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2018 ANNUAL SITE ENVIRONMENTAL REPORT

Los Alamos
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LOS ALAMOS NATIONAL LABORATORY GOVERNING POLICY FOR THE ENVIRONMENT

- We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements.
- We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public.
- We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

ANNUAL SITE ENVIRONMENTAL REPORT FOR 2018
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Los Alamos National Laboratory 2018 Annual Site Environmental Report

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ABSTRACT

Los Alamos National Laboratory's (the Laboratory's) annual site environmental reports are prepared annually by the Laboratory's environmental organizations, as required by U.S. Department of Energy Order 231.1B, Administrative Change 1, *Environment, Safety, and Health Reporting*, and Order 458.1, Administrative Change 3, *Radiation Protection of the Public and the Environment*.

The following chapters in this report discuss our success in complying with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climate conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Monitoring); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, soil, and vegetation (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

This report follows plain language guidelines, as required for federal agencies by the Plain Language Act of 2010. More information about plain language can be found at http://www.plainlanguage.gov/index.cfm. You will notice we have substantially reduced the use of acronyms and abbreviations and are using active voice and personal pronouns.

We hope you find this report useful. If you have suggestions for improving this report, additional questions, or want a copy of this report, please contact us at envoutreach@lanl.gov, or call the Communications Office at 505-665-7000.

This report, its supplemental tables, and the 2018 *Annual Site Environmental Report Summary* are available at http://www.lanl.gov/environment/environmental-report.php.

Note: This document has been revised since it was initially published on September 23, 2019. The revisions included corrections to figure and table references, changes in heading levels, adding blank pages where appropriate, and changes of an editorial nature.

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Los Alamos National Laboratory (the Laboratory) is located in Los Alamos County in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. The mission of the Laboratory is to solve national security challenges through scientific excellence. Inseparable from our focus on excellence in science and technology is our commitment to environmental stewardship and full compliance with environmental protection laws. Part of the Laboratory's commitment is to report on its environmental performance. This site environmental report

Sandia Canyon at the Laboratory

- characterizes the Laboratory's environmental performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment;
- summarizes environmental occurrences and responses;
- confirms compliance with environmental standards and requirements;
- highlights significant programs and efforts; and
- describes property clearance activities in accordance with U.S. Department of Energy (DOE) Order 458.1.

Los Alamos National Laboratory has changed substantially during its 75-year history. Undoubtedly, the future will continue to bring significant changes to the mission and operations of the Laboratory. Regardless of these changes, we are committed to operating the site sustainably.

The Laboratory's Governing Policy on Environment

We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements. We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and the public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

Environmental stewardship requires an active management system to provide environmental policy, planning, implementation, corrective actions, and management review. We use an Environmental Management System to accomplish this. The Laboratory has been certified to the International Organization for Standardization 14001 standard for the Environmental Management System since April 2006.

The following chapters in this report discuss a range of topics: our success in complying with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climate conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Monitoring); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, soil, and vegetation (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

There were two changes in the management of the Laboratory in 2018: (1) Newport News Nuclear BWXT-Los Alamos (N3B) became the Laboratory's legacy waste cleanup contractor in April 2018 and (2) Triad National Security LLC (Triad) became the Laboratory's management and operating contractor in November 2018.

2018 Environmental Performance Summary

Our environmental performance can be summarized as follows:

- The Laboratory operated under 17 different types of environmental permits and legal orders (Table 2-17 in Chapter 2).
- The Laboratory shipped approximately 3,300 tons of low-level radioactive waste offsite for disposal at approved treatment, storage, and disposal facilities.
- Four shipments of transuranic waste were sent from the Laboratory to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.
- The Laboratory was fully in compliance with its Clean Air Act, Title V Operating Permit emission limits.
- We discharged approximately 102 million gallons of liquid effluents from eight permitted outfalls. Two of the 826 outfall samples collected exceeded effluent quality limits in the outfall permit, one for chlorine and one for PCBs.
- The New Mexico Environment Department granted certificates of completion for 26 remedial sites in fiscal year 2018. Of the remaining sites, 134 are deferred because of ongoing operations, and 941 have investigations or corrective actions either in progress or pending.
- Seven environmental occurrences were reported under DOE Order 232.2, Occurrence Reporting and Processing of Operations Information (Table 2-10 in Chapter 2).
- Two areas of the regional aquifer at Laboratory have groundwater contaminants that are of sufficient concentration and extent to warrant actions, such as interim measures, further characterization, and potential remediation under the 2016 Consent Order: RDX contamination in the vicinity of Technical Area 16 and chromium contamination beneath Sandia and Mortandad Canyons.
- No unplanned releases of radioactive liquids occurred on Laboratory property. We made 15 reports of unplanned nonradioactive liquid releases to the New Mexico Environment Department.
- Over 27 million gallons of reclaimed wastewater was used in the cooling towers of the Strategic Computing Complex.

- Radiological doses to the public from Laboratory operations were less than 1 millirem per year, and health risks are indistinguishable from zero.

2018 Environmental Monitoring

During 2018, we found the following:

- Three groundwater wells in the Chromium Investigation monitoring group had levels of chromium that decreased between 2017 and 2018 or during 2018, suggesting the interim measure for chromium plume migration that began in February 2018 may be having positive effects.
- Over time, storm water–related transport of sediments is generally resulting in lower concentrations of Laboratory-derived chemical and radionuclides in sediment than previously existed in the sampled locations.
- Over 840 birds were banded to monitor breeding and migrating birds at the Laboratory.
- Most radionuclide and most chemical concentrations in soil, plants, and wildlife from onsite and perimeter locations were either not detected, were similar to background, or were below screening levels protective of biota.
- A project to compare benthic macroinvertebrate communities between perennial, ephemeral wet, and ephemeral dry stream reaches found that abundance and species richness varied significantly among all types of stream reaches, and that there were more disturbance-tolerant species in ephemeral systems than in perennial systems. There were no significant difference between locations on Laboratory property and off Laboratory property.
- The 2018 biota dose assessment confirms previous assessments and shows that there are no harmful effects to the biota populations at LANL from Laboratory radioactive materials.

An additional summary of this report can be found in the Los Alamos National Laboratory Annual Site Environmental Report Summary. The full report and the summary are available on the Laboratory's website: http://www.lanl.gov/environment/environmental-report.php.

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Chapter 1 – INTRODUCTION

Los Alamos National Laboratory (the Laboratory) is committed to act as a steward of the environment and to achieve its mission in accordance with all applicable environmental requirements. The Laboratory sets continual improvement targets, measures and documents progress, and shares results with the workforce, sponsors, and the public. The Laboratory reduces environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

CONTENTS

BACKGROUND AND PURPOSE

Background

In March 1943, a small group of scientists came to Los Alamos, New Mexico, for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. By 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved over time. The current mission is to solve national security challenges through scientific excellence.

The United States Atomic Energy Commission took ownership of Los Alamos Laboratory in 1946. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory. The U.S. Department of Energy (DOE) took ownership in 1977, and Los Alamos Scientific Laboratory became known as Los Alamos National Laboratory (LANL, or the Laboratory) in 1981. The National Nuclear Security Administration, a semiautonomous agency within DOE, has overseen the management and operating contract for the Laboratory since 2000.

From 1943 through May 2006, the Laboratory was operated by the Regents of the University of California. In June 2006, Los Alamos National Security LLC received the contract to operate the Laboratory. It operated the Laboratory through 2018. In 2014, DOE decided to separate the cleanup of legacy waste from the management and operating contract. The legacy waste cleanup work was transitioned to a bridge contract under DOE's Office of Environmental Management in October 2015. A new contractor, Newport News Nuclear BWXT–Los Alamos, LLC (N3B), took over the legacy waste cleanup in April 2018. Triad National Security, LLC was awarded the most recent contract to operate the Laboratory, and this organization took over managing the Laboratory in November 2018. Currently, both the National Nuclear Security Administration and the Office of Environmental Management maintain field offices in Los Alamos, New Mexico.

Purpose

This document serves as a consolidated site environmental report, fulfilling the annual reporting requirements of both the National Nuclear Security Administration and DOE's Office of Environmental Management for the site under DOE Orders 231.1B Chg 1, *Environment, Safety, and Health Reporting*, and 458.1 Chg 3, *Radiation Protection of the Public and the Environment*. In this document, "we" refers to the people who work at Los Alamos National Laboratory, including employees of both DOE and contractor organizations.

As part of the Laboratory's commitment to protecting the environment, we monitor and report on how Laboratory activities affect the environment. The objectives of this annual report are to

- characterize the site's environmental performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials;
- summarize environmental occurrences and responses;
- document compliance with environmental standards and requirements;
- highlight significant programs and efforts; and
- summarize property clearance activities.

The chapters in this report discuss our compliance with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climatic conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Monitoring); how we monitor the movement of chemicals and radionuclides by stormwater runoff (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, soil, and vegetation (Chapter 7, Ecosystem Health); and finally, what radioactive dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

ENVIRONMENTAL SETTING

Location

Los Alamos National Laboratory is in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The Laboratory property is about 40 square miles in size. This value includes the areas with active operations managed by the management and operating contractor and the legacy cleanup contractor, along with some additional DOE properties, such as a proposed land transfer tract in Rendija Canyon. The Laboratory is located on the Pajarito Plateau, a series of fingerlike mesas separated by canyons at the eastern edge of the Jemez Mountains. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet at the edge of White Rock Canyon. Most Laboratory and community developments are on the mesa tops.

At the end of 2018, 11,617 people were employed by the primary contractors at the Laboratory and an additional 2,833 people were employed by Laboratory subcontractors. The LANL-affiliated work force resides predominantly in Los Alamos, Santa Fe, Rio Arriba, Bernalillo, and Sandoval counties and includes regular workers, temporary workers, and students.

New Mexico's 2018 population was 2,095,428 people (Census 2019a) and the estimated population within a 50-mile radius of Los Alamos was 353,342 residents (StatsAmerica 2019). The counties with substantial land within 50 miles of the Laboratory are Los Alamos, Santa Fe, Sandoval, and Rio Arriba. The estimated 2017 racial and ethnic composition of the population within these counties, based on data from the U.S. Census Bureau's American Community Survey, is shown in Table 1-1 (Census 2019b). Figure 1-2 shows municipalities and tribal properties within 50 miles of the Laboratory.

The land surrounding the Laboratory is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by Santa Fe National Forest, the U.S. Bureau of Land Management, Bandelier National Monument, the U.S. General Services Administration, and Los Alamos County. The townsite of Los Alamos borders the Laboratory to the north, and the townsite of White Rock borders it to the east. The Pueblo de San Ildefonso also borders the Laboratory to the east. Santa Clara Pueblo is north of the Laboratory but does not share a border (Figure 1-1).

TABLE 1-1. ESTIMATED RACIAL AND ETHNIC COMPOSITION OF THE POPULATION WITHIN LOS ALAMOS, SANTA FE, SANDOVAL, AND RIO ARRIBA COUNTIES DURING 2017 (CENSUS 2019B)

Race	Number of People
White alone	257,343
Black or African American alone	4,124
American Indian and Alaska Native alone	28,925
Asian alone	5,113
Some other race alone	36,558
Two or more races	11,752
Ethnicity	**Number of People**
Hispanic or Latino, of any race	159,371
Not Hispanic or Latino	184,444

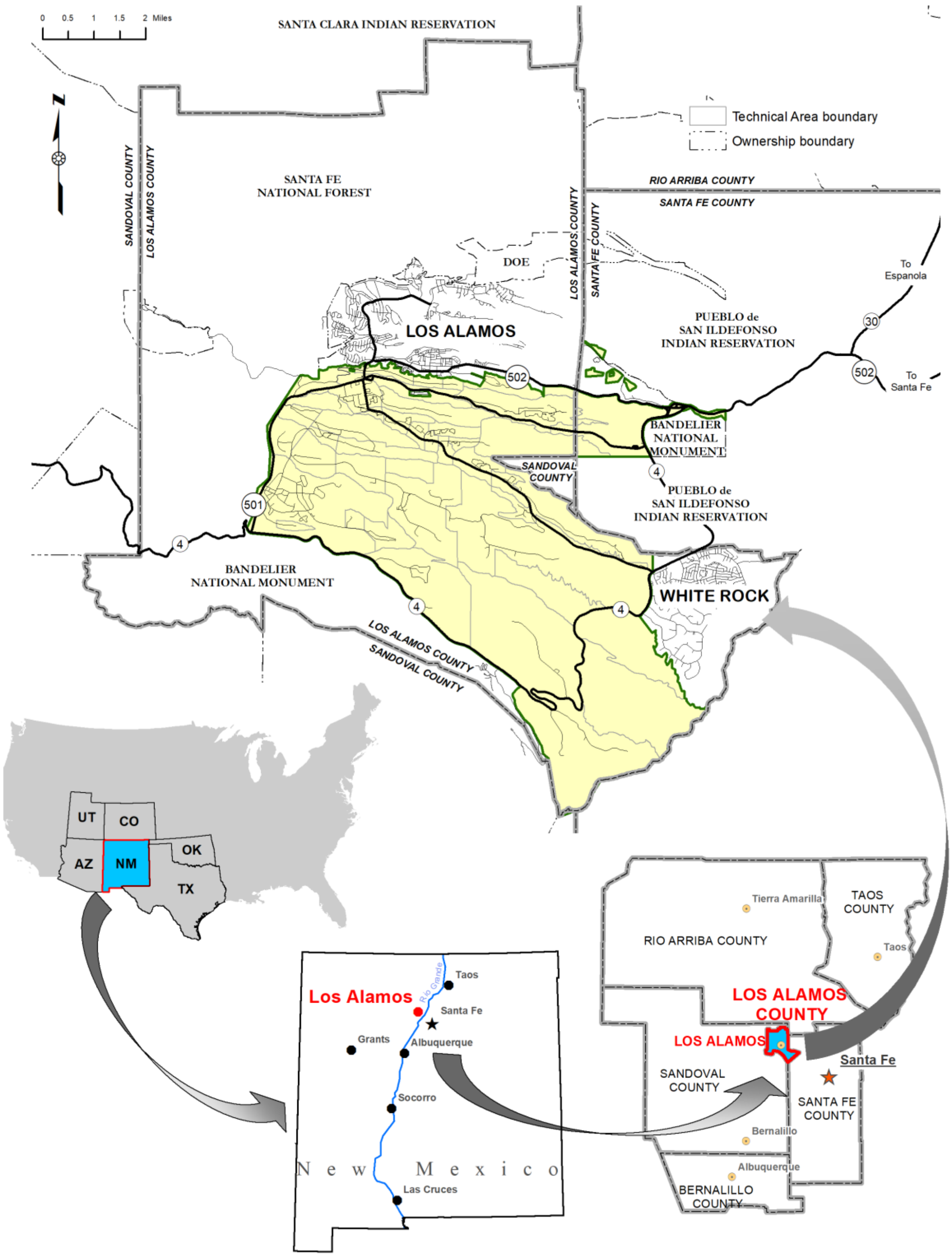


Figure 1-1. Regional location of the Laboratory

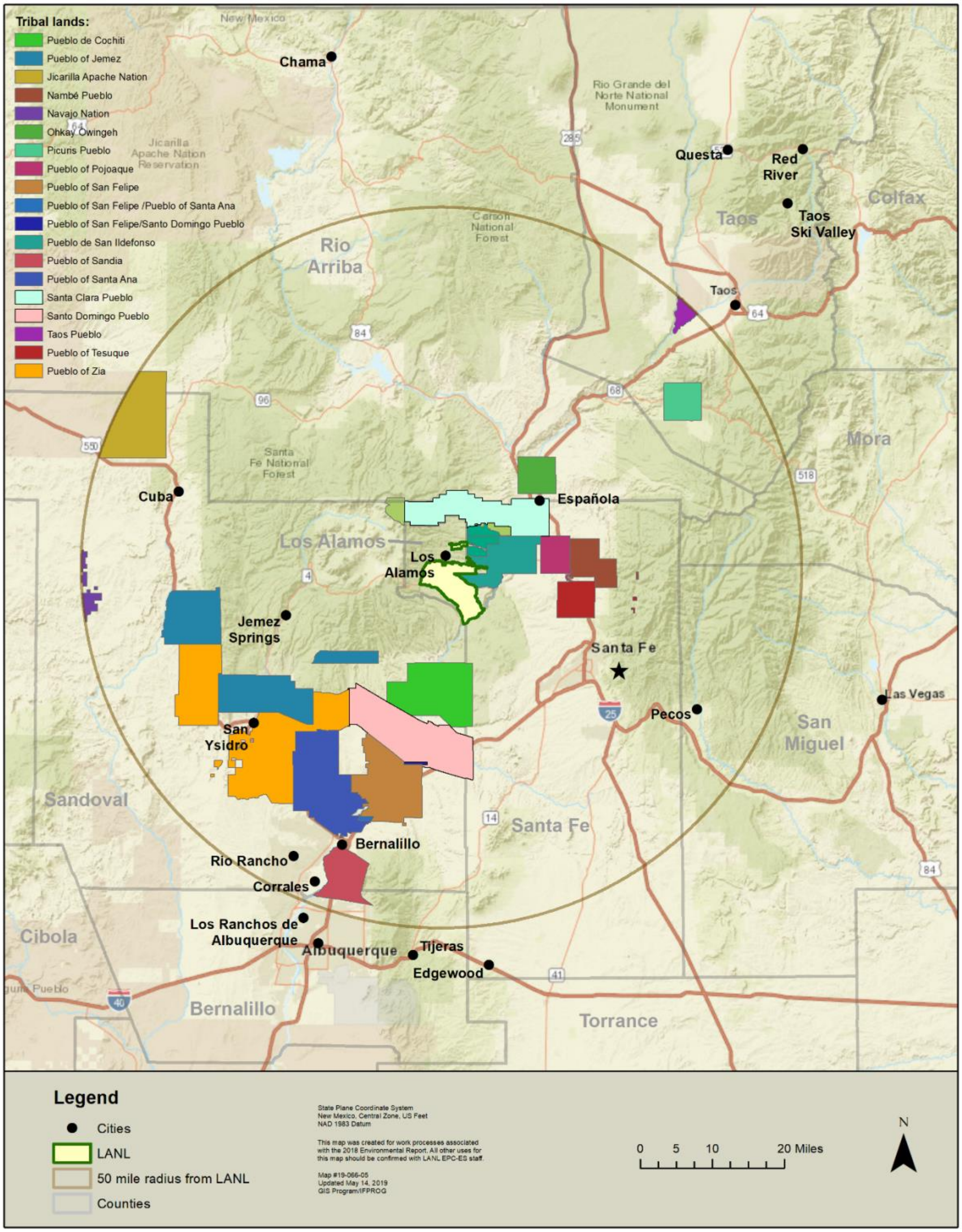


Figure 1-2. Municipalities and Tribal Properties within a 50-mile radius of the Laboratory

Geology

Los Alamos lies along the Rio Grande rift. The Rio Grande rift is a continental rift—a massive crack in the earth's crust formed by the upwelling of hot rocks deep below the surface. A continental rift becomes an elongated valley in the landscape, bounded by faults. Faults are breaks where rocks that make up the earth's crust slide past each other. The modern rift boundary in the Los Alamos area consists of a local master fault and three subsidiary faults, known as the Pajarito fault zone. Past and present studies investigate the earthquake hazards associated with these faults (Gardner et al. 1990, Larmat and Lee 2017).

The Jemez Mountains are the remnant of a large collapsed volcanic field. The high levels of volcanic activity in this area are associated with the same geologic forces that produced the Rio Grande rift. The Tschicoma Formation is an older rock layer of volcanic dacite that forms much of the Jemez Mountains. Most of the mesas of the Pajarito Plateau are formed from Bandelier Tuff. Tuff is a type of soft rock that forms from ash released during volcanic eruptions. The Bandelier Tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation of the Jemez Mountains. Eastward near the Rio Grande, a layer of sand and gravel that underlies the Bandelier Tuff, known as the Puye Formation, becomes visible in places. The Puye Formation is important in storing groundwater. Basalt rocks originating from material from the Cerros del Rio volcanos east of the Rio Grande mix with the Puye Formation along the river and extend beneath the Bandelier Tuff to the west in places.

These rock formations all overlie the sediments of the Santa Fe Group, which extend between the Laboratory and the Sangre de Cristo Mountains and are more than 3,300 feet thick. The Santa Fe Group sediments are also important for groundwater storage.

Climate

Los Alamos County has a semiarid climate—more water is lost through evaporation and transpiration than is received as annual precipitation. Annual temperatures and amounts of precipitation vary across the site because of the 1,000-foot elevation change and the complex topography. Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional snow storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm.

Daily temperatures are highly variable. On average, winter temperatures range from 30 °F to 50 °F during the daytime and from 15 °F to 25 °F during the nighttime. The Sangre de Cristo Mountains to the east of the Rio Grande act as a barrier to wintertime arctic air masses, making the occurrence of subzero temperatures rare. On average, summer temperatures range from 70 °F to 88 °F during the day and from 50 °F to 59 °F during the night.

From 1981 to 2010, the average annual precipitation (which includes both rain and the water equivalent of snow, hail, or any other frozen precipitation) was 19 inches. The average annual snowfall was 59 inches. The rainy season begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico lifts over the Jemez Mountains. Thunderstorms yield short, heavy downpours and an abundance of lightning. Local lightning density, among the highest in the United States, is estimated at 15 strikes per square mile per year.

The complex topography of the Pajarito Plateau influences local wind patterns. Daytime winds in the Los Alamos area are predominately from the south, as heated daytime air moves up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and are typically from the west, a result of prevailing upper-level winds from the west and the downslope flow of cooled mountain air.

The climatology of Los Alamos County is summarized in Chapter 4, Air Quality, and explained further in Dewart et al. (2017).

Hydrology

Surface water in the Los Alamos region occurs primarily as ephemeral flow, associated with individual rain storms and lasting only a few hours to days, or intermittent flow, associated with events like snow melt and lasting only a few days to weeks. Some springs on the edge of the Jemez Mountains supply water to western sections of some canyons on Laboratory property, but the amount of water is not enough to maintain surface flows to the eastern Laboratory boundary.

Groundwater in the Los Alamos area occurs in three modes: (1) water in the near-surface sediments in the bottoms of some canyons (alluvial groundwater), (2) water in porous rock layers underlain by a more solid rock layer and therefore perched above the regional aquifer (intermediate perched groundwater), and (3) the regional aquifer in the saturated Santa Fe Group sediments.

The regional aquifer is the only aquifer in the area capable of serving as a municipal water supply. The source of most recharge to the regional aquifer appears to be rain and snow that fall on the Jemez Mountains. A secondary source is local infiltration of water in canyon bottoms on the Pajarito Plateau (Birdsell et al. 2005). The upper portion of the regional aquifer beneath the Laboratory discharges into the Rio Grande through the springs in White Rock Canyon.

Biological Resources

The Pajarito Plateau is very biologically diverse, partly because of the dramatic 5,000-foot elevation change from the Rio Grande up to the Jemez Mountains and partly because of the many steep canyons that dissect the area. The major types of vegetative cover in this area include the following: (1) one-seed juniper (*Juniperus monosperma*) savannas along the Rio Grande on the eastern border of the plateau, extending upward on the south-facing sides of canyons at elevations between 5,600 and 6,200 feet; (2) juniper woodlands with scattered piñon (*Pinus edulis*) trees, generally between 6,200 and 6,900 feet in elevation and covering large portions of the mesa tops and north-facing slopes at the lower elevations; (3) ponderosa pine

(*Pinus ponderosa*) woodlands on the western portion of the plateau at between 6,900 and 7,500 feet in elevation; and (4) mixed-conifer woodlands and forests at elevations of 7,500 to 9,500 feet, overlapping the ponderosa pine community both in the deeper canyons and on north-facing slopes and extending onto the slopes of the Jemez Mountains. Local wetlands and riparian areas enrich the diversity of plants and animals found on the plateau.

The frequent drought conditions prevalent throughout New Mexico since 1998 have resulted in the loss of many trees. Between 2002 and 2005, more than 90 percent of the mature piñon trees in the Los Alamos area died from a combination of drought stress and bark beetle infestation (Breshears et al. 2005). Large numbers of mature ponderosa pine and other conifer trees in the area have also died. This mortality of forest trees is projected to continue into the 2050s (Williams et al. 2013).

Two major wildfires have also affected the Laboratory: the Cerro Grande fire in 2000 and the Las Conchas fire in 2011. Both fires resulted in loss of forest trees on the slopes of the Jemez Mountains west of the Laboratory and were followed by large flash floods that caused extensive soil erosion and some damage to infrastructure. A 1,000-year storm event in September 2013 also resulted in flooding and damage.

Cultural Resources

The Pajarito Plateau is an archaeologically complex region. Surveys of approximately 90 percent of DOE land in Los Alamos County have identified over 1,800 prehistoric and historic cultural sites. Nearly 79 percent of the sites were constructed and used by Ancestral Pueblo people during the thirteenth, fourteenth, and fifteenth centuries. However, there is evidence of human activity on this landscape from the Paleoindian Period (16,000–8,000 BC) through the Historic Period (seventeenth century–present). Cultural resource specialists at the Laboratory document and evaluate these cultural sites for their eligibility in the National Register of Historic Places.

We have evaluated over 300 buildings and structures associated with the Manhattan Project and Cold War periods (1943–1990) at the Laboratory for listing in the National Register of Historic Places. Of these, 172 buildings have been declared eligible. The Manhattan Project National Historical Park, managed by the National Park Service, was established in 2014. Currently, facilities associated with the Manhattan Project National Historical Park at Los Alamos National Laboratory comprise nine individual buildings associated with the design and assembly of Gadget (the atomic bomb tested at Trinity Site), the Little Boy weapon (the atomic bomb detonated over Hiroshima, Japan), and the Fat Man weapon (the atomic bomb detonated over Nagasaki, Japan). Eight additional Laboratory buildings and structures, identified in the park legislation, are considered eligible properties.

LABORATORY ACTIVITIES AND FACILITIES

The current mission of the Laboratory is to solve national security challenges through scientific excellence. The current goals of the Laboratory are to: (1) deliver national nuclear security and broader global security mission solutions; (2) attract, inspire, and develop world-class talent to ensure a vital future workplace; (3) foster excellence in science and engineering disciplines essential for national security missions; and (4) enable mission delivery through next-generation facilities, infrastructure, and operational excellence. Mission focus areas include

- nuclear deterrence and stockpile stewardship;
- protecting against nuclear threats;
- emerging threats and opportunities; and
- energy security solutions.

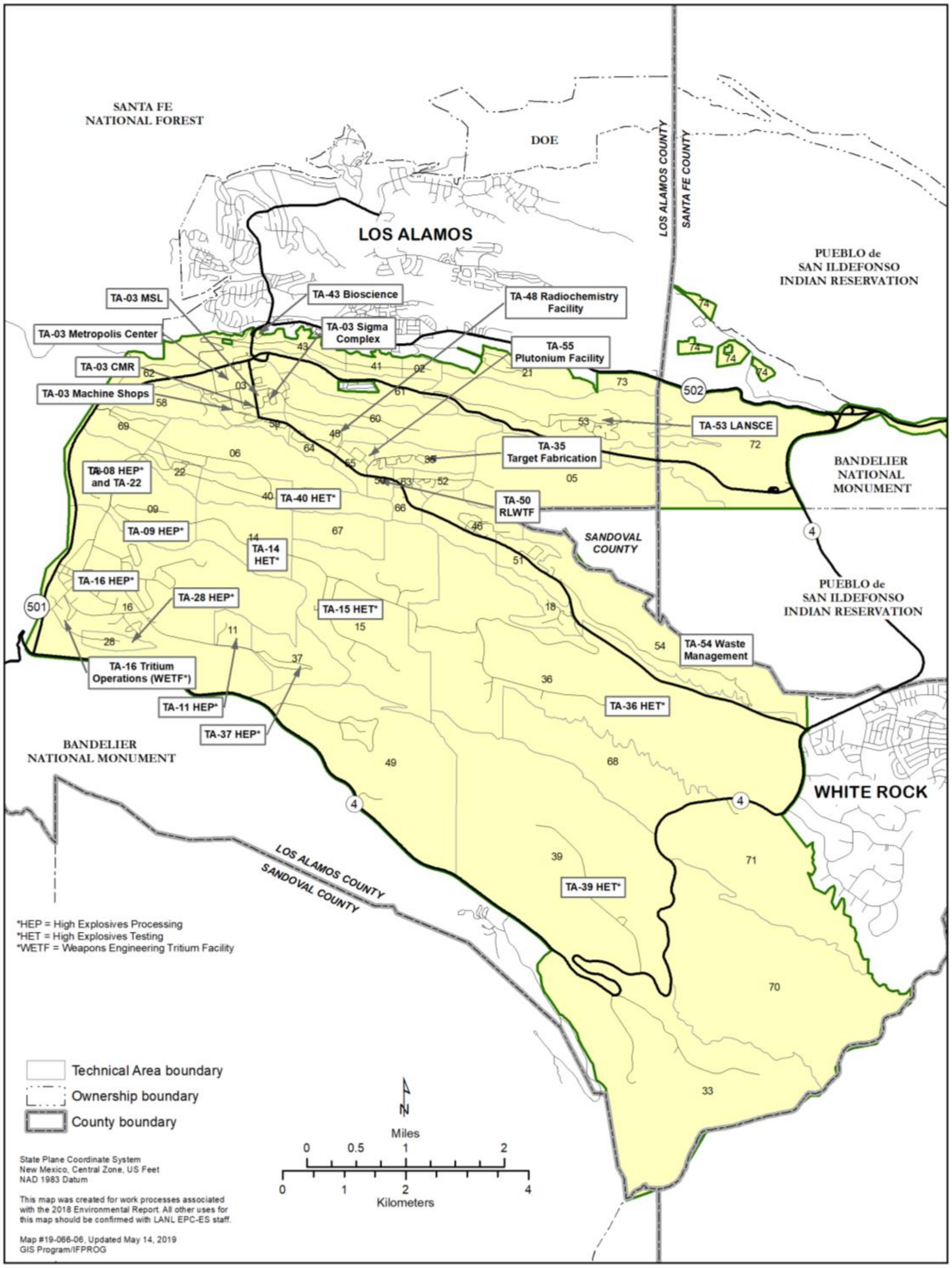
The Laboratory property is organized into 49 technical areas, which contain buildings, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-3 and Appendix C, *Descriptions of Technical Areas and their Associated Programs*). Developed areas account for less than half of the total land area; many portions of the Laboratory act as buffer areas for security, safety, and possible future expansion. The Laboratory has about 904 permanent buildings and temporary structures, with approximately 8.2 million square feet under roof (LANL 2019).

The DOE/National Nuclear Security Administration issued a site-wide environmental impact statement in May 2008 (DOE 2008). In the 2008 Site-Wide Environmental Impact Statement, the Laboratory identified 15 facilities as being key for evaluating the potential environmental impacts of continued operation (Table 1-2). Activities in the key facilities represent the majority of environmental impacts associated with Laboratory operations.

The remaining Laboratory facilities were identified as non-key facilities. Examples of non-key facilities include the Nonproliferation and International Security Center; the National Security Sciences Building, which is the main administration building; and the Technical Area 46 sewage treatment facility.

TABLE 1-2. KEY FACILITIES

Facility	Technical Area(s)
Plutonium Facility Complex	55
Chemistry and Metallurgy Research (CMR) Building	03
Sigma Complex	03
Materials Science Laboratory (MSL)	03
Target Fabrication Facility	35
Machine Shops	03
Nicholas C. Metropolis Center for Modeling and Simulation	03
High Explosives Processing (HEP) Facilities	08, 09, 11, 16, 22, 37
High Explosives Testing (HET) Facilities	14, 15, 36, 39, 40
Los Alamos Neutron Science Center (LANSCE)	53
Biosciences Facilities (formerly Health Research Laboratory)	03, 16, 35, 43, 46
Radiochemistry Facility	48
Radioactive Liquid Waste Treatment Facility (RLWTF)	50
Solid Radioactive and Chemical Waste Facilities	50, 54
Weapons Engineering Tritium Facility (WETF)	16



Note: See Table 1-2 for acronym definitions.

Figure 1-3. Technical Areas (TAs) and key facilities of the Laboratory in relation to surrounding landholdings

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Chapter 2 – COMPLIANCE SUMMARY

Compliance with environmental laws, regulations, and policies is part of Los Alamos National Laboratory's environmental stewardship and helps us attain our overall goal of environmental sustainability.

CONTENTS

INTRODUCTION

Environmental laws are designed to protect human health and the environment by

- regulating the handling, transportation, and disposal of materials and wastes;
- regulating impacts to biological and cultural resources and air, soil, and water; and
- requiring analysis of the environmental impacts of new operations.

This chapter provides a summary of our compliance with state and federal environmental regulations and permits and DOE environmental orders during 2018.

RADIATION PROTECTION AND MANAGEMENT OF RADIOLOGICAL WASTES

DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*

DOE Order 458.1 establishes requirements for DOE facilities to protect the public and the environment from undue risk from radiological releases. The order requires DOE facilities to ensure the radiological dose to the public from their activities does not exceed 100 millirem in any given year. It also provides dose limits for wildlife and plants. The order requires DOE facilities to keep radiological doses to the public and the environment as low as reasonably achievable and to monitor for routine and non-routine releases of radioactive materials. Property released from the facility (for example, surplus property, waste shipped for disposal offsite, or transferred land parcels) cannot exceed dose limits of 25 millirem per year above background for real estate or 1 millirem per year above background for moveable items. The DOE Order 458.1 requires that the public be notified (1) of any radiation doses resulting from LANL operations; (2) of the release of property that has potential to contain residual radioactivity; and (3) of the establishment and use of authorized limits for property releases.

Estimated Maximum Possible Radiological Dose to the Public

In 2018, the estimated maximum possible radiological dose to a member of the public from Laboratory operations was less than 1 millirem (Whicker et al. 2019). Radiation doses to wildlife and plants were below limits. Details of the Laboratory's annual radiological dose estimates for the public are presented in Chapter 8, and dose estimates for wildlife and plants are presented in Chapter 7.

Property Released from the Laboratory

For release of property, Tract A-16-b (about six acres within DP Canyon) was transferred to Los Alamos County during 2018 (LANL 2016a). LANL also surveys and releases smaller personal property items, such as tools and furniture, from radiologically controlled areas on an on-demand basis, as described in radiation protection policies and procedures. These items typically remain onsite and, once cleared, there are no restrictions on their use.

Establishment and Use of Authorized Limits

Screening action levels for radionuclides in soils are evaluated every year to determine if an update is needed. In 2016, recalculation of the screening action levels was required due to a significant update to version 7.0 of the dose assessment code RESRAD (Yu et al. 2001) and to apply "reference person" dosimetry (LANL 2016b). LANL requested DOE evaluate these values for use as authorized limits for land conveyance and transfer and they were approved in early 2017. These authorized limits were used in the transfer of Tract A-16-b in 2018.

DOE Order 435.1 Chg 1, *Radioactive Waste Management*

Laboratory operations generate four types of wastes containing radioactive materials: low-level radioactive waste (also called low-level waste), mixed low-level waste, transuranic waste, and mixed transuranic waste. Radioactive waste generated during Laboratory operations must (1) meet Laboratory onsite storage requirements and (2) meet requirements for transportation to and disposal at the final facility. All aspects of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1 Chg 1 and DOE Manual 435.1-1.

Onsite Low-level Radioactive Waste Disposal

Material Disposal Area G at Technical Area 54 (Area G) is the only active waste disposal facility at the Laboratory. Operations began at Area G in 1957 and included the disposal of low-level radioactive waste, certain infectious waste containing radioactive materials, asbestos-containing material, polychlorinated biphenyls (PCBs), and temporary storage of transuranic waste. Mixed low-level waste and mixed transuranic waste have been stored in surface structures at Area G. The capacity to dispose of low-level waste at Area G is very limited; waste is accepted for disposal only under special circumstances and with prior authorization. In 2018, we disposed of no low-level waste in Area G.

Planning for the closure of Area G has been underway since 1992. We are working with the New Mexico Environment Department Hazardous Waste Bureau under the 2016 Compliance Order on Consent to develop and implement corrective measures for the solid waste management units at Area G. Environmental monitoring at Area G currently includes (1) a direct radiation thermoluminescent dosimeter monitoring network (Chapter 4); (2) an environmental

> **What are the types of radioactive waste?**
>
> **Transuranic Waste** – Waste is classified as transuranic waste when the activity of alpha-emitting transuranic radionuclides with half-lives of 20 years or more (such as plutonium, cesium, and strontium) is greater than 100 nanocuries per gram of waste.
>
> **Low-level Waste** – Low-level radiological waste contains added radioactivity, but does not contain high-level waste (the highly radioactive waste resulting from the reprocessing of spent nuclear fuel, transuranic waste, or tailings from the milling of uranium or thorium ore). It also does not contain any waste defined as hazardous under the Resource Conservation and Recovery Act.
>
> **Mixed Transuranic Waste** – Mixed transuranic waste is transuranic waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.
>
> **Mixed Low-level Waste** – Mixed low-level waste is low-level waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.

air station monitoring network (Chapter 4); (3) a groundwater monitoring network (Chapter 5); and (4) periodic soil, vegetation, and small mammal sampling (Chapter 7). Table 2-1 provides the 2018 status of the DOE low-level waste disposal facility management process for Area G.

TABLE 2-1. DOE LOW-LEVEL WASTE DISPOSAL FACILITY MANAGEMENT STATUS FOR AREA G

Management Process Phase	Status
Performance Assessment/Composite Analysis	Revision 4 was approved in 2009 (LANL 2008). The annual determination of adequacy for fiscal year 2018 was published in May 2019.
Closure Plan	Plan issued in 2009 (LANL 2009).
Performance Assessment/Composite Analysis Maintenance Program	Plan issued in 2011 (LANL 2011). Updated analyses and modeling of erosion and groundwater transport were completed in 2018 (Atchley et al. 2018, Pawar et al. 2018),
Disposal Authorization Statement	Revision 2 was issued November 15, 2018. This revision identifies the DOE Environmental Management field office in Los Alamos as the responsible field office.

Offsite Low-level Radioactive Waste Disposal

Most Laboratory low-level waste disposal occurs at offsite DOE treatment, storage, and disposal facilities (such as at the Nevada Nuclear Security Site) and commercial treatment, storage, and disposal facilities approved by DOE, including Energy Solutions, located in Clive, Utah, and the Waste Control Specialists site in Andrews, Texas. In 2018, LANL shipped 3,073,418 kilograms of low-level waste offsite for disposal.

Transuranic Waste Disposal

In 2018, LANL made four transuranic waste shipments from the Laboratory to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

MANAGEMENT OF OTHER SOLID WASTES

Hazardous Wastes: Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act regulates hazardous wastes from generation to disposal. Hazardous wastes include all solid wastes that are (1) listed as hazardous by the U.S. Environmental Protection Agency; (2) ignitable, corrosive, reactive, or toxic; (3) batteries, pesticides, lamp bulbs, or contain mercury; and (4) a hazardous waste as listed above that has been mixed with a radiological waste (mixed waste). Under the Resource Conservation and Recovery Act, facilities that treat, store, or dispose of hazardous wastes must obtain a permit from their regulatory authority.

The state of New Mexico is authorized by the U.S. Environmental Protection Agency to issue and enforce hazardous waste facility permits. On November 8, 1989, the New Mexico Environment Department issued the first LANL Hazardous Waste Facility Permit for the storage and treatment of hazardous waste at the Laboratory. The Laboratory's Hazardous Waste Facility Permit establishes the standards for LANL's management of hazardous wastes. The permit allows for the storage and sometimes treatment of hazardous waste at 27 separate hazardous waste management units (sites) at the Laboratory. It also provides specific reporting requirements to the New Mexico Environment Department and to the public.

What do these waste terms mean?

Treatment – Waste treatment is any process that changes the physical, chemical, or biological characteristics of a waste to minimize its threat to the environment.

Storage – Waste storage is the temporary holding of waste before the waste is treated, disposed of, or stored somewhere else. A **storage unit** stores hazardous waste. Examples include tanks, containers, drip pads, and containment buildings.

Disposal – Waste disposal is the discharge, deposit, injection, or placing of any waste on or in the land or water. A disposal facility is any site where the waste is intentionally placed and where it will remain.

Remediated Waste – waste that has undergone treatment.

Permit Modifications, Reports, and Other Activities

Permit conditions sometimes need to be revised during the life of the permit to address new information, changes in a facility, or changes in regulatory requirements. We submitted seven permit modifications to the LANL Hazardous Waste Facility Permit to the New Mexico Environment Department for approval in 2018. Notice of these permit modification requests were mailed to members of the public who signed up for a LANL facility mailing list maintained by the New Mexico Environment Department.

The seven permit modifications submitted in 2018 were Class 1 modifications, which are minor changes that keep a permit current with routine changes to the facility or its operations. Three of the permit modification requests involved routine changes associated with (1) modifying unit descriptions and figures, (2) modifying the waste stream descriptions list in the Waste Analysis Plan, and (3) adding or changing a Solid Waste Management Unit covered in the permit.

In addition to the three permit modifications listed above, four additional Class I permit modifications requests were approved by the New Mexico Environment Department in 2018.

- In February 2018, we submitted a request to add N3B as the new co-operator under the permit, and to transfer control of hazardous waste management units at Technical Area 54, Areas G, H, and L from Los Alamos National Security, LLC to N3B.
- In May 2018, the New Mexico Environment Department approved our request to modify the waste acceptance criteria at the Technical Area 63 Transuranic Waste Facility. This modification allowed the Transuranic Waste Facility to accept waste generated after April 21, 2011, which allows the facility to store additional mixed transuranic waste containers generated prior to the original date to prepare them for shipment for disposal at the Waste Isolation Pilot Plant near Carlsbad, New Mexico. Before this modification, the facility could only accept waste generated after December 31, 2015.
- In August 2018, the New Mexico Environment Department approved a request to allow treatment by macroencapsulation of hazardous waste debris. Treatment by macroencapsulation allows waste that is restricted from land disposal to meet applicable treatment standards at permitted storage units, so that the waste can be shipped offsite for disposal.
- Effective November 2018, the New Mexico Environment Department approved the request to add Triad National Security, LLC as a new co-operator under the permit and reflect the transfer of control for the remaining hazardous waste management units from Los Alamos National Security, LLC to Triad.

The management and operating contractor and N3B coordinated to send demolition activity notifications to the New Mexico Environment Department for the quarters ending in June, September, and December in 2018. One fiscal year 2018 notification was also sent for LANL covering all relevant demolition activities from October 1, 2017, to September 30, 2018. The fiscal year notification was submitted to the New Mexico Environment Department along with the December 2018 quarterly report. In 2018 no emergency treatment approvals were needed or requested under the New Mexico Hazardous Waste Act.

Inspections, Noncompliances, and Notices of Violation

The Laboratory provides advance written notice to the New Mexico Environment Department of any changes to any permitted unit or activity that may result in a noncompliance with the permit, and provides both verbal and written reports of any noncompliance that may endanger human health or the environment when the noncompliance is discovered. Noncompliances that do not threaten human health or the environment, such as an exceedance of a storage holding time, are compiled and reported to the New Mexico Environment Department on an annual basis.

Individual notices or reports of LANL noncompliances with the Hazardous Waste Facility Permit for fiscal year 2018 were sent to the New Mexico Environment Department in letters dated:

- February 8, 2018, Request for Accumulation and Storage Extension at the Los Alamos National Laboratory;
- March 19, 2018, Notification of Noncompliance with the Los Alamos National Laboratory (LANL) Hazardous Waste Facility Permit; and
- April 26, 2018, Delayed Notification of Waste Characterization Discrepancies and Addendum to the Los Alamos National Laboratory (LANL) Hazardous Waste Facility Permit Reporting Instances of Noncompliance and Releases for Fiscal Year 2017.

The Laboratory submitted the fiscal year 2018 noncompliance report to the New Mexico Environment Department in November 2018. The Laboratory reported 69 instances of noncompliance with the LANL Hazardous Waste Facility Permit. Reported noncompliances included water in sumps, container labeling issues, inadequate aisle spacing, missed inspections, and one leaking container that was over packed within 24 hours of identification. Other instances of noncompliance were associated with delayed posting of correspondence to the LANL Public Reading Rooms and delayed email notifications to individuals on the LANL facility mailing list.

The above-mentioned noncompliances were identified by the management and operating contractor through internal site-wide compliance assessments conducted by Laboratory hazardous waste management experts. N3B utilized weekly inspections to identify noncompliance with the Permit. Laboratory staff continue to develop and improve waste management tools and processes to facilitate compliance with record-keeping requirements in the permit. They also work with waste handling personnel and waste management personnel to identify and implement corrective actions that will prevent recurrences of other types of noncompliances. Throughout 2018, we continued efforts to ensure an accurate operating record, including (1) recharacterizing some waste items and containers, (2) creating new waste stream profiles and updating inventory reports and labels, and (3) creating new policies and procedures for the legacy cleanup work scope. In addition, the Laboratory worked toward a carefully considered restart of operations at the Technical Area 54, Area G facility.

A notice of violation was issued to the Laboratory on March 18, 2018, with no associated penalties, citing five violations noted during a 2017 inspection by the New Mexico Environment Department. The New Mexico Environment Department determined that the violations cited in the notice were adequately addressed and that no further action was required. The New Mexico Environment Department also issued a notice of violation for the storage of hazardous waste containers for greater than one year at a permitted unit. A penalty was assessed at $61,750.00.

On December 13, 2018, a notice of violation was issued to Los Alamos National Security, LLC by the Utah Department of Environmental Quality associated with a leaking package received at the Clive, Utah, Energy Solutions location. The Laboratory responded with corrective actions to the notice of violation.

LANL's Nitrate Salt–Bearing Waste

Treatment of 60 containers of remediated nitrate salt waste at LANL resulted in the generation of 336 "daughter" containers. The treated nitrate salt daughter containers are safely stored at the Laboratory, and these drums will undergo certification before being shipped to the Waste Isolation Pilot Plant for disposal.

Upon completing treatment of all remediated nitrate salt waste containers, staff began to prepare for the treatment of the unremediated nitrate salt containers. Repackaging began on December 4, 2017, of the 27 unremediated nitrate salt containers, by a liner pull from the old drum and placement in a new drum. Treatment of the unremediated nitrate salt containers in the glovebox at the Waste Characterization Repackaging and Reduction Facility began on December 14, 2017, and concluded on March 13, 2018.

Settlement Agreement and Stipulated Final Order

In 2014, the New Mexico Environment Department's Hazardous Waste Bureau issued compliance orders for New Mexico Hazardous Waste Act violations stemming from the improper treatment of transuranic waste shipped from the Laboratory to the Waste Isolation Pilot Plant. The January 22, 2016, settlement agreement between DOE and the New Mexico Environment Department includes five supplemental environmental projects, which the Laboratory implemented through 2018.

1. Road Improvement Project – Improve routes at the Laboratory used for the transportation of transuranic waste to the Waste Isolation Pilot Plant.

   In 2018, the U.S. Army Corps of Engineers completed the road improvement design and began the first portion of the Road Improvement Project. This included milling and inlay of new asphalt along New Mexico State Route 502 and complete full-depth reconstruction on the main hill. All of this work was completed by Albuquerque Asphalt Inc. Once the first phase was completed, the U.S. Army Corps of Engineers selected a design engineering firm to manage the redesign of the State Route 4 and East Jemez Road intersection. The selected firm, Bohannon Houston, developed five options for the redesign of the intersection. The Integrated Project Team briefed the County of Los Alamos, New Mexico Department of Transportation Region 5, and New Mexico Department of Transportation state management. After reviewing all five designs, a concept was selected, and Bohannon Houston submitted a cost estimate to complete the design and construction. The design is scheduled to be completed in July 2019.

2. Triennial Review Project – Conduct an independent, external triennial review of environmental regulatory compliance and operations.

   In accordance with the January 2016 Settlement Agreement and Stipulated Final Order, an independent, external triennial review of environmental regulatory compliance and operations was conducted at LANL. This first triennial review was conducted in 2018, and the final report was issued on September 14, 2018. The Review Team identified 22 observations: 20 potential deficiencies, and 2 positive practices. The report concluded: "Overall, the management of air quality, ground water, and hazardous waste at LANL is effective and the LANL personnel consistently work to improve their procedures and management techniques."

3. Watershed Enhancement Project – Design and install engineering structures in and around the Laboratory to reduce storm water velocity and decrease sediment load to improve water quality in the area. This project includes a Low Impact Development Master Plan for the Laboratory (LANL 2017a).
    - Construction on the building 03-0028 parking lot project was completed in September 2018 and certified to the New Mexico Environment Department in October 2018.
    - Construction on building 53-0365 west parking lot project was completed in October 2018 and was certified to the New Mexico Environment Department in November 2018.
    - Construction on the main gate entry storm water pond was coordinated with the Potable Water Line Replacement Project activities, detailed below. Construction activities were completed in November 2018.
    - Four designs incorporating five projects identified in the Low Impact Development Master Plan were completed in August 2018 and certified to the New Mexico Environment Department in November 2018. These designs are available for implementation based on either available watershed enhancement or facility funding.
    - The upper Mortandad watershed wetland restoration was completed in 2017 and certified to the New Mexico Environment Department in July 2018.
    - Construction on the North Ancho watershed project was completed in July 2018, and certification to the New Mexico Environment Department occurred in October 2018.
    - Construction on the lower Sandia watershed project was completed in November 2018, and certification to the New Mexico Environment Department occurred in December 2018.
    - The upper Cañon de Valle project construction activities began in September 2018. Construction is scheduled to be completed in April 2019.
    - The mid-Mortandad watershed project design was completed in April 2018, and construction activities began in October 2018. Construction is scheduled to be completed in 2019.
    - Four additional storm water low-impact development designs were completed in 2018. These include designs for Technical Area 3 Physics Building south parking lot, Technical Area 3 Wellness Center, Technical Area 3 Building 123 parking lot, and Technical Area 53 East La Mesita Drive.
4. Surface Water Sampling Project – Conduct targeted sampling for sediment, storm water run-off, atmospheric deposits, and aquatic life in watersheds in and around the Laboratory to better understand surface water quality and stream reach characteristics

in the region, and share these results with the public and the New Mexico Environment Department.

- In 2018, we completed the following monitoring efforts:
  - We collected 22 storm water samples from ten sites in developed watersheds in and around the Laboratory.
  - We collected 17 storm water samples from eight sites in undeveloped reference watersheds to the west and north of the Laboratory and Los Alamos town site.
  - We collected eight atmospheric deposition samples from two sites in undeveloped reference watersheds to the west and north of the Laboratory and Los Alamos town site.
  - We did not collect any storm water samples from three sites at Laboratory firing sites.
- We collected samples of aquatic life from stream reaches in six watersheds in and around the Laboratory.
- We evaluated four locations in watersheds in and around the Laboratory using the New Mexico Environment Department's Hydrology Protocol Level 2 Criteria (New Mexico Environment Department 2011). The Hydrology Protocol distinguishes between ephemeral, intermittent, and perennial stream reaches and documents the uses supported by those waters.
- To improve the capabilities of the four Accord Pueblos in monitoring storm water, nine sites were established to collect storm water samples for the Pueblos. Two samples were collected in 2018.

5. Potable Water Line Replacement Project – Replace aging potable water lines and install metering equipment for Laboratory potable water systems.

   A contract was awarded to Sierra Canyon Construction on July 9, 2018, for Phases A (East Jemez Road) and Phase B (Bikini Atoll Road). In 2018, we completed approximately 65% of the pipe installation for Phase A, including directional drilling and connection to the existing system on Diamond Drive. Extensive potholing to locate utilities was completed in 2018 for Phase B.

The 2016 Compliance Order on Consent

The 2016 Compliance Order on Consent (modified in 2017; available at https://www.env.nm.gov/hazardous-waste/lanl/) is a settlement agreement between the New Mexico Environment Department and DOE addressing cleanup of legacy wastes. It supersedes the Compliance Order on Consent that was issued in 2005. The order guides and governs the ongoing cleanup of legacy waste at the Laboratory through an annual work planning process. Campaigns are planned using risk-based criteria to group, prioritize, and implement corrective actions. The annual planning process allows for revisions to cleanup campaigns based on actual work progress, changed conditions, and funding.

The Laboratory has two types of legacy waste corrective action sites: (1) Solid Waste Management Units and (2) Areas of Concern. Solid Waste Management Units are areas where solid wastes were spilled or disposed of. Examples of these Units include certain septic tanks, firing sites, landfills, sumps, and areas that historically received liquid effluents from outfalls. Areas of Concern are areas that may have received a hazardous waste or hazardous constituents through soil movement or effluent flow. Examples include canyon bottoms downstream from historical outfalls.

As of November 5, 2018, the Laboratory had 1,405 corrective action sites listed in Appendix A of the 2016 Compliance Order on Consent. During fiscal year 2018, 13 sites received certificates of completion with controls, 13 sites received certificates of completion without controls, and no sites were changed to a deferred status. Therefore, at the end of fiscal year 2018, 89 corrective action sites had certificates of completion with controls, 241 had certificates of completion without controls, and 134 sites were deferred until they no longer have active operations. The remaining 941 Solid Waste Management Units and Areas of Concern had investigations or corrective actions (or both) either in progress or pending. The cleanup of the PCB-contaminated site near the former Omega research reactor in Los Alamos Canyon was also completed during 2018.

The Compliance Order on Consent also addresses remediation of groundwater containing contaminants that resulted from Laboratory operations. Groundwater remediation activities are discussed in detail in Chapter 5, Groundwater Monitoring.

During the fiscal year we submitted the following documents to the New Mexico Environment Department Hazardous Waste Bureau as part of the Consent Order deliverables:

- five investigation reports,
- no cleanup status reports,
- one remedy completion report,
- Periodic Monitoring Reports for three watersheds,
- an annual update on the Integrated Facility Groundwater Monitoring Program,
- an annual update for Los Alamos/Pueblo Canyon Sediment Monitoring,
- one report on the Sandia Canyon wetland performance, and
- several reports on groundwater program activities.

Mixed Wastes: Federal Facility Compliance Act

The Federal Facility Compliance Act requires federal facilities that generate or store mixed waste to submit a Site Treatment Plan that includes a schedule for developing treatment capacities and technologies to treat all the facility's mixed waste. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the Laboratory requiring a Site Treatment Plan for mixed radioactive and hazardous wastes.

The Laboratory's Site Treatment Plan allows the Laboratory to store accumulated mixed waste at permitted storage units for more than one year, which is otherwise prohibited by the Land Disposal Restrictions provision of the Resource Conservation and Recovery Act, while identifying treatment and disposal options for the mixed waste inventory. The Site Treatment Plan provides enforceable time periods in which the facility is required to treat or otherwise meet land disposal restriction requirements for the accumulated waste.

The Laboratory submits an annual Site Treatment Plan update to the New Mexico Environment Department for approval. The update documents the amount of mixed waste that was stored at the Laboratory under the plan provisions during the previous fiscal year. It also records the amount of mixed waste that has been shipped to approved Treatment, Storage, and Disposal Facilities. Waste volumes may be adjusted slightly by reconciliation during the review process. Approved Site Treatment Plan updates are available at http://www.env.nm.gov/hazardous-waste/lanl-ffco-stp/.

During fiscal year 2018, mixed low-level waste covered under the Site Treatment Plan at LANL has decreased due to the transuranic waste recharacterization process. There is a backlog of stored waste because of shipping pauses, limited shipments to the Waste Isolation Pilot Plant, and restrictions onsite at Area G. The restrictions delayed the final confirmation, characterization, certification, and shipment of mixed waste for offsite treatment and disposal. Approximately 163.5 cubic meters of mixed low-level waste were stored at LANL during fiscal year 2018, and approximately 58.4 cubic meters of mixed low-level waste was shipped offsite for treatment and/or disposal.

The mixed transuranic waste inventory covered under the Site Treatment Plan was approximately 338.51 cubic meters during fiscal year 2018.

Specific Chemical Wastes: Toxic Substances Control Act

The Toxic Substances Control Act addresses the production, import, use, and disposal of specific chemicals, including PCBs. The Laboratory is responsible for record keeping and reporting the import or export of small quantities of chemicals used for LANL research activities and the disposal of PCB-containing substances. PCB-containing substances include: (1) dielectric fluids, (2) solvents, (3) oils, (4) waste oils, (5) heat-transfer fluids, (6) hydraulic fluids, (7) slurries, (8) soil, and (9) materials contaminated by spills.

In 2018, the Laboratory shipped offsite for disposal or recycling 158 containers (a total mass of 536,091 kilograms) of PCB-containing wastes, 141 cubic yards of solid waste contaminated with PCBs, and 27 gallons of liquid waste contaminated with PCBs. PCB wastes, including fluorescent light ballasts and contaminated soils, were sent to a U.S. Environmental Protection Agency-authorized treatment and disposal facility in Veolia, Colorado.

Laboratory staff conducted 15 Toxic Substances Control Act reviews for chemicals imported or exported by the Laboratory's Property Management Group Customs Office in 2018. These reviews are to ensure certain chemical compounds follow the Toxic Substance Control Act requirements prior to them being imported or exported out of the country. These shipments were all properly categorized, and the chemical compound samples were sent to collaborative researchers in other countries.

Solid Non-hazardous Wastes

In 2018, the Laboratory's solid non-hazardous waste sent offsite totaled 2,883 cubic meters. The Laboratory sends sanitary solid waste, construction debris, and demolition debris to the Los Alamos County Eco Station for transfer to municipal landfills such as the municipal waste landfill in Rio Rancho, New Mexico. Los Alamos County operates this transfer station and is responsible to the state of New Mexico for obtaining all related permits for these activities. The Laboratory also sends solid non-hazardous waste to regional facilities in neighboring states of Arizona and Colorado.

AIR QUALITY AND PROTECTION

Clean Air Act

Title V Operating Permit

Under the Clean Air Act, the Laboratory is regulated as a major source of air pollutants based on its potential to emit nitrous oxides, carbon monoxide, and volatile organic compounds. The Laboratory has a Clean Air Act Title V Operating Permit, and is required to keep air emissions of regulated pollutants below permit limits. In 2018, LANL submitted two Title V administrative revision applications for the following:

- Designate the U.S. Department of Energy, National Nuclear Security Administration as Owner, with Los Alamos National Security, LLC, and Newport News Nuclear BWXT-Los Alamos, LLC as Co-Operators (P100-R2M2, May 7, 2018)
- Replace Los Alamos National Security, LLC with Triad National Security, LLC as a Co-Operator (P100-R2M3, October 17, 2018)

The Laboratory annually certifies its compliance with the Title V Operating Permit and reports all permit deviations that occurred to the New Mexico Environment Department. Deviations occur when any permit condition is not met. In 2018, the Laboratory had one Title V Operating Permit deviation. A boiler operated without pollution control equipment operating correctly for a period of eight hours, approximately. The boiler was shut down and taken off-line until corrective actions were completed. This deviation was included in the 2018 Annual Compliance Certification submittal. Table 2-2 summarizes the Laboratory’s emissions data.

TABLE 2-2. CALCULATED EMISSIONS OF REGULATED AIR POLLUTANTS REPORTED TO THE NEW MEXICO ENVIRONMENT DEPARTMENT IN 2018

Emission Unit	Pollutants (Tons)					
	Nitrous Oxides	Sulfur Oxides	Particulate Matter	Carbon Monoxide	Volatile Organic Compounds	Other Hazardous Air Pollutants
Asphalt plant	0.005	0.003	0.003	0.17	0.003	0.003
Technical Area 3 power plant (3 boilers)	10.13	0.11	1.33	6.99	0.96	0.33
Technical Area 3 power plant (combustion turbine)	4.34	0.30	0.59	0.59	0.19	0.12
Research and development chemical use	n/a*	n/a	n/a	n/a	11.3	5.9
Degreaser	n/a	n/a	n/a	n/a	0.011	0.011
Data disintegrator	n/a	n/a	0.39	n/a	n/a	n/a
Stationary standby generators†	3.20	0.11	0.14	0.73	0.14	0.002
Miscellaneous small boilers	20.3	0.12	1.63	16.32	1.16	0.39
Permitted generators (11 units)	1.53	0.035	0.086	1.66	0.69	0.0004
TOTAL	**39.51**	**0.68**	**4.17**	**26.46**	**14.45**	**6.76**

**n/a = not applicable*

†The stationary standby generators are no longer sources in the Laboratory's Title V permit. However, they are included in this Table for comparison with previous annual site environmental reports.

The Laboratory's emissions in 2018 were significantly lower than the permit limits; for example, nitrogen oxide emissions were approximately 14 percent of the permit limit, carbon monoxide emissions were 11 percent of the permit limit, and particulate matter emissions were 3 percent of the permit limit. No emissions in excess of permit limits occurred from any of the permitted sources.

Figure 2-1 depicts a five-year history of pollutant emissions at the Laboratory. Emissions from 2014 through 2018 remained relatively constant.

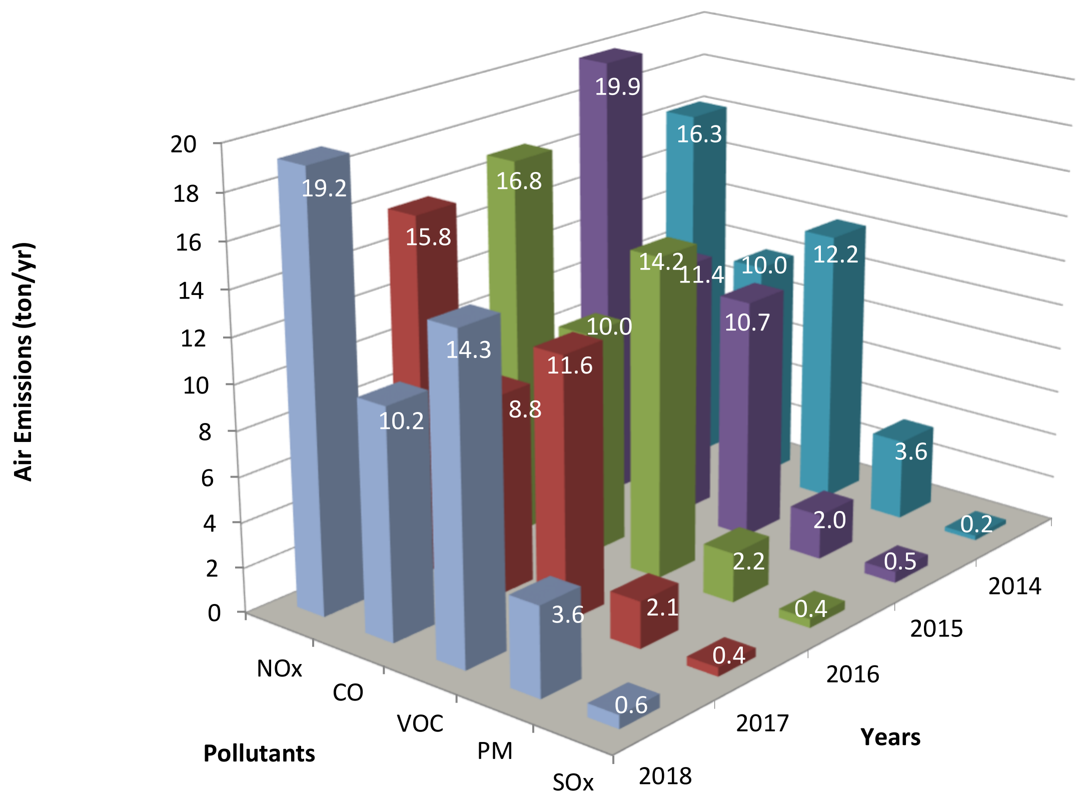

Figure 2-1. LANL criteria pollutant emissions from 2014 through 2018 for annual emissions inventory reporting. These totals do not include small boilers or standby generators.

Management of Refrigerants and Halons under Title VI – Stratospheric Ozone Protection

Title VI of the Clean Air Act regulates ozone-depleting chemicals, such as halons, chlorofluorocarbons, and hydrochlorofluorocarbons, as well as other non-ozone-depleting chemicals such as hydrofluorocarbons. These chemicals are primarily used as refrigerants, solvents, propellants, and foam-blowing agents. The regulation prohibits the Laboratory from knowingly venting or otherwise releasing into the environment any regulated chemical during maintenance, service, repair, or disposal of refrigeration equipment (such as air conditioners, refrigerators, chillers, or freezers) or fire-suppression systems. All technicians who work on refrigeration equipment at the Laboratory are certified by the U.S. Environmental Protection Agency. The Laboratory is working to remove refrigeration equipment that uses ozone-depleting substances and hydrofluorocarbons and substitute replacements that use more environmentally-friendly refrigerants listed as acceptable under the U.S. Environmental Protection Agency's Significant New Alternatives Program. In 2018, approximately 800 pounds of chlorodifluoromethane (HCFC-22) was sent to the United States Defense Logistics Agency's Ozone-Depleting Substances Reserve. Additionally, the Laboratory has made significant progress in eliminating halon use in fire-suppression systems, with only one remaining system that uses this chemical.

Regulation of Airborne Radionuclide Emissions under the Radionuclide National Emission Standards for Hazardous Air Pollutants

Emissions of airborne radionuclides are regulated under the Radionuclide National Emission Standards for Hazardous Air Pollutants, which sets a dose limit of 10 millirem per year to any member of the public for air emissions. The estimated maximum dose of air emissions to a member of the public in 2018 was 0.35 millirem, less than 5 percent of the limit (see Chapter 8, Public Dose and Risk Assessment).

New Mexico Air Quality Control Act

New Source Reviews

The Laboratory staff reviews plans for new and modified projects, activities, and operations to identify air quality compliance requirements. The State of New Mexico requires that new or modified sources of emissions be evaluated to determine whether they (1) do not require a construction permit because they are exempted under the New Mexico Administrative Code (“exempted”), (2) do not produce sufficient emissions to require a construction permit (“no permit required”), (3) require a notice of intent to construct, or (4) require both a notice of intent to construct and a construction permit. In 2018, the Laboratory submitted an air permit modification application for a major upgrade to the Technical Area 3 power plant (New Source Review Permit 2195B-M3). The three old boilers will be replaced with two new, more efficient boilers, and the existing combustion turbine will be fitted with a heat recovery steam generator to create a combined cycle unit. We also submitted two "No Permit Required" determination requests and received concurrence from the New Mexico Environment Department Air Quality Bureau. The first was for four small diesel engines used in a research project. The potential emissions from these engines are well below levels requiring a Construction Permit or a Notice of Intent. The second No Permit Required determination was for a thermal evaporator to evaporate treated wastewater. Also in 2018, we submitted to the State of New Mexico five “exempted” notifications for air emissions from the following exempt activities:

- Two emergency stand-by generators at Technical Area 55
- One emergency stand-by generator at Technical Area 50
- Sixteen small gas-fired comfort heaters and boilers
- One five-cell cooling tower
- Solvent change-out for existing degreaser

Asbestos Notifications

The National Emission Standards for Hazardous Air Pollutants require the Laboratory to provide advance notice to the New Mexico Environment Department for large renovation jobs that involve asbestos and for all demolition projects. The standards also require that facilities conducting activities involving asbestos mitigate visible airborne emissions and properly package and dispose of all asbestos-containing wastes. In 2018, 13 large renovation and demolition projects were completed. We provided advance notice to the New Mexico Environment

Department for each of these projects. All waste was properly packaged and disposed of at approved landfills.

SURFACE WATER QUALITY AND PROTECTION

Clean Water Act

The primary goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The Act requires National Pollutant Discharge Elimination System permits for several types of effluent and storm water discharges. The permits described below establish specific chemical, physical, and biological criteria and management practices the Laboratory must meet when discharging water. The U.S. Environmental Protection Agency, Region 6, provides and enforces the Laboratory's Clean Water Act permits. The New Mexico Environment Department certifies the permits as being protective of waters of the state and performs some compliance inspections and monitoring on behalf of the U.S. Environmental Protection Agency.

LANL's National Pollutant Discharge Elimination System Industrial and Sanitary Point-Source Outfall Permit

There are a total of 11 outfalls included in the Laboratory's National Pollutant Discharge Elimination System Industrial and Sanitary Point-Source Outfall Permit (#00228355 [Outfall Permit]) (Table 2-3). Six of the outfalls discharge cooling water from conventional cooling towers, and one outfall discharges treated sanitary waste. Five of the outfalls do not routinely discharge wastewater to the environment. The Laboratory is conducting a specific and continued effort to eliminate discharges to the environment under its Outfall Reduction Program.

TABLE 2-3. VOLUME OF EFFLUENT DISCHARGED FROM PERMITTED OUTFALLS IN 2018

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2018 Discharge (gallons)
03A048	53-963/978	Los Alamos Neutron Science Center cooling tower	Los Alamos	26,800,660
051	50-1	Technical Area 50 Radioactive Liquid Waste Treatment Facility	Mortandad	0
04A022*	3-2238	Sigma emergency cooling system	Mortandad	572,400
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	63,042
03A181	55-6	Plutonium Facility cooling tower	Mortandad	3,134,857
13S	46-347	Sanitary wastewater system plant	Sandia	0
001	3-22	Power plant (includes treated effluent from sanitary wastewater system plant)	Sandia	58,055,900
03A027	3-2327	Strategic Computing Complex cooling tower	Sandia	0
03A113	53-293/952	Los Alamos Neutron Science Center cooling tower	Sandia	436,570
03A199	3-1837	Laboratory Data Communications Center	Sandia	13,295,100
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2018 Total:	102,358,529

**This outfall's designation was changed from 03A022 to 04A022 in the October 2014 permit renewal to reflect only emergency cooling water and roof drain/storm water discharges to the outfall (cooling tower blowdown was diverted to the sanitary wastewater system plant).*

The Laboratory's current Outfall Permit requires weekly, monthly, quarterly, yearly, and term sampling of the effluents (treated industrial wastewater) released to the environment to demonstrate compliance with the permit's water quality limits. The sampling results are compared to the permit limits and are reported every month in a Discharge Monitoring Report to the U.S. Environmental Protection Agency and the New Mexico Environment Department. Additionally, any engineering changes or flow changes that would affect quality or quantity of the effluents are reported in a Notice of Planned Change to the U.S. Environmental Protection Agency and the New Mexico Environment Department. On April 1, 2019, LANL's Outfall Permit is due for its 5-year renewal.

Outfalls listed in the Outfall Permit #0028355 that did not discharge in 2018 include Outfalls 05A055, 051, 03A027, and 13S. Outfall 03A160 discharged from January to May 2018 and was then rerouted to the Sanitary Wastewater Treatment Plant. Staff collected 826 outfall samples in 2018. The analyses showed no exceedances above the permit limits except for two samples: one exceedance for total recoverable chlorine caused by a maintenance issue that was immediately fixed, and one exceedance for PCBs. Over the past two years, the Laboratory has been working on studies and projects to identify and reduce PCBs in water discharged through outfall 001. Efforts to clean up PCBs in upstream sumps, tanks, cleanouts, and manholes are ongoing. Staff have optimized the treatment process at the sanitary wastewater treatment plant to increase its ability to degrade and remove PCBs. These combined efforts have reduced PCBs in the effluent by approximately 90 percent in the last two years, and we are continuing to address these issues.

National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites

The National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites (Construction General Permit) regulates storm water discharges from construction sites covering one or more acres. Laboratory compliance with the Construction General Permit includes developing storm water pollution prevention plans and conducting site inspections during construction. A storm water pollution prevention plan describes the project activities, site conditions, best management practices for erosion control, and permanent control measures, such as storm water detention ponds, required for reducing pollutants in storm water discharges. LANL staff inspect the location and condition of storm water controls during construction and identify corrective actions if needed.

In 2018, the Laboratory was responsible for 30 storm water pollution prevention plans for construction sites, and performed 695 inspections. The U.S. Army Corps of Engineers managed an additional two construction sites with storm water pollution prevention plans, and performed 93 inspections. Ninety-six percent of the inspection items were in compliance for the Laboratory-managed projects, and 100 percent of the inspection items were in compliance for the U.S. Army Corps of Engineers-managed projects.

National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities

The National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities (Multi-Sector General Permit) regulates storm water discharges from specific industrial activities and their associated facilities. Industrial activities conducted at the Laboratory and covered under the Multi-Sector General Permit include: (1) metal and ceramic fabrication, (2) wood product fabrication, (3) hazardous waste treatment and storage, (4) vehicle and equipment maintenance, (5) recycling activities, (6) electricity generation, (7) warehousing activities, and (8) asphalt manufacturing.

In 2018, responsibilities for Multi-Sector General Permit compliance at the Laboratory transitioned from Los Alamos National Security, LLC to Newport News Nuclear BWXT – Los Alamos, LLC (N3B) for legacy waste cleanup work, and from Los Alamos National Security, LLC to Triad National Security, LLC for management and operation of the Laboratory. On May 1, 2018, N3B took over management of three facilities covered under the permit at Technical Area 54 (Area G, Area L, and the Maintenance Facility West). On November 1, 2018, Triad National Security, LLC took over the Laboratory's Management and Operating contract. These changes resulted in the U.S. Environmental Protection Agency's issuance of three new Multi-Sector General Permit tracking numbers and termination of one tracking number as shown in the following table (Table 2-4).

TABLE 2-4. MULTI-SECTOR GENERAL PERMIT TRACKING NUMBERS BY OPERATOR AND COVERED INDUSTRIAL ACTIVITY

Permit Tracking Number	Industrial Activities Covered	Responsible Operator	Operator Role	Date Permit Coverage Began
NMR050011	Technical Area 54 Maintenance Facility	N3B	Environmental Management Legacy Cleanup	5/2/2018
NMR050012	Technical Area 54 Areas G and L	N3B	Environmental Management Legacy Cleanup	5/2/2018
NMR053195	Metal and ceramic fabrication, wood product fabrication, hazardous waste treatment and storage, vehicle and equipment maintenance, recycling activities, electricity generation, warehousing activities, and asphalt manufacturing	Los Alamos National Security, LLC	National Nuclear Security Administration Operations and Management	10/3/2015, Terminated 10/31/2018
NMR050013	Metal and ceramic fabrication, wood product fabrication, vehicle and equipment maintenance, recycling activities, electricity generation, warehousing activities, and asphalt manufacturing	Triad National Security, LLC	National Nuclear Security Administration Operations and Management	11/1/2018

A permit tracking number issued by the U.S. Environmental Protection Agency to an operator authorizes storm water discharge from a specific facility or group of facilities. As the Laboratory's Multi-Sector General Permit implementation and compliance are now operator and facility specific, annual compliance activities are reported separately for each operator.

Management and Operating Contractor Compliance Summary

The Multi-Sector General Permit requires the implementation of storm water control measures, development of storm water pollution prevention plans, and monitoring of storm water discharges at 13 permitted LANL sites operated by the Laboratory's management and operating contractor. The requirements for compliance include:

- developing and implementing facility-specific storm water pollution prevention plans;

- inspecting facility storm water control and performing corrective actions as needed;
- sampling storm water run-off at facilities and comparing results to benchmark values, impaired water limits, and effluent limitations; and
- visually inspecting storm water run-off to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

Storm water monitoring under the Multi-Sector General Permit occurs from April 1 through November 30 each year. Under the current permit, the benchmark values for some pollutants are the same as New Mexico water quality standards.

If an exceedance occurs, it triggers corrective action, which includes evaluation of potential sources and either follow-up action or documentation of why no action is required. All of the identified corrective actions associated with exceedances in 2018 have been completed. An exceedance of a benchmark value does not trigger a corrective action if it is determined that the exceedance is solely attributable to natural background sources.

In 2018, we completed the following tasks as part of the Multi-Sector General Permit compliance:

- 106 inspections of storm water controls at the 13 active permitted sites,
- one annual inspection at each of 36 sites having "no exposure" status,
- one annual inspection at an inactive site,
- collection of 64 samples at 9 active permitted sites,
- 712 sampling equipment inspections,
- 43 visual inspections at 23 monitored discharge points,
- 69 visual inspections at 43 substantially identical discharge points,
- transformation of two active permitted sites to no-exposure status,
- transfer of three permitted sites to a new permittee (N3B),
- 151 corrective actions including:
  - 34 corrective actions to mitigate exceedances,
  - a new asphalt millings staging area with storm water controls,
  - 12 additional storm water control measures installed at four active permitted sites,
  - maintenance, repair, or replacement of 5 control measures at three active permitted sites,
  - 38 actions to remedy control measures inadequate to meet non-numeric effluent limits, and
  - 25 corrective actions to address unauthorized releases (spills) or discharges.

By meeting permit-defined criteria under Los Alamos National Security, LLC, Permit Tracking Number NMR053195, we were able to discontinue monitoring for 25 pollutants at a total of eight active permitted sites for part of 2018. Sixteen pollutants registered below benchmark values at four sites, so monitoring for these pollutants was discontinued. Also, monitoring for nine other pollutants was discontinued at seven sites because there was no detection of the pollutants at the sites.

This reduction in monitoring was only allowed under the Los Alamos National Security, LLC Permit Tracking Number NMR053195, which ended on 10/31/2018. Monitoring requirements were reset with the issuance of Triad National Security, LLC Permit Tracking Number NMR050013, and requirements to monitor for the full suite of parameters became effective on November 1, 2018.

Table 2-5 and Table 2-6 summarize the exceedance of water quality standards (i.e., impaired waters), effluent limitations, or quarterly benchmarks for the management and operating contractor's National Pollutant Discharge Elimination System Multi-Sector General Permit.

TABLE 2-5. 2018 EXCEEDANCES OF THE MANAGEMENT AND OPERATING CONTRACTOR'S NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM MULTI-SECTOR GENERAL PERMIT IMPAIRED WATERS* LIMITS

Discharge Point	Exceeded Parameters			Date(s) Exceeded
	Copper, dissolved	Adjusted Gross Alpha	Aluminum, Total Recoverable	
002	✓		✓	07/05/2018
005	✓	✓	✓	05/21/2018
009	✓		✓	07/08/2018
012		✓	✓	07/17/2018
017	✓		✓	05/21/2018
020	✓			05/21/2018
022	✓		✓	05/21/2018
026	✓			06/03/2018
029	✓	✓		05/21/2018 – adjusted gross alpha; 07/09/2018 – copper
031	✓			08/07/2018
032	✓	✓	✓	05/21/2018
042	✓	✓	✓	08/10/2018
073	✓		✓	07/17/2018 – copper; 08/16/2018 – aluminum
075	✓	✓	✓	05/21/0218

**An impaired waters exceedance means that the value exceeds a New Mexico surface water quality standard, as provided in Part20.6.4 of the New Mexico Administrative Code. Twenty-nine of 41 impaired waters results (70 percent) exceeded a New Mexico surface water quality standard.*

TABLE 2-6. 2018 EXCEEDANCES OF THE MANAGEMENT AND OPERATING CONTRACTOR'S NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM MULTI-SECTOR GENERAL PERMIT QUARTERLY BENCHMARKS*

Discharge Point	Exceeded Parameters			Date(s) Exceeded
	Copper, Dissolved	Iron, Total	Zinc, Dissolved	
002			✓	07/05/2018
005		✓		05/21/2018
017	✓			05/21/2018
020			✓	05/21/2018, 08/02/2018

**A quarterly benchmark exceedance means the value exceeded a benchmark value defined in the Multi-Sector General Permit. Benchmarks are not permit limits. The benchmark values for copper, aluminum, zinc, and cyanide are the same as New Mexico surface water quality standards. Five of 23 benchmark results measured (17 percent) resulted in a benchmark value exceedance.*

Legacy Cleanup Contractor (N3B) Compliance Summary

N3B completed the following corrective actions in 2018:

- Technical Area 54 Areas G and L – The combined results of routine facility inspections, visual assessments, and benchmark and impairment sampling generated 54 corrective actions conducted at 38 monitored or inspected locations containing either discharge points or installed storm water best management practices or storm water controls. All corrective actions were completed within 45 days of discovering the issue.
- Technical Area 54 Maintenance Facility West – The combined results of routine facility inspections, visual assessments, and impairment sampling generated eight corrective actions conducted at three locations containing either discharge points or installed storm water best management practices or storm water controls. All corrective actions initiated during 2018 were completed within 45 days of discovering the issue.

Table 2-7 summarizes the exceedance of water quality standards (i.e., impaired waters), effluent limitations, or quarterly benchmarks for the legacy cleanup contractor's National Pollutant Discharge Elimination System Multi-Sector General Permit.

TABLE 2-7. 2018 EXCEEDANCES OF THE LEGACY CLEANUP CONTRACTOR'S NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM MULTI-SECTOR GENERAL PERMIT QUARTERLY BENCHMARKS*

Discharge Point	Exceeded Parameters				Date(s) Exceeded
	Aluminum, Total Recoverable	Adjusted Gross Alpha	Magnesium, Total	Chemical Oxygen Demand	
049	✓				8/10/10
050			✓	✓	08/01/18
069			✓	✓	06/16/2018 & 08/01/18
072		✓	✓		07/09/2018 - adjusted gross alpha, magnesium; 8/10/18 - magnesium; 10/14/18 - magnesium

**A quarterly benchmark exceedance means the value exceeded a benchmark value defined in the Multi-Sector General Permit. Benchmarks are not permit limits. The benchmark values for aluminum are the same as New Mexico surface water quality standards. Forty-two of 134 benchmark results measured (31 percent) resulted in a benchmark value exceedance.*

LANL's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (from Solid Waste Management Units and Areas of Concern)

The Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (Individual Permit) authorizes discharges of storm water from certain Solid Waste Management Units and Areas of Concern (hereafter called sites) at the Laboratory. The U.S. Environmental Protection Agency issued the original permit in 2010, and it has been administratively continued. The 2010 permit conditions will be in effect until a new permit is issued. When N3B assumed responsibility for the Legacy Cleanup contract, they also assumed responsibility for the Individual Permit compliance activities.

The permit lists 405 sites that must be managed in compliance with its terms and conditions. The objective is to prevent the transport of contaminants to surface waters by storm water run-off from these sites. Constituents of concern potentially occurring at these sites include metals, organic chemicals, high explosives, and radionuclides.

The Individual Permit has technology-based requirements for storm water control. This means that storm water control measures that reflect best industry practices, considering their availability, economic achievability, and practicability, are required at each of the 405 permitted sites. Examples of control measures used to manage storm water under the Individual Permit include retention berms and coir logs. These storm water control measures are routinely inspected and are maintained as needed.

To monitor the effectiveness of the storm water controls, sites are grouped into 250 small sub-watersheds called site monitoring areas. Sampling locations have been identified within each of these site monitoring areas to most effectively sample storm water run-off from the sites. The sampling results are used to assess the effectiveness of the controls. The target action levels are based on the New Mexico water quality standards. We implement additional storm water controls if target action levels are exceeded.

Once all control measures have been installed and the results of sampling confirm that all pollutants of concern for a site monitoring area are below the target action levels, the Laboratory can certify to the U.S. Environmental Protection Agency that the corrective actions are complete for the sites in that site monitoring area. If all the storm water control measures have been installed, but the Laboratory cannot demonstrate that all analytical results are below target action levels (for example, if natural background concentrations at the site are above the target action levels), the Laboratory can request that a site be placed into alternative compliance, where the completion of the corrective action is accomplished according to an individually tailored compliance schedule determined by the U.S. Environmental Protection Agency.

In summary, the process of complying with the Individual Permit can be broken down into five categories: (1) installation and maintenance of control measures, (2) storm water confirmation sampling to determine effectiveness of control measures, (3) additional corrective action (if a target action level is exceeded), (4) reporting results of fieldwork and monitoring to the U.S. Environmental Protection Agency and the New Mexico Environment Department, and (5) certification of corrective action complete or requests for alternative compliance to the U.S Environmental Protection Agency.

In 2018, we completed the following tasks to comply with the requirements of the Individual Permit:

- Published an update to the 2017 Site Discharge Pollution Prevention Plan, which identified pollutant sources, described control measures, and defined the monitoring at all permitted sites
- Completed 848 inspections of storm water controls at the 250 site monitoring areas
- Completed 1,146 sampling equipment inspections
- Conducted storm water monitoring at 146 site monitoring areas
- Collected post-certification storm water samples and completed the monitoring at two site monitoring areas
- Collected eight extended baseline control confirmation samples at eight site monitoring areas
- Collected corrective action enhanced control confirmation samples at ten site monitoring areas
- Installed 31 additional control measures at 17 site monitoring areas
- Installed two replacement baseline controls at two site monitoring areas
- Installed three replacement enhanced controls at two site monitoring areas
- Held two public meetings as required by the Individual Permit

No alternative compliance requests were submitted in 2018. For more information on surface water quality at the Laboratory, see Chapter 6, Watershed Quality.

Table 2-8 summarizes the exceedance of target action levels for the Individual Permit.

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TABLE 2-8. 2018 EXCEEDANCES OF LANL'S NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM INDIVIDUAL PERMIT TARGET ACTION LEVELS

Site Monitoring Area	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Date(s) Exceeded	Description and Corrective Action
3M-SMA-0.2	Copper, dissolved	maximum target action level	1	1	07/15/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Gross Alpha	average target action level	1	1	07/15/2018	
	Mercury, total	average target action level	1	1	07/15/2018	
A-SMA-1.1	Mercury, total	average target action level	1	1	08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Aluminum, dissolved	maximum target action level	1	1	08/10/2018	
	Gross Alpha	average target action level	1	1	08/10/2018	
	Selenium, total	average target action level	1	1	08/10/2018	
A-SMA-3	Copper, dissolved	maximum target action level	1	1	08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Gross Alpha	average target action level	1	1	08/10/2018	
	Total PCB	average target action level	1	1	08/10/2018	
A-SMA-4	Gross Alpha	average target action level	1	1	07/23/2018	The site monitoring area is being evaluated for a corrective action recommendation.
CDV-SMA-7	Gross Alpha	average target action level	2	2	07/17/2018 08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.

Site Monitoring Area	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Date(s) Exceeded	Description and Corrective Action
CDV-SMA-9.05	Gross Alpha	average target action level	1	1	08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.
CHQ-SMA-1.02	Copper, dissolved	maximum target action level	1	2	08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.
CHQ-SMA-1.03	Total PCB	average target action level	1	1	08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Gross Alpha	average target action level	1	1	08/10/2018	
	Copper, dissolved	maximum target action level	1	1	08/10/2018	
CHQ-SMA-2	Copper, dissolved	maximum target action level	1	2	08/15/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Gross Alpha	average target action level	2	2	07/23/2018 08/15/2018	
CHQ-SMA-4	Total PCB	average target action level	1	1	07/23/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Gross Alpha	average target action level	1	1	07/23/2018	
	Selenium, total	average target action level	1	1	07/23/2018	
CHQ-SMA-7.1	Aluminum, dissolved	maximum target action level	1	1	07/23/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Copper, dissolved	maximum target action level	1	1	07/23/2018	
	Gross Alpha	average target action level	1	1	07/23/2018	

Site Monitoring Area	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Date(s) Exceeded	Description and Corrective Action
LA-SMA-3.1	Total PCB	average target action level	1	1	10/24/2018	The site monitoring area is being evaluated for a corrective action recommendation.
M-SMA-1.21	Copper, dissolved	maximum target action level	1	1	10/24/2018	The site monitoring area is being evaluated for a corrective action recommendation.
PJ-SMA-11	Copper, dissolved	maximum target action level	1	1	08/10/2018	The site monitoring area is being evaluated for a corrective action recommendation.
	Gross Alpha	average target action level	1	1	08/10/2018	
	Selenium, total	average target action level	1	1	08/10/2018	
PJ-SMA-18	Gross Alpha	average target action level	1	1	08/10/18	Result collected following certification of completion of corrective action: Installed control measures that eliminated exposure of site to storm water.
PJ-SMA-3.05	Gross Alpha	average target action level	1	1	09/03/2018	The site monitoring area is being evaluated for a corrective action recommendation.
PJ-SMA-5	Copper	maximum target action level	1	1	09/03/2018	The site monitoring area is being evaluated for a corrective action recommendation.
PT-SMA-4.2	Gross Alpha	average target action level	1	1	08/10/2018	The site monitoring area is being evaluated for a

Site Monitoring Area	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Date(s) Exceeded	Description and Corrective Action
						corrective action recommendation.
STRM-SMA-1.5	Silver, dissolved	maximum target action level	1	1	09/03/2018	Enhanced corrective action monitoring will continue.
	Gross Alpha	average target action level	1	1	09/03/2018	
W-SMA-1	Aluminum, dissolved	maximum target action level	1	1	10/24/2018	Result collected following certification of completion of corrective action: Installed control measures that eliminated exposure of site to storm water.
	Copper, dissolved	maximum target action level	1	1	10/24/2018	

The maximum target action level is the target for individual maximum values recorded at a site, and the average target action level is the target for the geometric mean of applicable monitoring results at a site. Target action levels are benchmarks, not permit limits.

Aboveground Storage Tank Program

The Laboratory’s Aboveground Storage Tank Program manages compliance with the requirements of the U.S. Environmental Protection Agency under the Clean Water Act and with the New Mexico Administrative Code regulations administered by the New Mexico Environment Department’s Petroleum Storage Tank Bureau. The Laboratory operates 10 tank systems with 12 storage tanks.

In 2018, the Petroleum Storage Tank Bureau staff inspected ten of the aboveground storage tanks at the Laboratory. Two facilities were issued Notices of Violation following the inspections. Inspection findings at one facility were addressed and received a Certificate of Compliance from the Petroleum Storage Tank Bureau, while corrective actions are in progress at the second facility. The Bureau also issued a Certificate of Compliance to document that a previous year's inspection findings had been corrected for one site.

The Laboratory also provided technical testimony to the New Mexico Environmental Improvement Board in support of the revisions to the aboveground storage tank regulations found in Part 20.5 of the New Mexico Administrative Code.

The U.S. Environmental Protection Agency requires spill prevention, control, and countermeasure plans for facilities with aboveground storage tank systems. In 2018, Laboratory staff updated two of these plans and conducted 30 inspections of facilities with plans. In 2018, the Laboratory was in full compliance with the federal Clean Water Act requirements for the tanks.

Clean Water Act Section 404/401 Permits

Section 404 of the Clean Water Act requires that the Laboratory receive verification from the U.S. Army Corps of Engineers that proposed projects within perennial, intermittent, or ephemeral watercourses comply with Clean Water Act nationwide permit conditions. Additionally, Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by the U.S. Army Corps of Engineers comply with state water quality standards. The New Mexico Environment Department reviews Section 404/401 permit applications and issues separate Section 401 certification letters, which may include additional requirements to meet state stream standards for individual Laboratory projects. Section 404/401 verifications and certifications that were issued or active at the Laboratory in 2018 are listed in Summary of Permits and Legal Orders section at the end of this chapter.

