Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

Sheila Gershen

Sheila Gershen
121 Placita de Oro
Santa Fe NM 87501

15130

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
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Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely, Virginia J. Miller
125 Calle Don Jose
Santa Fe NM 87501

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

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Sincerely,

John and Marissa Bingham
Santa Fe, NM

15132

November 19, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

Patricia C. Hodapp

PATRICIA C. Hodapp
2204 Calle Cariane, SF.NM 87505

15133

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

17 Lucero Rd
SF, NM 87508

15134

November ___, 2019

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c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

Teresa Seamster
Chair, Northern NM Sierra Club

November ___, 2019

By email to: Cody.Barnes@state.nm.us

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c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Please **deny** the draft permit and make a **recommendation** to the NMED Secretary that he require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Thank you for your careful consideration of my comments.

Sincerely,

Margaret Kahlen
2800 Cerrillos Rd. #156
Santa Fe, N.M. 87507

15136

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

Virginia A. Arnold

November 17, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

Betty Kuhn
Santa Fe, NM

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
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Sincerely,

Carolyn Kennedy

15140

November 16, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

Santa Fe

15141

November 17, 2019

By email to: Cody.Barnes@state.nm.us

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c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

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Sincerely,

JUSTINE WITHERSPOON
COLORADO RESIDENT

SETH WITHERSPOON
COLORADO RESIDENT

November ___, 2019

By email to: Cody.Barnes@state.nm.us

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c/o Cody Barnes, Hearing Clerk
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Jeanne Pierrat

November ___, 2019

By email to: Cody.Barnes@state.nm.us

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c/o Cody Barnes, Hearing Clerk
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New Mexico Environment Department
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Sincerely,

Mary B Eisele

15145

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
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Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

November ___, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

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Sincerely,

Linda P. Williams

November ___, 2019

By email to: Cody.Barnes@state.nm.us

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Sincerely,

Peter Thomas White

November ___, 2019

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Sincerely,

James C. Murray
6 Alcalde Loop
Santa Fe NM 87508

November ___, 2019

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Sincerely,

MARK SARDELLA
107 MESAVISTA
SANTA FE, NM
87501

November ___, 2019

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Sincerely,

Joanne O. McColdery

15153

November ___, 2019

By email to: Cody.Barnes@state.nm.us

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Sincerely,

Ada Browne
Santa Fe

15154

November ___, 2019

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Sincerely,

Ron Reini Keinen
1500 Pacheco St #607
Santa Fe NM 87505

November 17, 2019

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Jude Pardee

jude.pardee@gmail.com

November 17, 2019

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Sincerely,

Elizabeth West
(505) 984-1047

15157

From:	mark devolder
To:	Barnes, Cody, NMENV
Subject:	[EXT] DP-1132 Permit for RLWTF: Post-Hearing Comments (Conclusions)
Date:	Monday, November 18, 2019 9:38:34 AM
Attachments:	RLWTF Post-Hearing Comments Conclusions 111819 0a.docx

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Mon 11-18-19 9:36 a.m.

Dear Mr. Barnes:

Attached are a portion of my post-hearing comments related to the DP-1132 Permit for the RLWTF (third installment). There are number of issues which I have attempted to address about the safety of the RLWTF facility and processes. Some of my recollections go back approximately a decade, and my detailed understanding of those issues may not be currently as good as it once may have been. However, I have attempted to be as truthful and accurate as possible given the limited information provided at the DP-1132 Public Hearing on Thursday, 11-14-19. Please consider the comments as preliminary as I have not had time to extensively research most issues.

My concerns (in addition to my principal concern about water issues as they pertain to the rodent population in Los Alamos County) is the availability of useful technical information about the RLWTF and the safety of RWLTF facility and processes. Unfortunately, some of the information, photographs, and diagrams provided during the DP-1132 hearing are sketchy at best. You will note that I repeatedly indicate that information is unknown. However, I filled in the gaps as much as I was able based on my previous experience at LANL.

I updated my background information slightly from the previous submission for the Post Hearing Comments on the SET (same update as supplied in my second installment).

I have McAfee virus protection installed on my home computer.

Regards,

Mark DeVolder
P.O. Box 1155
Los Alamos, NM 87544
(505)-661-8799

To: Cody Barnes, NMED
From: Mark DeVolder, Public
Date: 11-18-19 9:05 a.m.
Subject: RLWTF Facility Post-Hearing Comments (Conclusions)
Computer File: RLWTF Post-Hearing Comments / RLWTF Post-Hearing Comments Conclusions 111819 0a

The following information is provided as post-hearing comments to the DP-1132 Permit Hearing for the RLWTF (Thursday 11-14-19 9:00 a.m. to 5:00 p.m.). The content is preliminary and additional comments (or more detail) will be provided prior to COB 11-8-19.

Background on Mark DeVolder

BSChE University of New Mexico - 1976
Cosden Oil and Chemical - 1976 thru 1977
Stauffer Chemical - 1977 thru 1979
Monsanto Chemical Intermediates - 1980
LANL employee - 1980 thru 2017 (Retired)
LANL Group L-1, Target Fabrication - 1980 thru 1981
LANL Group WX-1, Weapons Engineering - 1981 thru 1989, Work at Y-12 Plant, Rocky Flats Plant / RFP, Nevada Test Site, Q-Security Clearance, SIGMA-Level Security Access
LANL Group NMT-7 - 1989 to 1992 (Supervisor / Recordkeeper), Shipping and Receiving Nuclear Materials, Nuclear Material Blending Operations, Nuclear Material Vault Operations, NMT-7 Personnel Training Records, Personal Security Assurance Program (PSAP)-Certified
LANL Group NMT-8 (TA-55 Facilities Engineering Group) - 1992 to 1993, (Quality Assurance, Configuration Management, NMT-8 Safety Committee)
LANL Groups NMT-8, ADWEM-AB (Authorization Basis), NMT-14 (Safety Basis) - 1993 to 2013, TA-55 Facility Safety Analysis Report (1994), Hazard Analysis and Related Engineering work for TA-55 / RLUOB / RFP, TA-55 Recordkeeping, Guideline: *Design Standards for Integrating Chemical, Metallurgical and Ceramic Processes into Gloveboxes* (Copy to Merrick Engineers), Procedure: *Developing and Maintaining Equipment Data Books*, LANL Conference on Life-Cycle Engineering, System Engineering for 43 TA-55 Systems (Balance of Plant Systems), Recordkeeping for All TA-55 Systems, Personal Security Assurance Program (PSAP)-Certified.
LANL Group ES-55, 2013 to 2017, Recordkeeping for All TA-55 Systems / All RLUOB Systems / Some RLWTF Systems, Project Engineering for TA-55 / RLUOB / RLWTF, Glovebox Design Standards, Close-out of Legacy Engineering Projects (DCPs), Derivative Classifier Certification.

