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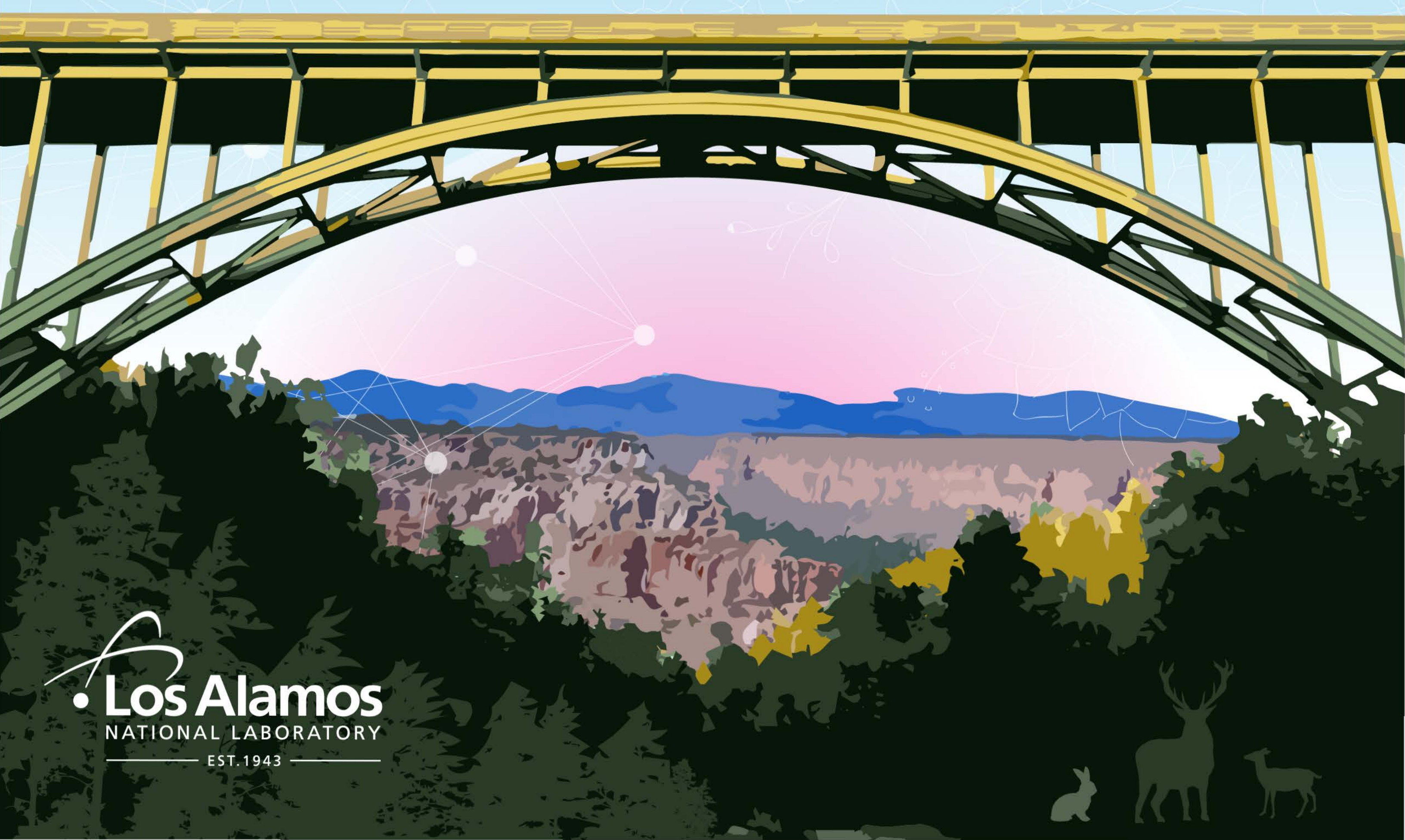

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- We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements.

- 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 2017
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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 2017 *Annual Site Environmental Report Summary* are available at http://www.lanl.gov/environment/environmental-report.php.

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Sandia Canyon at the Laboratory

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

- 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.

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.

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.

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).

2017 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).
- Thirteen different environmental inspections or audits were conducted by external regulators (Table 2-14 in Chapter 2).
- The Laboratory's Environmental Management System was certified under the International Organization for Standardization's new 14001:2015 Environmental Management System standard. We have maintained independent, third-party certification under the International Organization for Standardization's 14001 standard since April 2006.
- Treatment of all remediated nitrate salt waste drums at the Laboratory was completed in November 2017.
- The Laboratory was fully in compliance with its Clean Air Act, Title V Operating Permit emission limits.
- We discharged approximately 105 million gallons of liquid effluents from permitted outfalls. None of the 919 samples collected exceeded the effluent quality limits in the outfall permit.
- The New Mexico Environment Department granted certificates of completion for 62 remedial sites in fiscal year 2017. Of these, 55 sites were certified complete without controls, meaning no additional corrective actions or conditions are necessary. Certificates for the remaining seven sites were for corrective actions complete with controls.
- Two environmental occurrences were reported under DOE Order 232.2, Occurrence Reporting and Processing of Operations Information (Table 2-9 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.

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

2017 Environmental Monitoring

During 2017, we found the following:

- Two Mexican spotted owl nesting locations were observed on Laboratory property, and at least one owlet fledged.
- Consistent with prior years' data, no springs that discharge groundwater from beneath the Laboratory into White Rock Canyon or the Rio Grande had any constituent concentrations above 2016 Consent Order screening levels in 2017.
- 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.
- 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.
- An evaluation of fish chemical and radionuclide levels, benthic macroinvertebrate communities, sediment chemical and radionuclide levels, and sediment toxicity tests found that with few exceptions there were no significant differences in the Rio Grande above and below the northernmost drainage that discharges runoff from the Laboratory into the river. These results indicate that chemicals and radionuclides resulting from Laboratory operations that may be present in storm water and snow melt flows have not had an adverse effect on the Rio Grande aquatic ecosystem during 2008–2017.
- A great-horned owl that was collected at Area G had 14,800 picocuries per milliliter of tritium. The internal tritium dose to the great horned owl from this measured tissue concentration was 0.0043 rad per day. The dose was well below the DOE limit of 0.1 rad per day for animals.
- The 2017 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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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.

BACKGROUND AND PURPOSE

Background

In March 1943, a small group of scientists came to Los Alamos 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 3000 civilian and military personnel were working at Los Alamos Laboratory.

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

The 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 Los Alamos National Laboratory (LANL, or the Laboratory) in 1981. Federal staff with the National Nuclear Security Administration, a semiautonomous agency within DOE, have 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, a new organization, Los Alamos National Security, LLC, was contracted to operate the Laboratory. In 2014, DOE decided to separate cleanup of legacy wastes at the Laboratory from the management and operating contract. Legacy wastes are wastes that were generated at the Laboratory prior to 1999. The legacy waste cleanup work was transitioned to a bridge contract under DOE's Office of Environmental Management in October 2015, and a new contractor (Newport News Nuclear BWXT-Los Alamos [N3B]) took over the legacy waste cleanup in April 2018. A new management and operating contract for the Laboratory has been awarded by DOE, and Triad National Security, LLC will begin 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.

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 that 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 storm-water 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

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located 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 currently encompasses about 36 square miles and is situated on the Pajarito Plateau, a series of fingerlike mesas and canyons at the eastern edge of the

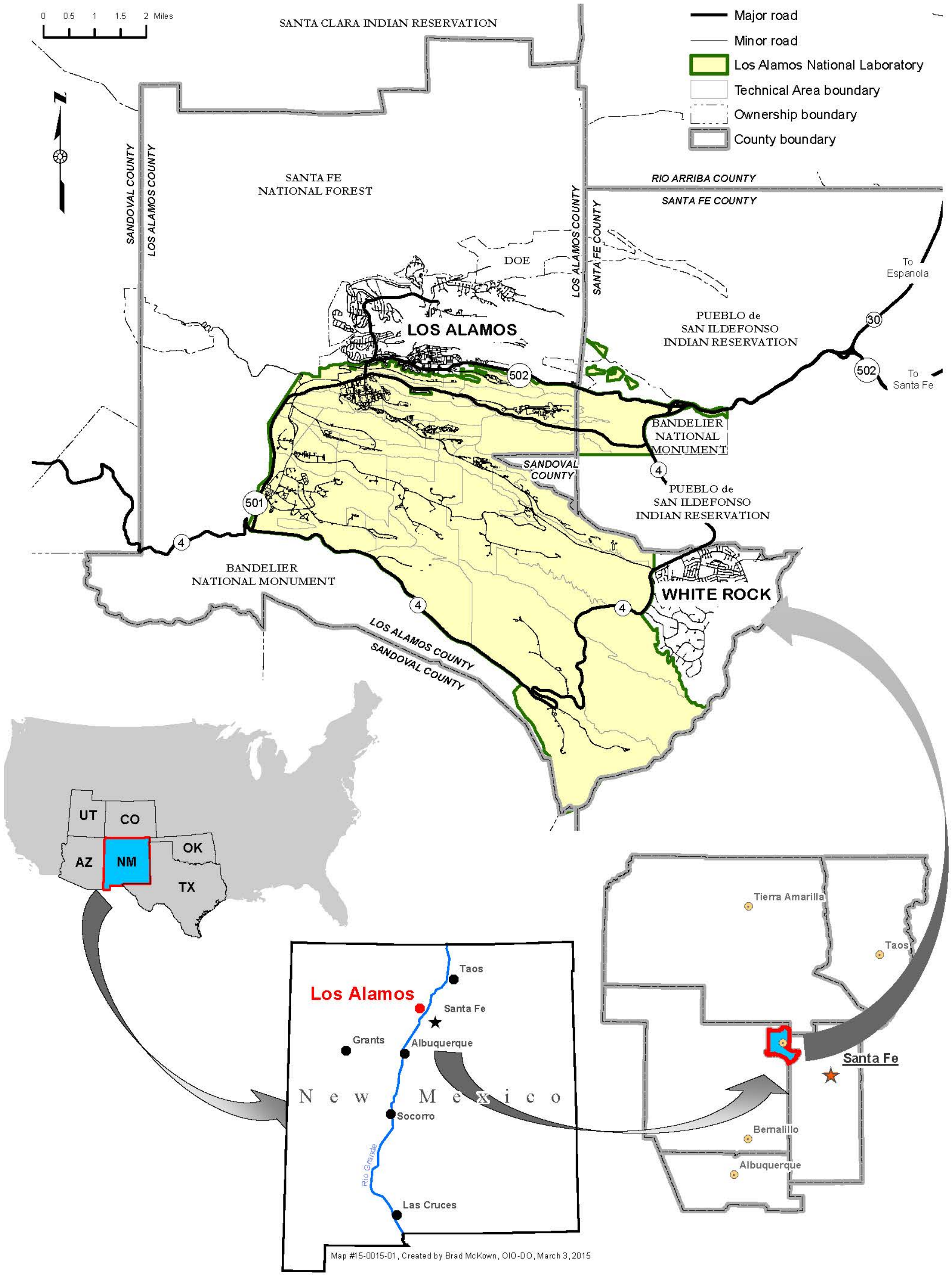


Figure 1-1 Regional location of the Laboratory

Jemez Mountains, bordered on the east by White Rock Canyon and the Rio Grande. Mesa tops range in elevation from approximately 7800 feet on the flanks of the Jemez Mountains to about 6200 feet at the edge of White Rock Canyon. Most Laboratory and community developments are confined to the mesa tops.

In 2016, the most recent year reported, the Laboratory employed 10,051 people and an additional 679 subcontractor workers (LANL 2018). The LANL-affiliated work force resides predominantly in Los Alamos, Santa Fe, and Rio Arriba counties and includes regular workers, temporary workers, and students.

New Mexico's estimated 2016 population was 2,082,669 (Census 2018a) and the estimated population within a 50-mile radius of LANL's zip code is approximately 348,863 residents (Census 2018b), of which approximately 29,625 are of Native American descent (Census 2018c). The population within a 50-mile (80-km) radius of the Laboratory (Figure 1-2) is used to calculate the radiation dose from Laboratory operations (LANL 2012).

The land surrounding the Laboratory is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the 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 Pueblo de San Ildefonso borders the Laboratory to the east. Santa Clara Pueblo is north of the Laboratory but does not share a border (Figure 1-1).

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 hazard associated with these faults (Gardner 1990, Larmat and Lee 2017).

The Jemez Mountains are the remnant of a large collapsed volcanic field. The high levels of volcanic activity in the 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 1000 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 3300 feet thick. The Santa Fe Group sediments are also important for groundwater storage.

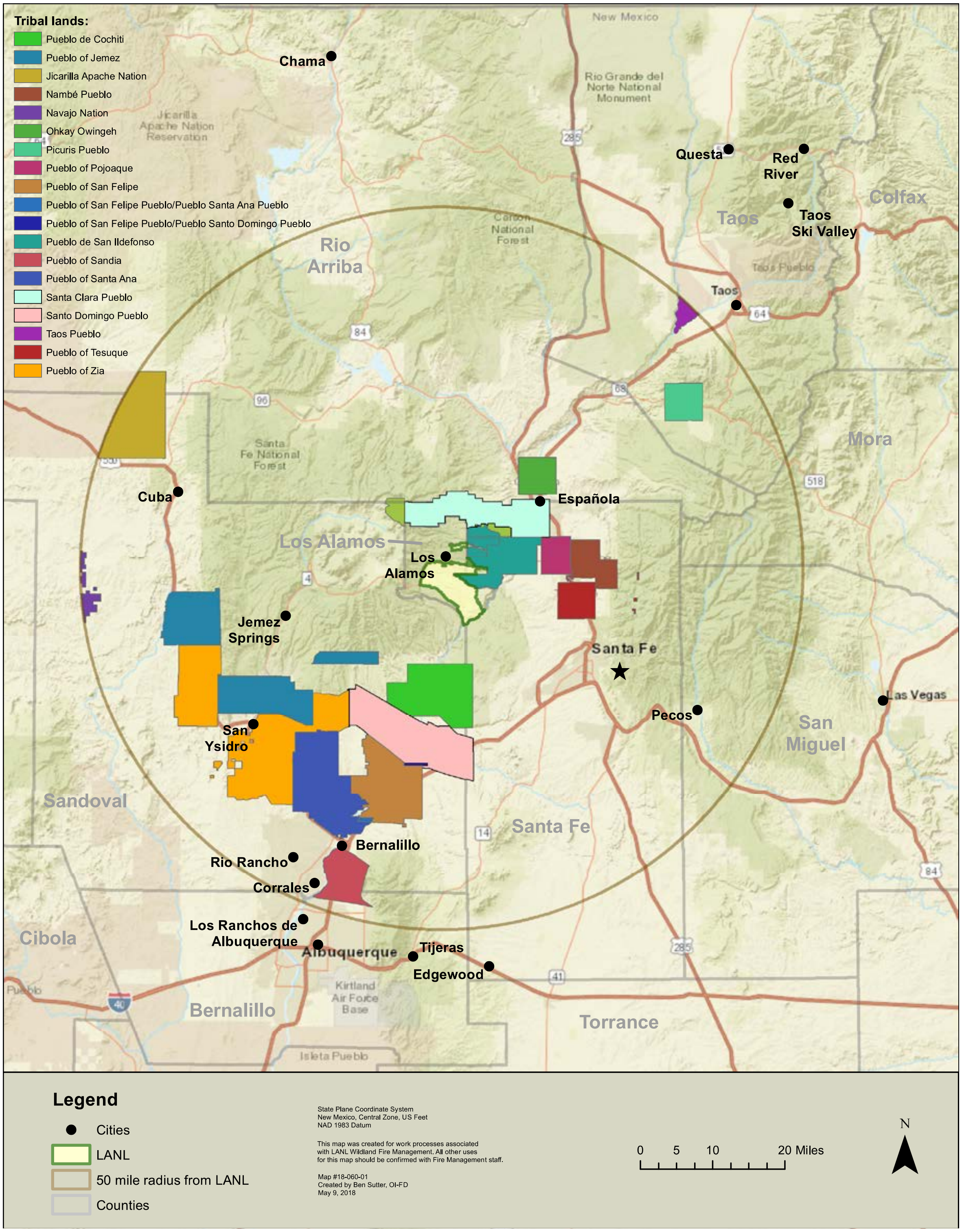


Figure 1-2 Municipalities and tribal properties within a 50-mile radius of the Laboratory

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 1000-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 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, which is associated with individual storms and lasting only a few hours to days, or intermittent flow, which is associated with events like snow melt and lasts only a few days to weeks. Springs on the edge of the Jemez Mountains that flow year-round do supply continuous water into 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 vegetative cover types in the 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 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. 2012).