The Energy Independence and Security Act: Storm Water Management Practices

Section 438 of the Energy Independence and Security Act of 2007 establishes storm water run-off requirements for federal development and redevelopment projects. Any federal project over 5,000 square feet that alters the flow of water over the surface of the ground must implement low-impact development controls to maintain pre-development water temperatures, flow rates, flow volumes, and duration. Examples of appropriate controls include vegetated swales, infiltration basins, permeable pavement, vegetated strips, rain barrels, and cisterns. The goal is to control run-off through infiltration, evapotranspiration, or harvest and reuse.

The Laboratory currently identifies projects for Section 438 compliance through the permits and requirements identification process and excavation permitting. LANL's Environmental Protection and Compliance Division is responsible for implementing Section 438 compliance and works with internal and subcontractor design and construction personnel to meet the requirements. Section 438 guidance is published in the LANL Engineering Standards Manual. In 2018, fewer than five projects were completed that required Energy Independence and Security Act compliance. As part of their Section 438 compliance, projects such as the Radiological Laboratory/Utilities/Office Building Paving and Swale project, the Technical Area 22 Office Complex, and the Technical Area 40 Dynamic Equations of State Project used swales, detention basins, and revegetation to manage storm water discharge.

New Mexico Water Quality Act: Surface Water Protection

Under the New Mexico Water Quality Act, the New Mexico Water Quality Control Commission adopts standards for surface waters of the state. The Standards for Interstate and Intrastate Surface Waters (Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code) establish surface water quality standards by defining designated surface water uses for the state, setting water quality criteria to protect those uses, and providing an anti-degradation policy. The Laboratory's National Pollutant Discharge Elimination System permits, along with any dredge and fill activities approved under Section 404 of the Clean Water Act, must be certified by the New Mexico Environment Department to ensure New Mexico water quality standards are met.

Additionally, under Section 303(d) of the Clean Water Act, the New Mexico Environment Department determines which stream reaches within the state are impaired for their designed use(s). The New Mexico Environment Department uses the Laboratory's surface water monitoring data in developing its list of impaired waters for the assessment units on Laboratory property. The discharge limits and monitoring requirements in the Laboratory's National Pollutant Discharge Elimination System permits are determined, in part, by the impairment status of affected water courses. In 2018, most assessment units at the Laboratory were evaluated as impaired, sometimes because of naturally occurring substances. See Chapter 6, Watershed Quality, for more information.

GROUNDWATER QUALITY AND PROTECTION

Safe Drinking Water Act

The Los Alamos County Department of Public Utilities supplies water for Los Alamos, White Rock, the Laboratory, and Bandelier National Monument. The Department issues an annual drinking water quality report, as required by the Safe Drinking Water Act. That report is available at https://www.losalamosnm.us/common/pages/DisplayFile.aspx?itemId=15763913. For 2018 the drinking water quality for Los Alamos met all U.S. Environmental Protection Agency regulations.

New Mexico Water Quality Act: Groundwater Quality Standards

In fiscal year 2018 we reported to the New Mexico Environment Department six instances of a contaminant detected in groundwater at a location where the contaminant had not been previously detected above a standard or screening level (Table 2-9). The standards and screening levels for this reporting requirement include: (1) the New Mexico Water Quality Control Commission groundwater standard, (2) the U.S. Environmental Protection Agency maximum contaminant level, and (3) the New Mexico Environment Department Soil Screening Levels Summary Table A-1 Values for Tap Water.

TABLE 2-9. 2018 LOCATIONS WITH FIRST-TIME GROUNDWATER QUALITY STANDARD OR SCREENING LEVEL EXCEEDANCES

Parameter Name	Location	Groundwater Zone	Sample Date	Result	Standard or Screening Level Value	Units	Type of Standard or Screening Level
Chromium	R-45 S1 well	Regional aquifer	12/18/2017	50.7	50	µg/L	New Mexico Groundwater Standard[a]
Fluoride	MCO-7 well	Alluvial	1/11/2018	1.75	1.6	mg/L	New Mexico Groundwater Standard
RDX	Bulldog Spring	Intermediate Spring	2/21/2018	7.69	7.02	µg/L	New Mexico Environment Department A1 Tap Water Screening Level[b]
Perchlorate	R-61 S1 well	Regional aquifer	6/18/2018	15.0	13.8	µg/L	New Mexico Environment Department A1 Tap Water Screening Level
Mercury	R-3 well	Regional aquifer	6/21/2018	2.01	2	µg/L	U.S. Environmental Protection Agency Maximum Contaminant Level[c]
Barium	Burning Ground Spring	Intermediate Spring	8/11/2018	1030	1000	µg/L	New Mexico Groundwater Standard

a. *New Mexico Water Quality Control Commission groundwater standards before December 21, 2018*
b. *March 2018 New Mexico Environment Department Soil Screening Levels Summary Table A-1 Values for Tap Water Screening Level*
c. *U.S. Environmental Protection Agency maximum contaminant level*
Note: µg/l = micrograms per liter; mg/l = milligrams/liter

New Mexico Water Quality Act: Groundwater Discharge Regulations

Under the New Mexico Water Quality Act, the New Mexico Water Quality Control Commission sets regulations for liquid discharges onto or below ground surfaces to protect groundwater. The New Mexico Environment Department enforces the groundwater discharge regulations and may require a facility that discharges effluents to submit a discharge plan and obtain a permit. At the beginning of 2018, the Laboratory had four discharge permits and one discharge permit application pending. On August 29, 2018, the New Mexico Environment Department issued Discharge Permit DP-1132 to the Laboratory for discharges from the Technical Area 50 Radioactive Liquid Waste Treatment Facility.

Technical Area 46 Sanitary Wastewater System Plant Discharge Permit DP-857

On December 16, 2016, the Laboratory was issued a renewal and modification for Discharge Permit DP-857, which applies to combined effluent discharges from the Technical Area 46 sanitary wastewater system plant, the Sanitary Effluent Reclamation Facility, and the Sigma Mesa evaporation basins.

The permit conditions require quarterly, semi-annual, and annual sampling of (1) the sanitary wastewater system plant's treated water product before discharge, (2) effluent from Outfalls 001 and 03A027 (outfalls that can discharge water from the sanitary wastewater system plant), and (3) alluvial groundwater well SCA-3 in Sandia Canyon. In 2018, none of the samples collected exceeded the New Mexico groundwater standards, and no inspection of Discharge Permit DP-857 facilities was conducted.

Domestic Septic Tank Disposal Systems Discharge Permit DP-1589

On July 22, 2016, the New Mexico Environment Department issued Discharge Permit DP-1589 to the Laboratory for discharges from eight septic tank disposal systems. These septic systems (a combined septic tank and leach field) are located in remote areas of the Laboratory where access to the sanitary wastewater system plant's collection system is not practicable. Four of the eight septic tank disposal systems are active; the remaining four systems are inactive because water service to the buildings using the systems are disconnected.

Discharge Permit DP-1589 requires monitoring and inspections for the Laboratory's septic tank disposal systems. These actions include, but are not limited to, the following: (1) routine septic tank sampling, (2) septic tank water-tightness testing, (3) inspection of the septic tank for the accumulation of scum and solids, and (4) inspection of the leach field disposal system.

Technical Area 50 Radioactive Liquid Waste Treatment Facility Discharge Plan and Permit Application DP-1132

On August 20, 1996, the Laboratory submitted a discharge plan and permit application for the Radioactive Liquid Waste Treatment Facility at Technical Area 50. On November 18, 2011, the New Mexico Environment Department requested an updated discharge plan and permit application for this facility, including the solar evaporative tank for discharged treated water located at Technical Area 52. We submitted an application on February 16, 2012, and supplemental information on August 10, 2012. On September 13, 2013, the New Mexico Environment Department issued a draft discharge permit for public review and comment.

On April 19, 2018, the New Mexico Environment Department held a public hearing in Los Alamos, New Mexico, on the Laboratory's application. Following issuance of the Hearing Officer's Report, the Secretary of the New Mexico Environment Department issued DP-1132 on August 29, 2018.

Discharge Permit DP-1132 contains 60 conditions that require the Laboratory to implement operational, monitoring and closure actions. Examples of these actions are (1) monthly sampling of treated effluent, (2) quarterly and annual groundwater monitoring at seven alluvial, perched-intermediate, and regional aquifer wells, (3) the installation of a soil moisture monitoring system beneath the Technical Area 52 solar evaporation tank, (4) the removal from service of seven tanks that do not have secondary containment, and (5) posting of select documents to the Laboratory’s Electronic Public Reading Room.

Land Application of Treated Groundwater Discharge Permit DP-1793

On July 27, 2015, the New Mexico Environment Department issued Discharge Permit DP-1793 to the Laboratory for the discharge of treated groundwater by land application (spraying treated groundwater onto the surface of the ground). Activities involving land application of treated groundwater include well pumping tests, aquifer tests, well rehabilitation, and groundwater tracer studies. Under the permit, individual work plans must be submitted for each land application project. Work plans are posted to the Laboratory’s Electronic Public Reading Room for a 30-day public comment period. Each work plan addresses how groundwater will be treated so that constituent concentrations are less than 90 percent of the New Mexico groundwater standards before discharge.

The 2017 annual report for DP-1793 was submitted to the New Mexico Environment Department on February 26, 2018. Sample results for all water that was land applied demonstrated that constituents of concern were below regulatory limits. All reports were submitted within compliance deadlines.

Injection of Treated Groundwater into Class V Underground Injection Control Wells Discharge Permit DP-1835

On August 31, 2016, the New Mexico Environment Department issued Discharge Permit DP-1835 for the injection of treated groundwater into six Class V underground injection control wells in Mortandad Canyon. This permit authorized the withdrawal of chromium-contaminated groundwater from three extraction wells, treatment by ion exchange, and the injection of treated groundwater back into the regional aquifer by six underground injection control wells. On June 28, 2017, we requested this permit language be modified since a fourth extraction well was planned. On July 21, 2017, the New Mexico Environment Department approved this request. Treated groundwater is sampled to demonstrate that chromium concentrations are less than 90 percent of the New Mexico groundwater standard for chromium (50 micrograms per liter) before injection.

Discharge Permit DP-1835 requires quarterly reporting to document (1) influent and discharge volumes, flow rates, and effluent sample results of the treatment systems; (2) volumes injected and water levels above static level for the injection wells; (3) volumes extracted from the extraction wells; (4) quarterly groundwater sample results and groundwater contour maps from the monitoring wells; (5) any operations or maintenance activities completed, including replacement of ion exchange vessels or well work-overs; (6) any periodic mechanical integrity testing completed; and (7) changes to operations.

The discharge permit also requires the demonstration of mechanical integrity of the distribution piping and injection wells within one year of the permit's effective date. In 2017, we began construction of the fourth extraction well and its associated piping. Since these activities were scheduled to extend beyond the one-year requirement, on August 28, 2017, we requested the initial demonstration of mechanical integrity of the distribution piping and injection wells be extended until June 30, 2018.

On November 21, 2017, the New Mexico Environment Department conditionally approved operational testing for the injection of treated groundwater at CrIN-1. Furthermore, they required the Laboratory in 2018 to provide recommendations for the injection system operation based on the operational test data collected.

Compliance Order on Consent Groundwater Activities

In 2018, the Laboratory performed groundwater protection activities as directed by the New Mexico Environment Department under the Compliance Order on Consent. Activities included sampling and testing groundwater from wells for general monitoring of groundwater quality, investigating the chromium and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) groundwater plumes, and supporting the chromium interim measure. Furthermore, a new regional aquifer groundwater monitoring well, R-69, was drilled and substantially completed as part of the RDX investigation. In April 2018, N3B assumed responsibility for the Compliance Order on Consent activities.

Interim measures are actions taken at a contaminated site to reduce chances of human or environmental exposures before the remedial investigation is complete. The goal of the chromium interim measure is to control migration of the chromium groundwater plume, while the Laboratory assesses cleanup methods. In 2018, water treatment operations supporting the chromium interim measure included (1) withdrawing chromium-contaminated groundwater from the regional aquifer using three extraction wells, (2) treating it using ion exchange, and (3) injecting the treated groundwater back into the regional aquifer using three injection wells. In 2018, the CrEX-1 and CrEX-2 wells were used for extraction starting in mid-February through mid-April and from late May through the end of the year. The CrEX-3 well was used for extraction starting in mid-February through mid-April and from late May through October 2018. The CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5 wells were used for injection during February and March. The CrIN-3, CrIN-4, and CrIN-5 wells were also used for injection starting in late May and through the end of 2018.

More information is available in Chapter 5, Groundwater Monitoring.

OTHER ENVIRONMENTAL STATUTES AND ORDERS

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impacts of proposed activities, operations, and projects. The DOE has analyzed the impacts of LANL operations and activities in a Site-Wide Environmental Impact Statement (DOE 2008a). The Records of Decision for the Site-Wide Environmental Impact Statement (DOE 2008b, DOE 2009) described the operations and activities the DOE has approved, and any required mitigations.

Laboratory staff specializing in the National Environmental Policy Act review proposed projects to determine if associated impacts have been analyzed in the 2008 Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory or other existing National Environmental Policy Act documents. In 2018, staff reviewed approximately 1,050 proposed projects. Projects or activities that do not have coverage under existing documents require new or additional analyses. Significant National Environmental Policy Act activities that occurred in 2018 are listed below.

In February 2018, the National Nuclear Security Administration published the "Environmental Assessment for the Los Alamos National Laboratory Paleoseismic Research Proposal Special Use Permit." The Special Use Permit is issued by the U.S. Department of Agriculture Forest Service. The environmental assessment analyzed a proposal for LANL to conduct paleoseismic research to help assess the potential for future seismic events in the area to meet DOE facility design criteria (U.S. Department of Agriculture Forest Service 2018). The proposed action included excavation of trenching segments along the Pajarito fault system and the construction of two access routes to the trenching sites. The DOE issued a Finding of No Significant Impact with mitigation measures (DOE 2018b).

In April 2018, the National Nuclear Security Administration published a Supplement Analysis to the 2008 Site-Wide Environmental Impact Statement (DOE 2018a). A Supplement Analysis is prepared to determine whether a supplement to an existing Environmental Impact Statement or a new Environmental Impact Statement is needed based on changes in federal actions or their impacts. This Supplement Analysis reviewed changes in operations since the publication of the 2008 Site-Wide Environmental Impact Statement and evaluated the continued adequacy of the 2008 Site-Wide Environmental Impact Statement for projected future LANL operations through 2022. The Supplement Analysis concluded that environmental impacts for existing operations and those projected for 2018 through 2022 have not substantially changed. The DOE National Nuclear Security Administration determined the preparation of additional supplementation of the 2008 Site-Wide Environmental Impact Statement or a new Site-Wide Environmental Impact Statement is not required at this time.

In May 2018, the National Nuclear Security Administration withdrew the Notice of Intent to prepare an Environmental Impact Statement for the operation of a biosafety level 3 facility at LANL. The National Nuclear Security Administration has determined that it does not currently have a need to operate a biosafety level 3 facility at LANL. Building 1076 within Technical Area 3 will be used as a biosafety level 1 and 2 facility.

In July 2018, the National Nuclear Security Administration published the “Final Environmental Assessment of Proposed Changes for Analytical Chemistry and Materials Characterization at the Radiological Laboratory/Utility/Office Building, Los Alamos National Laboratory, Los Alamos, New Mexico." The environmental assessment analyzed the need to recategorize the Radiological Laboratory/Utility/Office Building from a Radiological Facility to a Hazard Category 3 Nuclear Facility (DOE 2018c). The proposed action would result in an increased material at risk limit of 400 grams plutonium equivalent (15 percent of the 2,610 grams of plutonium equivalent allowed in a Hazard Category 3 Nuclear Facility) and would allow certain laboratory capabilities previously planned for Plutonium Facility Building 4 to be installed in the Radiological Laboratory/Utility/Office Building. The DOE issued a Finding of No Significant Impact with no mitigation measures (DOE 2018b).

Eight LANL projects were categorically excluded from further DOE NEPA review in 2018:

- Technical Area 3 Modular Laboratory Building (CX-270503)
- Supplemental Environmental Projects: Ancho and Sandia Canyons Watershed Enhancement Proposals (CX-017539)
- Technical Area 49 Open Burn Training Exercises and Simulations for Firefighting and Fire-Rescue Personnel (CX-017539)
- Supplemental Environmental Projects: Low-Impact Development (CX-017639)
- Supplemental Environmental Projects: Improvements to Transportation Routes Used for Transportation of Transuranic Waste to the Waste Isolation Pilot Plant (CX-120000)
- Middle Mortandad Watershed Enhancement Supplemental Environmental Project (CX-120001)
- Steam Plan Acquisition Project (CX-120002)
- Operation of the CLEAR Line at TA-55-4 (CX-270510)

National Historic Preservation Act

The National Historic Preservation Act of 1966, as amended, requires federal agencies to consider the effects of their activities on historic properties, including archaeological sites and historic buildings, and requires a mitigation plan for any adverse effects to the properties. LANL's Cultural Resources Management Plan (LANL 2017b) describes the process for implementing the National Historic Preservation Act and associated laws and regulations.

In fiscal year 2018, LANL archaeologists supported 37 Laboratory projects by performing new historic property surveys or verifying results from previous surveys. Additionally, archaeologists evaluated 71 archaeological sites and identified one new site for the eligibility of inclusion to the National Register of Historic Places. These findings were reported to the New Mexico State Historic Preservation Office, who concurred that 55 of the sites were eligible for inclusion in the Register.

LANL archaeologists conducted an annual inspection of the Museum of Indian Arts and Culture located in Santa Fe, New Mexico. The focus of the inspection was to ensure compliance with regulations for the preservation and curation of artifacts from archaeological sites excavated on Laboratory property since 1949. These inspections are required under the Code of Federal Regulations, Title 36, Part 79, Curation of Federally-Owned and Administered Archaeological Collections.

LANL cultural resources personnel specializing in architecture and historic buildings conducted archival documentation for six projects impacting historic buildings at Technical Areas 3, 8, 15, 16, 46, and 50. This work included interior and exterior building inspections and research on the historical use of the buildings. Cultural resources personnel examined the Laboratory's archives and records center, historical photographs, and the public reading room. Cultural resources staff also participated in surveillance and maintenance evaluations for the most significant historic properties located at the Laboratory, including the 17 buildings and structures that are either included in the Manhattan Project National Historical Park or that are Park eligible as referenced in the 2014 Manhattan Project National Historical Park legislation (see Chapter 3).

LANL cultural resources staff continues to conduct consultations with the Accord Pueblos (Pueblo de San Ildefonso, Santa Clara Pueblo, Pueblo of Jemez, and Pueblo de Cochiti) regarding the identification and preservation of traditional cultural properties, human remains, and sacred objects in compliance with the National Historic Preservation Act and the Native American Graves Protection and Repatriation Act.

Endangered Species Act

The Endangered Species Act requires federal agencies to protect federally listed threatened or endangered species, including their habitats. We implement these requirements through the Habitat Management Plan (LANL 2017c).

The Laboratory contains habitat for three federally listed species: the southwestern willow flycatcher (*Empidonax traillii extimus),* the Jemez Mountains salamander (*Plethodon neomexicanus),* and the Mexican spotted owl (*Strix occidentalis lucida).* Two other federally listed species occur near the Laboratory: the New Mexico meadow jumping mouse (*Zapus hudsonius luteus)* and the western distinct population segment of the yellow-billed cuckoo (*Coccyzus americanus)*. The southwestern willow flycatcher, yellow-billed cuckoo, and New Mexico meadow jumping mouse have not been observed on Laboratory property. In addition, several federal species of concern and state-listed species potentially occur within the Laboratory (Hathcock et al. 2015; Table 2-10).

TABLE 2-10. THREATENED, ENDANGERED, AND OTHER SENSITIVE SPECIES OCCURRING OR POTENTIALLY OCCURRING AT THE LABORATORY

Scientific Name	Common Name	Protected Status*	Potential to Occur†
Empidonax traillii extimus	Southwestern willow flycatcher	E	Moderate
Mustela nigripes	Black-footed ferret	E	Low
Strix occidentalis lucida	Mexican spotted owl	T	High
Coccyzus americanus	Yellow-billed cuckoo (western distinct population segment)	T, NMS	Moderate
Zapus hudsonius luteus	New Mexico meadow jumping mouse	E, NME	Low
Haliaeetus leucocepahlus	Bald eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed hummingbird	NMT	Low
Amazilia violiceps	Violet-crowned hummingbird	NMT	Low
Gila pandora	Rio Grande chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains salamander	E, NME	High
Falco peregrinus anatum	American peregrine falcon	NMT, FSOC	High
Falco peregrinus tundrius	Arctic peregrine falcon	NMT, FSOC	Moderate
Accipiter gentiles	Northern goshawk	NMS, FSOC	High
Lanius ludovicianus	Loggerhead shrike	NMS	High
Vireo vicinior	Gray vireo	NMT	Moderate
Myotis ciliolabrum melanorhinus	Western small-footed myotis bat	NMS	High
Myotis volans interior	Long-legged bat	NMS	High
Euderma maculatum	Spotted bat	NMT	High
Corynorhinus townsendii pallescens	Townsend's pale big-eared bat	NMS, FSOC	High
Nyctinomops macrotis	Big free-tailed bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red fox	NMS	Moderate
Ochotona princeps nigrescens	Goat peak pika	NMS, FSOC	Low
Lilium philadelphicum var. andinum	Wood lily	NME	High
Cypripedium calceolus var. pubescens	Greater yellow lady's slipper	NME	Moderate
Speyeria nokomis nitocris	New Mexico silverspot butterfly	FSOC	Moderate
Mentzelia springeri	Springer's blazing star	NMSOC, FSOC, FSS	Moderate

**C = Federal Candidate Species; E = Federal Endangered; FSOC = Federal Species of Concern; FSS = Forest Service Sensitive Species; NME = New Mexico Endangered; NMS = New Mexico Sensitive Taxa (informal); NMSOC = New Mexico Species of Concern; NMT = New Mexico Threatened; PE = Proposed Endangered; PT = Proposed Threatened; S1 = Heritage New Mexico: Critically Imperiled in New Mexico; T = Federal Threatened.*

†Low = No known habitat exists at the Laboratory. Moderate = Habitat exists, though the species has not been recorded recently. High = Habitat exists, and the species occurs at the Laboratory.

We review proposed projects to determine if they have the potential to impact federally listed species or their habitats. In 2018, biologists reviewed 823 excavation permits, 220 project profiles in the permits and requirements identification system, 23 minor siting proposals, and ten storm water pollution prevention plans for potential impacts to threatened or endangered species. If there is a potential for impacts, biologists work with project personnel to either modify the project to avoid the impacts or to prepare a biological assessment for consultation with the U.S. Fish and Wildlife Service. In 2018, we prepared one biological assessment. This assessment analyzed the impacts to listed species for the installation and operation of an upgraded asphalt batch plant and continued heavy equipment operations at Sigma Mesa (LANL 2018a). In 2018, we did not find any projects out of compliance with biological resource protection requirements.

We also conducted surveys for the Mexican spotted owl and southwestern willow flycatcher. In 2018, Mexican spotted owls were found on Laboratory property in the same nesting locations as past years. We found two Mexican spotted owl nests, but we were unable to determine nest success because of access restrictions triggered by wildfire risk in 2018. Southwestern willow flycatchers were not found during surveys, but four willow flycatchers of unknown subspecies were recorded during bird banding operations.

Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act, it is unlawful "by any means or manner to pursue, hunt, take, capture [or] kill" any migratory birds except as permitted by regulations issued by the U.S. Fish and Wildlife Service. As part of the Laboratory's Migratory Bird Treaty Act compliance, we review projects for potential impacts to migratory birds, and we carry out bird population monitoring projects. These efforts support DOE's commitment to "promote monitoring, research, and information exchange related to migratory bird conservation and program actions that may affect migratory birds…" as stated in the September 12, 2013, Memorandum of Understanding between the DOE and the U.S. Fish and Wildlife Service.

In project reviews, Laboratory biologists provide specific comments for projects that have the potential to impact migratory birds, their eggs, or nestlings. In general, projects that remove vegetation that may contain bird nests are scheduled before or after the bird nesting season.

In 2018, we continued annual breeding season and winter surveys for birds in all major habitat types and continued monitoring nest boxes for use by birds. As part of a long-term monitoring project at two open detonation sites and one open burn site, our point count surveys and nest box monitoring results continue to suggest that operations at these sites are not negatively affecting bird populations. In addition, biologists captured and banded birds during the breeding season in Sandia Canyon, to monitor breeding bird populations, and during fall migration in Pajarito Canyon, to monitor use of Laboratory lands by migrating birds. In 2018, 841 birds were banded at the Laboratory. We also continued to support bird population monitoring at Bandelier National Monument.

Floodplain and Wetland Executive Orders

We comply with Executive Order 11988, *Floodplain Management,* and Executive Order 11990, *Protection of Wetlands,* by preparing floodplain and wetland assessment for projects in floodplains or near wetlands. In 2018, three floodplain assessments were prepared: one assessment for a fire break on Potrillo Canyon (LANL 2018b) and two assessments for improvements at the Technical Area 72 live fire range (LANL 2018c; LANL 2018d). In addition, one wetland assessment was prepared for a supplemental environmental project in middle Mortandad Canyon (LANL 2018e). No violations of the DOE floodplain/wetland environmental review requirements were recorded.

Federal Insecticide, Fungicide, and Rodenticide Act; New Mexico Pesticide Control Act; and National Pollutant Discharge Elimination System Pesticide General Permit

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the distribution, sale, and use of pesticides (chemicals that destroy plant, fungal, or animal pests). The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the Act throughout the state. The New Mexico Pesticide Control Act applies to (1) the licensing and certification of pesticide workers, (2) record keeping, (3) equipment inspection, (4) application of pesticides, and (5) storage and disposal of pesticides. In 2018, pesticide usage was reported to the U.S. Environmental Protection Agency in accordance with the National Pollutant Discharge Elimination System Pesticide General Permit. Table 2-11 shows the amounts of pesticides the Laboratory used in 2018.

TABLE 2-11. PESTICIDES USED IN 2018

Herbicide	Amount
Velossa	98.09625 gallons
Ranger Pro Herbicide	44.2 gallons
Prokoz Surflan AS Specialty	3.8 gallons
Lesco Prosecutor Pro Non-Selective Herbicide	7.7 gallons
Insecticide	**Amount**
Maxforce Complete Brand Granular Insect Bait	1.45 pounds
Summit B.T.I Briquets	0.04 pounds
Terro PCO Liquid Ant Killer	0.13 gallons
PT Wasp Freeze II and Hornet Insecticide	2.9 gallons
Vikon S	0.12 gallons
Water Treatment Chemical	**Amount**
Garratt-Callahan Formula 314-T	1245 pounds
Garrett-Callahan Formula 316	5 pounds 14 ounces
Houghton Chemical Purobrom Tablets	6265 pounds

DOE Order 231.1B, *Environment, Safety, and Health Reporting*

DOE Order 231.1B, *Environment, Safety, and Health Reporting,* requires the timely collection of and reporting of information on environmental issues that could adversely affect the health and safety of the public and the environment at DOE sites. This report fulfills DOE Order 231.1B requirements to publish an annual site environmental report.

The intent of this report is to:

- characterize site environmental management performance, including effluent releases, environmental monitoring, types and quantities of radioactive materials emitted, and radiological doses to the public;
- summarize environmental occurrences and responses reported during the calendar year;
- confirm compliance with environmental standards and requirements;
- highlight significant programs and efforts, including environmental performance indicators, performance measures programs, or both; and
- summarize property clearance activities.

The Laboratory began environmental monitoring in 1945 and published the first comprehensive environmental monitoring report in 1970.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act requires emergency plans for more than 360 hazardous substances, if they are present at a facility in amounts above specified thresholds. We are required to notify state and local officials and the community under this Act about the following items: (1) changes at the Laboratory that might affect the local emergency plan or if the Laboratory's emergency planning coordinator changes; (2) leaks, spills, and other releases of listed chemicals into the environment if these releases exceed specified quantities; (3) the annual inventory of the quantities and locations of hazardous chemicals above specified thresholds present at the facility; and (4) total annual releases to the environment of listed chemicals that exceed specified thresholds. Table 2-12 identifies what community and emergency planning reporting the Laboratory did in 2018.

TABLE 2-12. STATUS OF EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT REPORTING IN 2018

Emergency Planning and Community Right-To-Know Act Section	Description of Reporting	Status (Yes, No, or Not Required)
Section 302-303	Planning notification	Not required
Section 304	Extremely hazardous substance or hazardous substance release notification	Not required
Section 311-312	Material safety data sheet/Hazardous chemical inventory	Yes
Section 313	Toxics release inventory reporting	Yes

For Section 313 reporting, the only listed chemical that met the criteria for reporting in 2018 was lead. In 2018, the largest use of reportable lead was from offsite waste transfers. Table 2-13 summarizes the reported releases in 2018. There are no compliance violations associated with this use or release of lead.

TABLE 2-13. SUMMARY OF 2018 TOTAL ANNUAL RELEASES UNDER EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT, SECTION 313

Reported Release	Lead (pounds)
Air emissions	3.22
Water discharges	0.22
Onsite land disposal	1139
Offsite waste transfers	17,419

DOE Order 232.2, *Occurrence Reporting and Processing of Operations Information*

DOE Order 232.2, *Occurrence Reporting and Processing of Operations Information*, requires reporting of abnormal events or conditions that occur during facility operations. An "occurrence" is one or more event or condition that may adversely affect workers, the public, property, the environment, or the DOE mission. Reportable environmental occurrences at the Laboratory for 2018 are listed in Table 2-14.

TABLE 2-14. 2018 ENVIRONMENTAL OCCURRENCES

Title	Description and Comments	Status
Outfall 001 Sample Exceeds National Pollutant Discharge Elimination System Limit	On Tuesday, September 18, 2018, the Utilities and Institutional Facilities Operations Director received notification that the National Pollutant Discharge Elimination System Permit No. NM0028355 PCB limit of 0.00064 micrograms per liter had been exceeded at Outfall 001. The sample results reported a value of 0.0133 micrograms per liter total PCB at Outfall 001. In accordance with the permit requirements, LANL environmental compliance personnel notified the Environmental Protection Agency and the New Mexico Environment Department Surface Water Quality Bureau of the permit exceedance. The cause of noncompliance and source of exceedance were investigated. The discharge did not cross the Laboratory boundary or reach the Rio Grande.	Closed

Title	Description and Comments	Status
Drilling Fluid Released from Poly Container	On Thursday, April 12, 2018, the Deployed Environmental, Safety and Health - Weapons Facility Operations supervisor notified the Weapons Facility Operations manager that a total of 5,000 gallons of drilling fluid had been released at Well Pad CdV-9-1(i) within Technical Area 9 from two containers. Subsequent inspection found that the drilling fluid from both containers discharged into the storm water detention pond at the well pad. Approximately 3,700 of the 5,000 gallons released were absorbed into the surrounding soil. The DOE and the New Mexico Environment Department were notified. A fact finding was conducted on Monday, April 16, 2018. As a result of this incident, Environmental Remediation - Field Services workers inspected all large storage tanks within Weapons Facility Operations area for leaks, and put up vehicle barricades around the tanks at Well Pad CdV-9-1(i). In addition, Environmental Remediation - Field Services personnel developed a rounds/inspection/maintenance checklist.	Closed
Sanitary Waste Water Release to the Environment	On Monday, May 7, 2018, Utilities and Institutional Facilities Division workers arrived at Technical Area 16, Building 332 to empty the facility's sanitary wastewater holding tank. They discovered and estimated that less than 500 gallons of sanitary wastewater had overflowed from the tank and discharged onto the surrounding soil. The workers immediately pumped the liquid from the holding tank and disinfected the impacted area. They then began to investigate the cause of the overflow and found that a facility toilet had a faulty float valve, causing the toilet to continually run and discharge water into the holding tank. They immediately replaced the faulty float valve with a new one. Additionally, they performed troubleshooting on the tank level indicator, which had not indicated a full tank during inspection the prior evening. They found the beacon light that indicates when the tank is full would not illuminate due to a burned out bulb. They subsequently replaced the bulb. The release was reported to the New Mexico Environment Department.	Closed

Title	Description and Comments	Status
Receipt of Notice of Violation with Proposed Civil Penalties for Violations of LANL's Hazardous Waste Operating Permit	On Thursday, November 8, 2018, the Los Alamos National Laboratory Environmental Compliance and Protection Division Leader received a Notice of Violation from the New Mexico Environment Department for three violations of the New Mexico Hazardous Waste Permit Regulations and LANL's Hazardous Waste Operating Permit relating to waste characterization and waste manifest discrepancies. Specifically, the Notice of Violation cited the following violations for failure to: (1) notify New Mexico Environment Department within three days of a hazardous waste characterization discrepancy, citing four examples; (2) conduct preliminary characterization of a waste stream prior to actual generation and generate a Waste Profile Form, citing six examples; and (3) properly complete a hazardous waste manifest by following the instructions in 40 CFR 262 Appendix, citing six examples. Additionally, a Notice of Proposed Penalty letter relating to the Notice of Violation was received at the same time, with proposed civil penalties totaling $116,250 to settle the violations. A stipulated final order was signed by Triad, NNSA, and the New Mexico Environment Department in 2019. In addition, the Laboratory agreed to include compliance requirements in all subcontracts for shipment or disposal of waste, and require that all regulated waste be processed for disposition through the Waste Management Services group.	Closed
Receipt of Notice of Violation with Proposed Penalties Associated with Hazardous Waste Storage Time Exceedance	On Thursday, April 5, 2018, the Los Alamos National Laboratory received a Notice of Violation from the New Mexico Environment Department with proposed civil penalties of $31,208 for violations of the Hazardous Waste Act, the Hazardous Waste Regulations, and the LANL Facility Hazardous Waste Permit. Specifically, LANL had stored hazardous waste containers over the 90-day storage time limit in central accumulation storage areas, and had stored hazardous waste containers over the 1-year storage time limit in permitted areas. As part of the response to this Notice of Violation, Environmental Protection and Compliance Waste Management Services personnel shipped five hazardous waste containers stored over the 90-day storage time limit, along with other containers whose storage time was near the permit storage limit, to an offsite facility on Thursday, April 5, 2018. They also identified and implemented a series of nine additional corrective actions, and completed an effectiveness evaluation of those actions.	Closed

Title	Description and Comments	Status
Receipt of Notice of Violation with Proposed Penalties Associated With Failed Load Bracing During Hazardous Waste Shipment	On Tuesday, June 5, 2018, the Waste Management Services Group Leader notified the Environmental Waste Management Operations Facility Operations Director that Los Alamos National Laboratory received a Notice of Violation with proposed civil penalties of $1,500 from the State of Utah Department of Environmental Quality for a noncompliant LANL hazardous waste shipment. On February 23, 2018, Energy Solutions in Clive, Utah, received the LANL hazardous waste shipment that was shipped in violation of Department of Transportation regulations because the transporting packages were inadequately braced. The shipment contained four plastic drums of non-hazardous waste, two metal boxes of low-level radioactive waste, and one plastic container holding both non-hazardous and low-level radioactive waste. Subsequent review found that during transport a significant load shift occurred, at which point the load bracing failed, allowing a metal container to move forward, tip over, and break open the plastic container containing mixed waste, exposing the inner packaging, which remained intact. Following arrival at the Energy Solutions disposition site, Energy Solutions personnel performed contamination surveys and detected no contamination inside the shipping container. Energy Solutions then accepted and processed the waste for disposal per their normal procedures. The Laboratory required the shipping contractor, Navarro, to prepare and implement a corrective action plan, and provided the Director of the Division of Waste Management and Radiation Control for the state of Utah a written response describing the corrective actions.	Closed

Title	Description and Comments	Status
Receipt of Notice of Violation with Points Assessed for Violations of DOE/LANL's Generator Site Access Permit	On Thursday, December 20, 2018, the Los Alamos National Laboratory Environmental Compliance and Protection Division Leader notified the Science and Technology Operations Facility Operations Director that LANL had received a Notice of Violation from the Director of the Utah Division of Waste Management and Radiation Control as a result of a noncompliant LANL hazardous waste shipment received by Energy Solutions in Clive, Utah. On Monday, October 1, 2018, upon receipt of a mixed low-level waste shipment from the LANL Sigma facility, Energy Solutions personnel identified that approximately eight ounces of oil was leaking from one of the packages onto the bed of the truck. The waste profile indicated that the waste contained free liquids; however, the Nuclear Regulatory Commission form stated that the waste was solid with no free liquids. Energy Solutions personnel surveyed the items, received No Detectable Activity results, and relocated the items to their Mixed Waste Treatment Facility. Related to the Sigma Division cleanup project, other items have been drained of oil to the extent practical, repackaged in shrink-wrap with absorbent materials, and placed in overpacks with absorbent materials.	Open as of 5/8/2019. Causal analysis conducted on 4/8/2019.

INSPECTIONS AND AUDITS

Table 2-15 lists the environmental inspections conducted by regulating agencies and external auditors at the Laboratory during 2018.

TABLE 2-15. ENVIRONMENTAL INSPECTIONS AND AUDITS CONDUCTED AT THE LABORATORY DURING 2018

Date	Purpose	Performing Entity
2/5/2018–2/8/2018	Environmental Management System Surveillance Audit, covering clauses of the ISO 14001:2015 standard	NSF International
10/4/2018, 10/11/2018, and 10/18/2018	Petroleum storage tank inspections	New Mexico Environment Department
11/26/2018–11/28/2018	Environmental Management System Surveillance Audit, covering clauses of the ISO 14001:2015 standard	NSF International

CLIMATIC RISK ASSESSMENT

Updated in 2018, the National Climate Assessment explains what current and future climate change is likely to mean for the U.S. (Gonzalez et al. 2018). Predictions are made for temperature, precipitation (including snowpack), and wildland fires. DOE Order 436.1, *Departmental Sustainability*, directs the Laboratory to determine how its facilities and operations can mitigate risks associated with climatic factors, such as increasing temperatures and increasing wildland fire risk, and to identify the types of facilities/operations that could be impacted.

In 2015, we began tracking climatic risk indices relating to temperature, precipitation, wind, indicator species, and storm water flow. These indices will assist us in identifying when actions are necessary to protect facilities and operations.

Not all of the indicators are tracked on an annual basis. For example, breeding bird phenology will only be reported every three to five years. Below are the results of indices that were available in 2018.

Temperature

Temperature data have been collected in Los Alamos since 1910. Long-term trends in annual average temperatures are reported in the Meteorological Monitoring section of Chapter 4 and are shown in Figure 2-2. The temperatures between 1960 and 2000 had no trend. The years 2001–2010 were approximately 1.5 °F warmer than the previous 40 years, with the years 2011–2018 continuing to be significantly warmer (by approximately 3 °F) than the 1960–2000 averages. When average temperatures are broken down into summer and winter minimums and maximums, the summer minimum temperatures (Figure 2-3) demonstrate the strongest increasing trend from 1990 onward (an increase of approximately 4 °F).

Changes in temperature can also be assessed by changes in the number of heating and cooling degree days. Degree days are the difference between the daily average temperature and 65 °F. If the daily average temperature is below 65 °F, the difference measures heating degree days, and vice versa for cooling degree days. The number of heating and cooling degree days is used to estimate the annual power usage needed to supply heat or air conditioning in buildings. An increase in cooling (heating) degree days results in more energy required to cool (heat) buildings. Shown in Figure 2-4, cooling degree days have been increasing since 1990, while heating degree days have been decreasing (Figure 2-5).

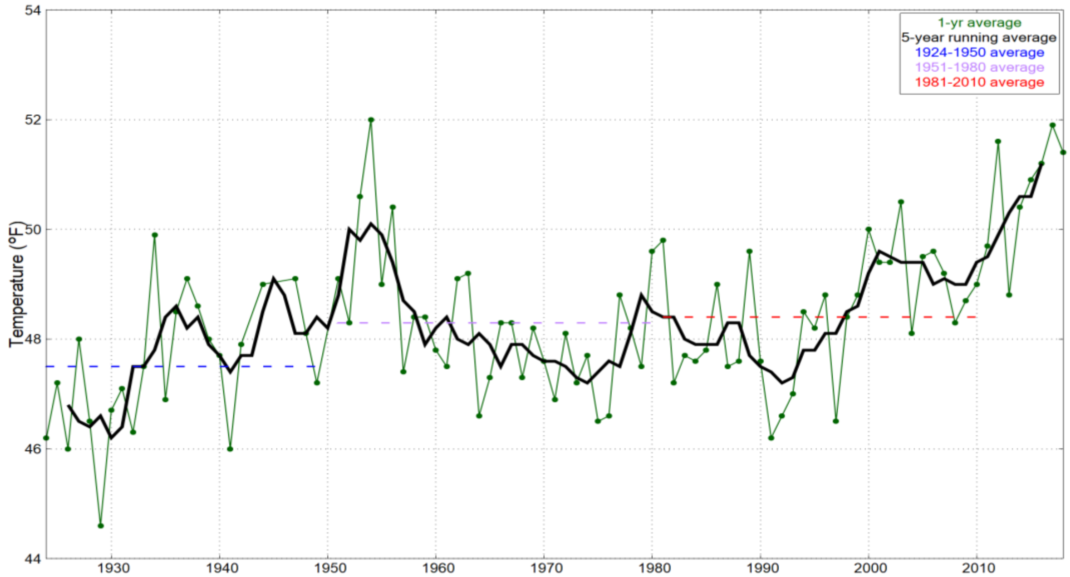


Figure 2-2. Annual average temperatures for Los Alamos. The dashed lines represent long-term climatological average temperatures, the black line represents the 5-year running average temperature, and the green line represents the 1-year average.

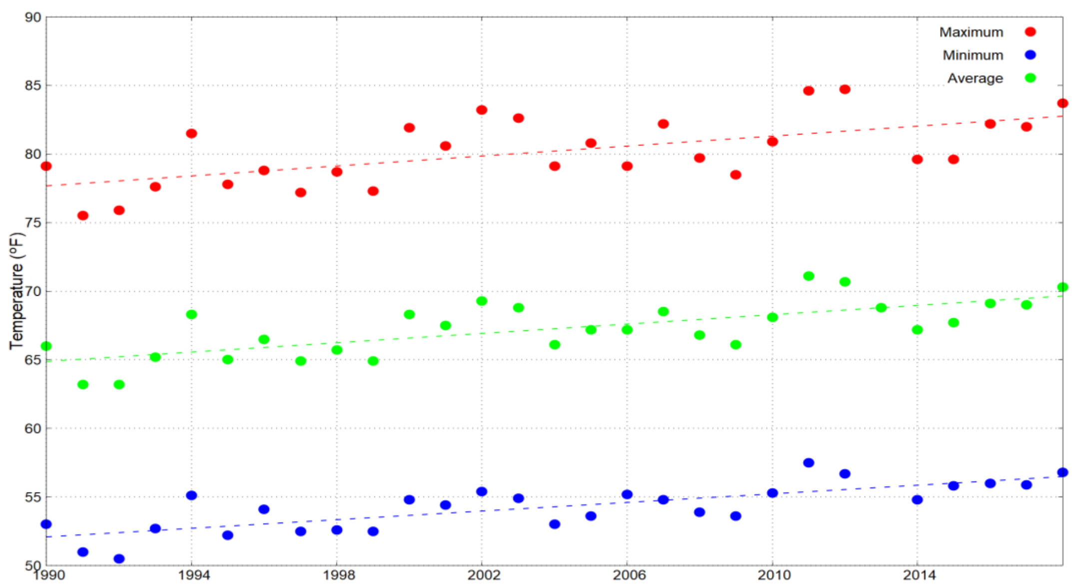


Figure 2-3. Average summer (June, July, August) Los Alamos temperatures. The dashed lines represent the trend line for maximum, minimum, and average summer temperatures, which show summer temperatures have been continuously increasing since 1990.

Similar to the annual average temperature, heating and cooling degree days did not exhibit any trend during 1950–1990. Since 1990, cooling degree days (Figure 2-4) have increased and heating degree days (Figure 2-5) have decreased. Thus, less energy has been needed to heat buildings, but more energy has been needed to cool buildings.

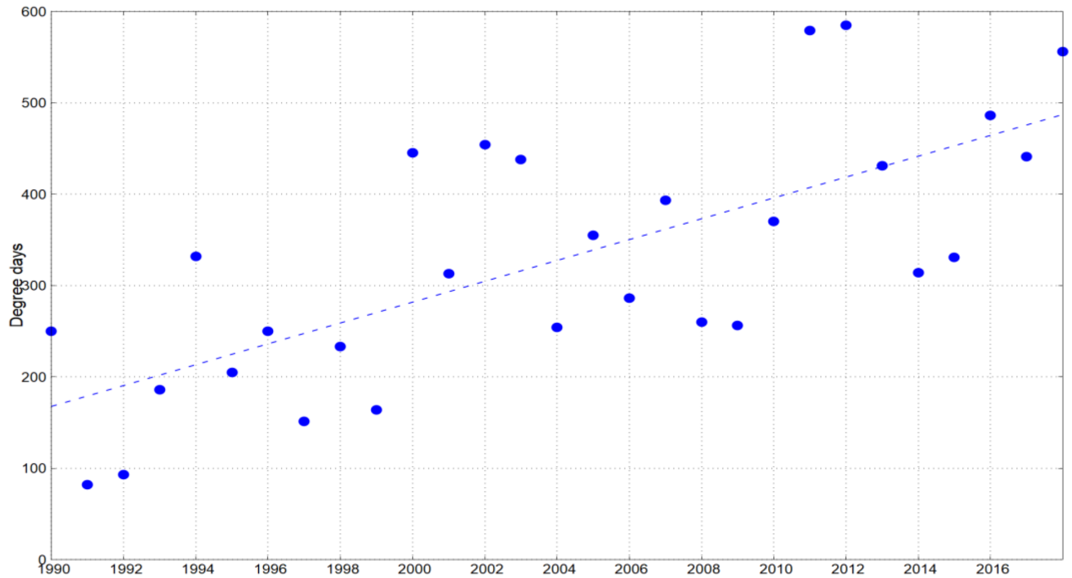


Figure 2-4. Los Alamos cooling degree days per year. The dashed line represents the trend line for cooling degree days, which shows cooling degree days have increased, resulting in more energy needed to cool buildings.

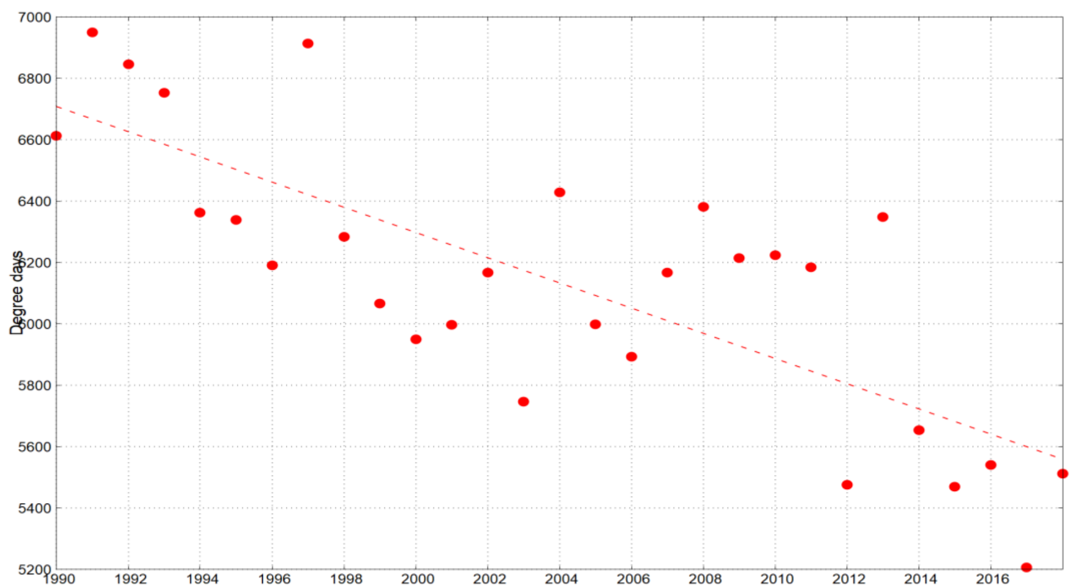
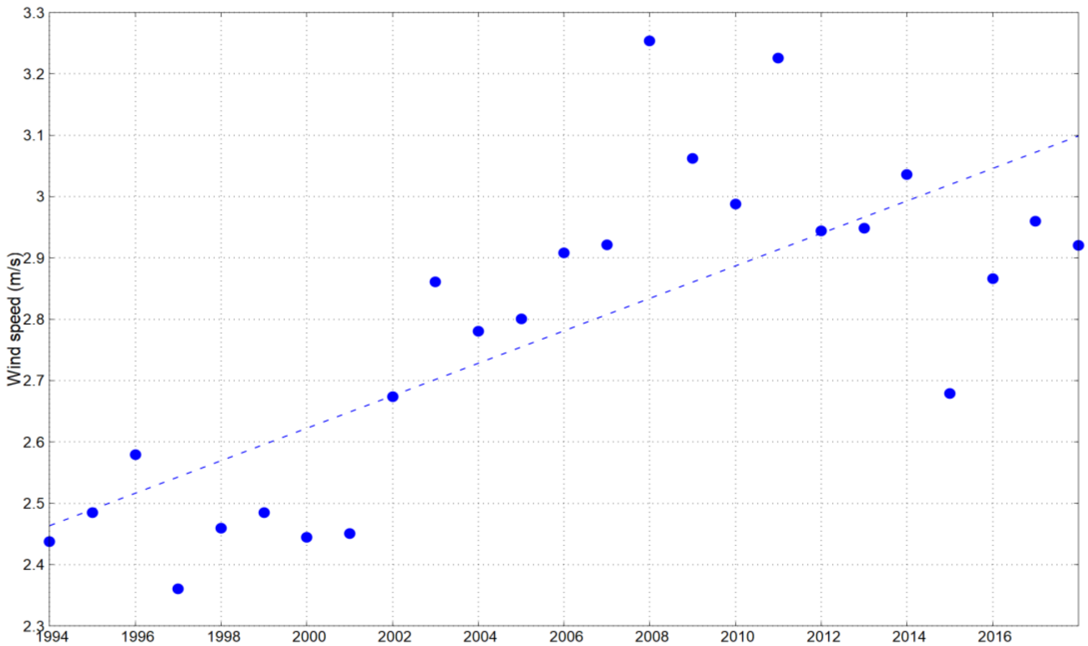


Figure 2-5. Los Alamos heating degree days. The dashed line represents the trend line for heating degree days, which shows heating degree days have decreased, resulting in less energy needed to heat buildings.

Wind Speed

The annual average wind speed measured at the Laboratory's meteorological tower of record at Technical Area 6 has increased approximately 20 percent over the past 20 years (Figure 2-6). Although not shown here, the monthly average wind speed during the spring months (windiest months) show an increase by approximately 1 meter per second. Winds are produced by low- and high-pressure weather systems that move across New Mexico. Near the ground's surface, wind speeds are also influenced by the type of vegetation present (for example, forests versus grasslands). Our current hypothesis is that the extensive loss of trees in the local area caused by wildfires, drought, and bark beetle infestations has led to a decrease in the amount of wind resistance provided by trees, allowing wind speeds near the surface to increase. There is no trend in the annual peak gusts recorded at Technical Area 6 since 1990 (Kelly et al. 2015).



Note: m/s = meters per second.

Figure 2-6. Technical Area 6 annual average wind speed at 12 meters above the ground. The dashed line represents the trend line for wind speed, which shows the annual average wind speed has been increasing since 1994.

Annual Red Flag Warnings

The National Weather Service issues Red Flag Warnings when critical weather conditions may result in extreme fire behavior. The National Weather Service began recording the number of Red Flag Warnings per year for the Los Alamos area in 2012 (Figure 2-7). Red Flag Warnings have increased over the past four years, but since 2012, there has not been a trend. Some Laboratory operations, including explosives testing, are restricted on days with Red Flag Warnings.

If the following weather conditions occur simultaneously for three or more hours, a Red Flag Warning can be issued:

- sustained winds at or above 20 miles per hour,
- relative humidity less than 15 percent, and
- above average temperatures.

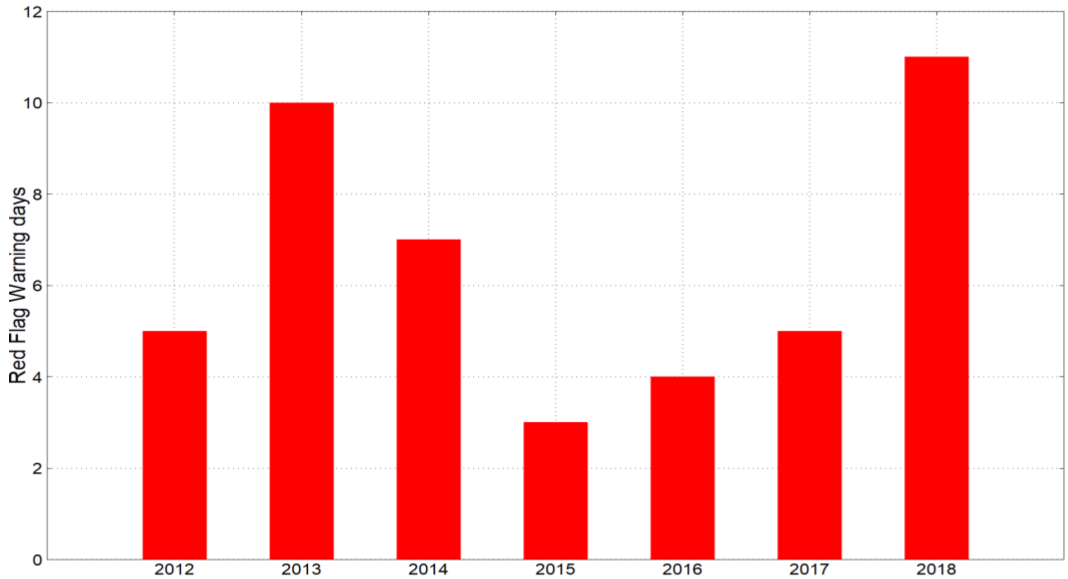


Figure 2-7. Number of National Weather Service Red Flag Warning days for zone 102 (Los Alamos). Since 2015, there has been an increase in the number of red flag days, but overall there has not been a trend.

Precipitation

We analyzed the annual average precipitation (Figure 2-8) and the number of days per year with heavy rain events (Figure 2-9). From 1924 through 2010, the annual average precipitation was 18 inches with a standard deviation of 4.4 inches. A long-term drought began in 1998, with significantly below-average precipitation under 15 inches between 2000 and 2003 and again in 2011 and 2012. Annual precipitation values were as low as 10 inches in 2003 and 2012.

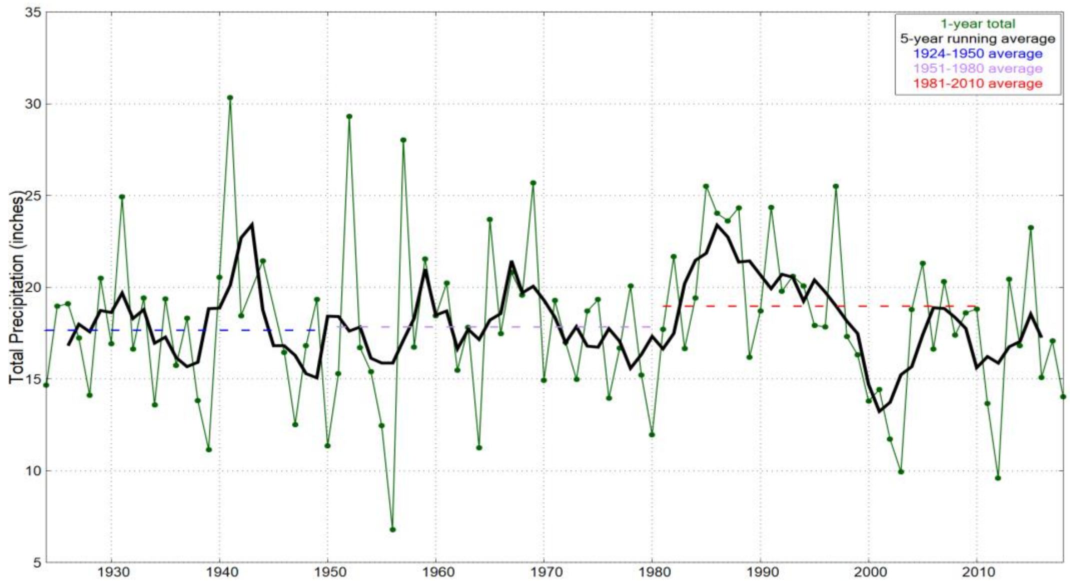


Figure 2-8. Annual precipitation totals for Los Alamos. The dashed lines represent long-term climatological average total precipitation, the black line represents the 5-year running average precipitation, and the green line represents the 1-year total precipitation. Significant drought since the 1990s has resulted in below average precipitation in many recent years.

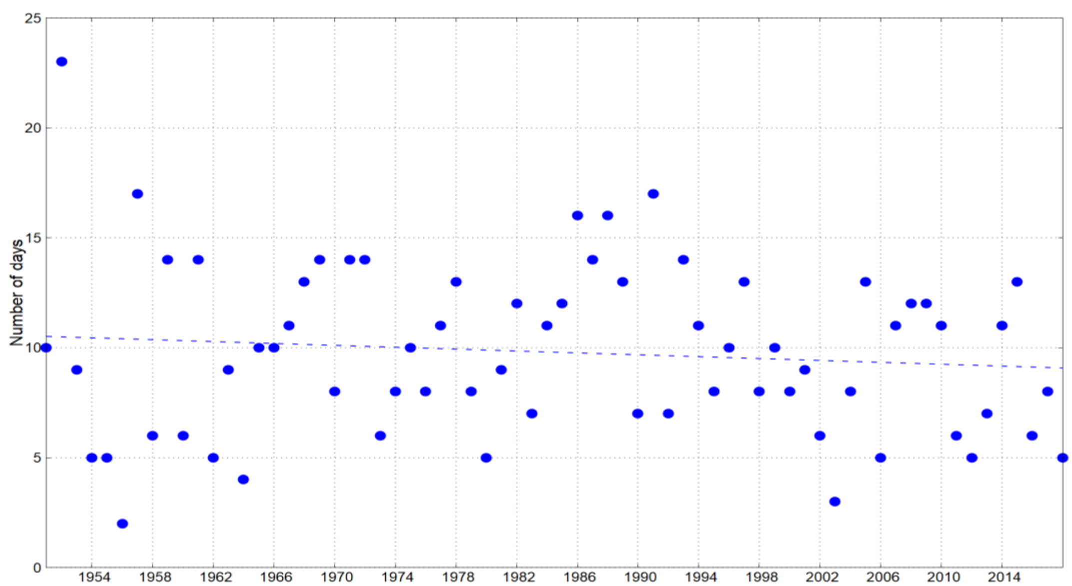


Figure 2-9. Number of days per year with precipitation >0.5 inches. The dashed line represents the trend line for days with precipitation >0.5 inches. The slight decreasing trend since 1950 is not statistically significant.

The frequency of heavy rain events (Figure 2-9), defined as precipitation greater than 0.5 inches in one day, does not demonstrate a significant long-term trend since 1950. Although not shown here, there is also no trend in the heaviest events (precipitation >0.75 inches or >1.0 inch per day) in the past 50 years.

Annual average snowfall (Figure 2-10) demonstrates a decrease in the long-term trend since 1950. Since the drought began in 1998, there have been only three years with above-average recorded snowfall (1981–2010 average = 57 inches).

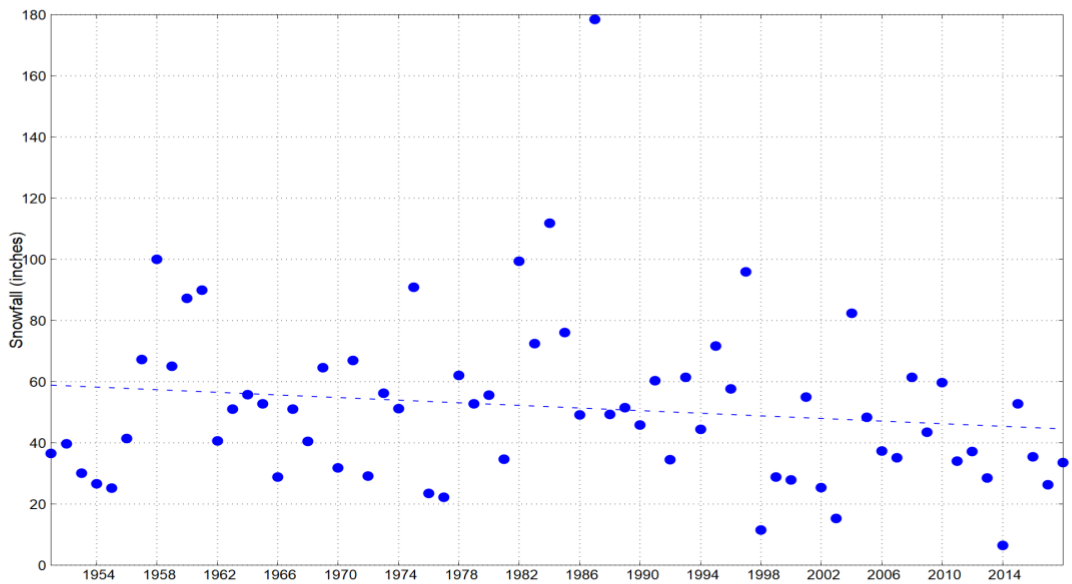


Figure 2-10. Annual average Los Alamos snowfall. The dashed line represents the trend line for snowfall, which shows a decrease in annual snowfall.

Climatic Summary

Average temperatures in Los Alamos have increased over the past 15 to 25 years, consistent with the predictions of the National Climate Assessment for the southwestern U.S. The annual average temperatures for the southwest are predicted to rise by 3.7 °F–4.8 °F by 2036–2065, and the temperatures measured at Los Alamos are consistent with these predictions. Increases in cooling degree days and reductions in heating degree days will produce increased summer air-conditioning costs and reduced winter heating costs.

Although the predictions of precipitation changes are less certain than temperature predictions, the National Climate Assessment predicts decreasing winter and spring precipitation in the southwest. The Laboratory's data are consistent with these predictions, in particular over the last 20 years, with below-average snowfall in 85 percent of the years. The National Climate Assessment does not make a specific prediction for the southwest for heavy precipitation events. The Laboratory's data does not show a trend in heavy precipitation events in Los Alamos.

The National Climate Assessment predicts increasing wildland fires in the southwest as a result of warming, drought, and insect outbreaks. Two major wildland fires have impacted the Laboratory in the past 20 years: the 2000 Cerro Grande fire and the 2011 Las Conchas fire. Precursors to these fires included warm, dry years, and local bark beetle infestations

(LANL 2012). The Los Alamos data are consistent with the predictions of increasing wildland fires. The annual average wind speed has been increasing, probably related to the reduction in forest cover caused by tree mortality. Increases in average wind speeds affect emergency planning in the event of an aerial release of hazardous substances.

UNPLANNED RELEASES

Air Releases

In 2018, there were no unplanned air releases.

Liquid Releases

In 2018, no unplanned releases of radioactive liquids occurred on Laboratory property.

We made 15 reports of unplanned nonradioactive liquid releases to the New Mexico Environment Department in 2018, as required by the New Mexico Water Quality Control Commission regulations (Table 2-16). Corrective actions were taken for all liquid releases and were communicated to the New Mexico Environment Department.

TABLE 2-16. 2018 UNPLANNED WATER RELEASES

Material Released	Number of Instances	Approximate Total Release (Gallons)
Potable water	7	119,000
Cooling tower water	1	12,000
Drilling water	1	5,000
Sanitary wastewater	1	2,225
Cooling system water	1	4,700
Steam condensate	1	37,000

SUMMARY OF PERMITS AND LEGAL ORDERS

Table 2-17 presents the environmental permits and legal orders the Laboratory operated under in 2018.

TABLE 2-17. ENVIRONMENTAL PERMITS AND LEGAL ORDERS WHICH THE LABORATORY OPERATED UNDER IN 2018

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Los Alamos National Laboratory Hazardous Waste Facility Permit	A permit regulating management of hazardous wastes at the Laboratory, including storage and treatment. This permit also has standards for closure of indoor and outdoor areas used for hazardous waste storage or treatment. https://www.env.nm.gov/hazardous-waste/lanl-permit/	Renewed November 2010	December 2020	New Mexico Environment Department
Administrative Compliance Order No. HWB-14-20	An order issued for violations of the Hazardous Waste Act and the Laboratory's Hazardous Waste Facility Permit associated with the Waste Isolation Pilot Plant drum breach. As part of the settlement, DOE is funding a series of projects, including road improvements on transport routes to the Waste Isolation Pilot Plant. https://www.energy.gov/sites/prod/files/2015/01/f19/LANL%20ACO%20120614.pdf;	Issued December 6, 2014 Settlement Agreement and Stipulated Final Order issued on January 22, 2016	None	New Mexico Environment Department
Compliance Order on Consent	An order giving requirements for the investigation, corrective actions, and monitoring of solid waste management units and areas of concern. https://www.env.nm.gov/wp-content/uploads/2016/05/Consent-Order-modified-Feb-2017.pdf	Issued March 1, 2005 Revised October 29, 2012 Replaced by 2016 Compliance Order on Consent on June 24, 2016 2016 Compliance Order on Consent modified February 2017	None	New Mexico Environment Department

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Federal Facilities Compliance Order [for Mixed Wastes]	An order requiring the Laboratory to submit an annual update to its Site Treatment Plan for treating all of its mixed hazardous and radiological wastes (mixed waste). https://www.env.nm.gov/HWB/documents/LANL_10-4-1995_FFCO.pdf and https://www.env.nm.gov/HWB/documents/LANL_FFCO_5-20-1997_Ammendment.pdf	Issued October 4, 1995 Amended May 20, 1997	None	New Mexico Environment Department
Authorization to Discharge [from Outfalls] Under the National Pollutant Discharge Elimination System	A permit authorizing the Laboratory to discharge industrial and sanitary liquid effluents through outfalls under specific conditions, including water quality requirements and monitoring requirements. http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-15-23948	Issued August 12, 2014 Effective October 1, 2014 Modified May 1, 2015	September 30, 2019	U.S. Environmental Protection Agency
National Pollutant Discharge Elimination System Pesticide General Permit	A permit authorizing the discharge of pesticides at the Laboratory that have potential to enter waters of the U.S. https://www.regulations.gov/document?D=EPA-HQ-OW-2015-0499-0118	Issued October 31, 2011 Reissued October 31, 2016	October 31, 2021	U.S. Environmental Protection Agency
Clean Air Act, Title V Operating Permit	A permit regulating air emissions from Laboratory operations (i.e., emissions from the power plant, asphalt batch plant, permanent generators, etc.). These emissions are subject to operating, monitoring, and record-keeping requirements. https://cswab.org/wp-content/uploads/2017/04/Los-Alamos-Final-P100R2-Title-V-permit-2015.pdf	Issued August 7, 2009 Reissued October 17, 2018	February 27, 2020	New Mexico Environment Department

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
New Mexico Air Quality Control Act Construction Permits	Permits regulating construction or modification of air emissions sources, including the following:			New Mexico Environment Department
	• Technical Area 03 power plant Permit modification 2 (NSR 2195-B-M2)	Issued September 27, 2000 Reissued November 1, 2011	None	
	• Asphalt plant at Technical Area 60 Permit revision 1 (GCP3-2195-G)	Issued October 29, 2002 Reissued September 12, 2006	None	
	• 1600-kilowatt generator at Technical Area 33 Permit revision 4 (NSR 2195-F R4)	Issued October 10, 2002 Reissued December 12, 2013	None	
	• Two 20-kilowatt generators and one 225-kilowatt generator at Technical Area 33 (NSR 2195-P)	Issued August 8, 2007	None	
	• Data disintegrator (NSR 2195-H R1)	Issued October 22, 2003 Revised June 14, 2006	None	
	• Chemistry and Metallurgy Research Replacement facility, Radiological Laboratory/Utility/Office Building Permit revision 2 (NSR 2195-N)	Issued September 16, 2005 Reissued September 25, 2012	None	
	• LANL exemption notifications - rock crusher removed (NSR 2195)	Issued June 16, 1999	None	
	• Technical Area 35, building 213, beryllium machining (NSR 632 R1)	Issued December 26, 1985 Revised June 14, 2006	None	
	• Technical Area 03, building 141, beryllium technology facility (NSR 634 M2R1)	Issued October 30, 1986 Revised June 14, 2006	None	
	• Technical Area 55 beryllium machining (NSR 1081 M1R7)	Issued July 1, 1994 Revised June 14, 2006	None	

<table>
<tr><th>Name</th><th>Activity</th><th>Issuing and Revision Dates</th><th>Expiration Date</th><th>Administering Agency</th></tr>
<tr><td rowspan="2">Clean Water Act, Section 404/401 Permits</td><td>The U.S. Army Corps of Engineers authorizes certain work within water courses at the Laboratory under Clean Water Act Section 404 permits. The projects below were authorized to operate under a Section 404 nationwide permit with Section 401 certification.</td><td>Effective March 19, 2017 (all current nationwide Section 404 permits) – a previous version was in effect until March 18, 2017.</td><td rowspan="3">March 18, 2022 (all current nationwide Section 404 permits)</td><td rowspan="3">U.S. Army Corps of Engineers and New Mexico Environment Department (all permits and verifications)</td></tr>
<tr><td>Mid -Mortandad Supplemental Environmental Project
Upper Cañon de Valle Supplemental Environmental Project
Cañon de Valle, Water Canyon E256, E262, and E262.5 Gage Repairs
Stream Gage E229.7, Cañada del Buey
Chromium pipeline project</td><td>Permit verification received March 27, 2018

Permit verification received March 21, 2018

Project Pending</td></tr>
<tr><td>Clean Water Act, Section 404/401 Permits (cont.)</td><td>The following projects had an ongoing annual monitoring requirement:
Sandia Canyon, Technical Area 72 firing site storm water controls
Water Canyon storm drain reconstruction project
Mortandad Wetland Enhancement
The following projects have an ongoing maintenance requirement:
Hillside 137 storm water project
Los Alamos Canyon Weir
Los Alamos LA-SMA-2.1</td><td>Annual monitoring and reporting required through 2019
Annual monitoring and reporting required through 2021
Annual monitoring and reporting required through 2022</td></tr>
</table>

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities	A general permit (not LANL-specific) authorizing the discharge of pollutants during construction activities under specific conditions. Conditions include water quality requirements, inspection requirements, erosion and sediment controls, notices of intent to discharge, preparation of storm water pollution prevention plans, and other conditions. (https://www.epa.gov/sites/production/files/2016-09/documents/cgp2012_finalpermitpart1-9-updatedurl.pdf)	Effective February 16, 2017	February 16, 2022	U.S. Environmental Protection Agency
National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activity	A general permit (not LANL-specific) authorizing facilities with some industrial activities to discharge storm water and some non-storm-water run-off. The permit provides specific conditions for the authorization, including pollutant limits to meet water quality standards, inspection requirements, compliance with biological and cultural resource protection laws, and other conditions. (http://www.epa.gov/sites/production/files/2015-10/documents/msgp2015_finalpermit.pdf)	Effective June 4, 2015	June 4, 2020	U.S. Environmental Protection Agency

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
[Individual Permit] Authorization to Discharge [from Solid Waste Management Units and Areas of Concern] Under the National Pollutant Discharge Elimination System	A permit authorizing the Laboratory to discharge storm water from 405 Solid Waste Management Units and Areas of Concern under specific conditions. Conditions include requirements for monitoring and for corrective actions where necessary to minimize pollutants in the storm water discharges. (https://www.env.nm.gov/swqb/documents/swqbdocs/NPDES/Permits/NM0030759-LANLStormwater.pdf)	Issued November 1, 2010	October 31, 2015 Application for renewal submitted to the U.S. Environmental Protection Agency in 2014 Administratively extended by the U.S. Environmental Protection Agency pending issuance of new permit	U.S. Environmental Protection Agency
Groundwater Discharge Permit DP-857	A permit authorizing discharges to groundwater from the Laboratory's sanitary wastewater system plant and the Sanitary Effluent Reclamation Facility.	Issued December 16, 2016	December 16, 2021	New Mexico Environment Department
Groundwater Discharge Permit DP-1589	A permit authorizing discharges to groundwater from the Laboratory's eight septic tank/disposal systems.	Issued July 22, 2016	July 22, 2021	New Mexico Environment Department
Groundwater Discharge Permit DP-1793	A permit authorizing discharges to groundwater from the Laboratory's land application of treated groundwater.	Issued July 27, 2015	July 27, 2020 Transferred to N3B on April 30, 2018	New Mexico Environment Department
Groundwater Discharge Permit DP-1835	A permit authorizing discharges to groundwater from the Laboratory's injection of treated groundwater into six Class V underground injection control wells.	Issued August 31, 2016	December 1, 2021 Transferred to N3B on April 30, 2018	New Mexico Environment Department
Groundwater Discharge Permit DP-1132	A permit authorizing discharges to groundwater from the Laboratory's Radioactive Liquid Waste Treatment Facility to three discharge locations: Outfall 051, mechanical evaporator system, or solar evaporation tank system.	Issued August 29, 2018	August 29, 2023	New Mexico Environment Department

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Chapter 3 – ENVIRONMENTAL PROGRAMS

Los Alamos National Laboratory's governing policy on the environment is the following:

"We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements. We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and the public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs."

CONTENTS

INTRODUCTION

In its long-term strategy for environmental stewardship and sustainability, Los Alamos National Laboratory (LANL, or the Laboratory) set forth seven environmental grand challenges, described in Figure 3-1, to clean up the past, control the present, and create a sustainable future.

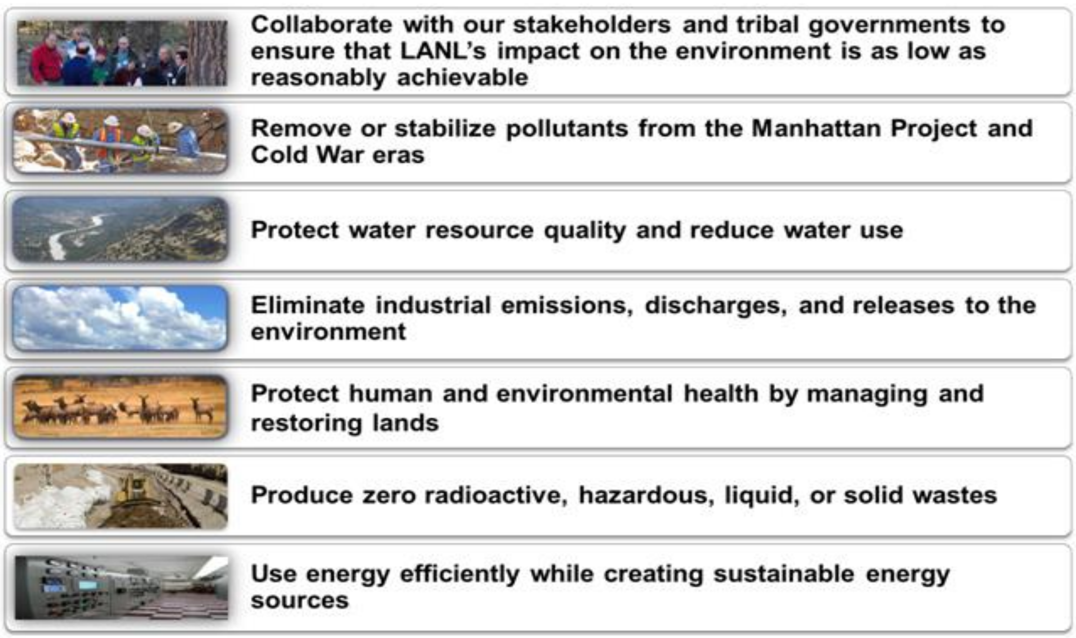

Figure 3-1. Environmental Grand Challenges—The Laboratory's goals for a sustainable future

These seven grand challenges provide a vision for the Laboratory's Environmental Management System. We maintain dedicated or "core" programs and staff to address tasks, such as protection of air, water, cultural, and biological resources; management of waste; and legacy waste cleanup and environmental remediation. In addition, we have deployed staff and resources to support environmental performance within all Laboratory organizations. This chapter describes the institutional processes and dedicated programs that the Laboratory uses to manage its environmental performance and their status for 2018.

INSTITUTIONAL PROCESSES

Environmental Management System

Certification of the Laboratory's Environmental Management System to the International Organization for Standardization's 14001 Standard

The Laboratory has maintained independent, third-party certification for its Environmental Management System since April 2006. In 2017, the Laboratory's Environmental Management System was certified under the updated 14001:2015 standard.

In 2018, N3B began the process of building its own Environmental Management System to better align with its specific procedures and work controls. In October, it established an Integrated Project Team with members from across N3B organizations to identify institutional objectives and annual targets for 2019 to be approved by the N3B Program Manager. The N3B Environmental Management System will work toward conducting audits each year to seek International Organization for Standardization 14001 certification.

2018 Environmental Management System Program Activities

The Deputy Laboratory Director for Operations chairs the Environmental Senior Management Steering Committee for the management and operating contractor. The committee sets institutional objectives and annual targets for the Laboratory's environmental performance. The three institutional objectives for our environmental performance are (1) clean the past, (2) control the present, and (3) create a sustainable future.

Within these three objectives, the Laboratory's Environmental Senior Management Steering Committee identified the following targets for the 2018 fiscal year.

Clean the Past

- Continue to comply with the requirements of the Compliance Order on Consent with the New Mexico Environment Department
- Continue implementation of remediation activities for the chromium plume in groundwater beneath Sandia and Mortandad Canyons
- Continue to implement the institutional Facility Footprint Reduction Plan
- Continue to disposition legacy and abandoned equipment, materials, and metals
- Execute remediation of nitrate salt waste
- Manage interfaces with new environmental management contractor (N3B)

Control the Present

- Implement tasks from enduring mission waste management strategy as prioritized by managers
- Improve the site cleanout and workplace stewardship program
- Establish a more cost effective and sustainable method for disposing of difficult waste
- Implement the Supplemental Environmental Projects associated with the Waste Isolation Pilot Plant Settlement Agreement
- Implement pollution prevention and federal sustainability requirements, including the LANL Site Sustainability Plan

- Implement and maintain integrated site planning and engage Environment, Safety, and Health early in the planning process
- Facilitate selection of DOE-approved sustainable products by increasing awareness and modifying ordering systems

Create a Sustainable Future

- Analyze the processes and develop a plan to incentivize line management to avoid generating wastes while continuing correct waste disposal
- Develop a path forward to meet energy sustainability goals
- Develop environmentally sustainable solutions that improve energy, water, air, soil, radioactive material or waste management, chemical or material use

The Laboratory annually updates a list of the significant environmental aspects that could be associated with activities onsite. Table 3-1 lists and describes the environmental aspects identified for 2018, along with some example activities.

Managers and teams from each Laboratory directorate develop environmental action plans each year using the institutional objectives and targets along with their evaluation of their own work activities. In 2018, we developed and tracked 275 actions in 14 of these action plans.

TABLE 3-1. LANL SIGNIFICANT ENVIRONMENTAL ASPECTS

Environmental Aspects	Description	Examples
Air emissions	Activities that release or have the potential to release material into the air.	• Point-source air emissions from stacks, vents, ducts, or pipes • Use of greenhouse gas contributors such as refrigerants, vehicles, and electricity generated with coal
Interaction with surface water and storm water	Activities that release or have the potential to release pollutants into a watercourse or through direct discharge to or contact with storm water (for example, discharge onto the ground near a waterway).	• Discharges from permitted outfalls • Spills and unintended discharges • Activity within the boundary of a watercourse
Discharge to wastewater systems	Activities that release or have the potential to release material to or from a wastewater treatment system (sanitary, chemical, or radiological).	• Laboratory sinks • Kitchens and bathrooms • Wastewater collected and transported to a wastewater facility

Environmental Aspects	Description	Examples
Interaction with drinking water supplies/systems or groundwater	Activities that release or have the potential to release material into the groundwater. This includes planned or unplanned releases onto the ground or into surface water that have the potential to migrate to groundwater. Impacts can be positive or negative.	• Potable water use in kitchens, bathrooms, and laboratory settings • Cooling tower water supply use • Installation or abandonment of groundwater wells or associated systems • Landscape watering • Land application of water or injection of treated water into an aquifer • Septic systems and sanitary holding tanks • Permitted wastewater storage basins • Water treatment systems
Work within or near floodplains and wetlands	Placement of structures or impoundments in a floodplain or wetland, or activities that release or have the potential to release material onto or into a floodplain, wetland, or area of overland flow.	• Monitoring well operations • Structures built in a floodplain or wetland • Activities that disrupt the integrity of a floodplain or wetland
Interaction with wildlife and/or habitat	Activities that impact or have the potential to impact federally protected wildlife or their habitats, migratory birds, and other wildlife not managed under any federal law.	• Landscape development • Removal of weeds, trees, brush, or invasive species • Road easement maintenance • Installation and operation of fencing, buildings, power lines, towers, drainage, or other structures • Installation and operation of outdoor lighting • Work operations that generate noise
Biological hazards	Activities that generate, use, or dispose of biological agents. This excludes human viral, bacterial, or blood-borne pathogens.	• Management of medical materials and byproducts

Environmental Aspects	Description	Examples
Interaction with soil resources	Activities that disturb surface or subsurface soils, or release or have potential to release material onto or into the ground. This includes planned or unplanned deposition of air-borne particulates and releases of solids or liquids onto or into the ground, and activities that may result in migration or deposition of radioactive constituents onto or into the ground. Activities may result from routine work or from unusual or emergency events.	• Above ground or below ground water, sewer, gas, or wastewater lines; chemical or liquid storage tanks; equipment (such as transformers) • Ground-disturbing activities, for example, construction, utility line repair, or maintenance of dirt roads • Operations that result in point source air emissions from stacks, vents, ducts, or pipes • Operations that are sources of diffuse air emissions such as open burning/open detonation, remediation activities, and decontamination and decommissioning projects • Installation and maintenance of surface-water and storm-water controls • Physical removal of wood for fire suppression and control; introduction or removal of vegetation (native or non-native)
Spark- or flame-producing activities	Activities that cause or have the potential to start a fire or wildfire.	• Off-road vehicle use • Construction or outdoor maintenance work activities • Outdoor spark- or flame-producing operations • Forest fuel mitigation activities • Outdoor recreational and other activities during high wildland fire risk season • Smoking
Cultural resource disturbance	Activities that impact or have the potential to impact cultural resources. Resources include historical buildings, buildings of special significance, archaeological sites, traditional cultural properties, and historic homesteads and trails. Activities may result from routine work or from emergencies or off-normal events.	• Expansion of existing developed areas (trails, walkways, clearings, roads) • Ground-disturbing activities below grade or surface areas • Maintenance, modification, or demolition of potential or designated historic structures • Off-road vehicle use • Vegetation removal and weed mitigation activities • Archaeological excavations

Environmental Aspects	Description	Examples
Visual resources	Activities that impact or have the potential to impact visual landscapes.	• Construction of access roads, fencing, utility corridors, and power transmission systems through nonurban areas • Construction, management, and maintenance of staging areas, storage yards, debris piles, litter, and other "eye-sores" • Design, construction, management, and maintenance of buildings, towers, stacks, domes, signs, etc. • Smoke, steam, dust • Tree thinning • Security or after-hours lighting
Hazardous or radioactive material waste packaging and transportation	Activities that handle, package, or transport hazardous waste or radioactive materials.	• Transportation of chemicals • Transportation of low-level radiological waste, mixed low-level waste, or transuranic waste
Radioactive waste generation and management	Activities that generate or manage (handle, store, or dispose of) radioactive waste.	• Laboratory or research and development procedures using or generating radioactive material • Cleanup of historical waste disposal areas • Development of alternative processes or controls that reduce radioactive materials utilization and/or cross-contamination
Hazardous or mixed-waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) hazardous or mixed waste.	• Laboratory or research and development procedures using or generating hazardous materials • Disposal of unused, unspent laboratory chemicals • Development of alternative processes or controls that reduce the quantity of radioactive or hazardous materials used or reduce radioactive or hazardous characteristics
Solid or sanitary waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) non-hazardous and nonradioactive waste intended for disposal at a municipal or industrial waste landfill.	• Laboratory, machining, and process operations wastes (non-hazardous or nonradioactive) • Non-recyclable waste, for example, some office waste and some construction and demolition debris

Environmental Aspects	Description	Examples
Interaction with contaminated sites	Activities that have the potential to increase or spread contamination because they are conducted within the boundary of or in close proximity to contaminated areas. Contaminated areas include solid waste management areas, radiological sites, nuclear facilities, or high-explosive sites.	• Construction • Remediation • Demolition • Open-detonation
Chemical (industrial and laboratory) use and storage	Activities that result in the purchase, use, management, or storage of chemicals. Activities may result from routine work or from unusual or emergency events.	• Chemical use in research laboratories • Vehicle operation and maintenance (fuels, coolants, lubricants, etc.) • Building cleaning and maintenance (janitorial supplies)
Radioactive material use and storage	Activities that handle or store radioactive materials.	• Radioactive material machining or processing • Change in location of activities or operations involving work with radioactive materials • Evaluation of processes and operations to increase efficient use of materials
Surplus properties and material management	Activities that manage (handle or store) in-use materials, surplus supplies, real estate, or other property.	• Managing (leasing, renting, selling, or purchasing) inactive real estate • Managing (storing, using, recycling, reusing, disposing of) surplus property • Cleanup and recommissioning of work areas • Decontamination and decommissioning facilities • Furniture, laboratory equipment, all material stock/supply, storage, and staging

Environmental Aspects	Description	Examples
Resource use and conservation	Activities or practices that impact resource use and affect conservation; may increase or reduce demand or wastes, may drive increases in efficiency of resource use (labor, natural material, energy, etc.), use of alternative material, or reuse/recycling opportunities.	• Applying sustainable design principles, for example, cool roofs, natural lighting, insulated glass, recycled or low-impact building materials • Procuring alternative energy or fuel sources for the Laboratory • Amount or change in the amount of energy or water required for a scope of work • Reusing and repurposing materials, equipment, and supplies • Purchasing "green" or environmentally preferable products
Storage of materials in tanks	Activities that involve handling or storing materials in tanks.	• Operating or maintaining aboveground tanks in accordance with the Laboratory's hazardous waste permit
Engineered nanomaterials	Activities that create nanoparticles, which are intentionally created particles with two or three dimensions between 1 and 100 nanometers. This definition includes 1. biomolecules (proteins, nucleic acids, and carbohydrates), 2. nanoscale forms of radiological materials, 3. nanoparticles incidentally produced by human activities or natural processes, and 4. ultrafine particles such as those produced by diesel engines and forest fires.	• Nanotechnology research and development that generates nanoparticles requiring environmental controls, for example, an exhaust system with high-efficiency particulate air filtration for airborne particulates. • Disposal of nanoparticulate waste as Resource Conservation and Recovery Act–regulated waste or as New Mexico special waste.

The Environmental Management System Program undertakes external audits and internal assessments every year. All findings and corrective actions generated from these audits and assessments are tracked to closure in an institutional tracking system. In 2018, findings from two external certification audits and one internal assessment generated opportunities for improvement related to waste handling and storage. No findings of nonconformity were issued to LANL against International Organization for Standardization 14001:2015 by their registrar in 2018. More information on the Laboratory's Environmental Management System is available at http://www.lanl.gov/environment/protection/environmental-management-system.php.

Pollution Prevention

The Laboratory's Pollution Prevention Program focuses on source reduction as defined in the Pollution Prevention Act of 1990. The program provides technical and financial analyses and support for innovative projects to reduce sources of pollutants. The program accepts pollution prevention proposals from across the Laboratory and selects projects after a comparative ranking using scoring criteria that emphasize source reduction, return on investment, transferability, and support of the LANL mission.

The Pollution Prevention Program currently focuses on all types of radioactive waste, green chemistry, process improvement projects, and sustainable acquisition. The program also supports the Site-Wide Clean Up and Workplace Stewardship Program and the Site Sustainability Plan. Completed projects are recognized through internal and external communications. An annual awards competition includes pollution prevention activities and other types of projects, such as waste minimization and recycling.

The Pollution Prevention Program is involved with hazardous waste minimization, including submission of an Annual Hazardous Waste Minimization Report to the New Mexico Environment Department. Part of the hazardous waste stream at LANL is unused chemicals. The Pollution Prevention Program staff are involved in an initiative to develop an on-site chemical pharmacy that would allow for tighter control of chemical purchases, dispensing of chemicals at volumes specific to researcher needs, and return of unused chemicals. This increased management of chemical purchases and the associated opportunity for chemical reuse could reduce hazardous waste generation.

The Pollution Prevention Program also engages in site-wide initiatives to address environmental risks that may affect the successful completion of the LANL mission. For example, based on analyses of water use on site, program staff are currently working with scientists and operators to identify ways to reduce cooling tower water usage.

The following are three examples of 2018 pollution prevention projects that illustrate the work of LANL scientists and engineers to achieve source reduction at the Laboratory.

Dissolving Post-Detonation Debris with Ammonium Bifluoride Project

Nuclear forensics is the investigation of nuclear materials to determine their origin and history. This project explored using micro-X-ray fluorescence spectrometry as a pre-screening tool for nuclear forensic analyses, and using ammonium bifluoride as a digestion reagent for dissolving samples. These methods have the potential to eliminate the use of the hazardous substance hydrofluoric acid in the pre-screening process and to reduce the generation of hazardous wastes.

Measuring Neptunium without Chemical Reagents Project

Neptunium is an important element in nuclear forensics. It is a by-product of nuclear reactors and provides important clues to the origin and history of nuclear materials. This project aims to develop the use of monochromatic wavelength dispersive high-resolution X-rays to determine trace neptunium and to calculate the age of the nuclear materials. Successful use of this technique has the potential to (1) eliminate the use of hazardous chemicals, (2) eliminate a mixed radioactive waste stream, and (3) improve worker health and safety by reducing the radiation dose exposure. If successful, this technique may be extended to mobile detection and pre-detonation nuclear forensics.