Data to Support Adequacy of Engineering and Administrative Controls for RLWTF Processes

I was depending on information in the NMED Fact Sheet for the DP-1132 to make a final determination on the efficacy of the Engineering and Administrative Controls for RLWTF

processes. It appeared that there was very little useful information to establish the efficacy of the Engineering and Administrative Controls for either the Solar Evaporation Tank (SET) or the Mechanical Evaporator System (MES). Such information might include but is not limited to the following: General Flow Diagrams / Block Diagrams, Process Flow Diagrams (PFDs), Piping and Instrumentation Diagrams (P&IDs), a listing of LANL facilities providing effluents to the RLWTF (that is, partial flows which make up the WMRM influent), chemical and radionuclide composition of influent to the WMRM, detailed descriptions of RLWTF primary and secondary treatment processes (that is, pre-existing processes which will continue to be utilized, proposed processes, and processes which will be decommissioned), Equipment Data Book information (for example, vendor literature on process equipment, capacity information on MES equipment), hazard analyses for processes, annual summaries of and individual Unreviewed Safety Question Determinations or USQDs, operating / inspection / maintenance procedures for processes (for example, procedures for installing gaskets and torquing piping flanges), procedures for related administrative activities (for example, acquisition of chemical samples requiring chemical / radiological analysis), Office of Nuclear Safety documentation (for example, *Operating Experience Weekly Summary* information as it pertains to the LANL RLWTF, DOE Occurrence Reporting information as it pertains to the LANL RLWTF, LANL Title I / Title II / Title III engineering documents for new RLWTF processes and structures, Quality Assurance data on Systems / Structures / Components (SSCs) (for example, design mix information for concrete, data on reinforcing bar, concrete placement information, metal certifications / mill certifications, information on rework, etc.), calculations, seismic calculations / analyses, construction reports, construction photos, etc.). Without such information, there is no way to determine the safety or reliability of the processes proposed for DP-1132 permitting or the adequacy of engineering and administrative controls.

NMED Analysis of Engineering and Administrative Controls for RLWTF Processes to Independently Assure Process Safety

Per the NMED Fact Sheet found on the NMED website, NMED is responsible for assuring the safe operation of the proposed RLWTF processes. There exists a concern on my part that NMED did not provide a sufficient basis for assuring that the processes are safe.

After reviewing the NMED fact sheet, I am also at a loss to understand which if any of the RLWTF processes will be decommissioned and when that decommissioning will occur.

NMED personnel toured the facilities / processes proposed for DP-1132 permitting. However, NMED personnel provided virtually no technical information on the configuration or safety of the facilities or proposed processes during the DP-1132 hearing. Similarly, there was little if any discussion about operating / inspection / maintenance procedures or administrative procedures.

It would appear that NMED has worked well with LANL in the past and trusts the judgement and actions of LANL and DOE personnel. NMED has guidelines for monitoring well configurations. Various requirements for the discharge of treated water effluents are specified in the New Mexico Administrative Code (NMAC). When LANL / DOE work to implement the

guidance / requirements, it probably establishes what NMED perceives as acceptable compliance behavior. However, the lack of technical information about liquid waste treatment processes and specific feedback from NMED personnel on the proposed processes (that is, NMED tour reports of facilities / processes and NMED reports on the efficacy of engineering and administrative controls) begins to show a certain lack of independency from LANL / DOE. If it is the responsibility of NMED to assure that the operation of the proposed RLWTF processes is safe, there was insufficient evidence presented during the DP-1132 hearing to confirm that the necessary technical information was made available by LANL / DOE to complete an adequate safety assessment and that NMED thoroughly evaluated such information (for example, the previously listed technical information related to engineering and administrative controls).

WMRM

It would appear that the influent from the WMRM is gathered from upstream LANL (radiological / other) facilities and processes. (Note: There is some confusion on my part about Low Level Liquid Waste (LLLW) which I thought was processed by the RLWTF and other terms such as Transuranic Waste [Transuranic Liquid Waste], LLLW Facilities, and TRU Waste Facilities. It would be helpful as a member of the Public if I had a better understanding of this terminology as it relates to LANL liquid waste streams and facilities.) Lacking any detailed information and trying to decode the vague information provided in the NMED fact sheet, it appears that influent from the WMRM is fed to a variety of parallel waste treatment processes (or a sequence of primary and secondary waste treatment processes). There may be interim tank storage of treated effluent from the various processes. The stored effluent may be sampled and analyzed to determine if further processing is needed to remove additional chemical and / or radiological contamination in order to meet discharge limits. If discharge limits are met, then treated effluent in some type of interim storage tank may be routed to Outfall 051. It is unknown how much additional treatment is required to meet discharge limits (that is, internal recycling of treated effluent or distribution to various waste treatment processes). It is unknown if there is any mixing or blending of treated waste effluent and how this effort might be accomplished. It is unknown if there are any radioactive solids which are extracted from the liquid waste streams and how those solids are processed further downstream. (Note: There is mention of a filtration process in the NMED Fact Sheet.) This may account for the separation of radioactive solids (from radioactive liquid wastes) and designated as TRU solid waste which may be packaged in drums and shipped to WIPP. The scope of the TRU waste would seemingly be outside of the scope of the DP-1132 Permit effort for the RLWTF. However, it may be that the Mechanical Evaporator System (MES) has the potential of creating TRU solids during operation. Again, this points to the need for Process Flow Diagrams, Piping and Instrumentation Diagrams, and Process Descriptions to establish what the feedstocks (influents) and products are associated are from various RLWTF processes. The monitoring wells help to confirm that effluent from Outfall 051 was properly analyzed prior to release and that process upsets / transients / emergency situations / conduct of operations issues (for example, improper valve line-ups), or maintenance issues (for example, internally leaking valves) did not somehow corrupt the release and or quality of treated effluents which were supposed to be within discharge limits. Most of this is conjecture on my part. To the Public, such processing might seem bewildering; however,

such recycling / blending operations are quite common and useful in the refining and chemical processing industries (CPI). It is clear that RLWTF personnel at LANL, DOE personnel, and NMED most likely have a much better understanding of the RLWTF operations having monitored those operations for some number of years. It is disappointing that the processing methodology cannot in some manner be conveyed in a logical and understandable manner to the Public. This would allow for better and more informed decision making as well as improved confidence by the Public in the safety of the facilities as well as safe operating and maintenance practices deemed necessary by LANL, DOE, and NMED.

Monitoring Wells

One of the LANL technical experts who attended the DP-1132 hearing indicated (after the hearing proceedings) that rodents had inundated one (or more) of the monitoring wells. The extent and damage of the infestation was not provided. No information on clean-up of the monitoring well or remediation of the monitoring well issue was provided. The LANL representative also indicated that a program is in place for addressing the rodent issue. It is disturbing that the water monitoring wells, which contain sensitive monitoring equipment and/or instrumentation, are not sufficiently robust in configuration to exclude rodents and rodent detritus as well as prevent rodent attack (for example, chewing on cables / cable insulation / other materials). Without any detailed information on the rodent infestation and information on the rodent exclusion program, it is difficult to ascertain the impact on the monitoring well equipment / instrumentation, the validity / integrity of the monitoring well data, or the duration that monitoring well data may have been corrupted. (Note: Redundant monitoring wells may help to offset this concern.) If the monitoring well equipment / instrumentation were properly designed, there would not have been any rodent intrusion / infestation. The same may apply for insect intrusion / infestation. It would appear that NMED, LANL, and DOE need to work jointly on the issue of rodent (insect) intrusion/infestation and work on amending and updating the monitoring well guidelines to assure that the monitoring well data obtained in the future is accurate.