Two major wildfires have also affected the Laboratory: the Cerro Grande fire in May 2000 and the Las Conchas fire in June and July 2011. Both fires resulted in loss of forest trees on the slopes of the Jemez Mountains west of the Laboratory.

Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 90 percent of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural sites, and more than 1800 sites have been recorded. Nearly 73 percent of the sites were constructed and used by Ancestral Puebloan people during the thirteenth, fourteenth, and fifteenth centuries.

Buildings and structures associated with the Manhattan Project and early Cold War period at the Laboratory (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places. More than 300 such buildings have been evaluated for inclusion in this listing, and 158 have been declared eligible. Facilities considered to have national historic significance dating from 1963 to the end of the Cold War in 1990 are also being evaluated. The Manhattan Project National Historical Park, managed by the National Park Service, was created in 2014. This historical park includes 17 Laboratory structures.

LABORATORY ACTIVITIES AND FACILITIES

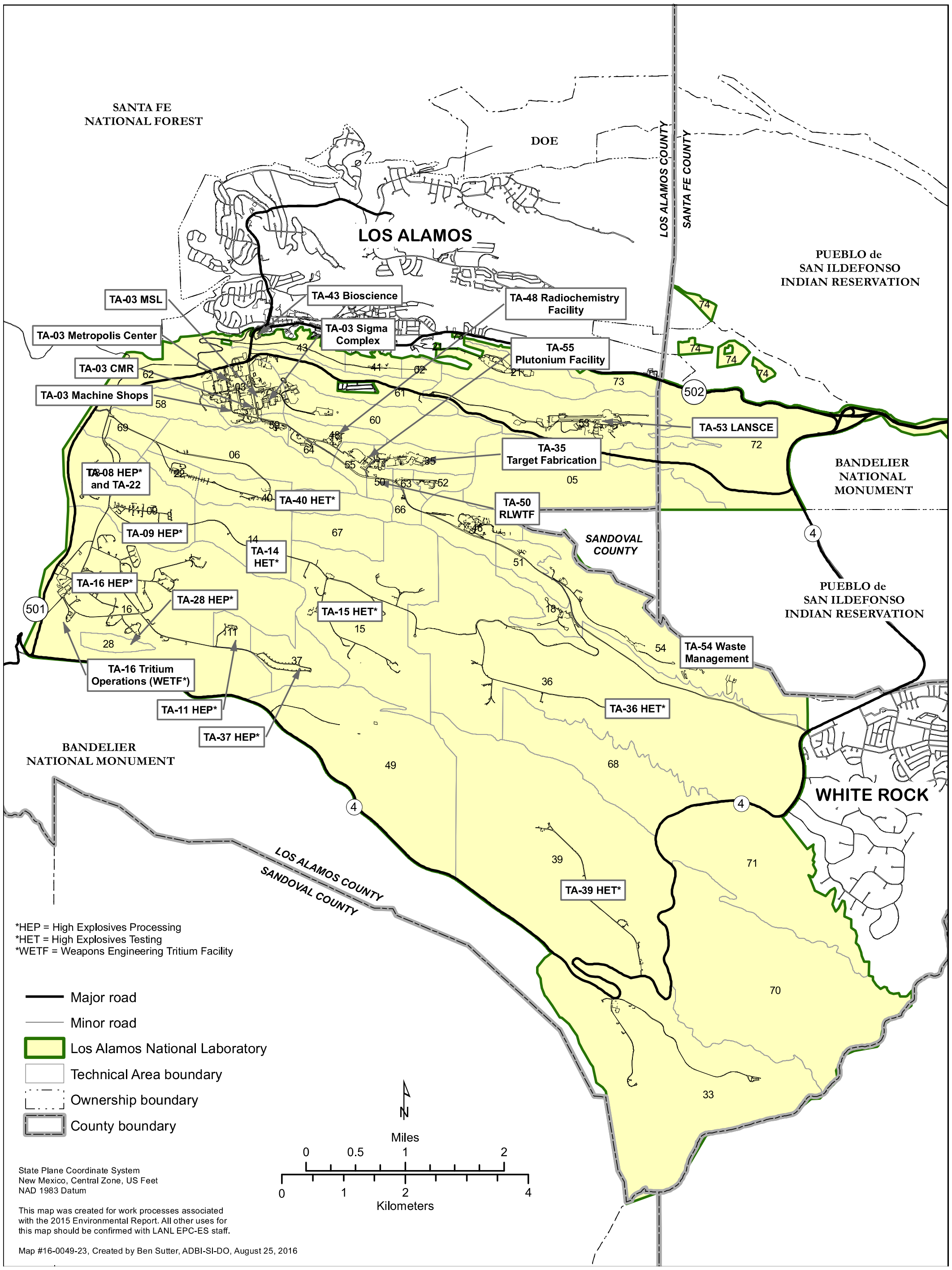
The current mission of the Laboratory is, "To solve national security challenges through scientific excellence." The current goals of the Laboratory are to deliver national nuclear security and broader global security mission solutions and to foster excellence in science and engineering disciplines essential for national security missions by attracting, inspiring, and developing world-class talent to ensure a vital future workplace and by enabling 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 is organized into technical areas, which are defined areas that may contain building sites, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-3 and Appendix C, Descriptions of Technical Areas and their Associated Programs). However, these uses account for less than half of the total land area; many portions of Laboratory land act as buffer areas for security and safety. The Laboratory has about 976 structures, with approximately 8.2 million square feet under roof (LANL 2018). The current area of the Laboratory is about 36 square miles.

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, 15 Laboratory facilities were identified as "Key Facilities" to evaluate the potential environmental impacts of Laboratory operations (Table 1-1). Activities in the Key Facilities represent the majority of environmental impacts associated with Laboratory operations.

In the 2008 Site-Wide Environmental Impact Statement, the remaining Laboratory facilities were identified as "Non-Key Facilities." The Non-Key Facilities can be found in 30 of the Laboratory's 49 technical areas (LANL 2010). 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.



See Table 1-1 for acronym definitions.

Figure 1-3 Technical areas and Key Facilities of the Laboratory in relation to surrounding landholdings

Table 1-1
Key Facilities

Facility	Technical Area(s)
Plutonium 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)	08, 09, 11, 16, 22, 37
High-explosives testing (HET)	14, 15, 36, 39, 40
Los Alamos Neutron Science Center (LANSCE)	53
Biosciences Facilities (formerly Health Research Laboratory)	43, 03, 16, 35, 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: Information from 2008 site-wide environmental impact statement.

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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.

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

(1) regulating the handling, transportation, and disposal of materials and wastes;

(2) regulating impacts to biological and cultural resources and air, soil, and water; and

(3) requiring analysis of the environmental impacts of new operations.

Based on these laws and U.S. Department of Energy (DOE) orders, Los Alamos National Laboratory (LANL or the Laboratory) operations comply with many federal and state regulations, permits, policies, and standards. The U.S. Environmental Protection Agency or the New Mexico Environment Department administers most of the laws. DOE orders describe requirements for environmental protection and control of radionuclides for DOE facilities.

This chapter provides a summary of our compliance with state and federal environmental regulations and permits and DOE environmental orders during 2017.

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 requires DOE facilities to protect the public and the environment from undue risk from radiological activities. 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. DOE facilities are directed 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. Laboratory real estate that is transferred to other owners (for example, the land transfer tracts), and moveable items that are released from the Laboratory (for example, surplus equipment sold to the public, or waste sent for offsite disposal) 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 of any radiation doses resulting from LANL operations and of the release of property (either real estate or moveable items) that has potential to contain residual radioactivity.

Estimated Maximum Possible Radiological Dose to the Public

During 2017, the estimated maximum radiological dose to a member of the public from Laboratory operations was less than 1 millirem (see Chapter 8, Public Dose and Risk Assessment). Radiation doses to wildlife and plants were also below DOE limits. Details of the Laboratory's 2017 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

Land transfer tracts A-16-a (containing the former site of Material Disposal Area B, located on DP Mesa), A-5-2, and A-5-3 were transferred to Los Alamos County at the end of 2017 (LANL 2014 a, b; LANL 2017a). The Laboratory released approximately 50,000 pounds of metal in 2017 for recycling from the Los Alamos Neutron Science Center accelerator (Whicker and McNaughton 2018). Radiological surveys of the metal indicated that it did not contain levels of radioactivity beyond that which is naturally occurring. Laboratory staff also survey and release smaller personal property items (e.g., tools, furniture, and personal protective equipment) each year from radiologically controlled areas, as described in radiation protection policies and procedures.

Screening action levels for radionuclides in soils are evaluated periodically to determine if an update is needed. In 2016, screening action levels were updated because of an update to the dose assessment computer code RESRAD (Yu et al. 2001) and to use "reference person" dosimetry (LANL 2016), which is consistent with DOE technical guidance. The changes generally increased the screening action levels. The Laboratory requested that DOE evaluate the updated levels for use as authorized limits for land conveyance and transfer in 2016. These updated levels were approved as authorized limits for real estate releases in early 2017, and were used in the transfer of Tract A-16-a (LANL 2017a).

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. Currently, only low-level waste is disposed of at Area G. Mixed low-level waste and mixed transuranic waste are 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. During 2017, we disposed of a total of 492 kilograms of 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 a direct radiation thermoluminescent dosimeter monitoring network (Chapter 4); an environmental air station monitoring network (Chapter 4); a groundwater monitoring network (Chapter 5); and periodic soil, vegetation, and small mammal sampling (Chapter 7). Table 2-1 provides the 2017 status of the DOE low-level waste disposal facility management process for Area G.

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 Waste – Mixed waste includes a radioactive waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.

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 2017 was published in May 2018 (LANL 2018).
Closure Plan	Plan issued in 2009 (LANL 2009b).
Performance Assessment/Composite Analysis Maintenance Program	Plan issued in 2011 (LANL 2011). Two special analyses were completed during fiscal year 2017 (LANL 2018).
Disposal Authorization Statement	Revision 1 issued March 17, 2010 (DOE 2010)

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 EnergySolutions, located in Clive, Utah and the Waste Control Specialists site in Andrews, Texas. During 2017, we sent 5,058,687 kilograms of low-level waste offsite for disposal.

Transuranic Waste Disposal

One transuranic waste shipment from the Laboratory to the Waste Isolation Pilot Plant in Carlsbad, New Mexico was completed in November 2017.

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 (EPA); (2) ignitable, corrosive, reactive, or toxic; (3) batteries, pesticides, lamp bulbs, or contain mercury; or (4) a hazardous waste as listed above that has been mixed with a radiological waste (mixed waste).

The Resource Conservation and Recovery Act mandates a hazardous waste facility permit for facilities that treat, store, or dispose of hazardous wastes. The Laboratory's Hazardous Waste Facility Permit was initially granted in 1989 and was renewed in 2010. The Laboratory does not dispose of hazardous waste onsite, but it does treat and store these wastes.

The Laboratory's Hazardous Waste Facility Permit, which is issued by the New Mexico Environment Department, currently covers 24 hazardous waste storage units, one hazardous waste storage and treatment unit, one liquid hazardous waste tank system, and one hazardous waste stabilization unit. The permit's operating requirements include reporting requirements to the New Mexico Environment Department's Hazardous Waste Bureau and to the public.

What does this waste term 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.

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.

Permit Modifications, Reports, and Other Activities

Eleven permit modifications to the Laboratory's Hazardous Waste Facility Permit were submitted to the New Mexico Environment Department in 2017. Notice of these modifications were mailed to members of the public on the Laboratory facility mailing list maintained by the New Mexico Environment Department. Four permit modifications were notifications of minor changes. These consisted of administrative changes only, including updates to organization names and language clarification in Attachment D (Contingency Plan); figure updates in Attachment N (Figures) and Attachment G (Closure Plans*)*; and facility description updates for the permitted unit located at Technical Area 63.

Five permit modifications were Class 1 permit modification requests requiring prior approval to modify the Permit. We sought approval to (1) split one existing solid waste management unit into two separate units, (2) update a treatment process, (3) update the tools used at a treatment unit, (4) add a structure back into the Permit, and (5) remove a refrigeration unit from a permitted unit. Additionally, one Class 2 permit modification request was submitted to request the addition of three container storage units at Technical Area 55, and one Class 3 permit modification request was submitted to address changes to the permit agreed to in an April 2017 settlement agreement.

During 2017, the New Mexico Environment Department issued three approvals for emergency treatments to treat hazardous waste chemicals in unstable containers. These treatments were performed in a total containment vessel. The destructions of the chemicals were completed in a controlled and safe manner. No residues or hazardous materials remained upon completion of these treatments.

As required by the Laboratory's Hazardous Waste Facility Permit, four quarterly and one annual demolition activity notifications were submitted to the New Mexico Environment Department in 2017. Additional permit reporting and activities for 2017 include the Community Relations Plan, which was published on the Laboratory's environmental web page in August, and the annual training session for the public on use of the electronic public reading room. The training was held in October, and attendance was up from previous years. A waste minimization report was submitted on December 1, 2017.