Plasma Physics Sulfur Hexafluoride Elimination Project

High-voltage equipment that produces short pulses of power is used in research in both nuclear fusion and astrophysics. At the Laboratory, sulfur hexafluoride is currently used in combination with argon gas to insulate rail gap switches to prevent electrical arcs from forming in the high-voltage equipment. Sulfur hexafluoride is a potent greenhouse gas. The Plasma Physics Program began development of a new design for rail gap switches that can use compressed air or oil instead of the sulfur hexafluoride and argon mixture. In 2017, the program showed that the new design is effective. In 2018, the program conducted further performance testing. The benefits of this project include increased flexibility in experimental set-ups, reduced labor, and the elimination of the use of sulfur hexafluoride. The Plasma Physics Program has confirmed applicability of the new rail gap switches to similar equipment in the DOE complex and elsewhere.

Site Sustainability

LANL is taking action to enable future mission work, replace aging infrastructure, and meet a growing demand for electricity. New electric generation sources are needed to provide energy conservation and competitive pricing with the most flexible approach for continued operations. LANL developed a detailed Power Procurement Strategy Plan that balances cost, risk, known market conditions, and environmental and operational goals for future power requirements. Major strategies include (1) the replacement of the current LANL Steam Plant with a new, more energy-efficient Combined Heat and Power Plant, (2) planning a 10-MegaWatt Photovoltaic development, and (3) implementing a Smart Labs Program to increase energy efficiency in existing work spaces. The Laboratory’s sustainability efforts and goals align well with the new Executive Order 13834, Efficient Federal Operations, which requires federal agencies to prioritize actions that enable more effective accomplishment of their missions, cut costs, reduce waste, and enhance the resilience of federal infrastructure and operations.

The Laboratory’s vision for sustainability is an integral part of our mission to meet the nation’s scientific challenges. LANL has made significant improvements in energy consumption and water efficiency over the last ten years including the following achievements:

- Planning, evaluating, and continually improving operations to sustainably use energy and water
- Replacing existing energy sources with energy sources that emit low-levels of greenhouse gases
- Preventing pollution
- Reducing or eliminating the generation of waste
- Planning for organizational resiliency

The fiscal year 2019 Site Sustainability Plan focuses on three primary strategies: (1) make targeted investments for efficiency, (2) transparently track our progress through metrics, and (3) engage employees and programs at all levels in the Laboratory. The intent of the Site Sustainability Program is to include energy and water conservation and cleaner production measures into everyday business practices.

Successes and Challenges

Successes from 2018 include the following:

- Assessed ten facilities to support High Performance Sustainable Buildings and Smart Labs initiatives, which includes data collection, records retrieval, and field support in conducting ventilation assessments
- Prepared recommissioning reports in four facilities
- Assessed twenty-one facilities as required by the Energy Independence and Security Act, totaling 1,570,635 square feet
- Implemented energy analytics and fault detection software, SkySpark, which is now in 40 buildings
- Completed building automation system upgrades from pneumatic to digitally-controlled systems in three facilities
- Sent over 27 million gallons of reclaimed wastewater from Sanitary Effluent Recycling Facility to the Strategic Computing Complex for reuse within its cooling towers
- Achieved a cost avoidance of $700,000 through pollution prevention projects
- Continued implementation of a Smart Labs Program for energy efficiency in Laboratory space
- Defined the scope for Phase 1 of the Steam Plant Acquisition Project

The Laboratory reduced its water intensity (gallons used per square foot of building) by 14 percent compared with fiscal year 2007 and achieved a five percent reduction in energy intensity (British thermal units used per square foot of building), even though an additional 2,000 employees were hired and new mission work started. We placed major emphasis on implementing the Smart Labs, building automation systems, and recommissioning programs. Our sustainability investments are designed to reduce growth in energy demand, while supporting hiring and mission growth.

In fiscal year 2019 through investments in Smart Lab buildings, building automation systems, lighting, and other efficiency projects, the Laboratory plans to achieve the following goals:

- Maintain or reduce the energy intensity levels compared to 2018
- Reduce the consumption of water from 2018 levels

More information on the Laboratory’s Site Sustainability Plan is available at http://www.lanl.gov/environment/sustainability/goals/index.php. Table 3-2 provides the Laboratory's specific site sustainability goals, our progress towards meeting those goals in fiscal year 2018, and planned strategies for making additional progress towards those goals.

TABLE 3-2. FISCAL YEAR 2018 STATUS AND PLANNED STRATEGIES FOR THE LABORATORY'S SITE SUSTAINABILITY GOALS

Goal	Fiscal Year 2018 Status	2-Year Plans	5-Year Plans	10-Year Plans
Greenhouse Gas Production				
Achieve a 50% reduction in scope 1 and 2 greenhouse gas emissions by fiscal year 2025 compared to fiscal year 2008.	LANL achieved a 16% reduction in Scope 1&2 greenhouse gas emissions compared to FY 2008.	LANL plans to reduce greenhouse gas emissions by completing the first phase of the Steam Plant Replacement Project.	The Steam Plant Replacement Project phases 2 and 3 will be completed. LANL will pursue an onsite 10-megawatt photovoltaic system.	LANL will pursue investments in renewable energy as needed to support mission growth.
Achieve a 25% reduction in scope 3 greenhouse gas emissions by fiscal year 2025 compared to fiscal year 2008.	LANL achieved a 22% reduction in Scope 3 greenhouse gas emissions compared to FY 2008.	LANL will install personal vehicle charging stations. LANL is investigating a federal tax incentive for employees who carpool and use bus transportation.	As LANL invests in local energy sources, transmission and distribution emissions will reduce. LANL will continue to install personal vehicle charging stations as needed.	

<table>
<tr><th>Goal</th><th>Fiscal Year 2018 Status</th><th>2-Year Plans</th><th>5-Year Plans</th><th>10-Year Plans</th></tr>
<tr><td colspan="5">Energy Management</td></tr>
<tr><td>For buildings included in this goal, achieve a 25% reduction of energy intensity (British thermal units used per gross square foot) by fiscal year 2025 compared to fiscal year 2015.</td><td>LANL achieved a 5% reduction in energy intensity compared to fiscal year 2015.</td><td colspan="3">LANL will continue to invest in energy reduction initiatives, which include (1) building automation system upgrades for heating, ventilation, and air conditioning and (2) retrofits or upgrades to inefficient lighting in older facilities. LANL will implement Smart Labs in eight facilities over the next 10 years.</td></tr>
<tr><td>Complete Energy Independence Security Act Section 432 continuous (4-year cycle) energy and water evaluations.</td><td>LANL met the annual target of completing 25% of the energy and water assessments.</td><td colspan="3">LANL will continue to evaluate covered facilities on a four-year cycle to identify energy and water conservation measures and prioritize and implement energy and water conservation projects.</td></tr>
<tr><td>Meter all individual buildings for electricity, natural gas, steam, and water, where energy management is cost effective and appropriate.</td><td>LANL has a total of 338 meters, which consist of 264 electric meters, 47 natural gas meters, 1 steam meter, and 26 water meters.</td><td colspan="3">LANL plans to install meters during major renovations and in facilities with planned Smart Lab upgrades.</td></tr>
<tr><td colspan="5">Water Management</td></tr>
<tr><td>Reduce potable water intensity (gallons used per gross square foot) by 36% by fiscal year 2025 compared to fiscal year 2007.</td><td>LANL achieved a 14% reduction in water intensity compared to FY 2007.</td><td>LANL will continue Sanitary Effluent Reclamation Facility operations and implement targeted water conservation actions. LANL will also increase water metering.</td><td>LANL will continue Sanitary Effluent Reclamation Facility operations and implement targeted water conservation actions. LANL plans to make improvements in cooling tower operations.</td><td>LANL will continue Sanitary Effluent Reclamation Facility operations and implement targeted water conservation actions. LANL will operate a newly built supercomputing facility with minimal water use.</td></tr>
</table>

Goal	Fiscal Year 2018 Status	2-Year Plans	5-Year Plans	10-Year Plans
Waste Management				
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris, each year.	LANL diverted 53% of non-hazardous solid waste in fiscal year 2018.	LANL will maintain recycling and source reduction programs to sustain performance levels above 50%.		
Divert at least 50% of construction and demolition waste each year.	LANL diverted 98% of waste from construction and demolition activities.	LANL will continue waste diversion efforts to sustain performance levels above 50% and close to 100%.		
Fleet Management				
Reduce fleet-wide per-mile greenhouse gas emissions by 30% by fiscal year 2025 compared to fiscal year 2014.	LANL has 327 low greenhouse gas vehicles.	LANL will continue to acquire fuel-efficient vehicles and low-greenhouse-gas emitting vehicles.		
Reduce annual petroleum consumption by 20% by fiscal year 2015 compared to fiscal year 2005 and maintain the 20% reduction.	LANL achieved a 33% reduction in fleet petroleum usage compared to FY 2005.	LANL will continue to acquire fuel-efficient vehicles and plug-in vehicles.		
Increase annual alternative fuel consumption by 10% by fiscal year 2015 compared to fiscal year 2005 and maintain the 10% increase.	LANL increased fleet alternative fuel use by 278% compared to FY 2005.	LANL will continue to acquire fuel-efficient vehicles and offer E-85 fuel for operations vehicles.		
Have at least 50% of new government passenger vehicles be vehicles that produce zero emissions or are plug-in hybrid electric vehicles by fiscal year 2025.	LANL has five net-zero emission or plug-in hybrid electric vehicles (~2% of the passenger vehicle fleet).	Economically priced plug-in hybrid vehicles available through General Services Agency are needed before LANL can cost-effectively expand the plug-in hybrid fleet.		

Goal	Fiscal Year 2018 Status	2-Year Plans	5-Year Plans	10-Year Plans
Clean & Renewable Energy				
Acquire a minimum of 25% of the Laboratory's total electric and thermal energy from renewable or alternative sources by fiscal year 2025 and maintain at least 25% clean energy usage thereafter.	LANL acquired 2% of its total electrical and thermal energy from onsite renewable or alternative resources.	LANL is in the planning phase for a 10-megawatt photovoltaic installation onsite.	LANL will complete a 10-megawatt photovoltaic installation onsite. The main coal-powered source of electricity for the Laboratory will shut down by 2022 and investments in low-carbon sources are planned by the utility.	LANL will pursue investments in firmed-wind as needed to support mission growth.
Acquire a minimum of 30% of the Laboratory's total electric energy from renewable or alternative sources by fiscal year 2025 and maintain at least 30% clean electric energy usage thereafter.	LANL acquired 4% of its electric energy from the 3 megawatt Abiquiu Low Flow Turbine and from Los Alamos County's megawatt-scale photovoltaic plant.	LANL is in the planning phase for a 10-megawatt photovoltaic installation on site.	LANL will complete a 10-megawatt photovoltaic installation onsite. The main coal-powered source of electricity for the Laboratory will shut down by 2022 and investments in low-carbon sources are planned by the utility.	LANL will pursue investments in firmed-wind as needed to support mission growth.

Goal	Fiscal Year 2018 Status	2-Year Plans	5-Year Plans	10-Year Plans
Green Buildings				
Comply with the revised Guiding Principles for High-Performance Sustainable Buildings for a minimum of 17% of LANL's existing buildings that are >5,000 gross square feet by 2025, with progress to 100% thereafter.	LANL achieved an average of 90% implementation of the revised Guiding Principles for High-Performance Sustainable Buildings in 34 facilities. A total of 5% of the qualifying buildings comply with the Guiding Principles.	LANL will continue to focus on elements of the Guiding Principles providing a high return on investments, such as a program to maintain energy savings. High Performance Sustainable Buildings certification is planned for five facilities every two years.		
Achieve an energy, waste, or water net-zero value in 1% of existing buildings that are >5,000 gross square feet by fiscal year 2025.	LANL's focus is on elements of the Guiding Principles providing a high return on investments.	LANL will continue to focus on elements of the Guiding Principles providing a high return on investments.	LANL will work to include “net-zero ready” concepts in the Engineering Standards Manual for major modifications.	Existing facilities should incorporate “net-zero ready” design elements for major modifications.
Achieve a net-zero energy value in all designs for new buildings >5,000 gross square feet beginning in fiscal year 2020.	LANL is evaluating its 10-Year Site Plan for opportunities to implement net-zero design elements for new buildings.	LANL will benchmark with other DOE facilities with existing net-zero facilities.	LANL will work to include “net-zero ready” concepts in the Engineering Standards Manual.	New facilities should incorporate “net-zero ready” design elements.

Goal	Fiscal Year 2018 Status	2-Year Plans	5-Year Plans	10-Year Plans
Increase regional and local planning coordination and involvement.	The Laboratory sponsors and engages in ongoing relationships with all neighbors to promote common goals and interest, and resolve cross-jurisdictional issues.	The Laboratory will continue to participate as a positive partner with many community efforts. In addition, LANL, a large stakeholder, has the ability to bring diverse entities together in a common effort.		
Acquisition and Procurement				
Promote sustainable acquisitions and procurements to the maximum extent practicable, ensuring that provisions specifying biobased products are included in 95% of applicable contracts.	All new construction contracts contain a new "Green, Sustainable Products" clause.	Other major contracts will be updated to include sustainability clauses.		
Measures, Funding, and Training				
Implement annual targets for energy savings performance contracts in fiscal year 2017 and annually thereafter as part of Section 14 of Executive Order 13693.	The Steam Plant Acquisition Project was awarded as an energy savings performance contract.	Phase 1 of the Steam Plant Acquisition Project will be completed.	Phases 2 and 3 of the Steam Plant Acquisition Project will be completed.	LANL will investigate other energy saving performance contract options.

Goal	Fiscal Year 2018 Status	2-Year Plans	5-Year Plans	10-Year Plans
Electronics Stewardship				
Select products registered in the Electronic Product Environmental Assessment Tool for at least 95% of eligible purchases.	100% of eligible electronic acquisitions are environmentally sustainable.	LANL will continue to acquire environmentally sustainable electronic products.		
Enable power management on 100% of eligible personal computers, laptops, and monitors.	LANL uses power management for 100% of its eligible computers.	LANL will continue to use power management in 100% of its eligible computers. Laboratory staff will continue to evaluate products that may provide a workaround to the issue of power management interfering with cybersecurity scanning.		
Enable automatic duplexing on 100% of eligible computers and imaging equipment.	It is not technically possible to configure automated duplex printing for Windows computers.	As new automatic duplexing features become available for Windows computers, LANL will evaluate implementation.		
Reuse or recycle 100% of used electronics with environmentally sound disposition methods.	The Laboratory works with a certified recycler for equipment recycling.	LANL will continue to recycle to the maximum extent possible while still complying with site security requirements.		
Establish a power usage effectiveness target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers.	LANL achieved a power usage effectiveness ranging from 1.38 to 1.65 in its three existing data centers.	LANL will continue to increase server virtualization efforts and retire existing legacy systems.		

Site Cleanup and Workplace Stewardship Program

Materials and equipment abandoned after projects are completed, programs ending, or staff retiring are a recurring institutional problem. The Laboratory established the Site Cleanup and Workplace Stewardship Program in 2013 to assist with the proper disposition of these items and to prevent similar issues from occurring in the future. The program and the responsible organizations partner to develop work plans, clean indoor and outdoor spaces and plan sustainable housekeeping practices. Site Cleanup and Workplace Stewardship works closely with the Property Management Group, Environmental Protection and Compliance Division, and the Infrastructure Programs Office to make sustainable improvements in institutional processes. One goal of the program is to divert as much material as possible from waste streams.

In 2018, the Site Cleanup and Workplace Stewardship Program

- Continued the initiative to improve management of storage structures at LANL including
  - Validating the owning organization, location, signage needs, and points-of-contact for some of the 1200+ storage structures onsite
  - Adding a point-of-contact sign to each storage structure
  - Working with the owning organizations to clean out and remove unneeded storage
  - Cleaning out and removing over 15 storage structures as part of this initiative

- Coordinated over 25 cleanup projects across the Laboratory including
  - Technical Area 58 Mercury Road - planning for removal and disposition of an abandoned radar trailer with significant unknown hazards
  - Technical Area 60 Sigma Mesa - finished phase four of cleanup, which included recycling several old metal tanks, cleaning up wood and metal debris, removing legacy equipment for salvage, downsizing abandoned concrete piles for recycling and disposition as industrial waste, and adding chains, signs, and stanchions to prevent future accumulations of abandoned equipment and debris
  - Technical Area 53, Building 1 - removed metal magnet stands to be released for recycle, disassembled electronics cabinets, and sent the cabinets to recycling. Electronics will be handled as mixed low-level waste.
  - Technical Area 48 - cleaned out and removed an old shed and two transportainers
  - Technical Area 51 - cleaned out lab space and two transportainers belonging to the Earth and Environmental Sciences Division
  - Technical Area 53 - removed metal for recycle from two old transportainers
  - Technical Area 35 - cleaned out a storage yard and two sheds
  - Technical Area 3, Physics Building - cleaned up storage room and installed access control
  - Technical Area 3, Satellite Area - transportainer cleanout and relocation

- Fabrication and installation of signs with structure numbers and point-of-contact information on 300 storage structures

- Coordinated metal recycling project with funding from NA532 Office of Nuclear Materials Integration including
  - Supported release of 84 potentially activated metal items (weighing ~800,000 pounds total) to be shipped to a metal recycler in 2019
  - Consolidated and relocated several hundred shielding blocks at Technical Area 53 into a controlled and inventoried staging area
  - Removed from a hillside a 98,000-pound shielding block and surveyed it for potential release; the survey detected greater than background radiation levels and the item was not released.
  - Removed from the machine shop three legacy lathes and sent them to recycle

- Assisted with development of workplace stewardship requirements to add to Program Description 902, "Space Management"
- Assisted with the development of an institutional process to assess conditions for unneeded storage containers and to manage requests for their reuse and reassignment

Greenhouse Gas Reduction

In fiscal year 2018, LANL achieved a 16 percent reduction in Scope 2 greenhouse gas emissions compared to fiscal year 2015. LANL purchased a total of 57,000 renewable energy credits (megawatt-hours) to help achieve the annual target for the Clean and Renewable Energy goal. In addition, the Sustainability Program's energy reduction projects contributed to Scope 1 and 2 greenhouse gas emissions reductions. LANL's energy use is expected to steadily increase over the next 10 years as high performance computing and expanded programmatic activities at the Los Alamos Neutron Science Center consume greater quantities of electrical power. LANL is also pursuing a 10-megawatt solar photovoltaic installation to increase onsite power production and reduce greenhouse gas Scope 1 and 2 emissions by 12,500 metric tons of carbon dioxide annually.

Project Review

All new or modified activities or projects conducted at the Laboratory must be reviewed for environmental compliance and other requirements. The Integrated Review Tool is a web-based application that serves as the entry portal for excavation, fill, and soil disturbance permitting; and permits and requirements identification. Work owners or planners enter their project information into the tool, and subject matter experts review the projects and identify the applicable permits and requirements for performing the work.

In 2018, subject matter experts reviewed 817 projects for excavation, fill, and soil disturbance permitting, and reviewed 220 projects for permits and requirements identification. The Integrated Project Review Program coordinates environmental subject matter expert reviews and interacts with work owners and planners across the Laboratory. The program is represented by subject matter experts from the following compliance programs: Air Quality, Biological Resources, Cultural Resources, Environmental Health Physics, Individual Permit Program, National Environmental Policy Act, Solid Waste Management Units and Areas of Concern, Resource Conservation and Recovery Act, Waste and Materials Management, and Water Quality.

N3B project managers use the Integrated Review Tool for some projects, and internal N3B procedures for the remaining projects. In 2018, N3B created procedures N3B-P351, Project Review Process, and N3B-P101-17, Excavation/Fill/Soil Disturbance, to identify compliance requirements for new or modified activities. During 2018, 20 projects were reviewed through the N3B Project Review Process, and six projects were reviewed following the N3B Excavation/Fill/Soil Disturbance procedure. The procedures engage with subject matter experts from the following N3B compliance programs: Air Quality, Biological Resources, Cultural Resources, Safety and Industrial Hygiene, National Environmental Policy Act, Resource Conservation and Recovery Act, Waste and Materials Management, and Water Quality.

Over the last several years, the Integrated Project Review Program has supported integration of project review processes as well as improvements in the Integrated Review Tool. Improvements to the excavation portion of the tool continued in 2018, including expanding the number of separate areas that can be mapped and reviewed for a single project. This significant improvement means that work owners or planners who in the past submitted up to 30 review requests per year to capture activities such as mowing along LANL roadways may now submit just one review request per year. While this requires subject matter experts to be very specific and detailed in their comments, it is also a substantial time and effort savings for repeat users of the tool. In 2018, Permits and Requirements Identification for the Requestor training was in development. It will be implemented through the Laboratory's training system in 2019.

DEDICATED "CORE" PROGRAMS

Air Quality Programs

The Laboratory maintains a rigorous Air Quality Compliance Program addressing emissions of both radioactive and non-radioactive air pollutants. The program consists of three main parts: compliance and permitting, stack monitoring, and ambient air monitoring.

Compliance and Permitting. We operate under a number of air emissions permits issued by the New Mexico Environment Department as well as approvals for construction of new facilities or operations issued by the U.S. Environmental Protection Agency. These permits and approvals require pollution-control devices, stack-emissions monitoring, and reporting of monitoring results.

We are authorized to operate equipment and use materials that produce air emissions under the conditions defined in our Title V Operating Permit. Our permitted emission sources include a steam plant, a combustion turbine, boilers and heaters, emergency generators, beryllium operations, chemical use, degreasers, data destruction (paper shredder), and a small asphalt batch plant. Each source type has its own emission limits for both criteria air pollutants and hazardous air pollutants. The Title V Operating Permit also includes facility-wide emission limits for criteria and hazardous air pollutants. As part of compliance with the Title V Operating Permit, we report emissions and provide monitoring records from the permitted sources twice a year to the New Mexico Environment Department. The New Mexico Environment Department inspects the Laboratory annually for compliance.

What are these air quality terms?

A **stack** is a vertical chimney or pipe that releases gases produced by industrial processes into the air.

Criteria air pollutants are six specific pollutants regulated by the U.S. Environmental Protection Agency under the Clean Air Act because they cause smog, acid rain, or other health hazards.

Hazardous air pollutants are chemicals and radionuclides that at high-enough levels are known or suspected to cause cancer, other serious health effects, or adverse environmental effects.

Stack Monitoring. As described in greater detail in Chapters 2 and 4, the Laboratory rigorously controls and monitors emissions of radioactivity from building stacks, as required by the Clean Air Act. We evaluate these operations to determine the potential for stack emissions to affect the public or the environment. In 2018, 27 stacks were continuously sampled for the emission of radioactive materials to the air.

Ambient Air Monitoring. The Laboratory operates an extensive network of ambient air quality monitoring stations to detect other possible radioactive emissions (discussed further in Chapter 4). The network includes stations located onsite, in adjacent communities, and in regional locations. In 2018, we operated 38 ambient air quality monitoring stations at distances up to 25 miles from the Laboratory.

Water Quality Programs

The Laboratory has multiple programs dealing with the quality of surface waters. We maintain compliance with five National Pollutant Discharge Elimination System permits: the outfall permit, the individual permit for storm water discharges, the construction general permit, the multi-sector general permit, and the pesticide general permit (all discussed further in Chapter 2). The Laboratory conducts environmental surveillance monitoring on surface water base flow, storm water flow, and deposited sediments (see Chapter 6).

In 2018, we continued the process for renewal of the Laboratory's individual permit for storm water discharges. We submitted the renewal application for the individual permit to the U.S. Environmental Protection Agency on March 27, 2014. The current individual permit LANL is operating under has been administratively continued until a new final permit is issued by the U.S. Environmental Protection Agency.

In 2018, the Laboratory operated under five groundwater discharge permits by the New Mexico Environment Department. These permits covered discharges from the sanitary wastewater system plant and the sanitary effluent reuse facility; discharges from eight septic tank systems; land application of treated groundwater, injection of treated groundwater into the aquifer through six underground injection control wells, and the TA-50 Radioactive Wastewater Treatment Facility.

We maintained the Laboratory’s site-wide network of storm water gage stations for monitoring flow and collecting storm water samples in all major canyons. We also continued operating the automated notification system that provides the operators of Santa Fe's Buckman Direct Diversion (which diverts water from the Rio Grande for Santa Fe's drinking water supply) early notification of storm water flows through Los Alamos Canyon into the Rio Grande. We documented the effectiveness of installed sediment-control measures for the Los Alamos/Pueblo Canyon watershed and the Sandia Canyon wetland to the New Mexico Environment Department.

Sanitary Sewage Sludge Management

On March 24, 2014, the New Mexico Environment Department Solid Waste Bureau approved the Laboratory's application to operate a compost facility to compost solid wastes produced by the Laboratory's Sanitary Waste Water System. Full-scale operations at the Technical Area 46 Sanitary Waste Water System Compost Facility began in late 2014. The compost will be land-applied at the Laboratory for beneficial use. This includes landscaping, post-construction remediation, and range land restoration. Before compost can be land-applied, it must meet pollutant concentration limits, Class A pathogen requirements, and vector attraction reduction requirements as specified in the U.S. Environmental Protection Agency's Standards for the Use or Disposal of Sewage Sludge in the Code of Federal Regulations Title 40, Part 503. Because of this project, sewage biosolids will no longer be transported offsite for landfill disposal.

In 2018, the facility produced 28.7 tons of composted biosolids. Finished compost was stockpiled at the Sanitary Waste Water System Compost Facility. With approval from the New Mexico Environment Department, a new in-vessel composter was brought online for pilot testing. The in-vessel system provides better control of environmental conditions such as temperature, moisture, and airflow. All compost produced to this point will be composted a second time through the in-vessel system. In 2018 and beyond, compost will be land-applied at predetermined sites within Laboratory boundaries. Final disposition of compost is subject to site selection criteria, management practices, administrative controls, and application rates. For example, compost will not be applied in canyon bottoms, wetlands, or in areas with shallow perched alluvial groundwater. Application rates will not exceed agronomic rates provided by the New Mexico State University Cooperative Extension Service (Robert Flynn, personal communication, 5 February 2013).

Cultural Resources Management

Approximately 90 percent of DOE land in Los Alamos County has been surveyed by the Laboratory's cultural resources staff for prehistoric and historic cultural resources, resulting in the identification of more than 1,800 sites that date throughout the past 10,000 years. Nearly 79 percent of the Laboratory's sites are associated with Ancestral Pueblo people: buildings, villages, trails, agricultural features, rock art, and more. However, the cultural resources sites at the Laboratory also include Archaic Period lithic scatters, late 19th and early 20th century Homestead sites, and Laboratory buildings used during the Manhattan Project and Cold War eras (~1943-1990).

In 2018, the Laboratory's cultural resources management initiatives included the following:

- Completing cultural resources surveys on all DOE property
- Evaluating and determining the potential eligibility for archeological sites to be listed with the National Register of Historic Places
- Evaluating and determining the potential eligibility for historic buildings to be listed with the National Register of Historic Places
- Conducting outreach activities and tours

In 2018, we conducted archaeological site recording and project avoidance for a wide variety of ground-disturbing undertakings. The major projects included (1) Area 1 Waterline Installation Project in Technical Areas 15 and 36, (2) completion of a legacy project in Technical Area 54, (3) Technical Area 49 Training Facility Expansion Project, and (4) Lower Sandia Watershed Controls in Technical Area 72.

We assessed the condition of Nake'muu Pueblo and updated photographic records in September 2018. We supported reoccurring Laboratory technical meetings with Santa Clara Pueblo and Jemez Pueblo. In addition, in 2018 we supported DOE's technical meeting with Pueblo de San Ildefonso, Santa Clara Pueblo, Cochiti Pueblo, and Jemez Pueblo. Five cultural resources team members received wildland fire training and were certified to support emergency operations in case of wildfire on Laboratory property. We continued to monitor seasonal recreational use of trails in Technical Areas 70 and 71 and of DOE preservation easements in Pueblo Canyon.

In 2018, we supported several projects that involved decontamination and decommissioning of Laboratory buildings by completing the Technical Area 46 context report, assessing 12 historic buildings for eligibility for the National Register of Historic Places, and documenting historic buildings at Technical Areas 46 and 3. Other historic building work included re-evaluating three buildings at Technical Area 22, adding to a historic property in Technical Area 3, and re-installing power poles near a historic property in Technical Area 22. We conducted archival photography of buildings in Technical Areas 3, 8, 15, 16, 46, and 50, and we continued to work with the Bradbury Science Museum to integrate the Laboratory's historical artifacts into the museum's catalog system.

In 2018, N3B hired a Registered Professional Archaeologist to manage cultural resources compliance for the legacy waste cleanup projects. Initial activities included establishing N3B's cultural resources management program through purchasing field equipment, obtaining documents, and building network databases. N3B cultural resources staff presented three briefings to employees on the importance of archaeological sites and historic buildings at the Laboratory.

Manhattan Project National Historical Park

Legislation establishing the Manhattan Project National Historical Park (Park) received Congressional approval on December 19, 2014 (Figure 3-2). A Memorandum of Agreement between the Secretary of the Interior and Secretary of Energy was signed in 2015 defining Park management responsibilities. The Park consists of units at Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. Nine individual buildings at the Laboratory that are associated with the design and assembly of the "Gadget" (the atomic bomb tested at Trinity Site), the "Little Boy" weapon (the bomb detonated over Hiroshima, Japan), and the "Fat Man" weapon (the bomb detonated over Nagasaki, Japan) are part of Park properties at LANL. Eight additional Laboratory buildings and structures, identified in the park legislation, are considered "park-eligible" properties.

In 2018, the Laboratory's cultural resources staff worked with the National Park Service staff on two priority projects at Park and Park-eligible properties under an Interagency Agreement—the stabilization of the Pond Cabin and window restoration at the Slotin Building (Figure 3-3).

Cultural resources staff coordinated repairs with the National Park Service on window restoration at the Slotin Building. The window restoration work included repair of glazing, installation of new window glazing compound, replacing missing window components, and painting the trim the original green color used by the U.S. Army Corps of Engineers during the Manhattan Project. Also in 2018, a stabilization and repair project was started for the restoration of two concrete bunkers; one within the Manhattan Project National Historical Park boundaries and the other determined eligible for the National Register of Historic Places. All three projects return the buildings to their original Manhattan Project-era appearance (Figure 3-4).

Routine surveillance and maintenance inspections were conducted at all 17 Park and Park-eligible properties, and on 18 Cold War era buildings identified as candidates for long-term preservation.

The DOE hosted public tours of the Manhattan Project era structures at Pajarito Site in Technical Area 18. One hundred visitors saw the site in four tours over two mornings. In conjunction with Los Alamos Science Fest and the 75th anniversary of the Laboratory, visitors had the opportunity to learn about the history of the Pajarito Plateau from 10,000 years in the past, through the Homesteading era and into significant events of the Manhattan Project at Los Alamos. Additional tours were held for local stakeholders.

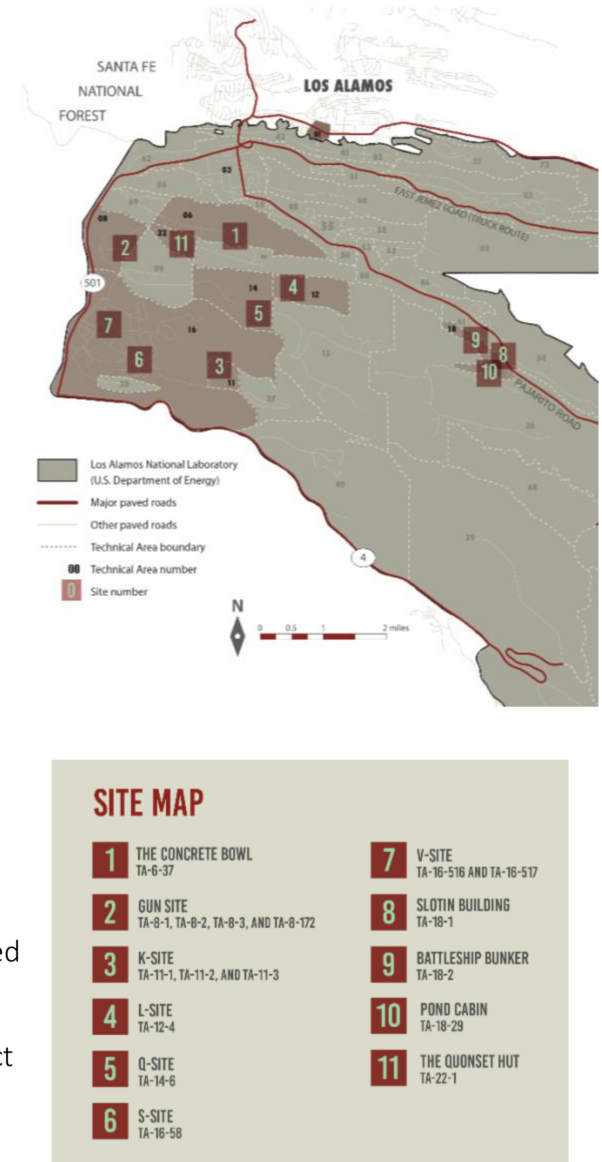

Figure 3-2. Map of the Manhattan Project National Historical Park buildings at Los Alamos National Laboratory

Figure 3-3. Slotin Building window restoration work in June 2018

Figure 3-4. Marks from wood forms in the original concrete of the battleship bunker will need to be replicated in the new concrete.

Biological Resources Management

The goal for biological resources management at the Laboratory is to minimize impacts to sensitive species and their habitats and to ensure all activities comply with federal and state requirements for biological resources protection. The Laboratory contains habitat for three species federally listed as either threatened or endangered. Two of these species, the Mexican spotted owl and the Jemez Mountains salamander, have been found on the site. The Southwestern willow flycatcher has not been documented on Laboratory property.

2018 Accomplishments

We annually inform and educate the Laboratory workforce about biological resources compliance and restrictions on timing and location of work activities to protect federally listed species. The biological resources staff also provide information on impacts to migratory birds from vegetation removal projects and other known hazards to birds such as open pipes and bollards. We also provide safety briefings on encountering wildlife.

Laboratory biologists annually conduct surveys for the presence of threatened and endangered species that have habitat on LANL property. In 2018, surveys for the Mexican spotted owl confirmed the presence of owls in both Mortandad and Threemile canyons. Southwestern willow flycatchers were not found during surveys in 2018, and the weather was too dry to conduct surveys for Jemez Mountains salamanders.

Throughout 2018, we attended or presented at conferences, workshops, and meetings for professional and educational development, collaboration, and outreach. Notable activities included presenting at the Expanding Your Horizons Workshop for 5th-8th grade girls, and attending the American Ornithological Society annual conference and the New Mexico Avian Conservation Partners Meeting.

LANL biologists were coauthors on four peer-reviewed publications in 2018. The papers addressed organic chemical concentrations in bird eggs and tissues (Gaukler et al. 2018a), inorganic element concentrations in bird eggs and tissues (Gaukler et al. 2018b), the effects of piñon pine (Pinus edulis) mortality on bird communities (Fair et al. 2018), and responses of bird populations to fire (Saracco et al. 2018).

2018 Biological Resources Program Reports

LANL biologists supported many projects across the Laboratory with compliance and monitoring activities in 2018. Published reports supporting projects included the following:

- "2017 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory" (LA-UR-18-22897)
- "Wetland Assessment for the Middle Mortandad Controls Supplemental Environmental Project at Los Alamos National Laboratory" (LA-UR-18-20325)
- "Floodplain Assessment for the Proposed Fire Break at the Lower Slobbovia Firing Site at Los Alamos National Laboratory" (LA-UR-18-20885)
- "Floodplain Assessment for the TA-72 Outdoor Fire Range Upgrades at Los Alamos National Laboratory" (LA-UR-18-23647)
- "Biological Assessment for the Installation and Operation of an Upgraded Asphalt Batch Plant and Continued Heavy Equipment Operations at Sigma Mesa on Federally Listed Threatened and Endangered Species at Los Alamos National Laboratory" (LA-UR-18-29417)
- "2018 Los Alamos National Laboratory Paleoseismic Trenching Project Biological Resource Compliance Report for the U.S. Fish & Wildlife Service" (LA-UR-18-31695)

Wildland Fire Management

The LANL Wildland Fire Program focuses on providing a consistent and standardized approach to fuels treatment, training, and enhancing wildland fire response capabilities at LANL. The program staff are located at the Technical Area 49 Interagency Fire Center along with members from the United States Forest Service and National Park Service. The LANL Wildland Fire Program collaborates with the Los Alamos Fire Department, National Park Service, United States Forest Service, Bureau of Indian Affairs, Northern Pueblo Agencies, and the New Mexico State Forestry Division to enhance wildland fire preparedness. The primary objective of the LANL Wildland Fire Program is to provide wildland fire preparedness through fuels mitigation, integration of wildland fire technology, and interagency training.

Key Functions

- Developing and executing LANL wildfire mitigation projects, such as establishing and maintaining of fire breaks, defensible space, fire roads, and tree thinning
- Developing wildland fire plans, procedures, and checklists
- Updating the LANL Wildland Fire Management Program website to ensure fire conditions and fire danger ratings are available to the workforce
- Updating the LANL Wildland Fire Program database to ensure the program has the ability to produce maps that can generate site-specific concerns, such as potential release sites and archeology sites
- Conducting training, drills, and exercises with internal and external wildland fire organizations

Prior to the 2018 fire season, the Wildland Fire Program completed mitigations by (1) stripping and recontouring 12 fire breaks, each approximately 60 feet wide with a total length of 12 miles; (2) grading and repairing approximately 60 miles of fire roads; (3) treating defensible space areas around 202 occupied structures; and (4) maintaining fuel mitigation treatments on 700 acres.

The Wildland Fire Program conducted a self-assessment during the 2nd Quarter of fiscal year 2018 that resulted in program enhancements including

- New response checklists for LANL Emergency Managers and Wildland Fire Program Staff
- All LANL wildland fire responders being compliant with National Wildfire Coordinating Group standards for their respective positions
- Proper personal protective equipment for all wildland fire responders
- An enhanced notification process from Santa Fe Dispatch to ensure that the LANL Emergency Operations Support Center is notified of fires in the region (10-mile radius)

In 2018, four wildland fire drills were conducted following the assessment to enhance wildland fire preparedness. The LANL Wildland Fire Program conducted several presentations on wildland fire preparedness for organizations throughout the Laboratory, covering fire restrictions, preparedness tips at work, and preparedness tips at home. Program staff worked with personnel from the Environmental Compliance and Protection Division to combine LANL's Forest Health Plan and Wildland Fire Plan into an integrated Forest Health and Wildland Fire Mitigation Plan.

Waste Management

The Laboratory produces several types of regulated wastes, including low-level radioactive wastes, mixed low-level radioactive and hazardous wastes, transuranic wastes, New Mexico special wastes, and others. Enduring mission wastes at the Laboratory are administered separately from the legacy wastes, which are defined as the wastes generated before 1999.

Legacy wastes became the responsibility of the DOE Office of Environmental Management on October 1, 2015, and are discussed as part of environmental remediation.

The LANL Enduring Mission Waste Management Plan outlines the strategies employed to compliantly and efficiently disposition enduring mission wastes. The Plan also incorporates pollution prevention strategies to significantly reduce the volume and toxicity of waste generated. Waste minimization efforts have greatly reduced or eliminated many sources of radioactive and hazardous waste across the Laboratory. Offsite shipping to government and commercial treatment, storage, and disposal facilities has minimized onsite waste disposal. A Transuranic Waste Facility has been constructed that allows the staging of transuranic waste for offsite shipment. Replacement of the aging Radioactive Liquid Waste Treatment Facility has also been approved, and construction has begun on low-level radioactive and transuranic liquid waste facilities.

Remediated Nitrate Salts and Shipments to the Waste Isolation Pilot Plant

In 2018, the Laboratory completed the treatment of 27 containers of unremediated nitrate salt wastes that were located at Technical Area 54 at the Waste Characterization, Reduction, and Repackaging Facility. The treatment process removed the hazardous characteristic of ignitability from these containers and they can now be accepted at the Waste Isolation Pilot Plant. In addition, the Laboratory has worked closely with the DOE Carlsbad Field Office, Central Characterization Project, the National Transuranic Waste Program, and other National Nuclear Security Administration laboratories to integrate Waste Isolation Pilot Plant waste acceptance criteria requirements into operational procedures and ship transuranic waste to the Waste Isolation Pilot Plant.

Environmental Remediation

In accordance with the 2016 Compliance Order on Consent, the Environmental Remediation Program investigates and, where necessary, remediates sites to ensure that chemicals and radionuclides in the environment associated with releases from past operations do not result in an unacceptable chemical risk or radiological dose to human health or the environment. (For more information about the 2016 Compliance Order on Consent, please see Chapter 2, The 2016 Compliance Order on Consent section.) In April 2018, N3B assumed responsibility for Compliance Order on Consent activities. Sampling is conducted to determine if releases have occurred and, if so, whether the nature and extent are defined or further sampling is warranted. Using the environmental data obtained for a site, human health and ecological risk assessments are conducted. Sites are remediated if the risk assessments indicate potential adverse impacts to human health, the environment, or both. Corrective actions are complete at a site when N3B has demonstrated and documented, to the regulatory authority's satisfaction, that further sampling is not warranted and the chemicals and radionuclides present do not pose an unacceptable risk or dose to humans, plants, or wildlife. Table 3-3 presents a summary of the reports submitted and site investigations conducted in 2018 by N3B in support of the Compliance Order on Consent.

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TABLE 3-3. SUMMARY OF REPORTS SUBMITTED AND SITE INVESTIGATIONS CONDUCTED IN 2018 UNDER THE N3B ENVIRONMENTAL REMEDIATION PROGRAM

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Known Sites Completion	46, 50	2	One site in TA-46 [SWMU 46-004(q)] and one site in TA-50 [SWMU 50-006(d)] were remediated to address potential unacceptable risk for industrial workers. At SWMU 46-004(q), mercury-contaminated soil was excavated during 2018 and removal areas were expanded both laterally and vertically based on confirmation sampling results. A total of 2.9 cubic yards of mercury-contaminated soil was excavated and packaged for transportation to an off-site disposal facility. At SWMU 50-006(d), americium-241 and cesium-137-contaminated soil and tuff was excavated during 2018, and removal areas were expanded both laterally and vertically based on confirmation sampling results. A total of 11.5 cubic yards of americium-241 and cesium-137-contaminated soil and tuff was excavated and packaged for transportation to an off-site disposal facility.
Conclusions/Recommendations: All cleanup objectives were met and no further corrective actions are required at these sites. Details and results of the sampling and remediation will be presented in a campaign completion report to be submitted to the New Mexico Environment Department in 2020.			
Middle Los Alamos Canyon Aggregate Area sampling and remediation	02	1	Removal of PCB-contaminated soil was conducted to address potentially unacceptable risk for industrial workers and recreational users in the depth interval 0.0–1.0 ft below ground surface (bgs) and to meet the Toxic Substances Control Act bulk PCB remediation waste cleanup level for low-occupancy areas. Soil was excavated during 2018 and removal areas were expanded both laterally and vertically based on confirmation sampling results. A total of 282 cubic yards of PCB-contaminated soil was excavated and packaged for transportation to an off-site disposal facility.
Conclusions/Recommendations: Remediation was designed to result in no potential unacceptable risk/dose to human health and the environment for industrial workers and recreational users. Following completion of investigation sampling and remediation activities, characterization data for SWMU 02-014 were evaluated to identify chemicals of potential concern, evaluate nature and extent of contamination, and assess risk to human health. SWMU 02-014 was determined to not pose an unacceptable human health risk or dose under the industrial, recreational, residential, and construction worker scenarios. Based on the results of data evaluations, corrective action complete without controls is recommended for SWMU 02-014. Details and results of the sampling and remediation are presented in an addendum to the Phase II investigation report for Middle Los Alamos Canyon Aggregate Area, Revision 2. The addendum to the IR was submitted to the New Mexico Environment Department in April 2019 (LANL 2019).			

Note: TA = Technical Area

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Environmental Health Physics Program

> **What is health physics?**
>
> Health physics is the branch of radiation science that deals with effects of ionizing radiation on human health.

The Environmental Health Physics Program provides technical support to the Laboratory for radiation protection of the public and the environment. We use analytical measurements and radiological assessment models to calculate dose estimates for the public and for plants and animals. These estimates are communicated to regulatory agencies and the public.

DOE Order 458.1, Radiation Protection of the Public and the Environment*,* also requires us to oversee releases to the public of real estate and moveable property (such as surplus equipment and wastes) that have the potential to contain residual radioactivity. Examples include land tracts that are transferred to other owners and debris from building demolition activities.

Our environmental health physicists support emergency planning and response by providing technical support and dispersion modeling for accident response as well as recommendations for protective actions. We also provide technical support for environmental remediation projects.

Soil, Foodstuffs, and Biota Monitoring

The Soil, Foodstuffs, and Biota Monitoring Program collects a wide variety of samples for the analyses of radionuclides, inorganic elements (mostly metals), and organic chemicals, for example, PCBs. The program routinely collects soil, native vegetation, foodstuffs (including fruits, vegetables, grains, milk, eggs, fish, meat, and honey), small mammals, such as mice, and other animals that have died due to natural causes or accidents, such as road kill. These samples are collected from Laboratory property, the surrounding communities, and from regional background locations. The data generated from these sampling efforts are used to (1) determine whether Laboratory operations are affecting levels of chemicals or radionuclides in the environment, (2) monitor for new releases, (3) calculate estimates of radiation dose for the public and for biota, and (4) conduct risk assessments. The program looks at indicators of ecosystem health by comparing chemical levels in these samples with background levels, screening levels, and effects levels, and by examining wildlife population and community characteristics. The program is described in detail in Chapter 7.

2018 Accomplishments

The primary focus of the program's efforts in 2018 was sampling soil and native understory vegetation from locations near major operations at the Laboratory, in the surrounding communities, and from regional background locations. The samples were analyzed for radionuclides, inorganic elements (mostly metals), and organic chemicals. Additionally, annual sampling was conducted around Area G, the Dual-Axis Radiographic Hydrodynamic Test Facility, and flood retention structures. Specifically, soil and native vegetation overstory samples were collected around the perimeter of Area G and near the boundary between Technical Area 54 and the Pueblo de San Ildefonso border. These samples were analyzed for radionuclides. Soil, sediment, nonviable bird eggs, nestlings that died of natural causes, and small mammals (i.e., rodents) were analyzed for radionuclides, inorganic elements (mostly metals), and high explosives around the Dual-Axis Radiographic Hydrodynamic Test Facility. Nonviable bird eggs and nestlings that died of natural causes were also collected near firing sites and from Bandelier National Monument and analyzed for metals. Small mammals were collected upstream of the sediment retention structures located in Los Alamos and Pajarito canyons and from a background location in Espanola and analyzed for inorganic elements and organic chemicals. The program also opportunistically collected and analyzed tissues from mule deer (Odocoileus hemionus), Rocky Mountain elk (Cervus elaphus nelsoni), coyote (Canis latrans), gopher snake (Pituophis catenifer), and great horned owl (*Bubo virginianus*). Lastly, the program assessed community assemblages and population indices of benthic macroinvertebrates collected from a variety of ephemeral-intermittent and perennial streams on the Pajarito Plateau. Detailed results from the program's 2018 monitoring efforts are reported in Chapter 7, Ecosystem Health.

Meteorology Program

DOE Order 458.1, Radiation Protection of the Public and the Environment, and DOE Order 151.1D, Comprehensive Emergency Management System, require DOE facilities to measure site meteorological variables. The variables measured are determined by the level of radiological activities, the topography of the site, and the distances to critical receptors. The LANL Meteorology Program maintains a network of five meteorological towers that measure temperature, wind, humidity, pressure, precipitation, and solar radiation across the site. These data are used for emergency planning in the event of a chemical or radiological release, regulatory compliance in the areas of air quality, water quality, and waste management, and for supporting monitoring programs for surface water and environmental radiation. Weather data can be accessed internally at https://weather.lanl.gov or externally at https://weathermachine.lanl.gov. No new weather stations were added in 2018. Meteorological conditions at LANL for 2018 are reported in Chapter 4, Air Quality.

Natural Phenomena Hazard Assessment

DOE Order 420.1C, Facility Safety, requires that nuclear facility structures, systems, and components must effectively perform their intended safety functions under the effects of natural phenomena hazards. As a part of this requirement, occurrences of natural phenomena hazards (for example, earthquakes, floods, and high winds) are reviewed every ten years to determine if major modifications to nuclear facilities are required by significant increases in risk from natural phenomena. No meteorological assessments were conducted in 2018. An updated seismic hazard analysis of the Pajarito fault system around the Laboratory is currently underway.

Land Conveyance and Transfer Project

Section 632 of Public Law 105-119 directed DOE to transfer excess land at the Laboratory to Los Alamos County and to the Secretary of the Interior in trust for the Pueblo de San Ildefonso. As of the end of 2018, 21 tracts have been conveyed to Los Alamos County, three tracts have been conveyed to the Los Alamos County School District, and three tracts have been transferred to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso.

Conveyances to Los Alamos County support local community economic development by providing lands for housing, commercial uses, and recreation. Nearly 400 housing units, including low-income apartments and over 160 market-rate single family homes, are being developed on previously conveyed tracts.

The Land Conveyance and Transfer Project staff continues to work with the DOE National Nuclear Security Administration Los Alamos Field Office to complete the outstanding compliance activities and requirements needed to convey the remaining tracts. Three tracts (A-16-a, A-5-2, A-5-3) totaling nearly 90 acres were conveyed to Los Alamos County in January 2018. In November 2018, the 5.76-acre Tract A-16-b in DP Canyon was conveyed to Los Alamos County for recreational and open space uses.

Awards and Recognition

The Laboratory was the recipient of a DOE gold-level GreenBuy Award for 2018. LANL reached the leadership goal for 20 products in six different categories, achieving excellence in sustainable acquisition. The GreenBuy Awards program recognizes DOE sites for excellence in "green purchasing." The Laboratory won gold-level recognition in 2016, 2017, and 2012 and bronze in 2011, the year the award was launched. DOE also recognized LANL with a GreenBuy Prime Award for having won the GreenBuy gold-level award three times.

LANL won pollution prevention awards from the National Nuclear Security Administration in several categories in 2018:

- Patricia Gallagher – Environmental Stewardship and Sustainability Champion (Large Site Award)
- Materials Science Gets Building Science – Laboratory Rehabilitation (Large Site Award)
- Biobased Lubricant Used in Metal Cutting Identified as Waste Diversion Strategy and Safety Improvements (Large Site Award)
- In-House Liquid Nitrogen Plant for the Production of Cryogens (Honorable Mention)
- A Sulfur Hexafluoride Alternative to Pulsed Power Systems (Honorable Mention)
- Smart Lab Project (Honorable Mention)

The Laboratory was also recognized for its outstanding sustainability practices with a BioPreferred Award from the U.S. Department of Agriculture. The award honors outstanding achievements in supporting the Federal BioPreferred Purchasing Preference Program. The LANL team found that one gallon of biobased oil could replace approximately 55 gallons of petroleum-based oil for lubricating their equipment (Figure 3-5). Significant savings were realized by transitioning to the biobased lubricant. The biobased oil was also an improvement because it did not stain the concrete floor.

Figure 3-5. A 55-gallon drum of petroleum-based oil for lubrication can be replaced by one gallon of biobased oil.

LABORATORY ENVIRONMENTAL DATA PROCESS

Analytical chemical and radiological data presented in this *Annual Site Environmental Report* can be found in the public IntellusNM database at http://www.intellusnm.com.

Data collection process starts with sample planning. Field collection forms and chains of custody are generated ahead of time. When field sampling is complete, the samples are delivered to the Sample Management Office at LANL following standardized procedures. The Sample Management Office tracks the samples and ships them to the designated analytical laboratory.

Once analytical laboratories have completed their analyses, they electronically upload the results into LANL's Environmental Information Management System. Staff review and auto-validate the electronic data files. Auto-validation of the data entails running a specified electronic review of the data based on defined analytical chemistry review criteria. The analytical results are then flagged with applicable data qualifiers and reason codes and are processed to the final data tables in the Environmental Information Management System.

If any errors are found that are the result of analytical laboratory processing, the analytical laboratory is notified to correct the issues and resubmit the data. If errors are the result of LANL processing (such as incorrect location identification), the Sample Management Office fixes the issue. Once data validation is complete, data in the Environmental Information Management System are available to our environmental programs for review, analysis, and reporting.

Non-analytical field data (such as soil type or texture) may be collected in conjunction with analytical sample data. Field data are imported directly into a working database and are subject to automated format checking and manual quality assurance reviews in accordance with the responsible environmental program's standard operating procedures. Once reviewed, these data are also available in the Environmental Information Management System.

Once data (field and analytical) are validated and available in the Environmental Information Management System, they are released to the IntellusNM website (http://www.intellusnm.com). This is true for all data except for data associated with third parties and for selected data with hold flags applied by LANL. We treat data collected at locations owned by third parties in accordance with supplementary agreements between the Laboratory and the landowners. All data associated with a third-party landowner are reviewed and auto-validated in the same manner as data from LANL locations. However, instead of direct nightly release to the IntellusNM website, third-party analytical results are sent by email to the landowners for their information and review. During the review process, these data are withheld from release to IntellusNM. Once the landowner has finished review or the agreed-upon holding period has elapsed, these data are released to the IntellusNM website.

DOE Consolidated Audit Program

LANL uses offsite analytical laboratories for radiological and chemical analysis of environmental samples. The services of these laboratories are procured though a formal contract. These analytical laboratories are required to have a documented quality assurance/quality control program and to participate in the DOE Consolidated Audit Program. The DOE Consolidated Audit Program is a DOE-Headquarters program that conducts annual audits of analytical laboratories and commercial waste treatment, storage, and disposal facilities that provide services to DOE sites throughout the complex. Audits by the DOE Consolidated Audit Program are one of the methods that DOE uses to meet the requirements in DOE Order 414.1D, Quality Assurance*,* specifically paragraph 1b(3), where it states that DOE's goal is to achieve quality work based on certain principles. The list of the commercial laboratories assessed under the DOE Consolidated Audit Program can be found on https://www.energy.gov/ehss/downloads/list-commercial-laboratories-assessed-under-doecap-ap. All analytical laboratories used by LANL's Sample Management Office are on the list.

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Chapter 4 – AIR QUALITY

The purpose of Los Alamos National Laboratory's (the Laboratory's) air-quality surveillance program is to protect public health and the environment. We address the question, "Are there adverse effects to humans, plants, or animals from Laboratory-produced radioactive airborne materials or direct radiation?" Air quality is monitored by five programs, each described in a section of this chapter: (1) ambient air sampling at public locations, (2) exhaust stack sampling at Laboratory facilities, (3) gamma and neutron direct radiation monitoring near radiation sources and in public locations, (4) particulate matter monitoring, and (5) meteorological monitoring of the local climate and weather. A primary objective is to measure levels of airborne radiological materials in order to calculate radiological doses to humans, plants, and animals. Results are compared with U.S. Department of Energy and U.S. Environmental Protection Agency standards. During 2018, the emissions from Laboratory operations were far below the applicable regulatory limits.

CONTENTS

AMBIENT AIR SAMPLING FOR RADIONUCLIDES

Introduction

Los Alamos National Laboratory's (LANL's or the Laboratory's) air-sampling network measures levels of airborne radionuclides in order to monitor the releases from Laboratory operations. Radioactivity in the air is compared with the regulatory limits for members of the public (DOE 2011). During 2018, the Laboratory operated 38 environmental air-monitoring stations to sample radionuclides in airborne particulate matter (Figure 4-1 and Figure 4-2). Sampling locations are categorized as regional, perimeter, onsite, or waste site. The waste site locations monitor radionuclides near the Laboratory's low-level radioactive waste disposal area and radioactive waste storage area, Area G, at Technical Area 54. These stations are operated continuously; filters are changed out every two weeks and sent to an analytical laboratory for analysis.

Quality Assurance

The quality assurance program satisfies requirements in Title 40 Part 61 of the Code of Federal Regulations, Appendix B, Method 114 (U.S. Environmental Protection Agency 1989). The quality assurance project plan and implementing procedures specify the requirements and implementation of sample collection, sample management, chemical analysis, and data management. The requirements follow U.S. Environmental Protection Agency methods for sample handling, chain of custody, analytical chemistry, and statistical analyses of data.

Regional Background Levels

The atmosphere contains background levels of radioactivity consisting of naturally occurring radionuclides and also radioactive materials from nuclear weapons tests and nuclear accidents. We monitor the air to determine if the Laboratory is adding radioactivity to the atmosphere. Background levels are measured at regional monitoring stations located in the communities of El Rancho, Española, and Santa Fe. The results are summarized in Table 4-1.

TABLE 4-1. AVERAGE BACKGROUND RADIONUCLIDE ACTIVITIES IN THE REGIONAL ATMOSPHERE

Analyte	Units	U.S. Environmental Protection Agency Public Dose Limit	Average Background Activities
Tritium	pCi/m^3	1500	1 ± 1
Americium-241	aCi/m^3	1900	0 ± 1
Plutonium-238	aCi/m^3	2100	0 ± 1
Plutonium-239/240	aCi/m^3	2000	1 ± 1
Uranium-234	aCi/m^3	7700	17 ± 5
Uranium-235	aCi/m^3	7100	1 ± 1
Uranium-238	aCi/m^3	8300	17 ± 4

Note: pCi/m^3 = picocuries per cubic meter; aCi/m^3 = attocuries per cubic meter.

Perimeter, Onsite, and Waste Site Radionuclides

Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and cosmic-ray interactions with the air (Eisenbud and Gesell 1997). Measurements of water vapor in the air and tritium in the water vapor are used to calculate the amount of tritium in the air. During 2018, tritium concentrations were similar to recent years and well below U.S. Environmental Protection Agency limits (Table 4-2). The highest annual tritium activity at any offsite station was 0.3 percent of the U.S. Environmental Protection Agency public dose limit.

What are cosmic rays?

Cosmic rays are fragments of atoms that rain down upon the Earth from

TABLE 4-2. AIRBORNE TRITIUM AS TRITIATED WATER ACTIVITIES FOR 2018—GROUP SUMMARIES

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (pCi/m³)		Maximum Annual Station Activity (pCi/m³)	U.S. Environmental Protection Agency Public Dose Limit (pCi/m³)
Regional	3	1	±1	1	1500
Perimeter	25	1	±1	4	1500
Onsite	2	5	N/A	8	1500
Waste site	1	591	N/A	591	1500

Note: pCi/m³ = picocuries per cubic meter, N/A = not applicable.

For tritium, the waste site data are measured at a location at the southern boundary of Area G (station 160, Figure 4-2), which is not publicly accessible. Nevertheless, concentrations are well below the public dose limit of 1,500 picocuries per cubic meter.

The analytical methods comply with U.S. Environmental Protection Agency requirements in Title 40 Part 61 of the Code of Federal Regulations, Appendix B, Method 114 (U.S. Environmental Protection Agency 1989).

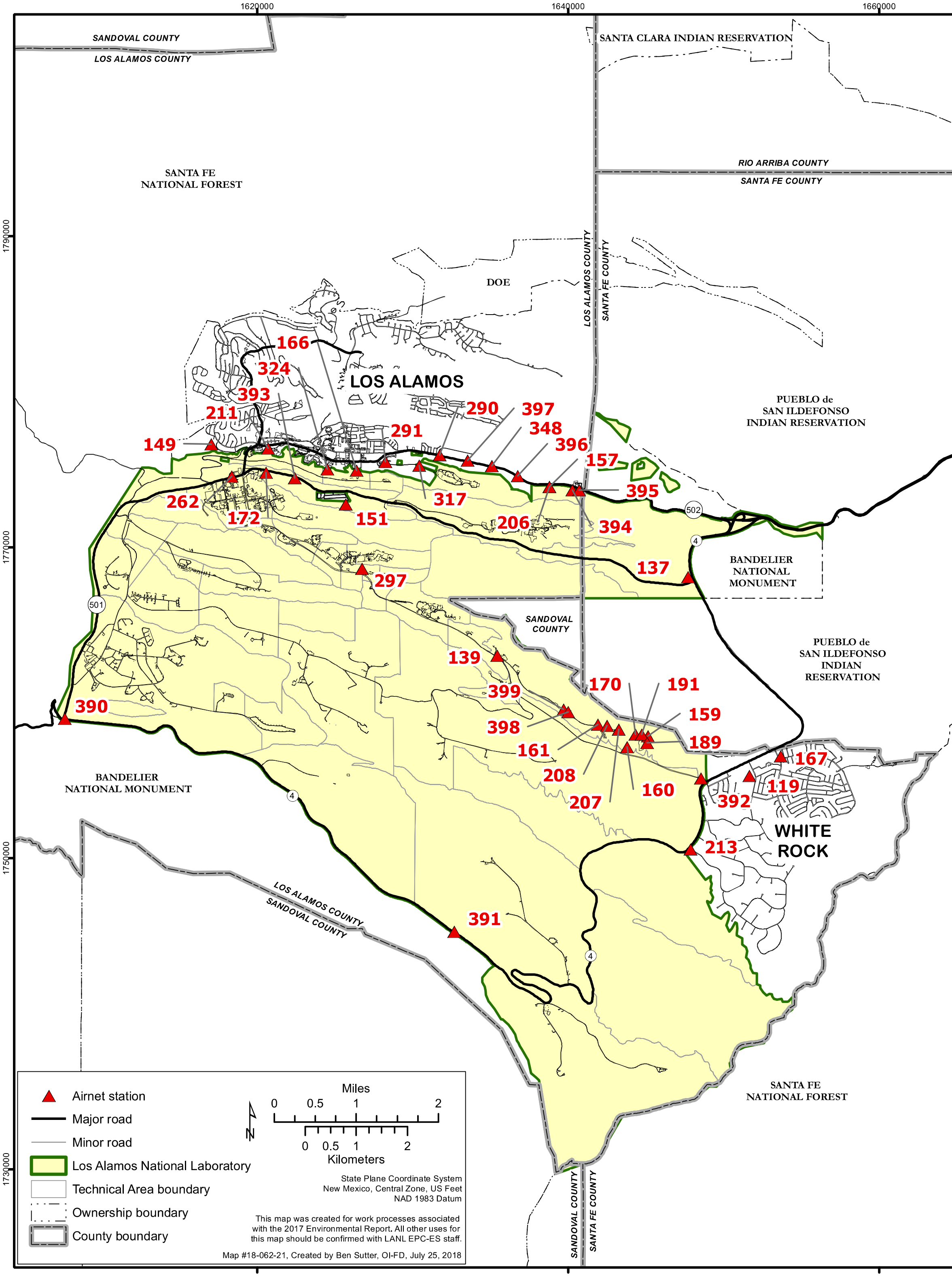
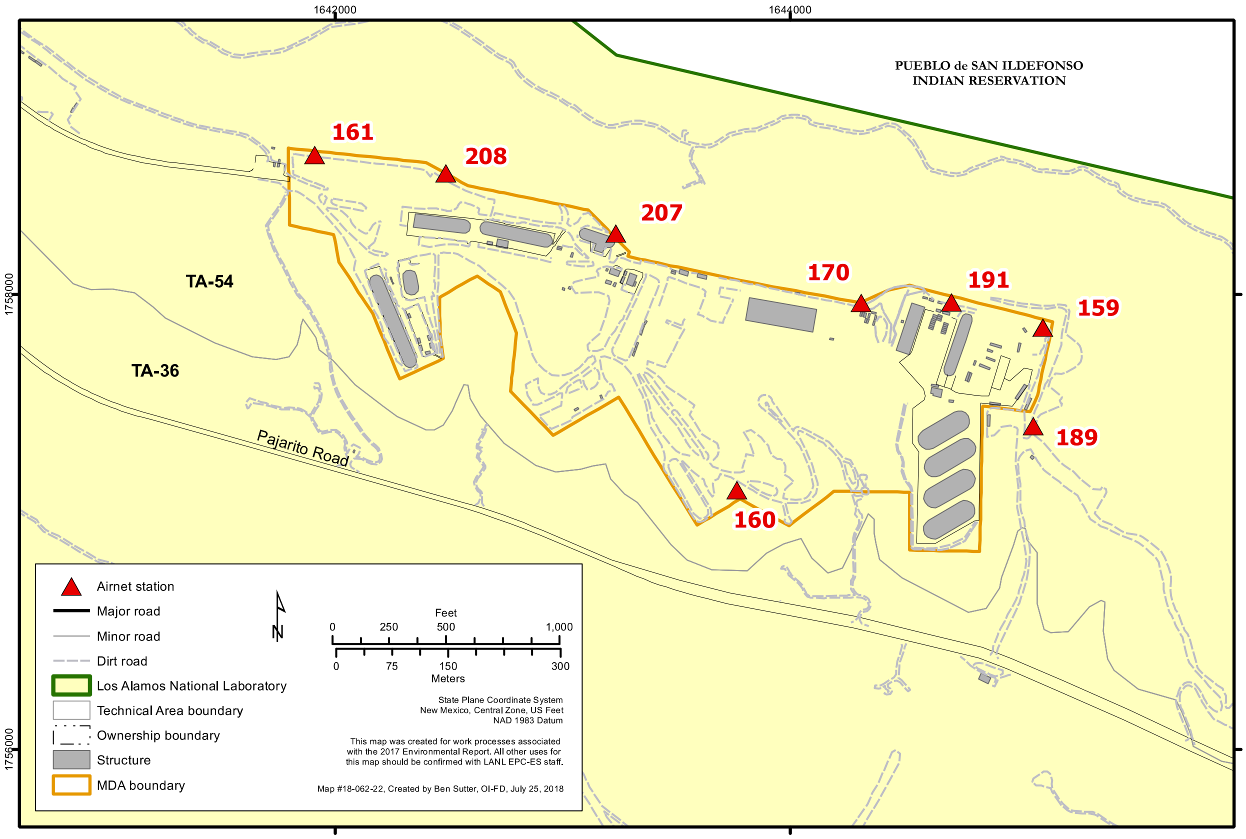


Figure 4-1. Environmental air-monitoring stations at and near the Laboratory



Note: MDA = Material disposal area; TA = Technical area

Figure 4-2. Environmental air-monitoring stations at the Laboratory's Technical Area 54, Area G

Americium-241

Table 4-3 summarizes the 2018 sampling data for americium-241. The results are similar to recent years and less than 0.1 percent of the regulatory limits.

TABLE 4-3. AIRBORNE AMERICIUM-241 ACTIVITIES FOR 2018—GROUP SUMMARIES

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (aCi/m³)		Maximum Annual Station Activity (aCi/m³)
Regional	3	0	±1	0
Perimeter	25	0	±1	1
Onsite	2	0	±1	1
Waste site	8	0	±1	0

Note: aCi/m³ = attocuries per cubic meter

Plutonium

Plutonium from global fallout occurs worldwide at low levels. Table 4-4 summarizes the LANL plutonium-238 and plutonium-239/240 data for 2018, which are similar to recent years.

In 2018, the uncertainties were larger than usual because of impurities in the tracer material used by the analytical laboratory. The analytical laboratory discovered the tracer issue and reported it to the Laboratory and to the New Mexico Environment Department. For plutonium-238, the maximum values of two attocuries per cubic meter represent two-standard-deviation outliers and are not statistically significant.

TABLE 4-4. AIRBORNE PLUTONIUM-238 AND PLUTONIUM-239/240 ACTIVITIES FOR 2018—GROUP SUMMARIES

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m³)		Maximum Annual Station Activity (aCi/m³)	
		Plutonium-238	Plutonium-239/240	Plutonium-238	Plutonium-239/240
Regional	3	0 ± 2	1 ± 1	0	1
Perimeter	25	1 ± 2	1 ± 2	2	6
Onsite	2	1 ± 1	2 ± 2	0	3
Waste site	8	0 ± 2	2 ± 2	2	4

Note: aCi/m3 = attocuries per cubic meter

South of the original Technical Area 01, the steep slope of Los Alamos Canyon contains legacy plutonium-239, and dust from this hillside causes detectable levels of plutonium-239 in the air. The maximum concentration reported in Table 4-4, six attocuries per cubic meter, is 2 percent of the U.S. Environmental Protection Agency limit. This is less than last year as a result of cleanup (Haagenstad 2017).

Uranium

The isotopes uranium-234, uranium-235, and uranium-238 are found in nature. In natural uranium, uranium-234 activity is generally equal to uranium-238 activity (Walker et al. 1989). Uranium that has been enriched by processing (enriched uranium) has higher levels of uranium-234 and uranium-235. Uranium that has been depleted by processing (depleted uranium) has higher levels of uranium-238. The data reported at the waste site indicate depleted uranium with an average concentration 0.2 percent of the U.S. Environmental Protection Agency limit. Similar concentrations were detected at perimeter locations. See Table 4-5.

TABLE 4-5. AIRBORNE URANIUM-234, -235, AND -238 ACTIVITIES FOR 2018—GROUP SUMMARIES

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m3)		
		Uranium-234	Uranium-235	Uranium-238
Regional	3	17 ± 5	1 ± 1	17 ± 4
Perimeter	25	9 ± 6	0 ± 1	11 ± 9
Onsite	2	8 ± 1	0 ± 1	8 ± 1
Waste site	8	11 ± 3	0 ± 1	18 ± 9

Note: aCi/m3 = attocuries per cubic meter

Gamma Spectroscopy Measurements

Air samples are analyzed for the following gamma ray–producing radionuclides: cobalt-60, cesium-134 and -137, iodine-131, sodium-22, and protactinium-234m. These radionuclides were not detected.

Conclusion

All measured activities of airborne radioactive material were far below all regulatory limits.

EXHAUST STACK SAMPLING FOR RADIONUCLIDES

Introduction

Radioactive materials are used in some Laboratory operations. The buildings that house those operations may vent radioactive materials to the environment through an exhaust stack or other release point. The Laboratory's stack monitoring team monitors emission points that could cause a public dose greater than 0.1 millirem in a year. Each of these stacks is sampled in accordance with Title 40, Part 61, Subpart H of Code of Federal Regulations (U.S. Environmental Protection Agency 1989).

Sampling Methodology

Radioactive stack emissions can be one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, or (4) gaseous mixed activation products. For each of these emission types, the sampling method is described below.

Emissions of radioactive particulate matter are sampled using a glass-fiber filter. A continuous sample of air from the stack is pulled through a filter that captures small particles of radioactive material. Filters are collected weekly and shipped to an offsite analytical laboratory.

Charcoal cartridges are used to sample emissions of vapors and volatile compounds generated by operations at the Technical Area 53 Los Alamos Neutron Science Center, at the Chemistry and Metallurgy Research Building, and at Technical Area 48.

Tritium emissions are measured with collection devices known as bubblers to determine the total amount of tritium released, and also whether it is in the elemental or oxide form. The bubblers pull a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects any tritium oxide that may be part of a water molecule. The air is then passed through a palladium catalyst that converts the elemental tritium to the oxide form. The sample is then pulled through three additional vials containing ethylene glycol, which collect the newly formed tritium oxide.

The stack monitoring team measures gaseous mixed activation products emissions from Los Alamos Neutron Science Center activities using real-time monitoring data. A sample of air from the stack is pulled through an ionization chamber that measures the total amount of radioactivity in the sample.

Data Analysis

Methods

This section discusses the analysis methods for each type of the Laboratory's emissions. The methods comply with U.S. Environmental Protection Agency requirements in 40 Code of Federal Regulations 61, Appendix B, Method 114 (U.S. Environmental Protection Agency 1989).

Check of the Total Activity

Each week the glass-fiber filters are collected, and the total activity is measured before the filters are shipped to an offsite analytical laboratory where they are analyzed using spectroscopy to identify radionuclides. These data are used to quantify emissions of radionuclides, and the results are compared with the total activity measurements to ensure that all radionuclides are identified.

Vaporous Activation Products

Each week the charcoal cartridges are collected and shipped to an offsite analytical laboratory where they are analyzed using spectroscopy. These data are used to identify and quantify the presence of vaporous material.

Tritium

Each week, tritium bubbler samples are collected and transported to the Laboratory's Health Physics Analysis Laboratory, where the amount of tritium in each vial is determined by liquid scintillation counting.

Gaseous Mixed Activation Products

Continuous monitoring is used for gaseous mixed activation products at the Los Alamos Neutron Science Center. There are two reasons for the use of continuous monitoring. First, standard filter paper and charcoal filters will not collect gaseous emissions. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed offsite. The monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. The real-time current that this ionization chamber measures is recorded on a strip chart, and the total amount of charge collected in the chamber over the entire accelerator operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these gaseous mixed activation products.

Analytical Results

Table 4-6 provides detailed emissions data for Laboratory buildings with sampled stacks. Table 4-7 provides a detailed listing of the total stack emissions in the groupings of gaseous mixed activation products and particulate matter plus vapor activation products. Table 4-8 presents the half-lives of the radionuclides typically emitted by the Laboratory.

Conclusions and Trends

Emission-control systems for particulates such as plutonium and uranium continue to work well, and particulate emissions remain very low, in the micro-curie range. Emissions of short-lived gases and vapors are slightly higher than last year, as a result of increases in operations at Technical Area 53. During 2018, the radioactive emissions from all Laboratory sources amount to approximately 1 percent of the regulatory limit.

TABLE 4-6. AIRBORNE RADIOACTIVE EMISSIONS FROM LANL BUILDINGS WITH SAMPLED STACKS IN 2018. VALUES ARE EXPRESSED IN SCIENTIFIC NOTATION.

Technical Area and Building Number	Tritium (Curies)	Americium-241 (Curies)	Plutonium (Curies)	Uranium (Curies)	Thorium (Curies)	Particulate Matter plus Vapor Activation Products (Curies)	Gaseous Mixed Activation Products (Curies)
TA-03-029		1.2×10^{-7}	5.6×10^{-7}	3.4×10^{-6}	6.9×10^{-8}		
TA-16-205/450	2.4×10^{1}						
TA-48-001			4.2×10^{-10}	6.2×10^{-9}		6.9×10^{-3}	
TA-50-001			3.1×10^{-8}	1.4×10^{-7}			
TA-50-069			2.9×10^{-11}	6.7×10^{-10}			
TA-53-003	1.9×10^{1}					1.2×10^{-4}	5.5×10^{1}
TA-53-007	4.7					2.9×10^{-3}	1.8×10^{2}
TA-54-231/412				1.2×10^{-8}			
TA-55-004	1.5		2.1×10^{-9}	5.4×10^{-8}	7.1×10^{-9}		
TA-55-400				5.3×10^{-8}			
Total	4.9×10^{1}	1.2×10^{-7}	5.9×10^{-7}	3.7×10^{-6}	7.6×10^{-8}	9.9×10^{-3}	2.35×10^{2}

TABLE 4-7. DETAILED RESULTS OF ACTIVATION PRODUCT SAMPLING FROM LANL STACKS IN 2018

Building No.	Nuclide	Emission (Curies)*	
TA-48-001	Arsenic-73	0.0000061	6.1×10^{-6}
TA-48-001	Arsenic-74	0.0000004	4.0×10^{-7}
TA-48-001	Bromine-77	0.00016	1.6×10^{-4}
TA-48-001	Gallium-68	0.0033	3.3×10^{-3}
TA-48-001	Germanium-68	0.0033	3.3×10^{-3}
TA-48-001	Mercury-197	0.000057	5.7×10^{-5}
TA-48-001	Mercury-197m	0.000057	5.7×10^{-5}
TA-48-001	Selenium-75	0.000042	4.2×10^{-5}
TA-53-003	Argon-41	2.2	2.2×10^{0}
TA-53-003	Beryllium-7	0.000043	4.3×10^{-5}
TA-53-003	Bromine-77	0.0000031	3.1×10^{-6}
TA-53-003	Bromine-82	0.000072	7.2×10^{-5}
TA-53-003	Carbon-11	52	5.2×10^{1}
TA-53-003	Sodium-24	0.0000038	3.8×10^{-6}
TA-53-007	Argon-41	12	1.2×10^{1}
TA-53-007	Bromine-76	0.000075	9.0×10^{-5}
TA-53-007	Bromine-82	0.0025	2.5×10^{-3}
TA-53-007	Carbon-10	0.42	4.2×10^{-1}
TA-53-007	Carbon-11	84	8.4×10^{1}
TA-53-007	Mercury-197	0.00017	1.7×10^{-4}
TA-53-007	Mercury-197m	0.00017	1.7×10^{-4}
TA-53-007	Nitrogen-13	34	3.4×10^{1}
TA-53-007	Nitrogen-16	0.69	6.9×10^{-1}
TA-53-007	Sodium-24	0.000053	5.3×10^{-5}
TA-53-007	Oxygen-14	0.81	8.1×10^{-1}
TA-53-007	Oxygen-15	49	4.9×10^{1}

**The value for emission for each building and nuclide is listed in both standard and scientific notation.*

TABLE 4-8. RADIONUCLIDE HALF-LIVES

Nuclide	Half-Life
Tritium	12.3 years
Beryllium-7	53.4 days
Carbon-10	19.3 seconds
Carbon-11	20.5 minutes
Nitrogen-13	10.0 minutes
Nitrogen-16	7.13 seconds
Oxygen-14	70.6 seconds
Oxygen-15	122.2 seconds
Sodium-22	2.6 years
Sodium-24	14.96 hours
Argon-41	1.83 hours
Cobalt-60	5.3 years
Arsenic-73	80.3 days
Arsenic-74	17.78 days
Bromine-76	16 hours
Bromine-77	2.4 days
Bromine-82	1.47 days
Selenium-75	119.8 days
Strontium-90	28.6 years
Cesium-134	2.06 years
Cesium-137	30.2 years
Osmium-191	15.4 days
Mercury-197	2.67 days
Mercury-197m	23.8 hours
Uranium-234	244,500 years
Uranium-235	703,800,000 years
Uranium-238	4,468,000,000 years
Plutonium-238	87.7 years
Plutonium-239	24,131 years
Plutonium-240	6,569 years
Plutonium-241	14.4 years
Americium-241	432 years

MONITORING FOR GAMMA AND NEUTRON DIRECT-PENETRATING RADIATION

Introduction

Gamma and neutron radiation levels are monitored by the Direct-Penetrating Radiation Network (McNaughton 2018) and supplemented by the Neighborhood Environmental Watch Network. The objectives are to monitor gamma and neutron radiation in the environment as required by DOE Order 458.1.

Dosimeters are devices that measure exposure to ionizing radiation. We deployed dosimeters at a total of 80 locations to monitor direct-penetrating radiation in the environment during 2018. Thermoluminescent dosimeters (which monitor gamma and neutron radiation) are deployed at every environmental air-monitoring station (Figure 4-1 and Figure 4-2). Additional thermoluminescent dosimeters are deployed at Technical Areas 53 and 54, which are potential Laboratory sources of direct-penetrating radiation (Figure 4-3 and Figure 4-4). Together all these locations make up the Direct-Penetrating Radiation Network. Neighborhood environmental watch network stations, which measure gamma radiation, are situated near these areas but off of Laboratory property. The locations are listed in Supplemental Table S4-1.

Gamma radiation occurs naturally in ranges from 100 millirem to 200 millirem per year, so it is difficult to distinguish the much smaller levels of radiation contributed by the Laboratory. Radiation from the Laboratory is identified by higher radiation levels near the source and reduced radiation levels at greater distances.

Neutron Radiation

Neutron doses are measured near known or suspected sources of neutrons, including Technical Areas 53 and 54. At 52 locations, the accuracy of the neutron measurements is enhanced by the addition of Lucite blocks that reflect neutrons into the dosimeter. The neutron background is measured at locations far from Laboratory sources (Table S4-1).

Quality Assurance

The Radiation Protection Division dosimetry laboratory is accredited by the DOE Laboratory Accreditation Program, and the Radiation Protection Division provides quality assurance for the dosimeters.

Results

Detailed results are listed in Supplemental Table S4-1. Locations with a measurable contribution from Laboratory operations are discussed below.

Los Alamos Neutron Science Center at Technical Area 53

Figure 4-3 shows the locations of the dosimeters at Technical Area 53. Previous studies (McNaughton 2013) discuss the possibility that a member of the public on East Jemez Road, south of Technical Area 53, could be exposed to gamma and neutron radiation from the Los Alamos Neutron Science Center in Technical Area 53.

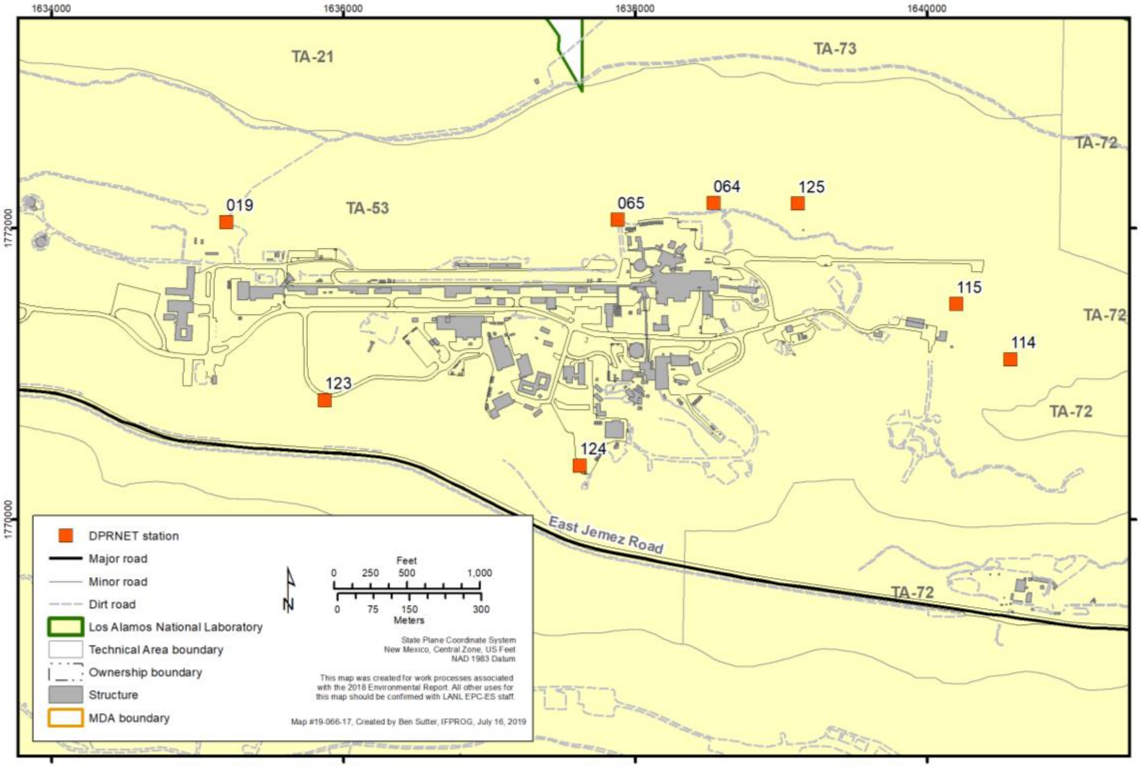


Figure 4-3. Locations of thermoluminescent dosimeters at Technical Area (TA) 53 that are part of the direct-penetrating radiation monitoring network (DPRNET)

During 2018, dosimeter #115 in Technical Area 53 measured a gamma dose of 169 millirem per year, which is 39 millirem per year above the background of 130 millirem per year. Calculations (McNaughton 2013) show that the gamma dose at East Jemez Road is 0.2 percent of the dose measured by dosimeter #115, so the gamma dose at East Jemez Road was 0.1 millirem per year.

Also, dosimeter #124 at Technical Area 53 measured a neutron dose 7 millirem per year above background. Calculations (McNaughton 2013) show that the neutron dose at East Jemez Road is 10 percent of this value so the neutron dose at Jemez Road was 0.7 millirem per year.

Technical Area 54, Area G

Figure 4-4 shows the locations of the dosimeters at Technical Area 54, Area G. Area G is a controlled-access area, so the Area G data do not represent a potential public dose.

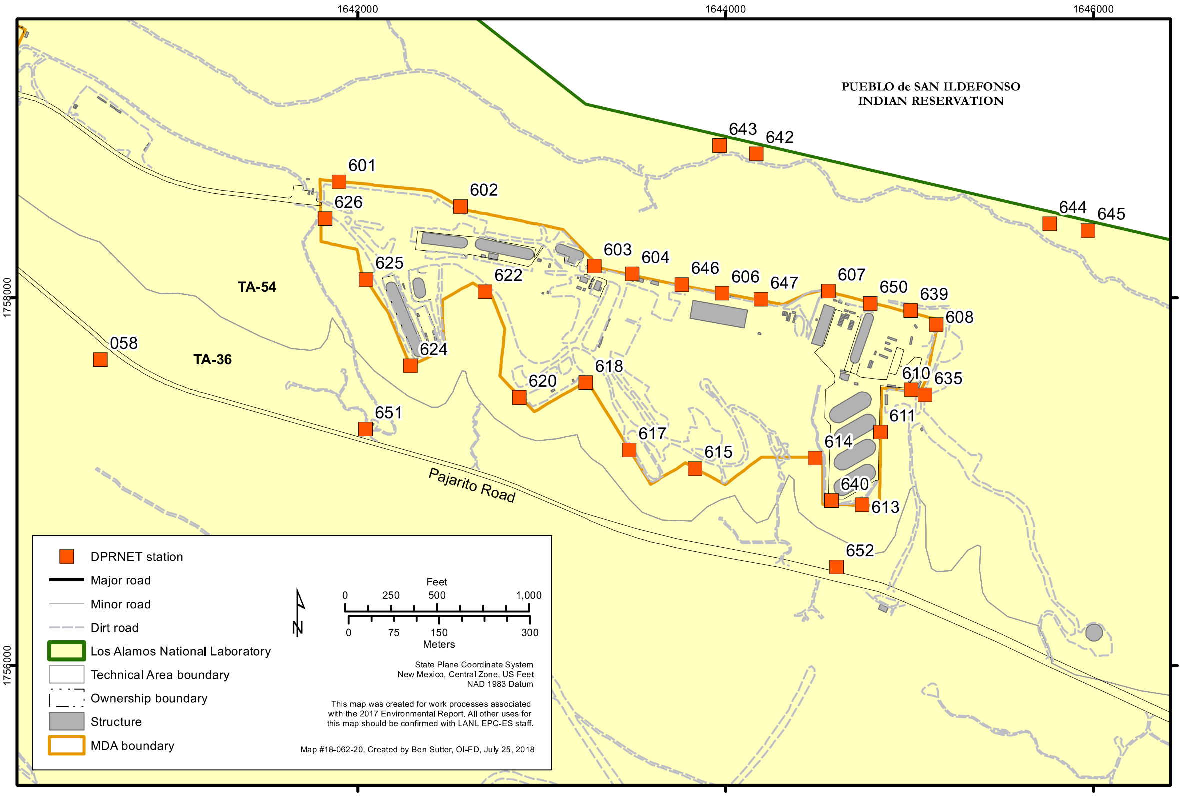


Figure 4-4. Locations of thermoluminescent dosimeters at Area G that are part of the direct-penetrating radiation monitoring network (DPRNET)

Dosimeters #642 through #645 are in Cañada del Buey. After subtracting background, the 2018 annual neutron dose measured by these dosimeters was 3 millirem. This is the dose that would be received by a person who is at the location of the dosimeters 24 hours per day, 365 days per year. As discussed in Chapter 8, an occupancy factor of 1/20 is applied (National Council on Radiation Protection and Measurements 2005), so the dose in Cañada del Buey at the dosimeters is calculated to be 3/20 ≈ 0.15 millirem per year, which is similar to previous years.

Neighborhood Environmental Watch Network

On September 26 and November 1, 2018, the Neighborhood Environmental Watch Network recorded 1 microrem per hour spikes of radiation from activated air near Technical Area 53. We compared these spikes to spikes of radiation recorded at East Gate between October and November 2005, which resulted in an estimated dose of 2.9 millirem. The magnitude of the 2018 spikes represented less than 3 percent of the dose of the much larger spikes recorded in 2005. Multiplying 2.9 millirem by 3 percent led to the conclusion that the 2018 dose associated with this radiation was less than 0.1 millirem.

Conclusion

Generally, the data are similar to previous years and show that emissions of direct-penetrating radiation from Laboratory facilities were far below the DOE limits.

TOTAL PARTICULATE MATTER AIR MONITORING

Introduction

Particulate matter consists of smoke, dust, and other material that can be inhaled. Generally, it is not radioactive. Particulate air matter can be harmful in high concentrations.

The total amount of particulate matter is monitored at two locations: near the intersection of New Mexico State Road 4 and Rover Boulevard in White Rock, and at the Los Alamos Medical Center in Los Alamos.

Ambient Air Particulate Matter Concentrations

During 2018, the particulate matter concentrations remained well below the U.S. Environmental Protection Agency standard of 35 micrograms per cubic meter for particulate matter smaller than 2.5 micrometers. Typical concentrations (>95 percent of the time) were less than 10 micrograms per cubic meter. The highest concentrations occurred during the spring from windblown dust and during the summer from distant wildfires.