(Note: My entire reason for attending the DP-1132 Permitting Hearing for the RWLTF was due to my concern about rodent infestation issues in and around Los Alamos County. It is my understanding (from Los Alamos County maintenance personnel working to clean debris out of below-grade water meter enclosures) that the infestation of gophers, ground squirrels, mice, etc. is different in Los Alamos than in White Rock where infestations do not occur. Water released to the Los Alamos ecosystem contributes to the growth of such species as scrub oak which is a nesting material and food for gophers. It appears that ground squirrels are miners who create underground tunnel networks and transfer dirt and tuff substances to below-grade Los Alamos County water meter enclosures. Mice and gophers are nest builders that infest various unprotected enclosures. Mice and gophers are able to squeeze through openings which are smaller than their normal body size. Mice and gophers also vary in size according to their age.)

A Properly Informed Public

Due to a lack of comprehensive and understandable (transparent) information related to the RLWTF (obviously a "complex facility"), the information presented in the DP-1132 hearing is of limited use to the Public. Without detailed information, the Public is unable to do much if any critical thinking and make any reasonable assessment of either the liquid waste management processes, the arrangement of those processes, or the safety of the processes.

LANL / DOE Defensiveness

It is disturbing to hear anything about information being removed from Public records. It was disturbing that witnesses providing testimony supportive of LANL / DOE positions appear to have been coached and their presentations scripted to minimize the amount of information presented at the hearing. It was disturbing to see the tightly knit group of LANL / DOE attorneys and witnesses walking / moving / conversing as a block during and after the hearing. During the DP-1132 hearing proceedings, The LANL/DOE witnesses seemed to be looking at the LANL/DOE attorneys as if the witnesses wanted some kind of guidance or approval on how they should answer questions. For such qualified witnesses, it was disturbing in some instances how little they seemed to know when asked questions about their area of expertise.

Photographic information and diagrams were minimal. (Note: I can get more information in the way of photographs while trying to purchase a $10 item on eBay than I got at the DP-1132 hearing for a "complex" nuclear facility.)

It was particularly disturbing to hear LANL attorney objections raised about seismic-related issues. The attacks of the LANL attorney on Ms. Arrens (Ehrens?) was particularly disturbing given that most of hear testimony seemed to have a considerable credibility. For a witness who is a lawyer and not "a geologist" or "engineer", Ms. Arrens seemed to convey a good deal of reasonable and useful information about how nuclear facilities need to be constructed (that is, proper anchorage of equipment, secondary containment, drainage sumps, etc.). This is the kind of information which begins to give me some confidence in the safety of a nuclear facility and the processes found in a facility such as the RLWTF.

I have experienced seismic events in both New Mexico and San Francisco. It was momentarily much like being on a boat in a surrounded by turbulent water in a lake or at sea (that is, turbulent water with a vertical and a horizontal impulse or movement). I have also seen videos footage of earthquake events in a retail store, shaker table videos of 3- and 5-level building models which resonated at different frequencies. I have read internet documentation on earthquake destruction in California and Japan and read DOE guidance on best practices for seismic design in DOE facilities. I am familiar with the concept and design of both longitudinal and transverse piping supports and also recognize the contribution they make to the safety of facility piping installations. I have retrieved and studied Larry Goen's (LANL Engineering Division Leader who prepared seismic documentation - Seismic Calculations / Diagrams / computer runs for

TA-55 systems) seismic reports, repeatedly provided tours and information to LANL / contractor personnel tasked with seismic analysis responsibilities at LANL, and researched LANL records to find specific information to support seismic analysis efforts. Although I am not a qualified structural or seismic engineer, I have been repeatedly involved in seismic-related analysis efforts and understand the need of such efforts in relationship to both reactor and non-reactor nuclear facilities. The LANL and DOE attorney's contention that such information should be removed from DP-1132 hearing records and attacks upon Ms. Arrens' testimony at the DP-1132 hearing leaves me wondering why they would not be more supportive of hearing the witness's comments – particularly if the goal of LANL and DOE is to construct, operate, and maintain a "safe" facility. The same seismic information would also empower NMED in their role to assure the "safety" of RLWTF processes. (Note: I would be unhappy if my post-hearing comments on potential seismic sloshing of effluent in the SET was removed from the hearing testimony.)

After viewing photographs presented at the DP-1132 hearing and listening to Ms. Arrens' testimony, I did not see much evidence of seismically-qualified anchorage of equipment at the RLWTF or piping fitted with either longitudinal or transverse seismic bracing. Additionally, I am at a total loss as to how the evaporator equipment in the Mechanical Evaporator System (MES) and the plastic tent surrounding that equipment is provided with any kind of anchorage feature (that is, anchorage to a either a concrete pad or asphalt located below the plastic tent).

Interactions with Lance Plater

When I worked in the NMT-14 Safety Basis Group, I shared an office with Lance Plater. Lance was assigned to prepare Unreviewed Safety Question Determinations (USQDs) for the RLWTF. Like most people who share an office, we talked about our respective work.

I have received training over a period of many years, have prepared USQDs myself, and recognize the importance of the documentation in preserving the safety envelope for a nuclear facility.

I worked with Lance at a time when LANL was tasked with coming up to speed with acceptable Conduct of Operation (for example, proper process valve line-ups, shift change overs, etc.), Conduct of Maintenance, and Conduct of Engineering practices for LANL nuclear facilities. Lance would often come into the office with some RLWTF issue which required an immediate response. One or more times, an "as-found condition" was discovered where equipment not approved for installation by the DOE had already been installed. This is not unusual in any kind of DOE nuclear facility. Sometimes there were procedural compliance issues which required preparation of a USQD.

Over-all I got the impression from that there where many ongoing safety-related issues for the older RLWTF where processes had continually been upgraded since the facility was originally constructed.

Around the same time frame, I can also recall that there were numerous LANL / DOE discussions about seismic-related issues for the facility, the inadequacy of the RLWTF building to meet current seismic requirements, and the need to construct more modern liquid waste treatment facilities which would meet current and more rigorous seismic requirements (that is, more rigorous requirements than the original requirements when the facility was originally constructed), and the availability of funding (or lack of funding) to construct new liquid waste treatment facilities.

In addition, Lance had a flow diagram of the RLWTF hanging on the wall of our office. The information on the diagram coincided with the testimony provided by Ms. Arrens' at the DP-1132 hearing (that is, there are many tanks in the facility). In addition, the diagram showed the shape of tanks. I can recall approximate length to diameter ratios for the tanks. The diagram also showed a complex piping network associated with the tanks. I have also toured portions of the RLWTF and have some rudimentary understanding of the activities performed there.

Waste Minimization

What I would like to see at LANL and the RLWTF is a gradual decrease in the release of chemicals, radionuclides, and particularly water to the environment. Reducing water to the environment would help to reduce the growth of food available for rodents which in turn may help to reduce the rodent population.

The operation and maintenance of upstream facilities of the RLWTF is extremely important to help reduce the introduction of chemicals, radionuclides, and water to the environment as well as reduce the burden of solid wastes sent to WIPP. Minimizing the potential for fires and preventing water leaks in upstream facilities is extremely important. Reducing the potential for fires in all radiological facilities reduces the potential for generation of contaminated fire protection water which ultimately goes to the RLWTF for treatment.