Inspections, Noncompliances, and Notices of Violation

Laboratory personnel with expertise in hazardous waste management advise and assess Laboratory waste generators, waste management coordinators, and waste workers. Walk-downs of waste management areas provide one-on-one assistance and guidance on the proper characterization, storage, and management of hazardous and mixed waste in accordance with federal and state regulations, DOE orders, and Laboratory policy.

Between April 17 and April 20, 2017, the New Mexico Environment Department conducted a hazardous waste compliance inspection at the Laboratory. A notice of violation was issued on July 20, 2017, citing eight violations noted during the inspection. The notice of violation was resolved in December 2017, after the New Mexico Environment Department determined that the violations cited in the notice were adequately addressed and that no further action was required.

In November 2017, we submitted our annual noncompliance report to the New Mexico Environment Department's Hazardous Waste Bureau. The report listed instances of noncompliance with the Hazardous Waste Facility Permit conditions and any releases from, or at, a permitted unit that did not pose a threat to human health or the environment. The data is reported by fiscal year, October 1, 2016 through September 30, 2017, to coincide with the Laboratory's Hazardous Waste Facility Permit reporting requirements.

The report cited 25 instances of noncompliance with the Hazardous Waste Facility Permit during fiscal year 2017. The majority of the occurrences of noncompliance were associated with container labeling issues and missed inspections. Additional instances of noncompliance for this time frame were communicated to the New Mexico Environment Department in letters dated March 8, 2017, *Request for Extension of Alternative Inspection Requirements for Shed 1028 at Technical Area 54, Area G, Pad 5,* and October 24, 2017, *Notification of Anticipated Noncompliance with the Los Alamos National Laboratory (LANL) Hazardous Waste Facility Permit; EPA ID No. NM890010515*. The letter dated March 8, 2017, served as a request for the continuation of alternative inspections at Technical Area 54, Shed 1028. The letter dated October 24, 2017 served as a notification of an anticipated noncompliance associated with a cutting tool that was used in a non-sparking capacity to repackage waste containers but was not a non-sparking tool. There were no releases of hazardous waste or hazardous waste constituents at, or from, a permitted unit during the reporting timeframe. Copies of these letters are available to the public the Laboratory's electronic public reading room website, http://eprr.lanl.gov/oppie/service.

The above-mentioned self-disclosures of noncompliance were identified through site-wide compliance assessments to identify systemic compliance issues and develop resolutions. The Laboratory continues to work towards developing additional qualifications and training requirements for waste management personnel to improve understanding and knowledge of requirements of the permit. The Laboratory has also developed improved waste management tools to ensure operating record compliance with the permit, and Laboratory managers are working with waste workers and waste management personnel to identify and implement corrective actions that will either minimize or prevent recurrence of instances of noncompliance with the permit, or could accomplish both.

LANL's Nitrate Salt–Bearing Waste Container Isolation Plan

In February 2014, a drum from the Laboratory was determined to be the container that breached in the underground repository at the Waste Isolation Pilot Plant. Laboratory scientists determined that the drum's contents, an incompatible mixture of nitrate salts and organic absorbent, together with high temperatures and internal pressure, could create a potential for exothermic chemical reactions. Based on this finding, the New Mexico Environment Department issued Administrative Order 5-19001, requiring the Laboratory to develop an Isolation Plan to isolate, secure, and treat all nitrate salt–bearing waste at the Laboratory. The Isolation Plan was revised twice in 2017. Revision 8 included the removal of a restriction on the forklift used to move waste containers at the treatment facility. Revision 9 allowed for the storage of multiple containers that contain liquids within the refrigerator at the treatment facility.

In May 2017, after numerous internal and external readiness assessments and the successful processing of two surrogate containers, the first container of remediated nitrate salt waste was successfully treated at the Laboratory. The treatment involved removing the waste from the drums and mixing it with water and zeolite, an inert material, to render the waste non-reactive. The resulting mixture was repackaged in new drums in accordance with the Waste Isolation Pilot Plant Waste Acceptance Criteria. Treatment of all remediated nitrate salt waste drums at the Laboratory was completed in November 2017. In total, after 173 days of processing, treatment of the 60 parent containers of remediated nitrate salt waste 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 of the unremediated nitrate salt containers, via a liner pull from the old drum and placement in a new drum, began on December 4, 2017. Treatment of the unremediated nitrate salt containers in the glovebox at the Waste Characterization Repackaging and Reduction Facility started on December 14, 2017.

Settlement Agreement and Stipulated Final Order

On December 6, 2014, the New Mexico Environment Department issued an Administrative Compliance Order (HWB-14-20) for violations of the Hazardous Waste Act and the Laboratory's Hazardous Waste Facility Permit associated with nitrate salt–bearing waste treatment and storage. A Settlement Agreement was signed and Stipulated Final Order HWB-14-20 was entered into by the New Mexico Environment Department, DOE, and Los Alamos National Security, LLC on January 22, 2016. The stipulated final order required the completion of nine corrective actions associated with waste management at the Laboratory.

Progress on ongoing corrective actions was communicated to the New Mexico Environment Department on January 22, 2017 and July 22, 2017.

Supplemental Environmental Projects

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 will implement 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 2017, the National Nuclear Security Administration Los Alamos Field Office executed an interagency agreement with the U.S. Army Corps of Engineers (the Corps). The Corps will manage design and construction activities for the Road Improvement Project. Construction began in 2018.

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

   Onsite inspections for the first triennial review were completed in March 2018.

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.

   - The low impact development master plan and standards documents were completed in September 2017.
   - A design for the main gate entry storm water pond was completed, and construction began in 2017.
   - The building 03-0028 low-impact development project design was completed in December 2017.

4. Surface water sampling project – Conduct increased sampling and monitoring capabilities for storm water run-off in and around the Laboratory with the results of sampling and monitoring shared with the public and the New Mexico Environment Department.

   In early 2017, we established the following sampling and monitoring locations:

   - Ten sites in developed watersheds in and around the Laboratory were established to collect sediment and storm water samples and vehicular use data. Eight storm water and 18 sediment samples were collected in 2017.
   - Eight sites in undeveloped, or reference, watersheds to the west and north of the Laboratory and Los Alamos town site were established to collect sediment

and storm water samples. Sixteen storm water samples and 32 sediment samples were collected in 2017.

- Two sites in undeveloped, or reference, watersheds to the west and north of the Laboratory and Los Alamos town site were established to collect atmospheric deposition samples. Six samples were collected in 2017.
- Three sites were established to collect storm water samples at Laboratory firing sites that are not covered by a permit or storm water program. Four storm water samples were collected in 2017.
- Reaches were defined within six watersheds in and around the Laboratory to collect aquatic life species. As of the end of 2017, 10 samples have been collected.
- Reaches within five watersheds in and around the Laboratory were identified to evaluate with the New Mexico Environment Department's Hydrology Protocol (NMED 2011). The Hydrology Protocol distinguishes between ephemeral, intermittent, and perennial stream reaches and documents the uses supported by those waters as a result of the flow regime. Thirty-six locations were assessed in 2017.
- 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. Eighteen samples were collected in 2017.

In addition, the Intellus NM website was redesigned to improve access to Laboratory monitoring data, including improving the Intellus query flow, enhancing visualization tools, and providing for multisite selection for data queries.

5. Potable water line replacement project – Replace aging potable water lines and install metering equipment for Laboratory potable water systems.

   In 2017, we advertised and awarded the design portion of the waterline and metering project. Most of the design work was completed during 2017. The design was submitted to the New Mexico Environment Department for review and approval on January 31, 2018.

The 2016 Compliance Order on Consent

The 2016 Compliance Order on Consent is a settlement agreement between the New Mexico Environment Department and the U.S. Department of Energy 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: solid waste management units and areas of concern. Solid waste management units are areas where solid wastes were spilled or disposed of. Examples of solid waste management 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 constituent through soil movement or effluent flow. Examples include canyon bottoms downstream from historical outfalls.

As of November 2017, the Laboratory had 1,403 corrective action sites listed in Appendix A of the 2016 Compliance Order on Consent. Of these, 76 had certificates of completion with controls, 229 had certificates of completions without controls, and 135 sites were deferred until they no longer have active operations. The remaining 963 solid waste management units and areas of concern had investigations or corrective actions (or both) either in progress or pending. During fiscal year 2017, seven sites received certificates of completion with controls, 55 sites received certificates of completion without controls, and 17 sites were changed to a deferred status. During the fiscal year, we submitted seven investigation reports, two cleanup status reports, one remedy completion report, annual updates on the Integrated Facility Groundwater Monitoring Program and the Los Alamos/Pueblo Canyon Sediment Monitoring, one report on the Sandia Canyon wetland performance, and several reports on groundwater program activities. The Upper and Middle Los Alamos Canyon Aggregate Area cleanups were completed, except for one PCB-contaminated site.

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

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 hazardous waste 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 updates its site treatment plan annually. The update to the site treatment plan documents the amount of mixed waste that has been stored at the Laboratory under the plan provisions during the previous fiscal year and its management.

During fiscal year 2017, mixed low-level waste covered under the site treatment plan increased from approximately 60 cubic meters to 60.64 cubic meters. The transuranic waste recharacterization process will continue to produce waste with between 10 and 100 nanocuries per gram of radiation. There is a backlog of stored waste as a result 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. Recently generated waste accounted for approximately 3.54 cubic meters of stored mixed low-level waste during the 2017 fiscal year, and approximately 11.35 cubic meters of mixed low-level waste was shipped offsite for treatment, disposal, or both.

The mixed transuranic waste inventory covered under the site treatment plan increased from approximately 961 cubic meters to 1037 cubic meters during fiscal year 2017. As of December 31, 2017, the Laboratory made one transuranic waste shipment to the Waste Isolation Pilot Plant.

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 related to disposal of PCB-containing substances and the import or export of small quantities of chemicals used in LANL research activities. PCB-containing substances include dielectric fluids, solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills.

During 2017, the Laboratory shipped 46 containers of PCB-containing wastes offsite for disposal or recycling. The total mass of PCB waste was 3,304.67 kilograms. PCB wastes, including fluorescent light ballasts, were sent to a U.S. Environmental Protection Agency-authorized treatment and disposal facility in Veolia, Colorado. During 2017, the U.S. Environmental Protection Agency did not perform a PCB site inspection. A total of six Toxic Substances Control Act import/export reviews were conducted in 2017 for chemicals for the Laboratory’s Property Management Group Customs Office. The purpose of these reviews is to ensure that shipments of certain chemical compounds that are sent out of the country are correctly classified for Toxic Substances Control Act purposes. In all six instances noted above, the shipments were properly categorized, and the material samples were sent to collaborative researchers in other countries.

Solid Nonhazardous Wastes

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 for obtaining all related permits for this activity from the State of New Mexico. The Laboratory also sends solid waste to regional facilities in the neighboring states of Arizona and Colorado. Laboratory solid non-hazardous waste sent offsite in 2017 totaled 3,720 cubic meters, or 3,278,509 kilograms.

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. We submitted a Title V permit modification application in July 2016 for five small spray evaporators to replace a larger unit that was taken out of service and received the new permit, P100-R2M1, on February 3, 2017.

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 2017, the Laboratory did not have any Title V Operating Permit deviations.

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 2017

Emission Unit	Pollutants (tons)					
	Nitrous Oxides	Sulfur Oxides	Particulate Matter	Carbon Monoxide	Volatile Organic Compounds	Other Hazardous Air Pollutants
Asphalt plant	0.004	0.002	0.003	0.16	0.003	0.003
Technical Area 03 power plant (3 boilers)	9.83	0.11	1.29	6.78	0.93	0.32
Technical Area 03 power plant (combustion turbine)	1.29	0.09	0.17	0.27	0.06	.035
Research and development chemical use	n/a[a]	n/a	n/a	n/a	10.3	5.2
Degreaser	n/a	n/a	n/a	n/a	0.002	0.002
Data disintegrator	n/a	n/a	0.43	n/a	n/a	n/a
Stationary standby generators[b]	4.34	0.17	0.20	1.13	0.21	0.003
Miscellaneous small boilers	19.25	0.12	1.55	15.38	1.10	0.37
Permitted generators (11 units)	0.48	0.008	0.018	0.37	0.043	0.0001
TOTAL	**35.19**	**0.50**	**3.66**	**24.09**	**12.65**	**5.93**

[a] n/a = not applicable

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

The Laboratory's emissions in 2017 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. Emissions from 2013 through 2017 are very similar and remain relatively constant.

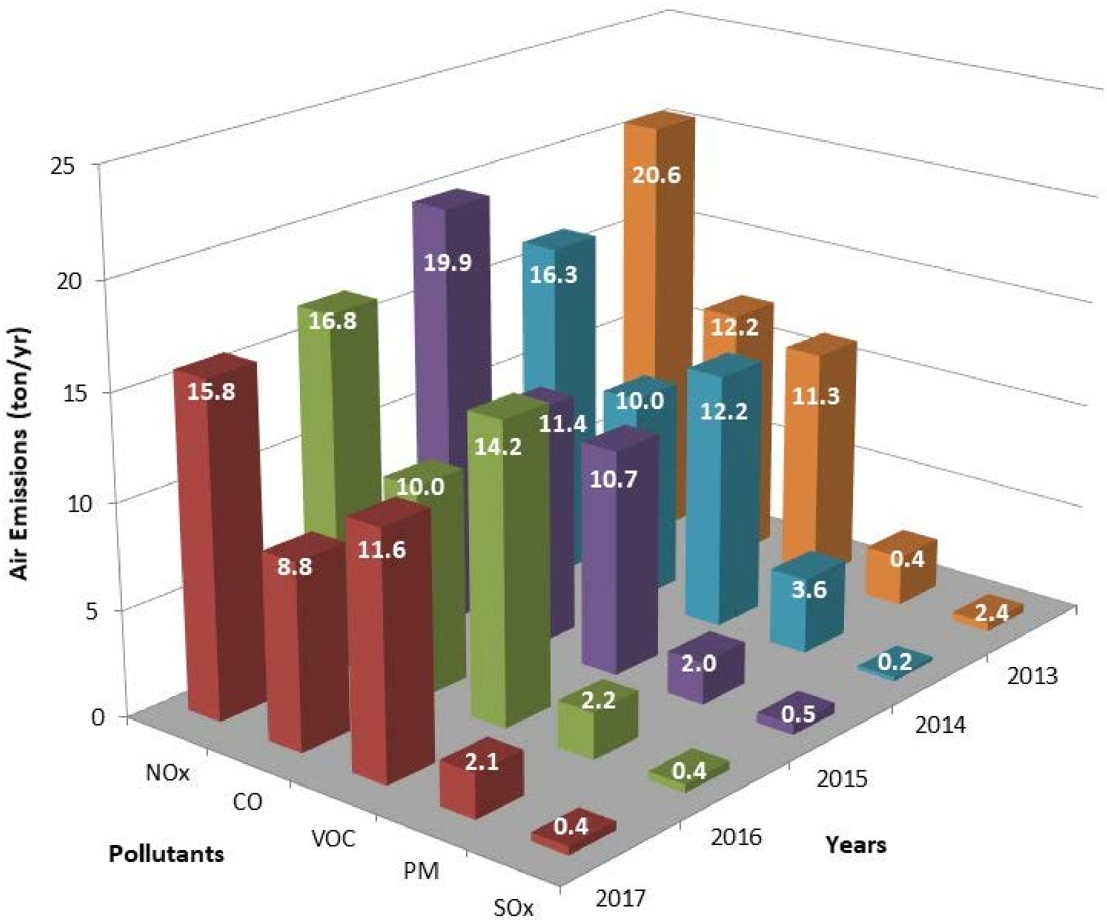


Figure 2-1 **LANL criteria pollutant emissions from 2013 through 2017 for annual emissions inventory reporting. These totals do not include small boilers or standby generators.**

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 Laboratory may not knowingly vent or otherwise release into the environment any Title VI regulated chemical during maintenance, repair, or disposal of refrigeration equipment (including air conditioners, refrigerators, chillers, and freezers) or fire-suppression systems. We are working to replace refrigeration equipment that uses ozone-depleting substances and hydrofluorocarbons with equipment that uses refrigerants listed in the U.S. Environmental Protection Agency's

Significant New Alternatives Program. In 2017, approximately 430 pounds of halon were sent to the U. S. Defense Logistics Agency's Ozone Depleting Substances Reserve. We have made significant progress in eliminating halon use in fire-suppression systems, with only two remaining locations that use systems with halon.