METEOROLOGICAL MONITORING

Introduction

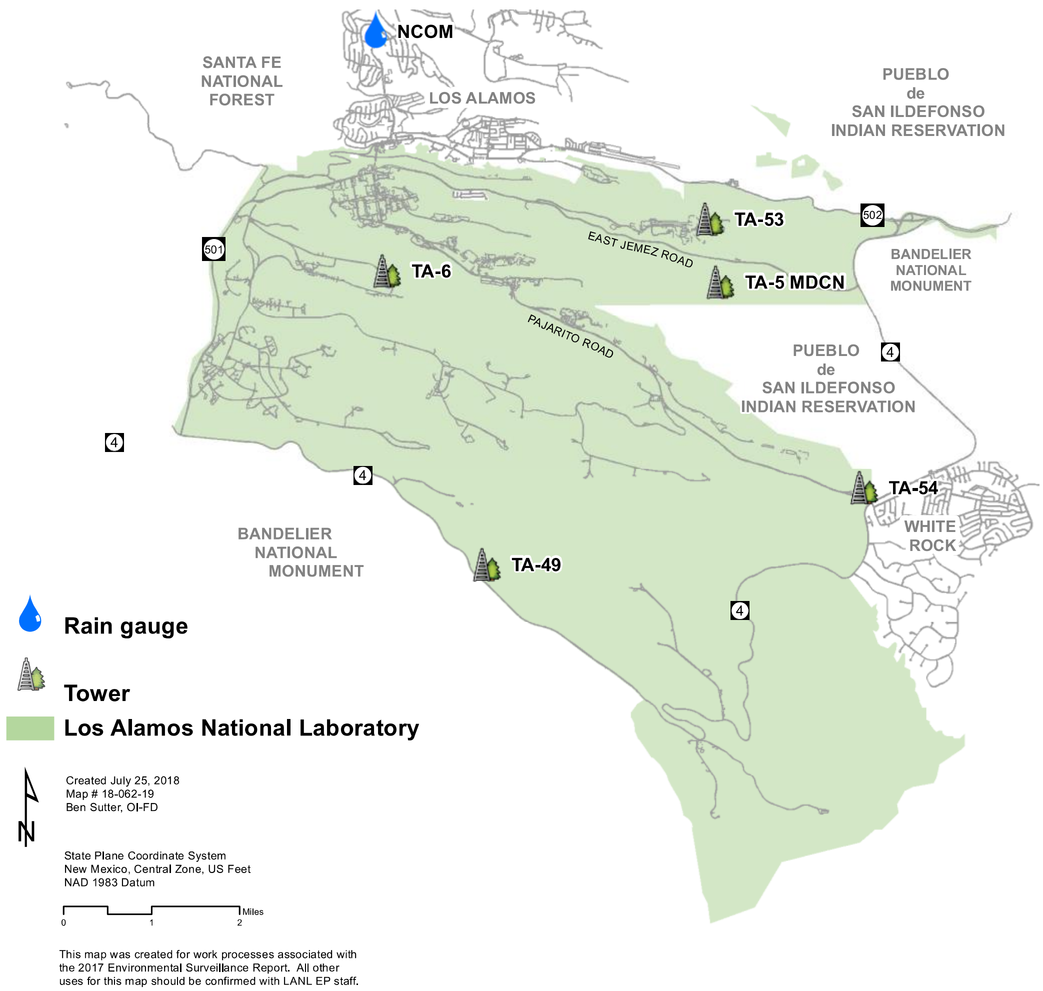
Weather data are important for many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. The meteorological monitoring program measures wind speed and direction, temperature, pressure, relative humidity, dew point, precipitation, cloud cover, and solar and terrestrial radiation, among other variables. The meteorological monitoring plan (Dewart and Boggs 2014) provides details of the meteorological monitoring program. An electronic copy of the plan is available online at https://weathermachine.lanl.gov.

Monitoring Network

Currently, five towers are equipped to gather meteorological data at the Laboratory (Figure 4-5). Four of the towers are located on mesa tops (Technical Areas 06, 49, 53, and 54) and one is in the bottom of Mortandad Canyon (Technical Area 05). An additional precipitation gage is located in the North Community of the Los Alamos townsite. The Technical Area 06 tower is the official meteorological measurement station for the Laboratory.

Sampling Procedures, Data Management, and Quality Assurance

We place the weather-sensing instruments in areas with good exposure, usually in open fields, to avoid impacts on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open-lattice towers at Technical Areas 06, 49, 53, and 54. The multiple levels provide a vertical profile important in assessing wind speed and direction at different heights above ground and in assessing air stability conditions. The multiple levels also provide redundant measurements that support data quality checks. Boom-mounted temperature sensors on the towers are shielded and aspirated (provided with constant air circulation) to minimize effects from direct sunlight. The Mortandad Canyon station includes a 10-meter tripod tower that measures wind only at the top of the tower. Temperature and humidity are measured at ground level at all stations except the North Community station, which only measures precipitation.



Note: MDCN = Mortandad Canyon; NCOM = North community.

Figure 4-5. Locations of five meteorological monitoring towers and a rain gage

Data recorders at the stations read most of the instrument results every three seconds, average the results over a 15-minute period, and transmit the data by network connection, telephone modem, or cell phone to a programmed computer workstation. The workstation automatically edits measurements that fall outside of realistic ranges (Bruggeman et al. 2019). Time-series plots of the data are generated for a meteorologist to conduct a data quality review. Daily statistics such as daily minimum and maximum temperatures, daily total precipitation, and maximum wind gust are also generated and checked for quality. For more than 50 years, we have provided these daily weather statistics to the National Weather Service.

We follow manufacturers' recommendations and consider operating conditions to determine how often to calibrate the weather sensing instruments. All wind instruments are calibrated every six months. All other sensors are calibrated annually, with the exception of solar radiation sensors, which are calibrated every five years. An external audit of the instruments and methods is performed periodically. A subcontractor inspects and performs maintenance on the stations annually.

The LANL meteorology program met American National Standards Institute 2015 standards for data completeness with two exceptions. The pressure sensor at Technical Area 54 and the temperature sensor at Technical Area 49 were not providing accurate data, thus the instruments were replaced and the instrument issues were addressed. Bruggeman et al. (2019) report on data quality and completeness.

Climate

Los Alamos has a temperate, semiarid mountain climate. Humidity is low, and clear skies are present about 75 percent of the time. These conditions lead to high solar heating during the day and strong radiative cooling at night. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized here are from analyses of historical meteorological databases maintained by the Laboratory's meteorology program (Bowen 1990 and 1992 and Dewart et al. 2017).

Average precipitation is based on a 30-year average from 1981 to 2010 as measured at the official Laboratory station at Technical Area 06. Other Laboratory stations do not have data going back to 1981, which are necessary for a consistent averaging period. Table 4-9 presents the temperature and precipitation records set for Los Alamos from 1924 to 2018.

December and January are the coldest months, when 90 percent of minimum temperatures are between 4 °F and 31 °F. Ninety percent of maximum temperatures, which are usually reached in midafternoon, are between 25 °F and 55 °F. Wintertime arctic air masses that descend into the central United States usually warm somewhat before they reach the southern latitude of Los Alamos, so subzero temperatures are not common. Winds during the winter are relatively light, so extreme wind chills are also not common.

TABLE 4-9. RECORDS SET BETWEEN 1924 AND 2018 FOR LOS ALAMOS

Type of Measurement	Record	Date
Low temperature	–18 °F	January 13, 1963
High temperature	95.5 °F	June 19, 2016
Single-day rainfall	3.52 inches	September 13, 2013
Single-day snowfall	39 inches	January 15, 1987
Single-season snowfall	153 inches	1986–1987

Temperatures are highest from June through August, when 90 percent of maximum temperatures are between 67 °F and 89 °F. During the summer months, 90 percent of minimum temperatures are between 45 °F and 61 °F.

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.97 inches. The average annual snowfall is 57.5 inches. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are occasionally enhanced as a result of orographic lifting as the storms travel up the high terrain.

The rainy season typically begins in early July and ends in mid-September. Precipitation in July and August accounts for 34 percent of the annual precipitation. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convectively, orographically, or both convectively and orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

The complex topography of Los Alamos influences local wind patterns. Often a distinct daily cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow uphill. During the night, cool air that forms close to the ground tends to flow downhill. As the daytime breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerly winds of the Pajarito Plateau. Nighttime airflow enhances the local westerly winds. Flow in the east-west-oriented canyons of the Pajarito Plateau is generally aligned with the canyons, so canyon winds are usually from the west at night and from the east during the day. Winds on the Pajarito Plateau are faster during the day than at night. This is a result of vertical mixing that is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface, resulting in fast surface winds.

2018 in Perspective

Table 4-10 presents Los Alamos weather values during 2018. Figure 4-6 presents a graphical summary of Los Alamos temperature for 2018 with the daily high and low temperature at Technical Area 06 in comparison with the 1981 to 2010 normal values and record values from 1924 to the present. Temperatures were above average for 10 out of 12 months and precipitation was below average for 9 out of 12 months. In particular, January, May, and

June had significantly above average temperatures with greater than 5 degrees above average. The last line of Table 4-10 summarizes the year and shows that the overall average temperature was 3 °F above the 1981 to 2010 averages, total precipitation was 4.94 inches below the averages, and snowfall was 24 inches below the averages. The mean temperature has been above average since 2010, annual precipitation has been below average since 2016, and annual snowfall has been below average since 2011.

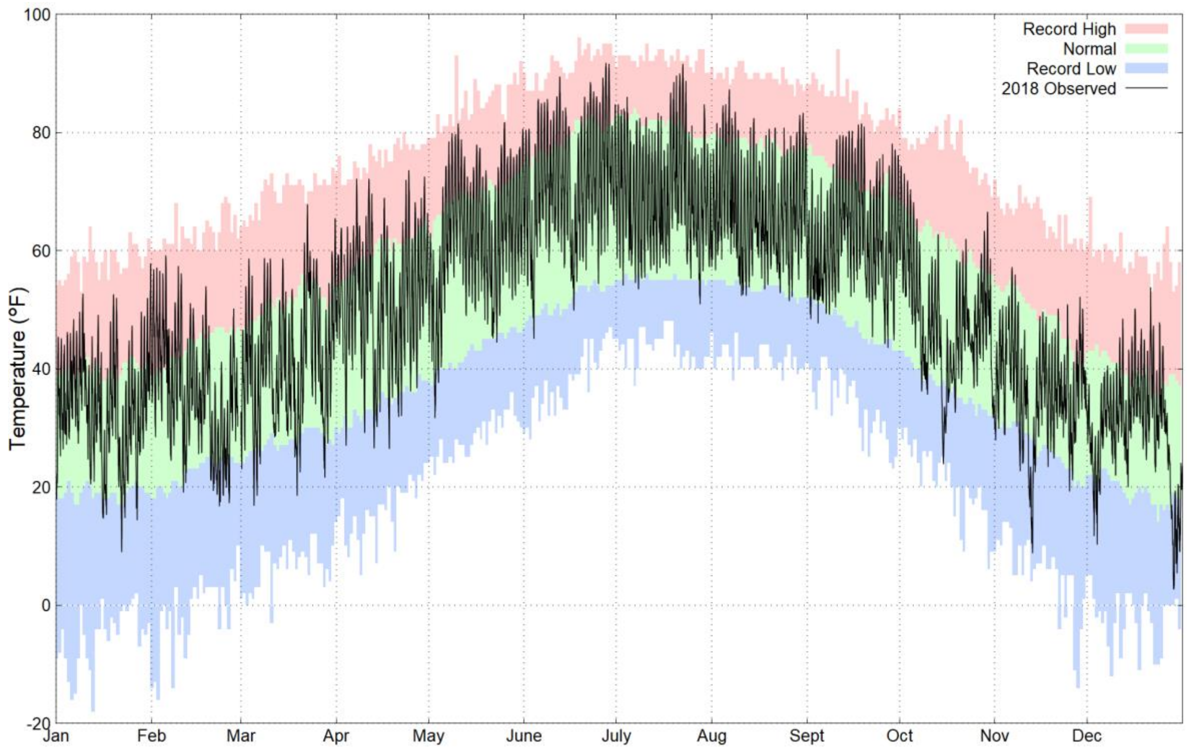


Figure 4-6. Los Alamos 2018 temperatures in degrees Fahrenheit compared with record values and normal values

TABLE 4-10. MONTHLY AND ANNUAL CLIMATOLOGICAL DATA FOR 2018 AT LOS ALAMOS

Month	Temperatures (°F)*								Precipitation (inches)*				12-meter† Wind (Miles Per Hour)*				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure‡	Highest	Date	Lowest	Date	Total	Departure‡	Total	Departure‡	Average Speed	Departure§	Speed	From	Date
January	45.9	22.7	34.3	5.0	59	31	8	22	0.06	−0.89	0	−13.3	4.8	−0.2	44	WSW	20
February	48.1	25.5	36.8	3.9	62	5	15	22	0.71	−0.15	5.6	−5.3	6.8	1.0	48	SSW	19
March	54.7	28.6	41.7	2.4	70	22	15	5	0.69	−0.51	0.2	−10.2	7.1	0.6	47	W	16
April	65.4	37.8	51.6	4.8	75	24	26	18	0.12	−0.94	0	−3.4	9.0	1.4	50	WSW	17
May	75.5	48.7	62.1	6.1	84	25	31	3	0.49	−0.90	0	−0.3	8.2	0.8	43	SW	18
June	85.2	57.5	71.3	6.2	94	27	44	4	0.49	−1.02	0	0	7.8	0.7	39	WNW	30
July	84.3	57.3	70.8	2.6	93	22	50	28	1.73	−1.09	0	0	6.4	0.8	36	NNE	29
August	81.6	55.7	68.6	2.8	88	6	50	26	1.82	−1.79	0	0	6.4	0.7	50	WSW	26
September	76.0	50.7	63.4	3.6	83	17	42	27	2.40	0.39	0	0	6.2	0.4	40	WNW	9
October	58.2	38.9	48.6	−0.6	76	1	24	15	3.29	1.74	0.1	−2.1	5.7	−0.3	33	SSW	7
November	46.9	27.0	36.9	−0.9	59	6	7	13	0.45	−0.53	6	1.1	5.2	−0.1	42	WNW	30
December	39.3	21.0	30.1	0.7	56	21	−0.4	29	1.78	0.77	21.6	9.4	4.8	0.3	45	WNW	12
Year	63.5	39.3	51.4	3.0	94	Jun 27	0	Dec 29	14.03	−4.94	33.5	−24.0	6.5	0.5	50	WSW	Apr 17 & Aug 26

* *Data from Technical Area 06, the official Los Alamos weather station*

† *Wind data measured at 12 meters above the ground*

‡ *Departure column indicates positive or negative departure from 1981 to 2010 (30-year) climatological average.*

§ *Departure column indicates positive or negative departure from 1990 to 2010 (21-year) climatological average.*

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Figure 4-7 is a graph of Los Alamos precipitation for 2018. Precipitation was below average for the entire year. September brought much-needed rain, but after the beginning of October, minimal precipitation fell the rest of the year. For the year, Los Alamos received 14.03 inches of precipitation (4.94 inches below average). Most of the year had significantly below average snowfall, but December helped the dry conditions with 21.6 inches of snow (177 percent above normal for the month). As a result of the lack of precipitation to start the year, the U.S. Drought Monitor determined Los Alamos County had exceptional drought conditions from May until the end of December (https://droughtmonitor.unl.edu).

At the Laboratory's monitoring stations across Los Alamos, approximately 50 percent of the annual precipitation falls during the summer monsoon season (based on the National Weather Service definition of June 15 to September 30). Typically, more precipitation is measured closer to the Jemez Mountains, and the Technical Area 54 tower near White Rock measures the least precipitation. Although not shown here, more precipitation fell during 2018 at Technical Area 06 and North Community compared to Technical Area 54.

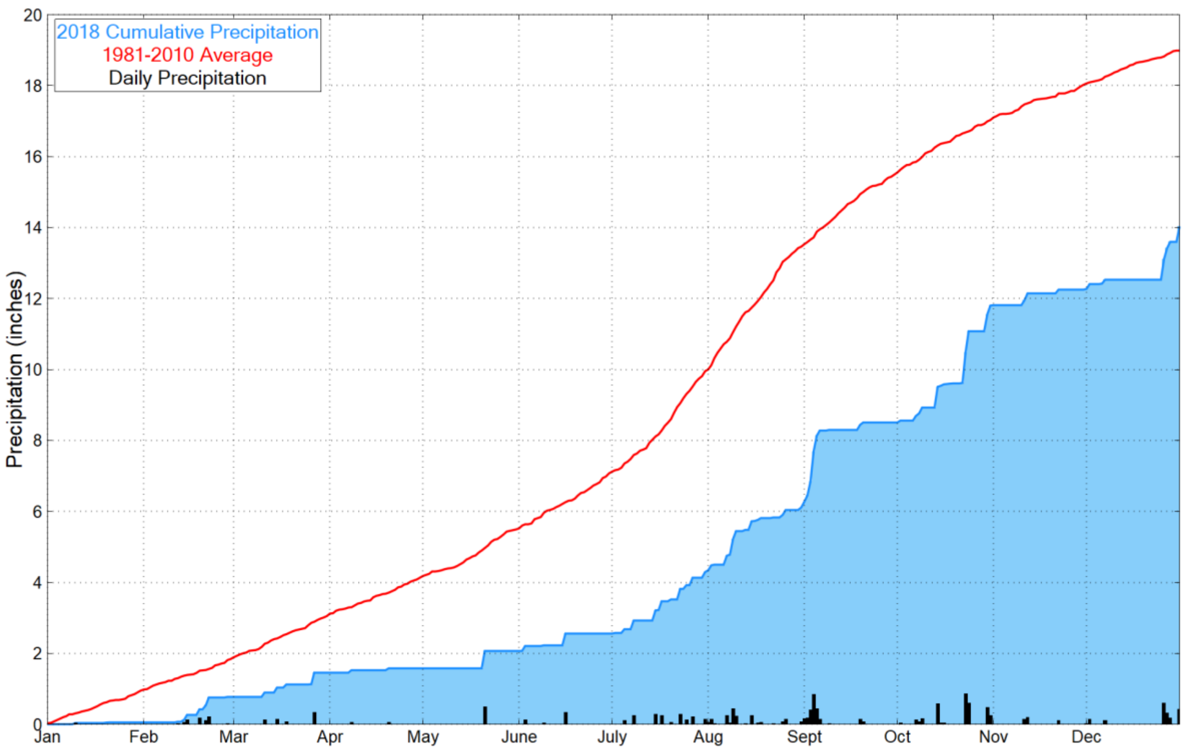

Figure 4-7. Technical Area 06 cumulative precipitation in 2018 versus 30-year average, and the daily precipitation in 2018

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-8. The wind roses are based on 15-minute average wind observations for 2018 at the four mesa-top stations. Wind roses depict the percentage of time that wind blows from each of 16 directions and the distribution of wind speed. During the day, winds are typically from the south and southwest, while at night the winds are from the west and northwest. Although not shown here, wind roses from different years are almost identical in terms of the distribution of wind directions, indicating that wind patterns are constant when averaged over a year.

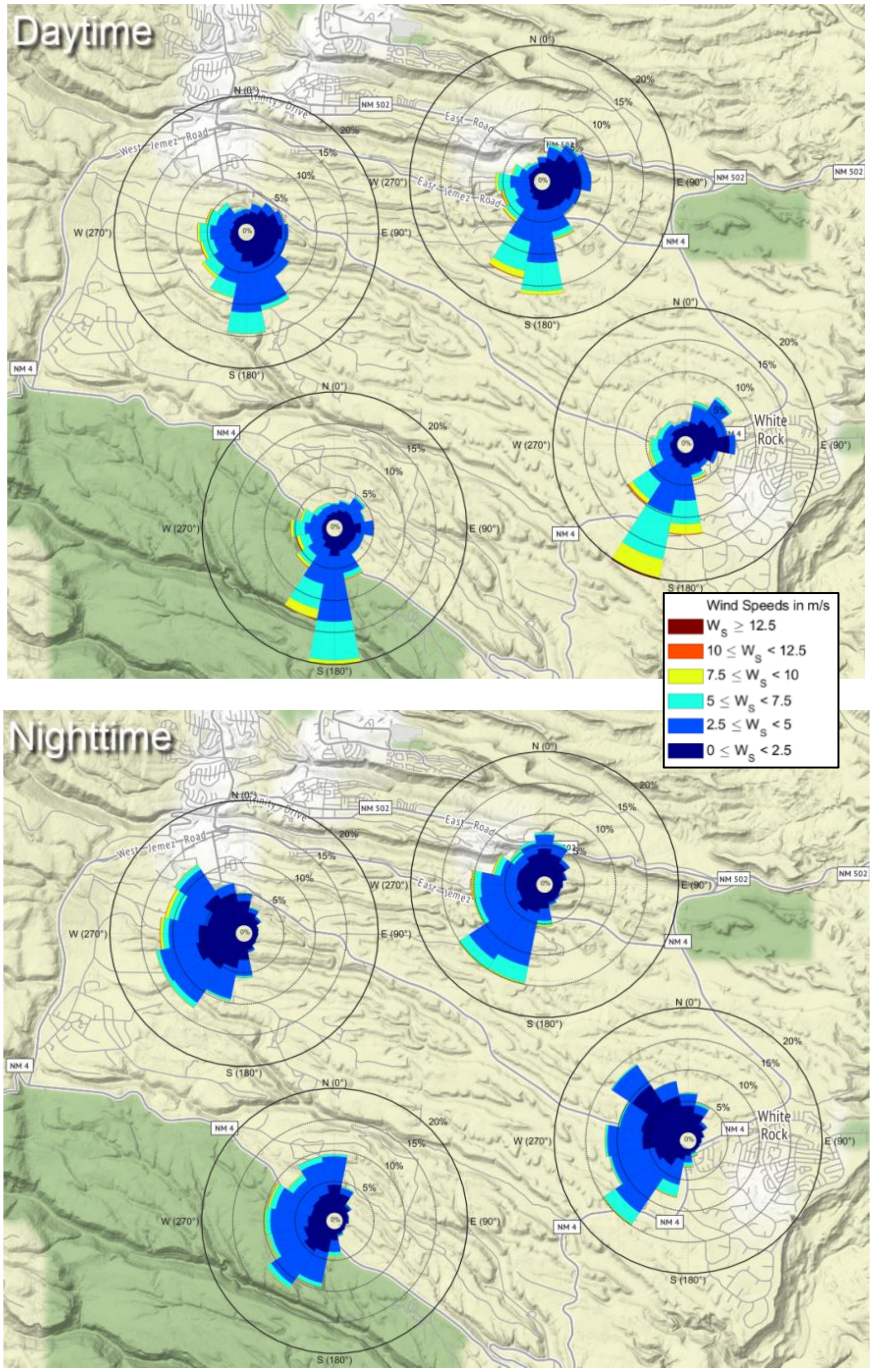

Figure 4-8. Wind roses for 2018 at the four mesa-top meteorological towers

Long-Term Climate Trends

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-9 shows the historical record of temperatures in Los Alamos from 1924 through 2018. The annual average temperature is the midpoint between daily high and low temperatures, averaged for the year. One-year averages are shown in green in Figure 4-9. To aid in showing longer-term trends, the five-year running average is also shown in black. With five-year averaging, for example, the warm spell during the past 15 years is more extreme than the warm spell during the early-to-mid 1950s and is longer-lived. Five of the hottest summers on record have occurred since 2002. The highest summertime (June, July, and August) average temperature on record was 71.1 °F, recorded during 2011.

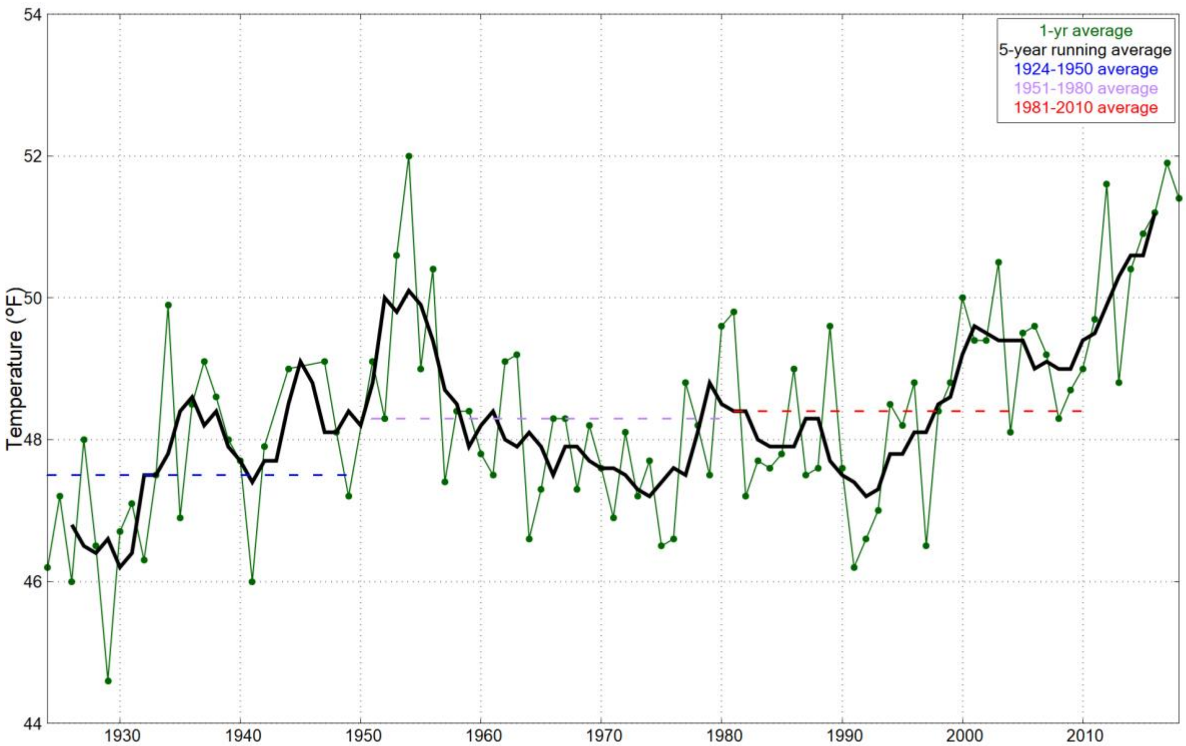

Figure 4-9. Temperature history for Los Alamos with the one-year average in green and five-year running average in black. The dashed lines represent long-term averages (25 and 30 years).

The average temperatures per decade, recorded at Technical Area 06, along with two times the standard error, are plotted in Figure 4-10 with the annual average temperatures for 2011–2018. Ninety-five percent of the annual average temperatures during each decade are found within the error bars. During the decades between 1960 and 2000, the annual average temperatures in Los Alamos varied only slightly from 48 °F. During the 2001–2010 decade, the annual average temperature increased to above 49 °F, and this value is statistically significantly higher than previous decades. The annual average temperatures from 2011 to 2018 continue to demonstrate a warmer climate for Los Alamos with an average of 50.7 °F. This is consistent with predictions for a warming climate in the southwestern United States (Intergovernmental Panel on Climate Change 2014).

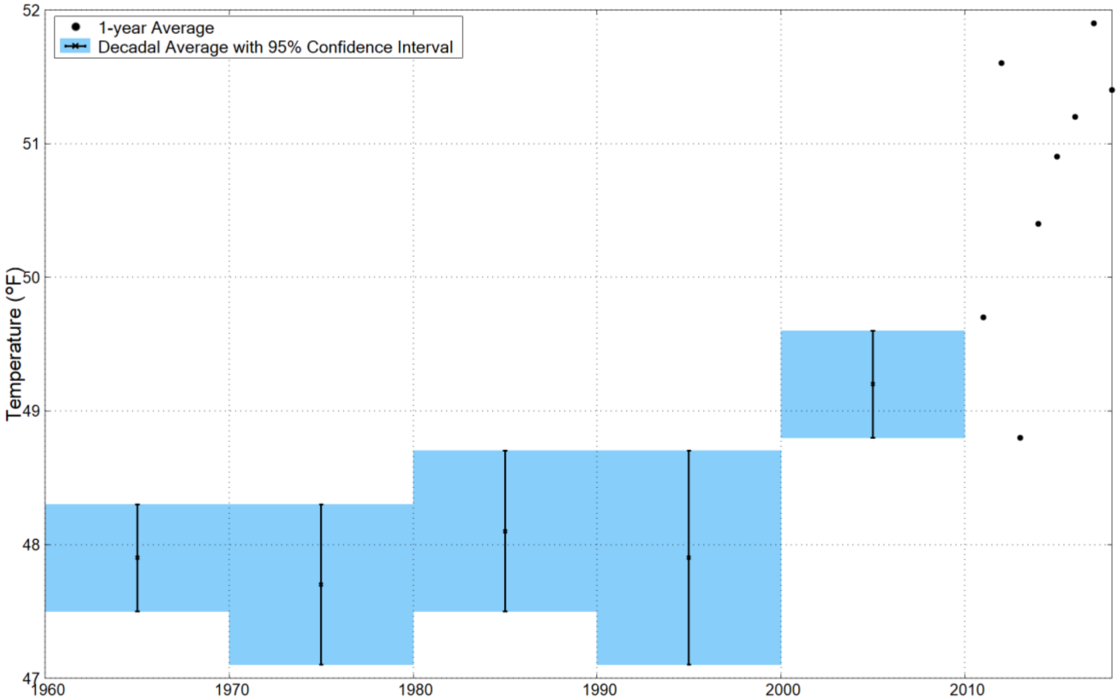

Figure 4-10. Technical Area 06 decadal average temperatures with two times the standard error for 1960 through 2010, and the annual average temperatures for 2011 through 2018

Figure 4-11 presents the historical record of the annual precipitation at Technical Area 06. As with the historical temperature profile, the five-year running average and the 30-year average values are also shown. The most recent drought has essentially spanned the years 1998 through 2018, although near-average precipitation years occurred from 2004 to 2010 and above-average precipitation occurred in 2015.

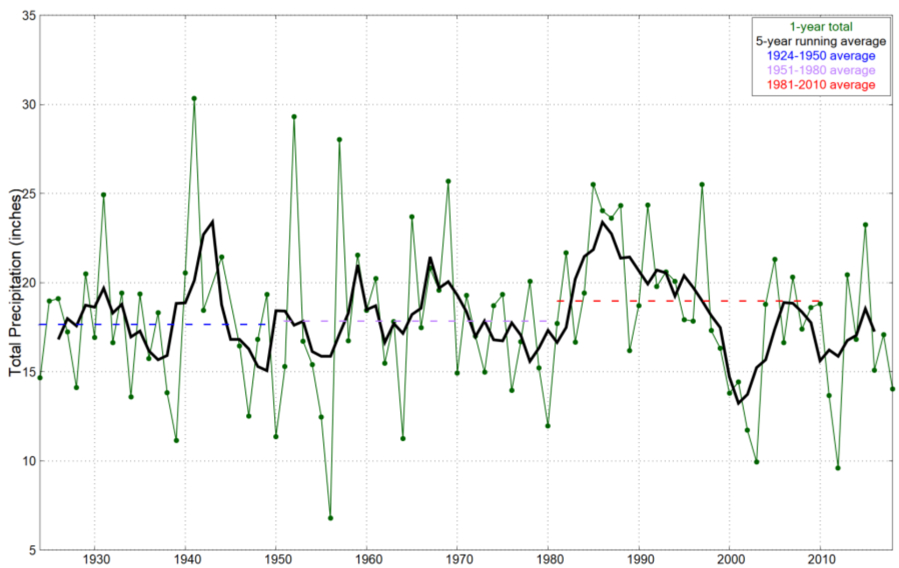

Figure 4-11. Total precipitation history for Los Alamos with the one-year total in green, five-year running average in black, and the dashed lines to represent long-term averages (25 and 30 years)

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Chapter 5 – GROUNDWATER MONITORING

Los Alamos National Laboratory (LANL, or the Laboratory) monitors and characterizes groundwater as part of its groundwater protection program. We collect and analyze hundreds of groundwater samples each year for a wide range of organic and inorganic constituents and radionuclides. We also implement measures to control contaminant migration.

Chemicals from historical Laboratory operations are present in some locations in perched-intermediate groundwater zones and in the regional aquifer. These chemicals are associated with past liquid effluent releases from Laboratory outfalls (the discharge point of a liquid waste stream into the environment). We use sampling results from some groundwater wells to define the nature and extent of known contaminant plumes, and to evaluate and model changes in plume location and concentrations over time. This information guides corrective actions where they are needed. We use other wells to monitor for any new contamination. The results are used to ensure compliance with the requirements of the U.S. Department of Energy orders and New Mexico and federal regulations.

Site-wide groundwater characterization and monitoring indicate that there are only two notable areas of groundwater contamination at the Laboratory: an RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) plume beneath Cañon de Valle in the Technical Area 16 vicinity and a chromium plume beneath Sandia and Mortandad Canyons.

RDX, primarily associated with historical machining of high explosives at Technical Area 16, has infiltrated into groundwater beneath Cañon de Valle. In some areas of perched-intermediate groundwater, it exceeds the New Mexico tap water screening level of 9.66 micrograms per liter. No screening level exceedances occur in the regional aquifer.

Hexavalent chromium from releases that occurred during 1956 to 1972 is present in the regional aquifer beneath Sandia and Mortandad Canyons at concentrations above the New Mexico groundwater standard of 50 micrograms per liter. Chromium corrective actions are ongoing.

The regional aquifer is the source of water for Los Alamos County and the Laboratory. Los Alamos County owns and operates the water supply system. The water supply wells are sampled quarterly and meet all federal and state drinking water standards.

CONTENTS

INTRODUCTION

Los Alamos National Laboratory (LANL, or the Laboratory) routinely monitors the quality of local groundwater. A regional aquifer is present beneath the Laboratory at depths ranging from 600 to 1,200 feet below the ground surface. Our groundwater monitoring and protection efforts focus on the regional aquifer and also include small areas of groundwater found within canyon-floor alluvium and within rocks and sediments at intermediate depths below the canyon bottoms and above the regional aquifer.

U.S. Department of Energy (DOE) Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment,* requires operators of DOE facilities to ensure that radionuclides from DOE activities do not cause private or public drinking water systems to exceed the drinking water maximum contaminant levels in the Code of Federal Regulations, Title 40, Part 141, National Primary Drinking Water Regulations. Operators must also ensure that baseline conditions of the groundwater quantity and quality are documented.

In 2016, DOE and the New Mexico Environment Department signed a new Compliance Order on Consent. The new consent order continues to require the Laboratory to submit an Interim Facility-Wide Groundwater Monitoring Plan to the New Mexico Environment Department each year. The monitoring locations, frequency of monitoring, and required analytes are updated in the plan each year. In April 2018 the legacy waste cleanup contractor Newport News Nuclear BWXT-Los Alamos, LLC (N3B) became responsible for implementing the groundwater program in accordance with the approved Interim Facility-Wide Groundwater Monitoring Plan requirements (LANL 2017a, N3B 2018). Some additional groundwater monitoring activities at the Laboratory are required under LANL's Hazardous Waste Facility Permit (see Chapter 2).

HYDROGEOLOGIC SETTING

The following section describes the distribution and movement of groundwater at the Laboratory and includes a summary of groundwater contaminant sources and distribution. Additional details can be found in reports available at the Laboratory’s electronic public reading room, located at http://eprr.lanl.gov.

The Laboratory is located in Northern New Mexico on the Pajarito Plateau. The Pajarito Plateau extends from the Rio Grande in the east to the Sierra de los Valles range of the Jemez Mountains in the west. Rocks composed of Bandelier Tuff cap the Pajarito Plateau (Figure 5-1). The tuff was formed from ash and other volcanic materials that erupted approximately 1.2 to 1.6 million years ago from the volcanic center of the Jemez Mountains. The tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet next to the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanic deposits (Figure 5-1). The Puye Formation, a largely unconsolidated sedimentary conglomerate, underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows, which originated mostly from a volcanic center east of the Rio Grande, extend into the Puye Formation beneath the Laboratory. These formations all overlie the sediments of the Santa Fe Group, which cross the Rio Grande valley and are more than 3,300 feet thick.

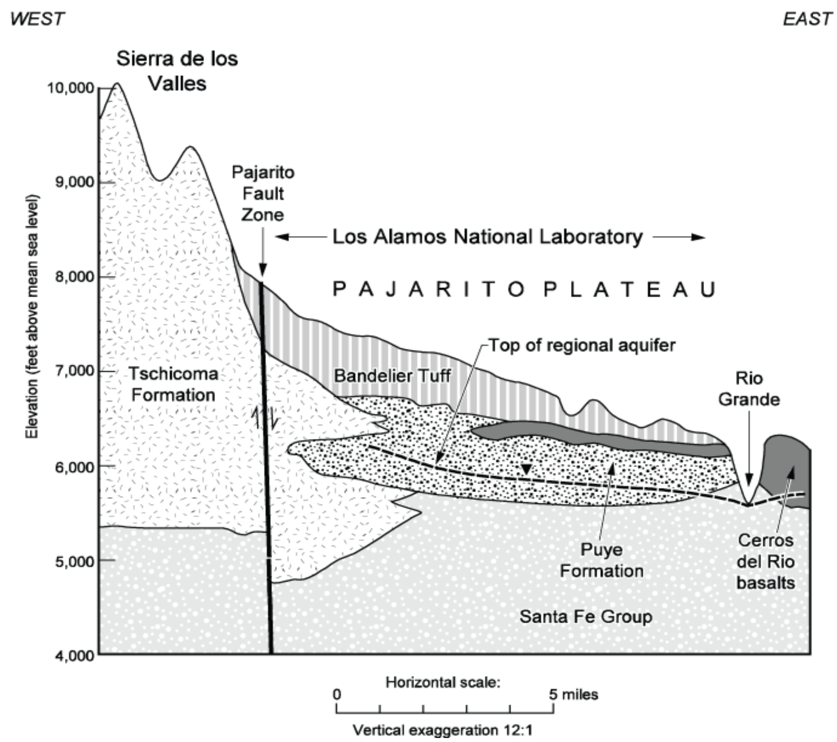

Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau

The Laboratory sits atop a thick zone of mainly unsaturated rock and sediments. Groundwater beneath the Pajarito Plateau occurs in three modes (Figure 5-2): (1) perched alluvial groundwater in the bottom of some canyons, (2) small areas of intermediate-depth perched groundwater, and (3) the regional aquifer.

Perched alluvial groundwater is a limited area of saturated rocks and sediments directly below canyon bottoms. Surface water moves through the alluvium until downward flow is disrupted by less-permeable layers of rock, resulting in shallow perched bodies of groundwater. Most of the canyons on the Pajarito Plateau have infrequent surface water flow and, therefore, little or no alluvial groundwater. A few canyons have saturated alluvium in their western ends supported by runoff from the Jemez Mountains. In some locations, surface water is supplemented or maintained by discharges from Laboratory outfalls.

Hydrogeologic Terms

Saturated rock or sediment is completely wet. **Unsaturated** rock or sediment has air in its pore spaces.

Alluvial groundwater is the zone of saturation that exists in sands and gravels in the base of canyons.

Perched groundwater is a zone of saturation of limited thickness that occurs above the regional aquifer.

The **regional aquifer** is a widespread area of mainly saturated sands and gravels that provide the water supply for Los Alamos County and the Laboratory.

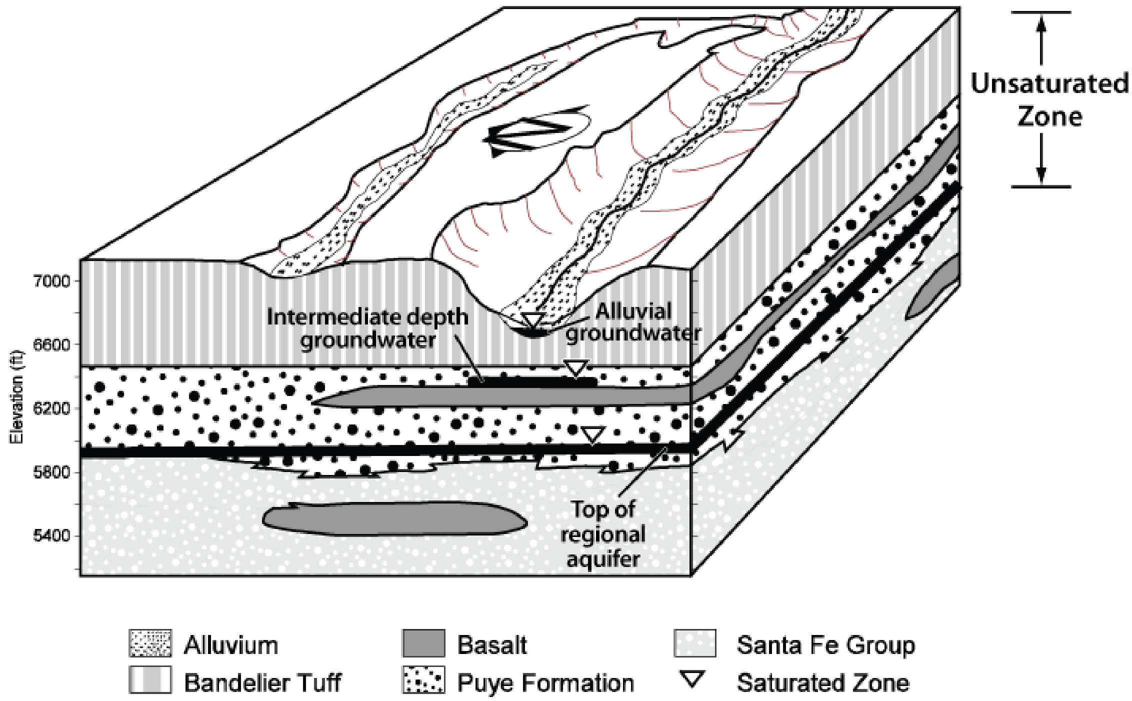

Figure 5-2. Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence: perched alluvial groundwater, perched intermediate-depth groundwater, and groundwater within the regional aquifer.

As alluvial groundwater moves down a canyon, it either evaporates, is used by plants, or percolates into underlying rock.

Perched-intermediate groundwater occurs within the lower part of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt beneath some canyons (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by water moving downward from alluvial groundwater until it reaches a layer of rock that allows little or no water to pass through. Depths of the perched-intermediate groundwater zones vary. For example, the depth to perched-intermediate groundwater is approximately 120 feet beneath Pueblo Canyon, 450 feet beneath Sandia Canyon, and 500 to 750 feet beneath Mortandad Canyon.

The uppermost level of water in the regional aquifer, known as the water table, occurs at a depth of approximately 1,200 feet below ground surface along the western edge of the plateau and 600 feet below ground surface along the eastern edge (Figure 5-1 and Figure 5-3). Studies indicate that water from the Sierra de los Valles is the main source of recharge for the regional aquifer (LANL 2005a). Groundwater in the regional aquifer generally flows east or southeast. The speed of groundwater flow varies but is typically around 30 feet per year. The regional aquifer is separated from alluvial and perched-intermediate groundwater by layers of unsaturated tuff, basalt, and sediment with generally low moisture content (< 10 percent). The limited extent of the alluvial and intermediate groundwater bodies, along with unsaturated rock that underlies them, restricts their contribution to recharging the regional aquifer, although locally they are important parts of the complete pathway to the regional aquifer.

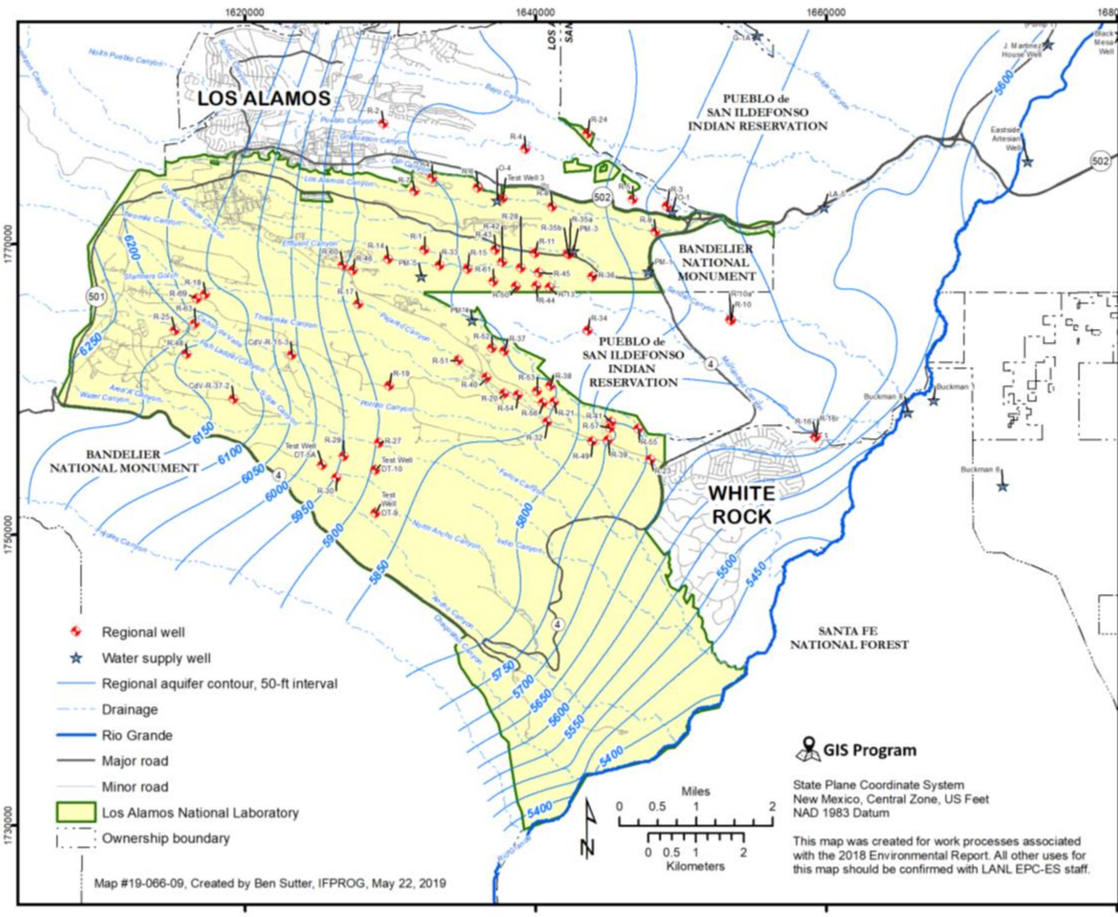

Figure 5-3. Contour map of average water table elevations for the regional aquifer. This map represents a generalization of the data.

GROUNDWATER STANDARDS AND SCREENING LEVELS

Regulatory Overview

The regulatory standards and screening levels listed in Table 5-1 are used to evaluate results from groundwater samples reported in this chapter.

Groundwater standards and screening levels are established by three regulatory agencies. DOE has authority under the Atomic Energy Act of 1954 to set standards for certain nuclear materials. The U.S. Environmental Protection Agency and the New Mexico Water Quality Control Commission set screening levels and standards for other constituents.

DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, establishes dose limits for radiation exposure and provides derived concentration technical standards for radionuclide levels in air and water based on those limits. For drinking water, DOE's derived concentration technical standards are calculated based on the U.S. Environmental Protection Agency's 4-millirem-per-year drinking water dose limit.

The U.S. Environmental Protection Agency Safe Drinking Water Act's maximum contaminant levels are the maximum permissible level of a contaminant in water delivered to any user of a public water system.

The New Mexico Water Quality Control Commission groundwater standards (Title 20 Chapter 6 Part 2 of the New Mexico Administrative Code) apply to all groundwater with a total dissolved solids concentration of 10,000 milligrams per liter or less. These standards include numeric criteria for many substances. In addition, the standards contain a separate list of toxic pollutants.

Section XXVI of the 2016 Compliance Order on Consent requires screening and reporting of groundwater data. Section IX of the 2016 Compliance Order on Consent describes the screening criteria as being the lower of either the New Mexico groundwater quality standard or the federal maximum contaminant level. If neither of these standards exist for a given chemical, the New Mexico Environment Department's tap water screening level is used. If no New Mexico Environment Department tap water screening level is available, then the U.S. Environmental Protection Agency's regional human health medium-specific screening level for tap water, adjusted to a 10^{-5} excess cancer risk, is used.

The U.S. Environmental Protection Agency updates the regional screening levels for tap water several times each year; 2018 values were used to prepare this chapter. Updated New Mexico Water Quality Control Commission groundwater standards went into effect in December 2018.

The New Mexico Water Quality Control Commission numeric criteria mostly apply to the dissolved (filtered) portion of specified constituents; however, the standards for mercury, organic compounds, and nonaqueous phase liquids apply to the total unfiltered concentrations of the constituents. The U.S. Environmental Protection Agency maximum contaminant levels and regional screening levels for tap water are applied to both filtered and unfiltered sample results.

For radioactivity in groundwater, we compare sample results with the New Mexico Water Quality Control Commission groundwater standards for combined radium-226 and radium-228, DOE's drinking water concentration technical standards (derived from DOE's 4-millirem-per-year dose limit), and with the U.S. Environmental Protection Agency maximum contaminant level drinking water standards.

The New Mexico Water Quality Control Commission groundwater standards apply to concentrations of nonradioactive chemicals in all groundwater samples. The U.S. Environmental Protection Agency maximum contaminant-level drinking water standards and the adjusted regional screening levels for tap water are used as screening levels for nonradioactive chemicals in most groundwater and are used as standards where appropriate for drinking water.

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TABLE 5-1. APPLICATION OF STANDARDS OR SCREENING LEVELS TO LANL GROUNDWATER MONITORING DATA

Sample Type	Constituent	Standards or Screening Levels	References	Notes
Water supply wells	Radionuclides	• New Mexico groundwater standards • Concentration technical standards derived from DOE's 4-millirem-per-year drinking water dose limit • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • DOE Order 458.1 Chg 3 • Code of Federal Regulations Title 40 Parts 141–143	The concentration technical standards (derived from DOE's 4-millirem-per-year drinking water dose limit) apply to water provided by DOE-owned drinking water systems. U.S. Environmental Protection Agency maximum contaminant levels apply to drinking water delivered to users from public drinking water systems.
Water supply wells	Nonradionuclides	• New Mexico groundwater standards • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • Code of Federal Regulations Title 40 Parts 141–143	U.S. Environmental Protection Agency maximum contaminant levels apply to drinking water delivered to users from public drinking water systems.
Non-water–supply groundwater samples	Radionuclides	• New Mexico groundwater standards • Concentration technical standards derived from DOE's 4-millirem-per-year drinking water dose limit • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • DOE Order 458.1 Chg 3 • Code of Federal Regulations Title 40 Parts 141–143	New Mexico groundwater standards apply to all groundwater. The concentration technical standards (derived from DOE's 4-millirem-per-year drinking water dose limit) and U.S. Environmental Protection Agency maximum contaminant levels are for comparison only.
Non-water–supply groundwater samples	Nonradionuclides	• New Mexico groundwater standards • U.S. Environmental Protection Agency maximum contaminant levels • U.S. Environmental Protection Agency regional screening levels for tap water	• 20.6.2 New Mexico Administrative Code • Code of Federal Regulations Title 40 Parts 141–143 • 2016 Compliance Order on Consent	A hierarchy of levels applies as screening levels for groundwater. See text for explanation.

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Procedures for Collecting Groundwater Samples

The Laboratory has several standard operating procedures for collecting groundwater samples and samples from springs that discharge groundwater. These procedures (or their equivalent used by sampling subcontractors) are used in accordance with the "Interim Facility-Wide Groundwater Monitoring Plan for the 2018 Monitoring Year, October 2017–September 2018" and the "Interim Facility-Wide Groundwater Monitoring Plan for the 2019 Monitoring Year, October 2018–September 2019" (LANL 2017a, N3B 2018).

POTENTIAL SOURCES OF CONTAMINATION

Historical discharges from Laboratory operations have affected all three groundwater zones. Figure 5-4 shows the key locations of historical effluent discharges that may have affected groundwater.

Drainages that received effluent in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize effluent discharge history at the Laboratory.

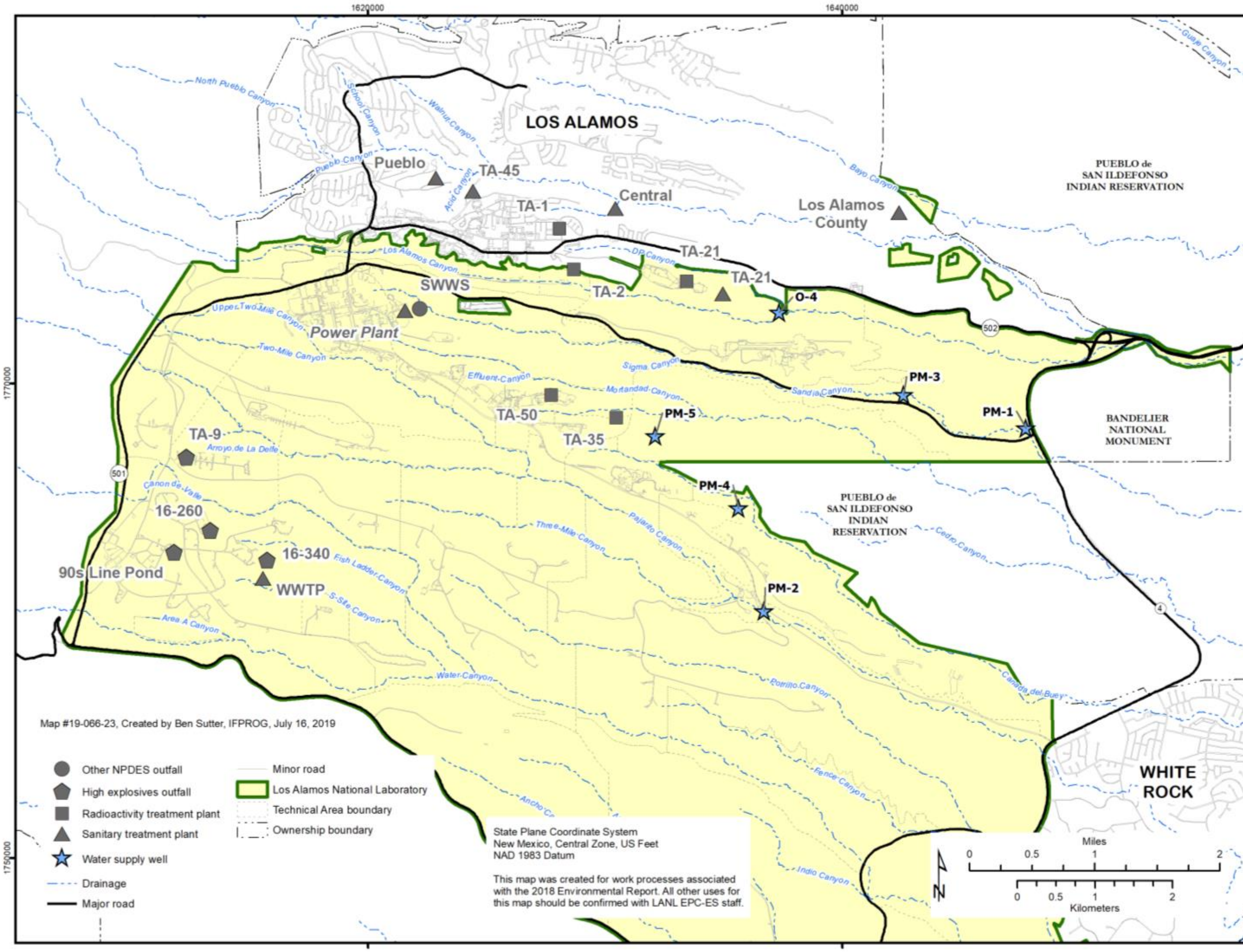
Sandia Canyon has received discharges of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems Plant. Water Canyon and its tributary Cañon de Valle have received effluents produced by high-explosives processing and experimentation. Over the years, Los Alamos County has operated several sanitary wastewater treatment plants in Pueblo Canyon. The Laboratory has also operated numerous sanitary treatment plants.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls and the volume of water discharged. The quality of the remaining discharges has been improved through treatment process improvements so that they meet applicable standards.

GROUNDWATER MONITORING NETWORK

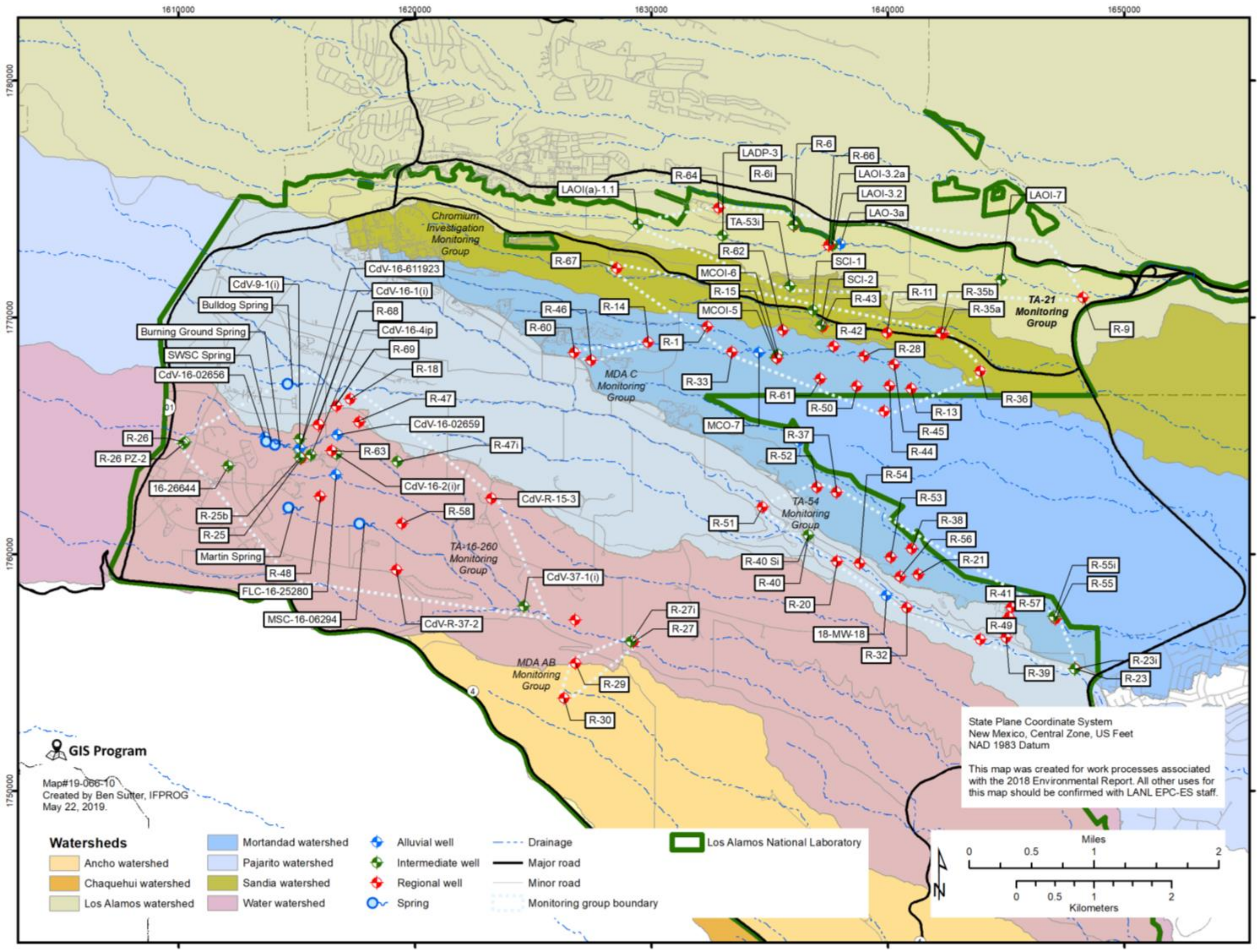
We monitor water quality and other characteristics at alluvial, perched-intermediate, and regional aquifer wells and at springs that discharge perched-intermediate and regional aquifer groundwater primarily in area-specific monitoring groups (Figure 5-5). Area-specific monitoring groups include Technical Area 54, Technical Area 21, Material Disposal Area AB, Material Disposal Area C, the Chromium Investigation, and the Technical Area 16 260 Outfall. Locations that are not included within one of these six area-specific monitoring groups are assigned to the General Surveillance monitoring group (Figure 5-6). Numerous springs along the Rio Grande are also monitored because they represent natural discharge from perched-intermediate and regional aquifer groundwater that flows beneath the Laboratory (Figure 5-7; Purtymun et al. 1980).

We also collect samples from 12 Los Alamos County water supply wells (Figure 5-7), from wells located on Pueblo de San Ildefonso lands, and from the Buckman well field operated by the city of Santa Fe. Groundwater monitoring locations on the Pueblo de San Ildefonso are shown in Figure 5-7; they mainly sample the regional aquifer. Vine Tree Spring (near the former sampling location Basalt Spring) and Los Alamos Spring represent perched-intermediate groundwater, and wells LLAO-1b and LLAO-4 represent alluvial groundwater.



Note: NPDES = National Pollutant Discharge Elimination System; SWWS = sanitary wastewater system; TA = technical area; WWTP = wastewater treatment plant

Figure 5-4. Major liquid release outfalls potentially affecting groundwater; most outfalls shown are currently inactive.



Note: MDA = Material disposal area

Figure 5-5. Groundwater monitoring wells and springs assigned to area-specific monitoring groups

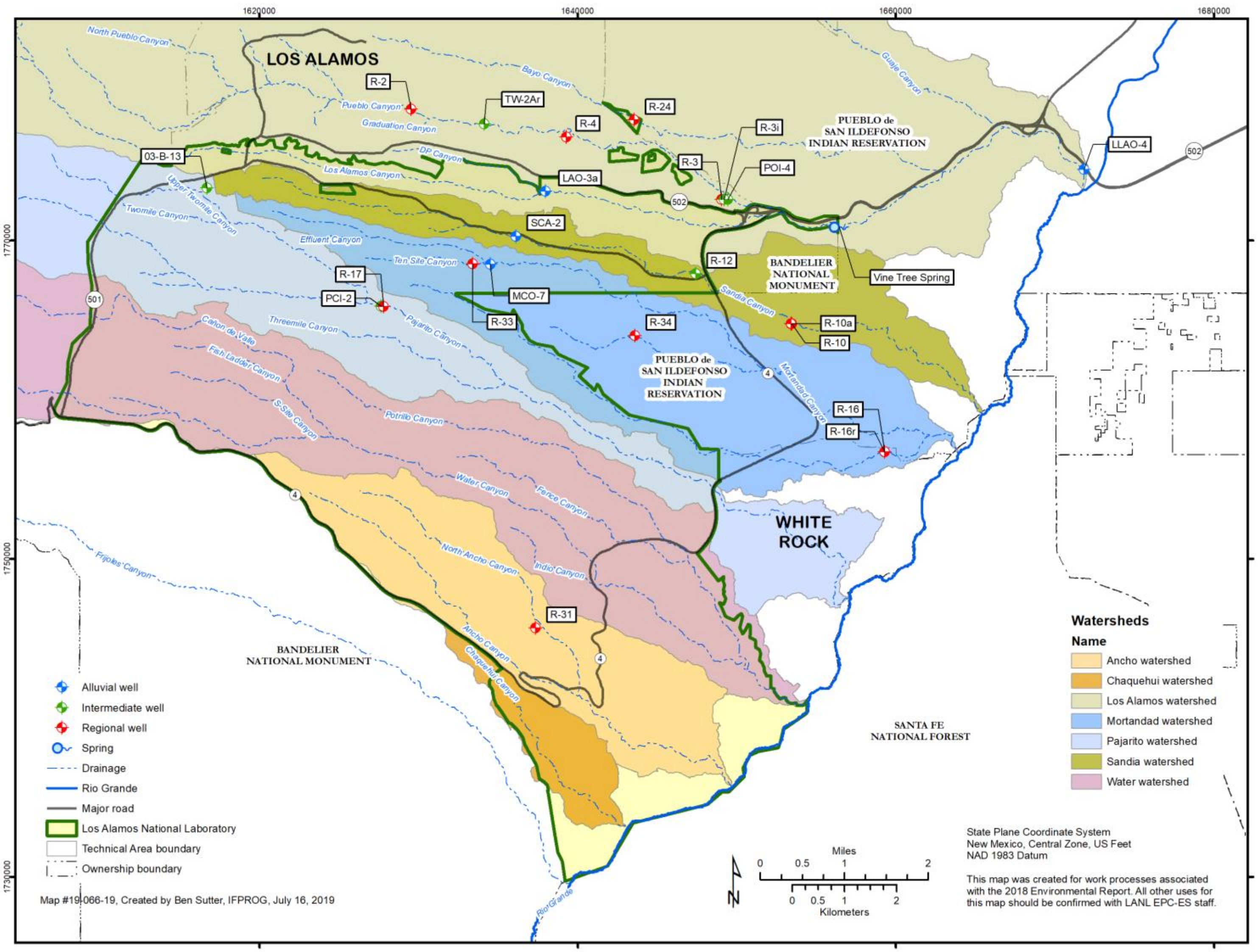


Figure 5-6. Groundwater monitoring wells and springs assigned to watershed-specific portions of the General Surveillance monitoring group.

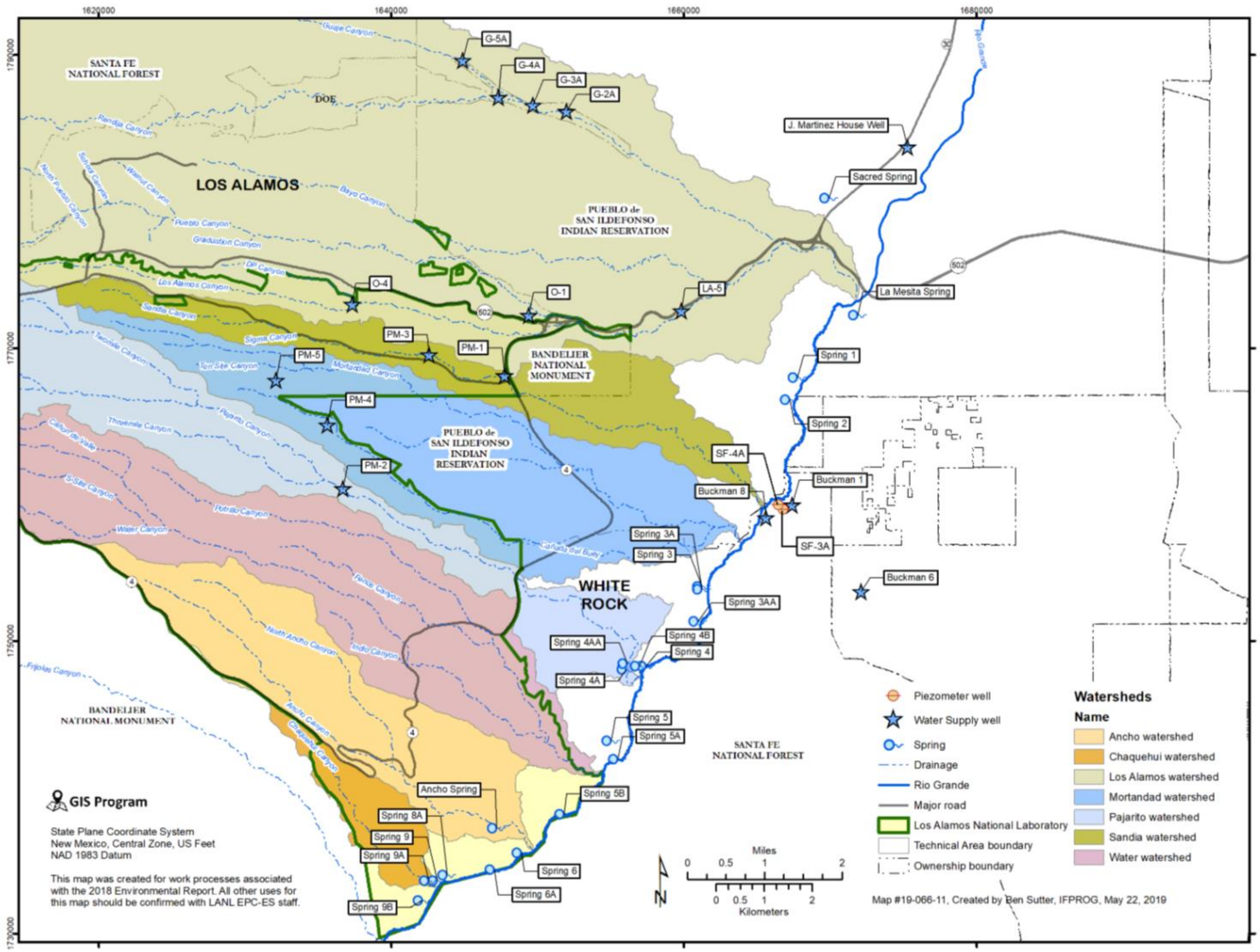


Figure 5-7. Water supply wells used for monitoring at Los Alamos County, the city of Santa Fe Buckman well field, and Pueblo de San Ildefonso, and springs used for groundwater monitoring in White Rock Canyon.

GROUNDWATER DATA INTERPRETATION

The groundwater monitoring data for 2018 are available from the Intellus New Mexico website at https://www.intellusnm.com.

Analytical laboratory results are reported relative to several defined limits. The method detection limit is the minimum concentration of a substance that can be detected with 99 percent confidence that the concentration is greater than zero. The method detection limit is determined from analysis of a set of standardized samples containing the analyte (40 Code of Federal Regulations Part 136, Appendix B). A second limit used by analytical laboratories is the practical quantitation limit, the minimum concentration of an analyte that can be measured with a high degree of confidence. The practical quantitation limit is approximately (but not always) three times the method detection limit or is the lowest point on the analytical laboratory's calibration curve. Analyte concentrations measured between the method detection limit and the practical quantitation limit are reported as estimated concentrations and marked with a "J" qualifier in the analytical report and in the results from the Intellus website.

A nondetect result indicates that the analytical laboratory did not detect the analyte in the sample. These results are marked with a "U" qualifier. The Laboratory reports nondetect results as either the practical quantitation limit value or the method detection limit value (depending on the reason for sampling and the year when the sample was collected), and it reports estimated concentrations as their actual estimated value. Because we sometimes report nondetect results at the practical quantitation limit value, the detected but estimated results (results between the method detection limit and the practical quantitation limit) can have a lower reported value than nondetect results for the same analyte.

The method detection limit and practical quantitation limit do not apply to radiological measurements. For radiological measurements, the minimum detectable activity is analogous to the method detection limit, though it is calculated for each measurement. To be considered a detected activity, a radiological measurement must be greater than the minimum detectable activity.

GROUNDWATER SAMPLING RESULTS BY MONITORING GROUP

The following sections discuss groundwater sampling results for the six area-specific monitoring groups and the General Surveillance monitoring group, springs along the Rio Grande, and Los Alamos County and City of Santa Fe water supply wells. The tables and discussions are grouped according to groundwater mode, proceeding from deepest (the regional aquifer) to shallowest (the alluvial groundwater). The accompanying tables and text mainly address constituents found at levels above applicable standards or screening levels. Other constituents that are below standards or screening levels, such as tritium, are discussed in a few cases to track trends where potential Laboratory influences are observed. The discussion addresses radionuclides, inorganic compounds, inorganic elements (primarily metals), and organic compounds for each groundwater zone. The accompanying plots and maps provide temporal and spatial context.

Water Supply Monitoring

Los Alamos County

We collected samples from 12 Los Alamos County water supply wells that produce water for the Laboratory and the community (Figure 5-7). These samples are supplemental to Los Alamos County's monitoring and specifically address potential Laboratory contaminants. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards as reported in the county's annual drinking water quality report (available at https://www.losalamosnm.us/common/pages/DisplayFile.aspx?itemId=15763913). The water supply wells have long screens (the slotted portion of a well that allows water to enter the well) up to 1,600 feet deep within the regional aquifer. Water quality samples collected from these wells therefore sample water over a large depth range. No water supply wells showed detections of Laboratory-related constituents above applicable drinking water standards.

City of Santa Fe

In 2018, we sampled three supply wells (Buckman-1, Buckman-6, and Buckman-8) in the City of Santa Fe's Buckman well field. Samples were also collected from four piezometers (wells typically used to measure water levels) in the well field (LANL 2012a). These samples are supplemental to the City of Santa Fe's monitoring and specifically address potential Laboratory contaminants. No Laboratory-related constituents were present above standards for these locations. The City of Santa Fe publishes an annual water quality report that provides additional information (https://www.santafenm.gov/water_quality).

Technical Area 21 Monitoring Group

Technical Area 21 is located on a mesa north of Los Alamos Canyon (Figure 5-4). DP Canyon borders the north side of the mesa and joins Los Alamos Canyon east of the technical area. Technical Area 21 consists of two past operational areas, DP West and DP East, both of which produced liquid and solid radioactive wastes. The operations at DP West included plutonium processing, while the operations at DP East included the production of weapons initiators and tritium research. From 1952 to 1986, a liquid waste treatment plant discharged effluent containing radionuclides from the plutonium-processing facility at Technical Area 21 into DP Canyon (Figure 5-4).

Sources of potential groundwater pollutants in the vicinity of the Technical Area 21 monitoring group include the effluent outfall [Solid Waste Management Unit 21-011(k)], adsorption beds and disposal shafts at Material Disposal Area T, adsorption beds at Material Disposal Area U, the former Omega West reactor cooling tower (Solid Waste Management Unit 02-005), DP West, DP East, waste lines, an underground diesel fuel line, and sumps. The Technical Area 21 monitoring group includes monitoring wells in perched-intermediate groundwater and in the regional aquifer. The monitoring objectives for the Technical Area 21 monitoring group are presented in each annual Interim Facility-Wide Groundwater Monitoring Plan.

Samples from several wells that monitor perched-intermediate groundwater in the Technical Area 21 monitoring group have tritium that likely originated from the former liquid waste treatment plant, the Omega West Reactor, or both. Tritium concentrations in perched-intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 in 2018 are generally consistent with concentrations measured in recent years (Figure 5-8; see Figure 5-5 for well locations). The highest tritium concentration among these wells in 2018 is 1,820 picocuries per liter in R-6i, up from 1,750 picocuries per liter in 2017. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter.

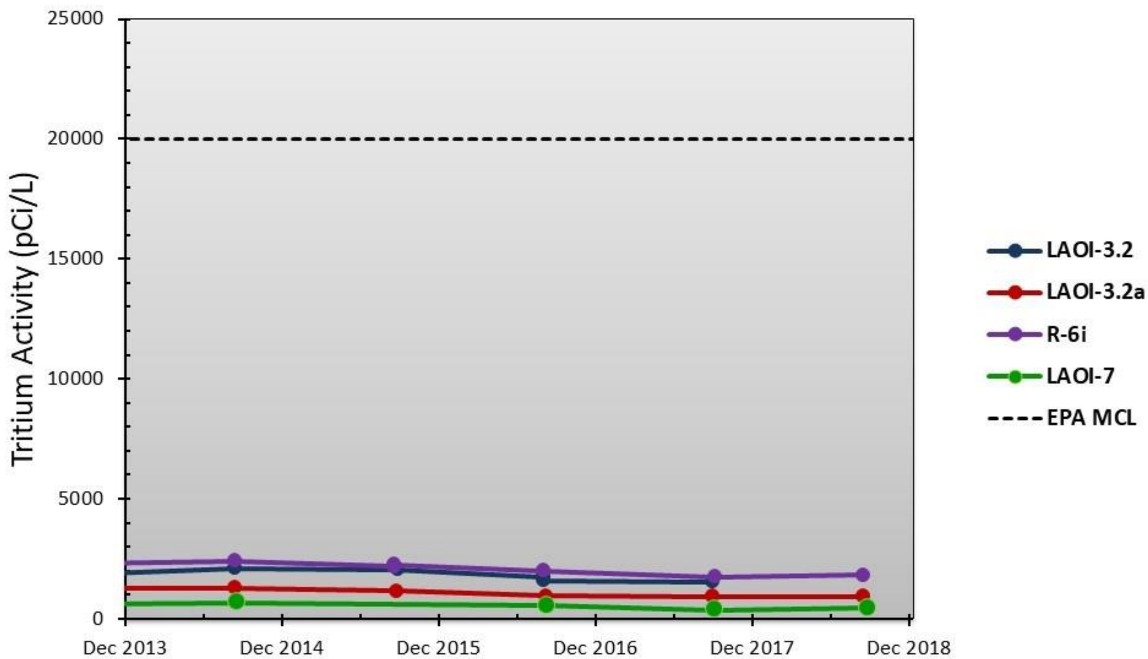


Figure 5-8. Tritium concentrations in sampled perched-intermediate groundwater from wells in the Technical Area 21 monitoring group in Los Alamos Canyon. EPA MCL = The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water.

Chromium Investigation Monitoring Group

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons (Figure 5-5). Sandia Canyon has a small drainage area that begins in Technical Area 03. The canyon receives treated sanitary effluent from the Technical Area 46 sanitary wastewater system plant and cooling tower discharges from computing facilities and the Technical Area 03 power and steam plants through National Pollutant Discharge Elimination System outfall 001. From 1956 to 1972, potassium dichromate was used as a corrosion inhibitor in the cooling system at the power plant (LANL 1973) and was included in the effluent discharged through the outfall. These discharges of potassium dichromate are the source of the elevated concentrations of hexavalent chromium observed in perched-intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons.

A conceptual model for the sources and spatial distribution of chemicals and radionuclides in groundwater in this area is presented in the Investigation Report for Sandia Canyon, the Phase II Investigation Report for Sandia Canyon (LANL 2009a, 2012b), and in the Compendium of Technical Reports Conducted Under the Work Plan for Chromium Plume

Center Characterization (LANL 2018a). The conceptual model indicates that chromium originated from releases into Sandia Canyon and then migrated in the subsurface along geologic perching horizons to locations in the regional aquifer beneath Mortandad Canyon.

Monitoring in this group in 2018 primarily focused on characterizing and understanding the transport and fate of chromium and related contaminants in perched-intermediate groundwater and within the regional aquifer. We also evaluated the performance of an interim mitigation measure to address chromium plume migration while a final remedy for the plume is evaluated.

Chromium is present in the regional aquifer above the New Mexico Environment Department groundwater standard of 50 micrograms per liter in an area that is approximately one mile in length and about a half mile wide (Figure 5-9 and Figure 5-10). This chromium is found within 50 to 100 feet of the surface of the regional aquifer (LANL 2009a, 2012b, 2017b, 2018b). The 2018 chromium concentrations exceeded the New Mexico groundwater standard of 50 micrograms per liter in four regional aquifer wells: R-42, R-62, R-50 screen 1, and R-43 screen 1 (Figure 5-11).

Although having high annual variability, wells within the center of the plume (for example, R-42 and R-28) have historically shown a relatively flat long-term chromium trend. Recently, sampling results from well R-28 have displayed a significant decrease in chromium, dropping below the New Mexico groundwater standard to a maximum chromium concentration of 30.9 micrograms per liter. Two of three wells along the edge of the plume (R-43 screen 1 and R-50 screen 1) have elevated concentrations of chromium compared to 2017. The third well along the edge of the plume, R-45 screen 1, has shown a decreased concentration from a high in 2017 of 50.7 to a maximum concentration of 46.4 micrograms per liter in 2018, which is below the New Mexico groundwater standard. Furthermore, while R-50 screen 1 is still above the standard, recent sampling has shown a decreasing trend in chromium concentration to 83.5 micrograms per liter. These results suggest a positive effect of the remediation activities that started in February 2018.

Two perched-intermediate wells had chromium concentrations above the standard: SCI-2 and MCOI-6. The trend for chromium in these two wells is shown in Figure 5-12.

A small area with perchlorate contamination is also present in groundwater beneath Mortandad Canyon. The primary source of perchlorate was effluent discharges from the Radioactive Liquid Waste Treatment Facility from 1963 until March 2002. Perchlorate is present in two perched-intermediate wells, MCOI-5 and MCOI-6 (Figure 5-13). In perched-intermediate well MCOI-6, the perchlorate concentration trends are relatively stable, with increasing concentrations observed at MCOI-5. Perchlorate is present in the regional aquifer, specifically at wells R-61 and R-15. Although R-15 perchlorate levels are below the standard in the 2016 Compliance Order on Consent, the R-61 screen 1 has shown concentrations that are above the 13.8 micrograms per liter standard. We continue to monitor and to evaluate whether the elimination of the source of perchlorate will result in decreasing concentrations in these perched-intermediate wells.

Another constituent detected in the Chromium Investigation monitoring group is 1,4-dioxane in perched-intermediate wells MCOI-5 and MCOI-6 (Figure 5-14). The trend has been primarily flat at MCOI-6, but has recently shown an upward trend: well MCOI-5 has had a continued increasing trend over the last few years. Concentrations of 1,4-dioxane are not present above the screening level of 4.59 micrograms per liter in the regional aquifer.

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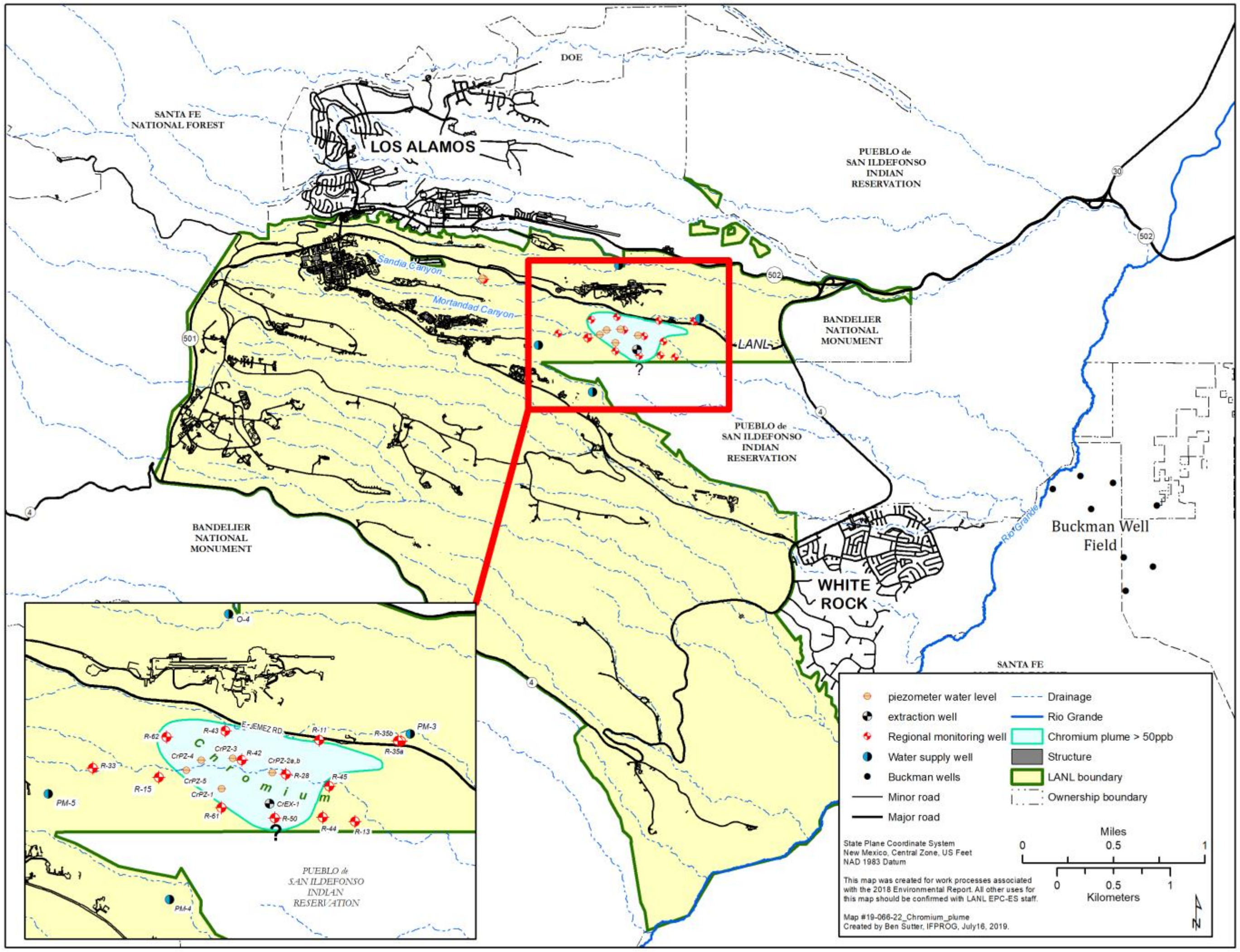

Figure 5-9. Approximation of the chromium plume footprint in the regional aquifer, as defined by the 50 microgram per liter New Mexico Environment Department groundwater standard

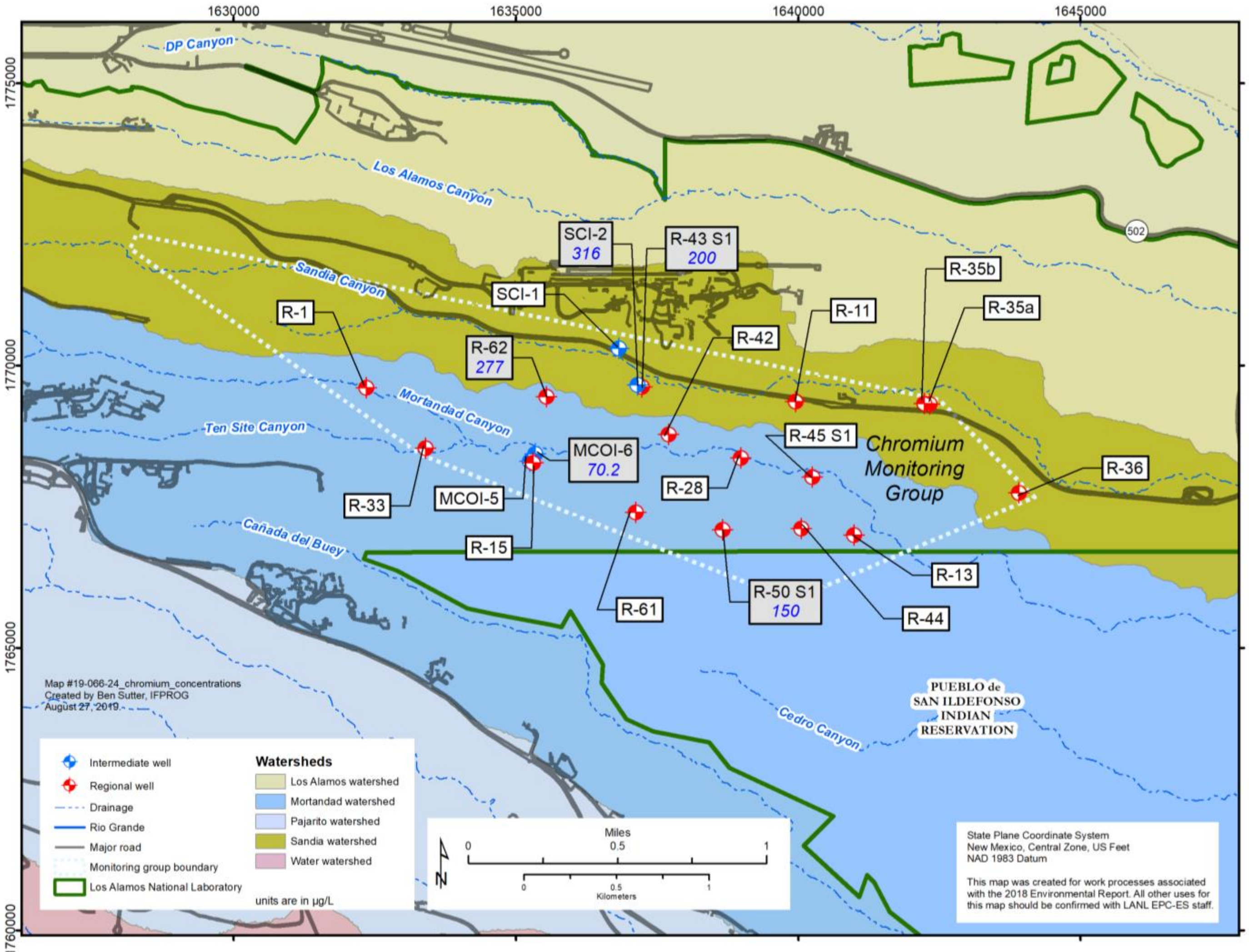

Figure 5-10. The Chromium Investigation monitoring group perched-intermediate and regional aquifer monitoring wells. The white dashed outline encompasses the wells included in the monitoring group. Labels for the wells include maximum chromium concentrations in 2018 at wells with recorded concentrations greater than the New Mexico groundwater standard of 50 micrograms per liter (µg/L).