Historically, LANL has provided training to employees on Waste Minimization and this is a good practice. LANL also provides Pollution Prevention Awards. However, the over-all waste minimization effort is voluntary and implementation is a personal choice. This is where LANL management at all levels needs to step in and strongly advocate for the waste minimization effort and champion this effort tirelessly.

To minimize water going to the environment, some attention should be given to the issue of landscaping (that is, the planting of trees and shrubs) which may be part of the new construction projects. I see no conflict if LANL chooses to move pre-existing landscaping materials elsewhere from the 44 square mile LANL site to other LANL site locations. This should be accomplished with some discretion as rodents tend to thrive better in the Los Alamos ecosystem than in lower elevation ecosystems such as White Rock.

During WWII, the Japanese did a lot with a little. LANL should do the same if possible. This is primarily the result of dedication and hard work. Americans worked pretty hard during WWII also.

During WWII, Manhattan Project personnel would work night and day to solve tough technical problems. This work ethic carried on after WWII. Rick Hemphill, a supervisor at LANL, recently told me that the expectation has always been that LANL employees would work 50 or more hours per week. He indicated that in recent years LANL employees are good at working 40 hours per week. This takes me back to the issue of dedication and hard work, which is the only way to stay on top of the waste minimization effort.

Following LANL procedures, minimizing process upsets, spending funds wisely, and ensuring facility problems are quickly identified / repaired is very important. This takes dedication, thinking outside the box, and avoiding an attitude of "that is not my problem." If a person works for LANL, then it is their problem. It is also their responsibility to themselves, their families, and the Public.

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From:	mark devolder
To:	Barnes, Cody, NMENV
Subject:	[EXT] Retransmittal: DP-1132 Permit for RLWTF: Post-Hearing Comments (History / Other)
Date:	Monday, November 18, 2019 3:00:22 PM
Attachments:	RLWTF Post-Hearing Comments History 111819 0a.docx

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Mon 11-18-19 2:58 p.m.

Dear Mr. Barnes:

**I am transmitting my input again because the font type on my Microsoft Word file was corrupted.

Attached are a portion of my post-hearing comments related to the DP-1132 Permit for the RLWTF (fourth and final installment). The information provided includes my initial pre-hearing notes as well as information developed after the closure of the hearing on Thursday, 11-14-19. Please consider the comments as preliminary as I have not had time to extensively research most issues.

I updated my background information slightly from the previous submission for the Post Hearing Comments on the SET (same update as supplied in my second installment).

I have McAfee virus protection installed on my home computer.

Regards,

Mark DeVolder
P.O. Box 1155
Los Alamos, NM 87544
(505)-661-8799

To: Cody Barnes, NMED
From: Mark DeVolder, Public
Date: 11-18-19 2:42 p.m.
Subject: RLWTF Facility Post-Hearing Comments (Historical / Other)
Computer File: RLWTF Post-Hearing Comments / RLWTF Post-Hearing Comments History 111819 0a

Reference 1: Morris, Edmund. Theodore Rex. New York. Random House. 2001. (Note: Theodore Roosevelt presidency.)
Reference 2: Liker, Jeffrey. *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*.

The following information is provided as post-hearing comments to the DP-1132 Permit Hearing for the RLWTF (Thursday 11-14-19 9:00 a.m. to 5:00 p.m.). The content is preliminary and additional comments (or more detail) will be provided prior to COB 11-8-19.

Background on Mark DeVolder

BSChE University of New Mexico - 1976
Cosden Oil and Chemical - 1976 thru 1977
Stauffer Chemical - 1977 thru 1979
Monsanto Chemical Intermediates - 1980
LANL employee - 1980 thru 2017 (Retired)
LANL Group L-1, Target Fabrication - 1980 thru 1981
LANL Group WX-1, Weapons Engineering - 1981 thru 1989, Work at Y-12 Plant, Rocky Flats Plant / RFP, Nevada Test Site, Q-Security Clearance, SIGMA-Level Security Access
LANL Group NMT-7 - 1989 to 1992 (Supervisor / Recordkeeper), Shipping and Receiving Nuclear Materials, Nuclear Material Blending Operations, Nuclear Material Vault Operations, NMT-7 Personnel Training Records, Personal Security Assurance Program (PSAP)-Certified
LANL Group NMT-8 (TA-55 Facilities Engineering Group) - 1992 to 1993, (Quality Assurance, Configuration Management, NMT-8 Safety Committee)
LANL Groups NMT-8, ADWEM-AB (Authorization Basis), NMT-14 (Safety Basis) - 1993 to 2013, TA-55 Facility Safety Analysis Report (1994), Hazard Analysis and Related Engineering work for TA-55 / RLUOB / RFP, TA-55 Recordkeeping, Guideline: *Design Standards for Integrating Chemical, Metallurgical and Ceramic Processes into Gloveboxes* (Copy to Merrick Engineers), Procedure: *Developing and Maintaining Equipment Data Books*, LANL Conference on Life-Cycle Engineering, System Engineering for 43 TA-55 Systems (Balance of Plant Systems), Recordkeeping for All TA-55 Systems, Personal Security Assurance Program (PSAP)-Certified.
LANL Group ES-55, 2013 to 2017, Recordkeeping for All TA-55 Systems / All RLUOB Systems / Some RLWTF Systems, Project Engineering for TA-55 / RLUOB / RLWTF, Glovebox Design Standards, Close-out of Legacy Engineering Projects (DCPs), Derivative Classifier Certification.

Excerpts from Reference 1

p. 486 There had been *Forest Conservation* and *Water Conservation* in his [Theodore Roosevelt's] first message [to Congress], …

p. 486 … a writ preaching the common sanctity of wood and water and earth and flora and fauna…

p. 486 … purging the countryside of pollution, …

p. 495 … he [Theodore Roosevelt] resumed his … …reading of Guglielmo Ferrero's five volume *The Greatness and Decline of Rome.* He was struck by the similarity of many conditions endemic to ancient imperial and modern industrial civilizations.

p. 496 One thing the Romans had understood very well was the role of fresh water in sluicing, sanitizing, irrigating, and beautifying both landscapes and townscapes. Old Father Tiber had been the *fons et origo* of a spreading web of canals, viaducts, underground pipes, and fountains that linked communities more effectively than any system of law.

p. 515 Theodore Roosevelt hosts the first conservation conference, May 1908.

My Comment: Governors from all over the United States attended the conference.

p. 517 … he (George Washington] had seen clearly that the future of the United States could be linked in perpetuity only by a common power network. To that end, the Father of the Country [George Washington] had pressed for, and brought about, an interstate waterways conference between Virginia and Maryland.

p. 517 He [Theodore Roosevelt] proceeded to catalog the irresponsibility; with which Americans, over more than a century and a quarter, had successively abused water, mineral, and forest resources.

p.517 The pristine waterway scheme of the Founding Fathers was now neglected, underused, and ill managed. The "soils of unexampled fertility" that had greeted pioneer farmers were leaching away through ignorance, washed into the streams, polluting the rivers, denuding the fields, and obstructing navigation."