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 from air emissions. The estimated maximum dose to a member of the public in 2017 via air emissions was 0.47 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 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. The Laboratory reviews plans for new and modified projects, activities, and operations in order to identify air quality compliance requirements. We submitted two "exempted" notifications during 2017: one for an emergency stand-by generator at Technical Area 54 and one for 15 small gas-fired comfort heaters and boilers. We did not submit any "no permit required" determination requests in 2017.

In February 2017, the Laboratory received a modification to the Title V Operating Permit to operate five small spray evaporators. These small units were not subject to the requirement for construction permitting under new source review.

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 2017, 15 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 that 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

As of 2017, there are a total of 11 outfalls on the Laboratory's National Pollutant Discharge Elimination System Industrial and Sanitary Point-Source Outfall Permit (Outfall Permit) (Table 2-3). Six of the outfalls discharge cooling water from conventional cooling towers and one discharges treated sanitary waste. The Laboratory's current Outfall Permit requires weekly, monthly, quarterly, yearly, and term sampling to demonstrate compliance with different effluent quality limits. We report analytical results to the U.S. Environmental Protection Agency and the New Mexico Environment Department.

Table 2-3
Volume of Effluent Discharged from Permitted Outfalls in 2017

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2017 Discharge (gallons)
03A048	53-963/978	Los Alamos Neutron Science Center cooling tower	Los Alamos	27,768,347
051	50-1	Technical Area 50 Radioactive Liquid Waste Treatment Facility	Mortandad	0
04A022*	3-2238	Sigma emergency cooling system	Mortandad	483,080
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	222,165
03A181	55-6	Plutonium facility cooling tower	Mortandad	3,014,326
13S	46-347	Sanitary wastewater system plant	Sandia	0
001	3-22	Power plant (includes treated effluent from sanitary wastewater system plant)	Sandia	61,558,300
03A027	3-2327	Strategic Computing Complex cooling tower	Sandia	0
03A113	53-293/952	Los Alamos Neutron Science Center cooling tower	Sandia	222,615
03A199	3-1837	Laboratory Data Communications Center	Sandia	11,214,500
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2017 Total:	104,790,402

* This outfall's designation was changed from 03A022 to 04A022 in the October 1, 2014, permit 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).

Outfalls listed on the Outfall Permit that did not discharge in 2017 included Outfalls 05A055, 051, 03A027 and 13S. During 2017, none of the 919 samples collected from industrial outfalls exceeded effluent limits.

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. We inspect the location and condition of controls at the site and identify corrective actions if needed.

During 2017, the Laboratory had 25 storm water pollution prevention plans for construction sites, including one for a National Nuclear Security Administration project not managed by the Laboratory's management and operating contractor. The Laboratory's management and operating contractor performed 554 storm water inspections. Oversight staff for two federalized construction projects at the Laboratory performed 52 storm water inspections. Corrective action reports are prepared for storm water management issues observed during inspections. If an issue is not fixed within the timeframe specified in the report, a noncompliance is issued to the project. The management and operating contractor inspectors found 94.9 percent of the inspection items to be in compliance, and the federalized project inspectors found 96.1 percent of inspections to be in compliance.

On November 28, 2017 the New Mexico Environment Department performed a compliance evaluation inspection of the Technical Area 03 Substation Replacement Project and raised concerns with the storm water pollution prevention plan records for the project. The general contractor took immediate actions at that time to address the issues as discussed during the inspection. The formal notification from the New Mexico Environment Department was received on December 28, 2017 and further follow up actions were taken in 2018.

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 covered under the Multi-Sector General Permit include 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.

The Multi-Sector General Permit requires the implementation of control measures, development of storm water pollution prevention plans, and monitoring of storm water discharges from 14 permitted sites. Compliance with the requirements is achieved by

- developing and implementing facility-specific storm water pollution prevention plans,
- implementing corrective actions identified during inspections,
- monitoring storm water run-off at facility samplers for benchmark parameters, impaired water constituents, 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 as required by the Multi-Sector General Permit occurs from April 1 through November 30 of each year. Under the current permit, which took effect in late 2015, the benchmark values for some pollutants are the same as New Mexico water quality standards. As such, some pollutant limits are significantly more stringent now than under the previous permit, and exceedances of permit limits occur more frequently. Some of these permit limit exceedances may be caused by natural background conditions.

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 2017 have been completed. A benchmark exceedance does not trigger a corrective action if it is determined that the exceedance is solely attributable to natural background sources. A study to identify naturally occurring background concentrations in storm water run-off from these sites is pending.

In 2017, we completed the following tasks:

- Completed 118 inspections of storm water controls at the 14 permitted sites and one annual inspection at each of 34 sites having no-exposure status and at one inactive site
- Collected 199 samples at 14 permitted sites
- Completed 533 sampling equipment inspections
- Conducted 86 visual inspections at 24 monitored discharge points and 432 visual inspections at 46 substantially identical discharge points
- Converted one permitted site to no-exposure status
- Completed 254 corrective actions including:
    - 75 corrective actions to mitigate exceedances
    - Installation of one additional control measure at one permitted site
    - Maintenance, repair, or replacement of 50 control measures at nine permitted and three no-exposure sites
    - 78 actions to remedy control measures inadequate to meet non-numeric effluent limits

  - o 48 corrective actions to address unauthorized releases (spills) or discharges
  - o Correction of two storm water pollution prevention plan non-conformances
- Discontinued monitoring of 25 pollutants at eight permitted sites by meeting permit-defined criteria:
  - o Quarterly benchmarks: Discontinued monitoring of 16 pollutants at four permitted sites due to the average of four results not exceeding the benchmark
  - o Impaired waters pollutants: Nine pollutants at seven permitted sites were not expected to be present and were not detected

Tables 2-4 through 2-6 summarize the exceedance of water quality parameter (i.e., impaired waters), effluent limitations, or quarterly benchmark limits for the Laboratory's National Pollutant Discharge Elimination System Multi-Sector General Permit.

Table 2-4
2017 Exceedances of LANL's National Pollutant Discharge Elimination System Multi-Sector General Permit Impaired Waters* Limits

Discharge Point	Exceeded Parameters			Date(s) exceeded
	Copper, dissolved (Cu)	Adjusted Gross Alpha (AGA)	Aluminum, total recoverable (Al)	
002	✓	✓		04/04/2017
004		✓	✓	05/09/2017
005	✓	✓	✓	04/04/2017
009	✓		✓	04/01/2017
012		✓	✓	07/26/2017
017	✓		✓	05/09/2017
020	✓			08/08/2017
022	✓		✓	04/01/2017
026	✓		✓	04/01/2017
029	✓	✓	✓	05/09/2017 – Al; 06/01/2017 – AGA; 06/06/2017 – Cu
031	✓			07/26/2017
032	✓		✓	04/01/2017 – Al; 04/04/2017 – Cu
039	✓	✓	✓	07/26/2017
042	✓		✓	04/29/2017
049			✓	04/29/2017
051			✓	09/27/2017
072			✓	09/28/2017
073	✓			07/18/2017
075	✓	✓	✓	07/31/2017 – AGA, Al; 09/28/2017 – Cu

* An impaired waters exceedance means that the value exceeds a New Mexico surface water quality standard, as provided in Part 20.6.4 of the New Mexico Administrative Code. Thirty-two of 62 impaired waters results (52 percent) exceeded the New Mexico surface water quality standard.

Table 2-5
2017 Exceedances of LANL's National Pollutant Discharge Elimination System Multi-Sector General Permit Effluent Limitations*

Discharge Point	Exceeded Parameters		Date exceeded
	Total Suspended Solids	Limit Type	
043	✓	Daily Max	10/05/2017

* An effluent limitation exceedance means that the value exceeds a limit for specific industrial activities as defined in the Multi-Sector General Permit. One of three effluent limitation results (33.3 percent) exceeded the limit.

Table 2-6
2017 Exceedances of LANL's National Pollutant Discharge Elimination System Multi-Sector General Permit Quarterly Benchmarks*

Discharge Point	Exceeded Parameters							Date(s) exceeded
	Copper, dissolved (Cu)	Aluminum, total recoverable (Al)	Iron, total (Fe)	Zinc, dissolved (Zn)	Magnesium, total (Mg)	Chemical Oxygen Demand (COD)	Cyanide, total (CN)	
002		✓	✓	✓				04/04/2017 – Fe; 06/01/2017 – Zn; 10/05/2017 – Fe, Al
004		✓	✓					05/09/2017
005			✓					04/04/2017, 08/07/2017
009			✓					04/01/2017, 10/05/2017
017	✓	✓	✓	✓				05/09/2017 – Fe, Al; 06/25/2017 – Cu; 08/11/2017 – Fe; 10/04/2017 – Fe, Al, Cu, Zn
020				✓				10/04/2017
047					✓			04/29/2017, 10/04/2017, 10/05/2017
050					✓	✓		04/04/2017 – Mg; 06/01/2017 – COD, Mg; 08/03/2017 – Mg; 10/04/2017 – Mg
051					✓			09/27/2017
069					✓	✓		04/01/2017 – Mg; 06/06/2017 – COD, Mg; 08/03/2017 – Mg
072					✓		✓	09/28//2017 – Mg, Cn; 10/05/2017 – Mg
073						✓		07/26/2017

* 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 Cu, Al, Zn, and CN are the same as New Mexico surface water quality standards. Forty-two of 134 benchmark results measured (31 percent) resulted in a benchmark 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 Laboratory's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (Individual Permit) authorizes discharges of storm water from 405 solid waste management units and areas of concern (sites) at the Laboratory. Controls that reflect best industry practices are applied at each of the 405 sites to minimize or eliminate movement of pollutants off the site.

To sample the storm water run-off, the 405 sites are grouped into 250 site monitoring areas that discharge to a common drainage point. Storm water samples collected from these locations are analyzed to determine the effectiveness of the controls. The Individual Permit field team uses ultra-high frequency telemetry to monitor the condition of automated samplers and to notify them when a sampler collects storm water discharge.

When target action levels for pollutants, based on New Mexico surface water quality standards, are exceeded in the samples, the Individual Permit requires additional corrective actions at the site. A site is removed from the Individual Permit when the corrective actions for the site are certified as complete by the U.S. Environmental Protection Agency or when an alternative compliance strategy is approved.

In 2017, we completed the following tasks:

- Published the 2016 update to the Site Discharge Pollution Prevention Plan. It (1) identifies pollutant sources, (2) describes the control measures, and (3) describes the monitoring at all regulated sites.
- Completed 1,331 inspections of storm water controls at the 250 site monitoring areas
- Completed 1,237 sampling equipment inspections
- Conducted storm water monitoring at 159 site monitoring areas
- Collected post-certification storm water samples at two site monitoring areas and completing the monitoring at those sites
- Collected corrective action enhanced control confirmation samples at nine site monitoring areas
- Installed 64 additional control measures at 32 site monitoring areas
- Installed eight replacement baseline controls at seven site monitoring areas
- Installed two enhanced controls at two site monitoring areas
- Received certification of completion of corrective action for 10 site monitoring areas or sites
- Documented one site monitoring area completed with results less than target action levels
- Held two public meetings as required by Individual Permit
- Completed website updates and public notifications

No alternative compliance requests were submitted during 2017. For more information on surface water quality at the Laboratory, see Chapter 6, Watershed Quality.

Table 2-7 summarizes the exceedance of target action levels for the Individual Permit.

Table 2-7
2017 Exceedances of LANL's National Pollutant Discharge Elimination System Individual Permit Target Action Levels

Site Monitoring Area	Parameter	Type of exceedance[a]	Number of exceedances	Total number of samples taken	Date(s) exceeded	Description and Corrective Action
3M-SMA-4	Copper, dissolved	maximum target action level	1	1	07/26/2017	Prepare request for alternative compliance
ACID-SMA-2	Total PCBs	average target action level	2	2	7/8/2017 7/26/2017	Prepare request for alternative compliance
	Aluminum, dissolved	maximum target action level	1	2	07/26/2017	
	Gross Alpha	average target action level	2	2	7/8/2017 7/26/2017	
ACID-SMA-2.1	Total PCBs	maximum target action level	2	2	8/7/2017 8/23/2017	Prepare request for alternative compliance
	Aluminum, dissolved	maximum target action level	1	2	08/07/2017	
	Copper, dissolved	maximum target action level	1	2	08/07/2017	
	Gross Alpha	average target action level	2	2	8/7/2017 8/23/2017	
CDV-SMA-2.42	Total PCBs	average target action level	2	2	6/25/2017 10/5/2017	Install enhanced control measures
	Aluminum, dissolved	maximum target action level	1	2	06/25/2017	
	Copper, dissolved	maximum target action level	1	2	06/25/2017	
	Gross Alpha	average target action level	2	2	6/25/2017 10/5/2017	
LA-SMA-1	Total PCBs	average target action level	1	1	07/26/2017	Result collected following certification of completion of corrective action: Installed control measures that eliminated exposure of site to storm water.
	Gross Alpha	average target action level	1	1	07/26/2017	
M-SMA-1.2	Copper, dissolved	maximum target action level	1	1	09/29/2017	Prepare request for alternative compliance

Site Monitoring Area	Parameter	Type of exceedance[a]	Number of exceedances	Total number of samples taken	Date(s) exceeded	Description and Corrective Action
PT-SMA-1	Copper, dissolved	maximum target action level	1	1	09/26/2017	Prepare request for alternative compliance
	Gross Alpha	average target action level	1	1	09/26/2017	
S-SMA-6	Total PCBs	average target action level	2	2	7/26/2017 9/29/2017	Install enhanced control measures
	Aluminum, dissolved	maximum target action level	1	2	07/26/2017	
	Copper, dissolved	maximum target action level	2	2	7/26/2017 9/29/2017	
	Gross Alpha	average target action level	2	2	7/26/2017 9/29/2017	
	Lead, dissolved	maximum target action level	2	2	7/26/2017 9/29/2017	
STRM-SMA-4.2	Silver, dissolved	maximum target action level	1	2	07/29/2017	Install enhanced control measures
	Aluminum, dissolved	maximum target action level	2	2	7/29/2017 9/27/2017	
	Copper, dissolved	maximum target action level	2	2	7/29/2017 9/27/2017	
T-SMA-7	Gross Alpha	average target action level	1	1	09/12/2017	Prepare request for alternative compliance
W-SMA-9.5	Gross Alpha	average target action level	1	2	06/25/2017	Install enhanced control measures
	Mercury, total	average target action level	1	2	06/25/2017	

[a] 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.