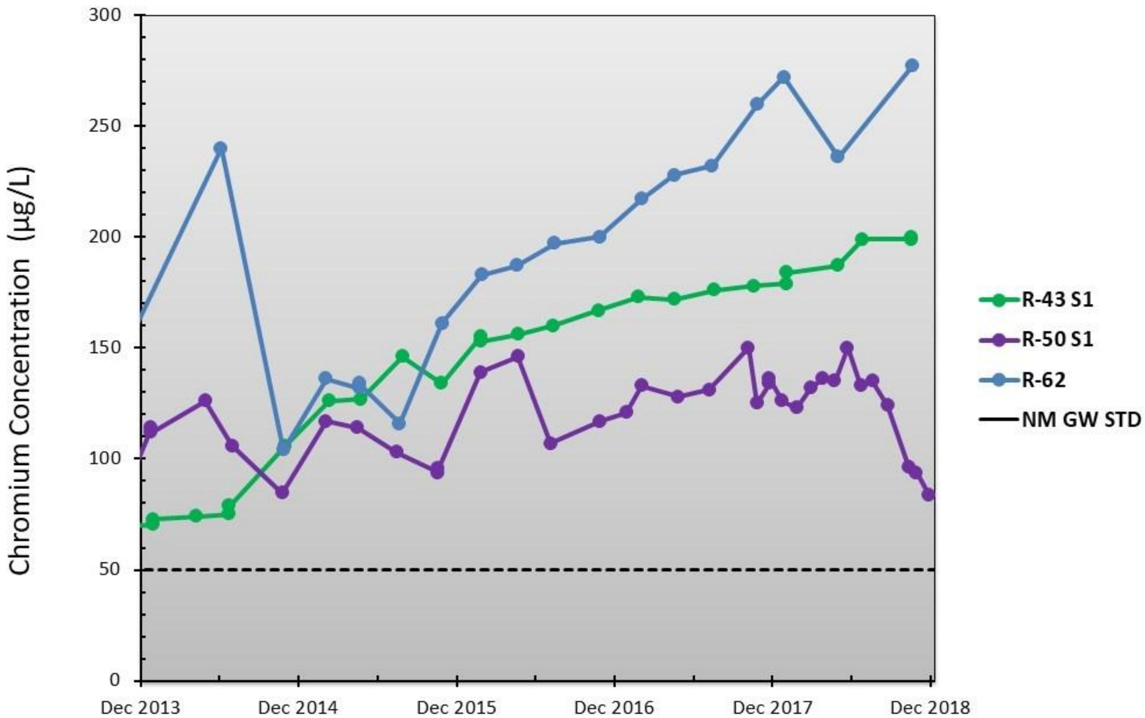

Figure 5-11. Trends in chromium concentrations for three of the regional aquifer wells in the middle of the chromium plume that exceeded the New Mexico Groundwater Standard (NM GW STD) for chromium of 50 micrograms per liter (µg/L)

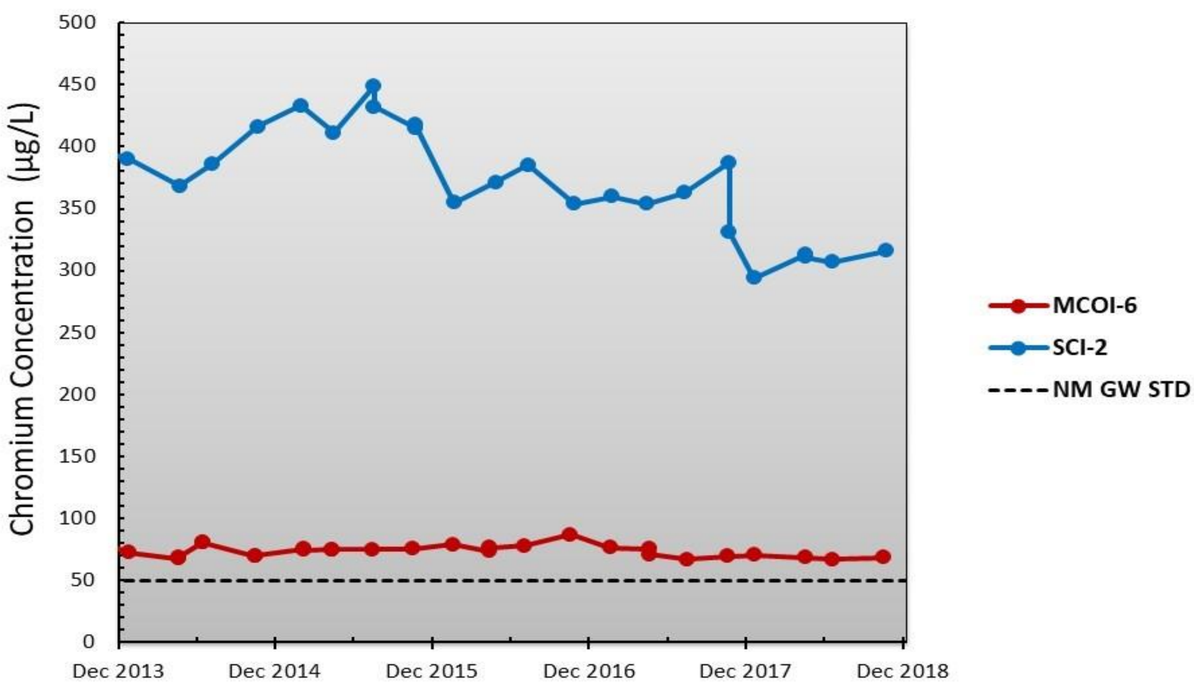

Figure 5-12. Trends in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with chromium concentrations that exceeded the New Mexico Groundwater Standard (NM GW STD) of 50 micrograms per liter (µg/L)

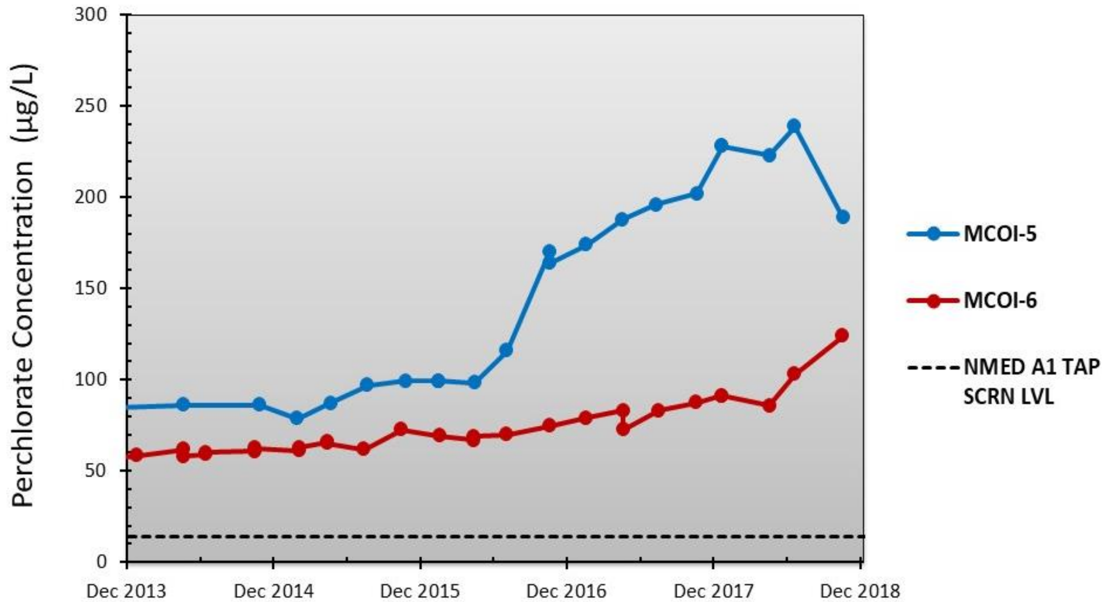

Figure 5-13. Trends in perchlorate concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with perchlorate detections above the New Mexico tap water screening level of 13.8 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

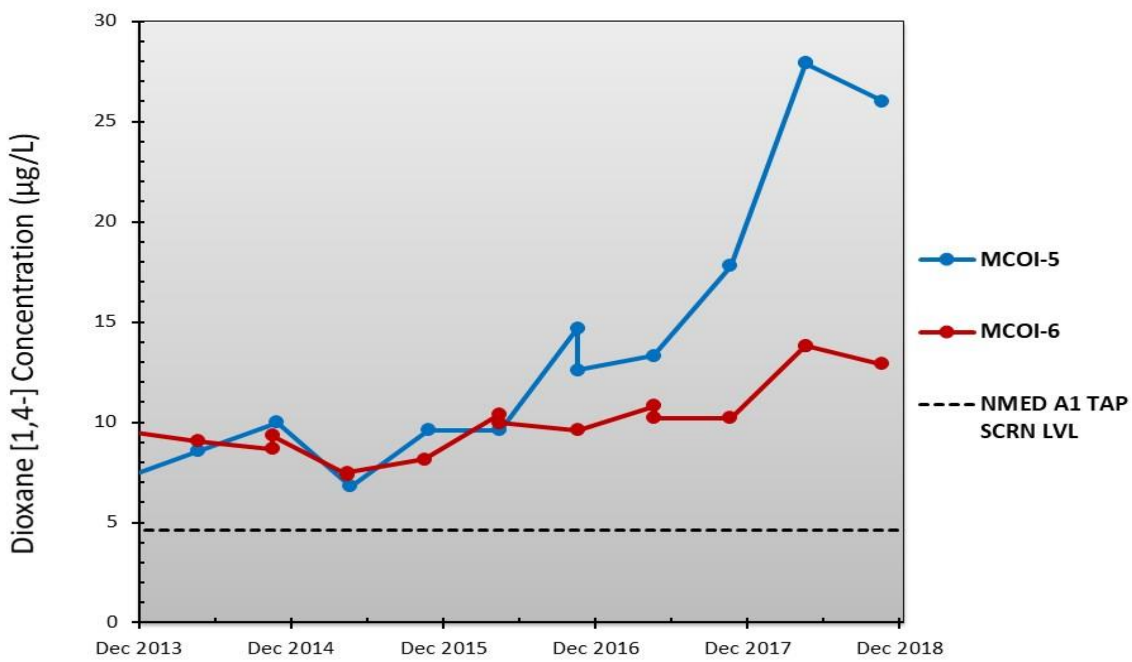

Figure 5-14. Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells with detections of 1,4-dioxane in the Chromium Investigation monitoring group. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level).

Perched-intermediate wells MCOI-5 and MCOI-6 have tritium concentrations far below the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water of 20,000 picocuries per liter (Figure 5-15). Tritium concentrations in the regional aquifer are generally less than 200 picocuries per liter.

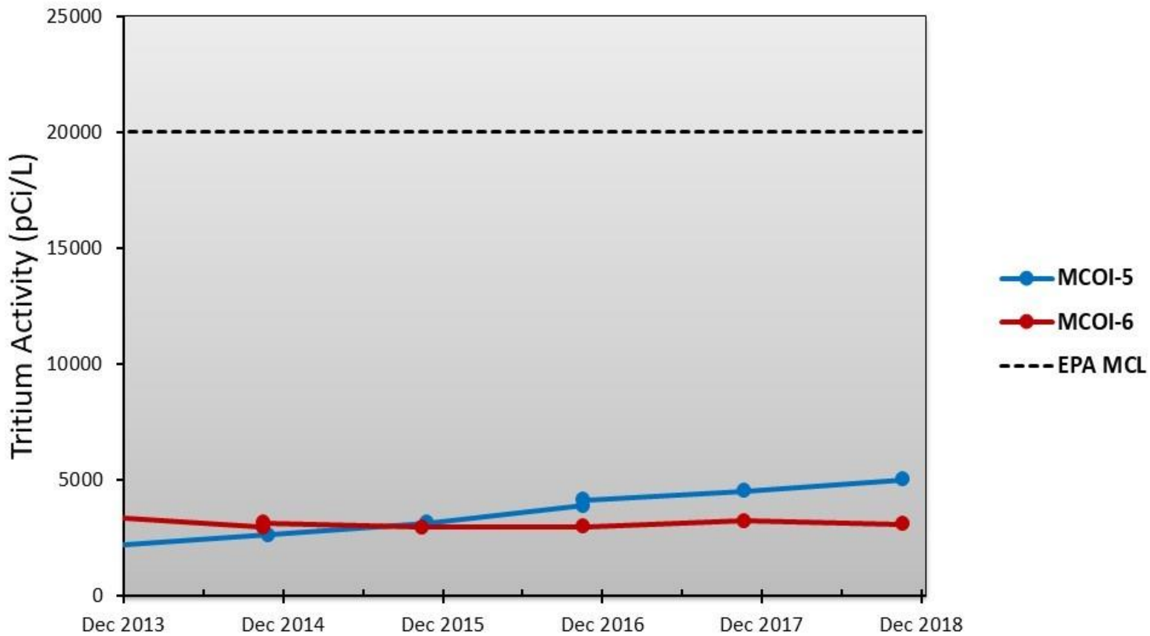

Figure 5-15. Tritium concentrations in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter (pCi/L).

The observation of increasing chromium concentrations in monitoring wells along the downgradient portion of the plume led the Laboratory to propose and implement actions to address plume migration. The Laboratory's Interim Measures Work Plan for Chromium Plume Control (LANL 2015a) presented an approach that uses extraction wells and injection wells to control plume migration. This approach was analyzed in the Environmental Assessment for Chromium Plume Control Interim Measure and Plume-Center Characterization (DOE 2015). The Laboratory is using three extraction wells and three injection wells to control plume migration, with the objective of establishing and maintaining the portion of the plume containing 50 micrograms per liter or more of chromium completely within the Laboratory boundary. To accomplish this, we are extracting contaminated groundwater from specific extraction wells, piping the extracted water to an above-ground ion exchange treatment system, and, following treatment, injecting the clean treated water back into the regional aquifer through injection wells located in the downgradient portion of the area of contamination. Extraction and injection activities were conducted in mid-February through mid-April and from late May until October of 2018.

The Investigation Work Plan for Chromium Plume-Center Characterization presents a set of activities to more fully characterize the aquifer and contaminant distribution in support of an eventual recommendation for a remediation strategy (LANL 2015b). Key activities involve pumping from a centroid extraction well and conducting various bench- and field-scale experiments to evaluate the use of chemicals and bio-amendments to treat chromium within the aquifer. A series of reports on these studies comprise the Compendium of Technical Reports Conducted Under the Work Plan for Chromium Plume Center Characterization (LANL 2018a).

Material Disposal Area C Monitoring Group

Material Disposal Area C is located on Mesita del Buey in Technical Area 50, at the head of Ten Site Canyon. It is an inactive landfill where solid low-level radioactive wastes and chemical wastes were disposed of between 1948 and 1974. Vapor-phase volatile organic compounds and tritium are present in the upper 500 feet of the unsaturated soil and rock beneath Material Disposal Area C (LANL 2011a). The primary volatile organic compound is trichloroethene. The Material Disposal Area C monitoring group includes nearby regional aquifer monitoring wells (Figure 5-5). Monitoring data indicate no groundwater contamination is present in the regional aquifer immediately downgradient of Material Disposal Area C, and no perched-intermediate zones have been encountered in the area.

Technical Area 54 Monitoring Group

Technical Area 54 is situated in the east-central portion of the Laboratory on Mesita del Buey. The technical area includes four material disposal areas designated as Areas G, H, J, and L; a waste characterization, storage, and transfer facility (Technical Area 54 West); active radioactive waste storage operations at Area G; hazardous and mixed-waste storage operations at Area L; and administrative and support areas.

At Technical Area 54, groundwater monitoring is conducted to support both (1) monitoring of solid waste management units and areas of concern (particularly Areas G, H, and L) under the Compliance Order on Consent and (2) the Laboratory’s Hazardous Waste Facility Permit. The Technical Area 54 monitoring group includes both perched-intermediate and regional wells (Figure 5-5).

Monitoring data show vapor-phase volatile organic compounds are present in the upper portion of the unsaturated zone beneath Areas G and L. The primary vapor-phase volatile organic compounds at Technical Area 54 are 1,1,1-trichloroethane; trichloroethene; and Freon-113. Tritium is also present (LANL 2005b, 2006, 2007).

There are a small number of detections of a variety of pollutants, including several volatile organic compounds, from the groundwater monitoring network around Technical Area 54. However, no constituents have been detected above applicable standards or screening levels. Tritium was not detected in any of the regional aquifer groundwater monitoring wells in the Technical Area 54 monitoring group. The sporadic and limited spatial nature of the volatile organic compound detections and the lack of tritium suggests that Technical Area 54 may not be the source of the detected compounds (LANL 2009b). Further evaluations of existing groundwater data near Technical Area 54 and detailed descriptions of analytical results in perched-intermediate and regional groundwater at Technical Area 54 are presented in the corrective measures evaluation reports for Material Disposal Areas G, H, and L (LANL 2011b, 2011c, 2011d).

Technical Area 16 260 Monitoring Group

Water Canyon and Cañon de Valle (a tributary of Water Canyon) cross the southern portion of LANL where the Laboratory develops and tests explosives. In the past, the Laboratory released wastewater into both canyons from several high-explosives-processing facilities in Technical Areas 16 and 09 (Figure 5-4). The Technical Area 16 260 monitoring group was established for the upper Water Canyon/Cañon de Valle watershed to monitor substances released from Consolidated Unit 16-021(c)-99, which includes the Technical Area 16 260 outfall and associated solid waste management units. The Technical Area 16 260 outfall discharged high-explosives bearing water from a high-explosives machining facility to Cañon de Valle from 1951 through 1996. These discharges served as a primary source of high-explosives and inorganic element contamination in the area (LANL 1998, 2003, 2011e). Data indicate that springs, surface water, alluvial groundwater, and perched-intermediate groundwater contain explosive compounds, including RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine); HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine); TNT (2,4,6-trinitrotoluene); and barium. RDX has been detected in the regional aquifer in wells R-18, R-63, and R-68 (Figure 5-16 and Figure 5-17). In addition, the volatile organic compounds tetrachloroethene and trichloroethylene, and boron have been detected in springs, alluvial groundwater, and perched-intermediate groundwater. Low concentrations of tetrachloroethene have been detected in the regional aquifer in wells R-25 screen 5 and R-18.

The primary transport pathway for these constituents is thought to involve infiltration in Cañon de Valle of effluent from the Technical Area 16 260 outfall mixed with seasonally variable amounts of naturally occurring surface water and alluvial groundwater and percolation through unsaturated rock layers to perched-intermediate groundwater zones and ultimately into the regional aquifer.

RDX is the primary groundwater contaminant in this area and the only contaminant that exceeds its groundwater standard (9.66 micrograms per liter) in the regional aquifer. One regional aquifer well, R-68, has shown RDX concentrations above the standard. RDX concentrations at R-68 are likely associated with RDX that was carried down during drilling of the well. More stable concentrations recorded during 2018 represent the actual concentrations present in the aquifer at the R-68 location during that period. RDX concentrations in regional monitoring wells R-63 and R-18 were below the groundwater standard, but are exhibiting somewhat increasing trends (Figure 5-17).

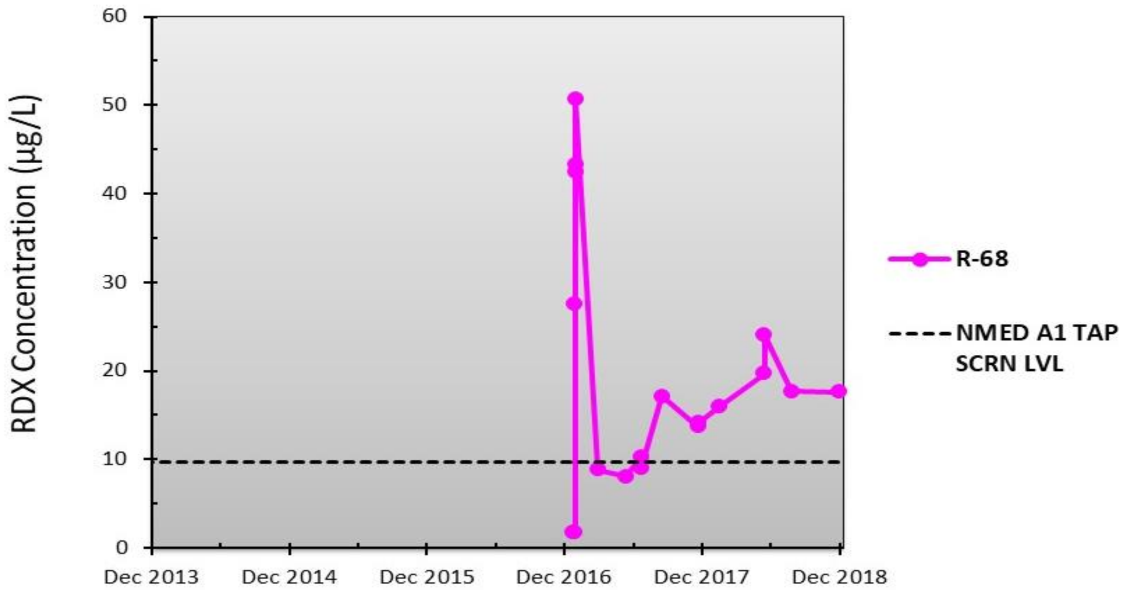

Figure 5-16. RDX concentrations in regional aquifer well R-68. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

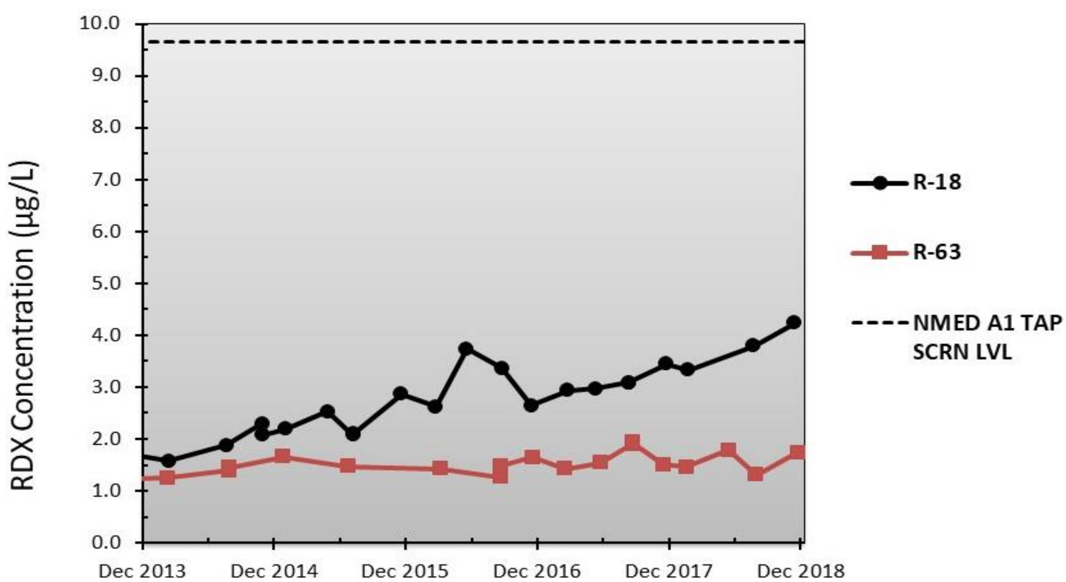

Figure 5-17. RDX concentrations in regional aquifer wells R-18 and R-63. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

Figure 5-18, Figure 5-19, and Figure 5-20 show RDX concentrations in springs, alluvial wells, and perched-intermediate wells in the Technical Area 16 260 Monitoring Group. The springs discharge from perched-intermediate groundwater zones.

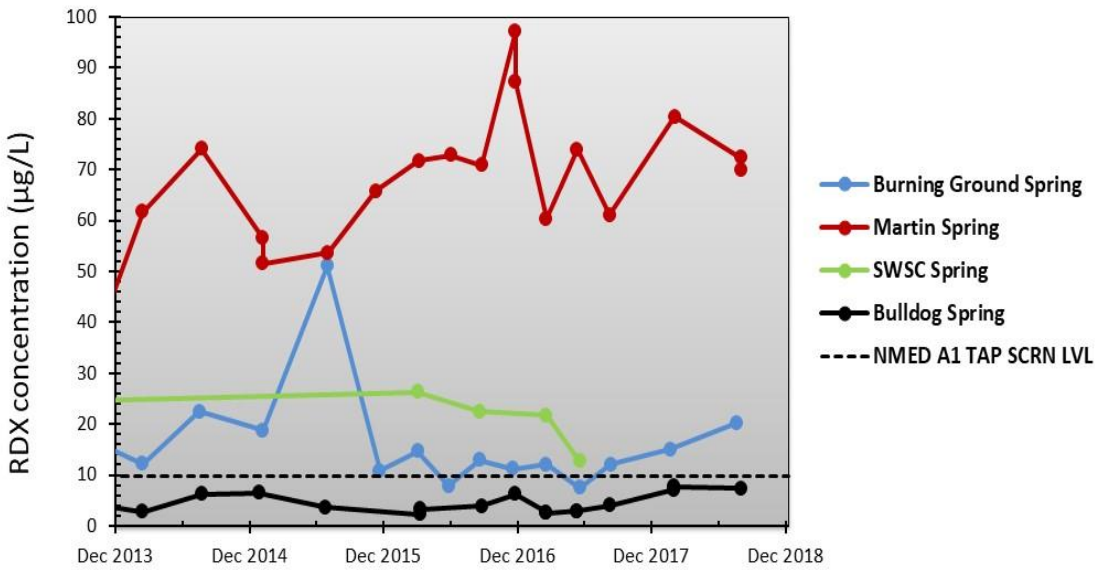

Figure 5-18. RDX concentrations in two springs in Cañon de Valle, one spring in Martin Spring Canyon, and one spring in Bulldog Gulch, in Technical Area 16 (see locations in Figure 5-5). The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

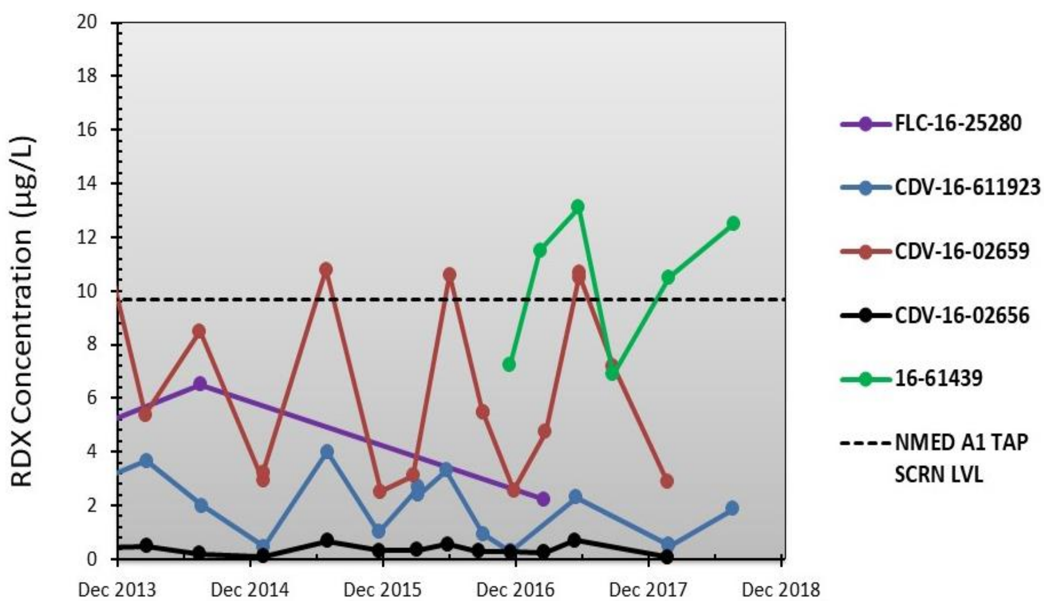

Figure 5-19. RDX concentrations in alluvial groundwater wells in Cañon de Valle and Fishladder Canyon. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

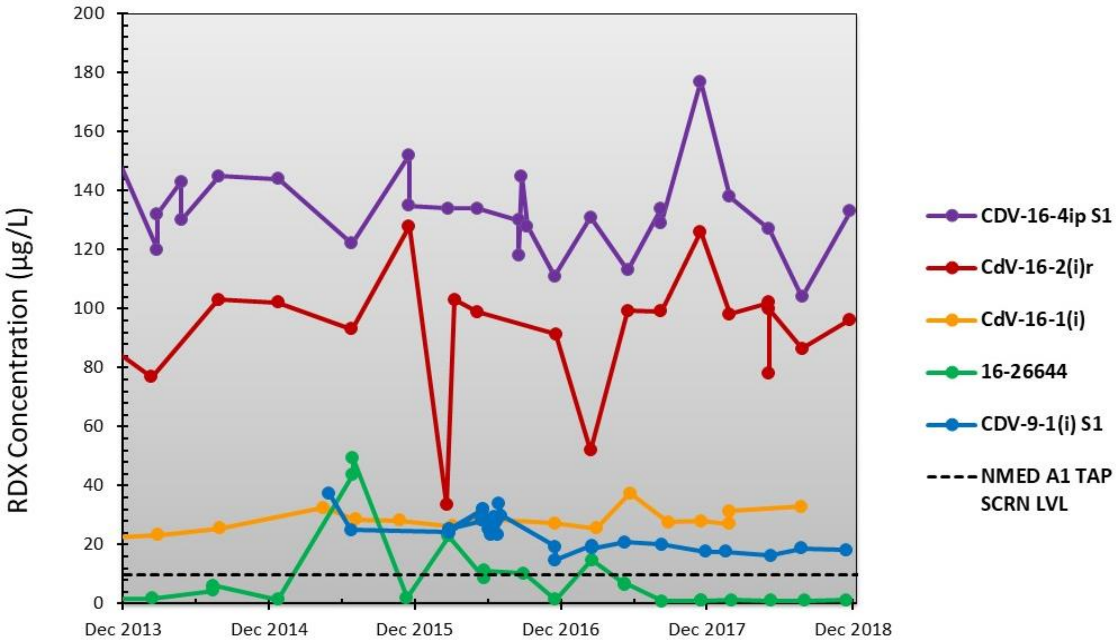

Figure 5-20. RDX concentrations in perched-intermediate groundwater wells. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

Of the springs sampled, the concentrations of RDX are highest in Martin Spring (Figure 5-18). RDX concentrations at Burning Ground Spring have been relatively steady over the last five years (Figure 5-18), with the exception of one sample collected in July 2015. SWSC Spring, near the former location of the Technical Area 16 260 outfall, does not have consistent flow, and was not sampled in 2018.

RDX concentrations in alluvial monitoring wells show significant variability because of seasonal influences, but remain relatively low (Figure 5-19). RDX concentrations in each of the perched-intermediate wells show some variability (Figure 5-20). Long-term monitoring of some of these springs and alluvial wells is now included in the annual Interim Facility-Wide Groundwater Monitoring Plan (N3B 2018).

Other substances, including tetrachloroethene, trichloroethene, boron, and barium, are present in all groundwater zones but are well below applicable standards in the regional aquifer. The investigation that is related to more fully understanding the extent and implications of RDX contamination in perched-intermediate and regional groundwater is ongoing and will be presented in a report scheduled for completion in 2019.

Material Disposal Area AB Monitoring Group

The Material Disposal Area AB monitoring group is located in Technical Area 49. Technical Area 49, also known as the Frijoles Mesa Site, is located on a mesa in the upper part of the Ancho Canyon drainage. Part of the area drains into Water Canyon (Figure 5-5). The canyons in the Ancho watershed are mainly dry with no known persistent alluvial groundwater zones and no known perched-intermediate groundwater.

Material Disposal Area AB was the site of nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987, LANL 1988). The testing involved isotopes of uranium and plutonium; lead and beryllium; explosives such as TNT, RDX, and HMX; and barium nitrate. Some of this material remains in shafts in the mesa top. Further information about activities, solid waste management units, and areas of concern at Technical Area 49 can be found in earlier Laboratory reports (LANL 2010a, 2010b).

In 2018, no constituents were found in Material Disposal Area AB monitoring group wells at concentrations above standards or screening levels.

White Rock Canyon Monitoring Group

The springs that flow along and near the Rio Grande in White Rock Canyon discharge predominantly regional aquifer groundwater (Purtymun et al. 1980). A few springs appear to represent discharge of perched-intermediate groundwater. Some other springs may discharge a mixture of regional aquifer groundwater, perched-intermediate groundwater, and percolation of recent precipitation (Longmire et al. 2007).

The White Rock Canyon springs serve as important monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande (Figure 5-7). Consistent with prior years' data, no springs that discharge groundwater from beneath the Laboratory into White Rock Canyon had any constituent concentrations above applicable groundwater standards or screening levels in 2018.

General Surveillance Monitoring

Los Alamos Canyon on Laboratory Property

Alluvial well LAO-3a in Los Alamos Canyon (Figure 5-6) continues to show strontium-90 concentrations above the U.S. Environmental Protection Agency's 8 picocuries per liter strontium-90 maximum contaminant level for drinking water (Figure 5-21). Alluvial well LAUZ-1 had not been sampled since 2011, but was sampled in 2018. In 2018, the concentration of strontium-90 was 15.6 picocuries per liter, which is below the 2011 concentration of 64.5 picocuries per liter. The source of the strontium-90 is Solid Waste Management Unit 21-011(k), which was an outfall from industrial waste treatment plants at Technical Area 21. Strontium-90 is persistent at this location but has not been detected migrating to downgradient locations (LANL 2004).

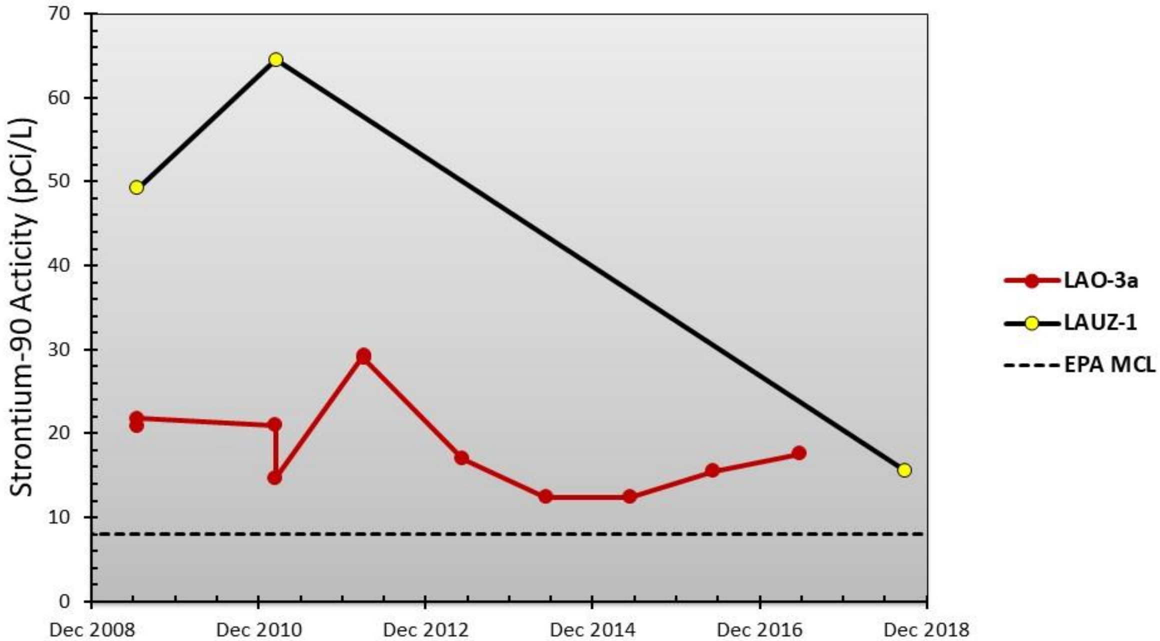

Figure 5-21. Strontium-90 concentrations at alluvial monitoring well LAO-3a and LAUZ-1. The U.S. Environmental Protection Agency maximum contaminant level for strontium-90 in drinking water value is 8 picocuries per liter (pCi/L). EPA MCL = U.S. Environmental Protection Agency maximum contaminant level for drinking water.

Lower Los Alamos Canyon

Vine Tree Spring on Pueblo de San Ildefonso land represents discharge of perched-intermediate groundwater. Sampling at Vine Tree Spring began as a replacement for nearby Basalt Spring, which had been sampled since the 1950s until it dried up around 2010. The perchlorate concentration in Vine Tree Spring for 2018 is consistent with prior years' data. The perchlorate contamination may be associated with historical Laboratory operations. For context, the perchlorate values are below the risk-based screening level of 13.8 micrograms per liter (Figure 5-22). The screening level for perchlorate is determined according to a hierarchical data-screening process required under the 2016 Consent Order.

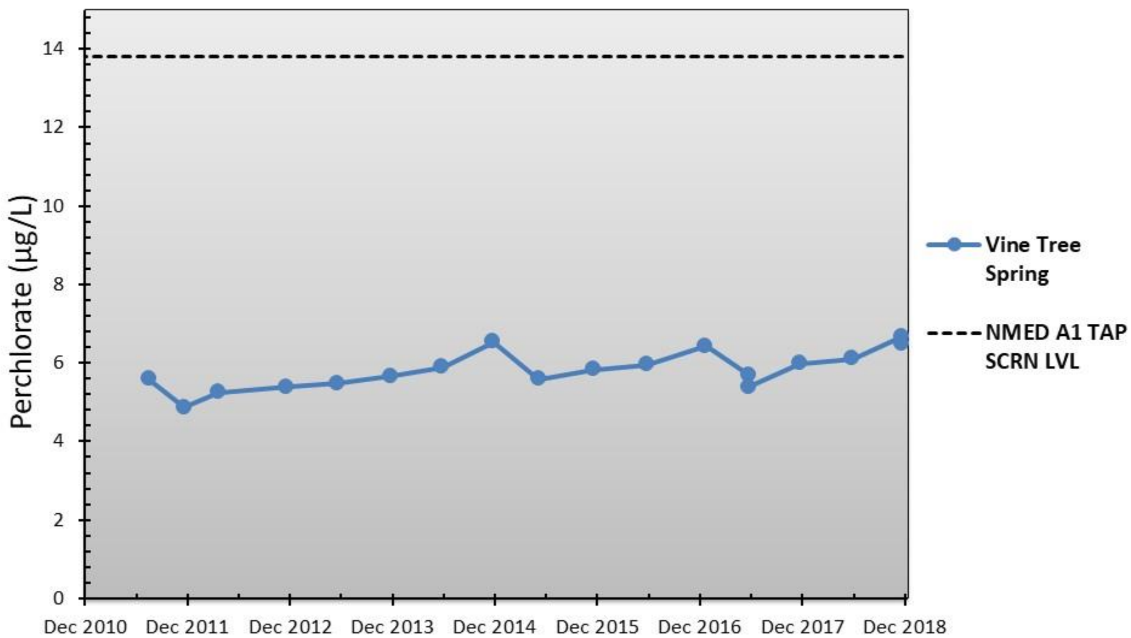

Figure 5-22. Perchlorate concentrations at Vine Tree Spring. The New Mexico risk-based screening level for perchlorate is 13.8 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

Sandia Canyon

The General Surveillance monitoring group wells located in Sandia Canyon that are not part of the Chromium Investigation monitoring group include regional aquifer wells R-10 and R-10a and perched-intermediate well R-12; wells R-10 and R-10a are on Pueblo de San Ildefonso land. No constituents were measured near or above standards or screening levels in these wells during 2018.

Mortandad Canyon

Several regional aquifer wells in Mortandad Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above standards or screening levels in these wells during 2018.

Under the groundwater discharge plan application for the Technical Area 50 Radioactive Liquid Waste Treatment Facility outfall, quarterly samples are collected for nitrate, fluoride, perchlorate, and total dissolved solids from three alluvial monitoring wells below the outfall in Mortandad Canyon: MCO-4B, MCO-6, and MCO-7. Perchlorate was detected at all three wells (Figure 5-23). Effluent treatment at the Radioactive Liquid Waste Treatment Facility was upgraded in 2002. Since that time the perchlorate concentrations from the wells remain low relative to past perchlorate concentrations in Mortandad Canyon alluvial groundwater. All results are below the perchlorate groundwater screening level. Nitrate, fluoride, and total dissolved solids are also far below applicable standards in these alluvial wells.

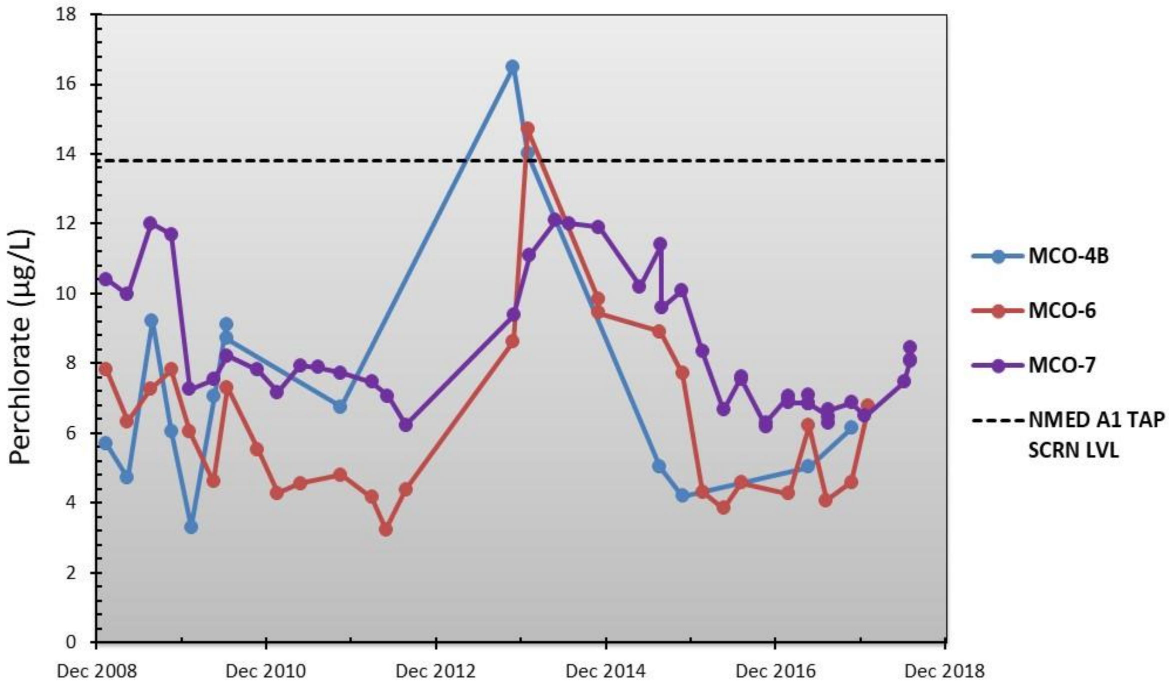

Figure 5-23. Perchlorate concentrations at General Surveillance monitoring group and groundwater discharge plan monitoring wells MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon alluvial groundwater. The New Mexico tap water screening level for perchlorate is 13.8 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was dry in 2018 and therefore not sampled.

Pajarito Canyon

Pajarito Canyon has a watershed that begins in the Sierra de los Valles west of the Laboratory. Twomile and Threemile Canyons at the Laboratory are tributaries of Pajarito Canyon. Saturated alluvium is present in portions of Pajarito Canyon, including a reach in lower Pajarito Canyon, but does not extend beyond the Laboratory's eastern boundary. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several high-explosives-processing sites at Technical Area 09. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at Technical Area 18. Waste management areas at Technical Area 54 occupy the mesa north of the lower part of the canyon.

Solid Waste Management Unit 03-010(a) is the outfall area from a former vacuum repair shop behind the warehouse at Technical Area 03. The outfall area is located on a small tributary to Twomile Canyon. A small zone of shallow perched-intermediate groundwater is present and is apparently recharged by runoff from adjacent parking lots and building roofs. This perched groundwater is sampled at a depth of approximately 21 feet by well 03-B-13. In 2018, samples from this well contained 1,1,1-trichloroethane at concentrations below the New Mexico groundwater standard (Figure 5-24). Concentrations of 1,4-dioxane in 03-B-13 were the lowest ever recorded (Figure 5-25).

Several other alluvial and perched-intermediate groundwater and regional aquifer wells in Pajarito Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above applicable standards or screening levels in these wells during 2018.

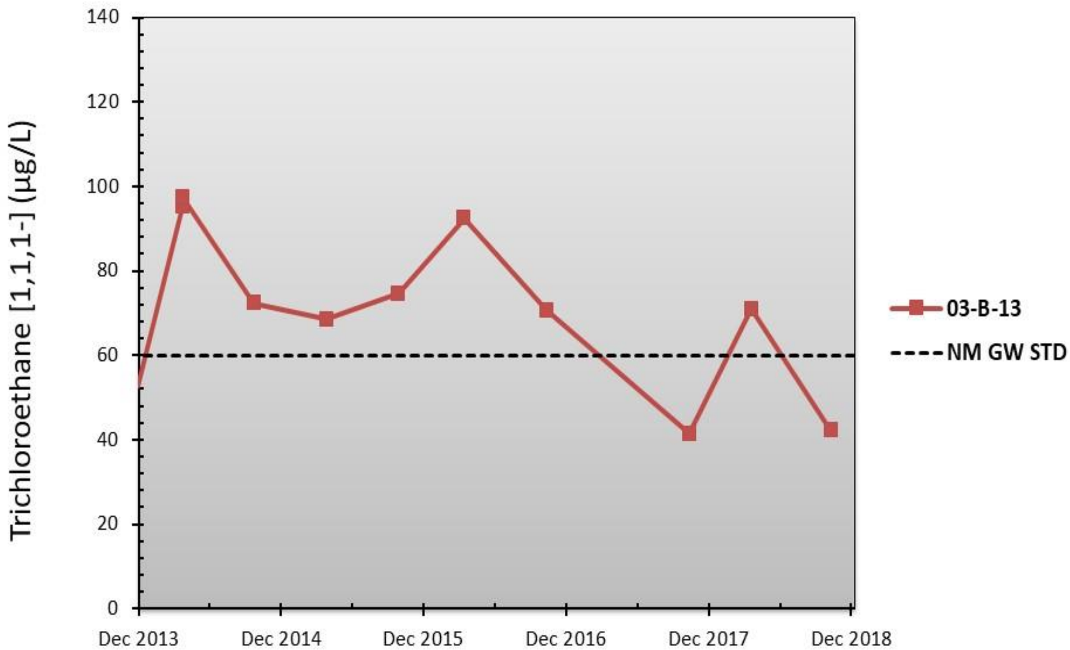

Figure 5-24. Concentrations of 1,1,1-trichloroethane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,1,1-trichloroethane is 60 micrograms per liter (µg/L). NM GW STD = New Mexico groundwater standard.

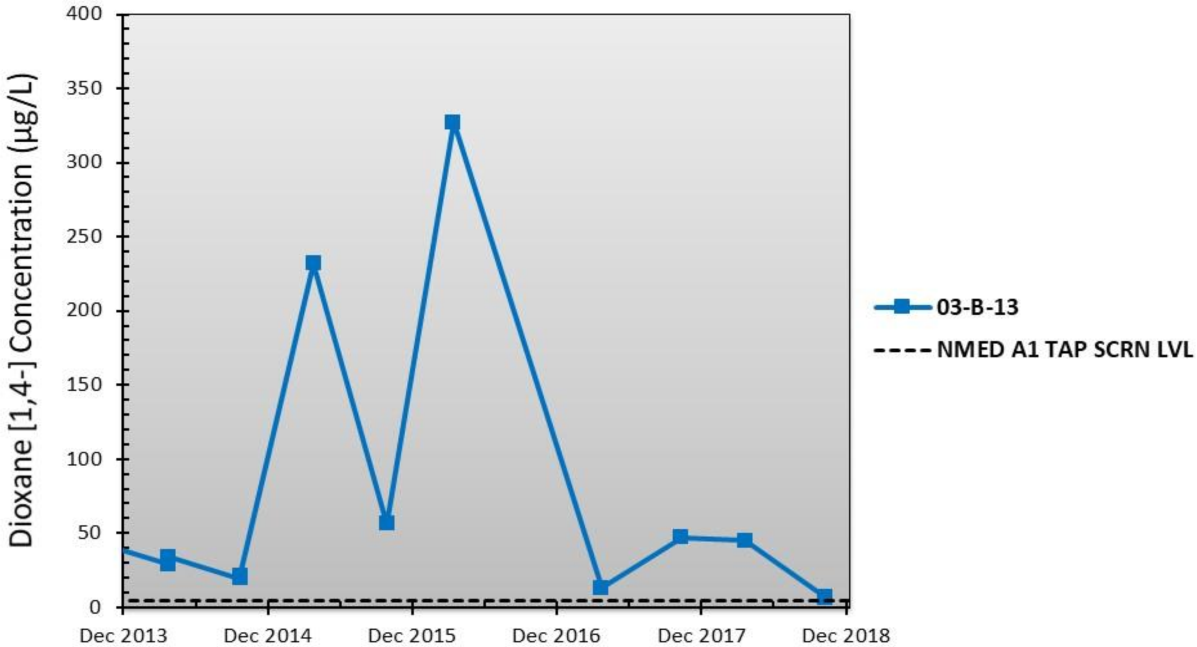

Figure 5-25. Concentrations of 1,4-dioxane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L). NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

Water Canyon

Water Canyon has only one General Surveillance monitoring group location, alluvial well WCO-1r. No constituents were detected above applicable standards or screening levels in this well in 2018.

SUMMARY

The Laboratory has been monitoring groundwater for many years. The groundwater monitoring network has been significantly expanded over the last decade. This expanded network has improved our understanding of the nature and extent of groundwater contamination. As described in this chapter, only two areas are showing groundwater contaminants that are of sufficient concentration and extent to warrant an action such as interim measures, further characterization, and potential remediation under the 2016 Consent Order: RDX contamination in the vicinity of Technical Area 16 and chromium contamination beneath Sandia and Mortandad Canyons. We will continue to implement interim measures in the chromium plume in 2019 and beyond. Further characterization work and studies to evaluate groundwater risks and potential remediation strategies are ongoing in both of these areas.

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Chapter 6 – WATERSHED QUALITY

Los Alamos National Laboratory (the Laboratory) collects and analyzes storm water runoff to check for a variety of substances and characteristics, such as chemical and radionuclide levels, the volume and duration of flow, and the total amount of suspended sediment. We compare these sampling results with New Mexico water quality standards, target action levels, and radiological dose guidelines. The State of New Mexico uses our surface water data in updating its determinations of impaired waters on and near the Laboratory every two years.

We also analyze newly deposited sediment samples each year for chemical and radionuclide levels. We compare sediment sampling results with human and ecological health screening criteria.

The data collected in 2018 and presented in this chapter are used to verify that during 2018, the storm water–related transport of chemicals or radionuclides did not cause levels of those substances to exceed the levels found during the canyons investigations of 2004–2011. We have found that over time, at any given sampling location, storm water–related transport of sediments generally results in similar or lower levels of Laboratory-released chemicals and radionuclides at that location than previously existed because of the deposit of new sediments. The results of the sediment and surface water data collected in 2018 support the conclusion that the risk assessments presented in the canyons investigation reports represent an upper bound of risks from these substances in the canyons for the foreseeable future. The Laboratory continues to have several impaired stream reaches, as defined by the New Mexico Environment Department. Laboratory industrial outfalls and dredge and fill activities are regulated to help minimize these impairments.

CONTENTS

INTRODUCTION

Effluents containing radionuclides, inorganic chemicals, and organic chemicals were discharged to canyons around Los Alamos National Laboratory (LANL or the Laboratory) during the early years of operations. Treatments to reduce contaminants in effluents began in the 1950s. Effluent discharges at the Laboratory have been conducted under permits from regulatory agencies since 1978.

There are also natural and non-Laboratory but human-related sources of chemicals and radionuclides, such as the natural composition of rocks and soils, substances associated with trees burned during forest fires, atmospheric fallout of radionuclides and of chemicals such as polychlorinated biphenyls (PCBs), and releases from other developed areas on the Pajarito Plateau. All of the above sources contribute to the measured levels of chemicals and radionuclides in surface water and sediment across the plateau.

We monitor chemical and radionuclide levels in surface water and sediment in and around the Laboratory to (1) document the water quality in streams within and downstream of the Laboratory and (2) evaluate risks to human and ecosystem health. Sampling results are compared with New Mexico water quality standards, target action levels, radiological dose guidelines, and human and ecosystem health screening criteria. The New Mexico Environment Department Surface Water Quality Bureau uses the surface water results to evaluate impairment of the Laboratory’s stream reaches under Section 303(d) of the Clean Water Act. They update the list of impaired stream reaches on Laboratory property every two years.

The data presented in this chapter originate from three Laboratory programs:

- Annual environmental surveillance sampling (N3B 2018a, N3B 2019a)
- The annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2017, N3B 2018b), which includes sampling of persistent surface water in streams
- Storm water runoff monitoring associated with the Individual Permit (the authorization to discharge [from solid waste management units and areas of concern] under the National Pollutant Discharge Elimination System) (N3B 2019b).

The legacy waste cleanup contractor Newport News Nuclear BWXT-Los Alamos (N3B) assumed responsibility for implementing the Laboratory's surface water and sediment surveillance programs, groundwater protection program, and the Individual Permit in April 2018.

At the Laboratory, we consider any soil that is either suspended in water or that has been deposited by surface water flows as sediment. Many of our sediment samples are collected from dry stream channels or adjacent floodplains, and not from aquatic habitats.

STANDARDS, SCREENING LEVELS, AND DESIGNATED USES FOR STREAM REACHES

Under Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code, stream reaches within the Laboratory boundary are classified as perennial (having water throughout the year), intermittent (having water for extended periods only at certain times of the year), or ephemeral (having water briefly only in direct response to precipitation) (New Mexico Water Quality Control Commission 2013). Based on their characteristics, the stream reaches are assigned one or more of the following designated uses: cold water aquatic life, marginal warm water aquatic life, limited aquatic life, livestock watering, wildlife habitat, primary (human) contact, and secondary (human) contact. The locations of these stream reaches and their classifications are shown in Figure 6-1, and their designated use(s) are given in Table 6-1.

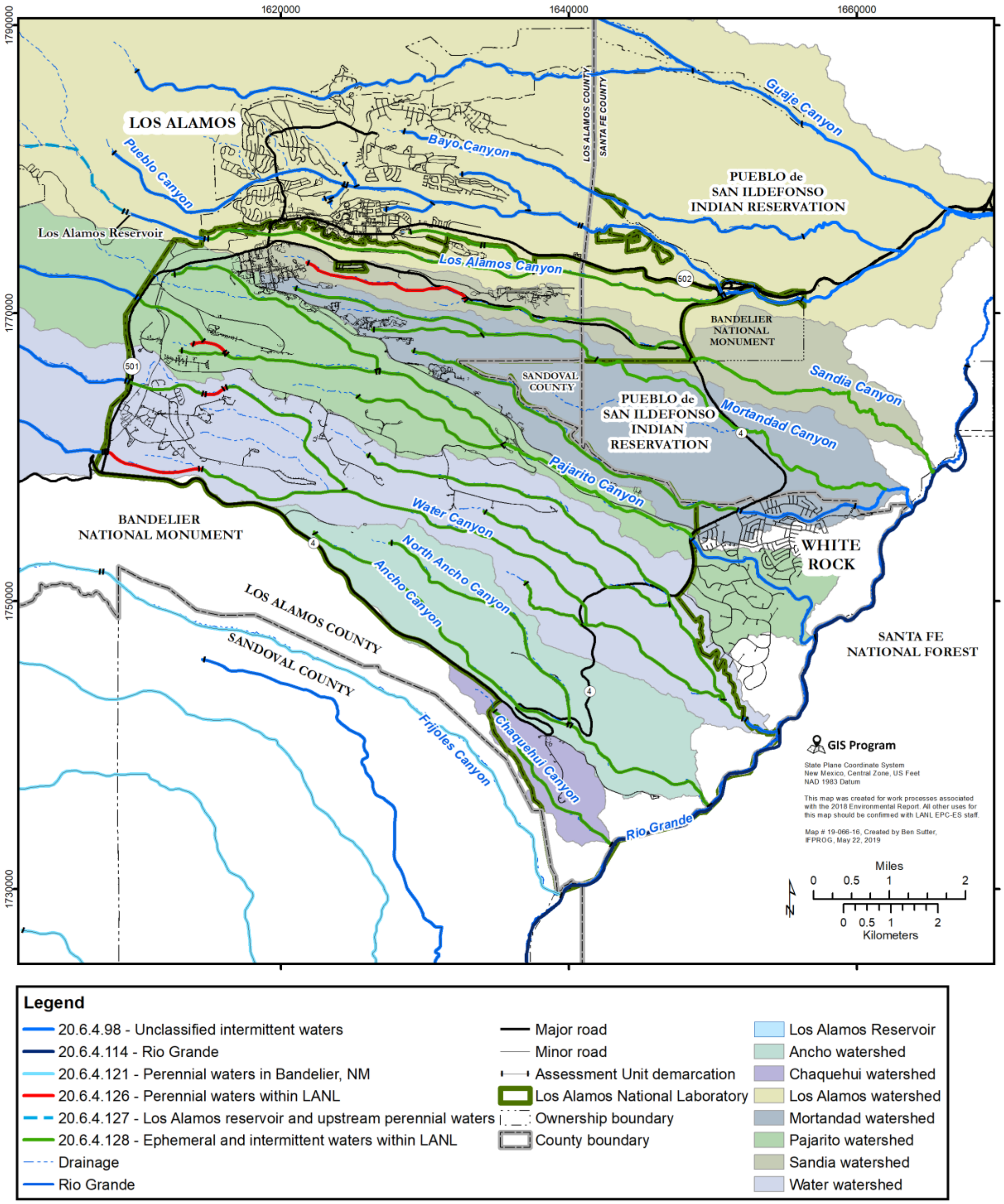

Figure 6-1. Stream reaches and watersheds within and around the Laboratory. Map shows the classifications of streams from Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code (New Mexico Water Quality Control Commission 2013).

Surface Water Standards and Screening Levels

The New Mexico Water Quality Control Commission establishes surface water quality standards for New Mexico in Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code. The current standards were approved by the Environmental Protection Agency on June 5, 2013, and can be found online at https://www.env.nm.gov/swqb/Standards/20.6.4NMAC.pdf (New Mexico Water Quality Control Commission 2013). We use the protocol employed by the New Mexico Environment Department for assessing attainment of surface water quality standards (New Mexico Environment Department 2015). In addition, hardness-dependent aquatic life criteria are calculated using water hardness values of concurrent samples where available, and 30 milligrams calcium carbonate per liter (mg $CaCO_3$/L) where hardness values are not available (U.S. Environmental Protection Agency 2006a, New Mexico Water Quality Control Commission 2013).

U.S. Department of Energy (DOE) Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, prescribes total dose limits associated with radionuclides. There are no drinking water systems on the Pajarito Plateau that rely on surface water. Therefore, the radiological assessment of surface water looks at potential exposures of wildlife and aquatic organisms (collectively known as “biota”). We compare radionuclide activities in surface water with the DOE biota concentration guides (DOE 2002, 2004) for water with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for either aquatic, riparian, or terrestrial animals are used for evaluation, depending on how often surface water is present at each location being evaluated. Perennial reaches are screened using aquatic and riparian animal biota concentration guides; intermittent reaches are screened using aquatic, terrestrial, and riparian biota concentration guides; ephemeral reaches are screened using terrestrial animal biota concentration guides.

We compare surface water results for gross alpha radioactivity and radium isotopes with the New Mexico water quality standards. The gross alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act of 1954. The gross alpha radioactivity data discussed in this chapter were not adjusted to remove these sources of radioactivity.

We compare surface water results from the Individual Permit site monitoring areas with the target action levels specified in the Individual Permit. Additional details for site monitoring area results are provided in the Individual Permit Annual Report (N3B 2019c).

What are these terms related to surface water?

Surface water – water on the surface of a continent, such as in a river, lake, or wetland

Watershed – the area of land that contributes water flow to a particular stream or river

Stream reach – a small section of a stream or river

Storm water – water that comes as runoff from rain and snowmelt events

Floodplain – an area of land adjacent to a stream that may receive water when the stream floods

Effluent – water resulting from industrial processes that is discharged to the environment

Base flow – the portion of a stream’s flow that is not from storm water, but rather discharges from the ground

Sediment Screening Levels

We compare sediment results for chemicals with the New Mexico Environment Department's risk-based soil screening levels (New Mexico Environment Department 2017) and sediment results for radionuclides with the Laboratory's risk-based screening action levels (LANL 2015a). If there are no New Mexico soil screening levels for a particular chemical, the U.S. Environmental Protection Agency's regional screening levels are used (U.S. Environmental Protection Agency 2016). Soil screening levels for inorganic and organic chemicals and screening action levels for radionuclides are levels considered safe for industrial, construction worker, or residential exposure scenarios. If concentrations of substances are below screening action levels or soil screening levels, then adverse human health effects are highly unlikely. In addition, we use sediment background values from Ryti et al. (1998) for reference. (Note: The New Mexico surface water quality standards only address total PCBs, while the soil screening levels address individual PCB congeners, but not total PCBs).

For protection of biota, we compare levels of radionuclides in sediment with the DOE biota concentration guides (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for riparian and terrestrial animals are used for evaluation.

Impairment Assessments for Stream Reaches

Each stream within the Laboratory boundary is divided into segments and may be further divided into assessment units, which are used by the state of New Mexico in its biennial stream impairment assessment. The state's findings for each assessment unit on and around Laboratory lands are provided in Table 6-1 (New Mexico Environment Department 2018). An assessment unit is considered impaired when one or more of the New Mexico surface water quality standards are not being met for one or more pollutants.

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TABLE 6-1. LANL ASSESSMENT UNITS, IMPAIRMENT CAUSE, AND DESIGNATED USE(S) THAT ARE SUPPORTED, NOT SUPPORTED, OR NOT ASSESSED

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Acid Canyon (Pueblo to headwaters)	PCBs,* copper,† aluminum	None	Wildlife habitat, livestock watering, marginal warm water aquatic life	Primary contact
Ancho Canyon (North Fork to headwaters)	PCBs	Wildlife habitat	Limited aquatic life	Secondary contact, livestock watering
Ancho Canyon (Rio Grande to North Fork Ancho)	Aluminum, gross alpha,‡ PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Arroyo de la Delfe (Pajarito Canyon to headwaters)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Cañada del Buey (within LANL)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life	Secondary contact, wildlife habitat
Cañon de Valle (below LANL gage E256)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Cañon de Valle (LANL gage E256 to Burning Ground Spring)	Gross alpha, aluminum, PCBs	None	Livestock watering, cold water aquatic life, wildlife habitat	Secondary contact
Cañon de Valle (upper LANL bnds to headwaters)	Gross alpha, aluminum, PCBs	Wildlife habitat	Marginal warm water aquatic life, livestock watering	Primary contact
Cañon de Valle (within LANL above Burning Ground Spring)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Chaquehui Canyon (within LANL)	Full support (livestock watering, wildlife habitat, limited aquatic life), not assessed (secondary contact)	Wildlife habitat, livestock watering, limited aquatic life	None	Secondary contact
DP Canyon (Grade Control to upper LANL bnd)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
DP Canyon (Los Alamos Canyon to grade control)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Fence Canyon (above Potrillo Canyon)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Graduation Canyon (Pueblo Canyon to headwaters)	Copper,[†] aluminum, PCBs	Livestock watering	Wildlife habitat, marginal warm water aquatic life	Primary contact
Indio Canyon (above Water Canyon)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Kwage Canyon (Pueblo Canyon to headwaters	Not assessed	Not applicable	Not applicable	Primary contact, wildlife habitat, livestock watering, marginal warm water aquatic life
Los Alamos Canyon (DP Canyon to upper LANL boundary)	Aluminum, gross alpha, total mercury, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Los Alamos Canyon (NM-4 to DP Canyon)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Mortandad Canyon (within LANL)	Aluminum, copper,[†] gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
North Fork Ancho Canyon (Ancho Canyon to headwaters)	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Pajarito Canyon (Arroyo de La Delfe to Starmers Spring)	Aluminum	Livestock watering, wildlife habitat	Cold water aquatic life	Secondary contact
Pajarito Canyon (lower LANL boundary to Twomile Canyon)	Aluminum, PCBs	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
Pajarito Canyon (Twomile Canyon to Arroyo de La Delfe)	PCBs, copper,[†] gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Pajarito Canyon (upper LANL boundary to headwaters)	PCBs, selenium, gross alpha, arsenic, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Pajarito Canyon (within LANL above Starmers Gulch)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Potrillo Canyon (above Water Canyon)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Pueblo Canyon (Acid Canyon to headwaters)	PCBs, gross alpha, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Canyon to Los Alamos Waste Water Treatment Plant)	PCBs, gross alpha, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Waste Water Treatment Plant to Acid Canyon)	PCBs, gross alpha	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Sandia Canyon (Sigma Canyon to National Pollutant Discharge Elimination System outfall 001)	PCBs, dissolved thallium, copper,[†] aluminum, gross alpha	None	Wildlife habitat, livestock watering, cold water aquatic life	Secondary contact
Sandia Canyon (within LANL below Sigma Canyon)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
South Fork Acid Canyon (Acid Canyon to headwaters)	Zinc,[†] copper,[†] PCBs, gross alpha	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Ten Site Canyon (Mortandad Canyon to headwaters)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Threemile Canyon (Pajarito Canyon to headwaters)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Twomile Canyon (Pajarito Canyon to headwaters)	PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Walnut Canyon (Pueblo Canyon to headwaters)	Copper,[†] PCBs	Wildlife habitat, livestock watering	Marginal warm water aquatic life	Primary contact
Water Canyon (Area-A Canyon to New Mexico 501)	Aluminum	Wildlife habitat, livestock watering	Cold water aquatic life	Secondary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Water Canyon (within LANL above New Mexico 501)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Water Canyon (within LANL below Area-A Canyon)	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

**PCBs are total PCBs in the water column.*

†Levels of these metals are considered an impairment for acute aquatic life standards.

‡Gross alpha levels in surface water samples are currently not adjusted to remove sources of radioactivity from source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act of 1954.

HYDROLOGIC SETTING

Laboratory lands contain all or parts of seven primary watersheds that drain into the Rio Grande (Figure 6-1). Listed from north to south, the major canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui canyons. Each of these watersheds includes tributary canyons of various sizes. Los Alamos, Pajarito, and Water canyons have their headwaters west of the Laboratory in the eastern Jemez Mountains, mostly within the Santa Fe National Forest. The remainder of the primary watersheds have their headwaters on the Pajarito Plateau. Only the Ancho Canyon watershed is located entirely on Laboratory land.

In 2018, there was no snowmelt runoff that crossed the downstream (eastern) boundary of the Laboratory. Total storm water runoff for 2018 measured at the downstream Laboratory boundary is estimated at 33.2 acre-feet. Most of this runoff occurred in Ancho, Chaquehui, and Mortandad canyons; minimal runoff (less than 1.0 acre-feet) occurred in Los Alamos, Pueblo, Sandia, Water, and Potrillo canyons and Cañada del Buey; and no runoff occurred in Pajarito Canyon. No effluent from the Los Alamos County Waste Water Treatment Facility reached the gaging station in lower Pueblo Canyon during storm events in 2018. Figure 6-2 shows the precipitation and storm water runoff volume for the Laboratory for the monsoonal period of June through October during the years 1995 to 2018.

SURFACE WATER AND SEDIMENT SAMPLING

Surface Water Sampling Locations and Methods

Surface water is sampled in all major canyons and tributaries on current or former Laboratory lands. This includes an emphasis on monitoring close to and downstream of potential sources of Laboratory-released substances, including monitoring at the downstream Laboratory boundaries and east of New Mexico State Road 4.

We maintain 37 stream gaging stations on and near the Laboratory, all of which are equipped with automated samplers that activate at the start of storm water runoff events. Storm water samples are also collected at eight additional stream channel locations without active gaging stations. The number of gaging stations and sample locations remains fairly constant from year to year. However, not all gaging stations and sample locations experience storm water flow in any given year, so the number of stations sampled varies among years. Locations of stream gaging stations and stream channel sampling locations are chosen to monitor surface water flow onto and off of Laboratory and former Laboratory lands and at the confluence of canyons. The number and locations of samples are adjusted in response to events such as major floods, forest fires, and changes to stream impairments.

The automated samplers at gaging stations collect water from the peak of the runoff event, referred to as the “first flush.” The year 2018 was the fourteenth year that the first flush of storm water was sampled at many gaging stations, which represents a significant change from 2003 and earlier when samples were collected continuously over a two-hour period. Higher suspended sediment concentrations tend to occur in the first flush compared with the average concentration over a runoff event (Malmon et al. 2004, 2007). As a result, current storm water sampling results are not directly comparable with data from 2003 and earlier (Figure 6-2). Beginning in 2010, we also collected multiple storm water samples during individual runoff events to evaluate changes in suspended sediment and constituent concentrations during the course of a runoff event.

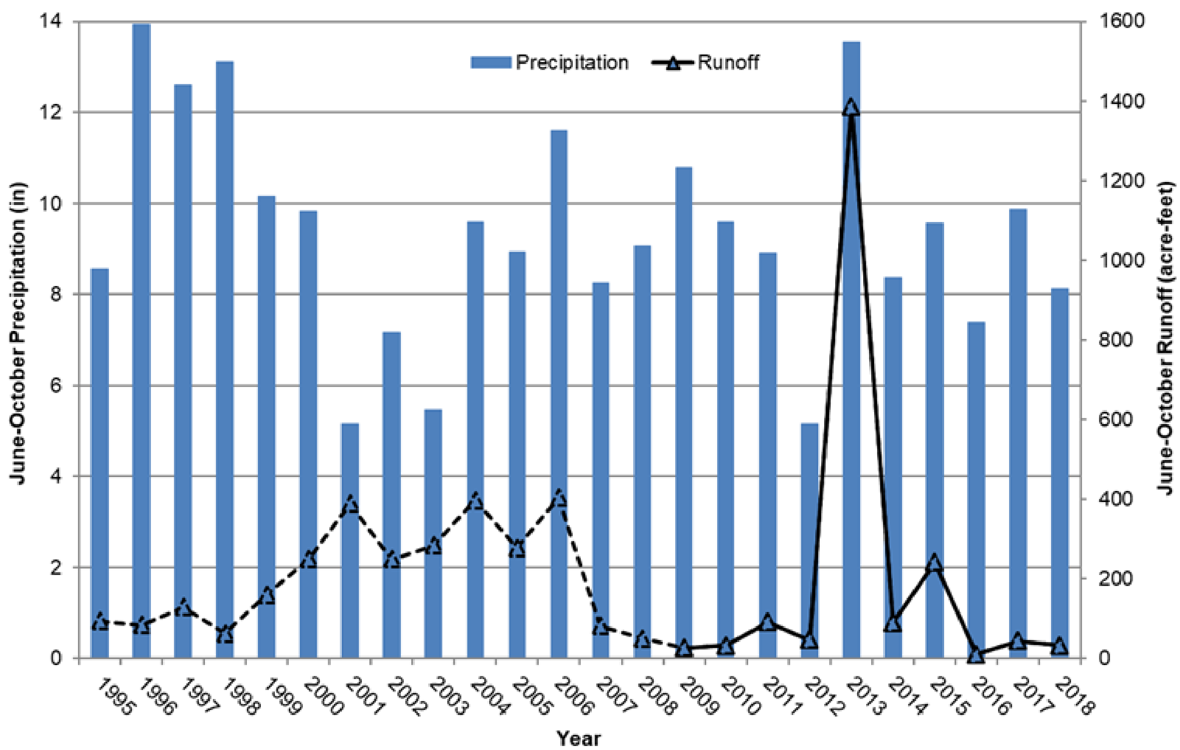


Figure 6-2. Total June-October precipitation from 1995 to 2018 averaged across the Laboratory's meteorological tower network (Technical Area 06, Technical Area 49, Technical Area 53, Technical Area 54, and northern community), and estimated June–October storm water runoff volume in Laboratory canyons from 1995 to 2018. Dashed line indicates data with potential quality issues.

To meet monitoring requirements under the Individual Permit, we have also installed samplers in 250 site monitoring areas to directly sample storm water runoff from 405 solid waste management units and areas of concern. These samplers are not kept on during months with freezing temperatures. Because rainstorms on the Pajarito Plateau are frequently very localized and not all rainfall events produce storm water runoff, not all active Individual Permit sampling locations collect samples each year.

Water discharged from springs is a type of base flow (the portion of stream flow that is not runoff). We collected grab samples of surface water below springs that discharge groundwater at locations identified in the "Interim Facility-Wide Groundwater Monitoring Plan for the 2018 Monitoring Year, October 2017–September 2018" and the "Interim Facility-Wide Groundwater

Monitoring Plan for the 2019 Monitoring Year, October 2018–September 2019" (LANL 2017, N3B 2018b).

Figure 6-3 shows locations sampled in 2018 for storm water at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs. Figure 6-4 shows locations of Individual Permit site monitoring areas where storm water runoff samplers collected compliance samples in 2018.

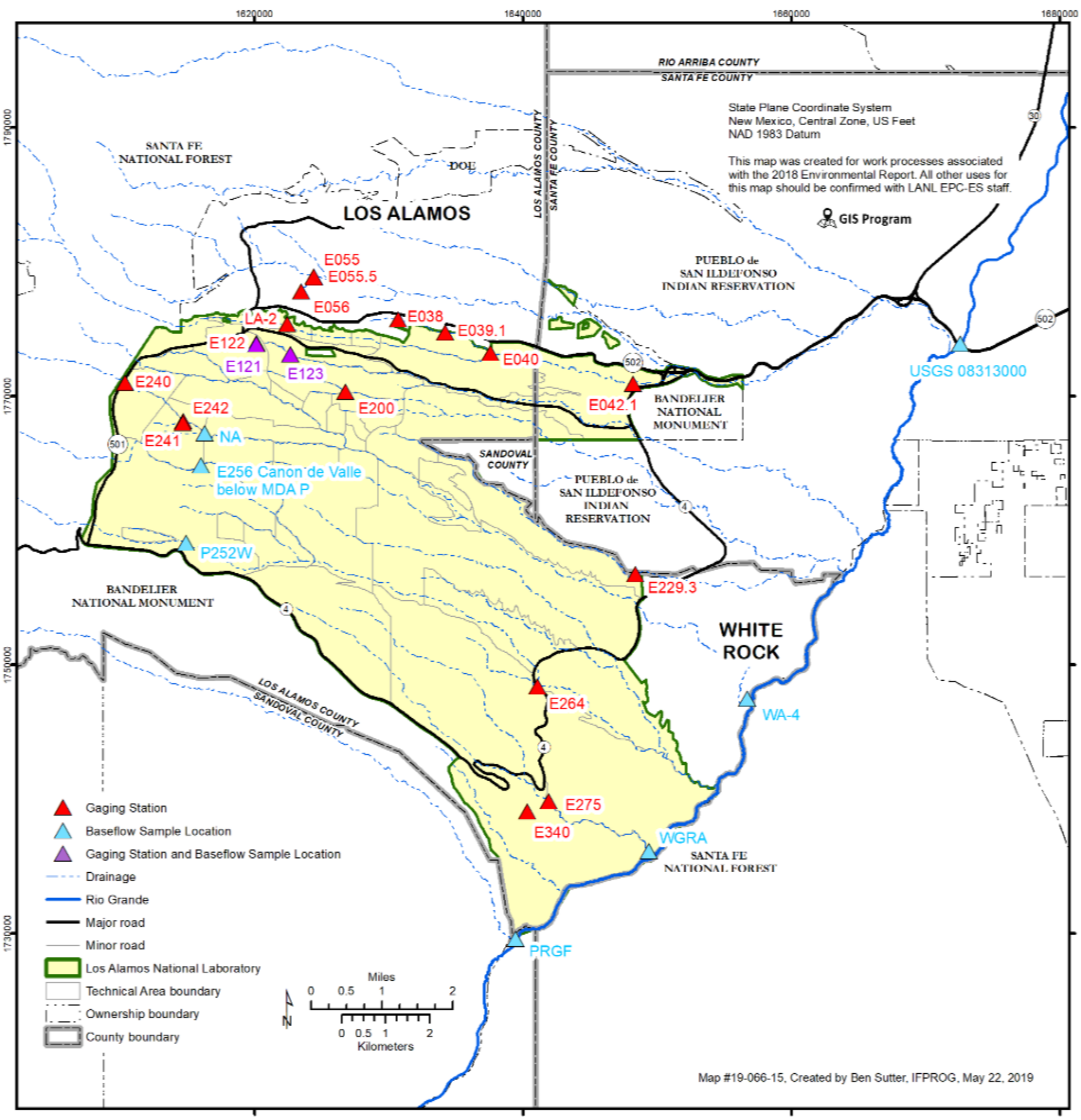


Figure 6-3. Locations sampled for storm water in 2018 at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs

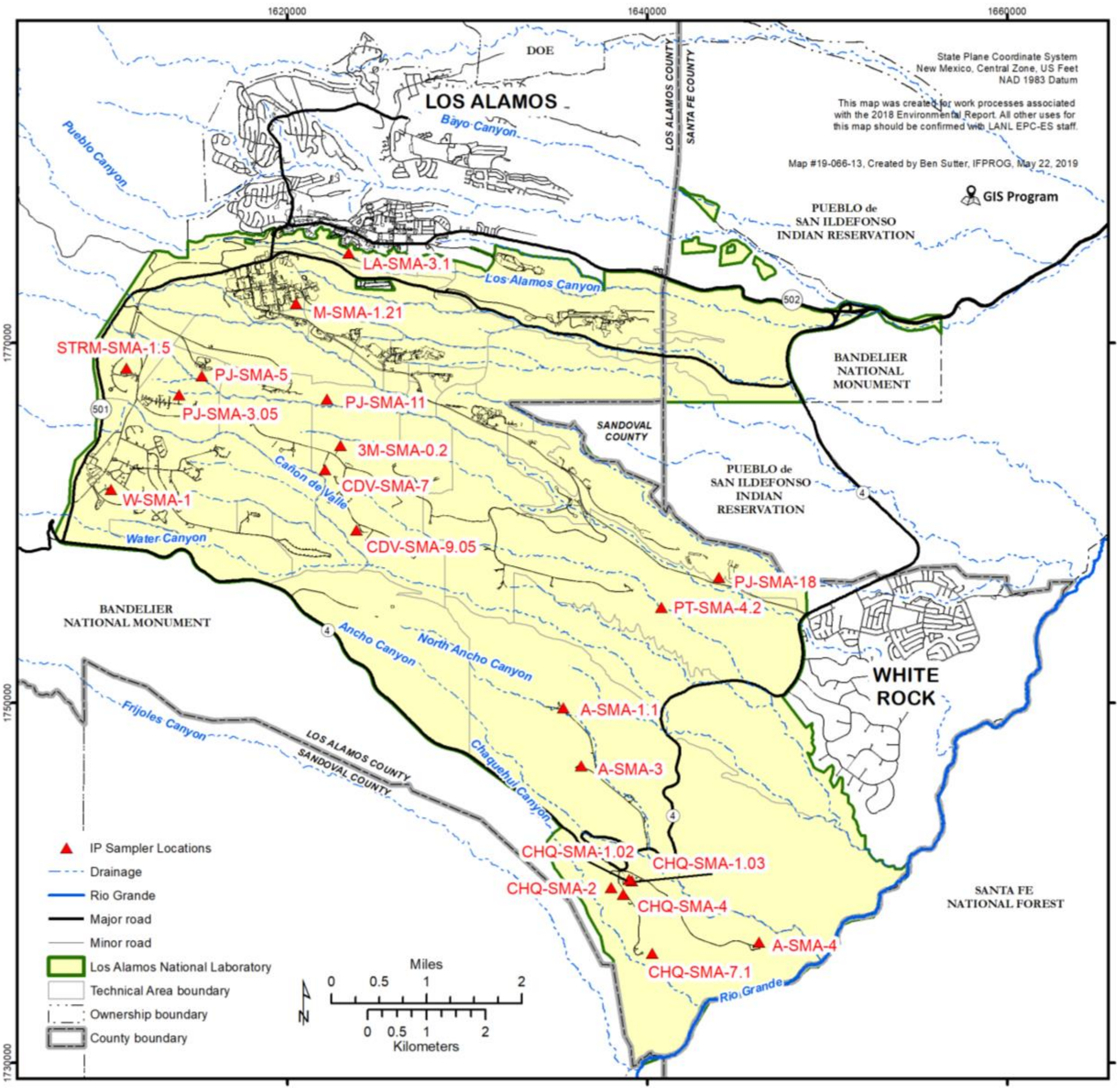
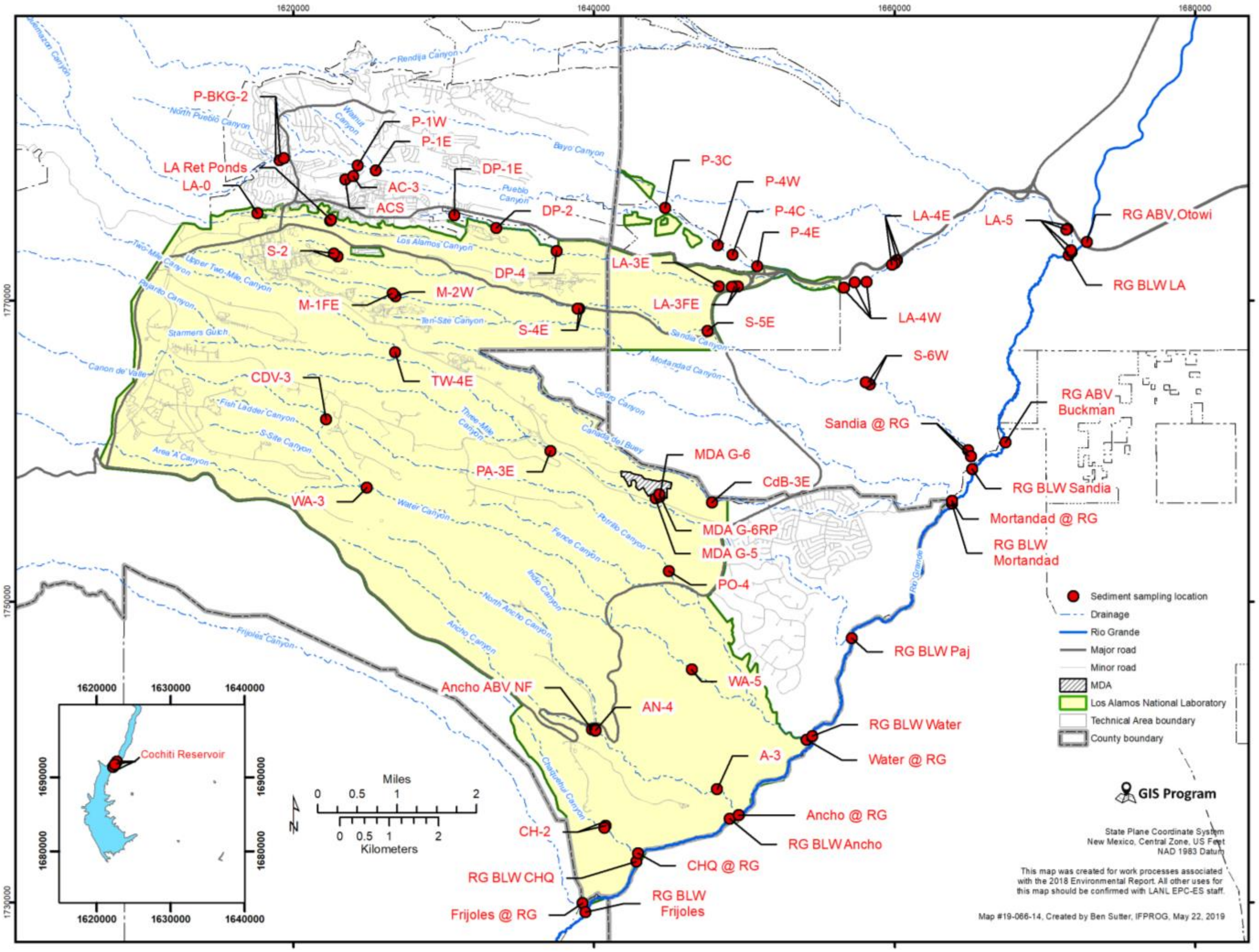


Figure 6-4. Individual Permit (IP) site monitoring areas where automated samplers collected compliance storm water samples in 2018

Sediment Sampling Locations and Methods

Figure 6-5 shows locations sampled for sediment in 2018 as part of the annual environmental surveillance program. Sediment samples were collected at a depth of between 0 and 12 inches, depending on the thickness of the uppermost sediment layer. We collected samples from stream channels and floodplains where new sediment was deposited during 2018. For streams with flowing water, sediment samples were collected near the edge of the main channel adjacent to, but not in, the water. During 2018, storm water runoff flowed in every canyon on Laboratory property except for Fence Canyon, in the Water Canyon watershed; therefore, sediment samples were collected from most watersheds.



Note: MDA = Material disposal area; RG = Rio Grande; BLW = below; @ = at; LA = Los Alamos Canyon; P = Pueblo Canyon; AC = Acid Canyon; S = Sandia Canyon; WA = Water Canyon; CDV = Cañon de Valle; ABV = above; CHQ = Chaquehui Canyon; CdB = Cañada del Buey; PA = Pajarito Canyon; M = Mortandad Canyon; PO = Potrillo Canyon; BKG = background.

Figure 6-5. Locations sampled in 2018 for sediment as part of the annual environmental surveillance program

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Quality Assurance

Sampling of storm flow, base flow, and sediment, as well as measuring stream flow, is performed according to written quality assurance and quality control procedures and protocols. Current versions of all procedures and guides are listed at https://ext.em-la.doe.gov/EPRR/ReadingRoom.aspx?room=2. These procedures ensure that the collection, processing, and chemical analysis of samples and the validation and verification of analytical data are consistent from year to year.

Sampling Results

Table 6-2 summarizes inorganic chemical results for 2018 storm water and base flow samples for locations that had at least one sample result that exceeded screening levels.

In Table 6-3, data summarizes organic chemical and radionuclide results for 2018 storm water and base flow samples for locations that had at least one sample result that exceeded screening levels. Table 6-4 summarizes results for chemicals in 2018 sediment samples for substances that had at least one sample result that exceeded screening levels. The surface water monitoring data for 2018 and previous years are available through the Intellus New Mexico website (https://intellusnm.com).

Results from compliance sampling for the Individual Permit are not presented in the tables below, but are discussed in the text and included in the figures below. Tables of the Individual Permit sampling results for 2018 are available in the Storm Water Individual Permit Annual Report (N3B 2019c). Tests are not performed for every substance in every Individual Permit sample; the analyses that are requested vary depending on the chemicals or radionuclides present in the solid waste management units and areas of concern within a site monitoring area.

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TABLE 6-2. 2018 STORM WATER AND BASE FLOW LOCATIONS FOR INORGANIC CHEMICALS WHERE AT LEAST ONE SAMPLE RESULT EXCEEDED SCREENING LEVELS

Location Description	Stream Gage No.	Dissolved Aluminum			Dissolved Cadmium			Dissolved Copper			Dissolved Lead			Total Mercury			Total Selenium			Dissolved Zinc		
		Analyses*	Detects†	Exceedances‡	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
Acid above Pueblo	E0	4	4	4	4	0	0	4	4	4	4	4	4	4	2	0	4	0	0	4	4	1
Ancho below State Road 4	E2	2	2	1	2	0	0	2	2	0	2	2	0	2	2	2	2	2	1	2	2	0
CDB above State Road 4	E2	1	1	1	1	0	0	1	1	0	1	0	0	1	1	0	1	1	1	1	0	0
Chaquehui tributary at TA-33	E3	1	1	1	1	0	0	1	1	1	1	0	0	1	1	0	1	1	0	1	1	0
Upper Los Alamos detention	LA-	1	1	0	1	0	0	1	1	1	1	0	0	1	0	0	1	0	0	1	1	0
DP above Los Alamos Canyon	E0	4	4	1	4	0	0	4	4	0	4	4	0	4	3	0	4	2	0	4	2	0
DP above Technical Area 21	E0	4	4	3	4	0	0	4	4	4	4	0	0	4	1	0	4	0	0	4	3	1
DP below grade control structure	E0	5	5	2	5	0	0	5	5	3	5	4	0	5	0	0	5	0	0	5	2	0
Los Alamos above low-head weir	E0	1	1	1	1	0	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	0
Mortandad below Effluent	E2	3	3	2	3	0	0	3	3	2	3	1	0	4	0	0	4	1	0	3	3	1
Pajarito below S-N Ancho E Basin confluence|	E2 42.	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Pajarito above Starmers	E2	2	2	1	2	0	0	2	2	0	2	0	0	2	0	0	2	0	0	2	2	0
Pueblo above Acid	E0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	0	0	1	1	0
Sandia below Wetlands	E1	6	5	5	6	0	0	6	5	5	6	5	5	6	3	0	6	0	0	6	4	0
Sandia left fork at Asphalt Plant	E1	2	2	2	2	0	0	2	2	2	2	2	0	2	1	0	2	1	1	2	2	0
Sandia right fork at Power Plant	E1	6	5	5	6	1	1	6	6	6	6	1	1	6	2	0	6	0	0	6	5	3
South fork of Acid Canyon	E0	2	2	2	2	0	0	2	2	2	2	2	2	2	1	0	2	0	0	2	1	0

**Analyses are the number of samples analyzed for that constituent.*
†Detects are the number of samples in which that constituent was detected.
‡Exceedances are the number of results that were detected above the screening level.
|Gray highlighting indicates base flow sampling locations, whereas no gray highlighting indicates storm water sampling locations.

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TABLE 6-3. 2018 STORM WATER AND BASE FLOW LOCATIONS FOR ORGANIC CHEMICALS AND RADIONUCLIDES WHERE AT LEAST ONE SAMPLE RESULT EXCEEDED SCREENING LEVELS

Location Description	Stream Gage Number	Total PCB			Gross Alpha		
		Analyses*	Detects†	Exceedances‡	Analyses	Detects	Exceedances
Acid above Pueblo	E056	4	4	4	4	4	4
Ancho below State Road 4	E275	2	2	2	2	2	2
CDB above State Road 4	E229.3	1	0	0	1	1	1
Chaquehui tributary at Technical Area 33	E340	1	1	1	1	1	1
Upper Los Alamos detention basins	LA-2	1	1	1	1	1	0
DP above Los Alamos Canyon	E040	4	4	4	4	4	4
DP above Technical Area 21	E038	4	4	4	4	4	3
DP below grade control structure	E039.1	5	5	5	5	5	3
Los Alamos above low-head weir	E042.1	2	2	2	1	1	1
Mortandad below Effluent Canyon	E200	4	4	4	4	4	3
Pajarito above Starmers	E241	2	1	0	2	2	1
Pueblo above Acid	E055	1	1	1	1	1	1
Sandia below Wetlands|	E123	5	5	5	6	5	1
Sandia left fork at Asphalt Plant	E122	1	1	1	2	2	2
Sandia right fork at Power Plant	E121	4	4	4	6	5	0
South fork of Acid Canyon	E055.5	2	2	2	2	2	2
Starmers above Pajarito	E242	1	1	1	1	1	1

Analyses are the number of samples analyzed for that constituent.

†*Detects are the number of samples in which that constituent was detected.*

‡*Exceedances are the number of results that were detected above the screening level.*

|*Gray highlighting indicates base flow sampling locations, whereas no gray highlighting indicates storm water sampling locations.*

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TABLE 6-4. 2018 SEDIMENT LOCATIONS WHERE AT LEAST ONE SAMPLE RESULT EXCEEDED SCREENING LEVELS

Location ID	Canyon	Reach Name	2,3,7,8-TCDD Toxic Equivalents			Chromium			Manganese			PCB-126		
			Analyses[*]	Detects[†]	Exceedances[‡]	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
LA-61570	Los Alamos	LA Ret Ponds (Upper LA detention basins)	1	1	1	1	1	0	1	1	0	1	1	1
LA-61575	Los Alamos	LA Ret Ponds (Upper LA detentions basins)	1	1	1	1	1	0	1	1	0	1	1	1
SI-60393	Los Alamos	LA-5 (Lower LA Canyon, San Ildefonso Pueblo)	—[§]	—	—	1	1	1	1	1	0	1	0	0
SA-61618	Sandia	S-2 (Sandia Wetlands)	1	1	0	1	1	1	1	1	0	1	0	0
SA-61617	Sandia	S-2 (Sandia Wetlands)	1	1	0	1	1	1	1	1	1[x]	1	1	0

[*] *Analyses are the number of samples analyzed for that constituent.*

[†] *Detects are the number of samples in which that constituent was detected.*

[‡] *Exceedances are the number of results that were detected above the residential cancer screening level except where noted.*

[§] *A dash (—) indicates that the analysis was not performed.*

[x] *Exceeds construction soil non-cancer screening level.*

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Discussion of Sampling Results

The screening levels provide a high level of confidence in determining a low probability of adverse risk to human health. They are not designed or intended to provide definitive estimates of actual risk and are not based on site-specific information (U.S. Environmental Protection Agency 2001). For example, on-site data are compared with residential screening levels, though there are no residences nearby. We evaluate human health effects from exposure to storm water in Chapter 8, Public Dose and Risk Assessment.