Initial Comments Developed in Preparation for the DP-1132 Permit Hearing on the RLWTF and Other Comments

The Hudson River in New York was badly polluted. New York State passed laws that led to positive pollution practices (that is, the quality of water returned to the River after industrial use had to be better than the quality of the water extracted from the river initially).

Assurances and hazard analyses are not a guarantee that chemical, radiological, and water releases will not occur to the environment.

It is recognized that there are issues with high-silica content (water hardness) in water supplied to Los Alamos County residences and businesses. If water hardness adversely affects plumbing in Los Alamos residences and businesses, similar issues may affect the RLWTF (for example, adverse effects on instrumentation and the inability to adequately shut-off / seal facility valves).

In 1994, George Werkema (DOE) came to LANL TA-55 to discuss the Authorization [Safety] Basis. He indicated that LANL personnel should look for "weaknesses" in Plant, Paper, and People. I take this to mean Plant [facilities and processes or Structures / Systems / Components], Paper [Procedures], and People [LANL Managers / LANL Employees, Contract Personnel, DOE Personnel, Regulatory Personnel including EPA and NMED, and the Public].

The only way to eliminate contamination is to totally eliminate the discharge to the environment. Given the problem in Los Alamos County with rodents, part of me wants to completely eliminate all discharges including any discharges of any amount of water. However, this could potentially have adverse impacts on LANL, northern New Mexico, and the Country. The only possible path forward is to steadily decrease the discharge to the environment of any and all chemicals, radionuclides, and water itself as much as possible over a reasonable period of years and/or decades. It is hoped that continued research, improved science and engineering technology, improved operation / maintenance practices, worker training, and attention to optimal waste minimization practices will help to achieve complete or near-complete release of all chemical, radionuclide, and water discharge to the environment. It goes without saying that this also applies to some extent to sanitary waste discharges to the environment.

Any improvements in litter control (food wrappers discarded by LANL employees or which blowout out of LANL employee-owned vehicles) would be helpful. A reduction in any of the following: creation of food-related trash / garbage, discard of food-related trash / garbage in LANL-provided receptacles, generation of food scraps from food preparation efforts at LANL, creation of items for food events at LANL (for example, potlucks and charity-related events) would help to minimize rodents issues at LANL and in Los Alamos County. Discarded food items and washing of food containers might be better done at home if LANL employees do not reside in Los Alamos County or live in White Rock where there are fewer rodent issues.

Following the guidance in the Book *The Toyota Way* (Reference 2), (that is, error-proofing processes might help to improve the operation and safety of RLWTF facilities and processes.

Perhaps it is too late at this point in time, but the Solar Evaporation Tank (SET) should not have been designed as a single tank. It should have been designed as a waffle tank (perhaps consisting of 6 to 8 sub-tanks). This would eliminate the need to drain the entire tank if there is a leak, would permit inspections, maintenance, and removal / replacement of individual sub-tank liners as needed. This would also allow for continued operation of the majority of sub-tanks comprising the SET.

Sugary solutions and residues contained beverage containers found in recycle bins at LANL are a source of nutrition for rodents.

Landscaping trimmings from LANL which may or may not be routed to the Los Alamos Ecostation are also a source of nutrition for rodents. Within the past two weeks I noticed a deer at the Ecostation munching on greenery in one of the discard piles. Perhaps rodents are performing their eating and food collection rituals at night.

I would appreciate any techniques which help to effectively manage the rodent population in Los Alamos County as long as such techniques are implemented in a manner which preserves the delicate balance of the Los Alamos County ecosystem.

I appreciate the opportunity that the DP-1132 Permit Hearing for the RLWTF afforded to express my concerns and opinions. Hopefully, my input will have a positive impact on managing the rodent population in Los Alamos County.

November 18, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon, and through groundwater to the extensive spring system at the Rio Grande.

In 1998, LANL stated it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection for human health and the environment than the proposed groundwater discharge permit under the NM Water Quality Act, including

- enhanced public participation and oversight, such as a Class 3 permit modification process for the new, multi-million dollar low-level radioactive waste treatment facility;
- enhanced seismic requirements that would address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers.

Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

Elliott Skinner

November 18, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
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Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

Linda Hibbs

November 18, 2019

By email to: Cody.Barnes@state.nm.us

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c/o Cody Barnes, Hearing Clerk
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Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

Patricia Padilla

November 18, 2019

By email to: Cody.Barnes@state.nm.us

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Sincerely,

Marlene Freelove

November 18, 2019

By email to: Cody.Barnes@state.nm.us

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c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
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WQCC No. 18-05 (A) and GWB 19-24 (P)

Dear Hearing Officer Virtue:

I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon, and through groundwater to the extensive spring system at the Rio Grande.

In 1998, LANL stated it would transition the RLWTF to a zero discharge facility. In November 2010, discharges through Outfall 051 stopped. LANL began to use a mechanical evaporator system. If there is no discharge, no groundwater discharge permit may be issued.

As a result, the NM Hazardous Waste Act must regulate the RLWTF. That law provides more protection for human health and the environment than the proposed groundwater discharge permit under the NM Water Quality Act, including

- enhanced public participation and oversight, such as a Class 3 permit modification process for the new, multi-million dollar low-level radioactive waste treatment facility;
- enhanced seismic requirements that would address recent (1,400 years ago) surface rupturing earthquakes on the Pajarito Plateau, where LANL is located; and
- protections for the tank systems that are used to treat the contaminated waters, including inspections and reviews by qualified Professional Engineers.

Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

November 18, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments about draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory
WQCC No. 18-05 (A) and GWB 19-24 (P)

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I oppose the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the 56-year old Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). Since 1963, hazardous waste has been handled, managed, treated, and stored at the RLWTF. Over this time, millions of gallons of treated hazardous and radioactive waste has been discharged through Outfall 051 into Effluent Canyon, which flows into Mortandad Canyon, and through groundwater to the extensive spring system at the Rio Grande.

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Please recommend to the NMED Secretary that he **deny** the draft permit and require LANL to apply for a Hazardous Waste Act permit for the RLWTF. Future generations will thank you. Your careful consideration of my comments is greatly appreciated.

Sincerely,

Catherine Colby

November 18, 2019

By email to: Cody.Barnes@state.nm.us

Richard L. C. Virtue, Hearing Officer
c/o Cody Barnes, Hearing Clerk
Office of Public Facilitation
New Mexico Environment Department
P.O. Box 5469
Santa Fe, NM 87505

Re: Public Comments by Citizens for Alternatives to Radioactive Dumping (CARD) on the DP-1132 discharge permit for the Radioactive Liquid Waste Treatment Facility at Los Alamos National Laboratory (GWB 19-24 [P])

Dear Hearing Officer Virtue:

CARD opposes the issuance of the New Mexico Environment Department's (NMED) draft Groundwater Discharge Permit (DP-1132) for the Radioactive Liquid Waste Treatment Facility (RLWTF) at Los Alamos National Laboratory (LANL). These comments, or written statement, will look at both the permit and the RLWTF as well as at the public process for this discharge permit.