Petroleum Storage Tank Bureau staff inspected three of the aboveground storage tanks at the Laboratory in 2016. The Bureau issued a certificate of compliance to document that previous inspection findings had been corrected for one site. A project is underway to correct 2016 inspection findings at another facility and should be completed in early 2018.

The Petroleum Storage Tank Bureau conducted inspections of four tank systems in 2017. The Laboratory provided 30-day notices to the Petroleum Storage Tank Bureau for a new tank installation and for proactive repairs on a system. The Laboratory also provided input for the repeal and replacement of 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 counter-measure plans for facilities with aboveground storage tank systems. In 2017, Laboratory staff updated five of these plans and conducted 30 inspections of facilities with plans. During 2017, the Laboratory was in full compliance with the federal Clean Water Act requirements for these tanks.

Clean Water Act Section 404/401 Permits

Section 404 of the Clean Water Act requires that the Laboratory receive U.S. Army Corps of Engineers verification that proposed work within perennial, intermittent, or ephemeral watercourses complies with nationwide Section 404 permit conditions. Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by 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 permit 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 2017 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.

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 (20.6.4 New Mexico Administrative Code) establish surface water quality standards that define designated uses of surface waters of the State, the water quality criteria necessary to protect those uses, and an antidegradation 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 their Clean Water Act Section 303(d) impaired waters listing for 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. During 2017, most assessment units at the Laboratory were evaluated as impaired to some extent, 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 of Public Utilities issues an annual drinking water quality report, as required by the Safe Drinking Water Act. That report is available at https://indd.adobe.com/view/50b3a008-30c5-466-b37e-2390168c2a41. For the latest year of publication (2017), the drinking water quality for Los Alamos met all U.S. Environmental Protection Agency regulations.

New Mexico Water Quality Act: Groundwater Quality Standards

We reported first-time exceedances of New Mexico groundwater quality standards at an individual well or spring to the New Mexico Environment Department for seven locations in 2017 (Table 2-8).

Table 2-8
2017 First-time Groundwater Quality Standard Exceedances

Parameter(s)	Location	Date
Nitrate-Nitrate as Nitrogen	Perched-intermediate well MCOI-5	1/13/2017
RDX, Barium	Technical Area 16 Permeable Reactive Barrier	2/14/2017
Chromium, Cobalt, Iron, Manganese	Regional well R-25	2/14/2017
Nitrate-Nitrate as Nitrogen	Water supply well PM-5	4/24/2017
RDX	Regional well R-68	5/11/2017
Total Dissolved Solids	Alluvial well 18-MW-18	6/14/2017
Cyanide, total	Spring 3AA	12/11/2017

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. In 2017, the Laboratory had four discharge permits and one discharge permit application pending.

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. During 2017, none of the samples collected exceeded the New Mexico groundwater standards. On November 2, 2017, the New Mexico Environment Department conducted an inspection of three domestic wastewater holding tanks and the Technical Area 60 Sigma Mesa Evaporation Basins. The inspector observed that the facilities met the operation and maintenance conditions required in discharge permit DP-857.

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 is disconnected.

Discharge permit DP-1589 requires monitoring and inspections for the Laboratory's septic tank disposal systems. These include, but are not limited to, the following: routine septic tank sampling, septic tank water-tightness testing, inspection of the septic tank for the accumulation of scum and solids, and inspection of the disposal system (leach field). On November 28, 2017, the New Mexico Environment Department conducted an inspection of three septic tank-disposal systems at Technical Area 33. The inspector found no issues with the three tanks inspected.

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 the facility and the Technical Area 52 solar evaporative tank. 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.

During 2017, the Laboratory and the New Mexico Environment Department held two negotiation sessions on the draft discharge permit. Following these sessions, the New Mexico Environment Department issued a revised draft discharge permit on May 5, 2017, for a 30-day public comment period. On December 15, 2017, the New Mexico Environment Department issued a notice of a public hearing on DP-1132. The permit was issued in 2018.

We have voluntarily conducted quarterly sampling of effluent from the Radioactive Liquid Waste Treatment Facility's outfall and of alluvial groundwater from nearby monitoring wells MCO-4B, MCO-6, and MCO-7 since 1999. When water is present, we test for nitrate (as nitrogen), fluoride, total dissolved solids, and perchlorate. No effluent samples were collected in 2017 because the Radioactive Liquid Waste Treatment Facility did not discharge any water; all treated water was evaporated onsite. None of the quarterly groundwater samples from the alluvial wells exceeded the New Mexico groundwater standards for the tested chemicals or water quality characteristics. The New Mexico Environment Department toured the Radioactive Liquid Waste Treatment Facility in May 2017.

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.

During 2017, the Laboratory operated under two work plans approved by the New Mexico Environment Department. Work plan #5, for the extraction, treatment, and land application of groundwater contaminated with chromium, was approved by the New Mexico Environment Department on June 15, 2017. Work plan #6, for the extraction, treatment, and land application of groundwater contaminated with high explosives, was approved by the New Mexico Environment Department on June 23, 2017. 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 under both work plans demonstrated 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. Discharge permit DP-1835 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 via 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.

The permit 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 for 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. During 2017, all quarterly reports were submitted within compliance deadlines.

Permit requirements also include demonstration of mechanical integrity of the distribution piping and injection wells associated with the discharge permit within one year of the permit's effective date. We began construction of the fourth extraction well and the associated piping in 2017. 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.

During 2017, the following construction activities related to this permit were completed: (1) extraction well CrEX-2, (2) injection well CrIN-6, (3) the collection network from the extraction system (extraction wells CrEX-1, CrEX-2, and CrEX-3) to the centralized treatment system, and (4) the distribution piping from the centralized treatment system to the injection wells (CrIN-1, CrIN-2, CrIN-3, CrIN-4, CrIN-5, and CrIN-6). As stated previously, construction of extraction well CrEX-4 and the associated piping to the collection network has begun.

During 2017, injection of treated groundwater occurred at all six injection wells. After we provided required notifications before injecting at CrIN-1 and CrIN-6, on September 1, 2017, the New Mexico Environment Department issued a notice to temporarily limit injection at these two locations. In this notification, the New Mexico Environment Department conditionally approved injection of treated groundwater at CrIN-1 for functional testing. On September 25, 2017, the New Mexico Environment Department conditionally approved injection of treated groundwater at CrIN-6 for functional testing. On November 21, 2017, the New Mexico Environment Department conditionally approved injection of treated groundwater at CrIN-1 for operational testing while requiring us to provide recommendations for the injection system operation to the New Mexico Environment Department in 2018 based on the operational test data collected.

Compliance Order on Consent Groundwater Activities

The Laboratory performed groundwater protection activities in 2017 as directed by the New Mexico Environment Department under the Compliance Order on Consent. More information is available in Chapter 5, Groundwater Monitoring. 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 installing new wells for the chromium interim measure. The goal of chromium interim measure is to control migration of the chromium groundwater plume while the Laboratory assesses cleanup methods. Planned operations for the chromium interim measure include withdrawing chromium-contaminated groundwater from the regional aquifer using four extraction wells, treating it using ion exchange, and injecting the treated groundwater back into the regional aquifer using six injection wells. In 2017, we installed one new injection well, CrIN-6, and one new extraction well, CrEX-4. Limited extraction, treatment, and injection occurred in this new system primarily from January through June 2017 using the CrEX-1 well for extraction and the CrIN-4 and CrIN-5 wells for injection. A new regional aquifer groundwater monitoring well, R-68, was completed as part of the RDX investigation.

DOE ORDER 232.2, *OCCURRENCE REPORTING AND PROCESSING OF OPERATIONS INFORMATION*

DOE Order 232.2, *Occurrence Reporting and Processing of Operations Information,* requires that abnormal events or conditions that occur during facility operations must be reported. An "occurrence" is one or more event or condition that may adversely affect workers, the public, property, the environment, or the DOE mission.

All reportable environmental occurrences at the Laboratory for 2017 are listed in Table 2-9. Criterion significance categories listed in Table 2-9 include the following:

- *Group 5:* Environmental
- *Criterion 5A(2):* Any release (on-site or off-site) of a pollutant from a DOE facility that is above levels or limits specified by outside agencies in a permit, license, or equivalent authorization, when reporting is required in a format other than routine periodic reports.
- *Group 9:* Noncompliance Notifications
- *Criterion 9(1):* Any written notification from an outside regulatory agency that a site/facility is considered to be in noncompliance with a schedule or requirement.
- *Significance Category 4*: Events or circumstances that were mitigated or contained by normal operating practices but where reporting provides potential learning opportunities for others.

Table 2-9
2017 Environmental Occurrences

Title	Description and Comments	Status
Criterion Significance Category: Criterion 5A(2), Significance Category 4		
Drilling Fluid Release Due to Piping System Failure	At 11:30, on Thursday, September 14, 2017, the Weapons Facility Operations Manager was notified that at the Technical Area 9 well pad CdV91i, while Environmental Remediation Field Service workers were evaporating drilling fluid, the piping system came apart at a joint resulting in the release of approximately 300 gallons of drilling fluid onto the well pad. Workers immediately shut off the equipment, paused work, secured the scene and notified their supervisor. The environmental subject matter expert confirmed that concentrations of the drilling fluid pollutants were above permitted limits for land application and that a report to the New Mexico Environmental Department was required. Verbal notification was made to the National Nuclear Security Administration Los Alamos Site Office Environmental Compliance Officer and the New Mexico Environment Department. The pump and piping system at well pad CdV91i will remain out of service until repairs to the piping system are completed and the New Mexico Environment Department approves the corrective actions.	Open (as of 5/24/2018)

Title	Description and Comments	Status
Criterion Significance Category: Criterion 9(1), Significance Category 4		
Receipt of Notice of Violation with Proposed Penalties Associated with the 2017 LANL Hazardous Waste Inspections	On July 28, 2017, LANL received a Notice of Violation from the New Mexico Environment Department with alleged violations of the New Mexico Hazardous Waste Act and the Hazardous Waste Management Regulations resulting from inspections conducted the week of April 17, 2017. Specifically, the notice of violation cited the following alleged violations: 1) failure to make a hazardous waste determination at various LANL sites; 2) failure to keep a hazardous waste container closed; 3) failure to mark containers as hazardous waste at a satellite accumulation area; 4) failure to provide hazardous waste training for employees signing hazardous waste manifests and handling hazardous waste; 5) failure to maintain personnel training records; 6) failure to maintain a facility to minimize the potential for fire, explosion or any unplanned sudden or non-sudden release of hazardous waste or its constituents to air, soil or surface water which could threaten human health or the environment; 7) failure to properly dispose of characteristic hazardous waste; and 8) failure to label and demonstrate the length of time universal waste lamps were accumulated. The Laboratory submitted a letter to the New Mexico Environment Department that responded to the allegations and detailed the corrective actions taken on August 18, 2017. Agreement was reached with the New Mexico Environment Department on a stipulated final order that resolved the Notice of Violation on November 7, 2017.	Closed

OTHER ENVIRONMENTAL STATUTES AND ORDERS

National Environmental Policy Act

The National Environmental Policy Act requires federal agencies to consider the environmental impacts of proposed activities, operations, and projects in decision-making. The act requires the preparation of environmental assessments or environmental impact statements for any projects or activities having the potential for significant environmental impacts and includes a public participation component. The Laboratory operates under a site-specific Site-Wide Environmental Impact Statement (DOE 2008a) and associated Records of Decision (DOE 2008b, DOE 2009) and Supplement Analyses.

Laboratory staff review proposed projects to determine whether they have coverage under the existing Site-Wide Environmental Impact Statement or other existing National Environmental Policy Act documents issued by DOE. Laboratory staff reviewed approximately 1,112 proposed projects for National Environmental Policy Act coverage in 2017. Projects or activities that do not have coverage under existing documents require new or additional National Environmental Policy Act analyses.

In 2017, DOE prepared a Supplement Analysis (DOE 2017a) to the 2015 Environmental Assessment for Chromium Plume Control Interim Measure and Plume Center Characterization (DOE 2015). The proposal included drilling additional extraction wells and installing associated infrastructure to improve the effectiveness of the current system to control chromium plume migration. DOE determined the environmental impacts of the proposed actions were bounded by analysis presented in the 2015 Environmental Assessment.

Nine projects received under DOE categorical exclusions in 2017:

- Los Alamos National Laboratory Domestic and Foreign Sealed Source Recovery Project (DOE 2017b)
- 115 kV Transmission Line (Norton Line) Grant of Easement for Right-of Way Contract Renewal (DOE 2017c)
- Los Alamos County Landfill Cap Repair Project (DOE 2017d)
- Los Alamos County Department of Public Utilities Proposed New Easement for the Construction and Operation of a Switchgear Substation and Underground Duct Bank including Electric Lines and Related Utility Appurtenances (DOE 2017e)
- Mortandad Wetland Enhancement Supplemental Environmental Project (DOE 2017f)
- Succeeding (New) Lease for the Los Alamos Transit Mix Plant (DOE 2017g)
- Los Alamos Canyon Reservoir Waterline Replacement Project (DOE 2017h)
- Uranium Machining Consolidation at Technical Area 3 Building 66 (DOE 2017i)
- Upper Cañon de Valle Watershed Enhancement Project (DOE 2017j)
- Technical Area 3 Modular Laboratory Building – Pilot Project (DOE 2017k)

DOE issued one formal determination on a project that was covered under existing National Environmental Protection Act documents:

- The Transuranic and Mixed-Transuranic Waste Mobile Loading Unit at Technical Area 55 – DOE determined that the proposal to prepare and load transuranic waste drums at Technical Area 55 for disposal at the Waste Isolation Pilot Plant was within the boundaries of activities previously analyzed in the 2008 Site-Wide Environmental Impact Statement (DOE 2008a). Processing and packaging of transuranic and mixed-transuranic waste at LANL have occurred at the Waste Compaction Reduction and Repackaging Facility and the Radioassay and Nondestructive Testing Facility.