Sediment data presented in this report are used to determine if the following conceptual model is still accurate: the process of sediment transport by storm water runoff observed in Laboratory canyons generally results in the same or lower levels of LANL-released substances in new sediment deposits than previously existed in a given reach. The results from 2018 verify this conceptual model and support the idea that the risk assessments presented in the canyons investigation reports (LANL 2004, 2005, 2006, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b, 2011c) represent an upper bound of potential human health risks in the canyons for the foreseeable future.

For sediment samples collected in 2018, there were minimal exceedances of screening levels. Residential soil screening levels were exceeded for PCB-126 and 2,3,7,8-TCDD Toxic Equivalents in two sediment samples collected in the upper sediment detention basins in Los Alamos Canyon. Residential soil screening levels were exceeded for chromium in two sediment samples collected in the wetland in Sandia Canyon and in one sample in lower Los Alamos Canyon on Pueblo de San Ildefonso land. Construction soil screening levels for manganese were exceeded in one sediment sample from Sandia Canyon.

For inorganic chemicals in storm water and base flow samples collected in 2018, Table 6-2 presents a summary of locations where New Mexico water quality standards were exceeded. Similarly, Table 6-3 presents exceedances for organic chemicals and radionuclides. Table 6-5 summarizes all storm water and base flow sample exceedances by analyte and categorizes them by applicable New Mexico water quality standards.

What is the Human Health–Organism Only Surface Water Quality Standard?

This is one of the surface water quality standards used by the state of New Mexico to identify whether a water body or stream reach has adequate water quality for its designated use(s). The intent of this standard is to protect the health of humans who eat fish or other aquatic wildlife (such as crayfish) that live in a lake, river, or stream.

TABLE 6-5. NUMBER OF LOCATIONS WHERE NEW MEXICO WATER QUALITY STANDARDS WERE EXCEEDED FOR STORM WATER OR BASE FLOW RESULTS IN 2018 FOR CONSTITUENTS WITH AT LEAST ONE EXCEEDANCE

Analyte	Livestock Watering	Wildlife Habitat	Acute Aquatic Life	Chronic Aquatic Life	Human Health-Organism Only
Dissolved Aluminum	—‡	—	26	17	—
Dissolved Cadmium	—	—	1	1	—
Dissolved Copper	—	—	26	18	—
Dissolved Lead	—	—	0	13	—
Total Mercury	—	2	—	—	—
Total Selenium	—	7	0	7	—
Dissolved Zinc	—	—	2	4	—
Gross alpha	46	—	—	—	—
Total PCB	—	31	1	31	41

‡*A dash indicates there is no standard for this chemical or radionuclide in this category.*

Constituents Related to Background Sources

Some chemicals and radionuclides may come from both naturally occurring sources and human-derived sources. Chemicals that are mainly or completely naturally occurring are discussed below, but results are not presented in figures. Chemicals from human sources that exceeded screening levels more than once in 2018 at a particular location for water samples are shown in Figures 6-6 through 6-14. Because of the smaller number of samples, the sediment data are not presented in figures, but exceedances are reported in Table 6-4.

In Figures 6-6 through 6-14, the points in the top panel show the locations of the stream gaging stations, sediment detention basins, base flow, and Individual Permit sites where surface water samples have been collected. For each constituent, the color of a point corresponds to the percentile in which the median concentration at that location falls. Mostly, these median values and the percentiles were calculated from data collected from 2005 to 2018, although in some cases, like total PCBs, analysis for the constituent did not begin until sometime after 2005. The percentiles were calculated from the dataset of all individual results for each constituent within the watershed. The range in concentrations represented by each percentile is provided at the top of the figure. The box plots in the bottom panel(s) include all results in the watershed for the constituent of interest for each year. The bottom and top of each box represent the 1st and 3rd quartiles, respectively, and the middle line shows the median concentration. Whiskers extend to 1.5 times the interquartile range (the height of the box). Outliers are not shown to better illustrate trends over time. Readers should note that these plots have been redesigned from previous years. Although they are no longer directly comparable, the new plots provide an improved spatial and temporal representation of the data.

Aluminum: Filtered storm water samples collected on the Pajarito Plateau in 2018 commonly contained aluminum concentrations above New Mexico water quality standards. However, most or all of this aluminum is likely naturally occurring (Reneau et al. 2010). Aluminum is a natural component of soil and Bandelier Tuff, and it is not known to be derived from Laboratory operations in any significant quantity. There were 10 exceedances of the target action limit for filtered aluminum concentrations in 20 Individual Permit–related runoff samples in 2018. Twenty-seven of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for aluminum (Table 6-1). However, the New Mexico Environment Department Surface Water Quality Bureau has stated that “the large number of exceedances” for aluminum in surface water on the Pajarito Plateau “may reflect natural sources associated with the geology of the region,” and that aluminum also exceeds 658 micrograms per liter (the acute aquatic life standard for a hardness of 30 mg $CaCO_3$/L) in other parts of the Jemez Mountains area (New Mexico Environment Department 2009).

Aluminum concentrations in sediment samples collected during 2018 were not detected above the residential soil screening level.

Arsenic: Arsenic has both natural and human-derived sources. Coal-fired power plants emit gaseous arsenic. While the Four Corners Generating Station coal-fired power plant has contributed to arsenic contamination, the Laboratory also operated coal-fired power plants historically. Arsenic is also found naturally in the local volcanic rocks. In 2018, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for arsenic. None of the eighteen Individual Permit-related samples exceeded the target action level for arsenic in 2018. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for arsenic (Table 6-1). It is located in upper Pajarito Canyon, upstream of the Laboratory.

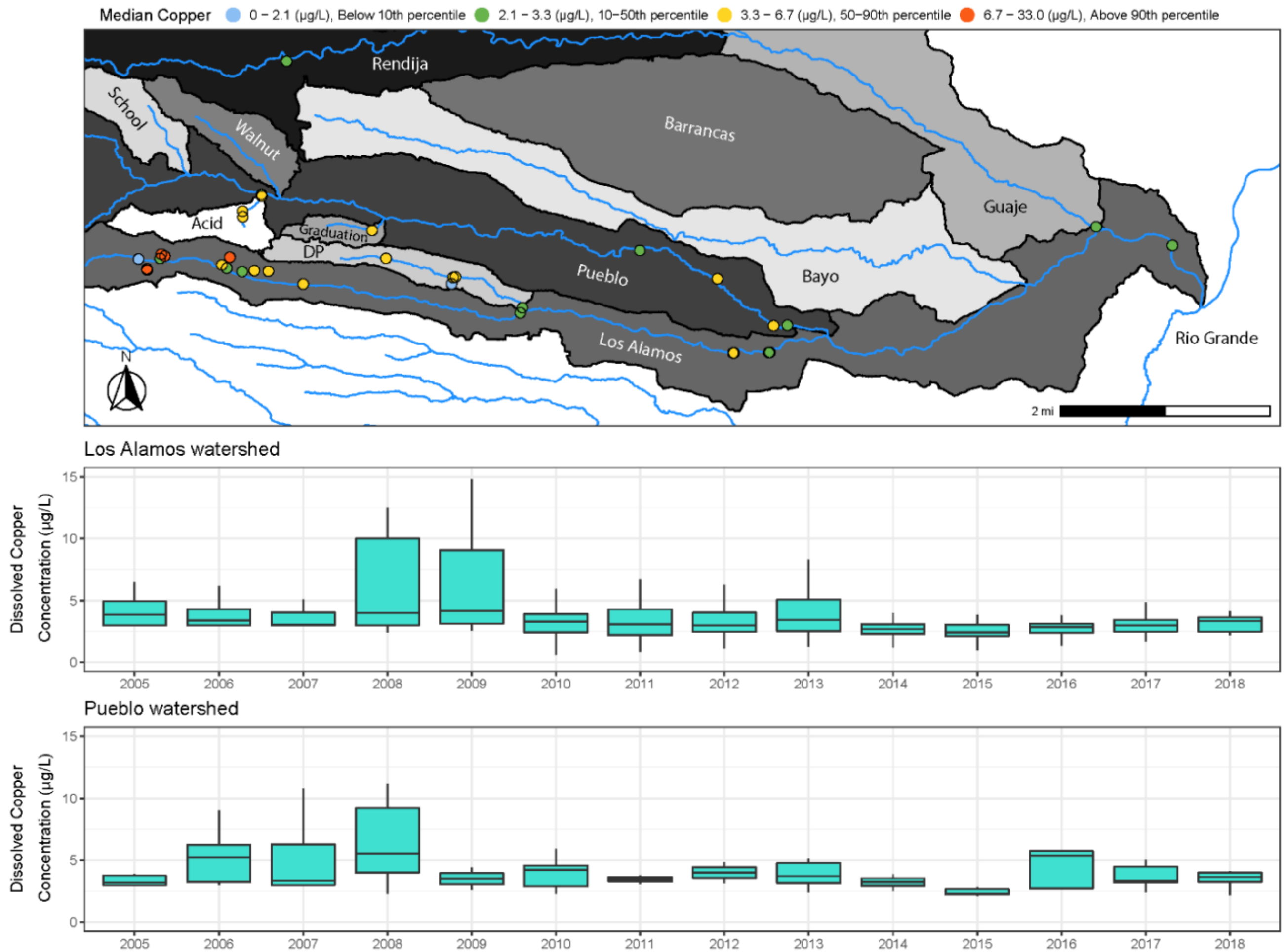
In 2018, no sediment samples exceeded screening levels for arsenic.

Copper: Copper is naturally occurring and it is also associated with explosives firing sites, forest fires, and developed areas, such as buildings and parking lots. Copper sources in developed landscapes include brake pad abrasion and building materials, such as flashing, plumbing pipes, and electrical components (TDC Environmental 2004, Göbel et al. 2007). In 2018, copper concentrations in filtered storm water were detected above the acute aquatic life standard in 26 samples and above the chronic aquatic life standard in 18 samples.

Historically, every watershed across the Laboratory has recorded elevated copper concentrations in storm water at some time, including all of the Laboratory’s upstream boundary gaging stations. Seven of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for copper (Table 6-1). Since the 2006 implementation of the Individual Permit, every watershed has had a target action level exceedance for copper in Individual Permit–related runoff samples. In 2018, there were 13 exceedances of the target action limit for filtered copper concentrations in 23 Individual Permit-related runoff samples.

Figures 6-6 and 6-7 show copper concentrations in filtered storm water and base flow for Los Alamos and Sandia Canyons.

In 2018, copper concentrations in sediment were not detected above the residential soil screening level.



Note: µg/L = microgram per liter.

Figure 6-6. Los Alamos Canyon copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2005 to 2018. Top Panel: median storm water copper values for each sampling location between 2005-2018. Bottom panels: the box plots show the median copper value (center line) and the range of measured values for each year for all sampled locations in the watershed.

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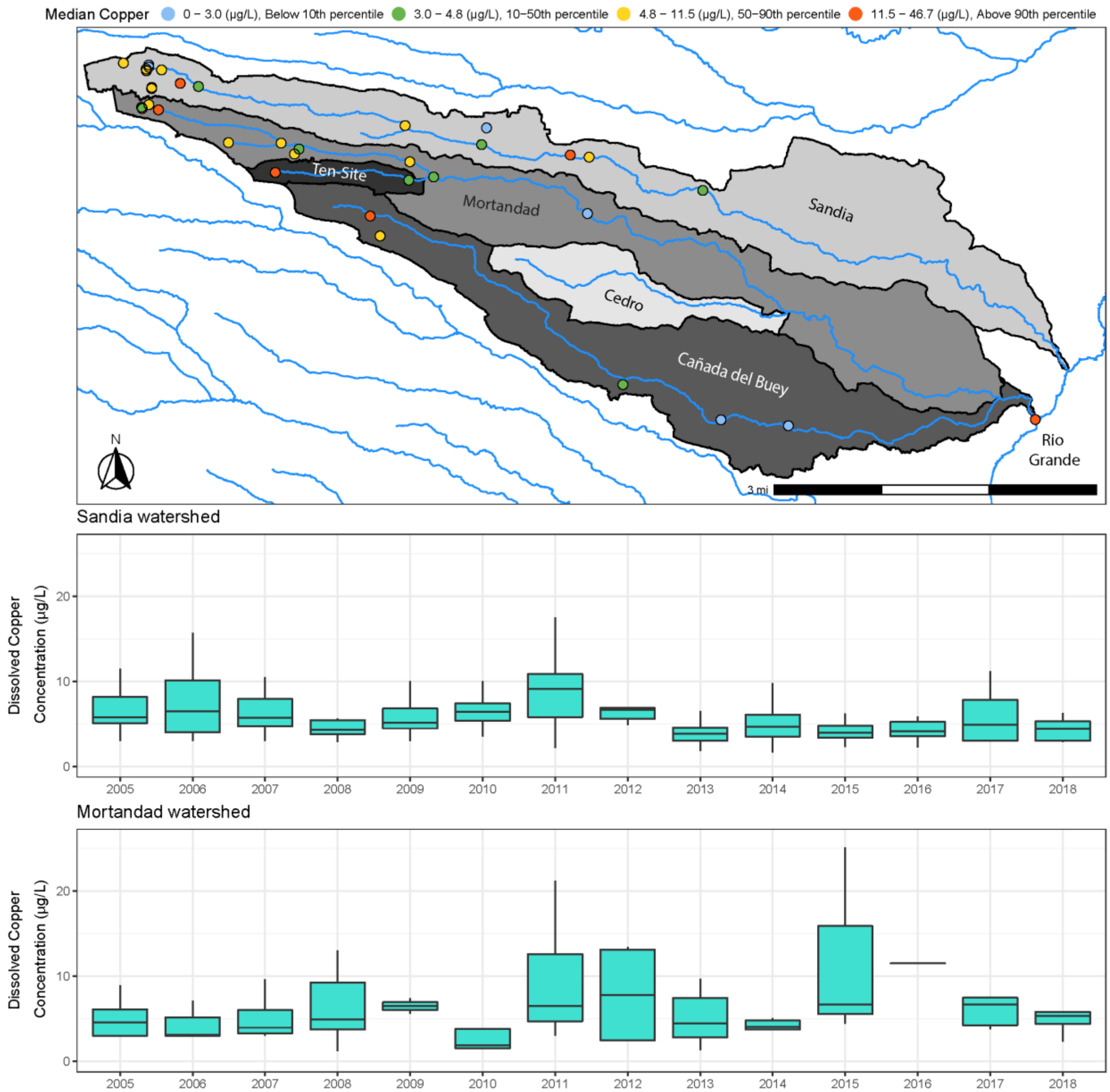

Figure 6-7. Sandia Canyon and Mortandad Canyon watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2005 to 2018. Top Panel: median storm water copper values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median copper value (center line) and the range of measured values for each year for all sampled locations in the watershed.

Lead: Lead is associated with developed areas, such as buildings and parking lots (Göbel et al. 2007). The major lead sources in developed landscapes are lead-based paints, building sidings, and the operation of automobiles (Davis and Burns 1999). Lead concentrations in filtered storm water in 2018 were detected above the chronic aquatic life standard in 13 samples. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for lead (Table 6-1). There were no exceedances of the target action limit for filtered lead concentrations in the 18 Individual Permit-related runoff samples in 2018. Figures 6-8 and 6-9 show lead concentrations in filtered storm water and base flow for Los Alamos and Sandia Canyons.

In 2018, lead concentrations in sediment were not detected above the residential soil screening level.

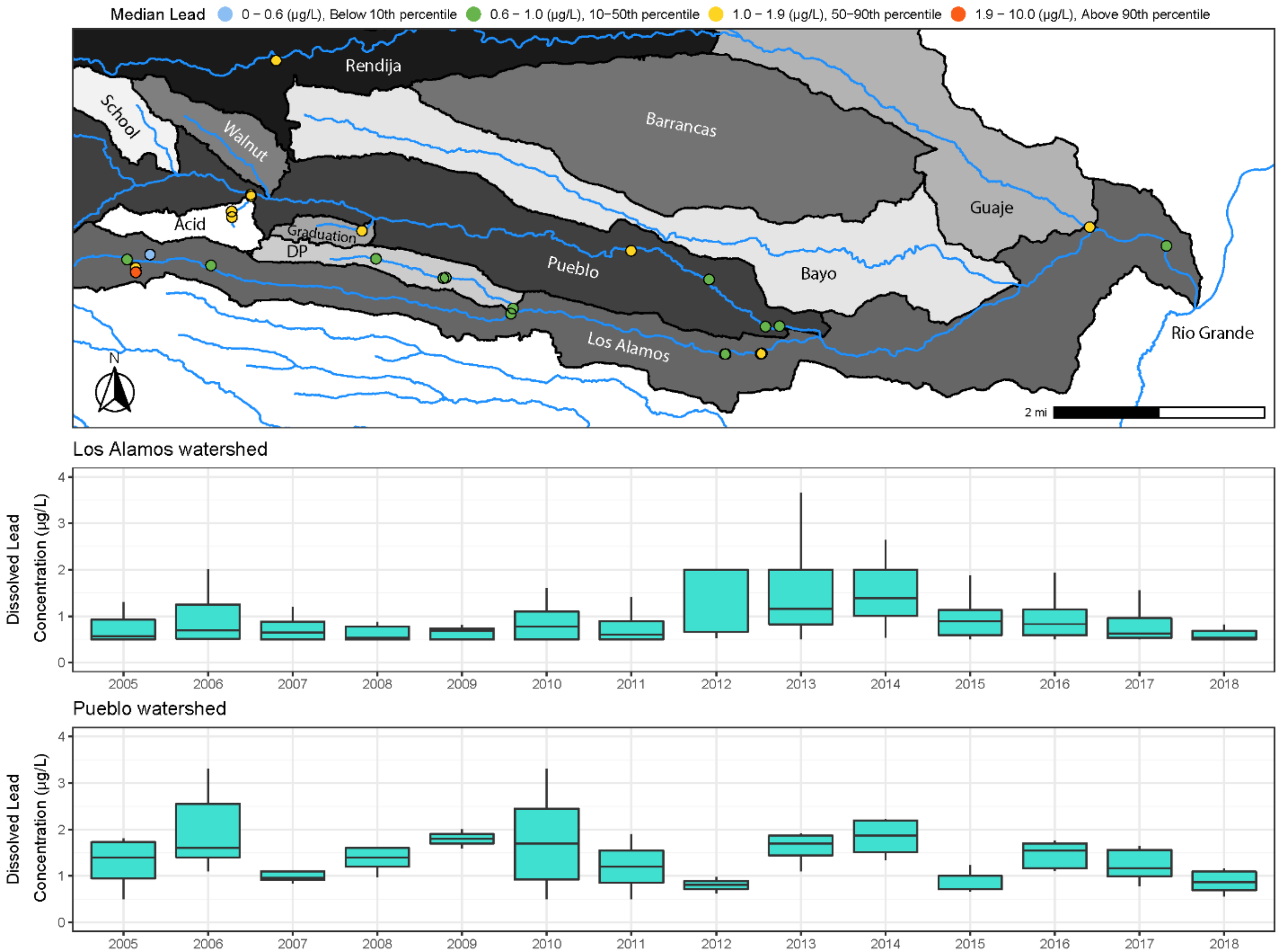

Figure 6-8. Los Alamos Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers, gaging stations, and base flow from 2005 to 2018. Top Panel: median storm water lead values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median lead value (center line) and the range of measured values for each year for all sampled locations in the watershed.

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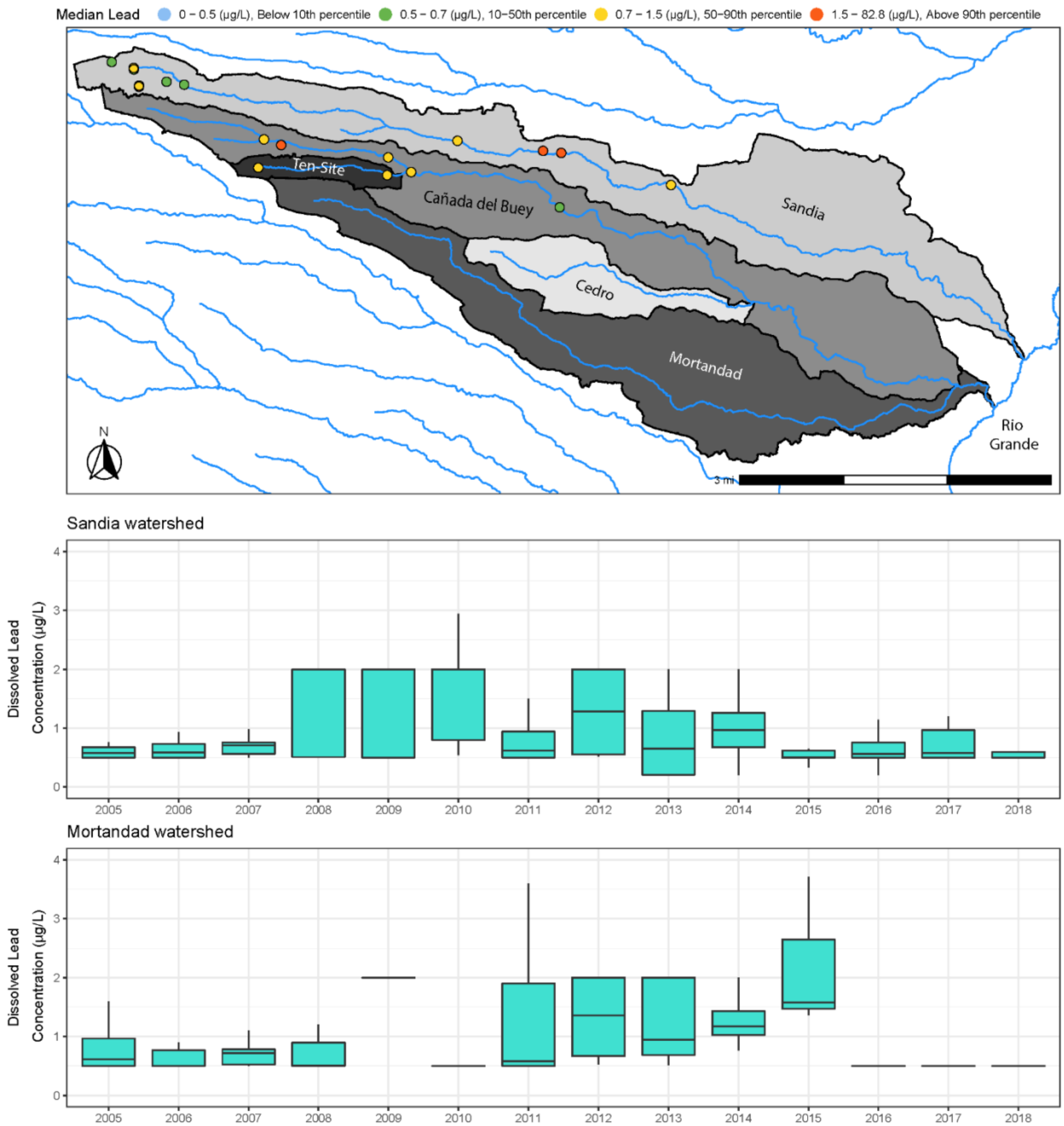


Figure 6-9. Sandia Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers, gaging stations, and base flow from 2005 to 2018. Top Panel: median storm water lead values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median lead value (center line) and the range of measured values for each year for all sampled locations in the watershed.

Manganese: Manganese is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released significant quantities of manganese. Dissolved manganese concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005). Filtered manganese concentrations were not detected above the acute or chronic aquatic life standards in storm water samples collected in 2018. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for manganese (Table 6-1).

In 2018, manganese concentrations in sediment exceeded the construction soil screening level (which is lower than the residential soil screening level) in one of 74 samples.

Selenium: Selenium is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released significant quantities of selenium. Total selenium concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005). In 2018, total selenium concentrations in storm water were detected above the wildlife habitat standard in seven samples and above the chronic aquatic life standard in seven samples. Total selenium concentrations exceeded the Individual Permit target action level in three of the 19 Individual Permit-related storm water samples collected in 2018. Only one of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for selenium (Table 6-1).

In 2018, selenium concentrations in sediment were not detected above the residential soil screening level.

Zinc: While naturally occurring, zinc can also be associated with developed areas. Zinc sources include automobile tires, galvanized materials, motor oil, and hydraulic fluid (Rose et al. 2001, Washington State Department of Ecology 2006, Councell et al. 2004). In 2018, filtered zinc concentrations in storm water samples were detected above the acute aquatic life standard in two samples and above the chronic aquatic life standard in four samples. Only one of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for zinc (Table 6-1) and it is located in the south fork of Acid Canyon. Since implementation of the Individual Permit, every watershed has had target action level exceedances of zinc concentrations at some point in time, but in 2018 there were no Individual Permit exceedances for zinc. Figure 6-10 shows zinc concentrations in filtered storm water and base flow for Sandia Canyon.

In 2018, zinc concentrations in sediment were not detected above the residential soil screening level.

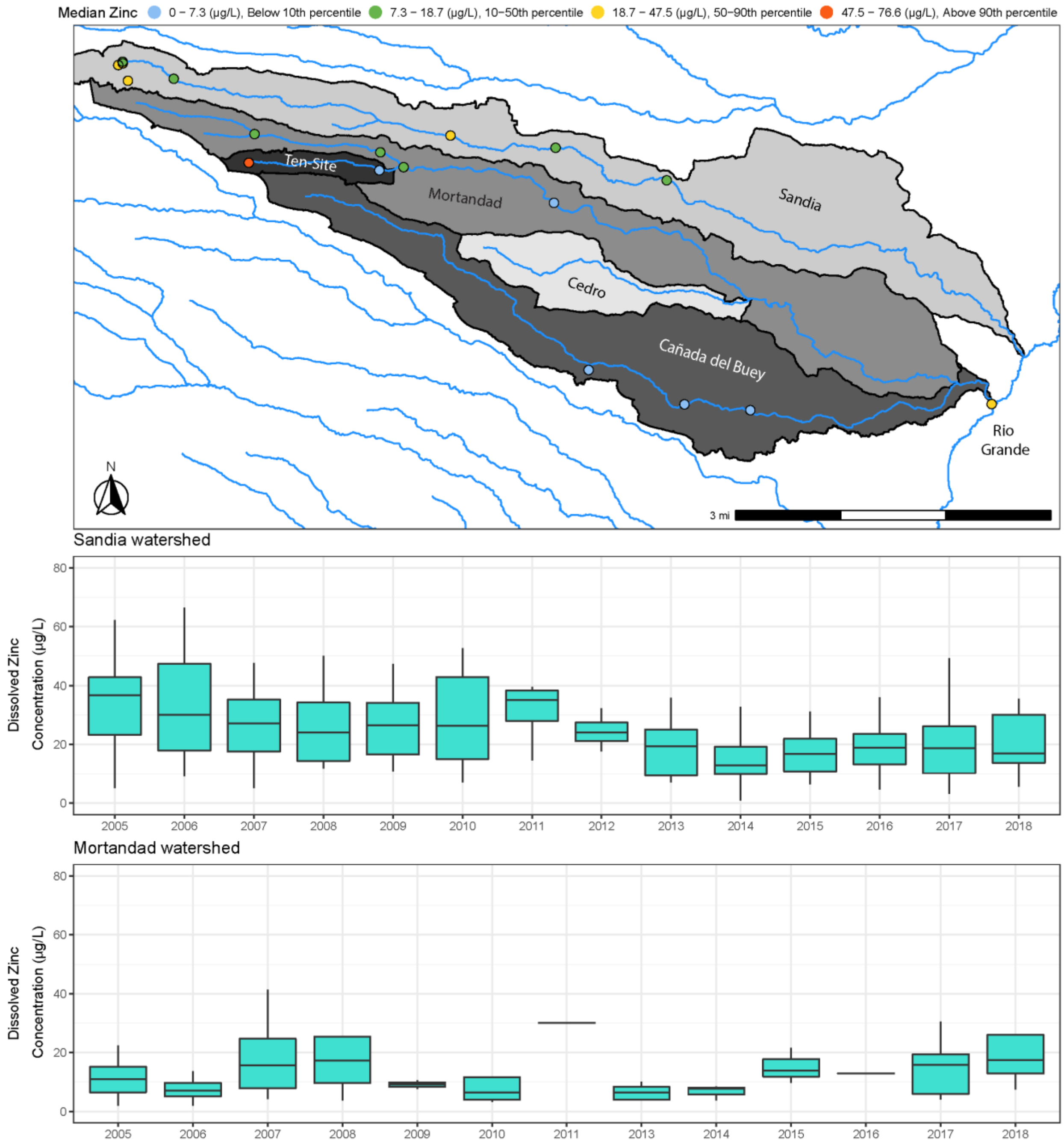


Figure 6-10. Sandia Canyon watershed zinc concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2005 to 2018. Top Panel: median storm water zinc values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median lead value (center line) and the range of measured values for each year for all sampled locations in the watershed.

Gross Alpha: The gross alpha activity is the sum of the radioactivity from alpha particle emissions from radioactive materials. Alpha particles are released by many naturally occurring radionuclides, such as isotopes of radium, thorium, and uranium, and their decay products. In 2018, 46 unfiltered storm water samples had gross alpha activities above the livestock watering standard. In 2011, 2012, and 2013, the highest gross alpha activities in storm water were measured in samples containing ash and sediment from the 2011 Las Conchas fire. Also, gross alpha activities were particularly high in runoff samples from the large September 2013 flood event. For sampling under the Individual Permit in 2018, gross alpha activity was above the target action level in 16 of 20 samples. Twenty-six of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for gross alpha radioactivity (Table 6-1). However, the analytical results from 2018 support earlier conclusions that the majority of the alpha radioactivity in storm water on the Pajarito Plateau is from the decay of naturally occurring isotopes in sediment and soil and that Laboratory impacts are relatively small (for example, see Gallaher 2007).

Sediment is not analyzed for gross alpha levels because sediment sampling is targeted to specific radionuclides of concern at a particular location.

Constituents Related to Los Alamos National Laboratory Operations

Several constituents were measured in storm water and sediment that were known to be released during historical Laboratory operations. The nature and extent of the constituents in sediment are described in detail in the canyons investigation reports referenced in the chapter introduction. The following discussion describes the occurrences of key constituents in 2018 storm water and sediment samples. Results for constituents that exceeded screening levels or standards more than once in 2018 at a particular sample location for storm water and base flow are shown in the figures associated with each chemical below.

Cadmium: Cadmium is associated with combustion of fossil fuel; industrial use such as refinement for nickel-cadmium batteries, metal plating, pigments, and plastics; and activities such as sewage sludge disposal and application of phosphate fertilizers (Agency for Toxic Substances and Disease Registry 2012). In 2018, filtered storm water results from one sample exceeded the acute and chronic aquatic life standards for cadmium. This sample was collected in upper Sandia Canyon at a gage location just downstream of Technical Area 03. In addition, cadmium concentrations exceeded screening levels in one of eighteen Individual Permit samples. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for cadmium (Table 6-1).

In 2018, no sediment results exceeded screening levels for cadmium.

Cesium-137: Cesium-137 is a radionuclide that is a byproduct of nuclear fission processes in nuclear reactors and nuclear weapons testing. In 2018, cesium-137 was not detected in any gaging station storm water samples or base flow samples. Individual Permit–related storm water samples are not analyzed for radionuclides.

In 2018, cesium-137 activity in sediment samples did not exceed the residential screening action level.

Chromium: Chromium is associated with potassium dichromate that was used as a corrosion inhibitor in the cooling system at the Technical Area 03 power plant (LANL 1973) and was discharged through outfall 001 from 1956 to 1972. Filtered storm water and base flow results did not exceed surface water quality standards in 2018 for chromium or chromium (III). None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for chromium (Table 6-1).

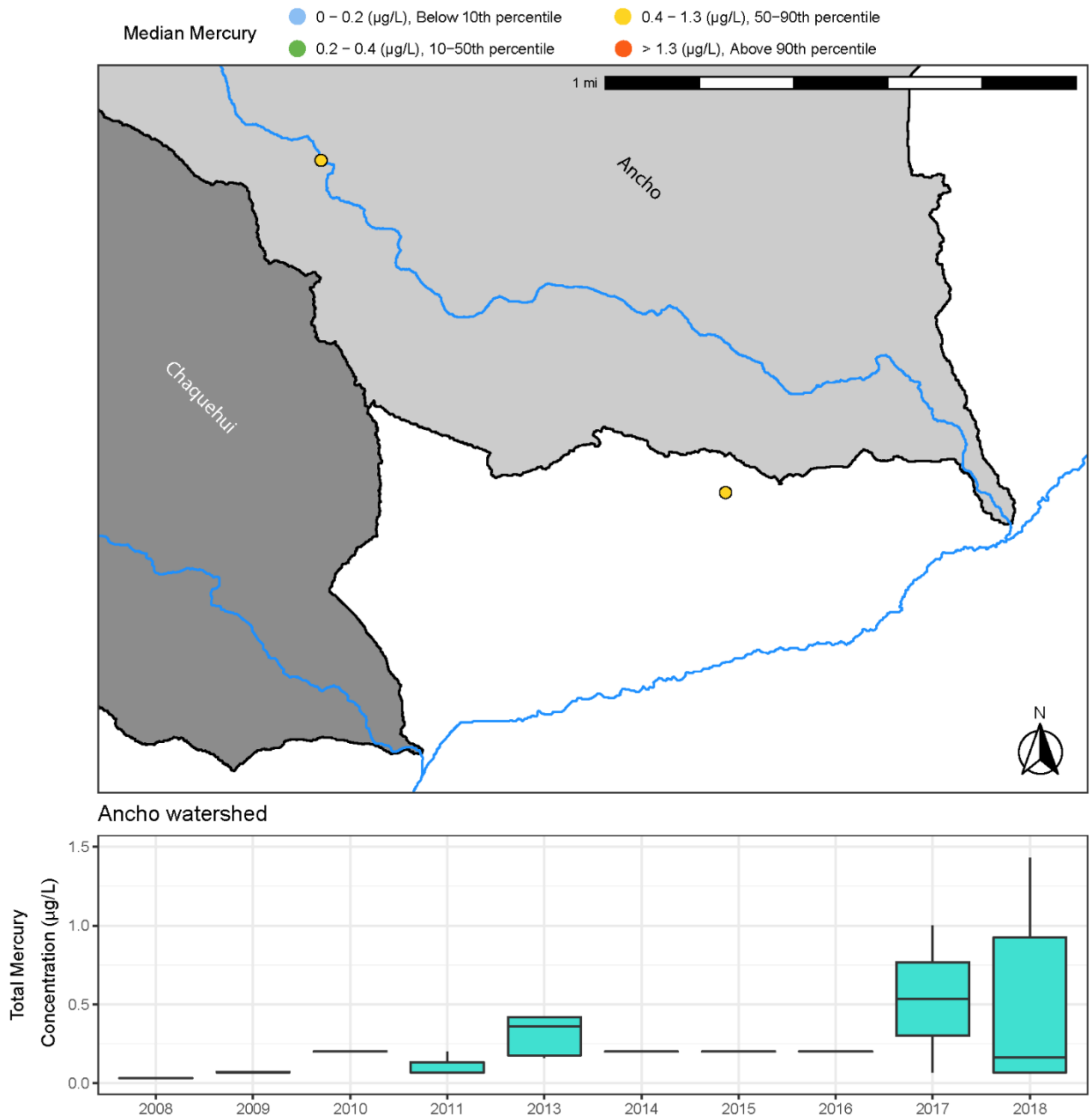
In 2018, the chromium residential soil screening level was exceeded in two sediment samples in the Sandia Canyon wetlands and in one sample in lower Los Alamos Canyon on Pueblo de San Ildefonso property (Figure 6-5; location LA-5).

Dioxins and Furans: Dioxins and furans are associated with the incineration of medical, industrial, municipal, and private wastes; municipal wastewater treatment sludge; coal-fired boilers; and diesel fuel emissions (U.S. Environmental Protection Agency 2006b). Forest fires are also a major, natural source of dioxins (Gullett and Touati 2003). Toxic equivalents are used to report the toxicity-weighted masses of mixtures of dioxins and furans. This is more meaningful than reporting the number of grams of dioxins or furans because toxic equivalents provide information on toxicity (U.S. Environmental Protection Agency 2010). In addition, there are surface water quality standards for a total dioxin toxic equivalent, whereas there are no standards for individual dioxins or furans. In 2018, no storm water gaging station results exceeded the human health–organism only standard. There were no exceedances of the target action level for 2,3,7,8-tetrachlorodibenzodioxin (one of the more toxic compounds) in Individual Permit–related storm water samples. In base flow samples analyzed for dioxins and furans (along the Rio Grande at the Otowi Bridge, Pajarito, Frijoles, and Ancho Canyons and in Los Alamos Canyon above the low-head weir), results were below surface water quality standards. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for dioxins/furans (Table 6-1).

In 2018, dioxins or furans were detected in sediments throughout Los Alamos and Pajarito Canyons. There were two exceedances of 2,3,7,8-TCDD toxic equivalent in the upper detention basins in Los Alamos Canyon. However, there were no exceedances of the more toxic compounds (2,3,7,8-tetrachlorodibenzodioxin and 2,3,7,8-tetrachlorodibenzofuran) in 2018.

Mercury: Natural sources of mercury include forest fires and fossil fuels such as coal and petroleum. Human activities such as mining and fossil fuel combustion have led to widespread global mercury pollution. While the Four Corners Generating Station coal-fired power plant has contributed to mercury contamination in the surrounding areas, the Laboratory also operated coal-fired power plants historically. In 2018, two of the unfiltered gaging station storm water results exceeded the wildlife habitat surface water quality standard for mercury. None of the filtered gaging station storm water results exceeded a surface water quality standard for mercury, and none of the filtered or unfiltered baseflow results exceeded a surface water quality standard for mercury. Two of the 18 Individual Permit–related samples exceeded the target action level for mercury in 2018. Only one of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for mercury. It is located in upper Los Alamos Canyon above the DP Canyon confluence. Figure 6-11 shows the unfiltered mercury data from Ancho Canyon.

In 2018, no sediment results exceeded screening levels for mercury.



Note: It is rare that there is enough water in Ancho Canyon for the samplers to collect. Apparent data gaps (missing years) are due to lack of water, not missing data.

Figure 6-11. Ancho Canyon watershed mercury concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2008 to 2018. Top Panel: median storm water mercury values for each sampling location between 2005 and 2018. Bottom panel: the box plots show the median mercury value (center line) and the range of measured values for each year for all sampled locations in the watershed.

Polychlorinated biphenyls (*PCBs*)*:* PCBs are stable, persistent organic compounds that break down slowly in the environment. They were commonly used as plastic and paint stabilizers and coolants in electrical appliances before they were banned in the United States in 1979. Many older construction materials, including caulking, paints, window putty, and electrical components, used PCBs (Durell and Lizotte 1998, Kakareka and Kukharchyk 2006). As these building components weather, PCBs accumulate on the landscape and are redistributed. PCBs are remobilized and distributed throughout the globe, including through atmospheric deposition (Chevreuil et al. 1996, Duinker and Bouchertail 1989, Grainer et al. 1990, LANL 2012).

PCBs are associated with materials used historically by the Laboratory, including transformers, oils/solvents/paints used in industrial activities, and a former asphalt batch plant in Sandia Canyon.

PCBs were detected in 42 of 44 gaging station storm water and base flow samples collected in 2018. Of 44 samples, 41 had concentrations above the human health–organism only standard, 31 had concentrations above the chronic aquatic life standard and wildlife standard (which are numerically equal), and one had concentrations above the acute aquatic life standard. In 2018, 6 of 10 Individual Permit storm water samples exceeded the target action level for total PCBs. Twenty-six of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for PCBs (Table 6-1). Figures 6-12 through 6-14 show total PCB concentrations in unfiltered storm water and base flow for Los Alamos, Sandia, and Ancho Canyons.

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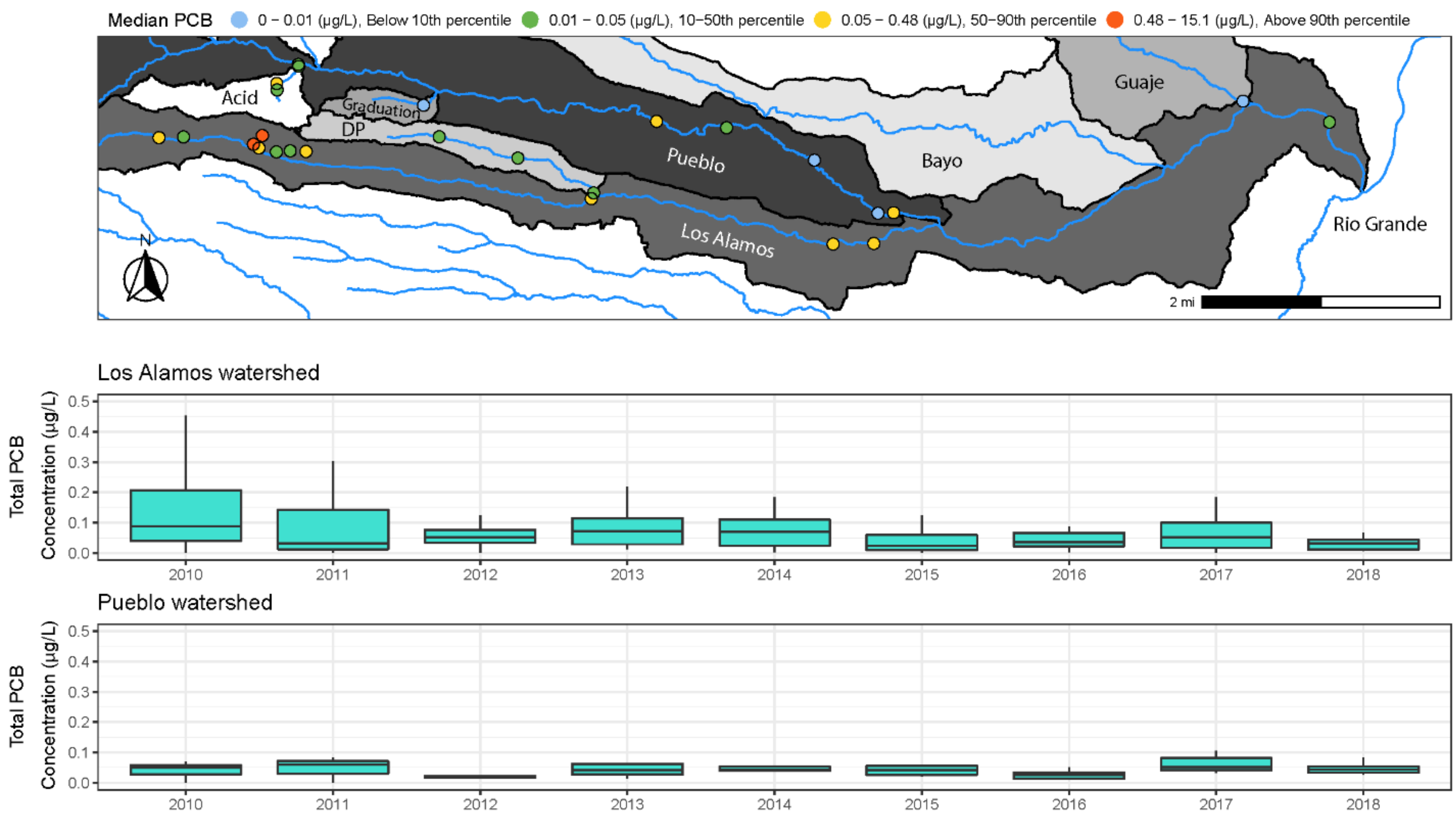

Figure 6-12. Los Alamos Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2018. Top Panel: median storm water total PCB values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median total PCB value (center line) and the range of measured values for each year for all sampled locations in the watershed.

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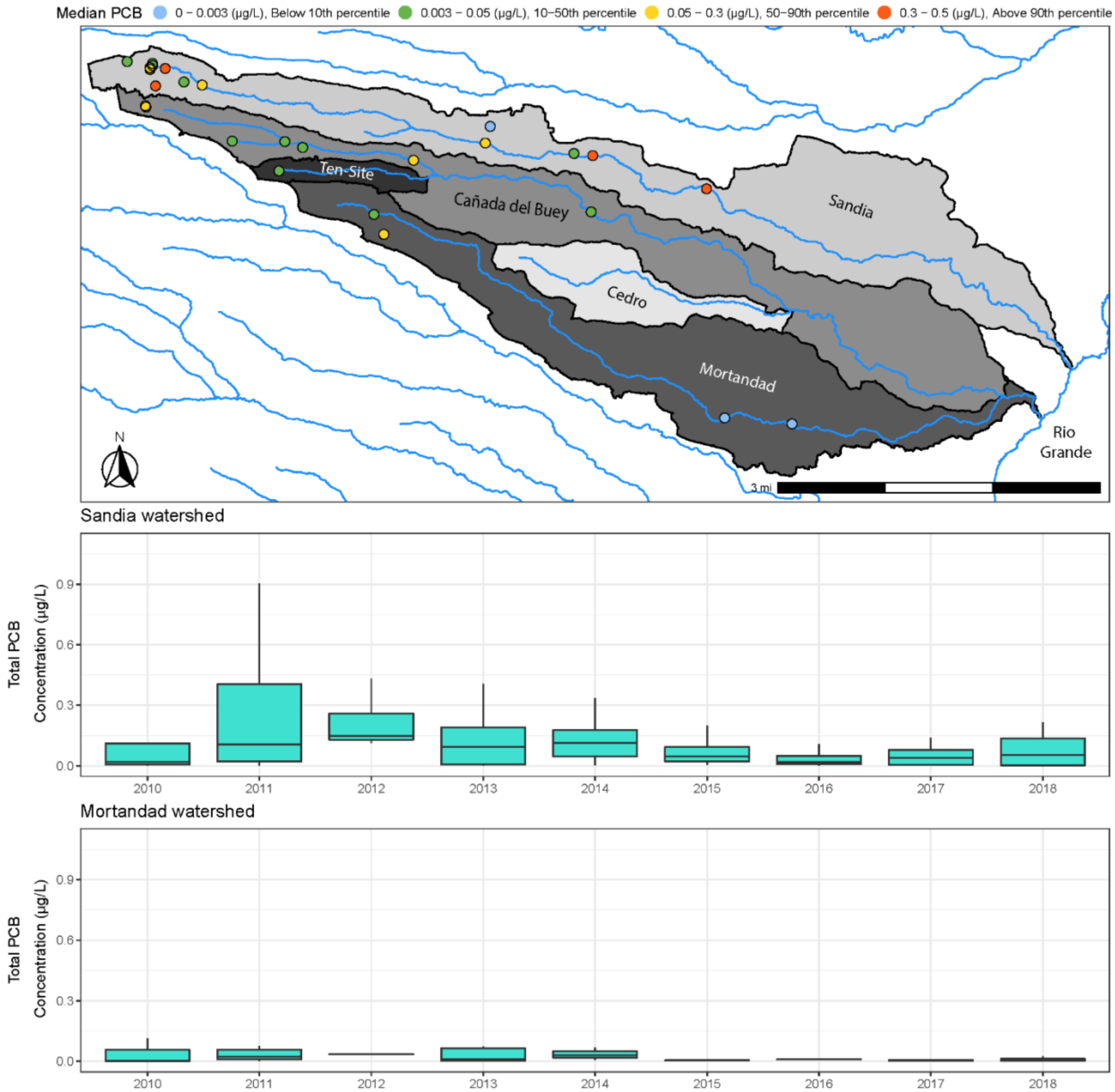
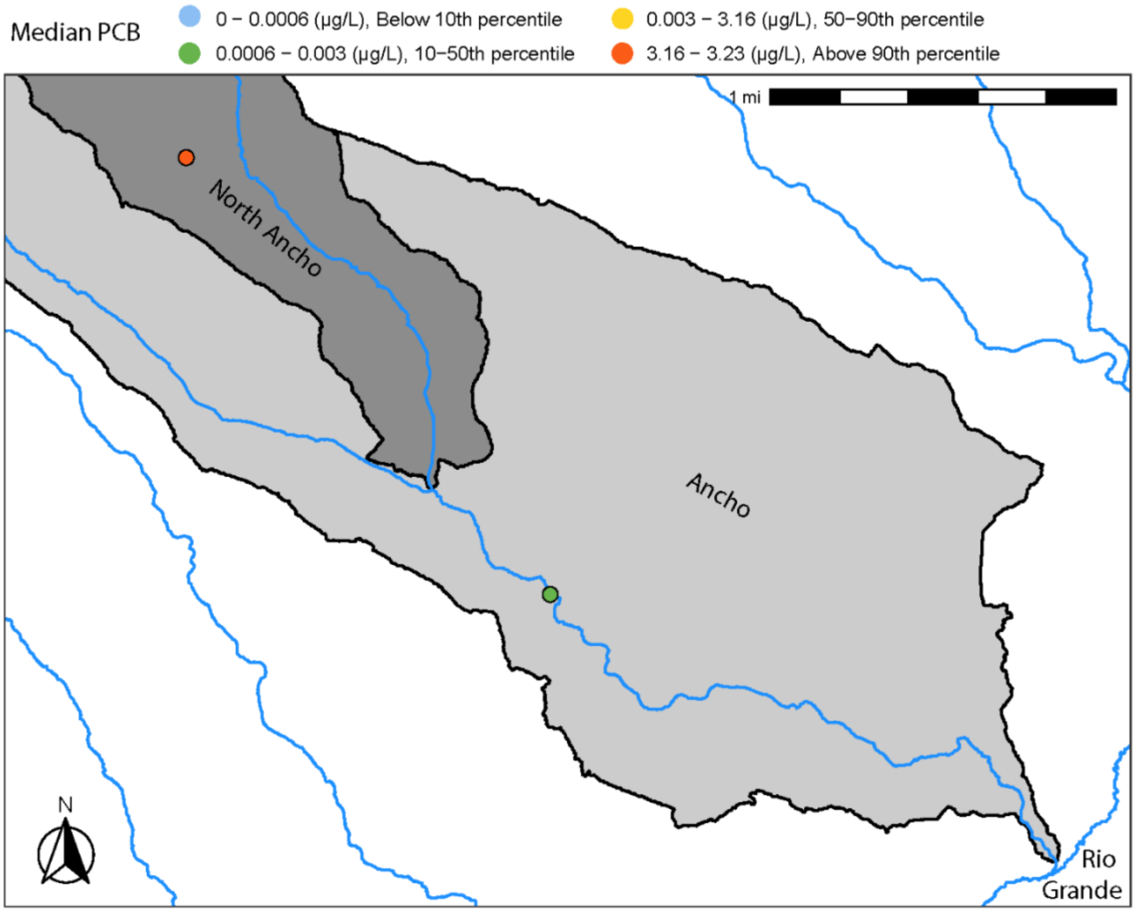
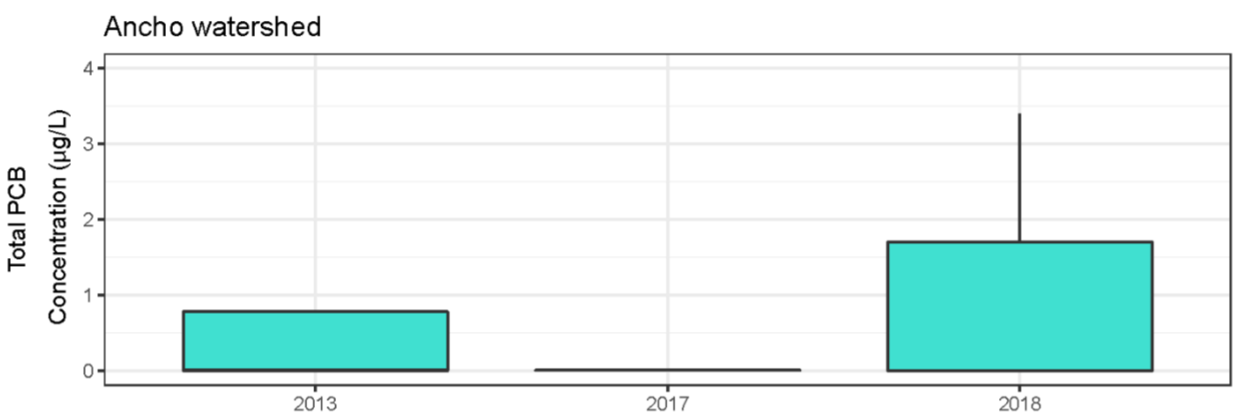


Figure 6-13. Sandia Canyon and Mortandad Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2018. Top Panel: median storm water total PCB values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median total PCB value (center line) and the range of measured values for each year for all sampled locations in the watershed.





Note: It is rare that there is enough water in Ancho Canyon for the samplers to collect. Apparent data gaps (missing years) are due to lack of water, not missing data.

Figure 6-14. Ancho Canyon watershed total PCB concentrations in unfiltered storm water samples from Individual Permit samplers and gaging stations and base flow from 2013 to 2018. Top Panel: median storm water total PCB values for each sampling location between 2005 and 2018. Bottom panels: the box plots show the median total PCB value (center line) and the range of measured values for each year for all sampled locations in the watershed.

In sediment, PCBs were detected in 75 of 91 samples; PCBs are widespread throughout the sampled areas. The residential soil screening level for PCB-126 (a specific congener of PCBs) was exceeded in two sediment samples in the upper Los Alamos Canyon detention ponds. The hillslope above the detention ponds is associated with historical Laboratory-related PCB contamination, and all of the water captured in the basins in 2018 infiltrated into the ground and did not contribute to downstream runoff.

Polycyclic Aromatic Hydrocarbons: Asphalt is prepared using petroleum products that contain polycyclic aromatic hydrocarbons, and operations at the former asphalt batch plant in Sandia Canyon released effluent from operations to the stream. In 2018, no storm water results at the gaging stations or base flow results exceeded the water quality standards for polycyclic aromatic hydrocarbons. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for polycyclic aromatic hydrocarbons (Table 6-1).

For the 12 of 18 polycyclic aromatic hydrocarbon compounds that have screening levels, none of the sediment results from 2018 exceeded these screening levels.

Thallium: Gaseous emissions from cement factories and coal-fired power plants have led to thallium pollution. While the Four Corners Generating Station coal-fired power plant has contributed to thallium contamination in the surrounding areas, the Laboratory also operated coal-fired power plants historically. In 2018, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for thallium. None of the eighteen Individual Permit-related samples exceeded the target action level for thallium in 2018. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for thallium (Table 6-1). It is located in upper Sandia Canyon from Sigma Canyon to outfall 001.

No sediment samples exceeded screening levels or background values for thallium in 2018.

CONCLUSIONS

Through the human health risk assessments in the canyons investigation reports, the biota dose assessment (Chapter 7), and human health risk assessment (Chapter 8) in this report, we have concluded that levels of chemicals and radionuclides present in storm water, base flow, and sediments are below levels that would impact human or biota health.

The box plots in Figure 6-6 through 6-14 show that the concentrations of chemicals exceeding screening levels in storm flow and base flow samples in 2018 fall within or below the ranges recorded in previous years. The exception to this is the mercury data in Ancho Canyon. Although the range of data in 2018 was larger than previous years, the median is lower. There is also relatively little data for this watershed, making it difficult to draw trends from the data.

We continue to observe very few sediment exceedances in 2018. All sediment exceedances, with the exception of LA-5, were located at the western (upstream) end of the Laboratory property. The chromium exceedance in lower Los Alamos Canyon has not been seen in previous years and should be investigated further.

The results of the storm water, base flow, and sediment data comparisons from samples collected in 2018 verify the conceptual model that storm water–related sediment transport observed in Laboratory canyons generally results in lower concentrations of Laboratory-released chemicals in the new sediment deposits than previously existed in deposits in a given reach. The results also support the idea that the risk assessments presented in the investigation reports represent an upper bound of potential human and ecological health risks in the canyons for the foreseeable future. Although some chemicals had concentrations in storm water, base flow, and sediment that were above screening levels in 2018, these transient events do not significantly affect human or biota health.

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CHAPTER 7 – ECOSYSTEM HEALTH

We monitor ecosystem health to determine whether operations at Los Alamos National Laboratory (LANL, or the Laboratory) affect plant or animal populations. We sample soil, sediment, plants, and animals on Laboratory property, near the Laboratory perimeter, and from background locations. We test these samples for levels of radionuclides, inorganic elements (such as metals), and organic chemicals (for example, polychlorinated biphenyls [PCBs], dioxins, furans, and high explosives). We also conduct radiation dose assessments for plants and animals occupying areas around specific Laboratory facilities and around sediment retention structures in canyon bottoms. The calculated doses are compared with background levels of radiation, screening levels, and federal standards for radiation doses to plants and animals.

During 2018, soil and vegetation samples were collected from 18 onsite locations, 12 perimeter locations, and six regional background locations. Onsite samples were primarily collected downwind of major LANL facilities. Additionally, in 2018 samples were collected around the perimeter of Material Disposal Area G at Technical Area 54, the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15 and in Los Alamos and Pajarito canyons. Deceased animals (primarily from animal-vehicle collisions) were collected opportunistically from various sites on and off the Laboratory.

We also report the results from surveys of bird abundance and diversity, as well as surveys for threatened and endangered species, conducted during 2018. Additionally, we report the result of benthic macroinvertebrate surveys from various sites on and off the Laboratory from perennial and ephemeral stream types.

Most radionuclide activities and chemical concentrations in soil, sediment, plants, and animals from onsite and perimeter locations were either not detected, were similar to background, or were below screening levels that are protective of biota. Surveys of bird abundance and diversity found no differences relative to control areas in species richness around open firing sites at Technical Areas 36 and 39, and one open-burn site at Technical Area 16; however, species diversity was higher at these locations when compared with their respective controls. Benthic macroinvertebrate community assemblages and population metrics varied among stream types and between locations. Biota dose assessments found that the radiation doses are far below the levels observed to have adverse effects on plants and animals.

CONTENTS

INTRODUCTION

An ecosystem includes living organisms, such as plants, animals, and microorganisms; nonliving physical environmental factors, such as soil, air, and water; and the interactions among these components (Smith and Smith 2012). The health of an ecosystem can be affected by environmental disturbances, including wildfire, flooding, drought, invasive species, climate shifts, chemical spills, construction projects, vegetation removal, and a host of other factors (Rapport 1998). Los Alamos National Laboratory (LANL or the Laboratory) provides habitat to many species of plants and animals (collectively called "biota"). The primary objective of ecosystem health monitoring is to determine if past or current releases of radionuclides and chemicals from Laboratory operations are affecting local plants and animals.

The monitoring program conducts two specific types of monitoring: institutional and facility-specific. Institutional monitoring occurs site-wide and is conducted on Laboratory property, around the perimeter of the Laboratory, and at regional background locations. Institutional monitoring is used to measure the levels of radionuclides and chemicals in areas outside of designated solid waste management units and to compare predictions of chemical and radionuclide transport models with actual results. Facility-specific monitoring is used to measure the nature and extent of radionuclides and chemicals associated with specific facilities, operations, and structures at the Laboratory.

Both institutional and facility-specific results are used to assess the effects of Laboratory-released chemicals and radionuclides on ecosystem health. This is accomplished by the following:

1. Measuring levels of radionuclides and other chemicals in soil, plants, and animals from areas on Laboratory property and near the perimeter of the Laboratory, and then comparing these levels with
   - levels measured from background locations that are not affected by Laboratory operations,
   - levels that scientists have determined should trigger further investigation, such as screening levels, and
   - levels that may cause adverse health effects.
2. Evaluating trends in radionuclide and chemical levels in soil, plants, and animals over time.
3. Assessing population parameters and species diversity of animals in areas that are potentially affected by Laboratory operations.
4. Estimating radiation dose and chemical risk to biota based on the collected information.

The Laboratory also monitors migratory bird species to meet regulatory commitments.

This chapter reports on levels of radionuclides, inorganic elements (mostly metals), and organic chemicals in soil and biota samples that were collected onsite at the Laboratory, from perimeter locations and from regional background locations. Specifically, we report on terrestrial ecosystem health for 2018, including (1) site-wide soil and vegetation monitoring results from locations at the Laboratory, around the perimeter, and from background locations; (2) facility-specific results, including monitoring around Area G, the Dual-Axis Radiographic Hydrodynamic Test Facility, and around two sediment retention structures; (3) results for chemical levels in mammals, birds, and a snake that were collected opportunistically; and (4) bird population abundance and diversity monitoring results. We conducted a special study between 2017 and 2018 for an aquatic health assessment in which benthic macroinvertebrate communities from perennial and ephemeral stream types and from different locations were assessed. Finally, we calculated an overall biota radiation dose for organisms occupying mesa tops and canyon bottoms. We compared our results with background levels, screening levels, and federal dose standards.

TERRESTRIAL HEALTH ASSESSMENT

One way we assess terrestrial ecosystem health is by monitoring levels of constituents in a variety of environmental media including soil, native vegetation, small mammals, bird eggs, and other animals collected opportunistically (as road kills, for example). Environmental samples are routinely analyzed for radionuclides, inorganic elements such as metals, and organic chemicals such as PCBs, high explosives, dioxins, furans, volatile organic compounds, and semi-volatile organic compounds.

Soil is useful for monitoring because it receives substances that are released in air emissions and particles that are transported by wind and water. Soil data can thus provide information about several modes of chemical and radionuclide transport. Monitoring soil over time also directly measures long-term trends of radionuclide and other chemical concentrations around nuclear facilities (DOE 2015).

Levels of constituents in soil collected at and near the Laboratory are compared with regional statistical reference levels calculated from samples collected at regional background locations. Radionuclides and other chemicals in soil collected from regional background locations come from naturally occurring elements in the soil or from manmade sources that are not attributed to the Laboratory. These sources include worldwide fallout of radioactive particles from nuclear facility accidents or testing of atomic weapons, and chemical releases from non-Laboratory sources such as power plants and automobile emissions. The regional statistical reference level for a chemical or radionuclide is the level below which 99 percent of the regional background locations results fall. As required by the U.S. Department of Energy (DOE), all background locations are at a similar elevation to the Laboratory, are more than 20 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (DOE 2015).

Levels of constituents in soil are also compared with ecological screening levels (LANL 2017a). Ecological screening levels include the highest level of a radionuclide or chemical in the soil that is known to not affect selected animals or plants (the no-effect ecological screening level) and the lowest level known to have caused an adverse effect on selected animals or plants (the low-effect ecological screening level) (LANL 2017a). Soil ecological screening levels exist for the following terrestrial ecological receptors: generic plant; earthworm—representing soil-dwelling invertebrates; desert cottontail (*Sylvilagus audubonii*)—representing mammalian herbivores; deer mouse (*Peromyscus maniculatus*)—representing mammalian omnivores; montane shrew (*Sorex monticolus*)—representing mammalian terrestrial insectivores; Botta's pocket gopher (*Thomomys bottae*)—representing burrowing mammals; gray fox (*Urocyon cinereoargenteus*)—representing mammalian carnivores; occult little brown bat (*Myotis lucifugus occultus*)—representing mammalian aerial insectivores; American robin (*Turdus migratorius*)—representing avian omnivores, herbivores, and insectivores; violet-green swallow (*Tachycineta thalassina*)—representing avian aerial insectivores; and American kestrel (*Falco sparverius*)—representing avian carnivores (LANL 2017a).

Monitoring levels of constituents in biological tissues provides information regarding whether chemicals in the environment are bioavailable to plants and animals and allows us to compare observed levels to levels that scientists have determined are potentially associated with adverse health effects to the individual plant or animal. Levels of chemicals in biological tissues are compared with the lowest observable adverse effect levels, if available. A lowest observable adverse effect level is the lowest concentration in tissue that has produced an adverse effect in an exposed population of animals or plants (U.S. Environmental Protection Agency 2014). Levels of radionuclides in tissues are compared with biota dose screening levels, which are set at 10 percent of the DOE limit for radiation doses to biota (DOE 2002, McNaughton 2006).

If a radionuclide in soil or in biota is detected at an activity that is higher than the screening levels, then the dose to biota using all of the available data is calculated using RESRAD-BIOTA software (version 1.8) (http://resrad.evs.anl.gov/codes/resrad-biota/), which is DOE's methodology for evaluating radiation doses to aquatic and terrestrial biota. This calculated dose is compared with DOE limits: 1 rad per day for terrestrial plants and aquatic animals, and 0.1 rad per day for terrestrial animals (DOE 2002).

We perform statistical tests to evaluate differences in constituents among sites and to examine trends in constituent levels over time. Examples of these tests include *t*-tests, analysis of variance, Kruskall-Wallis tests, Kendall's Tau tests, linear regressions, and generalized linear models. Samples collected within approximately the last 10 years are used in these tests because the samples are directly comparable: they were analyzed with similar analytical methods and instruments and have similar detection limits. We test a null hypothesis for each set of data, typically that there are no differences among locations, or that there are no trends over time. The tests for each data set have an associated probability, or p-value, of the null hypothesis being correct. We use a p-value of less than 5 percent ($p < 0.05$) as our threshold to reject the null hypothesis of no difference between locations or no trend over time. If the p-value is greater than 5 percent ($p > 0.05$), we accept the null hypothesis of no difference or no trend.

Institutional Soil and Vegetation Monitoring

Monitoring Network

Institutional surface soil and vegetation samples are collected once every three years. The majority of onsite soil-sampling stations are located on undisturbed mesa tops close to and, if possible, downwind from major facilities or operations at the Laboratory. In 2018, we collected surface soil and vegetation from 18 onsite locations, 12 perimeter locations, and six regional background locations (Figure 7-1). Many locations have been sampled for radionuclides since the early 1970s (Purtymun et al. 1980, 1987). In 2018, eight new monitoring locations were established and six previous monitoring locations were dropped.

Onsite soil sampling locations that have been historically monitored and continued to be monitored include (1) west and (2) east of Technical Area 53 (Los Alamos Neutron Science Center); (3) near Technical Area 33 (former firing sites and current experimental sites); (4) near Test Well DT-9 at Technical Area 49 (former experimental site and current hazardous materials training facility); (5) north of Technical Areas 50 and 35 (Plutonium Facility and Radioactive Liquid Waste Treatment Facility); (6) Potrillo Drive at Technical Area 36 (firing sites that support explosive testing); (7) R-Site Road east at Technical Area 15 (explosives firing sites); (8) K-Site at Technical Area 11 (high-explosives processing and storage areas and firing sites); (9) Technical Area 21 (former plutonium and tritium processing facilities); (10) Technical Area 51 (environmental research site of radioactive materials); (11) Twomile Mesa at Technical Area 06 (former radioactive materials processing facilities); and (12) south side of NM 502 at Technical Area 73 (Technical Area 21 and its associated solid waste management units, including historical waste disposal sites). Sampling locations that were new in 2018 include (1) Lower Slobbovia at Technical Area 36 (explosives firing sites); (2) Minie at Technical Area 36 (explosives firing sites); (3) Q site at Technical Area 14 (explosives firing sites); (4) Technical Area 16 (burning grounds); (5) Transuranic Waste Facility at Technical Area 63 (transuranic waste facility); and (6) Ten-Site Canyon at Technical Area 35 (received effluent from radioactive liquid waste treatment facility) (Figure 7-1). Locations that were dropped in 2018 include (1) east of Technical Area 54 (low-level radioactive and transuranic waste storage and disposal facilities) and (2) four of the five sample locations along the south side of NM 502 at Technical Area 73.

All but one of the perimeter stations are located within 2.5 miles of the Laboratory boundary. Most of these locations are located in inhabited or publicly accessible areas to the north and east of the Laboratory. Los Alamos townsite locations include (1) North Mesa, (2) the Sportsman's Club in Rendija Canyon, (3) along Quemazon Trail near Western Area, (4) east of the Los Alamos airport, and (5) Acid Canyon (new in 2018); White Rock locations include (6) the new White Rock housing development area off of NM 4 (bordering Technical Area 54; new in 2018); Pueblo de San Ildefonso locations include (7) White Rock (east), (8) Pueblo de San Ildefonso lands directly north of Technical Area 54, (9) near the Otowi Bridge over the Rio Grande, and (10) near Bandelier National Monument unit of Tsankawi at the intersection of NM 4 and East Jemez Road; west and southwest locations near the laboratory include (11) west of Technical Area 08, and (12) south of Technical Area 49 (Figure 7-1). One historically monitored perimeter location, west of the Los Alamos airport, was dropped in 2018.

Surface soil samples were collected from six regional background locations near (1) Ojo Sarco, (2) Dixon, and (3) Borrego Mesa (near Santa Cruz dam) to the northeast of the Laboratory, (4) Rowe Mesa (near Pecos) to the southeast of the Laboratory, (5) Youngsville to the northwest of the Laboratory, and (6) Jemez Springs to the southwest (Figure 7-1).

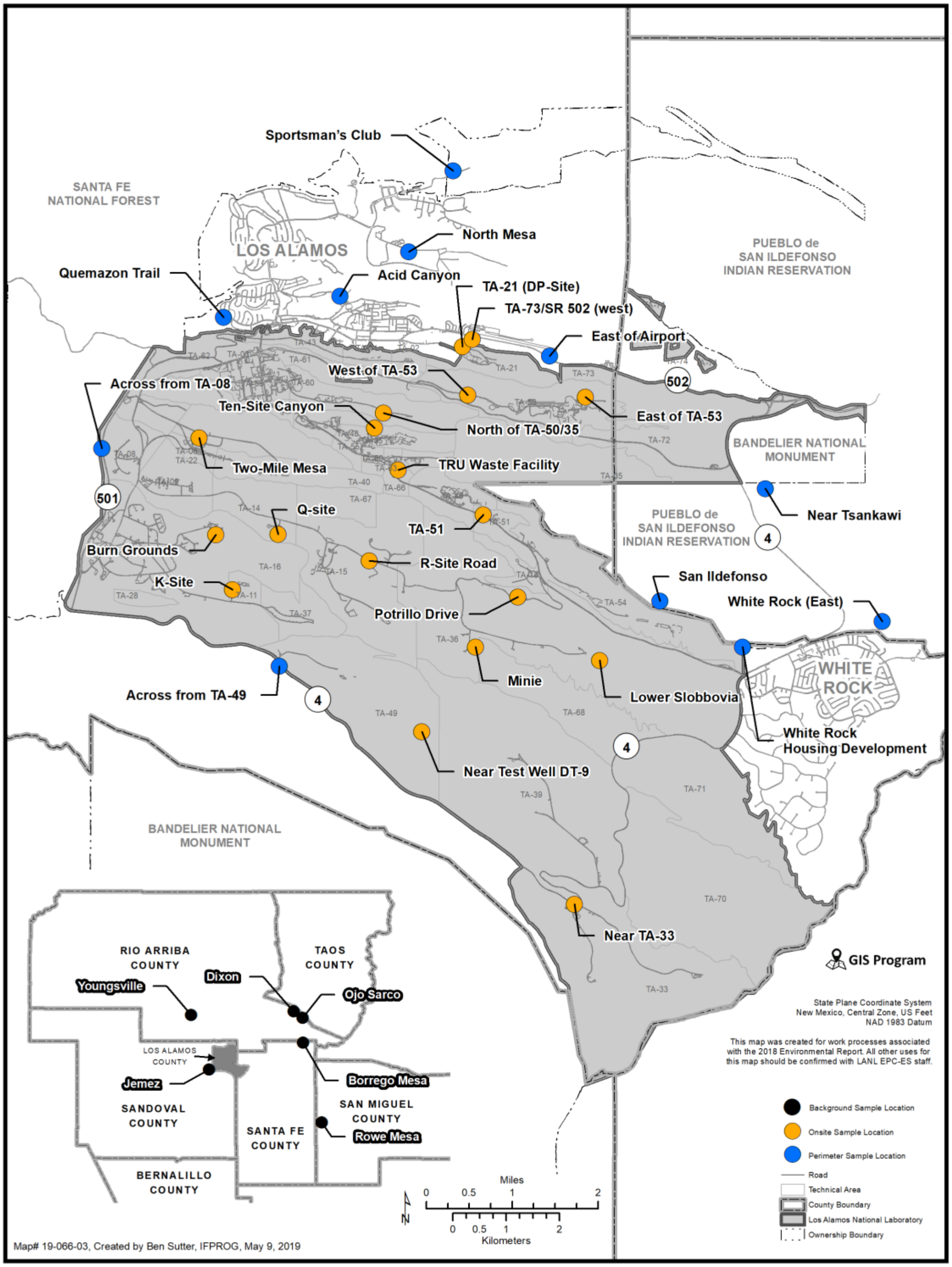


Figure 7-1. Onsite, perimeter, and regional background soil and vegetation sampling locations. The Otowi perimeter station is not shown but is about five miles east of the Laboratory, near the confluence of Los Alamos Canyon and the Rio Grande. TA = Technical Area, TRU = Transuranic.

Methods and Analyses

At each soil sampling location, five surface soil subsamples were collected at the center and in the corners of an approximately 10-meter by 10-meter square area. The subsamples were collected using a stainless steel soil ring 10 centimeters in diameter pushed five centimeters into the ground. The five subsamples per location were combined and mixed thoroughly in a large plastic bag to form a composite sample. Composite samples were placed into polyethylene sample bottles and then labeled, sealed with chain-of-custody tape, placed on ice, and submitted to the Laboratory's Sample Management Office. All samples were shipped under full chain of custody to the analytical laboratory ALS in Fort Collins, Colorado, for chemical analyses. These samples are analyzed for americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235/236, uranium-238, and for 23 inorganic elements (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, sodium, selenium, silver, thallium, vanadium, and zinc).

A separate soil grab sample was collected near the center of each soil sample location from the 0- to 15-centimeter depth using stainless steel scoops. Each grab sample was placed into an amber-colored glass sample bottle and then labeled, sealed with chain-of-custody tape, placed on ice, and submitted to the Laboratory's Sample Management Office. All samples were shipped under full chain of custody to the analytical laboratory GEL in Charleston, South Carolina, for chemical analyses. The grab samples were analyzed for commercial PCB Aroclor mixtures, high explosives compounds, dioxins, furans, semi-volatile organic compounds, and volatile organic compounds.

Native vegetation, either from understory plants (grasses and forbs) or from trees was collected in the same general location that soil samples were collected. During the years of institutional soil and vegetation monitoring, vegetation samples were alternated. In 2018, understory vegetation was collected and analyzed. Overstory vegetation was last collected in 2015 (Fresquez et al. 2016). Understory vegetation samples were clipped near the ground with care not to collect soil. Vegetation samples were placed into a zippered plastic bag and then labeled, sealed with chain-of-custody tape, placed on ice, and submitted to the Laboratory's Sample Management Office. All samples were shipped under full chain of custody to the analytical laboratory ALS in Fort Collins, Colorado, for chemical analyses and were analyzed for the same radionuclides and inorganic elements as the soil samples.

All soil chemical results were compared with the regional statistical reference level and with ecological screening levels. Vegetation chemical results were compared with the regional statistical reference levels, and radionuclide results were compared with biota dose screening levels. Radionuclide and inorganic element concentrations in both soil and vegetation were also analyzed for trends over time using the Kendall's Tau correlation test, and differences in concentrations among locations (onsite, perimeter, and background) were analyzed with an analysis of variance or a Kruskall-Wallis test.

Radionuclide Results in Soil

Uranium isotopes (uranium-234, uranium-235/236, and uranium-238) occur naturally in soil and were detected in all soil samples. The majority of the other radionuclides were either not detected or were below regional statistical reference levels; all were below the no-effect ecological screening levels (see supplemental Table S7-1; supplemental tables are provided separately in electronic format). For radionuclides, a not-detected value is one in which the result is less than the minimum activity detectable by the analytical measuring equipment.

Five onsite locations contained radionuclide levels that were higher than the regional statistical reference levels. Those locations were in Technical Areas 21, 63, and 73. One perimeter location, Acid Canyon, contained americium-241 (0.718 picocuries per gram) and plutonium-239/240 (8.32 picocuries per gram) at levels that exceeded the regional statistical reference levels of 0.019 and 0.057 picocuries per gram, respectively. These observations are in line with previous findings. Acid Canyon received radioactive waste from Laboratory operations between the mid 1940s and mid 1960s. The canyon has been remediated three times since then; however, residual radionuclides remain. Recent dose assessments within Acid Canyon are reported in Chapter 8 and in McNaughton et al. (2018).

Most radionuclide activities in soil did not differ between onsite, perimeter, and background locations, including americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, and uranium-235/236. Uranium-234 and uranium-238 were higher in soil collected from onsite locations when compared with regional background locations (Figure 7-2). The near 1:1 ratio of uranium-234 to uranium-238 activities indicate that these uranium activities are from naturally-occurring sources (U.S. Nuclear Regulatory Commission 2019). The concentrations observed at the LANL onsite locations in 2018 are within the range of Laboratory background concentrations from a previous study (Ryti et al. 1998).

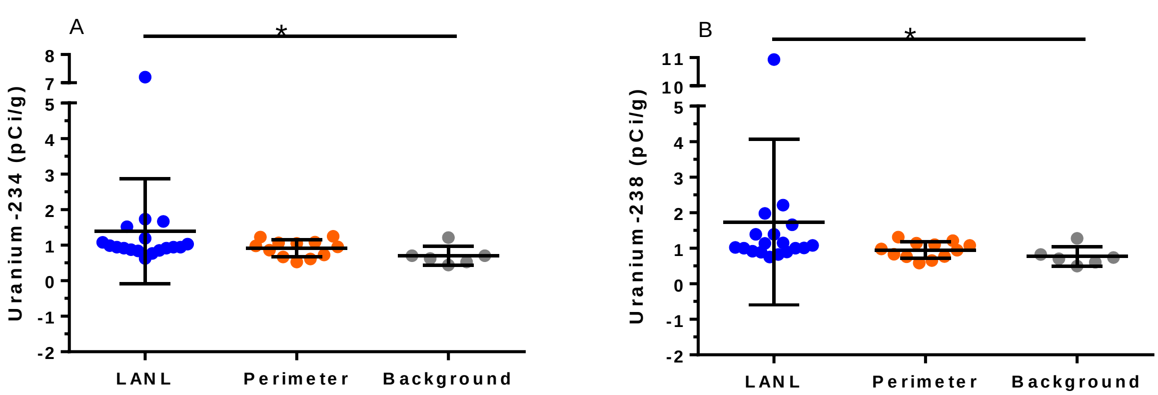


Figure 7-2. (A) Uranium-234 and (B) uranium-238 activities in surface soil samples collected from 18 onsite, 12 perimeter, and 6 regional background locations collected in 2018. Points represent individual locations, middle cross bars are means, and error bars represent standard deviation. A bar with an asterisk indicates significant pairwise differences. Note: pCi/g = picocuries per gram.

Soil radionuclide results in 2018 are similar to previous years. Activities of radionuclides at locations with histories of radionuclide detections are generally not increasing over time (Kendall's Tau, $p > 0.05$). The only area where a radionuclide activity has increased over time is at the DP site in Technical Area 21, where activities of americium-241, cesium-137, plutonium-239/240, and tritium are increasing. This increase could relate to the soil in the area being disturbed by current clean-up operations on the mesa. Though increasing, radionuclide levels observed at Technical Area 21 are far below ecological screening levels and are not expected to impact plants or animals.

Inorganic Element Results in Soil

Very few inorganic element results in soil exceeded the regional statistical reference levels (Table S7-2). Results that exceeded regional statistical reference levels included antimony and lead at two onsite locations, Technical Area 21 and 51; cadmium and lead at a perimeter location, Acid Canyon; lead at a perimeter location, Quemazon trail; and sodium along the perimeter across from Technical Area 49 (likely due to salted roads). All observed concentrations except for lead were below the low-effect ecological screening levels (Table S7-2).

Lead levels at Technical Area 21 (28 milligrams per kilogram), Quemazon trail (28 milligrams per kilogram), and at Acid Canyon (38 milligrams per kilogram) exceeded the low-effect ecological screening level of 23 milligrams per kilogram for the American robin (Table S7-2). Two major sources of lead in soil are from auto emissions and lead-based paint. Studies conducted in urban areas have shown that lead levels in soil are highest around building foundations and within a few feet of busy streets (Rolfe et al. 1977, Singer and Hanson 1969). Although lead is not presently used in household paint or gasoline, it can persist in the soil for a long time.

In 2015, elevated lead levels (140 milligrams per kilogram) were detected in the soil sample collected from Technical Area 21. This was a result of the demolition of a water tower in August of 2014 (Parsons 2014). The collapse of the tower onto the ground spread out fragments of lead-based paint from the tower, and the elevated lead levels observed at this site in 2018 are likely still caused by the paint from the water tower.

We do not know the reason for the elevated lead levels observed in Acid Canyon or at the Quemazon trail, but it is possible that the source of lead in Acid Canyon was from legacy waste discharges into the canyon. The soil sample collected at the Quemazon trail was near painted infrastructure; lead levels near the Quemazon trail have also been increasing over time (Kendall's Tau, $p < 0.05$).

A number of inorganic elements were higher in regional background locations when compared with onsite and perimeter locations, including aluminum, arsenic, barium, calcium, chromium, copper, iron, magnesium, nickel, potassium, and vanadium (Figure 7-3). Soil zinc concentrations were higher in background locations but only when compared with onsite soil locations. No inorganic elements were higher at onsite locations when compared with background locations.

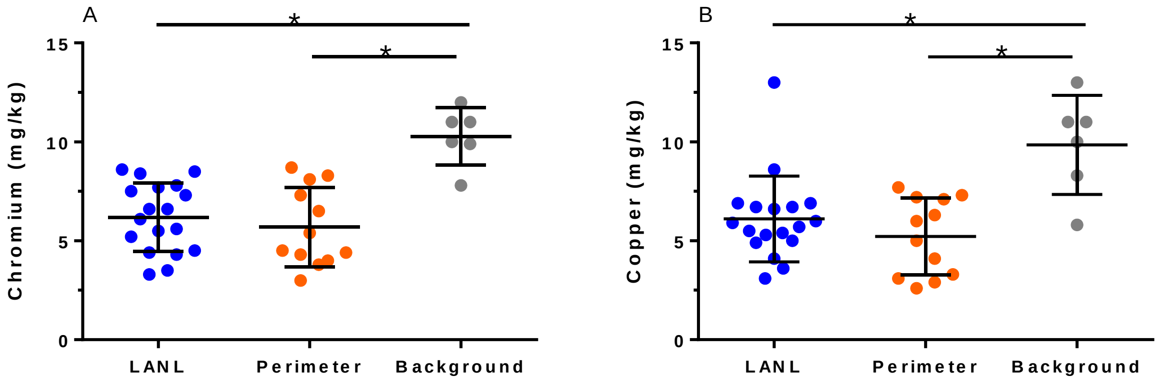


Figure 7-3. (A) Chromium and (B) copper concentration in surface soil samples collected from 18 onsite, 12 perimeter, and 6 regional background locations collected in 2018. Points represent individual locations, middle cross bars are means, and error bars represent standard deviation. A bar with an asterisk indicates significant pairwise differences.
Note: mg/kg = milligrams per kilogram.

Inorganic element results in soil collected in 2018 are generally similar with previous years and the majority of elements are not trending over time. Increasing selenium concentrations were observed at several soil sampling locations and include onsite locations (1) near Technical Area 33, (2) Potrillo drive near Technical Area 36, (3) Technical Area 51, (4) south side of NM 502 at Technical Area 73; and perimeter locations including the (5) Quemazon trail, (6) Sportsman's club, (7) Pueblo de San Ildefonso (north of Technical Area 54), and (8) near Bandelier National Monument unit of Tsankawi (near the intersection of NM 4 and East Jemez Road) (Kendall's Tau, $p < 0.05$). However, soil selenium concentrations were also increasing at four of the six regional background locations and thus the source of selenium driving these observations may not be Laboratory derived. Power plants are one of the leading causes of air pollution (U.S. Environmental Protection Agency 2019), including selenium emissions. It is possible that the Four Corners Power Plant (located in northeastern NM) operations could be the source of increasing selenium concentrations that have been observed not only in soil collected at the Laboratory, but also in soil collected from perimeter and background locations.

Dioxin and Furan Results in Soil

Dioxins and furans were analyzed in soil under the institutional monitoring program for the first time in 2018. The most toxic dioxin congener (tetrachlorodibenzodioxin-2,3,7,8) was not detected in any of the soil samples. Some dioxin and furan congeners were detected above the regional statistical reference level (Tables S7-3 and S7-4). Ecological screening levels only exist for tetrachlorodibenzodioxin-2,3,7,8; however, each congener was multiplied by its respective World Health Organization toxic equivalent factor (Van den Berg et al. 2006) and then compared with the tetrachlorodibenzodioxin-2,3,7,8 ecological screening levels. Three dioxin and four furan congeners were detected at the Transuranic Waste Facility at Technical Area 63 that were above the no-effect ecological screening level for the montane shrew but were below the low-effect ecological screening level (Tables S7-3 and S7-4).

PCB Aroclor Results in Soil

Similar with previous years, PCB Aroclors were not detected in the majority of soil samples. Only four onsite locations contained detectable concentrations of PCB Aroclors. Minie Site contained Aroclor-1242 and -1254, Technical Area 21 (DP-site) contained Aroclor-1254 and -1260, the south side of NM 502 at Technical Area 73 contained Aroclor-1254, and Ten-Site Canyon contained Aroclor-1260. All PCB Aroclor concentrations were below the lowest no-effect ecological screening level.

Semi-Volatile Organic Compound Results in Soil

All soil samples were analyzed for 74 semi-volatile organic compounds. The majority of these compounds were not detected. Only 16 compounds had detectable concentrations at any of the sampling locations. Two compounds exceeded the no-effect ecological screening level for the American robin, bis(2-ethylhexyl)phthalate (one location), and di-n-butylphthalate (six locations), but they were well below the low-effect ecological screening level. All other semi-volatile organic compounds were well below the no-effect ecological screening levels.

Volatile Organic Compound and High Explosive Results in Soil

Soil samples were analyzed for seven volatile organic compounds and 20 high explosive chemicals. None of the samples had detectable concentrations of volatile organic compounds or high explosive chemicals, and these results are similar with previous observations.

Radionuclide Results in Understory Vegetation

All radionuclide activities in understory vegetation, collected from onsite and perimeter locations, were either not detected (most results), below regional statistical reference levels, or far below biota screening levels (Table S7-5). These data are similar with previous results (Gonzales et al. 2000, Fresquez and Gonzales 2004, Fresquez et al. 2010), and no differences in radionuclide levels were observed among onsite, perimeter, and background locations (analysis of variance and Kruskall Wallis, $p > 0.05$).

Levels of most radionuclides were not trending over time; however, uranium-235/236 was increasing (Kendall's Tau, $p < 0.05$) in understory vegetation at two locations: (1) north of Technical Areas 50 and 35 and (2) Twomile mesa at Technical Area 06. As current uranium-235/236 activities are well below the biota dose screening levels. There is no ecological concern for this trend; however, it will continue to be monitored.

Inorganic Element Results in Understory Vegetation

The majority (98 percent) of inorganic element concentrations in understory vegetation collected from onsite and perimeter locations were below their regional statistical reference levels (Table S7-6). The few elements, including lead, that were above the regional statistical reference levels at some perimeter and onsite locations were at levels far below those considered toxic to plants (LeFebvre 2016).

Concentrations of chromium in understory vegetation were higher from regional background locations when compared with onsite and perimeter plants (analysis of variance, $p < 0.05$); additionally, understory vegetation had higher concentrations of mercury from background locations when compared with perimeter plants (analysis of variance, $p < 0.05$, Figure 7-4).

Approximately a dozen inorganic elements were either increasing or decreasing over time at more than a dozen onsite and perimeter locations. These results are inconsistent with past data. We combined overstory vegetation (collected in 2015 and 2009) with the understory vegetation (collected in 2018 and 2012) to perform the trend analyses, and the inconsistent results may suggest it is not appropriate for us to combine the differing vegetation types; however, the levels of inorganic elements were all below levels that are protective of biota, and most were below the regional statistical reference levels. The results do not provide any reason to be concerned about harm to plants or animals.

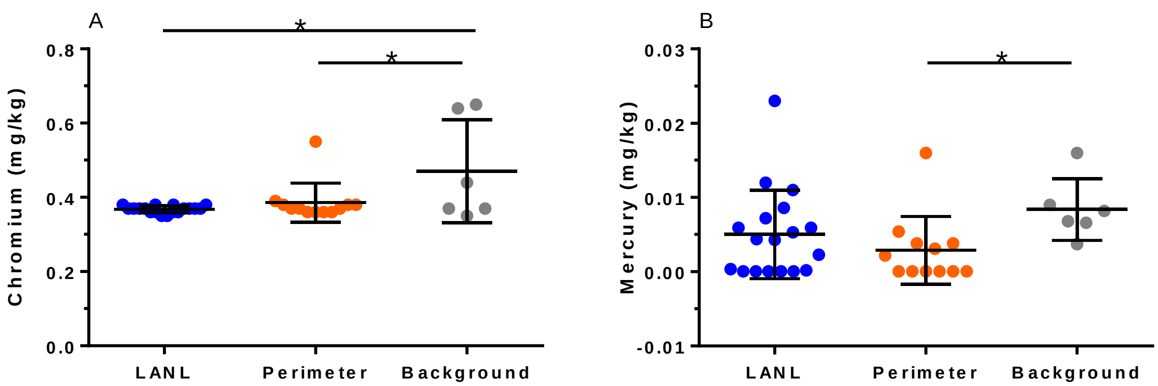


Figure 7-4. (A) Chromium and (B) mercury concentrations in composite understory vegetation samples collected from 18 onsite, 12 perimeter, and 6 regional background locations collected in 2018. Points represent individual locations, middle cross bars are means, and error bars represent standard deviation. A bar with an asterisk indicates significant pairwise differences. Note: mg/kg = milligrams per kilogram.

Facility Soil and Vegetation Monitoring

Area G at Technical Area 54

Area G was established in 1957 and is the Laboratory's primary low-level radioactive solid waste burial and storage site (DOE 1979, Martinez 2006; Figure 7-5). Tritium, plutonium, americium, and uranium are the main radionuclides in waste materials at Area G (Mayfield and Hansen 1983). The Laboratory has conducted soil, vegetation, and small mammal monitoring at Area G since 1980 to determine whether radionuclides are migrating beyond the waste burial area (LANL 1981, Mayfield and Hansen 1983).