The Facility and the Discharge Permit

In 1998, LANL said it would transition the RLWTF to a zero discharge facility and in 2010, all discharges through Outfall 051 ceased. At that time, LANL began to use a Mechanical Evaporator System (MES). Since then, all waste has been treated by evaporating the liquids and shipping any remaining hazardous, radioactive or mixed waste materials off-site for disposal. Despite NMED's recent release of non-contaminated water, true to NMED's statements in 1998 and 2010, no real discharge through Outfall 051 has occurred in almost ten years. Even the current fact sheet describes the new Solar Evaporative Tank (SET) as a zero-liquid-discharge unit, even though it has yet to begin operations.

Though the Fact Sheet claims the draft permit authorizes the discharge of treated water "via the Mechanical Evaporator System (MES) and the SET," in fact, the permit actually talks of discharges "to" these units instead of "via" them, as liquids are not expected to come out of them. The MES has been used exclusively for nearly ten years and during that time there has been no discharge from that unit.. The current "fake discharge" only points out that such a release is not part of any regular process currently being used at the Facility.

Thus, DP-1132 is also a "fake permit" because there is no discharge, hasn't been one in nearly ten years and there are no plans to discharge ever again as part of any process currently going

on at the Facility. The Facility, the so-called discharge, and the permit are all extremely controversial and have been for over two decades. As time passes, trying to claim that there is a discharge from the RLWTF becomes less and less viable. Releasing water through Outfall 051 before the permit hearing, only shows how desperate the Applicants (Department of Energy and Triad National Security, LLC) and NMED have become in trying to prove this Facility shouldn't be permitted and regulated under the New Mexico Hazardous Waste Act. Yet, that is really the only viable alternative. This Facility must be regulated under the Resource Conservation and Recovery Act (RCRA) and the Hazardous Waste Act as this is, a storage and treatment facility; there is no discharge. The DP-1132 permit application must be denied and the NMED Secretary must require LANL to apply for a Hazardous Waste Act permit for the Facility instead.

The Public Process for DP-1132

Unfortunately, the public process for DP-1132 has suffered from many of the same ills as have been evident in other recent (and past) discharge permit processes in the Ground Water Quality Bureau (GWQB). The Public Involvement Plant (PIP) for the permit is inadequate, both public notices are defective and the Fact Sheet, though including some additional information, is more a fact sheet about what is required for permits in the regulations than about what important and vital information is actually in this particular permit.

This public process has not identified all communities potentially affected by the proposed permit, nor has it accommodated the needs of those communities, statements in the PIP and the public notices notwithstanding.

Defective Public Involvement Plan (PIP)

The PIP states on page 1 that it "implements the "elements set for in the *[Public Participation] Policy,*" but the lack of any public involvement in the Public Involvement Plan has resulted in a defective PIP and misunderstandings about where the affected communities are and those communities' needs and concerns. CARD incorporates the January 19, 2017 Resolution Agreement between NMED and the U.S. Environmental Protection Agency and three implementing policies (public participation, limited English proficiency, and non-employee disability) into these comments. (https://www.env.nm.gov/general/epa-and-nmed-informal-resolution-agreement-no-09r-02-r6-public-participation-limited-english-proficiency-and-non-employee-disability-policies/)

There is also no information for the general public on how to appeal or revise the PIP and no clear path to request corrections, make suggestions, or provide community-based, local input. Thus the public continues to be shut out of any meaningful involvement in the Public Involvement Plans, problems continue, and the PIPs, including this one, are of only limited use.

1. Improper use of EJSCREEN: The GWQB has arbitrarily and capriciously used a 4-mile

radius in this PIP as the limits of where they will look to find the affected community. Use of such a radius has allowed the PIP to state that there are virtually only wealthy, highly educated, White people who speak English well in the affected community. Indeed, Los Alamos County is the wealthiest county in the entire country. At 4 miles the demographic percentages are:

Percentage minority population	27%
Percentage Hispanic population	17%
Percentage of American Indian population	1%
Percentage of persons speaking English "less than very well"	4%
Percentage of linguistically isolated households	3%
Percentage of households with $75,000+ income	69%
Percentage of households with less than $15,000 income	7%
Percentage with Bachelor's Degree or more	64%
Per capita income	$45,945.00

However, going out to a 30-mile radius shows quite different results:

Percentage minority population	64%	237% increase
Percentage Hispanic population	53%	312% increase
Percentage of American Indian population	7%	700% increase
Percentage of persons speaking English "less than very well"	9%	225% increase
Percentage of linguistically isolated households	4%	133% increase
Percentage of households with $75,000+ income	37%	54% decrease
Percentage of households with less than $15,000 income	14%	200% increase
Percentage with Bachelor's Degree or more	38%	59% decrease
Per capita income	$33,408.00	73% decrease

Going out to just 30 miles massively increases both the Hispanic and Native American populations. The number of potentially affected pueblos increases from one (Pueblo de San Ildefonso) to around eleven and Native American percentages go up 700%. The Hispanic population goes up more than 300%; the percentage of persons speaking English less than very well more than doubles, the percentage of households earning less than $15,000 per year

doubles; and the percentage of people with a BA or more decreases by almost half. The actual affected population is heavily minority, speaks English less well, is less educated and most earn far less money than those living within the 4-mile radius.

The GWQB has given no justification for choosing only a 4-mile radius in their EJSCREEN calculations and indeed there is no justification. Did the Bureau even look to see what the situation was beyond 4 miles? The choice of such a limited radius is shocking since there are many people in the Bureau who have lived in the area for years and are completely aware of the demographic makeup of the population beyond the 4-mile radius.

In addition, the Bureau cannot argue that the discharge (if there were a discharge) from the Facility could only affect people and the environment within the 4-mile radius. Agricultural land in Española worked by one of the Parties, Tewa Women United, and irrigated traditionally using Rio Grande water, has been highly contaminated because of discharges from LANL in the past. As the attached study, *Red Dust,* concludes in its 2013 abstract,

> *These findings indicate that LANL has polluted the lands inhabited by Indigenous communities. The nature and high levels of contaminants has also created an area in which health disparities are disproportionately high.*

There is even a suggestion in the study that dark leafy greens grown on this land with that water would be better used as soil remediation and then discarded in a hazardous waste dump than eaten. Clearly, discharge from the RLWTF could reach far beyond the 4-mile limit.

One wonders if GWQB personnel have been properly trained in using EJSCREEN. EPA's *EJSCREEN Fact Sheet* (attached) describes how EJSCREEN can be used "...to identify areas that may have higher environmental burdens and vulnerable populations..." not to limit investigation only to the wealthiest county in the country. The *Fact Sheet* specifically states that EJSCREEN shouldn't be used **"[a]s the sole basis for ... making a determination** regarding the existence or absence of EJ concerns..." (emphasis added), and that EJSCREEN outputs should be supplemented "...with additional information and local knowledge..." Yet using it as the sole basis for making their determination is exactly what the GWQB have done. The *Fact Sheet* also states that there is "...substantial uncertainty in the EJSCREEN demographic and environmental data, particularly when looking at small geographic areas..." Surely, this is perfectly illustrated by the differences in data found at 4 miles and 30 miles.