National Historic Preservation Act

The National Historic Preservation Act requires federal agencies to consider the effects their activities may have on historic properties, including archaeological sites and historic buildings. The act requires evaluation of impacts of a project on any historic properties and mitigation of any adverse effects. A cultural resources management plan (LANL 2017b) describes our process for implementing the National Historic Preservation Act. During 2017, the newly updated cultural resources management plan and an associated programmatic agreement were approved and signed by the State Historic Preservation

Office, the Advisory Council on Historic Preservation, and the National Nuclear Security Administration Los Alamos Field Office.

The summary of projects reported here is on a fiscal year basis to coincide with other cultural resources reporting requirements. During fiscal year 2017, we supported 43 projects that needed verification of previous historic property survey results. Seven new archaeological sites were identified. Twenty-six archaeological sites were determined eligible for the National Register of Historic Places.

We conducted the annual inspection of the Museum of Indian Arts and Culture in Santa Fe, New Mexico, to ensure appropriate preservation and curation of artifacts from 39 archaeological sites excavated on Laboratory property during 2002 through 2006 for the land conveyance and transfer project, along with artifacts from earlier Laboratory projects. These inspections are required under the Code of Federal Regulations, Title 36, Part 79, Curation of Federally-Owned and Administered Archaeological Collections.

We conducted archival documentation for three projects impacting historic buildings at Technical Areas 03, 16, and 46. This work included interior and exterior inspections and archival photography of the buildings and architectural documentation (collection of all drawings and plans related to the building). We conducted research on the historical uses of the buildings using source materials from the Laboratory archives and records center, historical photography, the Laboratory’s public reading room, and previously conducted oral interviews. Cultural resources staff participated in surveillance and maintenance evaluations of the Laboratory’s most significant historic properties (candidates for preservation), including the 17 buildings and structures referenced in the 2014 Manhattan Project National Historical Park legislation (see Chapter 3).

We continued to conduct consultations with pueblos regarding identifying and protecting 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, which includes their habitats. We implement these requirements through our 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 (Hathcock et al. 2015) potentially occur within the Laboratory (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[a]	Potential to Occur[b]
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 2-33okomi 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 2-33okomis nitocris	New Mexico silverspot butterfly	FSOC	Moderate
Mentzelia springeri	Springer's blazing star	NMSOC, FSOC, FSS	Moderate

[a] 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.

[b] 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 projects have the potential to impact federally listed species or their habitats. During 2017, we reviewed 910 excavation permits, 208 project profiles in the permits and requirements identification system, 32 minor siting proposals, and 11 storm water pollution prevention plans for potential impacts to threatened or endangered species. If there is a potential for impacts, biological resources staff 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. We prepared two biological assessments during 2017. Both assessments analyzed the impacts to listed species, first from the re-delineation of Mexican spotted owl habitat boundaries and construction of a new building over the top of an existing building adjacent to undeveloped core habitat in Technical Area 40 (LANL 2017d), and second from continued operations and expansion of the water monitoring programs at LANL (LANL 2017e). We did not find any projects out of compliance with biological resource protection requirements in 2017.

We also conducted surveys for the Mexican spotted owl, southwestern willow flycatcher, and Jemez Mountains salamander. Mexican spotted owls were found on Laboratory property again in 2017. Two Mexican spotted owl nesting locations were discovered, and at least one owlet fledged. Jemez Mountains salamander surveys on LANL were very limited in 2017 because of the lack of appropriate moisture needed to conduct surveys. Southwestern willow flycatchers were not found during surveys, but three willow flycatchers of unknown subspecies were detected.

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. In project reviews, Laboratory biologists provide specific comments for projects with 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.

During 2017, we continued annual breeding season and winter surveys in all major habitat types and continued monitoring avian nest boxes. As part of a long-term monitoring project at two open detonation sites and one open burn site, our avian point count surveys and nest box monitoring results continue to suggest that operations at these sites are not negatively affecting bird populations (Hathcock et al. 2018). In addition, biologists completed bird mist-netting during the breeding season in Sandia Canyon to monitor bird demographics and during fall migration in Pajarito Canyon to monitor use of Laboratory lands by migrating birds. In 2017, 1,041 birds were banded at the Laboratory. We also continued to support avian monitoring at Bandelier National Monument. All of 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.

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. Six floodplain assessments were prepared during 2017 for cleanup projects in Ancho and Los Alamos Canyons (LANL 2017f, LANL 2017g), a pipeline project in Los Alamos Canyon (LANL 2017h), three supplemental environmental projects in Cañon de Valle, Ancho, and Sandia Canyons (LANL 2017i, LANL 2017j), and a sediment and flow control project in DP Canyon (LANL 2017k). One wetland assessment and one wetland delineation report were prepared during 2017 for a supplemental environmental project in Mortandad canyon (LANL 2017k, LANL 2017l). No violations of the DOE floodplain/wetland environmental review requirements were recorded in 2017.

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 the licensing and certification of pesticide workers, record-keeping, and equipment inspection as well as application, storage, and disposal of pesticides. Pesticide usage in 2017 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 2017.

Table 2-11
Pesticides

Herbicide	Amount
Velossa	209 gallons
Ranger Pro Herbicide	100 gallons
Prokoz Surflan AS Specialty	8.5 gallons
Lesco Prosecutor Pro Non-Selective Herbicide	17.7 gallons
Insecticide	**Amount**
Maxforce Complete Brand Granular Insect Bait	1.1 pounds
Tempo Ultra WP	0.044 pounds
Prescription Treatment Brand P.I. Contact Insecticide Formula 1	0.25 pounds
PT Wasp Freeze II and Hornet Insecticide	6.2 pounds
Summit B.T.I Briquets	0.1145 pounds
Water Treatment Chemical	**Amount**
Garratt-Callahan Formula 314-T	3.75 pounds
Houghton Chemical Purobrom Tablets	6445 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 make several notifications under the Act: (1) to state and local emergency planning committees if any changes at the Laboratory might affect the local emergency plan or if the Laboratory's emergency planning coordinator changes, (2) notification of leaks, spills, and other releases of listed chemicals into the environment if these releases exceed specified quantities, (3) an 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 activity thresholds. Table 2-12 identifies what reporting the Laboratory did in 2017.

Table 2-12
Status of Emergency Planning and Community Right-To-Know Act Reporting in 2017

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 2017 was lead. The largest use of reportable lead is at the onsite firing range where security personnel conduct firearms training. Table 2-13 summarizes the reported releases in 2017. There are no compliance violations associated with this use or release of lead.

Table 2-13
Summary of 2017 Total Annual Releases under Emergency Planning and Community Right-to-Know Act, Section 313

Reported Release	Lead (pounds)
Air emissions	3.44
Water discharges	0.22
Onsite land disposal	1138
Offsite waste transfers	483

INSPECTIONS AND AUDITS

Table 2-14 lists the environmental inspections conducted by regulating agencies and external auditors at the Laboratory during 2017.

Table 2-14
Environmental Inspections and Audits Conducted at the Laboratory during 2017

Date	Purpose	Performing Entity
04/17/17–04/20/17 and 11/13/17–11/16/17	Resource Conservation and Recovery Act compliance inspection	New Mexico Environment Department
02/07/17	Baseline for 40 Code of Federal Regulations 194 – Certification or re-certification for the Waste Isolation Pilot Plant's compliance with disposal regulations	Environmental Protection Agency
5/25/2017	Pesticide compliance inspection	New Mexico Department of Agriculture
6/13/17	Inspect five storm water and habitat restoration projects permitted under Section 404 of the Clean Water Act	U.S. Army Corps of Engineers
3/24/17 and 10/17/17	Petroleum storage tank inspections	New Mexico Environment Department
4/17/17	[Waste] Generator Site Technical Review	DOE Carlsbad Field Office
5/22/17–05/25/17	Tier 1 Qualified Facility inspection of Technical Area 54 compliance with the spill prevention, control, and countermeasure rule	Environmental Protection Agency
5/16/17	Recertification audit for waste disposal at the Waste Isolation Pilot Plant	DOE Carlsbad Field Office
11/02/2017	Inspection of domestic wastewater holding tanks	New Mexico Environment Department
11/28/2017	Inspection of domestic septic tank-disposal systems	New Mexico Environment Department
11/28/2017	Compliance evaluation inspection of the Technical Area 03 Substation Replacement Project	New Mexico Environment Department
1/30/17 – 2/2/17	Environmental Management System Surveillance Audit. Final surveillance audit of the 3-year certification cycle covering clauses of the ISO 14001:2004 standard	NSF International Strategic Registrations
7/31/17 – 8/4/17	Environmental Management System Recertification Audit. Recertification and transition audit to the latest ISO 14001 standard (ISO 14001:2015)	NSF International Strategic Registrations

CLIMATIC RISK ASSESSMENT

The National Climate Assessment presents predictions on how the climate of the southwest may change over the next century (Garfin et al. 2014). 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.

We began tracking climatic risk indices for the Laboratory in 2015 relating to temperature, precipitation, wind, indicator species, and storm water flow. These indices will assist us in identifying when actions will be necessary to protect facilities and operations.

Not all of the indicators are tracked on an annual basis. For example, benthic macroinvertebrates and breeding bird phenology will only be reported every 3 to 5 years. Below are the results of indices that were available in 2017.

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 of this report 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 2011–2016 continuing to be significantly warmer (approximately 2.5°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.

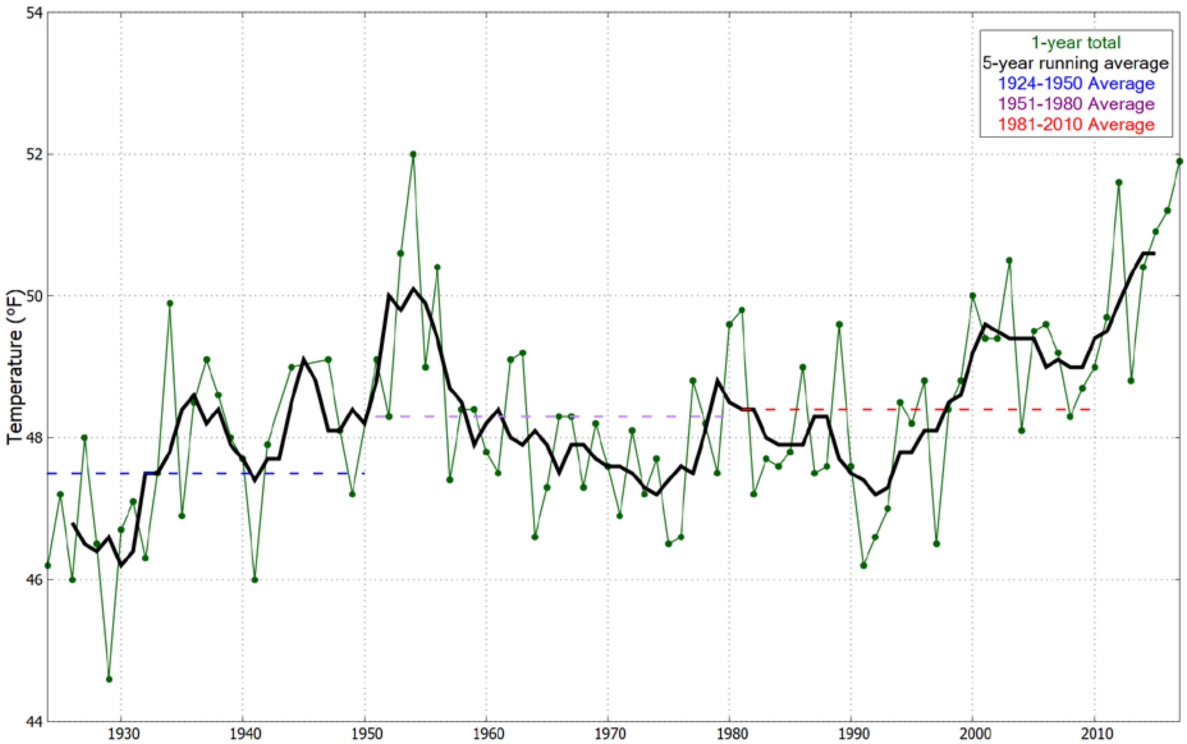


Figure 2-2 Annual average temperatures for Los Alamos

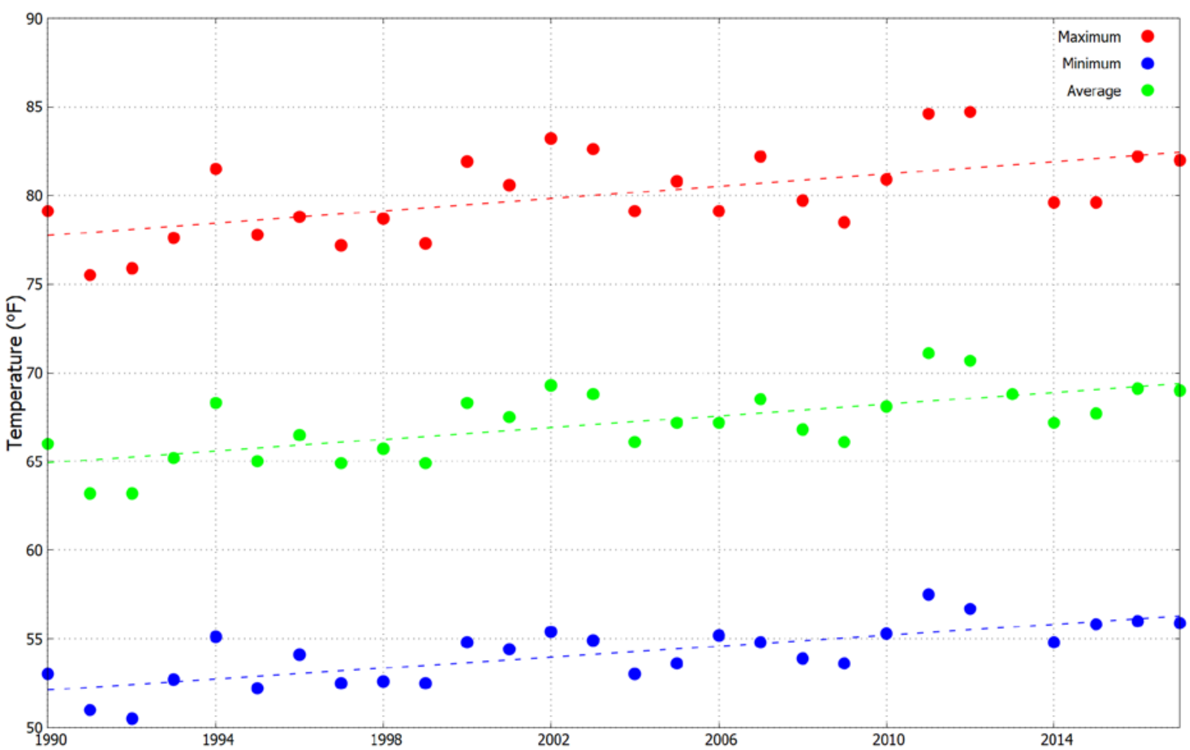


Figure 2-3 Average summer (June, July, August) Los Alamos temperatures

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.