We collect surface soil and vegetation on an annual basis for environmental monitoring purposes. Surface soil grab samples (0- to 6-inch depth) and composite tree samples, primarily of one-seed juniper (*Juniperus monosperma*), were collected in April 2018 at 13 designated locations around the perimeter of Area G. Soil and one composite tree sample were collected at the bottom of Cañada del Buey near the boundary between the Laboratory and the Pueblo de San Ildefonso (Figure 7-5). All samples were analyzed for tritium, americium-241, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235/236, and uranium-238.

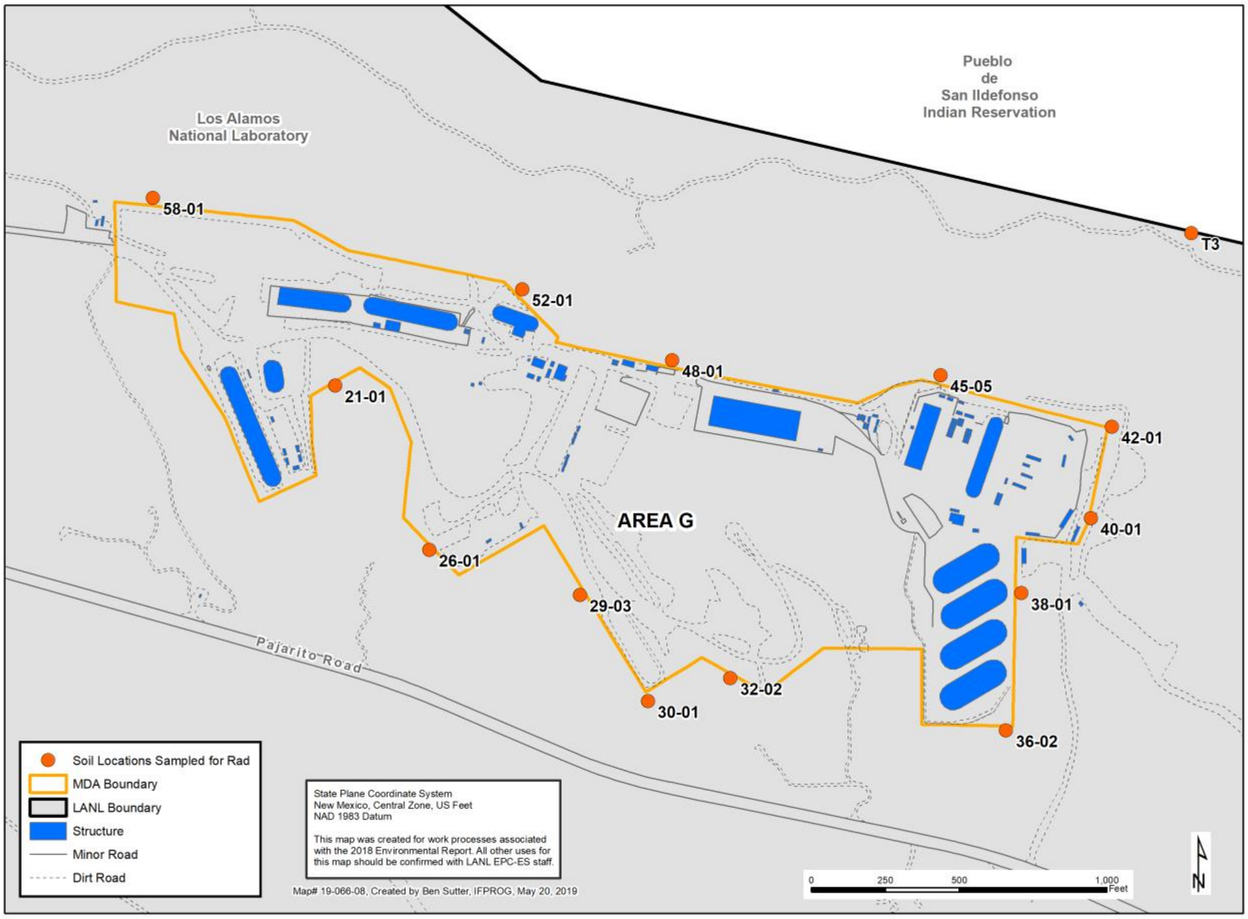


Figure 7-5. Locations of soil and vegetation samples collected around Area G in 2018. Note: MDA Boundary is Material Disposal Area.

Radionuclides in Soil and Vegetation at Area G

In 2018, cesium-137, uranium-234, uranium-235/236, and uranium-238 activities were below regional statistical reference levels in all soil samples collected around the perimeter of Area G. Similar to previous years, americium-241, plutonium-238, plutonium-239/240, and tritium were detected above regional statistical reference levels in many soil locations around the perimeter of Area G in 2018 (Table S7-7).

Americium-241, plutonium-238, and plutonium-239/240 in soil samples collected on the north, northeastern, and eastern side of Area G were above the regional statistical reference level. These concentrations are similar with previous years and are not increasing over time (Kendall's Tau, $p > 0.05$; see Figure 7-6). Similarly, levels of tritium in soil samples collected on the southern side of Area G were above the regional statistical reference level, which are consistent with data from previous years. Tritium levels are not statistically increasing over time (Kendall's Tau, $p > 0.05$; see Figure 7-6).

Similar to observations in 2017, plutonium-238 activities in soil increased at location 32-02 (Kendall's Tau, $p < 0.05$) during the time period between 2008 and 2018. The overall plutonium-238 levels at 32-02 are comparable to the regional statistical reference level and are below activities observed on the north, northeastern, and eastern sides of Area G.

Results from native trees (primarily one-seed juniper) can be an indicator of both uptake by roots and of deposition of radionuclides on the surfaces of leaves and branches. Tree samples were collected at the same general locations as the soil samples (Figure 7-5); however, because of a firebreak along the fence line, some of the trees are located more than 30 feet away from the fence around Area G, particularly on the northern and eastern sides.

The majority of radionuclides in overstory vegetation samples were either not detected or were below the regional statistical reference levels. All activities were below the biota dose screening levels (Table S7-8). Americium-241 levels in overstory vegetation samples are decreasing (Kendall's Tau, $p < 0.05$) over time at several locations at the northeastern corner of Area G, including 38-01, 40-01, and 45-05 (Figure 7-7); however, the percent of nondetects in these vegetation samples range between 20 percent and 50 percent and could be influencing the trend analyses' results.

Similar to previous years, tritium in overstory vegetation was highest (up to 40,600 picocuries per milliliter) in trees growing in the southern sections near the tritium disposal shafts. The overall trend in plant tritium is highly variable from year to year but the levels have not been increasing over time (Kendall's Tau, $p > 0.05$; Figure 7-7). Variability in plant tritium levels may be a result of any, or a combination, of the following: soil moisture, depth of roots, time of sampling, distance from the perimeter fence, temperature, or barometric pressure.

Plutonium-238 in overstory vegetation is increasing over time at location 29-03 (Kendall's Tau, $p < 0.05$). However, plutonium-238 levels in vegetation from 29-03 were below the regional statistical reference level. No other radionuclides activities in trees are increasing over time (Kendall's Tau, $p > 0.05$) and all levels are below the biota dose screening levels that are protective of plants. These data suggest that radionuclide activities observed here are not expected to cause adverse effects to the vegetation.

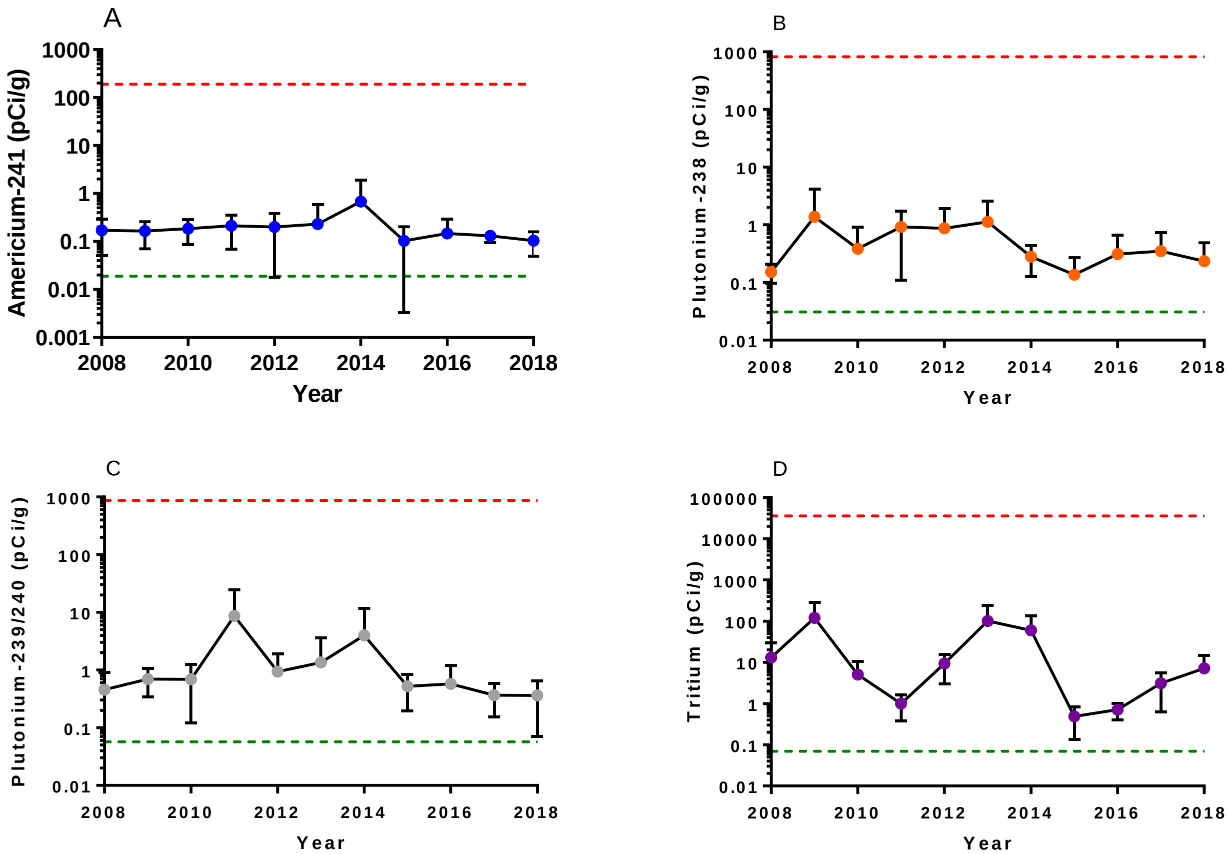


Figure 7-6. (A) Americium-241, (B) plutonium-238, (C) plutonioum-239/240 activities in surface soil samples collected from five locations on the northern, northeastern, and eastern side (locations 38-01, 40-01, 42-01, 45-05 and 48-01), and (D) tritium activities in surface soil samples collected from two locations on the southern side (locations 29-03 and 30-01) of Area G at Technical Area 54 from 2008 to 2018. Data are compared with the regional statistical reference level (green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent mean and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

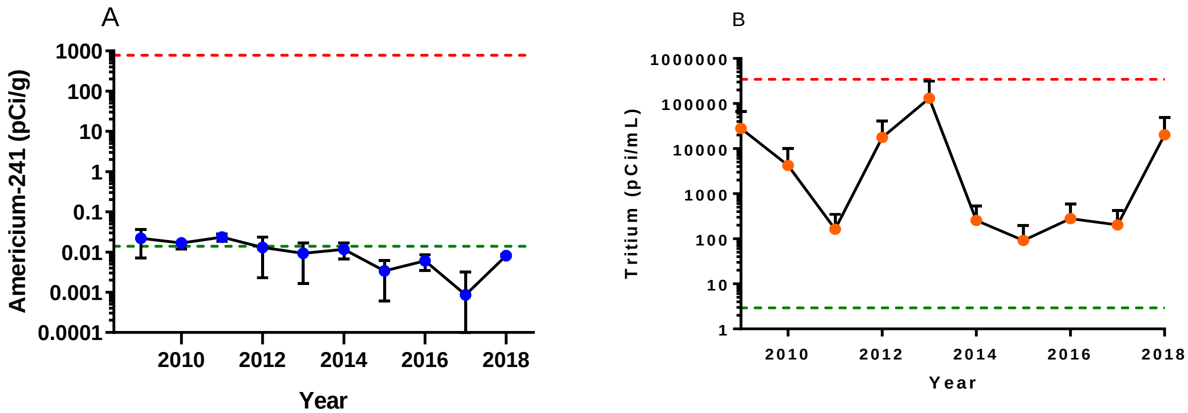


Figure 7-7. (A) Americium-241 activities in overstory vegetation samples collected from three locations on the northeastern corner of Area G (locations 38-01, 40-01 and 45-05), and (B) tritium activities in overstory vegetation samples collected from two southern locations (locations 29-03 and 30-01) around Area G at Technical Area 54 from 2009 to 2018. Data are compared with the regional statistical reference level (green dashed line) and biota dose screening level for overstory vegetation (red dashed line). Note the logarithmic scale on the vertical axis. Points represent mean and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram and pCi/mL = picocuries per milliliter.

Radionuclides in Soil and Vegetation near the Laboratory/Pueblo de San Ildefonso Boundary in Cañada del Buey

In 2018, a total of six soil samples were collected at the bottom of Cañada del Buey near the Technical Area 54 and Pueblo de San Ildefonso boundary. The soil samples were collected near the T3 location along an approximately 70 meter transect across an elevation gradient. One soil sample was collected near the fence (T-3E); sampling was done previously in this general area from 2006 to 2015. Soil was sampled at T-3B from 2016 to 2017; in 2018, a duplicate-split (homogenized in a bag and split into two sample containers) soil sample was collected at this location. Three additional locations along the transect were sampled in 2018 only.

The majority of radionuclide activities in soil were not detected or were below the regional statistical reference level, and all activities were below the ecological screening levels (Table S7-7). Specifically, americium-241 and plutonium-238 were not detected in any of the soil samples collected near the boundary in 2018 (Table S7-7). However, the analytical laboratory experienced tracer recovery difficulties, which ultimately led to higher detection limits for these samples.

All three uranium isotopes were detected in all soil samples collected near the Technical Area 54 and Pueblo San Ildefonso boundary. Some activities slightly exceeded the regional statistical reference level (Table S7-7). However, the near 1:1 ratio of uranium-234 to uranium-238 activities (Figure 7-8) indicate that these uranium activities are from naturally occurring sources

(U.S. Nuclear Regulatory Commission 2019) and the concentrations observed here are within the range of Laboratory background concentrations (Ryti et al. 1998).

Trends of radionuclide activities from 2008 through 2018 were evaluated by combining results from T-3B and T-3E, as results over multiple years exist for these locations. No radionuclide activities have a trend over time (Kendall's Tau, $p > 0.05$), including americium-241, plutonium-238, and plutonium-239/240 (Figure 7-8).

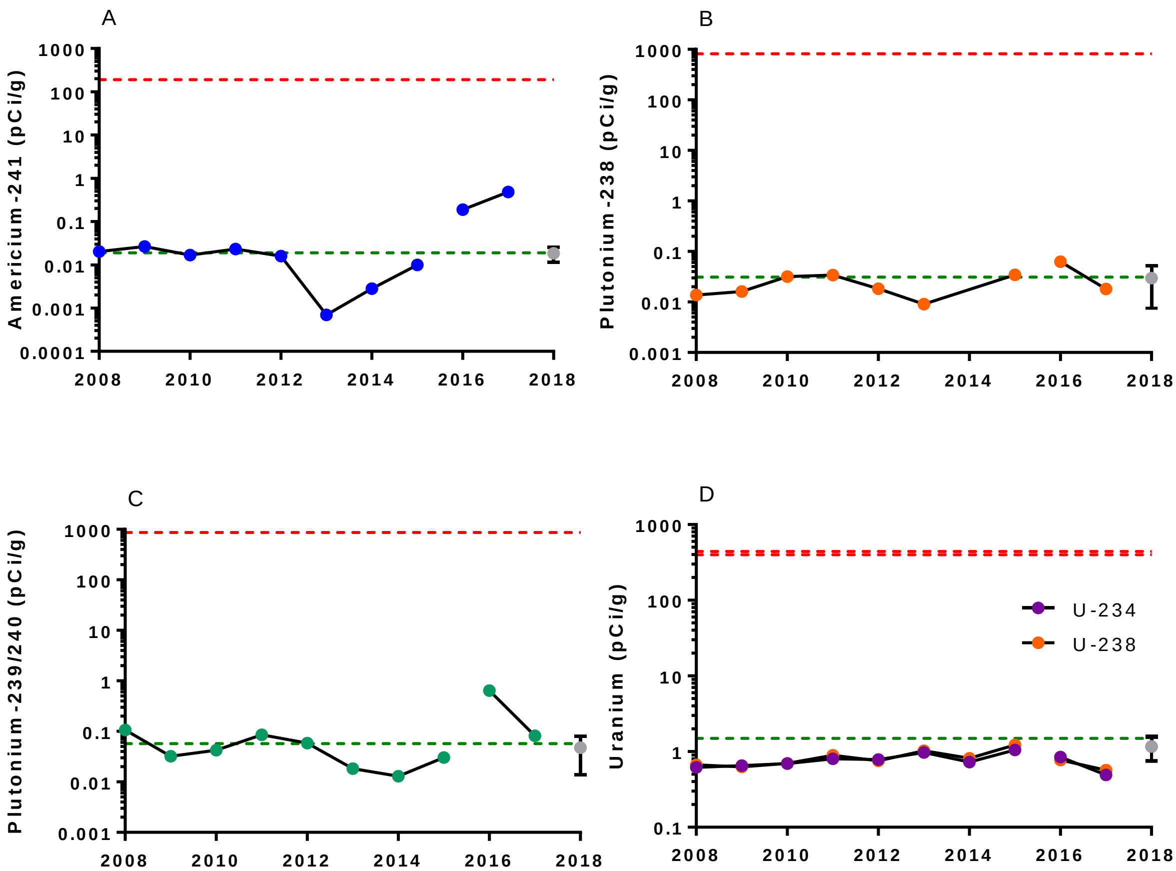


Figure 7-8. (A) Americium-241, (B) plutonium-238, (C) plutonium-239/240, and (D) uranium-234 and uranium-238 activities in soil collected near the Technical Area 54 and Pueblo de San Ildefonso border from 2008 through 2018. Results from 2008 through 2015 were near the T3-E location, results from 2016 through 2017 were near the T3-B location, and results from 2018 are the average of the two locations (gray points). Data are compared with the regional statistical reference level (green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent true values (between 2008 and 2017, n=1) or represent mean (in 2018, n=3), and error bars represent standard deviation. Note: pCi/g = picocuries per gram.

Radionuclides in overstory vegetation collected near the Technical Area 54 and Pueblo de San Ildefonso boundary were all below the regional statistical reference level, except for tritium, which was observed at 4.42 picocuries per milliliter (regional statistical reference level

2.94 picocuries per milliliter). All radionuclides are far below the biota dose screening level, which are protective of biota, and no radionuclides levels are trending over time in vegetation (Table S7-8).

Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15

The Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15 is a principal Laboratory explosives firing site. Soil, sediment from drainages, plants, and animals are monitored at the facility to determine whether constituents released from operations may be affecting plants or animals and if the levels are consistent with our expectations of radionuclide and chemical uptake. Environmental monitoring has occurred annually since 1996. The firing site began operations in 2000. Open-air detonations occurred from 2000 to 2002, detonations using foam mitigation were conducted from 2003 to 2006, and detonations within closed steel containment vessels have been conducted since 2007.

Monitored constituents in soil and sediment include radionuclides, beryllium (and other inorganic elements), and organic chemicals such as high explosives, dioxins, and furans. Routine biological samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility have included overstory branches, small mammals, bees, and bird eggs and nestlings. Samples of soil, sediment, and one type of biota are collected annually; typically, vegetation, bees, and small mammals sampling is rotated annually, so that each is sampled once in a three-year period. Bird samples are collected opportunistically when abandoned or infertile eggs or deceased nestlings are found in local nest boxes.

Composite surface soil samples from zero to two inches (five subsamples per location) were collected in June 2018 on the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter along the fence line (Figure 7-9). An additional soil composite sample was collected about 75 feet north of the firing point along the side of the protective berm. Sediment grab samples (zero to six inches) were collected on the north, east, south, and southwest sides within drainages around the facility (Figure 7-9). All soil and sediment samples were analyzed for radionuclides including tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235/236, and uranium-238; inorganic elements including aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc; and high explosives. The sample nearest to the firing point was also analyzed for dioxins and furans.

Constituent results in soil samples are compared with the baseline statistical reference levels. The baseline statistical reference levels for the Dual-Axis Radiographic Hydrodynamic Test Facility are based on samples collected at the facility during 1996 to 1999, before the beginning of firing site operations. The baseline level for each constituent is the levels below which 99 percent of samples from this time occurred (Nyhan et al. 2001). In cases where there are no baseline statistical reference levels (mostly inorganic elements like aluminum, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc), the soil and biota chemical results were compared with regional statistical reference levels.

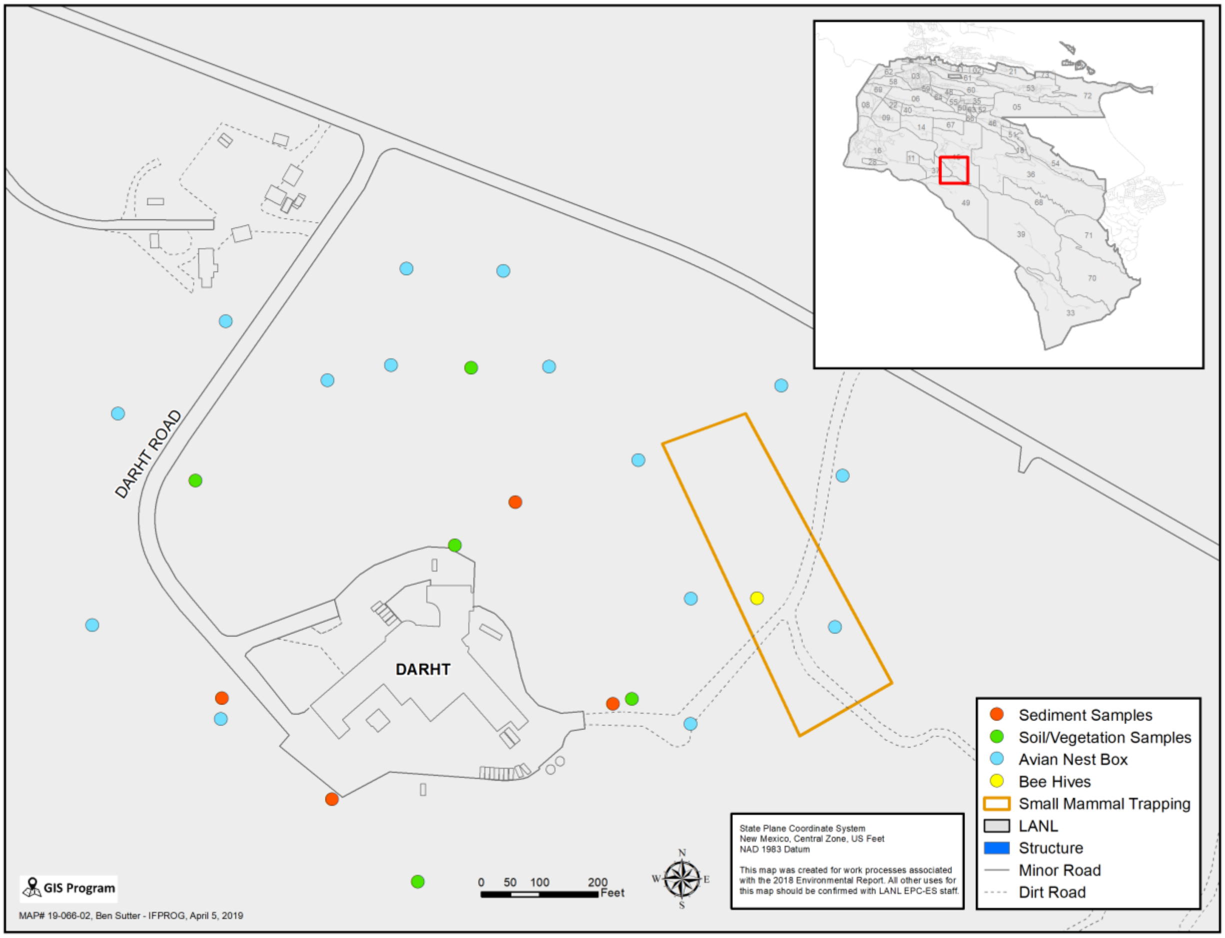


Figure 7-9. Soil, sediment, and biota sample locations at the Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) at Technical Area 15.

Small mammals, such as wild mice, are ideal for monitoring chemicals and radionuclide exposures and uptake in biological systems because of their close contact with soil, burrowing behavior, and omnivorous diets (Smith et al. 2002, Talmage and Walton 1991). Small mammals have been periodically trapped and collected from near the Dual-Axis Radiographic Hydrodynamic Test Facility and chemically analyzed. In 2018, one individual deer mouse was collected and analyzed for inorganic elements, one pinyon mouse (*Peromyscus trueii*) was collected and analyzed for dioxins and furans, and a composite of four individual brush mice (*Peromyscus boylii*) were collected and analyzed for radionuclides. Typically, we collect and analyze replicate samples; however, because of the effects of severe drought on small mammal abundance, we had poor trapping success. We captured small mammals using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee.

Wild bird eggs have sometimes been shown to reflect chemical exposures from the location where a female bird feeds during egg formation (Dauwe et al. 2005); however, the female's chemical body burdens from previous exposures, such as on migration routes or wintering grounds, can also become mobilized from lipid stores and deposited into eggs (Bustnes et al. 2010). Nestlings tend to reflect local chemical exposures due to their limited mobility. Eggs that did not hatch and nestlings that died of natural causes were collected from nest boxes surrounding the Dual-Axis Radiographic Hydrodynamic Test Facility and chemically analyzed (Figure 7-9). Three egg samples consisting of an individual western bluebird egg (*Sialia mexicana*), and two composite samples of four western bluebird eggs were collected and submitted for inorganic element analyses. One individual western bluebird nestling was collected and analyzed for inorganic elements and plutonium and uranium isotopes.

Radionuclides and Chemicals in Soil, Sediment, Small Mammals, and Bird Eggs and Nestlings at the Dual-Axis Radiographic Hydrodynamic Test Facility

Soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility did not contain detectable levels of tritium, americium-241, cesium-137, plutonium-238, or plutonium-239. The majority of samples did not contain detectable levels of strontium-90 (Table S7-9). In 2018, all soil and sediment samples contained all three isotopes of uranium; this result is consistent with previous years. Several samples contained activities of uranium that were higher than the regional statistical reference level and the baseline statistical reference level. The relative isotopic abundance of urainum-234, uranium-235, and uranium-238 activities indicate that the uranium in these samples are depleted uranium (uranium from testing activities) rather than natural uranium (e.g., 84.7 percent Uranium-238, 1.1 percent Uranium-235, and 15.2 percent Uranium-234 [International Atomic Energy Agency 2019]). All radionuclide activities are far below ecological screening levels that are protective of biota (Table S7-9).

Operations at the Dual-Axis Radiographic Hydrodynamic Test Facility have changed since 2007 to include the use of closed-containment vessels. Since 2008, uranium-238 activity near the firing point has mostly decreased to the baseline statistical reference level (Figure 7-10), though the trend is not statistically significant (Kendall's Tau, $p > 0.05$). Levels of radionuclides in soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility are not increasing over time (Kendall's Tau, $p > 0.05$).

All inorganic elements tested for were detected in all soil and sediments samples collected in 2018 around the Dual-Axis Radiographic Hydrodynamic Test Facility. Concentrations of aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, mercury, nickel, potassium, and silver were below all reference and screening levels including the baseline statistical reference levels, regional statistical reference levels, and both the no- and low-effect ecological screening levels (Table S7-10).

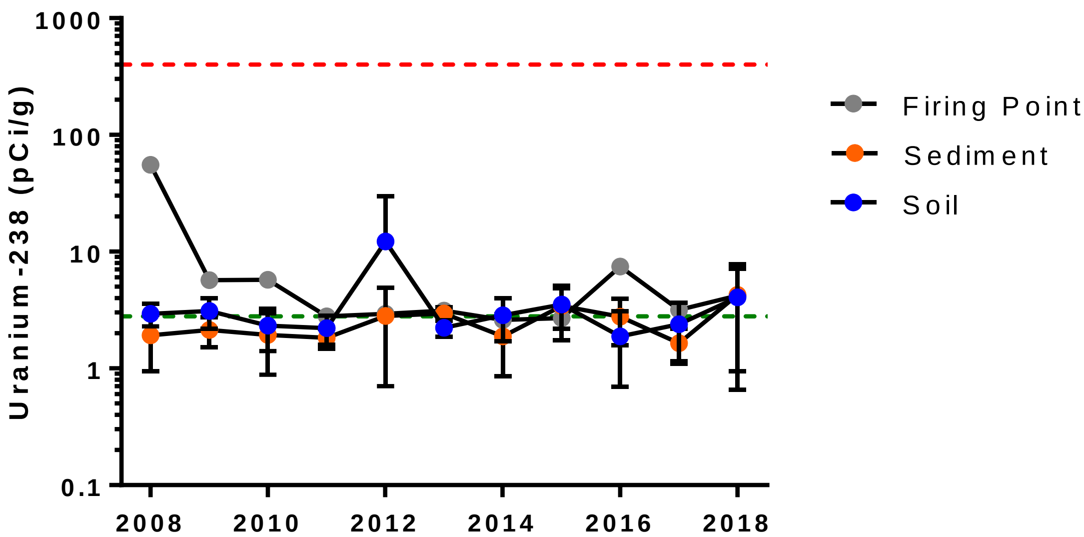


Figure 7-10. Uranium-238 activities in surface soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and in the firing point soil sample from 2008 to 2018 compared with the baseline statistical reference level (mean plus three standard deviations of soil uranium-238 pre-operations; green dashed line) and the lowest no-effect ecological screening level for the plant (red dashed line). Note the logarithmic scale on the vertical axis. Points represent true values (firing point) or represent means (sediment and soil) and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

Consistent with observations from previous years, several soil and sediment samples, including the sample collected at the firing point, contained concentrations of barium, manganese, selenium, thallium, and vanadium which exceeded the no-effect ecological screening level for the plant or the no- and low-effect ecological screening level for the American robin; however, all concentrations of these elements were below the regional statistical reference level and the baseline statistical reference level (when available); the regional statistical reference level of these elements were also above the no-effect ecological screening level (Table S7-10). Three sediment samples contained zinc concentrations that were higher than regional statistical reference level or were above the no-effect ecological screening level for the American robin (Table S7-10). Although concentrations of some inorganic chemicals exceeded the no-effect ecological screening levels, the majority were below the low-effect ecological screening levels. The number of locations with concentrations potentially associated with adverse effects at an individual level are minimal, and no impacts to populations or communities of plants and animals are expected.

Similar to 2017, selenium concentrations were increasing over time at the firing point and in all four sediment samples; arsenic was also increasing in soil samples collected on the east and south sides (Kendall's Tau, $p < 0.05$, Figure 7-11). In 2018, copper was also observed to be increasing in sediment collected from the east side of the Dual-Axis Radiographic Hydrodynamic

Test Facility (Kendall's Tau, $p < 0.05$). These trends will be monitored closely in future sampling. No other elements are increasing over time around the Dual-Axis Radiographic Hydrodynamic Test Facility.

Beryllium, listed as a chemical of potential concern before the start-up of operations at the facility (DOE 1995), was not detected above the baseline statistical reference level (1.3 milligrams per kilogram) in any of the soil or sediment samples during 2018. Beryllium concentrations in all soil and sediment samples from 2008 to 2019 have been below the baseline statistical reference level (Figure 7-11).

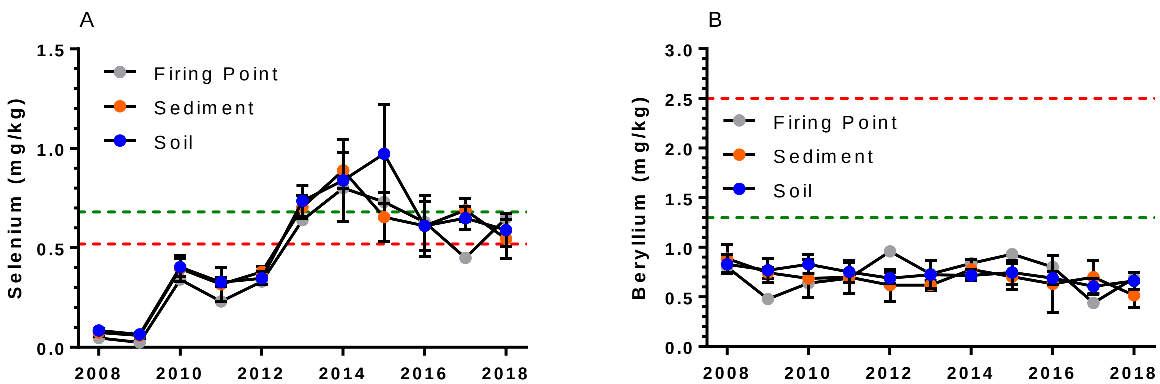


Figure 7-11. (A) Selenium and (B) beryllium concentrations in surface soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and in the firing point soil sample from 2008 to 2018, compared with the baseline statistical reference level (mean plus three standard deviations of soil concentrations pre-operations; green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the linear scale on the vertical axis. Points represent true values (firing point) or represent means (sediment and soil) and error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

Consistent with previous years, no high-explosive chemicals were detected in any of the soil or sediment samples collected within or around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility in 2018, including the sample closest to the firing point (Table S7-11). All furans and most dioxins, including 2,3,7,8-tetrachlorodibenzodioxin (TCDD), were not detected in the soil sample collected at the firing site (Table S7-12). The only dioxin congeners that were detected include 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at a concentration of 0.547 and 4.2 nanograms per kilogram, respectively. There are no ecological screening levels for these dioxin congeners; however, toxic equivalent factors for TCDD-like compounds can be used to determine the toxic equivalents of dioxin-like compounds. The toxic equivalent factor is 0.01 for 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 0.0003 for 1,2,3,4,6,7,8,9-octachlorodibenzodioxin (Van den Berg et al. 2006); multiplying the detectable concentrations of these congeners by their respective toxic equivalents factors yields a value that is orders of magnitude less than the no-effect ecological screening level for TCDD.

In bird eggs, several inorganic elements were not detected, including antimony, arsenic, beryllium, cadmium, lead, nickel, silver, thallium, and vanadium; these observations are similar with previous years. Mercury was detected above the regional statistical reference level (0.179 milligrams per kilogram) in two eggs at 0.21 and 0.21 milligrams per kilograms dry weight. These levels are below the lowest observable adverse effect level of 1.7 milligrams per kilogram dry weight (Thompson 1996). All other detectable concentrations of elements were below the regional statistical reference level (Table S7-13).

The only inorganic elements that were not detected in the nestling were beryllium, cobalt, mercury, and vanadium. The fact that mercury was detected in eggs, but not observed in the nestling, could suggest that the adult female birds ingested mercury at other locations, incorporated it into their tissues, and then redeposited the mercury into the eggs that were collected at the Dual-Axis Radiographic Hydrodynamic Test Facility. Another possible explanation is that mercury was not observed in nestling samples because the rapid growth of nestlings typically dilutes lipophilic contaminant levels in their tissues (Anderson and Hickey 1976). Antimony was detected in the nestling as above the regional statistical reference level; all other inorganic elements were below the regional statistical reference level (Table S7-13).

Plutonium-238, plutonium-239, uranium-234, and uranium-235/236 were not detected in the nestling sample; however, similar to nestlings evaluated in 2017, uranium-238 was observed (0.0095 picocuries per gram) but was far below the biota dose screening level (DOE 2002). Uranium isotopes 234, 235/236, and 238 have been detected in soils, sediments, and small mammals collected around the Dual-Axis Radiographic Hydrodynamic Test Facility at levels that have exceeded the regional statistical reference levels in the recent past (Gaukler et al. 2018a, Fresquez et al. 2016). These results suggest that uranium is bioavailable and is being incorporated into nestling tissues.

In a deer mouse sample, most inorganic elements were detected, except for mercury and vanadium. All inorganic elements were below the regional statistical reference level, including beryllium (Table S7-14). A number of inorganic elements were decreasing over time including beryllium (Figure 7-12), cobalt, copper, iron, magnesium, manganese, and silver (Kendall’s Tau, $p < 0.05$). Antimony and zinc however, were increasing over time (Kendall’s Tau, $p < 0.05$). These observations are not consistent with observations in soil or sediment from the general area and could be an artifact caused by small sample size. Regardless, the levels of antimony and zinc were below the regional statistical reference level.

Most radionuclides were not detected in the small mammal sample in 2018. Strontium-90 and all three uranium isotopes were detected and were above the regional statistical reference level, but were below the biota dose screening level that is protective of biota (Table S7-14). Both uranium-234 and uranium-238 activities in small mammals are decreasing over time between 2008 and 2018 (Kendall’s Tau, $p < 0.05$; Figure 7-12). The amount of uranium-238 in small mammals, as seen with soil, increased until the year 2007 and then decreased thereafter; the decrease is concurrent with the change from open-air and/or foam-mitigated detonations during the 2000–2006 period to closed vessel containment, starting in 2007.

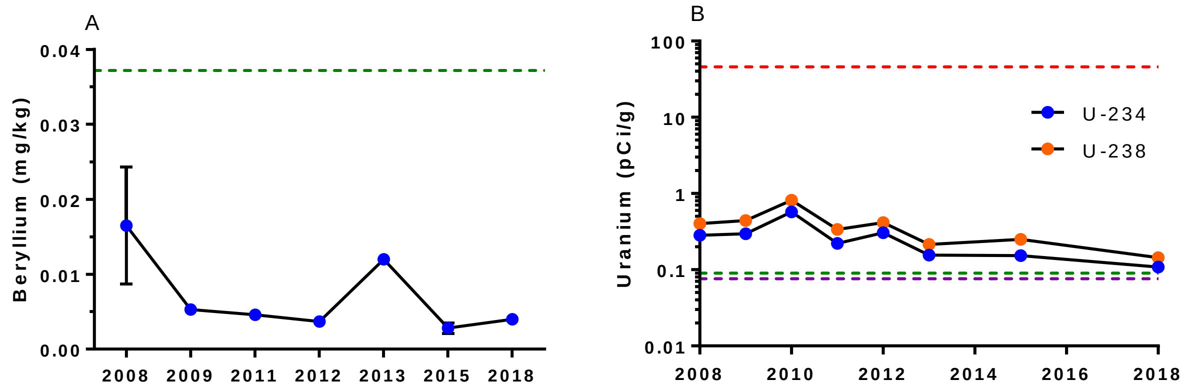


Figure 7-12. (A) Beryllium concentrations and (B) uranium-234 and uranium-238 activities in composite whole body mice collected near the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter at Technical Area 15 from 2008 to 2018 compared with the regional statistical reference level (mean plus three standard deviations of small mammals collected from background locations; beryllium and uranium-234: green dashed line, uranium-238: purple dashed line) and the biota dose screening level (red dashed line). Note vertical axis is a linear scale for beryllium and a logarithmic scale for uranium. Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: mg/kg = milligrams per gram and pCi/g = picocuries per gram.

Octachlorodibenzodioxin-1,2,3,4,6,7,8,9 was the only dioxin detected in the pinyon mouse and was below the regional statistical reference level. All other dioxins and all furans were not detected (Table S7-15). The majority of the results in soil, sediments, bird tissues, and small mammals are similar with previous results and constituents are decreasing over time. These results suggest that operations at the Dual-Axis Radiographic Hydrodynamic Test Facility are not negatively affecting the ecosystem.

Biota Monitoring at Sediment and Flood-Retention Structures

The Laboratory has constructed flood- and sediment-retention structures to reduce flood risks and to stop or slow the movement of sediments and associated chemicals and radionuclides off Laboratory property. Many chemicals and radionuclides in waste products adhere to soil and sediment particles. Storm water flows can transport these soil and sediment particles downstream in canyon bottoms.

The Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure were built following the Cerro Grande fire in 2000. As part of an environmental analysis of actions taken in response to the Cerro Grande fire, DOE identified various measures to minimize impacts resulting from the fire (DOE 2000). One of the measures is monitoring soil, surface water, groundwater, and biota upstream of flood-control structures, within sediment-retention basins, and within sediment traps to determine if constituent concentrations in these areas adversely affect plants or animals.

To this end, we collect native grasses and forbs and wild mice in the retention basins of the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure on an annual basis for environmental monitoring purposes.

We attempt to collect the following samples from each location annually: (1) a composite understory vegetation sample for radionuclide and inorganic element analyses; (2) a composite sample of five whole-body deer mice for radionuclide analyses; (3) three individual wild mice for inorganic elements analyses; and (4) three individual wild mice for PCB analysis. The following two sections report the 2018 results of this monitoring.

Los Alamos Canyon Weir

The Los Alamos Canyon weir is a water-control structure made of rock-filled wire cages called gabions. The weir was built in Los Alamos Canyon near the northeastern boundary of the Laboratory. The retention basin upstream of the weir covers more than one acre. Accumulated sediment was excavated from the retention basin in 2009, 2011, 2013, and 2014. Sediment excavated in 2009 was placed on the west side of the basin and stabilized, whereas sediment excavated in 2011, 2013, and 2014 was analyzed, placed on a plastic liner, contained within a berm, compacted, and seeded approximately 0.5 miles west of the weir in Los Alamos Canyon.

A composite understory vegetation sample was collected within the retention basin and submitted for radionuclide and inorganic element analyses in June 2018. Plants we collected include cheatgrass (*Bromus tectorum*), crested wheatgrass (*Agropyron cristatum*), kochia (*Bassia scoparia*), lambsquarters (*Chenopodium album*), pigweed (*Amaranthus* sp.), primrose (*Primula vulgaris*), redtop grass (*Agrostis gigantea*), sunflower (*Helianthus* sp.), sweet clover (*Melilotus offcinalis*), and western tansymustard (*Descurainia pinnata*). Several inorganic elements were not detected in understory vegetation (Table S7-16) and all concentrations of elements were below the regional statistical reference level. Levels of inorganic elements in vegetation are not trending over time (Kendall's Tau, $p > 0.05$).

Most radionuclides in understory vegetation were not detected or were below the regional statistical reference levels (Table S7-17). Americium-241, plutonium-239/240, and strontium-90 were detected above their regional statistical reference levels. All radionuclide activities were far below biota dose screening levels (Table S7-17).

Americium-241 and plutonium-239/240 activities appear to vary from year to year but are not increasing over time (Kendall's Tau, $p > 0.05$, Figure 7-13). The high variability may be a result of disturbances due to soil excavation at the weir or due to sampling variability; plants are collected at different locations within the basin each year. In addition, because of high-runoff events and water ponding, the stems and leaves of the plants may retain different amounts of sediment each year. Sediment on plant material can influence radionuclide results.

Small mammals were also collected from the retention basin in June 2018 using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. Due to the effects of severe drought in 2018 on small mammal abundance, we had poor trapping success and only captured three individual deer mice. One was analyzed for inorganic elements and two were analyzed for PCB congeners.

Results of inorganic element analyses in whole-body small mammals are in Table S7-18. All elements were detected in the deer mouse and concentrations of silver were above the regional statistical reference level. Most inorganic elements were not trending; however, antimony, cadmium, chromium, potassium, silver, and zinc were increasing (Kendall's Tau, $p < 0.05$). Increasing trends of chromium and zinc have stayed consistent through time (Figure 7-14), which suggest that these are real trends and not an artifact of small sample size or environmental variability. Though chromium and zinc are increasing over time, the overall concentrations of these two elements are similar to or below regional statistical reference levels and are thus not of ecological concern.

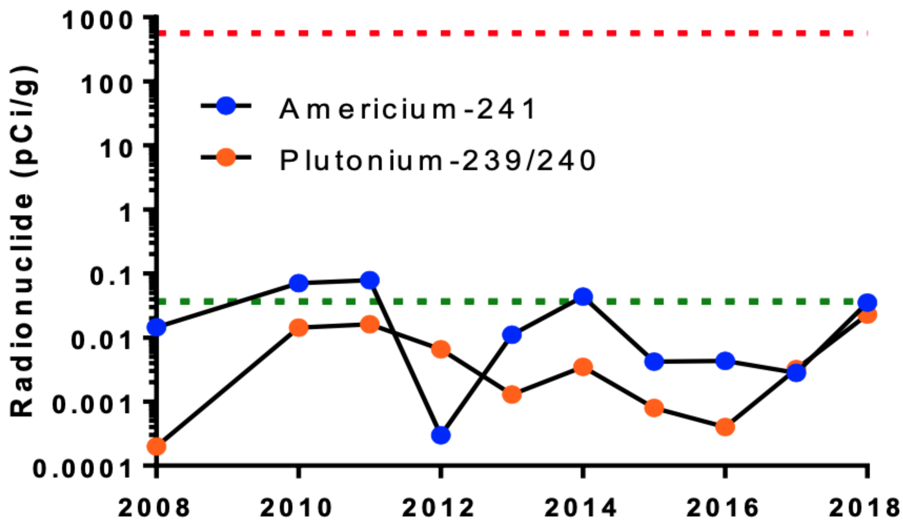


Figure 7-13. Americium-241 and plutonium-239/240 in understory vegetation collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2008 to 2018 compared with the biota dose screening level (red dashed line), and with the regional statistical reference level (green dashed line). Note the logarithmic scale on the vertical axis. Points represent true values; error bars are not available as only one sample was collected per year. Note: pCi/g = picocuries per gram.

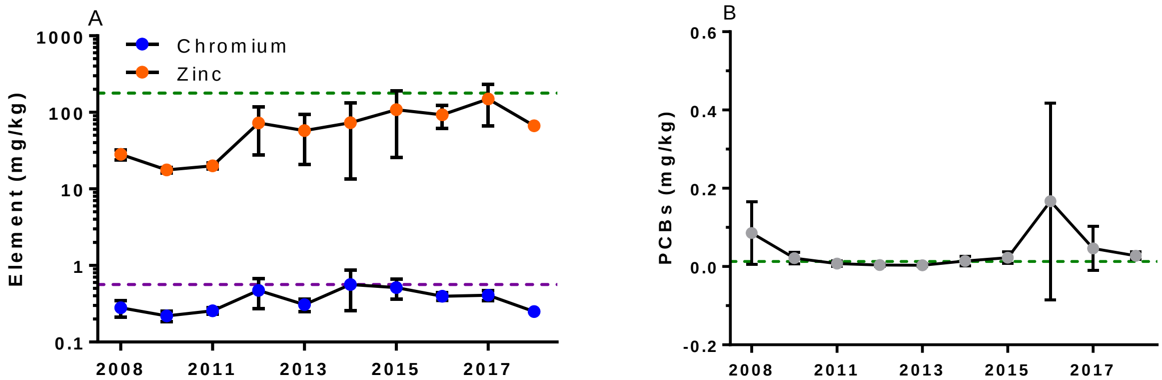


Figure 7-14. (A) Chromium and zinc and (B) PCB concentrations in an individual whole-body mice sample collected upstream (in the retention basin) of the Los Alamos Canyon weir from 2008 to 2018 compared with the regional statistical reference level (mean plus three standard deviations of small mammals collected from background locations; zinc and PCBs: green dashed line; chromium: purple dashed line). Note vertical axis is a logarithmic scale for chromium and zinc, and a linear scale for PCBs. Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: mg/kg = milligrams per gram.

Concentrations of total PCBs (0.034 and 0.021 milligrams per kilogram) in whole-body wild mice samples collected upstream from the Los Alamos Canyon weir were higher than the regional statistical reference level (Table S7-18). The concentrations observed here are two orders of magnitude below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, these levels are not expected to negatively affect the wild mouse population near the retention basin.

The levels of PCBs in small mammals collected from the upstream side of the retention basin vary over time (Figure 7-14). The variability in PCB concentrations may be related to the removals of sediment from the basin between 2009 and 2014 and accumulation of sediment since that time.

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure is located upstream of Technical Area 18. The structure extends 390 feet across the canyon and is about 70 feet high. The bottom of the retention structure is equipped with one 42-inch-diameter drainage culvert, which allows storm water to drain. Accumulated water is retained no longer than 96 hours behind the retention structure; water drains naturally into the existing streambed.

In September 2018, a composite understory vegetation sample was collected on the upstream side of the Pajarito Canyon flood-retention structure and analyzed for radionuclides and inorganic elements. Plants we collected include aster of unknown species (*Asteraceae* sp.), curly dock (*Rumex crispus*), dragon sagewort (*Artmisia dracunculus*), lambsquarter (*Chenopodium* *album*), mullein (*Verbascum thapsus*), and New Mexico hops (*Humulus lupulus*). Results from analysis of the composite vegetation sample show that all radionuclides were either not detected or were below the regional statistical reference level. All radionuclide activities were below the biota dose screening level (Table S7-19). No trends in radionuclide activities in vegetation collected upstream of the Pajarito Canyon flood-retention structure were observed from 2008 to 2018 (Kendall's Tau, $p > 0.05$).

The vegetation sample was ashed for radionuclide analyses before the sample was analyzed for inorganic elements by the analytical laboratory. This resulted in inorganic elements being reported on an ash weight whereas all previous results have been reported on a wet weight basis. Because of this, direct comparisons between concentrations at the Pajarito Canyon flood-retention structure with regional statistical reference levels and trends over time cannot be assessed. Most inorganic elements were detected.

Small mammals were also collected from the Pajarito Canyon flood-retention structure in September 2018. Small mammals were captured using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. Due to the effects of severe drought in 2018 on small mammal abundance, we had poor trapping success and only captured six individual mice (five deer mice and one western harvest mouse (*Reithrodontomys megalotis*); three were analyzed for inorganic elements, and three were analyzed for PCB congeners.

Most inorganic element concentrations in whole body mice were detected, and all concentrations were below the regional statistical reference levels (Table S7-20). Most inorganic elements in wild mice are not trending over time; however, antimony, sodium, and zinc are increasing (Kendall's Tau, $p < 0.05$, Figure 7-15). As these constituents are below the regional statistical reference levels and because sodium and zinc are essential minerals, these observations are not of ecological concern.

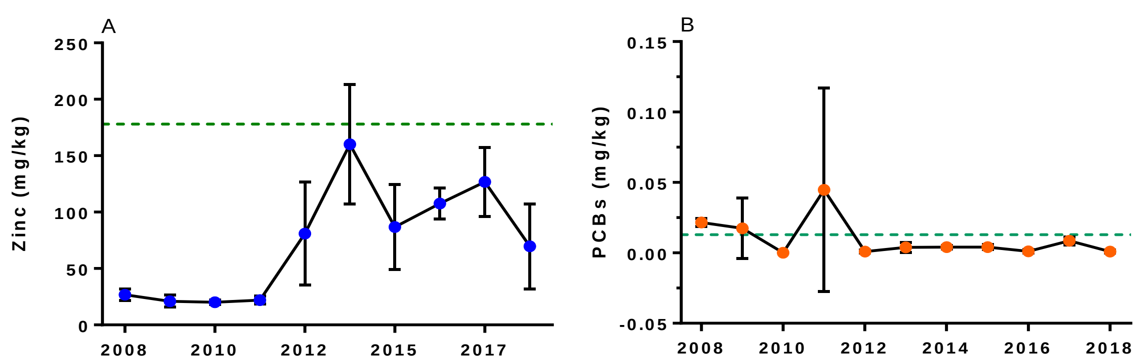


Figure 7-15. (A) Zinc and (B) PCB concentrations in individual whole-body mouse samples collected upstream (in the retention basin) of the Pajarito Canyon flood-retention structure from 2008 to 2018 compared with the regional statistical reference level (mean plus three standard deviations of small mammals collected from background locations; green dashed line). Note vertical axis is linear. Points represent the mean. Error bars represent standard deviation. Note: mg/kg = milligrams per gram.

For the mice collected upstream of the Pajarito Canyon flood-retention structure and submitted for PCB analyses, PCBs were detected in all three individuals (Table S7-20). The highest individual whole-body total PCB concentration in a deer mouse was 0.00217 milligrams per kilogram, which is three orders of magnitude below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, the current PCB levels are not expected to negatively impact the wild mouse population near the retention basin. Additionally, PCB concentrations in whole-body wild mice collected upstream of the Pajarito Canyon flood-retention structure are not trending over time (Kendall's Tau, $p > 0.05$; Figure 7-15).

Small Mammals Monitoring at Pueblo de San Ildefonso

Small mammals are collected on a triennial basis in Los Alamos Canyon downstream of the weir on Pueblo de San Ildefonso property. The goal of the monitoring is to determine whether constituents are migrating downstream of the Laboratory, past the Los Alamos Canyon weir.

Small mammals were collected in June and September 2018 using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. Due to the effects of severe drought in 2018 on small mammal abundance, we had poor trapping success and only captured five individual mice (one deer mouse, one pinyon mouse, and three brush mice); two were analyzed for inorganic elements and three were analyzed for PCB congeners.

Most inorganic element concentrations in whole body mice were detected, and most concentrations were below the regional statistical reference levels (Table S7-21). Arsenic and cobalt slightly exceeded the regional statistical reference levels. Trends over time were not analyzed, as inorganic element concentrations in small mammals from this location were only available in 2015 and 2018.

PCBs were detected in two of the three whole-body mice. Total PCB concentrations (0.00006 and 0.0006 milligrams per kilograms) were well below the regional statistical reference level (Table S7-21). Furthermore, the observed concentrations are well below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, the current PCB levels are not expected to negatively affect the wild mouse population near the retention basin. Additionally, PCB concentrations in whole-body wild mice collected downstream of the Los Alamos Canyon weir on Pueblo de San Ildefonso property are decreasing over time (Kendall's' Tau, $p < 0.05$; Figure 7-16). These data suggest that the Los Alamos Canyon weir is successful at retaining Laboratory-derived constituents onsite.

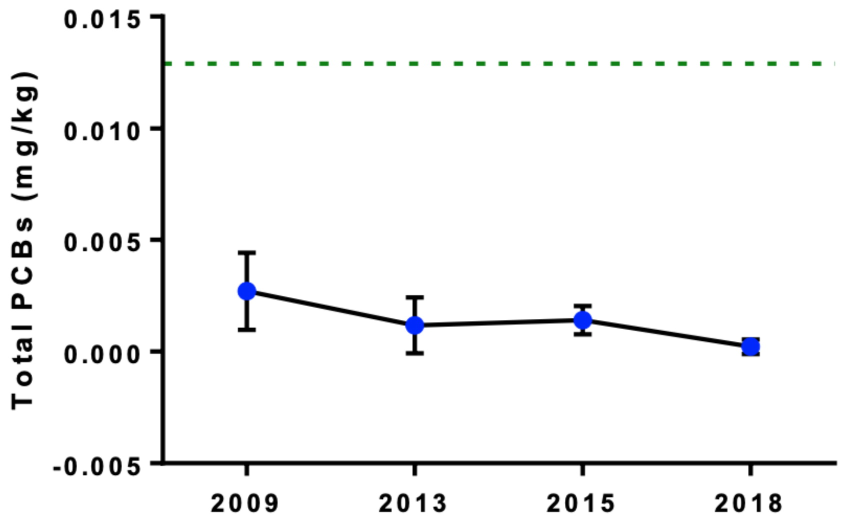


Figure 7-16. Total PCB concentrations in individual whole-body mouse samples collected downstream of the Los Alamos Canyon weir (retention basin) from 2009 to 2018 compared with the regional statistical reference level (mean plus three standard deviations of small mammals collected from background locations: green dashed line). Note vertical axis is a linear scale. Points represent the mean and error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

Large Animal Monitoring

Monitoring Network

The environmental monitoring and surveillance program has opportunistically collected road-killed mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus nelsoni*), from onsite, perimeter, and background sites since the 1970s (Los Alamos Scientific Laboratory 1973). To date, the program has collected and analyzed approximately 48 deer and 55 elk.

In 2015, the program has expanded by collecting other species including mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), black bear (*Ursus americanus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), great horned owl (*Bubo virginianus*), western screech owl (*Megascops kennicotti*), red-tailed hawk (*Buteo jamaiciensis*), and gopher snake (*Pituophis catenifer*) that were killed by vehicles or by other accidents.

Here we report concentrations of radionuclides, inorganic elements, and PCBs in tissues from two mule deer, four elk, two coyotes (one coyote was submitted as a duplicate and therefore yielded three sample results), two great horned owls, and one gopher snake collected in 2018 (Figure 7-17). The majority of animals collected were casualties of vehicle strikes, though others came from different sources. Hunters donated one deer and one elk sample, and one of the great horned owls died of electrocution. Leg muscle and leg bone were harvested from the deer, elk, and coyote; muscle was analyzed for radionuclides, inorganic elements, and PCBs, and bone was analyzed for radionuclides. Leg muscle was harvested from the owls and analyzed for PCBs; the remaining whole body (unwashed feathers included) was analyzed for radionuclides and inorganic elements. Muscle tissue was harvested from the gopher snake and analyzed for PCBs, while the remaining whole body was analyzed for radionuclides and inorganic elements.

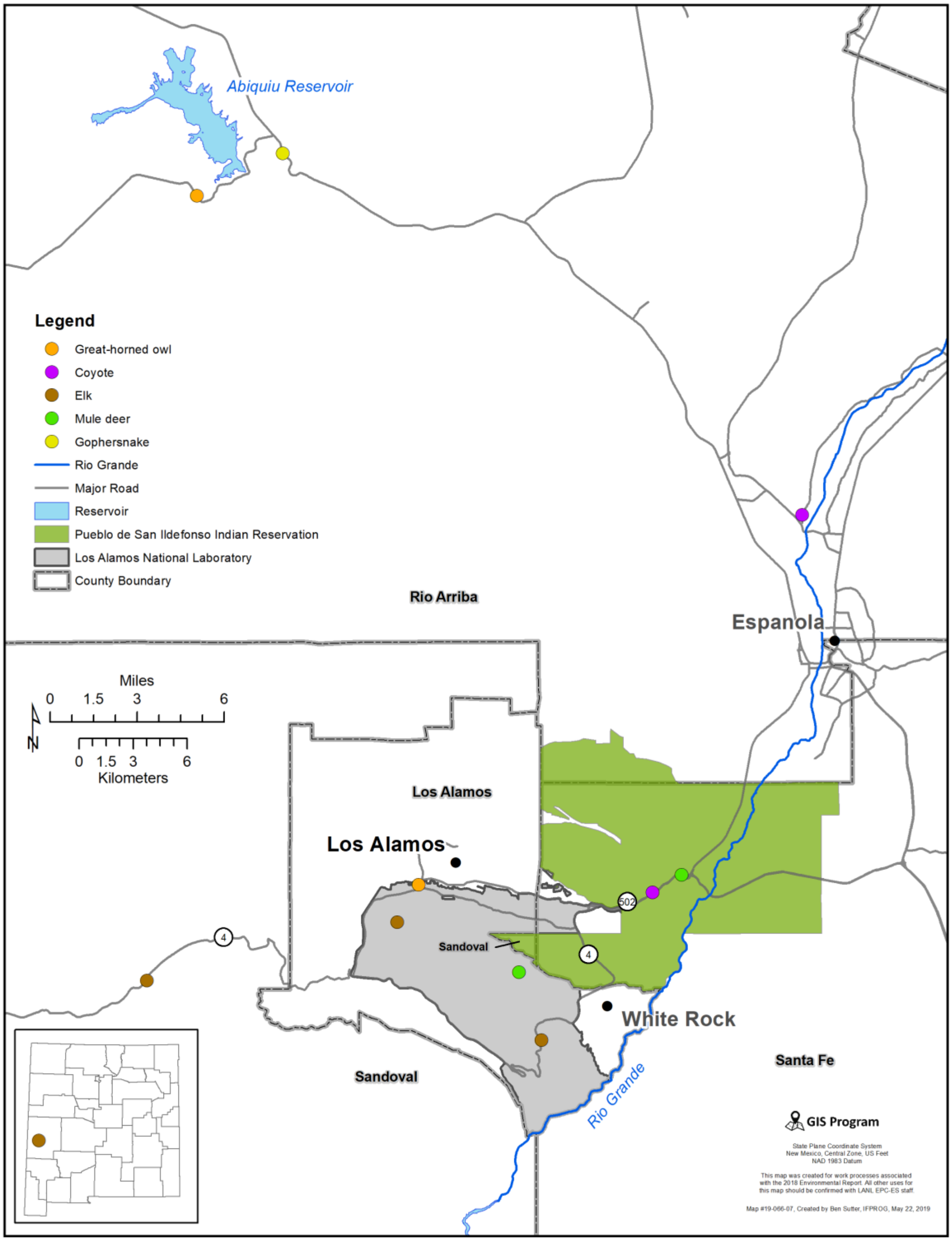


Figure 7-17. Locations of animals collected opportunistically from within and around the Laboratory in 2018.

Deer and Elk Monitoring

All radionuclides in deer and elk (muscle and bone) were either below the minimum detectable activity (most results) or similar to the regional statistical reference levels. All levels were well below the biota dose screening level (Table S7-22). These data are similar with past years.

Most inorganic elements in deer were below the regional statistical reference levels. Antimony, copper, iron, magnesium, manganese, nickel, sodium, and zinc were higher than the regional statistical reference in one or both of the deer. All inorganic elements observed in elk, except for chromium in one elk, were below the regional statistical reference levels (Table S7-23).

PCBs were detected in all deer and were below the regional statistical reference level (Table S7-24). PCBs were also observed in all elk samples. One elk collected from the Laboratory contained PCBs (0.00002 milligrams per kilogram) above the regional statistical reference level (Table S7-24). The PCB concentrations we observed in deer and elk are not expected to cause adverse effects. Although we do not have lowest observable adverse effect levels for mule deer or elk, adverse effects in other mammals are typically not observed until the 2.5 to 3 milligrams per kilogram range (Batty et al. 1990, Hoffman et al. 1996). Additionally, the concentrations we observed in both deer and elk are well below the U.S. Food and Drug Administration standard of 3 milligrams per kilogram for red meat consumption by humans (U.S. Food and Drug Administration 1987).

Coyote, Gopher Snake, and Owl Monitoring

All radionuclides in tissues of the coyote (Table S7-25) were either not detected (most results), or similar to the regional statistical reference level, and were far below biota dose screening levels. Radionuclides in a whole-body gopher snake and in the great horned owls (Table S7-26) were either not detected (most results), or were below biota dose screening levels; currently there are no regional statistical reference levels for these species.

All inorganic elements in the coyote collected from a perimeter location were below the regional statistical reference levels (Table S7-27). The inorganic element concentrations in the great horned owl collected from the Laboratory were similar or below levels in the great horned owl collected from a background location (Table S7-28). The inorganic elements in a gopher snake are reported in Table S7-28; currently there are no regional statistical reference levels available for comparisons for this species; however, all elements were within range of those previously observed in two gopher snakes collected at the Laboratory in 2017. No statistical comparisons could be made due to small sample size.

PCBs were detected in all three of the coyote samples and were below the regional statistical reference level (Table S7-29). PCBs were detected in both of the great horned owls; the individual collected from a background location contained 0.0081 milligrams per kilogram, and the individual collected from the Laboratory contained 1.68 milligrams per kilogram (Table S7-30). PCB concentrations are typically higher in predator species, such as the owls reported here, because these organic chemicals are lipophilic (absorbed by fats) and increase in concentration in animals that eat other animals (Eisler and Belisle 1996, Hornbuckle et al. 2006).

PCBs were not detected in the gopher snake that was collected from a background location (Table S7-30).

The total PCB concentrations observed in all animals monitored and reported here are overall quite low and are not expected to cause adverse effects, which are not typically observed until the 2.5 to 3 milligrams per kilogram range in other species (Batty et al. 1990, Hoffman et al. 1996).

BIOLOGICAL RESOURCES MANAGEMENT PROGRAM

Breeding Season Bird Capture and Banding at Sandia Canyon

We have been operating a bird banding station in the Sandia Canyon wetland since 2014. It is composed of 12 mist nets periodically deployed in and around the wetland. This wetland contains primarily broadleaf cattail (*Typha latifolia*) and some tree species, including Rio Grande cottonwood (*Populus deltoids*) and Russian olive (*Elaeagnus angustifolia*). The purpose of this study is to monitor the species, age, breeding status, and return rates of songbirds using this site.

Beginning in May each year, we conduct bird banding operations following a protocol called Monitoring Avian Productivity and Survivorship (DeSante 1992) administered by the Institute for Bird Populations. The Monitoring Avian Productivity and Survivorship program is a continent-wide collaborative effort among public agencies, non-governmental groups, and individuals to assist the conservation of birds and their habitats. Following a national protocol where methodologies are the same at every site allows data to be comparable among sites.

A standard U.S. Fish and Wildlife Service numbered band is put on each captured bird. All birds are identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. We use the aging and sexing criteria provided in Pyle (1997).

A total of 1,078 birds representing 66 species were banded during the breeding seasons of 2014 through 2018. In 2018 alone, we captured 264 birds representing 46 species. The most common recaptured bird at this site is the song sparrow (*Melospiza melodia*). The second most commonly captured species in 2018 was the pygmy nuthatch (*Sitta pygmaea;* Figure 7-18).

Figure 7-18. A juvenile pygmy nuthatch banded on July 25, 2018

Avian Nest Box Monitoring

The avian nest box network was established in 1997 to monitor the health of bird populations at the Laboratory, where there are now more than 500 nest boxes. The target species monitored with the nest box network are the western bluebird (Figure 7-19) and the ash-throated flycatcher (*Myiarchus cinerascens*). These species are secondary cavity nesters that readily nest in artificial nest boxes and are common around the Laboratory. Nonviable eggs collected opportunistically have been analyzed for radionuclides, inorganic elements, and organic chemicals (Gaukler et al. 2018b, Gaukler et al. 2018c) and used for biomonitoring at the Laboratory since the late 1990s (Becker 2003).

Beginning in April every year, the nest boxes are checked every one to two weeks during the breeding season. When an active nest is identified, it is monitored to determine the fate of the nest. Nestlings are banded when they are 12 days or older. In addition, the parents are also sometimes captured and banded using either a mist net set in front of the nest box or a trap door attached to the box (Figure 7-20).

The results of chemical analyses to date indicate that the levels of radionuclides, metals, PCBs, and organochlorine chemicals in the eggs of western bluebirds and ash-throated flycatchers collected at the Laboratory are not likely to cause adverse effects in breeding bird populations (Gaukler et al. 2018b, Gaukler et al. 2018c). In 2016, 92 nest boxes were placed south of the Laboratory in a natural area to serve as a reference site. Studies utilizing the reference boxes will better determine whether birds on Laboratory property have elevated levels of chemicals in their eggs. In 2017, nest boxes were placed around the Dual-Axis Radiographic Hydrodynamic Test Facility. During the 2018 season, the overall avian nest box network was monitored at lower levels than previous years. There were site-specific constraints from increased wildland fire prevention restrictions in 2018 that limited our access to some boxes. Although the number of boxes monitored in 2018 was lower, the overall occupancy and success rates did not decline from previous years.

Figure 7-19. Adult male and female western bluebirds perched on a tree limb above a nest box.

Figure 7-20. The trap door used to capture adult birds. This is an adult male western bluebird feeding nestlings inside the nest box.

Fall Bird Migration Capture and Banding at Pajarito Wetlands

Biologists at the Laboratory document fall migration patterns of passerines (songbirds) to monitor the status and trends of resident and migratory bird populations on Laboratory property. During the fall of 2018, we completed the ninth year of monitoring fall migration songbirds. Songbirds were captured at a mist-netting station located in a wetland and riparian complex in Technical Area 36 on the north side of Pajarito Road. The full report for this work is in Stanek and Hathcock (2019).

The fall banding station used 14 mist-nets that were 12 meters long with 30-millimeter mesh. After a bird was extracted from the mist-net, a standard U.S. Fish and Wildlife Service numbered band was put on each bird. All birds were identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. The aging and sexing criteria were based on Pyle (1997). Species evenness, richness, and diversity indices including Shannon-Weiner (Shannon and Weaver 1949) and Simpson (Simpson 1949) were used to evaluate the bird species diversity through the years. Additionally, we grouped birds into one of three diet classifications based on life history information available from Cornell's *The Birds of North America Online* (Birds of North America 2015). The three groups were (1) granivores, where diet consists primarily of seeds; (2) insectivores, where diet consists primarily of insects; and (3) omnivores, where the diet is split between the two. To investigate the influences of drought we assessed local (northern New Mexico) and regional (the southwestern United States) values of the Palmer Drought Severity Index (Dai 2017) and onsite LANL precipitation data. We used non-metric multidimensional scaling with a Bray-Curtis dissimilarity matrix to assess changes in the entire bird community through time. We fit environmental vectors, including the Palmer Drought Severity Index and local precipitation data, onto the non-metric multidimensional scaling ordination to assess their influences on community composition.

In 2018, a total of 342 birds representing 42 species were banded. During the fall seasons of 2010-2018 a total of 2,914 birds representing 79 species were banded. We did not see changes in diversity metrics over time (Table 7-1) and we saw no influence of the environmental variables on abundance, birds per net hour, or any of the diversity indices. We did see a positive relationship between the local northern New Mexico Palmer Drought Severity Index values and the percentage of hatch year birds (R^2 = 0.48, F(1, 7) = 8.47, p = 0.022) and the percentage of insectivorous birds (p = 0.04). The regional values of the Palmer Drought Severity Index for the southwestern United States also had a positive relationship with the percentage of insectivorous birds banded at the Pajarito wetlands (p = 0.007).

TABLE 7-1 . DIVERSITY INDICES OF BANDED BIRDS AT PAJARITO WETLANDS 2010-2018; P-VALUE < 0.05 INDICATES SIGNIFICANT CHANGES OVER TIME FOR EACH DIVERSITY INDEX.

Diversity Index	2010	2011	2012	2013	2014	2015	2016	2017	2018	p-value
Shannon (H')	2.741	2.991	3.106	3.243	3.032	3.295	3.285	3.306	3.066	0.058
Simpsons (1-D)	0.901	0.943	0.936	0.963	0.944	0.954	0.951	0.953	0.920	0.430
Species Richness	40	30	47	38	40	50	44	51	42	0.134

We saw no significant influences on the overall community composition from the three environmental variables (shown with blue arrows in Figure 7-21); however, community composition in earlier years was different from later years (p = 0.024). The species identified as contributing the most to community dissimilarities of earlier and later years were lesser goldfinch (*Spinus psaltria*), Audubon's warbler (*Setophaga coronata*), dark-eyed junco (*Junco hyemalis*), Wilson's warbler (*Cardellina pusilla*), orange-crowned warbler (*Oreothlypis celata*), bushtit (*Psaltriparus minimus*), ruby-crowned kinglet (*Regulus calendula*), chipping sparrow (*Spizella passerina*), and Virginia's warbler (*Oreothlypis virginiae*). Of these species, only Virginia's warbler and Audubon's warbler showed decreases in abundance through the years, but with non-significant declines (p > 0.05).

Between 2010 and 2018, the overall number of birds and species captured was variable. We saw significant differences in the bird community composition when we compared earlier years to later years. Of the species caught, only Audubon's warbler and Virginia's warbler showed declining trends in their abundances. Both of these species are insectivores. Data from surveys throughout the Virginia's warbler breeding range estimate that they have declined by 46 percent between 1970 and 2014 (Partners in Flight 2017). The variability in bird populations is likely driven by regional climatic factors, but more data are needed for robust assessments. Similar results for bird declines associated with variable drought conditions were found in piñon-juniper woodland ecosystems on the Pajarito Plateau (Fair et al. 2018). In fact, Palmer Drought Severity Index values for 2018 in the southwestern United States were the driest recorded in the last 123 years (National Oceanic and Atmospheric Administration 2018). These data suggest that the changes in species composition observed here are associated with increases in the duration and severity of drought throughout the study period.

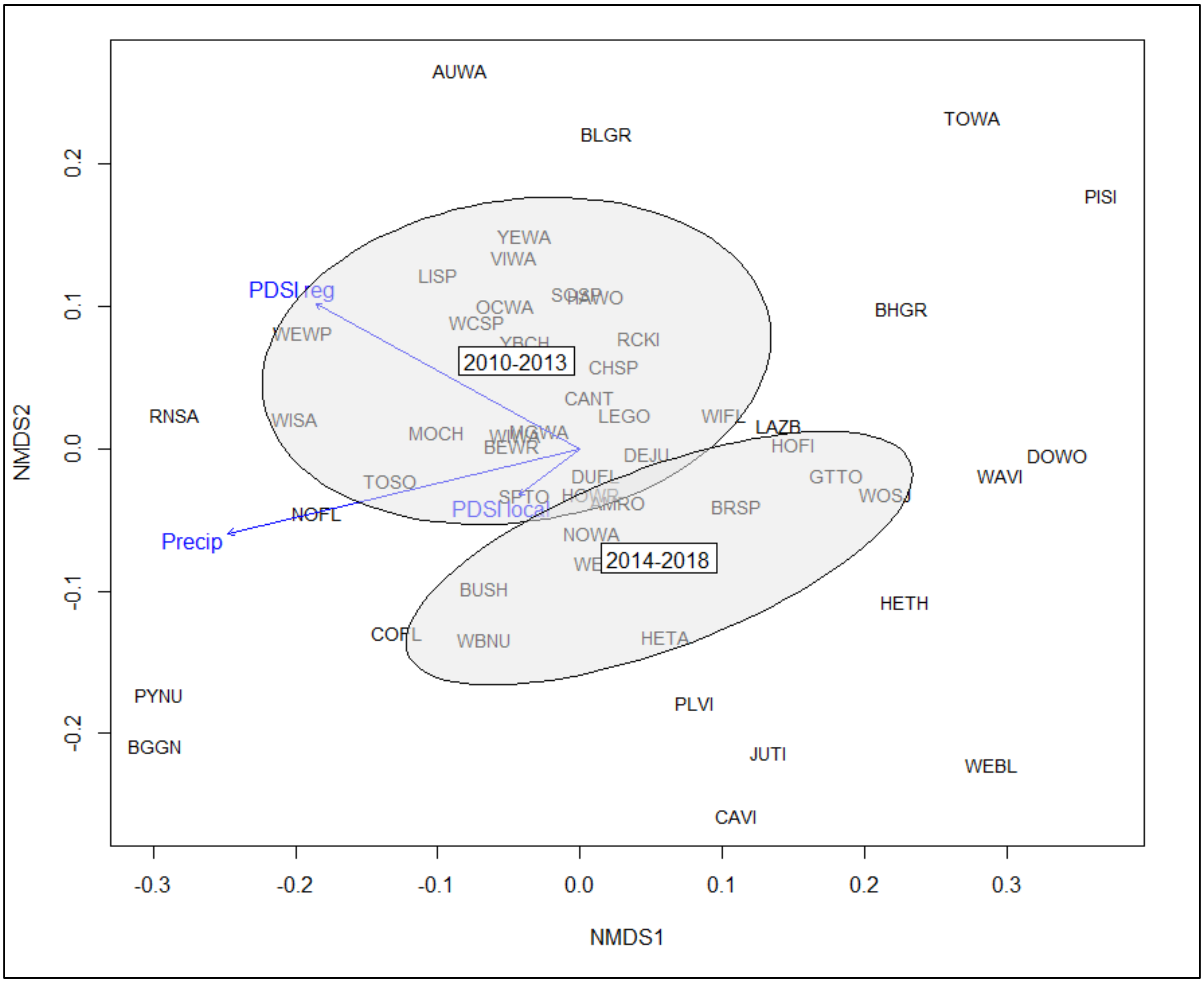


Figure 7-21. Non-metric multidimensional scaling of bird species comparing results from 2010 to 2013 and 2014 to 2018. Four-letter acronyms refer to individual bird species recorded during surveys. The English language bird names associated with each code can be found at https://www.birdpop.org/docs/misc/Alpha_codes_eng.pdf. Note: NMDS = non-metric multidimensional scaling.

Threatened and Endangered Species Surveys

In 2018, surveys were completed for one species protected under the Endangered Species Act, the Mexican spotted owl (*Strix occidentalis lucida*). Southwestern willow flycatcher (*Empidonax trailii extimus*) surveys were not conducted in 2018 due to access constraints and wildland fire prevention restrictions. Jemez Mountains salamander (*Plethodon neomexicanus*) surveys were not conducted in 2018 because of the lack of appropriate moisture needed to conduct surveys. The 2018 season saw drought levels that precipitated a closure of Laboratory forested areas and adjacent national forest lands because of severe fire danger.

The Mexican spotted owl generally inhabits mixed conifer forests, ponderosa pine, and gambel oak (*Quercus gambelii*) forests in mountains and canyons (U.S. Fish and Wildlife Service 2012). Mexican spotted owls in the Jemez Mountains of northern New Mexico prefer cliff faces in canyons for their nest sites (Johnson and Johnson 1985).

Under the Laboratory Threatened and Endangered Species Habitat Management Plan, Mexican spotted owl habitat has been identified based on a combination of cliff habitat and forest characteristics (LANL 2017b). Mexican spotted owl habitats are called areas of environmental interest. Currently, there are five Mexican spotted owl areas of environmental interest at the Laboratory spanning seven canyons. Surveys are conducted every year.

The survey results in 2018 had positive detections in the Mortandad-Sandia and Threemile Canyon areas of environmental interest. These two sites have been active in previous years. Due to the fire restrictions, nest checks were not completed until later in the breeding season and we were not able to determine nest success.

BIOTA DOSE ASSESSMENT

The purpose of the biota dose assessment is to ensure that plant and animal populations are protected from the effects of Laboratory radioactive materials, as required by DOE Order 458.1. This assessment follows the guidance of the DOE technical standard DOE-STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," for evaluating compliance with specified criteria on radiation dose to aquatic and terrestrial animals and aquatic plants (DOE 2002). We used the DOE dose calculation program RESRAD-BIOTA version 1.8.

The dose calculations are based on measurements of radionuclide concentrations in soil, sediment, water, plant tissue, and animal tissue. These concentrations are related by previously measured distribution coefficients, concentration ratios, and bioaccumulation factors, so if a particular type of data is unavailable it can be deduced from the others, and if several types are available they can be compared for consistency (DOE 2002, McNaughton 2013). Worst-case values and assumptions are used to provide a conservative assessment.

Previous biota dose assessments were reported in the Annual Site Environmental Reports and concluded that biota doses for populations at the Laboratory are well below the DOE limits of 1 rad per day for terrestrial plants and aquatic animals and 0.1 rad per day for terrestrial animals (DOE 2002).

The material potentially contributing to the biota doses at the Laboratory is legacy waste material. Ongoing remediation and radioactive decay result in decreasing concentrations, so a generally-decreasing trend in biota doses is expected; however, current operations and movement of soil or sediment may cause an accumulation of radioactive material, so key locations are re-assessed each year.

Mesa-Top Facilities

Area G

> **What is a rad?**
>
> "Rad" is an acronym for radiation absorbed dose. An absorbed dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy as a result of exposure to ionizing radiation. One rad is the same as 0.01 Gray. Different materials that receive the same exposure may not absorb the same amount of radiation.

This chapter reports new measurements of soil and vegetation around Area G. The results are generally comparable with previous years, though there is some year-to-year variation depending on the exact locations sampled. This year-to-year variation can be seen in the trend graphs of this chapter.

As recommended by the DOE standard (DOE 2002), this assessment uses the highest measured concentrations, and the resulting doses are reported in Table 7-2 and Table 7-3. At Area G, the largest dose contribution is from tritium, which is mostly concentrated near the southern edge of Area G, at locations 29-03 and 30-1 (Table 7-5). The results in Table 7-2 show that the biota doses at Area G are well below the DOE limits of 0.1 rad per day for animals, and Table 7-3 shows the doses are also below the limit of 1 rad per day for plants. Overall there are no measurable impacts to biota.

TABLE 7-2. DOSE TO TERRESTRIAL ANIMALS AT AREA G FOR 2018
DOE LIMIT: 0.1 RAD/DAY FOR TERRESTRIAL ANIMALS; 4.2 E-02 = 0.042 RAD/DAY

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	1.1E-10	1.1E-06	3.7E-08	8.5E-06	9.6E-06
Cs-137	7.9E-09	7.9E-06	1.0E-09	5.1E-07	8.4E-06
H-3	6.0E-03	1.2E-02	1.2E-02	1.2E-02	4.2E-02
Pu-238	8.6E-11	3.5E-07	1.8E-07	1.3E-05	1.3E-05
Pu-239	5.9E-11	2.4E-07	2.1E-07	1.3E-05	1.4E-05
U-234	1.3E-08	1.3E-06	9.7E-06	3.7E-05	4.8E-05
U-235	1.9E-08	1.9E-06	4.9E-07	1.8E-06	4.2E-06
U-238	9.0E-07	9.0E-05	8.6E-06	3.2E-05	1.3E-04
Medium Total	6.0E-03	1.2E-02	1.2E-02	1.2E-02	Overall Dose 4.2E-02

TABLE 7-3. DOSE TO TERRESTRIAL PLANTS AT AREA G FOR 2018
DOE LIMIT 1.0 RAD/DAY FOR TERRESTRIAL PLANTS; 3.1 E-02 = 0.031 RAD/DAY

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	1.1E-10	1.1E-06	1.6E-05	1.7E-05
Cs-137	7.9E-09	7.9E-06	5.1E-07	8.4E-06
H-3	6.0E-03	1.2E-02	1.3E-02	3.1E-02
Pu-238	8.6E-11	3.5E-07	3.9E-05	3.9E-05
Pu-239	5.9E-11	2.4E-07	6.5E-05	6.5E-05
U-234	1.3E-08	1.3E-06	3.7E-05	3.8E-05
U-235	1.9E-08	1.9E-06	1.8E-06	3.8E-06
U-238	9.0E-07	9.0E-05	3.2E-05	1.2E-04
Medium Total	6.0E-03	1.2E-02	1.3E-02	Overall Dose 3.1E-02

Dual-Axis Radiographic Hydrodynamic Test Facility

The Dual-Axis Radiographic Hydrodynamic Test Facility biota dose assessment uses the same methods described in the previous section. The largest doses were calculated from the soil data, indicating that the tissue-to-soil concentration ratios are overestimates. The largest soil activities were entered into RESRAD-BIOTA, and the results are reported in Table 7-4 and Table 7-5. The largest dose contribution is from uranium, most of which is the result of Laboratory operations. The activities of the other radionuclides are consistent with natural background and global fallout. Table 7-4 and Table 7-5 show that the biota doses are well below the DOE limits of 0.1 rad per day for animals and 1 rad per day for plants. There are no measurable impacts to biota.

TABLE 7-4. DOSE TO TERRESTRIAL ANIMALS AT DUAL-AXIS RADIOGRAPHIC HYDRODYNAMIC TEST FACILITY FOR 2018
DOE LIMIT: 0.1 RAD/DAY FOR TERRESTRIAL ANIMALS; 8.3E-04 = 0.00083 RAD/DAY

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	4.1E-12	5.9E-08	1.4E-09	4.6E-07	5.2E-07
Cs-137	7.0E-09	1.3E-05	9.0E-10	8.1E-07	1.3E-05
H-3	2.4E-08	8.8E-09	4.7E-08	8.7E-09	8.8E-08
Pu-238	1.1E-12	1.1E-08	2.4E-09	4.1E-07	4.2E-07
Pu-239	2.8E-13	4.5E-09	1.0E-09	2.6E-07	2.6E-07
Sr-90	2.1E-07	8.2E-06	1.7E-06	3.3E-05	4.3E-05
U-234	1.4E-08	5.4E-06	1.1E-05	1.5E-04	1.7E-04
U-235	3.2E-08	6.6E-06	8.1E-07	6.1E-06	1.4E-05
U-238	4.3E-06	4.0E-04	4.1E-05	1.4E-04	5.9E-04
Medium Total	4.5E-06	4.3E-04	5.4E-05	3.4E-04	Overall Dose 8.3E-04

TABLE 7-5. DOSE TO TERRESTRIAL PLANTS AT DUAL-AXIS RADIOGRAPHIC HYDRODYNAMIC TEST FACILITY FOR 2018
DOE LIMIT: 1.0 RAD/DAY FOR TERRESTRIAL PLANTS; 7.8E-04 = 0.00078 RAD/DAY

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	4.1E-12	5.9E-08	8.7E-07	9.3E-07
Cs-137	7.0E-09	1.3E-05	8.1E-07	1.3E-05
H-3	2.4E-08	8.8E-09	9.3E-09	4.2E-08
Pu-238	1.1E-12	1.1E-08	1.3E-06	1.3E-06
Pu-239	2.8E-13	4.5E-09	1.3E-06	1.3E-06
Sr-90	2.1E-07	8.2E-06	3.3E-05	4.1E-05
U-234	1.4E-08	5.4E-06	1.5E-04	1.6E-04
U-235	3.2E-08	6.6E-06	6.3E-06	1.3E-05
U-238	4.3E-06	4.0E-04	1.4E-04	5.5E-04
Medium Total	4.5E-06	4.3E-04	3.4E-04	Overall Dose 7.8E-04

Sediment-Retention Sites in Canyons

Los Alamos Canyon Weir

The Los Alamos Canyon weir receives stormwater runoff and sediment from areas with legacy materials at Technical Areas 01, 02, and 21. The soil and sediment trapped by the weir include slightly elevated activities of fission products and transuranic radionuclides. The largest doses were from natural uranium.

At this location during 2018, there were no measurements of radionuclides in animals because the unusually dry conditions reduced the number of small mammals that could be trapped, so the animal doses shown in Table 7-6 were deduced from the plant data. As shown in Table 7-6 and Table 7-7 the doses are all less than 0.1 percent of the DOE limits.

TABLE 7-6. DOSE TO TERRESTRIAL ANIMALS IN LOS ALAMOS CANYON WEIR FOR 2018
DOE LIMIT: 0.1 RAD/DAY FOR TERRESTRIAL ANIMALS; 7.2E-05 = 0.000072 RAD/DAY

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	4.4E-11	4.4E-07	1.5E-08	3.4E-06	3.9E-06
Cs-137	7.7E-09	7.7E-06	9.9E-10	5.0E-07	8.2E-06
Pu-238	9.4E-12	3.8E-08	2.0E-08	1.4E-06	1.4E-06
Pu-239	5.9E-12	2.4E-08	2.1E-08	1.3E-06	1.4E-06
Sr-90	0.0E+00	4.5E-06	0.0E+00	1.8E-05	2.3E-05
U-234	2.2E-09	2.2E-07	1.7E-06	6.4E-06	8.3E-06
U-235	4.2E-09	4.2E-07	1.1E-07	3.9E-07	9.2E-07
U-238	1.7E-07	1.7E-05	1.7E-06	6.2E-06	2.5E-05
Medium Total	1.9E-07	3.1E-05	3.5E-06	3.8E-05	Overall Dose 7.2E-05

TABLE 7-7. DOSE TO TERRESTRIAL PLANTS IN LOS ALAMOS CANYON WEIR FOR 2018
DOE LIMIT: 1 RAD/DAY FOR TERRESTRIAL PLANTS; 8.0E-05 = 0.00008 RAD/DAY

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	4.4E-11	4.4E-07	6.5E-06	7.0E-06
Cs-137	7.7E-09	7.7E-06	5.0E-07	8.2E-06
Pu-238	9.4E-12	3.8E-08	4.2E-06	4.2E-06
Pu-239	5.9E-12	2.4E-08	6.5E-06	6.5E-06
Sr-90	7.5E-08	4.5E-06	1.8E-05	2.3E-05
U-234	2.2E-09	2.2E-07	6.4E-06	6.6E-06
U-235	4.2E-09	4.2E-07	4.0E-07	8.2E-07
U-238	1.7E-07	1.7E-05	6.3E-06	2.4E-05
Medium Total	2.6E-07	3.1E-05	4.9E-05	Overall Dose 8.0E-05

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure does not receive significant quantities of LANL radionuclides. During 2018, any contribution from DOE operations was indistinguishable from background. The total biota dose in Pajarito Canyon is much less than 1 percent of the DOE limits and has no measurable impact on biota.

Site-Wide Assessment

Every three years, soil and vegetation samples are collected from selected locations throughout the Laboratory and these are used for the site-wide assessment shown in Table 7-8 and Table 7-9. The largest dose was from uranium at R-Site in Technical Area 15; however, the total biota dose is far below the DOE limits.

TABLE 7-8. SITE-WIDE DOSE TO TERRESTRIAL ANIMALS FOR 2018
DOE LIMIT: 0.1 RAD/DAY FOR TERRESTRIAL ANIMALS; 3.3E-03 = 0.0033 RAD/DAY

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	2.1E-10	2.1E-06	7.1E-08	1.6E-05	1.9E-05
Cs-137	2.5E-08	2.5E-05	3.2E-09	1.6E-06	2.6E-05
H-3	4.7E-09	9.5E-09	9.4E-09	9.4E-09	3.3E-08
Pu-238	5.2E-12	2.1E-08	1.1E-08	7.6E-07	7.9E-07
Pu-239	5.9E-10	2.4E-06	2.1E-06	1.3E-04	1.4E-04
Sr-90	3.4E-07	2.1E-05	2.7E-06	8.2E-05	1.1E-04
U-234	1.6E-07	1.6E-05	1.2E-04	4.6E-04	6.0E-04
U-235	2.2E-07	2.2E-05	5.5E-06	2.0E-05	4.8E-05
U-238	1.7E-05	1.7E-03	1.6E-04	5.9E-04	2.4E-03
Medium Total	1.7E-05	1.7E-03	2.9E-04	1.3E-03	Overall Dose 3.3E-03

TABLE 7-9. SITE-WIDE DOSE TO TERRESTRIAL PLANTS FOR 2018
DOE LIMIT: 1.0 RAD/DAY FOR TERRESTRIAL PLANTS; 3.6E-03 = 0.0036 RAD/DAY

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	2.1E-10	2.1E-06	3.1E-05	3.3E-05
Cs-137	2.5E-08	2.5E-05	1.6E-06	2.6E-05
H-3	4.7E-09	9.5E-09	1.0E-08	2.4E-08
Pu-238	5.2E-12	2.1E-08	2.3E-06	2.4E-06
Pu-239	5.9E-10	2.4E-06	6.5E-04	6.6E-04
Sr-90	3.4E-07	2.1E-05	8.2E-05	1.0E-04
U-234	1.6E-07	1.6E-05	4.6E-04	4.7E-04
U-235	2.2E-07	2.2E-05	2.1E-05	4.3E-05
U-238	1.7E-05	1.7E-03	6.0E-04	2.3E-03
Medium Total	1.7E-05	1.7E-03	1.8E-03	Overall Dose 3.6E-03

Animals at Other Locations

At other locations, road-killed animals provide information about the presence of radioactive material within their home ranges.