By ignoring the large numbers of people of color in the affected communities, NMED and the GWQB can have no understanding of the needs and concerns of these communities nor can they create adequate planning for public outreach to the communities. The only public outreach NMED has done is the minimum required by the regulations—and there is some question if even this minimum outreach has been achieved.

Community needs and concerns, including health needs, have not been incorporated into the draft permit nor into the public participation process—indeed they have not been investigated

at all even though NMED pledged that they would review community history, demographics, needs and concerns when they signed the Resolution Agreement. And though the PIP states it will include "a description of community/stakeholder groups..." again, the GWQB base this totally on the EJSCREEN preliminary results – preliminary results that have now become final results. There are no community stakeholder groups described in the PIP other than various government entities. The GWQB have made no effort to identify stakeholders in the affected communities nor any effort to create partnerships with private and public entities or to share information with affected communities, with environmental and environmental justice organizations, religious institutions, ditch associations, environmental, law and health departments at colleges and universities, and relevant community service organizations as federal guidance describes and the Resolution Agreement requires.

2. Limitations on LEP and the Disabled: Neither the *Public Participation Policy* nor the *Disability Policy* put financial or time limits on what NMED is required to do to make it possible for people with disabilities to have "...the opportunity for full participation in its ... actions," Indeed, the *Disability Policy* states that "NMED will provide, **at no cost to the individual** appropriate auxiliary aids and services including, for example, qualified interpreters to individuals who are deaf or hard of hearing..." (emphasis added). Yet the PIP states on page 2 that "accommodations or services for persons with disabilities will be arranged to the extent possible."

Limitations are also put on language assistance for Low English Proficiency (LEP) speakers as the PIP allows language assistance only "...as resources allow." LEP hearing-impaired callers are not even told that they can use a Spanish version of TDD or TTY systems. Only public comment notices and hearing notices are planned to be translated into Spanish and then only because of LANL's statewide significance. Fortunately, NMED also translated the Fact Sheet into Spanish, but this wasn't planned for in the PIP.

3. Notification: It is unclear if the notification process described on page 6 of the PIP was carried out adequately for public comment as the description of who will be noticed and how is vague and incomplete. Were Tribes, Pueblos and Sovereign Nations actually mailed notices? What about other government entities? Acequia and ditch associations are not even mentioned in the PIP though they are listed for notification in the regulations. This missed requirement is especially significant as one of the parties is an acequia association, the New Mexico Acequia Association.

Defective and Misleading Public Notices

Unfortunately, both public notices are also defective since information required by either the PIP or the regulations themselves is missing and the public notice continues to make incorrect claims that all communities potentially affected by the permit have been identified and that public participation has been expanded to accommodate community needs.

1. Defective PN-2 - missing & incomplete information: The PIP says there will be a statement on every public notice about the availability of language assistance, however, nothing at all about it has been incorporated into this public notice. And at 20.6.2.3108 (I) NMAC, the regulations require that a description of the procedures to be followed by the Secretary in making a final determination be included in every PN-2, but that is completely missing also.

The description of the activities leading to the discharge, contact information, location of the discharge, depth to affected groundwater and TDS are all nicely included in this public notice. However, the description of the quality of the discharge is lacking. Though we are told that the discharge could contain "...contaminants with concentrations above the standards of the regulations and that it may contain toxic pollutants," the public is not given any list of the contaminants or even of the types of contaminants. That is necessary if the public is to understand fully what is involved in this discharge so they can evaluate if the permit will be able to protect our groundwater adequately.

2. Defective Hearing Notice - missing, incorrect & incomplete information: Despite regulatory requirements to explain hearing procedures (20.6.2.3108 (L) NMAC), and further requirements to let the public know how to submit comments (20.6.2.3108 (F) NMAC), the public is only told they can submit oral or written statements at the permit hearing itself. In fact, written statements or statements of interest are accepted during the 30-day pre-hearing period and until the hearing is closed. However, the public is not told how or to whom we can submit these statements. We are referred to the hearing procedure regulations at least twice in the hearing notice, but this is insufficient as LEP persons can't access them at all and even the general public must have excellent English, good computer skills and excellent online search skills to find this one small statement in the regulations. This is not okay, especially since the Bureau has been told, at length, about this problem during the controversial Waste Control Specialists (WCS) ground water discharge permit (DP- 1817) process.

In addition, the hearing notice contradicts the PN-2 when it states on page 2 that the discharge "...will meet all numerical groundwater standards identified in 20.6.2. NMAC." In contrast, the PN-2 states "the discharge may contain water contaminants with concentrations above the standards ... and may contain toxic pollutants ..." Which is correct?

The hearing notice includes good information on the location of the discharge and the activities that contribute to the discharge as well as good information on the volume, depth to groundwater, and TDS concentrations.

And finally, a partial list of contaminants is provided. However, again the GWQB have left off mentioning all the radionuclides that could be in the discharge. Though NMED claims they don't need to describe anything they don't regulate (like transuranic (TRU) radionuclides, such as plutonium, americium, etc.), there is no such prohibition anywhere in the regulations. Since TRU waste is a primary component of the waste treated at the Facility, it is inappropriate for NMED to eliminate this information from public notices. Without complete information on everything that could or will be in the waste, the public cannot properly evaluate whether or not the permit is adequately protective.

3. Defective Hearing Notice - inadequate assistance notification: The public notice only makes the barest mention that people can request language assistance. It doesn't copy the language of the PIP that describes the possibility of document translation so people don't even know that is a possibility. People requesting assistance are told to contact the permit contact. However, all phone voice mail at NMED is English-only. And though information is given about requesting disability assistance, TTY information is also English-only, as once again the notice follows the PIP and leaves out any mention of the TTY Spanish option mentioned in the PN-2.

Defective Fact Sheet

Like many of NMED's permit fact sheets, this one is greatly flawed. Most of the public who participate in the permitting process never read the permit or other documents beyond public notices and, if provided, a fact sheet. The Fact Sheet should summarize and supplement the permit and should contain all vital information in the permit. The permit is far too long to be translated in its entirety, even if NMED were willing to do so. A good fact sheet is one of the best ways to involve the public whether it is the general public, the Minority public, or those needing disability or language assistance. A translated fact sheet is, in fact, the only way to provide enough vital information to the LEP public for them to be able to participate fully and equally in the permitting process, as the minimal information in even expanded public notices is inadequate for this. The English speaking public can always read the permit itself or the regulations. The LEP public cannot.

Unfortunately, this Fact Sheet's main problem is the lack of information provided. It was created to provide information about a permit that is over 100 pages long and yet it is only 7 pages long itself – quite a bit shorter than fact sheets meant to summarize permits only one fifth that size. Chunks of information on many conditions – many that are important – are just gone – omitted. The unusual practice of not numbering the permit conditions also makes the information in the Fact Sheet appear vague and confusing. This allows many conditions to be completely ignored without the public knowing they are missing.

Equally troubling is the habit of stating that "requirements" or "limitations" or "proscribed measures" in a section "meet" or "conform to" the regulations, without telling exactly how the conditions of this permit do that. This is more a fact sheet about the regulations and what's required in *any* permit than a fact sheet about this particular permit. Paragraph after paragraph state that the permit conditions conform to the regulations and seem to expect the public to agree without any supporting information from the actual permit.