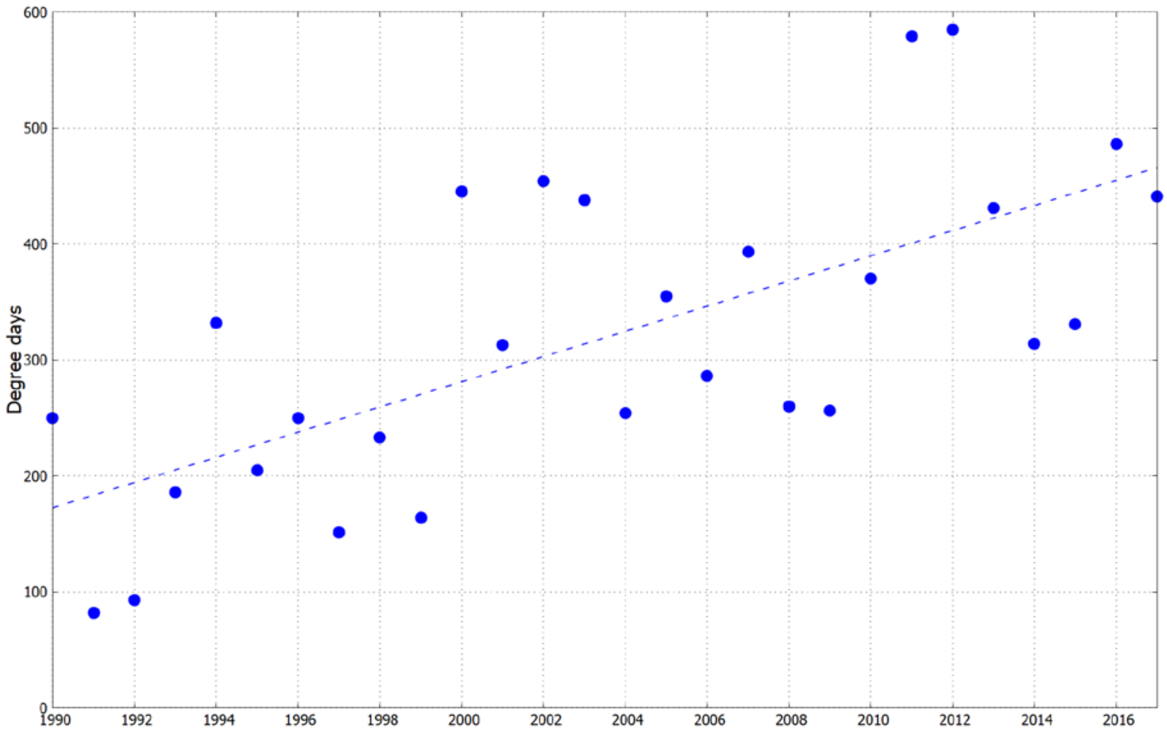


Figure 2-4 Los Alamos cooling degree days

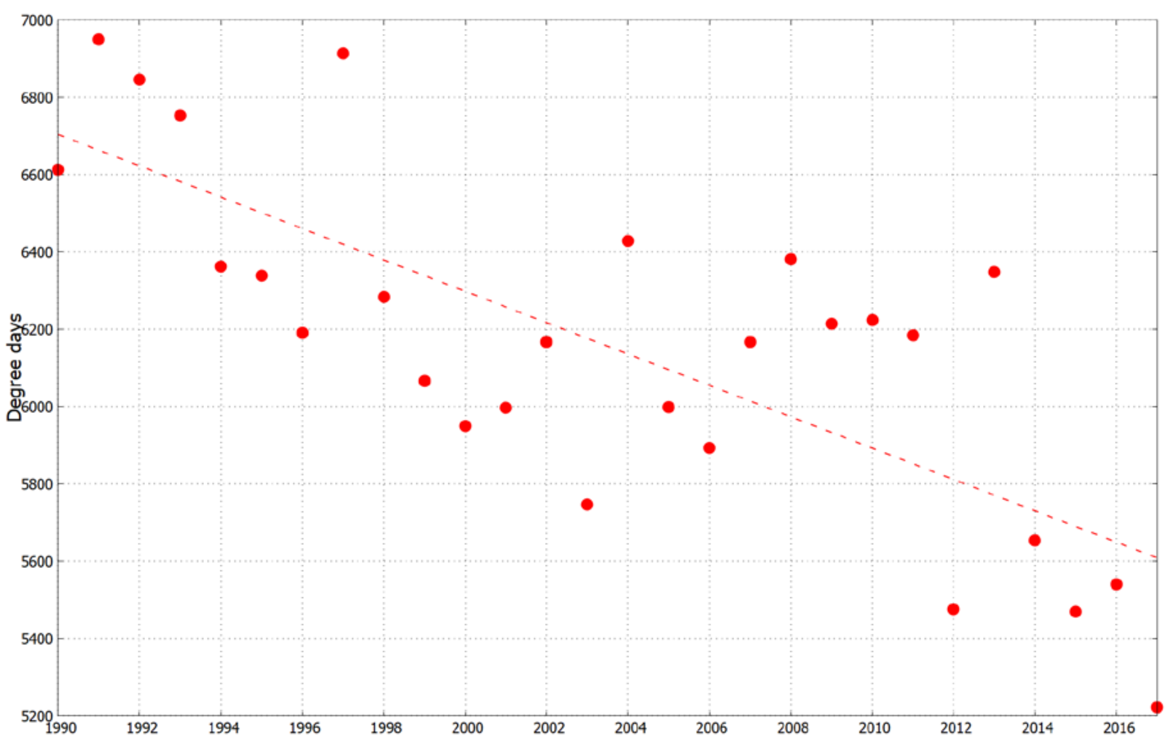
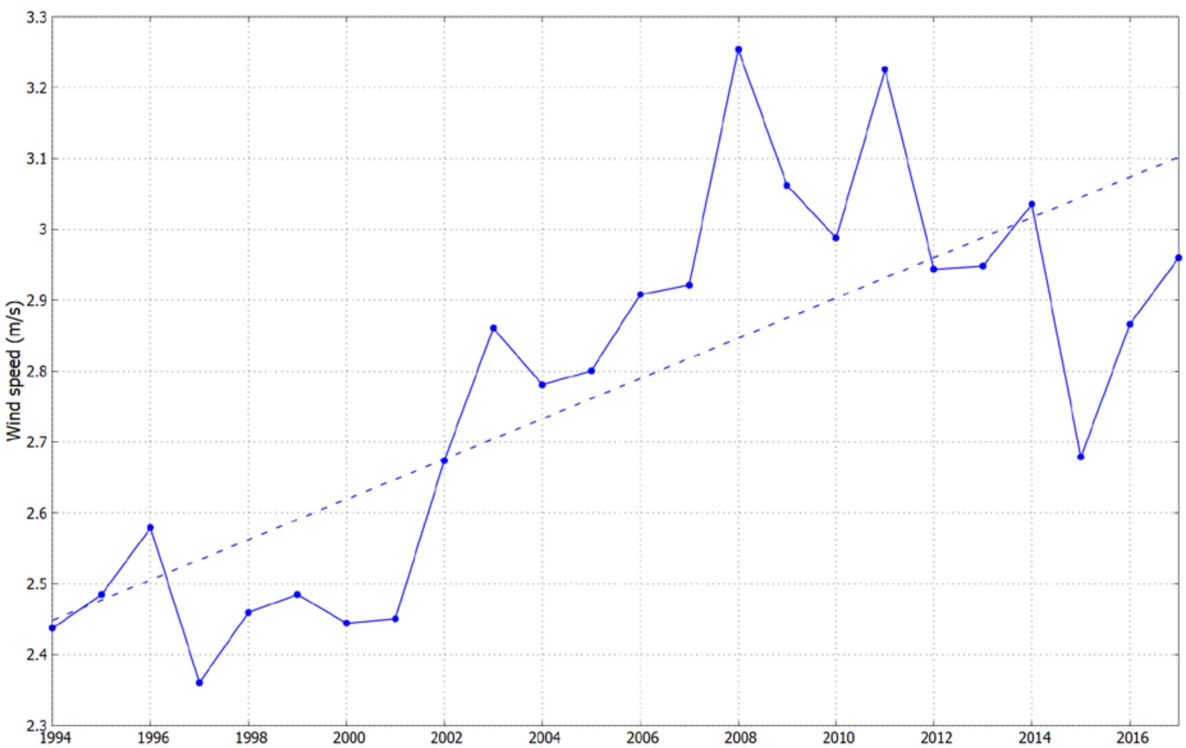


Figure 2-5 Los Alamos heating degree days

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

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). 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 of 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)**

Precipitation

We analyzed the annual average precipitation and the number of days per year with heavy rain events (Figure 2-8). 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.

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 over the past 50 years. 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) does not demonstrate a significant long-term trend. However, since the drought began in 1998, there have been only 3 years with above-average recorded snowfall (1981–2010 average = 57 inches).