Measurements of radioactive materials in large animals are reported in Tables S7-22 (deer and elk), S7-25 (coyote), and S7-26 (snake and owl). The concentrations of radionuclides are similar to background, the doses are much less than 1 percent of the DOE limits, and there is no measurable impact to these animals from radioactive material.

Conclusion

Previous biota dose assessments have shown that biota doses at the Laboratory are far below the DOE limits. The 2018 assessment confirms the previous assessments and shows that there are no harmful effects to the biota populations at the Laboratory.

SPECIAL STUDIES

Benthic Macroinvertebrate Surveys

As part of a 2016 settlement agreement between the New Mexico Environment Department and the DOE, the Laboratory agreed to complete five supplemental environmental projects, including a surface water sampling project. As part of this project, we conducted aquatic life surveys to identify the aquatic species found in perennial and ephemeral or intermittent streams on the Pajarito Plateau. The presence and types of benthic macroinvertebrates in a stream reach serve as indicators of water quality in that reach. The different species have varying tolerances for disturbance, including pollutants.

What are benthic macroinvertebrates?

Benthic macroinvertebrates are small animals (frequently worms or insect larve) living among the stones, sediments, downed woody material, and plants at the bottom of streams, rivers, and lakes.

Most of the stream reaches on the Pajarito Plateau are intermittent (they only flow for a few days to a few weeks each year in response to storms or snow melt) or ephemeral (they flow only in direct response to stormwater runoff). To investigate the differences in aquatic organisms found in these conditions, we assessed benthic macroinvertebrate communities between locations in ephemeral and perennial stream reaches. We also compared benthic macroinvertebrate samples collected from perennial and ephemeral stream reaches on Laboratory property with background locations.

Aquatic life surveys were conducted in perennial streams in October 2017 and 2018. Table 7-10 presents the stream locations, the number of reaches sampled per stream, and whether the perennial stream was effluent fed or naturally perennial. In the spring and summer of 2018 (March and April) samples were collected off Laboratory property in one ephemeral system at a background location (San Juan Mesa) and samples were collected from ephemeral systems in perimeter locations (Ponderosa and Burnt Mesa at Bandelier National Monument and within Acid, Graduation, Kwage, Pueblo, and Walnut canyons). Also, in the summer of 2018 we collected one ephemeral sample from Sandia Canyon near the University House on Laboratory property (Figure 7-22).

TABLE 7-10. LOCATIONS AND NUMBER OF REACHES SAMPLED FOR PERENNIAL STREAMS INCLUDED IN THE AQUATIC LIFE SURVEYS

Stream Location	Sampling Dates, Number of Sampled Reaches, and Type of Water Source		
	Fall 2017	Fall 2018	Water source
On the Laboratory			
Sandia Canyon	4 reaches	2 reaches	Effluent-fed stream
Ancho Canyon		1 reach	Naturally perennial
Burning Ground Spring		1 reach	Naturally perennial
Martin Spring Canyon		1 reach	Naturally perennial
Pajarito Canyon		1 reach	Naturally perennial
Water Canyon		1 reach	Naturally perennial
Perimeter Location			
Pueblo Canyon	2 reaches	2 reaches	Effluent-fed stream
Background Location			
Calaveras Canyon	2 reaches	2 reaches	Naturally perennial
Rio Cebolla	2 reaches	2 reaches	Naturally perennial

All surveys were conducted along nine transects of equal length within each 160-meter reach of the stream. In perennial streams, benthic macroinvertebrates were collected at each transect using a D-frame kick net. Benthic macroinvertebrates samples were processed on a 500-micron sieve and all material on the sieves were transferred to a sample container and preserved with 95 percent ethanol. In ephemeral systems when water was absent, benthic macroinvertebrates were hatched from dry sediment collected along each transect. The dry sediment samples were transported back to the laboratory, placed in a plastic tub, and inundated with dechlorinated tap water. We used an air bubbler in each tub to maintain dissolved oxygen concentrations. After two weeks of submersion, we collected samples using the same method as our regular wet sample collection. All samples were shipped to EcoAnalysts in Moscow, Idaho, for taxonomic identification. A complete description of sampling methods is described in Berryhill and Gaukler (2017).

We compared perennial, ephemeral wet (that is, collected from water), and ephemeral dry (that is, collected from dry sediment) benthic macroinvertebrate samples to assess differences between sample types. We also compared perennial and ephemeral systems on Los Alamos National Laboratory property to background sample locations. We compiled results for abundance, species richness, Simpson’s diversity index, and overall community composition. We used three metrics to evaluate water quality: the Hilsenhoff Biotic Index (Hilsenhoff 1988), Metals Tolerance Index (McGuire 2009), and the percent of pollution sensitive taxa (Ephemeroptera, Plecoptera, and Trichoptera).

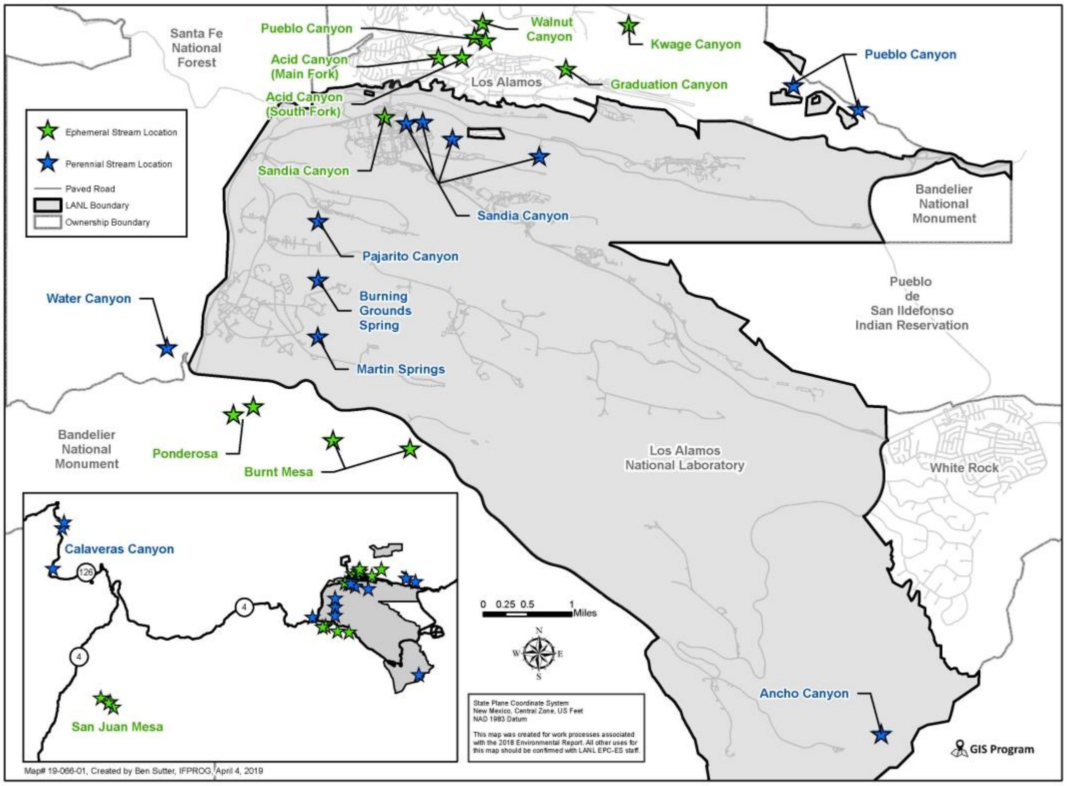


Figure 7-22. Locations of benthic macroinvertebrates collected within and around the Laboratory in 2017 and 2018

Abundance is the total number of individuals in a sample. Species richness is the number of species (taxa) in a sample. The Simpson's diversity index incorporates species richness and evenness and gives the probability that two individuals randomly selected from a sample will belong to the same species. Simpson's diversity index values range between zero and one, where values close to one represent maximum diversity and zero represent no diversity (all individuals are of the same species). The Hilsenhoff Biotic Index estimates the overall tolerance of the community to disturbance. It is calculated by weighting the relative abundance of each taxonomic group with their tolerance of disturbance. The values range from 0 to 10. A low value reflects a higher abundance of sensitive groups, indicating that the sampled area has a lower level of disturbance. The Metals Tolerance Index is used to identify samples with a high percentage of organisms tolerant of metals. This index is on a scale from 0 to 10, with higher values indicating a higher percentage of tolerant organisms, indicating more metal pollution. The percent of Ephemeroptera, Plecoptera, and Trichoptera index evaluates water quality by the relative abundance of three major orders of stream insects that have a low tolerance to water pollution. Population metrics and water quality indices were evaluated with an analysis of variance or a Kruskal-Wallis test for non-normal distributions.

We used non-metric multidimensional scaling with a Bray-Curtis dissimilarity matrix to assess differences in the benthic macroinvertebrate community composition. We tested differences between groups of interest using the nonparametric statistical method Adonis for two groups and Adonis pairwise comparisons tests for multiple groups. If significant differences were shown, we evaluated the contribution of each individual species on dissimilarities between groups found in the ordination with a simper analysis (Clark 1993). We used the package vegan (Oksanen et al. 2019) in the R statistical software version 3.5.0 for all data analyses (R Core Team 2019).

Benthic Macroinvertebrate Results

Benthic macroinvertebrates were found in 42 of the 46 samples that were taken from perennial and ephemeral streams. Benthic macroinvertebrate abundance and species richness were different among all sample types (Figure 7-23, $p < 0.001$). Simpson’s diversity index values showed differences between perennial and ephemeral wet samples, but not between any other pairwise comparisons (Figure 7-23, $p = 0.02$). Differences in the Hilsenhoff Biotic Index values between perennial and ephemeral wet and dry indicate that there were more disturbance-tolerant individuals in ephemeral systems than perennial systems (Figure 7-23, $p = 0.001$). No Ephemeroptera, Plecoptera, and Trichoptera taxa were observed in ephemeral dry samples and these taxa were higher in perennial samples when compared with ephemeral wet samples ($p < 0.001$). We saw no significant differences between perennial, ephemeral wet, or ephemeral dry samples for the tolerance of metals in water ($p < 0.05$).

Results showed differences in community composition between ephemeral wet, ephemeral dry, and perennial streams, (Figure 7-24, $p < 0.05$). The species that drove these differences were mainly Naididae (a benthic worm), Optioservus (a type of riffle beetle), Dasyhelea (a biting midge fly larvae), and Nematoda (a round worm). The organisms with lower tolerance of disturbance (Optioservus and Nematoda) were found in higher numbers in the perennial systems, while the organisms more tolerant of disturbance (Naididae and Dasyhelea) were found in greater abundance in the ephemeral systems.

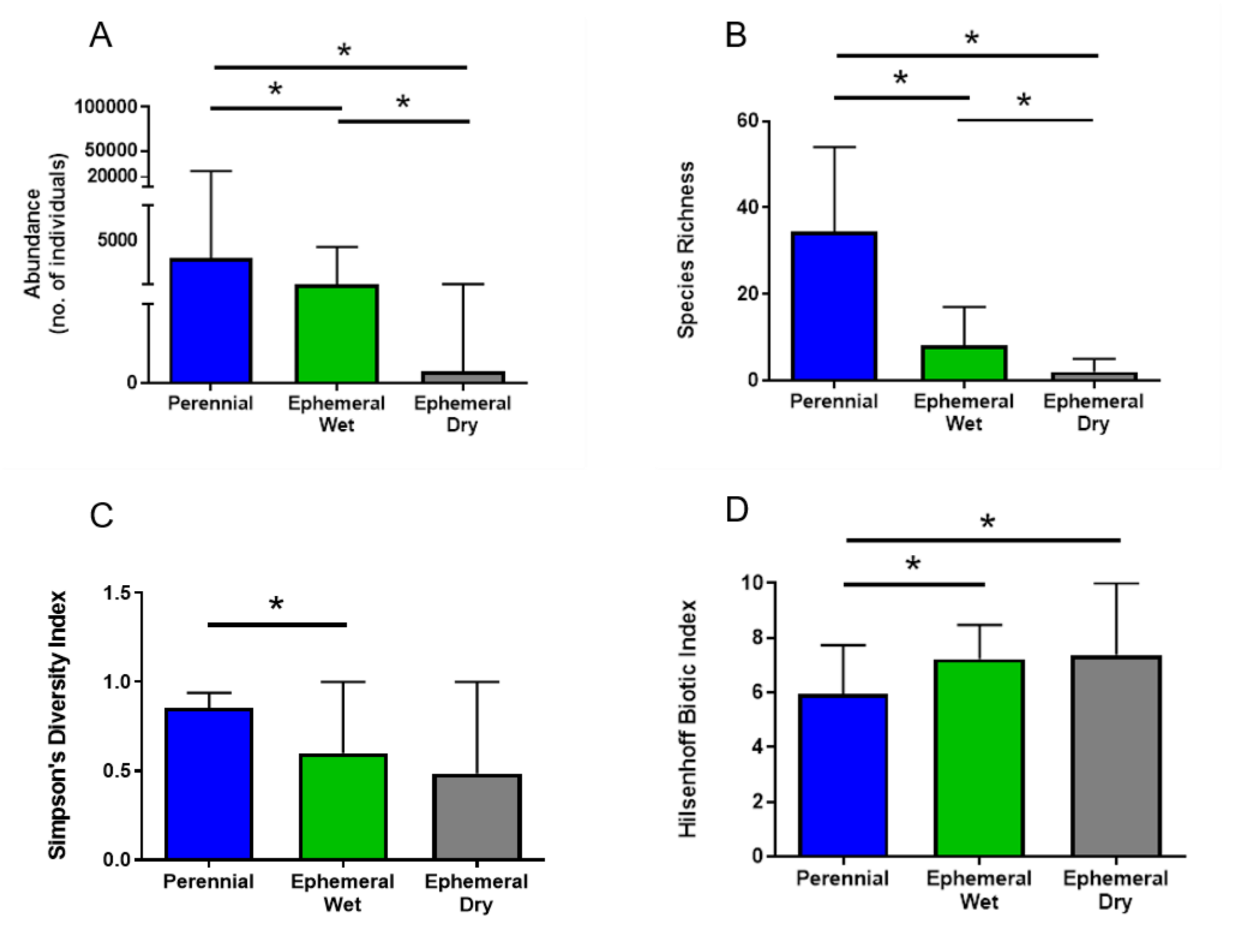


Figure 7-23. Median values of (A) abundance, (B) species richness, (C) Simpson's diversity index, and (D) the Hilsenhoff Biotic Index for perennial, ephemeral wet, and ephemeral dry sample types. A bar with an asterisk indicates significant pairwise differences or difference between groups (α = 0.05).

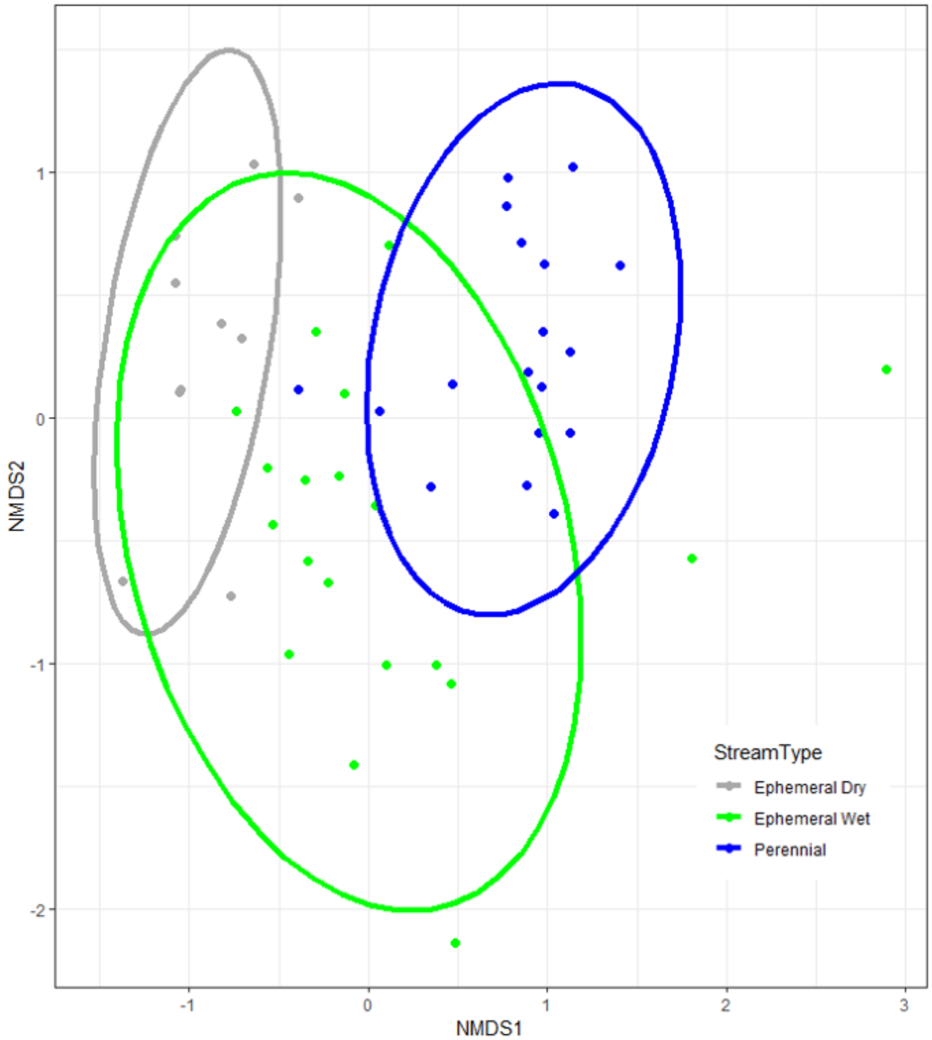


Figure 7-24. Non-metric multidimensional scaling results. Community composition for ephemeral wet, ephemeral dry, and perennial are significantly different from each other ($p < 0.05$). Points represent the community composition from each sample, ellipses are 95 percent confidence interval ellipses, and axes are arbitrary. Note: NMDS = non-metric multidimensional scaling.

Due to the lack of benthic macroinvertebrates in dry samples, we used only wet samples (that is, perennial locations and wet samples from ephemeral locations) to compare water quality metrics from the Laboratory and background locations. We saw no differences between benthic macroinvertebrate abundance, species richness, Simpson's diversity index, the percent of Ephemeroptera, Plecoptera, and Trichoptera, the Hilsenhoff Biotic Index, or tolerance of metals index between locations on Laboratory property and background locations ($p > 0.05$). Results showed differences in community composition between the Laboratory samples and background locations (Figure 7-25, $p = 0.004$). The species that drove these differences were mainly Optioservus (a type of riffle beetle), Dasyhelea (a biting midge fly larvae), Ostracoda (a small crustacean), Pisidium (a type of freshwater clam), and various Chironomidae (midges), as well Callibaetis sp. (a type of mayfly). Optioservus and Callibaetis were found in higher abundances at the Laboratory while Ostracoda and Pisidium had higher abundances at background locations. The various Chironmidae were found at both locations.

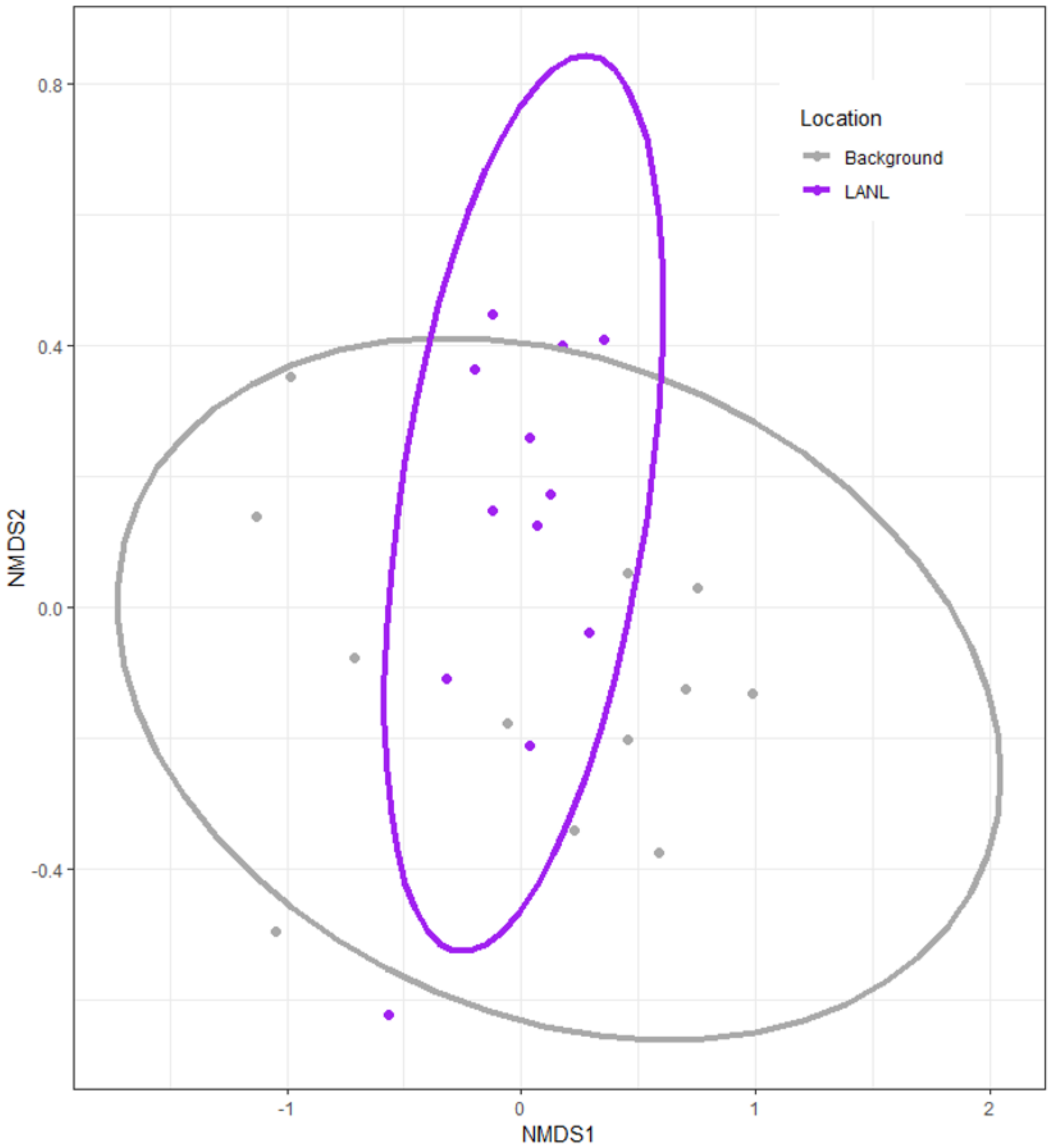


Figure 7-25. Non-metric multidimensional scaling results. Los Alamos National Laboratory and background community composition is significantly different from each other ($p < 0.05$). Points represent the community composition from each sample, ellipses are 95 percent confidence interval ellipses, and axes are arbitrary. Note: NMDS = non-metric multidimensional scaling.

The differences we saw in abundance, species richness, diversity, and community composition for ephemeral wet, ephemeral dry, and perennial systems indicate that stream reaches experiencing non-flow periods support benthic macroinvertebrate communities with fewer species than and different species from perennial reaches. The tolerance values of the benthic macroinvertebrate community were higher in ephemeral systems, particularly in ephemeral dry samples, indicating that these communities were more tolerant of disturbance. Similar to other studies, our results show that the macroinvertebrate community compositions of ephemeral systems contained only a limited set of species, presumably with particular trait combinations that can survive in the intermittent conditions (Giam et al. 2017, Piano et al. 2019.) Dry sediment samples contained extremely low abundances and species richness and are not recommended as a way to assess the quality of a stream reach. Wet samples from ephemeral streams can still represent stream water quality, but assessments should take into consideration the ephemeral nature of the stream and that it likely contains overall more tolerant organisms due to the drier conditions and potentially not due to pollution. More data comparisons from varying ephemeral and perennial locations are needed to make robust recommendations and assessments.

Metal pollution was not an issue for any of the streams that we sampled. Similarly, we did not detect differences in any of our metrics between stream systems on Los Alamos National Laboratory and background locations, including tolerance values of the benthic macroinvertebrate community and the water quality metrics. The community composition differences we did detect could be due to differences in habitat type at our background sample locations. These data suggest that our sample locations on Los Alamos National Laboratory property support healthy communities of aquatic life and are not of ecological concern.

Bird Monitoring at Open-Detonation and Open-Burn Firing Sites

An annual bird population monitoring program was started in 2013 as part of a Resource Conservation and Recovery Act permitting process for two open detonation sites and one open burn site. Open detonation sites are locations at the Laboratory where explosives are set off. The open burn site is a facility where materials are ignited for self-sustained combustion (for example, to remove residues of high explosives). The two open detonation sites included in the permitting process are Technical Area 36 Minie Site (Minie) and Technical Area 39 Point 6 (Technical Area 39); the open burn site is the Technical Area 16 Burn Ground (Technical Area 16). Together these are referred to as the treatment sites (Hathcock and Fair 2013; Hathcock 2014; Hathcock 2015; Hathcock et al. 2017; Hathcock et al. 2018). The ongoing objective of the population monitoring is to determine whether Laboratory operations at these sites impact bird species richness (the number of different species present), species diversity (a combination of the number of species present and their relative abundance), or composition (the presence or absence of each individual species). The full report for this work is in Hathcock et al. (2019).

Biologists at the Laboratory use point count methodology to record the birds present along transects at the three treatment sites and compared the results to surveys conducted in similar habitat types in less developed areas (control sites). Summer surveys provide information about which birds are breeding at each site. The habitat type at Minie and Technical Area 39 is a two-needle piñon (*Pinus edulis*) and one-seed juniper woodland habitat referred to as piñon-juniper. The habitat type at Technical Area 16 is a ponderosa pine (*Pinus ponderosa*) forested habitat referred to as ponderosa pine.

The data were analyzed to compare bird species richness, diversity, and composition between sites and among years. Three surveys were completed at each of the three treatment sites and the control sites between May and July 2018. A total of 842 birds representing 58 species were recorded at the three treatment sites. There were no differences between treatment and control sites for species richness in 2018. Species diversity was significantly different among the sites (Figure 7-26). The treatment sites had higher bird species diversity than the control sites.

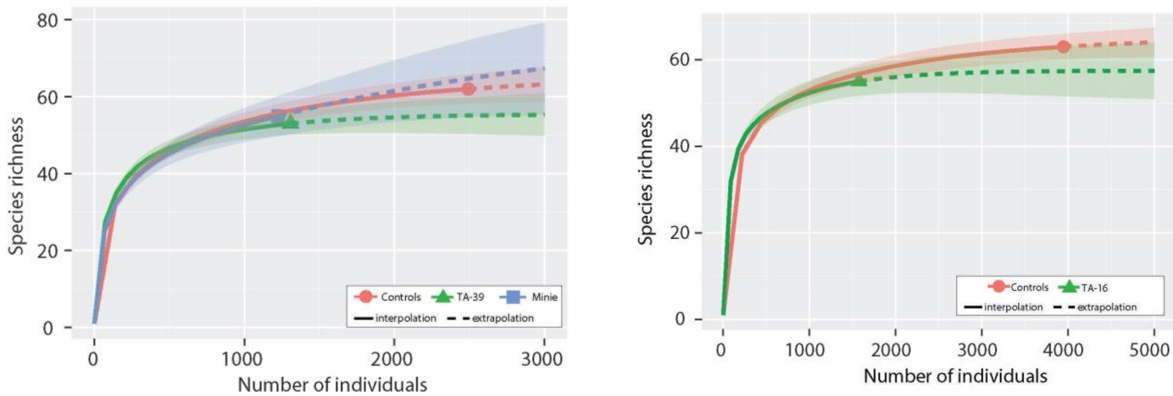


Figure 7-26. Species richness results from Minie and Technical Area 39 compared with piñon-juniper control sites, and results from Technical Area 16 compared with ponderosa pine control sites

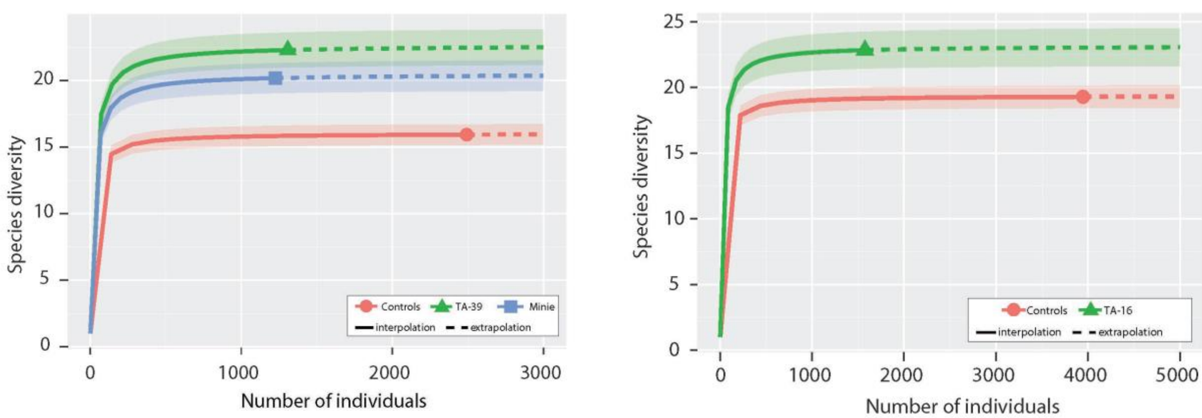
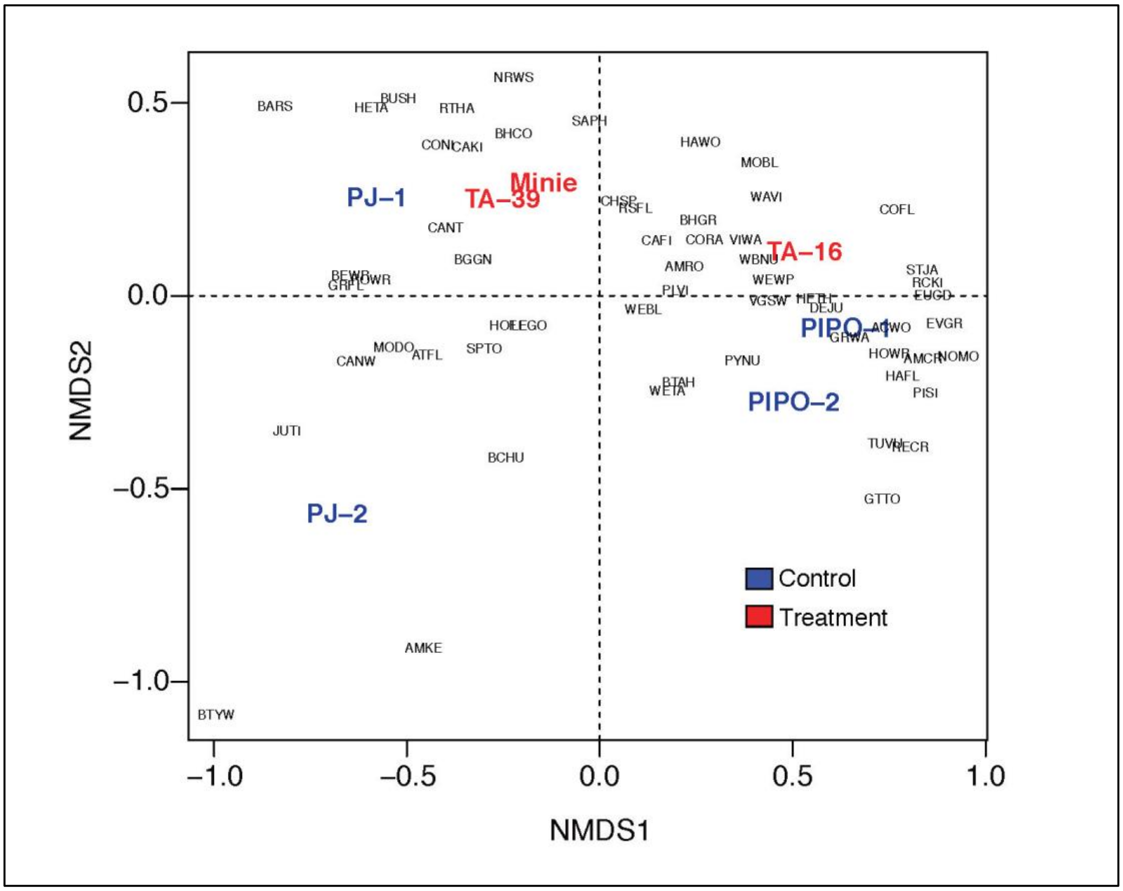


Figure 7-27. Species diversity results comparing Minie and Technical Area 39 with piñon-juniper control habitat, and results from Technical Area 16 compared with ponderosa pine control habitat

Multivariate analysis with ordination was used to analyze the data for patterns that may be explained by other environmental factors (Gardener 2014). The final configuration of points for 2018 using non-metric multidimensional scaling is represented in Figure 7-27 where the treatments and controls are plotted (k = 3, stress = 0.002). The different species composition between the left and right and the upper and lower part of the graph (dotted lines = the reference lines) correlate with the associated habitat types. Here, the piñon-juniper sites are grouped on the left and ponderosa pine sites on the right. In the plot it is clear that the piñon-juniper-2 (PJ-2) control transect is slightly different than the other piñon-juniper control and the two piñon-juniper treatments. The species that seem to be different in the piñon-juniper-2 control are the black-throated gray warbler (*Setophaga nigrescens*), American kestrel (*Falco* *sparverius*), black-chinned hummingbird (*Archilochus alexandri*), and juniper titmouse (*Baeolophus ridgwayi*). The ponderosa pine controls and treatment site are more closely aligned with one another. In 2018, the treatments were not statistically different than the controls overall (ANOSIM: R = -0.15, p = 0.67) and the two habitat types were statistically different, as expected (ANOSIM: R = 0.96, p = 0.037).



Note: NMDS = non-metric multidimensional scaling.

Figure 7-28. Non-metric multidimensional scaling of bird species and survey sites in 2018. Four-letter acronyms refer to individual bird species recorded during surveys. The English language bird names associated with each code can be found at https://www.birdpop.org/docs/misc/Alpha_codes_eng.pdf.

Chemicals in Bird Eggs and Nestlings at Open Detonation and Open Burn Firing Sites

In addition to the point count surveys, avian nest boxes have been placed at Minie, Technical Area 39, and Technical Area 16. Bird eggs and nestlings are useful for monitoring chemicals, radionuclide exposures, and uptake in biological systems because different species occupy many trophic levels. Additionally, the collection of nonviable eggs and/or nestlings that die of natural causes is noninvasive and is nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Sources of inorganic elements include both releases from human activities and natural geological sources. Birds can be exposed through a number of routes including diet, ingestion of soil, drinking water, and inhalation. Inorganic elements (mostly metals) and dioxins and furans are of interest at open detonation firing sites (Minie and Technical Area 39) and at the burn grounds at Technical Area 16 (Fresquez 2011).

In 2018, chemical concentrations were evaluated in nonviable western bluebird and ash-throated flycatcher eggs that were collected at the Laboratory near the open detonation sites at Minie and Technical Areas 39 and near the Technical Area 16 open burn site. Nonviable eggs were collected from nest boxes. No nestling samples were obtained in 2018 because the nest boxes located in the areas of interest did not have nestlings that died of natural causes that could be collected opportunistically. Due to limited sample mass, non-viable eggs were evaluated for inorganic elements only and were analyzed at ALS in Fort Collins, Colorado. The results could not be statistically compared with control site data due to small sample sizes. Results were compared with the regional statistical reference levels calculated from non-viable eggs from western bluebirds and ash-throated flycatchers at background locations on Bandelier National Monument in 2016 and 2018 (n = 8). Results were also compared with the lowest observable adverse effect levels from peer reviewed literature when available.

Results of Chemicals Concentrations in Bird Eggs

The majority of inorganic elements were either not detected or were below the regional statistical reference levels in bird eggs collected from Technical Area 16 (n = 4 samples), Minie (n = 2 samples), and Technical Area 39 (n = 2 samples; Table S7-31). Two samples collected from Technical Area 16 and one sample from Technical Area 39 contained mercury concentrations (0.23 to 0.62 milligrams per kilogram) that were above the regional statistical reference levels; however, they were well below the lowest observable adverse effect levels for mercury (1.67 milligrams per kilogram), suggesting that adverse health effects are not expected at the observed concentrations (Thompson 1996).

Copper was also detected above the regional statistical reference level in eggs collected from Minie and Technical Area 39 (4.1 to 9.2 milligrams per kilogram; Table S7-31). No reliable screening levels are available for copper, although it has been suggested that birds are relatively resistant to copper toxicity when compared with other taxa (Eisler 1998).

Other elements that exceeded the regional statistical reference level include iron, magnesium, manganese, selenium, and sodium, all of which are essential mirco- or macro-nutrients and needed by living organisms. No reliable screening levels are available for the majority of these elements. All selenium concentrations were below the lowest observable adverse effect levels (Heinz et al. 1989).

The overall results indicate that the levels of inorganic elements in the eggs of western bluebirds and ash-throated flycatcher at these firing sites are not likely to cause adverse effects in breeding bird populations. Most constituents were not detected in the non-viable egg samples. Most constituents that were detected were below regional statistical reference levels and all were below the lowest observable effect levels (when available). These data suggest that egg elements concentrations observed here are not of ecological concern.

QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

Quality Assurance Program Development

The sampling team collects soil, foodstuffs, and biota samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Laboratory's *Implementation of the Soil, Foodstuffs, and Biota Program, Quality Assurance Project Plan* (EPC-ES-QAPP-001) and in the following Laboratory procedures:

- *Soil and Vegetation Sampling for the Environmental Surveillance Program* (EPC-ES-TP-003)
- *Soil and Vegetation Sampling at Facility Sites* (EPC-ES-TP-006)
- *Soil Sampling for Land Transfer and Conveyance and Other Special Projects* (EPC-ES-TP-017)
- *Produce Sampling* (EPC-ES-TP-004)
- *Road Kill Sampling* (EPC-ES-TP-007)
- *Crayfish Sampling* (EPC-ES-TP-008)
- *Benthic Macroinvertebrate Sampling* (EPC-ES-TP-013)
- *Fish Sampling* (EPC-ES-TP-005)
- *Managing and Sampling Honey Bee Hives* (EPC-ES-TP-219)
- *Live Trapping of Small Mammals* (EPC-ES-TP-201)

In addition, procedures and protocols for biota dose assessment can be found in the *Technical Project Plan for Biota Dose Assessment* (ENV-ES-TPP-002).

These procedures ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results are conducted in a consistent manner from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of carefully documented procedures, listed above, which govern all aspects of the sample collection program.

The sampling team collects all samples under full chain-of-custody procedures to minimize the chances of data transcription errors. Once collected, samples are hand-delivered to the Laboratory's sample management office, which ships the samples via express mail directly to an external analytical laboratory under full chain-of-custody control. Sample management office personnel track all samples. Upon receipt of data from the analytical laboratory (electronically and in hard copy), the completeness of the field sample process and other variables is assessed. A quality assessment document is created, attached to the data packet, and provided to the project leader.

Field data completeness for sample collection in 2018 was 93 percent. Due to severe drought effects on small mammal abundance, we had difficulty trapping the total number of animals needed to meet our sampling plan goals, despite increased sampling effort over different periods of the season. We did not meet our small mammal totals at the Dual Axis Radiographic Hydrodynamic Test Facility (short four samples), Los Alamos Canyon weir (short four samples), Pajarito Canyon flood retention structure (short one sample), and Los Alamos Canyon at Pueblo de San Ildefonso (short two samples). All of these locations will be resampled for small mammals within one to three years.

Analytical Laboratory Quality Assessment

In 2018, analyses of americium-241, plutonium-238, and plutonium-239/240 by ALS in soil and vegetation samples collected around Area G at Technical Area 54 were affected by tracer recovery issues. The tracer standards for these radionuclides contained small amounts of americium-241, plutonium-238, and plutonium-239/240 which ultimately led to higher detection limits. The data are valid; however, the minimum detection concentration was not met.

Additionally, in 2018, ALS inadvertently ashed an understory vegetation sample for radionuclide analyses before it underwent inorganic element analyses. The lab proceeded to analyze the sample on an ashed basis; however, we were unable to use the data in our analyses as the basis for the samples was different (that is, ashed vs. wet). Lastly, two western bluebird nestling samples collected from a background location were sent to ALS for radionuclide and inorganic element analyses. While the analytical lab conducted the inorganic element analyses, it discarded the samples prior to radionuclide analyses. In total, we lost radionuclide results from three samples in 2018 due to laboratory error.

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Chapter 8 – PUBLIC DOSE AND RISK ASSESMENT

U.S. Department of Energy regulations limit the total annual radiological dose to the public from Los Alamos National Laboratory (LANL, or the Laboratory) operations to 100 millirem. Furthermore, doses must be as low as reasonably achievable and must not exceed 25 millirem from any one exposure pathway or from the storage of waste. The annual dose received by the public from airborne emissions of radionuclides is limited to 10 millirem.

The objective of this chapter is to use environmental sampling data collected from air, water, soil, and foodstuffs to answer the question, "What are the potential doses and risks to the public from the Laboratory's operations?" The assessments show that during 2018 all doses to the public were far below all regulatory limits and guidance and that the public is well protected. Radiological doses to the public from Laboratory operations are less than 1 millirem per year, and health risks are indistinguishable from zero.

CONTENTS

INTRODUCTION

In this chapter, dose and risk from radiological and chemical sources are assessed to ensure the public is protected and to demonstrate compliance with federal regulations and U.S. Department of Energy (DOE) orders. The data reported here and in the previous chapters are considered in the context of public exposure, using standard methods to calculate the potential effects of radiological dose and risk. The results are compared with regulatory limits and international standards.

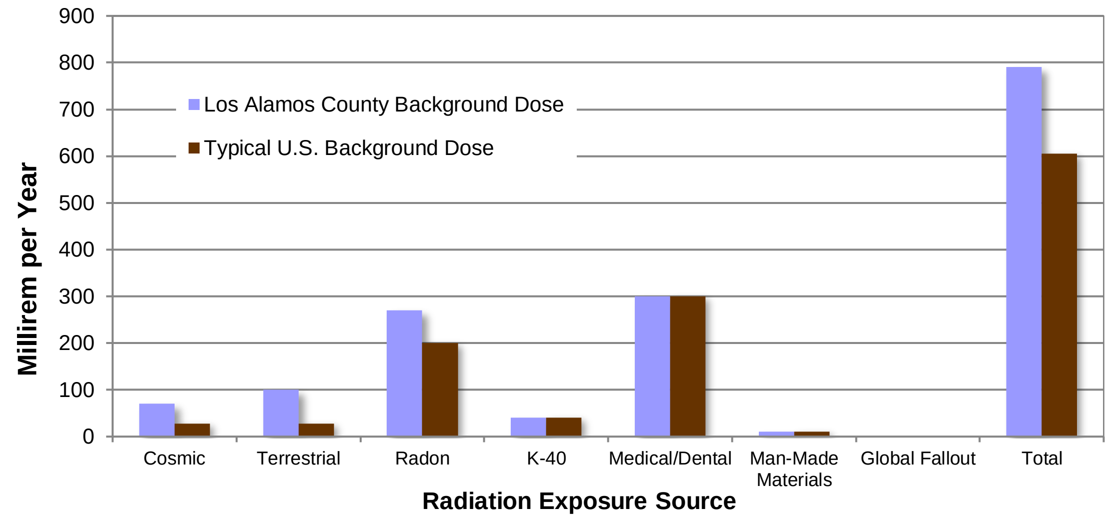
RADIOLOGICAL DOSE ASSESSMENT FOR THE PUBLIC

Overview of Radiological Dose

Radiological dose is the primary measure of harm from radiation. Doses are calculated using the standard methods specified in guidance documents (DOE 1988a, 1988b, 1991, 2011a, 2011b, 2015; U.S. Environmental Protection Agency 1988, 1993, 1997, 1999; ICRP 1996; Nuclear Regulatory Commission 1977). In this section, we assess doses to the public. Doses to plants and animals are assessed in Chapter 7.

DOE regulations limit the total annual dose to the public from Los Alamos National Laboratory (LANL) operations to 100 millirem. Furthermore, doses must be as low as reasonably achievable and must not exceed 25 millirem from any one exposure pathway, such as eating food or from the storage of waste (DOE 1999, 2011a; LANL 2008). The annual dose received by the public from airborne emissions of radionuclides is limited to 10 millirem by U.S. Environmental Protection Agency regulations (U.S. Environmental Protection Agency 1989). The annual dose from community drinking water supplies is limited by the Safe Drinking Water Act to 4 millirem (U.S. Environmental Protection Agency 2004).

To place these limits in context, the dose from natural background and from medical and dental procedures is about 800 millirem per year (Figure 8-1). The origins and reasons for the Los Alamos background dose are discussed briefly below and in detail in the paper by Gillis et al. (2014). In contrast, doses from Laboratory operations are typically less than 1 millirem per year.



Note: K-40 = Potassium-40

Figure 8-1. The average Los Alamos County radiation background dose compared with average U.S. radiation background dose (Gillis et al. 2014).

Exposure Pathways

Potential doses to the public from radionuclides associated with Laboratory operations are calculated by evaluating all potential exposure pathways. Total dose is the sum of three principal exposure pathways: (1) direct-penetrating (photon or neutron) radiation, (2) inhalation of airborne radioactive particles, and (3) ingestion of radionuclides in water or food.

Direct Radiation

We monitor direct-penetrating radiation from photons and neutrons at 80 locations in and around the Laboratory (see Chapter 4). Direct-penetrating radiation from Laboratory sources contributes to a measurable dose only within about one kilometer of the source. At distances more than one kilometer, dispersion, scattering, and absorption of the photons and neutrons attenuate the dose to much less than 0.1 millirem per year, which cannot be distinguished from natural background radiation. The only measurable above-background doses from direct-penetrating radiation originate from Technical Area 53 and Technical Area 54, as reported in Chapter 4.

Inhalation

At distances of more than 1 kilometer from Laboratory sources, any dose related to Laboratory operations is almost entirely from airborne radioactive emissions. Whenever possible, we use the airborne radioactivity levels directly measured by the air-sampling network reported in Chapter 4 (the Ambient Air Sampling for Radionuclides section) to calculate doses. Where local levels of airborne radioactivity are too small to measure or cannot be measured by the environmental air-monitoring station methods, doses are calculated using a model called CAP88 (Clean Air Act Assessment Package-1988, PC Version 4) (U.S. Environmental Protection

Agency 2013). CAP88 is an atmospheric-dispersion and dose-calculation computer code that combines stack emissions with meteorological data to estimate dose.

Some of the radionuclide emissions from Technical Area 53 are short-lived and cannot be measured by the environmental air stations. These emissions are measured at the stacks (Chapter 4, the Exhaust Stack Sampling for Radionuclides section), and the resulting estimated doses are calculated with CAP88.

The air-pathway dose assessment is described in detail in an annual air emissions report (Lattin and Fuehne 2019) and in Chapter 4.

Ingestion

Ingestion includes drinking liquids and eating food. We report measurements from water in Chapters 5 and 6, and measurements from soil, plants, and animals here and in Chapter 7.

Local drinking water contains no measurable radioactivity from current or historical Laboratory operations. For further information regarding Los Alamos County drinking water quality, refer to the Los Alamos Department of Public Utilities "2018 Annual Drinking Water Quality Report" (Los Alamos County 2019.)

Local produce is tested regularly and contains no measurable radioactivity from Laboratory sources. In 2018, two deer and four elk were tested for radionuclides and other materials. The onsite results were similar to those for regional elk and deer and were far below screening levels.

Dose from Naturally Occurring Radiation

Near Los Alamos, naturally occurring sources of radioactivity include (1) cosmic rays, (2) direct-penetrating radiation from terrestrial sources, (3) radon gas, and (4) elements that occur naturally inside the human body, such as potassium-40 (Figure 8-1). Additional man-made sources of radiation, including medical and dental uses of radiation and building products such as stone walls, raise the total average annual background dose to about 800 millirem (Gillis et al. 2014). Generally, any additional dose of less than 0.1 millirem per year cannot be distinguished from the dose generated by background levels of radiation.

Annual doses from cosmic radiation range from 50 millirem at lower elevations near the Rio Grande to about 90 millirem in the higher elevations west of Los Alamos (Bouville and Lowder 1988, Gillis et al. 2014). In addition, annual background doses from external gamma radiation (from natural terrestrial sources such as uranium and thorium and their decay products) range from about 50 millirem to 150 millirem (DOE 2012).

The inhalation of naturally occurring radon and its decay products constitutes a large proportion of the annual dose for a member of the public. Nationwide, the average annual dose from radon is about 200 millirem to 300 millirem (National Council on Radiation Protection and Measurements 1987). In Los Alamos County, the average residential radon concentration results in an annual dose of about 300 millirem (Whicker 2009a, 2009b).

An additional 30 millirem per year results from naturally occurring radioactive materials in the body, such as potassium-40, which is present in all food and living cells. Members of the U.S. population receive an average annual dose of 300 millirem from medical and dental uses of radiation (National Council on Radiation Protection and Measurements 2009). Another 10 millirem per year comes from man-made products, such as stone or adobe walls.

In total, the average annual dose from sources other than Laboratory operations is about 800 millirem for a typical Los Alamos County resident. Figure 8-1 compares the average radiation background in Los Alamos County with the average background dose in the United States.

Results and Dose Calculations

The objective of this section is to calculate doses to the public from Laboratory operations.

As required by DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, we calculated doses from the Laboratory to the following members of the public:

- the total human population within 80 kilometers (50 miles) of the Laboratory, and
- the hypothetical "maximally exposed individual."

For the hypothetical maximally exposed individual, the following are considered:

- the air-pathway dose, as required by the Clean Air Act (U.S. Environmental Protection Agency 1989),
- the onsite dose,
- other locations with measurable dose, and
- the offsite dose.

Dose from Ingestion of Foodstuff and Game Animals

Periodically, locally-produced fruits, vegetables, eggs, milk, and other foodstuffs are collected in Los Alamos County and analyzed for radionuclides and other materials. The results show that the levels of radioactivity in these foodstuffs are similar to background levels and that the potential dose from eating local foodstuff is far below 0.1 millirem per year.

Road-killed deer and elk have been collected within and adjacent to the Laboratory, including during 2018, and the LANL results were compared with regional data. The results show that there is no significant difference in radioactivity levels between local and regional deer and elk (Table S7-22). The levels are far below screening levels and show that the dose from consuming deer or elk meat is far below 0.1 millirem per year.

The Los Alamos County Annual Drinking Water Quality Report (Los Alamos County 2019) reports that alpha-particle emitters range from 0 to 0.9 picocuries per liter, and detailed measurements indicate that these are the result of naturally occurring uranium in the aquifer. The dose from this natural uranium is less than 0.1 millirem per year (DOE 2011b) and any contribution from man-made material is too small to measure and is essentially zero.

The conclusion is that the ingestion dose from Los Alamos National Laboratory operations is essentially zero.

Collective Dose to the Population within 80 Kilometers

The collective population dose from Laboratory operations is the sum of the doses for each member of the public within an 80-kilometer radius of the Laboratory (DOE 2011a). Outside of Los Alamos County, the doses are too small to measure directly, so the collective dose was calculated by modeling the transport of radioactive air emissions using CAP88. The doses from the pathways other than air are either negligible or nonexistent.

The 2018 collective population dose to persons living within 80 kilometers of the Laboratory is 0.09 person-rem (Lattin and Fuehne 2019). This dose is less than 0.001 millirem per person and is much less than the background doses shown in Figure 8-1.

Tritium contributed 46 percent of the dose from the Laboratory, and short-lived activation products, such as carbon-11 from the Los Alamos Neutron Science Center, contributed 54 percent. Collective population doses for recent years are shown in Figure 8-2. The trend-line for the past ten years shows a general decrease, which is the result of improved engineering controls at Los Alamos Neutron Science Center and the tritium facilities.

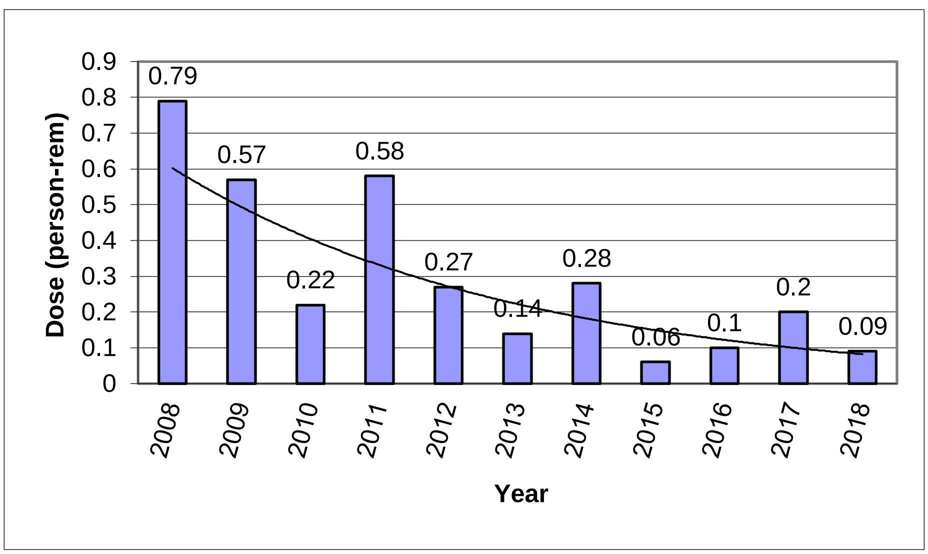


Figure 8-2. Annual collective dose (person-rem) to the population within 80 kilometers of the Laboratory

Dose to the Maximally Exposed Individual

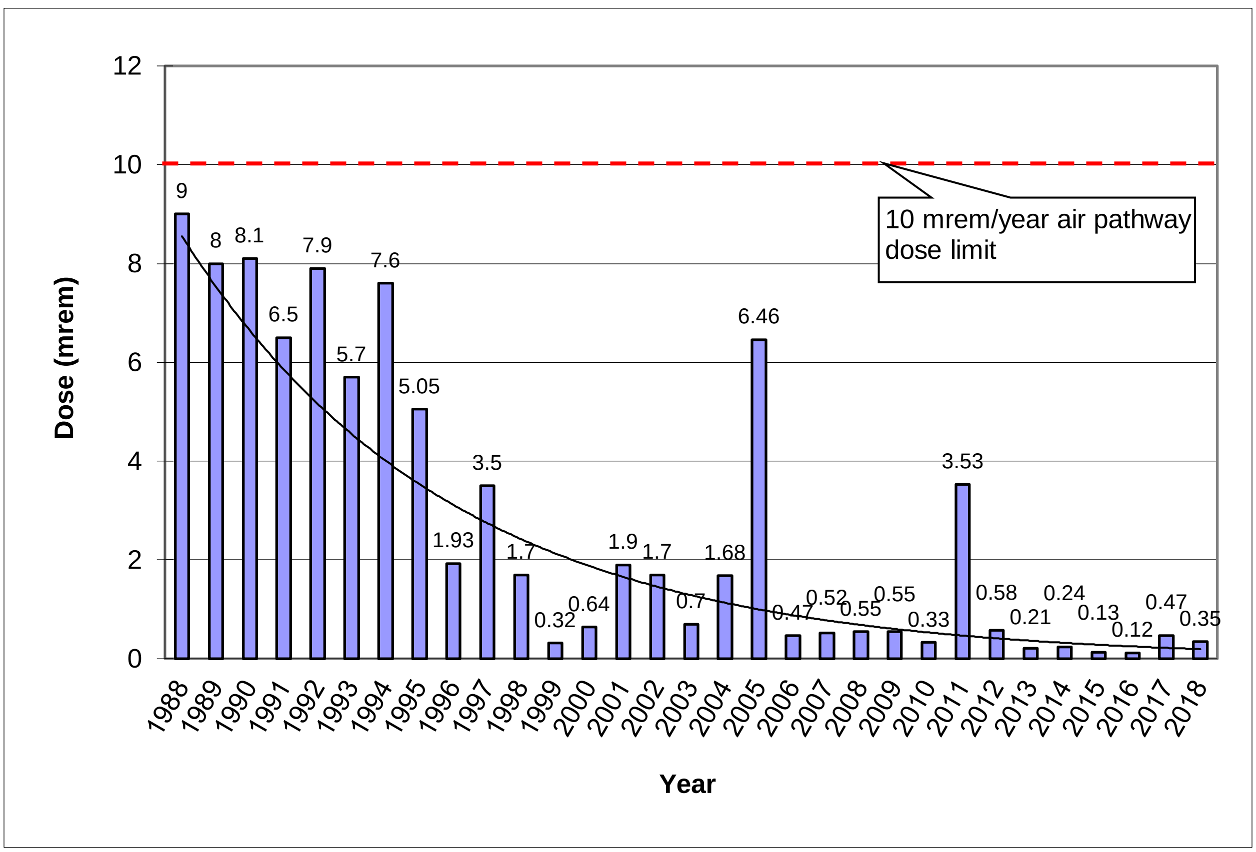
The "maximally exposed individual" is a hypothetical member of the public who receives the greatest possible dose from Laboratory operations (U.S. Environmental Protection Agency 1989, DOE 2011a). To determine the location where a member of the public would be maximally exposed, we consider all exposure pathways that could cause a dose and all publicly accessible locations, both within the Laboratory boundary (onsite) and outside the boundary (offsite.)

Maximally Exposed Individual Offsite Dose for 2018

The air-pathway dose calculations are described in an annual air emissions report (Lattin and Fuehne 2019). In 2018, the offsite location of the hypothetical maximally exposed individual was at 2470 East Road in the general area known as East Gate, close to environmental air-monitoring stations #157 and #206 (Chapter 4, Figure 4-1). The total offsite dose for a maximally exposed individual during 2018 was 0.35 millirem (Lattin and Fuehne 2019).

Contributions to this annual dose were from short-lived activation products from the Los Alamos Neutron Science Center stacks (0.155 millirem), other stack emissions (0.001 millirem), environmental measurements at air-monitoring stations (0.009 millirem), and the potential dose contribution from unmonitored stacks (0.188 millirem). Doses from ingestion and direct radiation were less than 0.01 millirem.

East Gate is frequently the location of the annual maximally exposed individual offsite dose at LANL because of Los Alamos Neutron Science Center operations; however, in 2017, the location was at 2101 Trinity Drive, in the general area of the original Technical Area 01, because of a remediation project in the area that has since been completed.



Note: mrem = millirem

Figure 8-3. Annual maximally exposed individual offsite dose

Maximally Exposed Individual Onsite Dose for 2018

The onsite locations where a member of the public could receive a measurable dose are on or near publicly accessible roads (McNaughton et al. 2013). The only location with a measurable Laboratory-generated dose is at East Jemez Road near Technical Area 53. As reported in Chapter 4 (the Monitoring for Gamma and Neutron Direct-Penetrating Radiation section), at this location in 2018 the neutron dose was 0.7 millirem and the gamma dose was 0.1 millirem for a total of 0.8 millirem. The contribution from stack emissions was less than 0.01 millirem. These are the doses that would be received by a hypothetical individual at this location 24 hours per day and 365 days per year; however, members of the public, such as joggers, bus drivers, or cyclists, spend less than 1 percent of their time at this location (National Council on Radiation Protection and Measurements 2005). Therefore, the onsite dose for a maximally exposed individual is less than 1 percent of 0.8 millirem, which is much less than the offsite dose for a maximally exposed individual described in the previous section.

Other Locations with Measurable Dose

As reported in Chapter 4, neutron dose was measured in Cañada del Buey, north of Technical Area 54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, emits neutrons. After subtracting background, the measured neutron dose in Cañada del Buey in 2018 was 3 millirem. After applying the standard factor of 1/20 for occasional occupancy (National Council on Radiation Protection and Measurements 2005), the individual neutron dose in 2018 was 3/20 ≈ 0.15 millirem.

The contribution from Laboratory stack emissions was less than 0.001 millirem. Within the boundaries of Area G, the average air concentration of transuranic material was 6 attocuries per cubic meter (Chapter 4, Tables 4-3 and 4-4) and the average uranium-238 concentration was 18 attocuries per cubic meter (Chapter 4, Table 4-5). Using the dose conversion factors from DOE Standard 1196 (DOE 2011b), and assuming 1/20 occupancy, the annual dose both within and near Area G was much less than 0.001 millirem. Thus, in 2018, the total dose in Cañada del Buey was 0.15 millirem.

In 2017, the location of the maximally exposed individual was near "Hillside 138" near Airnet station #324. Recently, Hillside 138 was remediated to recreational standards (Haagenstad 2017), and the Airnet dose in 2018 was less than 0.03 millirem.

The soil concentrations at Hillside 138 are now similar to those in Acid Canyon. For recreational users in Acid Canyon, the doses to adults and children are less than 0.1 millirem per year (McNaughton et al. 2018).

Maximally Exposed Individual Summary

At the offsite location for the maximally exposed individual, 2470 East Road, the direct-penetrating radiation and ingestion doses are essentially zero, so the largest all-pathway dose for 2018 was the same as the air-pathway dose of 0.35 millirem.

The calculated offsite doses for the maximally exposed individual each year for recent years are shown in Figure 8-3. As described in previous annual site environmental reports, the

6.46-millirem dose in 2005 resulted from a leak at Technical Area 53, and the 3.53-millirem dose in 2011 was from the remediation of Material Disposal Area B. The general downward trend is the result of improved engineering controls and ongoing remediation.

The dose of 0.35 millirem in 2018 is far below the 10 millirem annual air-pathway limit (U.S. Environmental Protection Agency 1989) and the 100 millirem DOE limit (DOE 2011a). The dose for the maximally exposed individual is less than 0.1 percent of the average U.S. background radiation dose shown in Figure 8-1.

Conclusion

The doses to the public from Laboratory operations are summarized in Table 8-1. Doses are far below all regulations and standards.

TABLE 8-1. LANL RADIOLOGICAL DOSES FOR CALENDAR YEAR 2018

Pathway	Dose to Maximally Exposed Individual (millirems per year)	Percentage of DOE 100-millirem-per-year Limit	Estimated Population Dose (person-rem)	Number of people within 80 kilometers	Estimated Background Population Dose (person-rem)
Air	0.35	0.35%	0.09	n/a*	n/a
Water	<0.1	<0.1%	0	n/a	n/a
Other pathways (foodstuffs, soil, etc.)	<0.1	<0.1%	0	n/a	n/a
All pathways	0.35	0.35%	0.09	~343,000	~268,000†

**n/a = Not applicable. Background population dose is not calculated for individual exposure pathways*

†Based on 780 millirem per person as shown in Figure 8-1

NONRADIOLOGICAL MATERIALS

Introduction

This section summarizes the potential human health risk from non-radiological materials released from the Laboratory in 2018. Air emissions are reported in Chapters 2 and 4; groundwater is reported in Chapter 5; surface water and sediment are reported in Chapter 6; and soil, plants, and animals are reported in Chapter 7. The results are summarized below.

Results Summary

Air

The data reported in Chapters 2 and 4 show that the Los Alamos air quality is good and well below all applicable state and federal air quality standards. The Laboratory's emissions are below the amounts allowed in LANL's Title V Operating Permit. There are no measurable health effects to the public from Laboratory air emissions.

Groundwater

Groundwater data are reported in Chapter 5.

We analyzed samples from Los Alamos County water supply wells in 2018. No water supply wells showed detections of Laboratory-related constituents above an applicable drinking water standard, and the drinking water supply meets New Mexico Environment Department and U.S. Environmental Protection Agency drinking water standards (Los Alamos County 2019).

Additional water sampling was conducted in the City of Santa Fe's Buckman well field. No Laboratory-related constituents were present above state or federal drinking water quality standards in this drinking water supply.

Within Laboratory boundaries, hexavalent chromium from the Laboratory has been detected above the New Mexico groundwater standard (50 micrograms per liter) in the regional aquifer below Mortandad Canyon. As described in Chapter 5, the Laboratory has begun remediation to control migration of this chromium plume.

The Los Alamos County drinking water contains 5 micrograms of naturally occurring chromium per liter that is unrelated to the Laboratory (Los Alamos County 2019). More information on groundwater quality is available in Chapter 5.

Surface Water and Sediment

The concentrations of chemicals in surface water and sediment for 2018 are reported in Chapter 6. The sediment data verify the conceptual model that movement and addition of sediment from repeated flood events results in lower concentrations of Laboratory-related constituents in newer sediment deposits compared with previous deposits. The data also show that the human health risk assessments in the canyons investigation reports (see Chapter 6) represent an upper bound of potential risks. Human exposure scenarios were discussed in the investigation reports. The conclusions in the investigation reports, that there were no human health risks, remain accurate because the constituent concentrations decrease with time.

In Chapter 6, we compared unfiltered storm water concentrations with drinking water standards as screening levels; although, storm water is not a drinking water source and therefore is not a significant pathway to human exposure. The plant and animal measurements reported in Chapter 7 confirm that there is not significant uptake into the food chain.

Chapter 6 presents data for PCBs in the surface water of the Pajarito Plateau. The foodstuffs that may use this water are primarily terrestrial animals, such as deer and elk. The data reported in Chapter 7 show that the concentrations of PCBs in deer and elk are far below the human health screening values and are unlikely to cause adverse human-health effects.

The only aquatic animals eaten by people that may be influenced by surface water runoff from the Laboratory are in the Rio Grande. In the Rio Grande, PCB concentrations in aquatic animals are similar upstream and downstream of LANL influence (LANL 2017, ASER Chapter 7). There is no detectable contribution from the Laboratory to PCB concentrations in aquatic animals in the Rio Grande.

We conclude there is no risk to the public from exposure to surface water and sediment resulting from either current or legacy Laboratory releases.

Soil, Plants, and Animals

Soil and biota sampling results are reported in Chapter 7. The results are similar to previous years. At offsite locations in 2018, chemical concentrations above human-health–based screening criteria were not detected.

Conclusion

The environmental data collected in 2018 show that at present there is no measurable risk to the public from materials released from the Laboratory. In all cases, the public doses and risks from Los Alamos National Laboratory operations are much smaller than the regulatory limits and the naturally occurring background levels.

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GENERAL FORMATION OF A STANDARD OR SCREENING LEVEL

An environmental standard is a value, generally defined by a regulator such as the U.S. Environmental Protection Agency, that specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water. A screening level is a value, which may be calculated by a regulator or by another party, that when exceeded in a sample result, indicates the sampled location may warrant further investigation or site cleanup. Standards and screening levels are crafted to protect a target group from chemical exposure when considering a given exposure pathway or scenario for a specific time frame. A target group may refer to, for example, the general public, animals, or a sensitive population like children. Pathways of exposure include inhalation of air and ingestion of water, soil, animals, or plants. Length of exposure is important because prolonged exposure to low levels of a potentially hazardous chemical may have adverse health effects, as may a short exposure to high levels. Scenarios describe the activities of a target group at the site, which influence both the length and likelihood of exposures. Examples of exposure scenarios include residential (living on a site) and construction worker (disturbing soil during construction activities at a site).

Throughout this report, levels of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. For environmental samples that do not have standards or guidelines, levels are compared with screening levels.

RADIATION STANDARDS

The U.S. Department of Energy (DOE) limits the radiation dose that can be received by members of the public as a result of normal operations at Los Alamos National Laboratory (LANL, or the Laboratory).

DOE Order 458.1, Chg 3, "Radiation Protection of the Public and the Environment," describes the current radiation protection standards for the public, referred to as public dose limits; limits are listed in Table A-1. DOE's public dose limits apply to the effective dose that a member of the public can receive from DOE operations. For all exposure pathways combined, the total limit is 100 millirem per year (mrem/yr).

TABLE A-1
DOE DOSE LIMITS
FOR EXTERNAL AND INTERNAL EXPOSURES

Exposure Pathway	Dose Equivalent at Point of Maximum Probable Exposure
Exposure of Any Member of the Public	
All pathways	100 mrem/yr
Air pathway only*	10 mrem/yr
Drinking water	4 mrem/yr

** This level is from the U.S. Environmental Protection Agency's regulations issued under the Clean Air Act (Code of Federal Regulations Title 40, Part 61, Subpart H).*

Radionuclide activities in water are compared with DOE's derived concentration guides to evaluate potential impacts to members of the public. The derived concentration guides for water are those concentrations in water that if consumed at a rate of 730 liters per year, would give a dose of 100 mrem/yr.

Table A-2 shows the derived concentration guides. For comparison with drinking water systems, the derived concentration guides are multiplied by 0.04 to correspond with the U.S. Environmental Protection Agency limit of 4 millirem per year.

In addition to DOE standards, in 1985 and 1989, the U.S. Environmental Protection Agency established the "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," in Title 40, Part 61, Subpart H of the Code of Federal Regulations. This regulation states that emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose of 10 millirem per year. DOE has adopted this dose limit (Table A-1). In addition, the regulation requires monitoring of all release points that can produce a dose of 0.1 millirem to a member of the public.

TABLE A-2
DOE'S DERIVED CONCENTRATION GUIDES FOR WATER[a]

Nuclide	Derived Concentration Guides for Water Ingestion in Uncontrolled Areas (pCi/L[b])	Derived Concentration Guides for Drinking Water Systems[c] (pCi/L)
Hydrogen-3	2,000,000	80,000
Beium-7	1,000,000	40,000
Strontium-89	20,000	800
Strontium-90	1000	40
Cesium-137	3000	120
Uranium-234	500	20
Uranium-235	600	24
Uranium-238	600	24
Plutonium-238	40	1.6
Plutonium-239	30	1.2
Plutonium-240	30	1.2
Americium-241	30	1.2

[a] Derived concentration guides for uncontrolled areas are based on DOE's public dose limit for the general public. Derived concentration guides apply to concentrations in excess of those occurring naturally or from worldwide fallout.
[b] pCi/L = Picocuries per liter.
[c] Drinking water derived concentration guides are 4% of the derived concentration guides for nondrinking water.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The types of monitoring required under the National Pollutant Discharge Elimination System and the limits established for sanitary and industrial outfalls can be found at http://water.epa.gov/polwaste/npdes/.

DRINKING WATER STANDARDS

For chemical constituents in drinking water, regulations and standards are issued by the U.S. Environmental Protection Agency and adopted by the New Mexico Environment Department as part of the New Mexico Drinking Water Regulations. To view the

New Mexico Drinking Water Regulations, go to https://www.env.nm.gov/drinking_water/laws-and-regs/.

Radioactivity in drinking water is regulated by U.S. Environmental Protection Agency regulations contained in Title 40, Part 141 of the Code of Federal Regulations and by the New Mexico Drinking Water Regulations, Sections 206 and 207. These regulations stipulate that combined radium-226 and radium-228 activity in drinking water may not exceed 5 picocuries per liter. Gross-alpha activity (including radium-226 but excluding radon and uranium) may not exceed 15 picocuries per liter. We use a screening level of 5 picocuries per liter for gross alpha to determine when further analysis for the radium isotopes is needed.

For man-made beta- and photon-emitting radionuclides, U.S. Environmental Protection Agency drinking water standards are limited to activities that would result in doses not exceeding 4 millirem per year. In addition, DOE Order 458.1 requires that persons consuming water from DOE-operated public water supplies do not receive a dose greater than 4 millirem per year. Derived concentration guides for drinking water systems based on this requirement are in Table A-2.

SURFACE WATER STANDARDS

Activities of radionuclides in surface water samples may be compared with either the DOE derived concentration guides (Table A-2) or the New Mexico Water Quality Control Commission stream standards, which reference the state's radiation protection regulations. The concentrations of nonradioactive constituents may be compared with the New Mexico Water Quality Control Commission stream standards, available at https://www.env.nm.gov/surface-water-quality/wqs/. The New Mexico Water Quality Control Commission groundwater standards can also be applied in cases where discharges may affect groundwater.

SOILS AND SEDIMENTS

If chemical or radionuclide levels in soil exceed regional statistical reference levels (regional background levels), the levels are compared with screening levels. The human health screening level for soil from publically accessible locations is the level that would produce (1) a dose of 15 millirem or greater to an individual for radionuclides, (2) an estimated excess cancer risk of 1 x 10-5 for cancer-causing chemicals, or (3) a hazard quotient greater than 1 for hazardous chemicals that do not cause cancer. The screening levels are different for different exposure scenarios. Screening levels for radionuclides are found in a Laboratory document (LANL 2015a); screening levels for nonradionuclides are found in a New Mexico Environment Department document (NMED 2015).

FOODSTUFFS

Federal standards exist for radionuclides and selected nonradionuclides (e.g., mercury and polychlorinated biphenyls [PCBs]) in foodstuffs. The Laboratory has established screening levels for radionuclides. If levels in foodstuffs exceed regional statistical reference levels, they are compared with screening levels and existing standards. The Laboratory has established a screening level of 1 millirem per year for activities of individual radionuclides in individual foodstuffs (e.g., fish, crops, etc.), assuming a residential scenario. The U.S. Environmental Protection Agency has established screening levels for mercury (EPA 2001) and PCBs (EPA 2007) in fish.

BIOTA

If radionuclide or chemical levels in biota exceed regional statistical reference levels, the levels are compared with screening levels. For radionuclides in biota, screening levels were set at 10% of the DOE standard (which is 1 rad per day for terrestrial plants and aquatic biota and 0.1 rad per day for terrestrial animals) by the Laboratory (DOE 2002). For chemicals, if a chemical in biota tissue exceeds the regional statistical reference level, (1) detected concentrations are compared with lowest observed adverse effect levels reported in published literature, if there is one available, and (2) chemical concentrations in the soil at the place of collection are compared with ecological screening levels (LANL 2015b).

REFERENCES

DOE 2002: “A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota,” U.S. Department of Energy Standard DOE-STD-1153-2002 (July 2002).

EPA 2001: “Water Quality Criterion for the Protection of Human Health: Methylmercury,” U.S. Environmental Protection Agency, Office of Science and Technology, EPA-823-R-01-001 (2001).

EPA 2007: “Section 4, Risk-Based Consumption Limit Tables” in *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2: Risk Assessment and Fish Consumption Limits,* Third Edition, U.S. Environmental Protection Agency, available at https://www.epa.gov/sites/production/files/2015-06/documents/volume2.pdf (2007).

LANL 2015a: “Derivation and Use of Radionuclide Screening Action Levels, Revision 4,” Los Alamos National Laboratory document LA-UR-15-24859 (September 2015).

LANL 2015b: “ECORISK Database,” Release 3.3, on CD, Los Alamos National Laboratory document LA-UR-15-27397 (October 2015).

NMED 2015: “Risk Assessment Guidance for Site Investigations and Remediation,” New Mexico Environment Department report (July 2015).

Throughout the Annual Site Environmental Report, the U.S. customary (English) system of measurement has generally been used. For units of radiation activity, exposure, and dose, U.S. customary units (that is, curie, roentgen, rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent units from the International System of Units are the becquerel, coulomb per kilogram, gray, and sievert, respectively. Table B-1 presents factors for converting U.S. customary units into units from the International System of Units.

TABLE B-1
APPROXIMATE CONVERSION FACTORS FOR SELECTED U.S. CUSTOMARY UNITS

Multiply U.S. Customary Unit	by	to Obtain International System of Units (Metric) Unit
degrees Fahrenheit	5/9 (first subtract 32)	degrees Celsius
inches	2.54	centimeters
cubic feet	0.028	cubic meters
acres	0.4047	hectares
ounces	28.3	grams
pounds	0.453	kilograms
miles	1.61	kilometers
gallons	3.785	liters
feet	0.305	meters
parts per million	1	micrograms per gram
parts per million	1	milligrams per liter
square miles	2.59	square kilometers
picocuries	37	millibecquerel
rad	0.01	gray
millirem	0.01	millisievert

Table B-2 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0 × 103, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the right of its present location. The number would then read 2000. If the value given is 2.0 × 10-5, the decimal point should be moved five numbers to the left of its present location. The result would be 0.00002.

TABLE B-2
PREFIXES USED WITH INTERNATIONAL SYSTEM OF UNITS (METRIC) UNITS

Prefix	Factor	Symbol
mega	1,000,000 or 106	M
kilo	1000 or 103	k
centi	0.01 or 10-2	c
milli	0.001 or 10-3	m
micro	0.000001 or 10-6	µ
nano	0.000000001 or 10-9	n
pico	0.000000000001 or 10-12	p
femto	0.000000000000001 or 10-15	f
atto	0.000000000000000001 or 10-18	a

DATA HANDLING OF RADIOCHEMICAL SAMPLES

Measurements of radioactivity in samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique, and results for individual measurements can be negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the ambient air monitoring network station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{½}$$

where

c_i = sample i,
$\bar{c}$ = mean of samples from a given station or group, and
N = number of samples in the station or group.

This value is reported as one standard deviation for the station and group means.

REFERENCE

Gilbert 1975: Gilbert, R.O., "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Battelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

APPENDIX C – DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas operated by Los Alamos National Laboratory (the Laboratory) in Los Alamos County are shown in Figure 1-3 in Chapter 1. The main programs conducted at each of the areas are listed in this appendix.

Technical Area	Activities
00 (off-site facilities)	The Technical Area 00 designation is assigned to structures leased by the U.S. Department of Energy that are located outside the Laboratory's boundaries in the Los Alamos townsite and White Rock.
02 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-megawatt nuclear research reactor, was located at Technical Area 02. The reactor was decontaminated and decommissioned in 2002. It is now the location of the Omega West Monument and interpretive panels. The monument commemorates the historic reactors and other historical events that took place at Technical Area 02.
03 (Core Area or South Mesa Site)	Technical Area 03 is the Laboratory's core scientific and administrative area, with approximately half of the Laboratory's employees and total floor space. It is the location of a number of the Laboratory's key facilities, including the Chemistry and Metallurgy Research Building, the Sigma Complex, the Machine Shops, the Material Sciences Laboratory, and the Nicholas C. Metropolis Center for Modeling and Simulation.
05 (Beta Site)	Technical Area 05 is located between East Jemez Road and the Pueblo de San Ildefonso, it contains physical support facilities and an electrical substation. It is also the site of the Laboratory's interim measure to control chromium plume migration in the regional aquifer.
06 (Twomile Mesa Site)	Technical Area 06, located in the northwestern part of the Laboratory, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, and buildings that are awaiting demolition.
08 (GT Site [Anchor Site West])	Technical Area 08, located along West Jemez Road, is a testing site where nondestructive dynamic testing techniques are used to ensure the quality of materials in items ranging from test weapons components to high-pressure dies and molds. Techniques used include radiography, radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
09 (Anchor Site East)	Technical Area 09 is located on the western edge of the Laboratory. Fabrication feasibility and the physical properties of explosives are explored at this technical area, and new organic compounds are investigated for possible use as explosives.
11 (K-Site)	Technical Area 11 is used for testing explosives components and systems, including vibration analysis and drop-testing materials and components under a variety of extreme physical environments. Facilities are arranged so that testing may be controlled and observed remotely, allowing devices that contain explosives, radioactive materials, and nonhazardous materials to be safely tested and observed.
14 (Q-Site)	Technical Area 14, located in the northwestern part of the Laboratory, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high-explosives machining, and permitted burning.

Technical Area	Activities
15 (R-Site)	Technical Area 15, located in the central portion of the Laboratory, is used for high-explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. Technical Area 15 is the location of two firing sites; the Dual-Axis Radiographic Hydrodynamic Test Facility, which has an intense high-resolution, dual-machine radiographic capability; and building 306, a multipurpose facility where primary diagnostics are performed.
16 (S-Site)	Technical Area 16, in the western part of the Laboratory, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. Technical Area 16 is also the location of high-explosives research, development, and testing; the High Explosives Wastewater Treatment Facility; the Tactical Training Facility; and the Indoor Firing Range.
18 (Pajarito Site)	Technical Area 18, located in Pajarito Canyon, was the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. All operations at Technical Area 18 have ceased, and the facility was downgraded to a less-than-Hazard Category 3 nuclear facility. All Security Category I and II materials and activities have been relocated to the Nevada National Security Site.
21 (DP Site)	Technical Area 21 is on the northern border of the Laboratory, next to the Los Alamos townsite. The former radioactive materials (including plutonium) processing facility was located in the western part of Technical Area 21. The Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility were located in the eastern part. Operations from these facilities have been transferred and demolition was completed in 2010.
22 (TD Site)	Technical Area 22, located in the northwestern portion of the Laboratory, houses the Detonator Production Facility. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
28 (Magazine Area A)	Technical Area 28, located near the southern edge of the Laboratory, was an explosives storage area. Technical Area 28 contains five empty storage magazines that are being decontaminated and decommissioned.
33 (HP Site)	Technical Area 33 is a remotely located technical area at the southeastern boundary of the Laboratory. Technical Area 33 is used for experiments that require isolation but do not require daily oversight. The National Radioastronomy Observatory's Very Long Baseline Array telescope is located at this technical area.
35 (Ten Site)	Technical Area 35, located in the north-central portion of the Laboratory, is used for nuclear safeguards research and development, primarily in the areas of lasers, physics, fusion, materials development, and biochemistry and physical chemistry research and development. The Target Fabrication Facility, located at Technical Area 35, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at Technical Area 35 include research in reactor safety, optical science, and pulsed-power systems, as well as metallurgy, ceramic technology, and chemical plating. Additionally, there are some Biosafety Level 1 and 2 laboratories at Technical Area 35.

Technical Area	Activities
36 (Kappa Site)	Technical Area 36, a remotely located area in the eastern portion of the Laboratory, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
37 (Magazine Area C)	Technical Area 37 is used as an explosives storage area. It is located along the eastern perimeter of Technical Area 16.
39 (Ancho Canyon Site)	Technical Area 39 is located at the bottom of Ancho Canyon. Technical Area 39 is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
40 (DF Site)	Technical Area 40, centrally located within the Laboratory, is used for general testing of explosives or other materials and development of special detonators for initiating high-explosives systems.
41 (W-Site)	Technical Area 41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.
43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	Technical Area 43 is adjacent to the Los Alamos Medical Center at the northern border of the Laboratory and is the location of the Bioscience Facilities (formerly called the Health Research Laboratory). The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at the Laboratory. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.
46 (WA Site)	Technical Area 46, located between Pajarito Road and the Pueblo de San Ildefonso, is one of the Laboratory's basic research sites. Activities have focused on applied photochemistry operations and have included development of technologies for laser isotope separation and laser enhancement of chemical processes. The Sanitary Wastewater Systems Plant is also located within this technical area.
48 (Radiochemistry Site)	Technical Area 48, located in the north-central portion of the Laboratory, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
49 (Frijoles Mesa Site)	Technical Area 49, located near Bandelier National Monument, is used as a training area and for outdoor tests on materials and equipment components that involve generating and receiving short bursts of high-energy, broad-spectrum microwaves. The Interagency Wildfire Center and helipad located near the entrance to the technical area are operated by the National Park Service.
50 (Waste Management Site)	Technical Area 50, located near the center of the Laboratory, is the location of waste management facilities, including the Radioactive Liquid Waste Treatment Facility and the Waste Characterization, Reduction, and Repackaging Facility. The Actinide Research and Technology Instruction Center is also located in this technical area.
51 (Environmental Research Site)	Technical Area 51, located on Pajarito Road in the eastern portion of the Laboratory, is used for research and experimental studies on the long-term impacts of radioactive materials on the environment. Various types of waste storage and coverings are studied at this technical area.

Technical Area	Activities
52 (Reactor Development Site)	Technical Area 52 is located in the north-central portion of the Laboratory. A wide variety of theoretical and computational research and development activities related to nuclear reactor performance and safety, as well as to several environmental, safety, and health activities, are carried out at this technical area.
53 (Los Alamos Neutron Science Center)	Technical Area 53, located in the northern portion of the Laboratory, includes the Los Alamos Neutron Science Center. This facility houses one of the largest research linear accelerators in the world and supports both basic and applied research programs. Basic research includes studies of subatomic and particle physics, atomic physics, neutrinos, and the chemistry of subatomic interactions. Applied research includes materials science studies that use neutron spallation and contribute to defense programs. The facility also irradiates targets for medical isotope production.
54 (Waste Disposal Site)	Technical Area 54, located on the eastern border of the Laboratory, is one of the largest technical areas at the Laboratory. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage.
55 (Plutonium Facility Complex Site)	Technical Area 55, located in the center of the Laboratory along Pajarito Road, is the location of the Plutonium Facility Complex. The Plutonium Facility provides chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms. Radiological operations in the Radiological Laboratory/Utility/Office Building began in 2014.
57 (Fenton Hill Site)	Technical Area 57 is located about 20 miles (32 kilometers) west of the Laboratory on land administered by the U.S. Forest Service. The site has been used by the Laboratory since 1974, subject to an interagency agreement between the U.S. Department of Energy and the U.S. Forest Service. The site was originally developed for the Hot Dry Rock geothermal energy program, which was terminated in 1995, and subsequently used for astronomical studies. In 2012, the Laboratory demolished and removed several small structures, trailers, equipment pads, and equipment and implemented site stabilization. Some astronomy activities may continue.
58 (Twomile North Site)	Technical Area 58, located near the Laboratory's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to Technical Area 03. The technical area houses the protective force running track, a few Laboratory-owned storage trailers, and a temporary storage area.
59 (Occupational Health Site)	Technical Area 59 is located on the south side of Pajarito Road adjacent to Technical Area 03. Technical Area 59 is the location of staff who provide support services in health physics, risk management, industrial hygiene and safety, policy and program analysis, air quality, water quality and hydrology, hazardous and solid waste analysis, and radiation protection. The medical facility at Technical Area 59 includes a clinical laboratory and provides bioassay sample analytical support.
60 (Sigma Mesa)	Technical Area 60 is located southeast of Technical Area 03. The technical area is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located at Technical Area 60. This facility is now being used as an unmanned aerial systems user facility.

Technical Area	Activities
61 (East Jemez Site)	Technical Area 61, located in the northern portion of the Laboratory, contains physical support and infrastructure facilities, including a sanitary waste transfer station operated by Los Alamos County, a photovoltaic array, and sewer pump stations. This is the former site of the Los Alamos County landfill, which is now closed and capped.
62 (Northwest Site)	Technical Area 62, located next to Technical Area 03 and West Jemez Road in the northwest corner of the Laboratory, serves as a forested buffer zone. This technical area is reserved for future use.
63 (Pajarito Service Area)	Technical Area 63, located in the north-central portion of the Laboratory, contains physical support and infrastructure facilities and is the location of the new Transuranic Waste Facility.
64 (Central Guard Site)	Technical Area 64 is located in the north-central portion of the Laboratory and provides offices and storage space.
66 (Central Technical Support Site)	Technical Area 66 is located on the southeast side of Pajarito Road in the center of the Laboratory. The Advanced Technology Assessment Center, the only facility at this technical area, provides office and technical space for technology transfer and other industrial partnership activities.
67 (Pajarito Mesa Site)	Technical Area 67 is a forested buffer zone located in the north-central portion of the Laboratory. No operations or facilities are currently located at the technical area.
68 (Water Canyon Site)	Technical Area 68, located in the southern portion of the Laboratory, is a testing area for dynamic experiments and also contains environmental study areas.
69 (Anchor North Site)	Technical Area 69, located in the northwestern corner of the Laboratory, serves as a forested buffer zone. The Emergency Operations Center is located here.
70 (Rio Grande Site)	Technical Area 70 is located on the southeastern boundary of the Laboratory. It is an undeveloped technical area that serves as a buffer zone.
71 (Southeast Site)	Technical Area 71 is located on the southeastern boundary of the Laboratory and is adjacent to White Rock to the northeast. It is an undeveloped technical area that serves as a buffer zone for the High Explosives Test Area.
72 (East Entry Site)	Technical Area 72, located along East Jemez Road on the northeastern boundary of the Laboratory, is used by protective force personnel for required firearms training and practice purposes.
73 (Airport Site)	Technical Area 73 is located along the northern boundary of the Laboratory, adjacent to NM 502. Los Alamos County manages, operates, and maintains the community airport under a leasing arrangement with the U.S. Department of Energy. Use of the airport by private individuals is permitted with special restrictions.
74 (Otowi Tract)	Technical Area 74 is a forested area in the northeastern corner of the Laboratory. A large portion of this technical area has been conveyed to Los Alamos County or transferred to the Department of the Interior in trust for the Pueblo de San Ildefonso and is no longer part of the Laboratory.

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For more information on environmental topics at Los Alamos National Laboratory (the Laboratory), access the following websites:

Current and past environmental reports and supplemental data tables	http://www.lanl.gov/environment/environmental-report.php
The Laboratory's website	http://www.lanl.gov/
U.S. Department of Energy/National Nuclear Security Administration Los Alamos Field Office	https://www.energy.gov/nnsa/locations
U.S. Department of Energy Environmental Management Los Alamos Field Office website	https://energy.gov/em-la/environmental-management-los-alamos-field-office
U.S. Department of Energy website	http://www.energy.gov/
The Laboratory's air quality pages	http://www.lanl.gov/environment/protection/monitoring/air-quality.php
The Laboratory's water quality pages	http://www.lanl.gov/environment/protection/monitoring/water-quality.php
The Laboratory's environmental stewardship pages	http://www.lanl.gov/environment/index.php
The Laboratory's environmental database	https://www.intellusnm.com/

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The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

Associate Directorate for Environment, Safety, and Health
Environmental Protection and Compliance Division
Environmental Stewardship Group, Environmental Compliance Programs Group, Waste Management Programs Group, and Waste Management Services Group
N3B Los Alamos – Environmental Remediation Program

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