Defective Description of the Proposed Discharge, Facility, and Permit:

Information on the discharge and the facility in this section is good, but again, this section needs to be fleshed out as there is only a little more information than would appear in a public notice. A more complete description of the MES and the SET and of the discharge piping, pathways and systems should have been included so the public could understand the influx

and outflow and what's going where. Maps would have been helpful here as well.

And a more complete description of the quality of the discharge should have been included without NMED censoring information about the discharge and deciding what's appropriate and not appropriate for the public to understand. There is no list of contaminants in the Fact Sheet, though one was provided in the hearing notice. Such a list should be included here, as well.

Though corrective action plans are described in some detail in five or more places in the permit, none of these is described at all in the Fact Sheet. Because of problems experienced by the public with such a "contingency plan" in the WCS permit, the public needs to have more detailed and accurate information on each of these plans so the public can evaluate if they are adequately protective or not.

Finally, there is no hydrological and geological information about the affected area in the Fact Sheet. In this, it mirrors the permit, but for the public to understand whether this permit is protective of ground and surface water, the public must be able to have at least a basic understanding of the affected geology and hydrology of the area, including seismic issues. These latter are many and serious and are not addressed at all in this permit.

The Regulatory Framework section is good and is one of the most complete sections in the Fact Sheet.

Defective Fact Sheet - Operational Plan – Conditions

Conditions are the heart of any discharge permit but the Fact Sheet starts describing them in only sketchily, and continues to do so throughout. And the Fact Sheet does not always copy the language or intent of the permit. Right away in the first paragraph, the permittees are "... required to post appropriate advisory signs at the Facility or at the discharge location." This does not conform to the language of the permit which only describes signs around the Facility – not around Outfall 051. Expanding where the signs can be posted in the Fact Sheet makes it seem that the discharge location will be more protected than it actually will.

The second paragraph states what the section requires and says those requirements conform to the regulations without describing how they conform.

The third paragraph describes other requirements and says they conform to the regulations without describing how they conform.

The fourth paragraph describes effluent quality limits and limits for toxic pollutants and exemptions for contaminants. Tables and lists are mentioned but not included; they should be. The Corrective Action Plan for effluent exceedances is not even mentioned and, as described above, should be not only mentioned, but detailed.

The first paragraph on page 5 again states that there are effluent quality limits and says they conform to the regulations without describing how they conform. One must ask: What are the limits? What's in the mentioned table of chemical constituent limits?

The second paragraph on page 5 refers to requirements in the installation and calibration of flow meters and says those requirements conform to the regulations without describing how they conform. No information is given on the location or number of flow meters. (There are four.)

Defective Monitoring and Reporting Conditions

The second paragraph under Monitoring and Reporting describes what is required in the quarterly monitoring reports. However, this section is very sketchy indeed beyond the simple list. Number and locations of monitoring wells are missing (there are seven wells), along with frequency of sampling and analysis of wells, effluent/influent waste streams and a list of analytes. All of this is just minimal information that should have been included. How can the public tell if the monitoring plan is sufficient without even knowing what is going to be monitored, where the monitoring points are and what the analytes are?

The next paragraph describes a moisture monitoring system to detect unauthorized releases from the SET and to establish baseline conditions. But there is no description of what this system is (neutron moisture probes), how many there are, or where they are located exactly. Again, information on corrective action plans if there are exceedances are completely left out.

All information on waste stream tracking, personnel and emergency response is also completely missing.

Defective Description of Contingency Plan Conditions

This paragraph addresses spills and states "... standard contingency conditions address the exceedance of groundwater standards, contaminant discharge limits," etc. However, once again, the public is told that the conditions conform to the regulations without describing how they conform. NMED may understand what "standard contingency conditions" are, but the public does not. No details at all about the corrective action plans are given.

Defective Description of Closure Conditions

Again, the first paragraph states that measures and timeframes for closure are described in the permit and that if there is contamination, remediation will be required. But none of this is described in the Fact Sheet. No information from the permit is included on closure requirements or corrective action plans for remediation.

The following paragraph mentions 6 specific "units" that will be shut down but doesn't say what they are (storage tanks). We're told that "upon cessation of operation of a unit" a

stabilization work plan will be submitted when actually, the time frame is 4 months for the plan.

The third paragraph mentions that there is an overall closure plan for the facility which is attached to the Permit. However, though two years of groundwater monitoring is mentioned, no complete summary of this closure plan is included and no link is given in the Fact Sheet to the closure plan online. However, even such a link wouldn't help LEP persons, since the closure plan, like the permit itself, is English-only, but if the Fact Sheet included a comprehensive and accurate summary of the vital information in the closure plan, that would have solved the information problem for everyone.

Incomplete information about the relationship of the 2016 Consent Order and the proposed Discharge Permit. The last paragraph under this section states that certain corrective action must be performed under the 2016 Consent Order between NMED and the Department of Energy, and not under this discharge permit. Again, there is no summary of the Consent Order and no links to it. There is no description of what Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) are. In fact, this is the first time the Consent Order is mentioned in the Fact Sheet even though many aspects of this discharge permit must relate to it. There is no description of the criteria to determine what corrective action will fall under the discharge permit and what will fall under the Consent Order. The lack of information about the Consent Order and the relationship between it and the discharge permit is a major failure to include important information.

General Terms and Conditions

It is stated in this section that "... these terms and conditions are standard in all discharge permits." Still, that is not an excuse simply to list them with no other information. The condition about complying with all other applicable laws, at least, is an important condition and should have been described in its entirety.

In Summary

This is a very controversial discharge permit that shouldn't even exist. It hardly does exist as there is no real discharge to be regulated. The limited information available to the public in the defective public notices and especially in the defective Fact Sheet that is almost completely empty of actual information about the permit, obstructs public participation possibilities and especially so for the LEP public.

The lack of care to make sure the Public Involvement Plan actually captures the affected communities and the lack of investigation of any of the communities' concerns, needs and history, including health concerns, shows an amazing lack of interest in protecting human health and the environment and an especial lack of interest in involving and protecting the People of Color who surround this DOE site in one of, if not the, highest concentrations of People of Color around any DOE site in the country. In a completely arbitrary way NMED has

been able to eliminate any attention to these people by eliminating them from attention even though at least some, if not many of them are already suffering from having been contaminated by past discharges from LANL. Since 2013, the public has asked that NMED require the Applicants to submit a federal RCRA/NM Hazardous Waste permit application for this facility to ensure protection of human health and the environment.

In the alternative, if real discharges are going to resume after nearly ten years, NMED needs to look at what the effect will be on these Minority residents, make sure that effect is dealt with and incorporated into the permitting analysis, and make sure that a regulatory compliant public process to review and correct the public notices, PIPs, fact sheets, and other documents released to the public, are incorporated into every permitting process in the future.

Please include these comments, along with the three attachments, in the Administrative Record for DP-1132.

Sincerely,

Deborah Reade
Research Director for CARD
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117 Duran Street
Santa Fe, New Mexico 87501
505-986-9284
reade@nets.com

Attachments here
1. *Red Dust*
2. *EPA EJSCREEN Fact Sheet*
3. *EJSCREEN ACS Report* (30 mile radius around LANL)