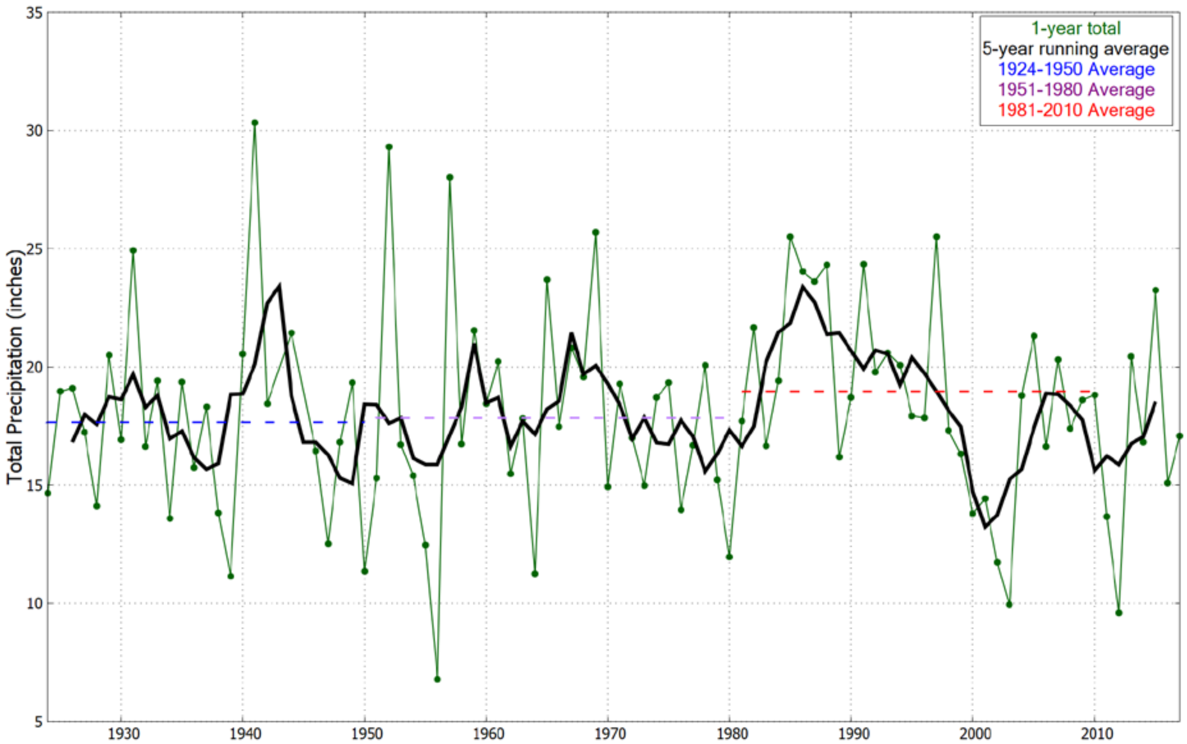


Figure 2-8 Annual precipitation totals for Los Alamos

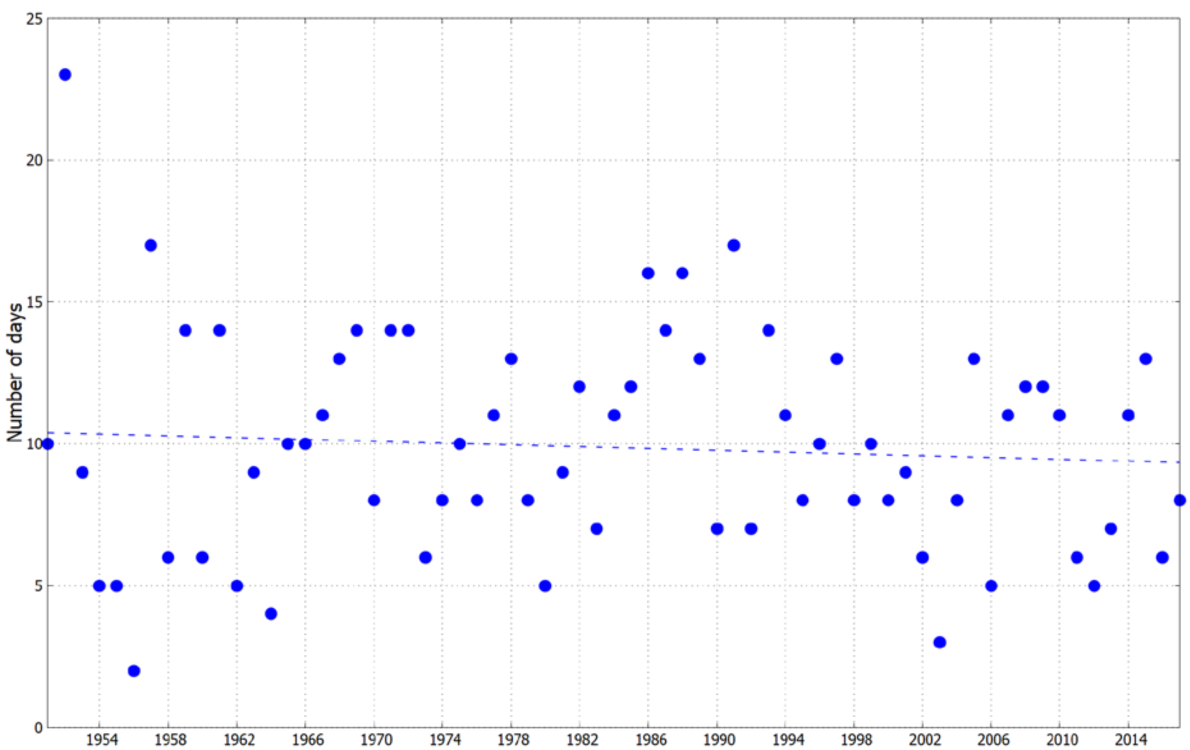


Figure 2-9 Number of days per year with precipitation >0.5 inches

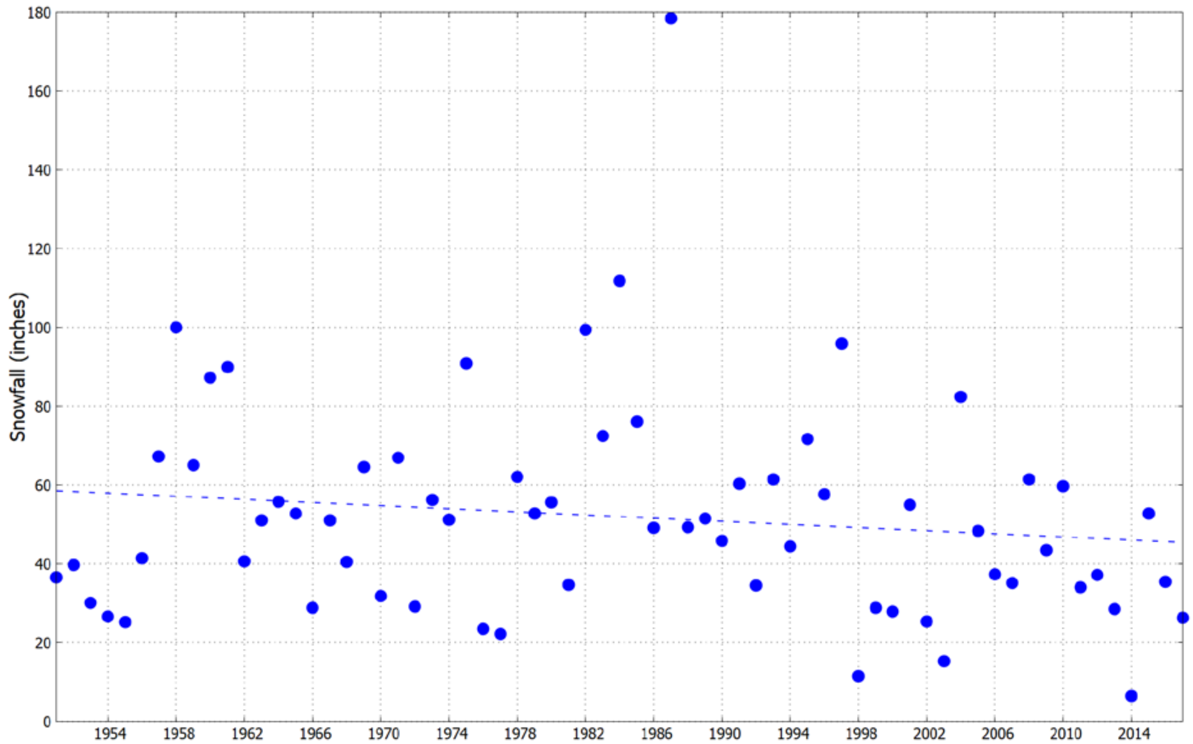


Figure 2-10 Annual average Los Alamos snowfall

Benthic Macroinvertebrates

The purpose of monitoring a benthic macroinvertebrate community is to provide an indication of the water quality within a water system (EPA 1998). Changes in benthic macroinvertebrate communities can serve as effective indicators of environmental changes and stress (Hilsenhoff 1987). Three studies have been completed since 2009 along the Rio Grande upstream and downstream of the Laboratory (LANL 2015). Each study measured the number of organisms, species richness, and species diversity. The data are presented as an average of both reaches within the Rio Grande in Table 2-15. There is no apparent trend in three years of sampling.

Table 2-15
Sampling Results for Benthic Macroinvertebrates

Year, Method, and Number of Sampled Sites	Abundance per Square Mile	Species Richness per Square Mile	Diversity Index
2009, rock basket, 10 sites	80	4.4	2.5
2011, kick net, 12 sites	173	3.2	1.4
2014, kick net, 15 sites	84	5.7	3.5

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 United States. The average temperatures are predicted to rise by 2.5 °F – 5.5 °F by 2041–2070, and the temperatures measured at Los Alamos indicate that our data 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. Our Los Alamos 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. Our data do 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. The Laboratory has been impacted by two major wildland fires in recent years: one in 2000 (Cerro Grande fire) and one in 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.

At this time, we do not see trends in the benthic macroinvertebrate community in the Rio Grande.

UNPLANNED RELEASES

Air Releases

There were no unplanned air releases during 2017.

Liquid Releases

No unplanned releases of radioactive liquids occurred on Laboratory property in 2017.

We made 13 reports of unplanned nonradioactive liquid releases made to the New Mexico Environment Department in 2017, as required by the New Mexico Water Quality Control Commission regulations (Table 2-16). Potable water discharge volumes included in Table 2-15 were calculated from the discharge rate for the known duration of the release when the start time of the release could not be precisely determined. Corrective actions were taken for all liquid releases and were communicated to the New Mexico Environment Department. All reportable releases from 2017 have received administrative closure from the New Mexico Environment Department except for a release of rinse water at the chromium extraction well CrEX-2. A request for closure for this release has been submitted by the Laboratory to the New Mexico Environment Department.

Table 2-16
2017 Unplanned Water Releases

Material Released	Number of Instances	Approximate Total Release (gallons)
Potable Water	7	80.56
Cooling Tower Water	1	1000
Drilling Fluid	1	300
Well Rinse Water	1	100
Sanitary Wastewater	1	400
Cooling system water	1	50
Diesel fuel	1	20

SUMMARY OF PERMITS AND LEGAL ORDERS

The following table (Table 2-17) presents the environmental permits and legal orders the Laboratory operated under in 2017.

Table 2-17
Environmental Permits and Legal Orders under which the Laboratory operated during 2017

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. The 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. http://www.wipp.energy.gov/library/Information_Repository_A/Directives_from_the_Secretary/FINAL_Principles_of_Agreement_4_30_15.pdf	Issued December 6, 2015 Settlement Agreement and Stipulated Final Order issued on January 22, 2016	None	New Mexico Environment Department
Administrative Order No. 5-19001	An order directing the Laboratory to develop and implement a nitrate salt–bearing waste container isolation plan and provide regular updates about nitrate salt–bearing waste containers to the New Mexico Environment Department. https://www.env.nm.gov/documents/LANLOrder5-19001.pdf	Issued May 19, 2014 Modified on July 10, 2014; April 27, 2015; May 8, 2015; and August 12, 2015	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. 2005 Compliance Order on Consent https://www.env.nm.gov/HWB/documents/LANL_10-29-2012_Consent_Order_-_MODIFIED_10-29-2012.pdf 2016 Compliance Order on Consent https://www.env.nm.gov/wp-content/uploads/2015/12/LANL_Consent_Order_FINAL.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

Table 2-17 (continued)

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 February 27, 2015	February 27, 2020	New Mexico Environment Department

Table 2-17 (continued)

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	
Clean Water Act, Section 404/401 Permits	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.	Effective March 19, 2017 (all current nationwide Section 404 permits) – a previous version was in effect until March 18, 2017.	March 18, 2022 (all current nationwide Section 404 permits)	U.S. Army Corps of Engineers and New Mexico Environment Department (all permits and verifications)
	• North Ancho SMA-2.5	Permit verification received February 1, 2017. Project completed May 10, 2017.		

Table 2-17 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
	• Burning Ground Treatment Removal	Permit verification received March 6, 2017. Project completed June 30, 2017.		
	• SWSC Spring Treatment Removal	Permit verification received March 13, 2017. Project completed May 5, 2017.		
	• Martin Spring Treatment Removal	Permit verification received March 10, 2017 Project completed May 4, 2017		
	• Mortandad Wetland Enhancement	Permit verification received June 2, 2017 Project completed August 28, 2017.		
	• Sandia Canyon (Lower) Area 1	Permit verification received December 14, 2017.		
	• Sandia Canyon (Lower) Area 2	Project verification received December 13, 2017.		
	• Upper Ancho Canyon	Permit verification received December 13, 2017.		
	• North Ancho Canyon Lower Structure	Permit verification received December 14, 2017.		

Table 2-17 (continued)

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Clean Water Act, Section 404/401 Permits (cont.)	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	 Annual monitoring and reporting required through 2019 Annual monitoring and reporting required through 2021 Annual monitoring and reporting required through 2022		
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 – a previous version expired on 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

Table 2-17 (continued)

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 Previous permit issued July 20, 1992, and administratively continued until the current permit issued	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	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	New Mexico Environment Department

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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."

INTRODUCTION

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

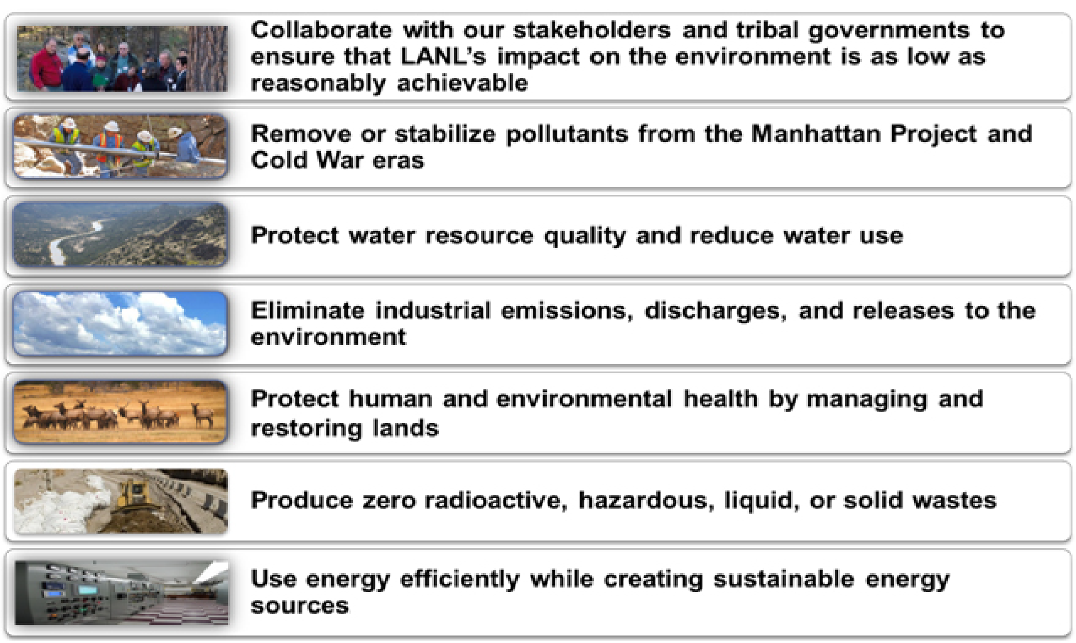

Figure 3-1 Environmental Grand Challenges—The Laboratory's goals for a sustainable future

We establish objectives and targets pertaining to these seven grand challenges through the Laboratory's certified 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 2017.

INSTITUTIONAL PROCESSES

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

The Laboratory's Environmental Management System was certified under the International Organization for Standardization's new 14001:2015 Environmental Management System standard in 2017. We have maintained independent, third-party certification under the International Organization for Standardization's 14001 standard since April 2006. To maintain certification, we have regular self-assessments and external audits. Certification is renewed at three-year intervals and previously has been renewed in 2009, 2012, and 2015. Transition to the new standard reset the Laboratory's three-year certification cycle and the next certification is anticipated in 2020.

The Principal Associate Director for Operations is the senior manager responsible for environmental performance at the Laboratory. This individual chairs the Environmental Senior Management Steering Committee. 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 2017.

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

Control the Present

- Continue to maintain and improve the Laboratory's environmental and waste management compliance programs
- Support the Supplemental Environmental Projects associated with the Waste Isolation Pilot Plant Settlement Agreement

- Ensure that integrated work management includes environmental controls to prevent unacceptable impacts or noncompliance
- Implement pollution prevention and federal sustainability requirements, including the Laboratory's Site Sustainability Plan
- Continue integrated operations initiatives to improve environmental performance:
    - Implement the enduring waste management strategy
    - Implement and maintain the site cleanup and workplace stewardship program, including establishing managed storage
    - Establish green maintenance standards for the Laboratory, and review and update standards annually
    - Implement and maintain integrated site planning
- Facilitate selection of DOE-approved sustainable products by increasing awareness and modifying ordering systems

Create a Sustainable Future

- Develop and deploy new environmentally sustainable technologies
- Implement and bring to closure the development of an integrated, geospatial governance model within a consolidated geographic information system for Laboratory operations
- Implement identified controls for adaptation to climate change
- Implement the new Cultural Resources Management plan for the Laboratory
- Employ the long-term strategy for environmental stewardship and sustainability and execute the annual work plan

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 2017, 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 2017, we developed and tracked 302 actions in 15 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

Environmental Aspects	Description	Examples
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
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.	• 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	Building 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 • Building structures 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
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, as well as 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)

Environmental Aspects	Description	Examples
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/historical resource disturbance	Activities that impact or have the potential to impact cultural or historical 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
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) nonhazardous and nonradioactive waste intended for disposal at a municipal or industrial waste landfill.	• Laboratory, machining, and process operations wastes (nonhazardous or nonradioactive) • Non-recyclable waste, for example, some office waste and some construction and demolition debris
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 activities • Remediation activities • Demolition activities • Open-detonation activities

Environmental Aspects	Description	Examples
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
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, o an exhaust system with high-efficiency particulate air filtration for airborne particulates or o 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. Findings from two external certification audits and one internal assessment during 2017 generated actions that supported the Laboratory's transition from the 2004 to the 2015 International Organization for Standardization's 14001 Environmental Management Systems standard. 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 develops initiatives that support the Grand Challenges, reduce costs, and reduce environmental liabilities. Specific target areas for projects include green chemistry, optimized water use, green procurement, and support for the Site Sustainability Plan. The Pollution Prevention program also

- compiles the hazardous waste minimization report required by the New Mexico Environment Department hazardous waste facility operating permit,
- works in conjunction with the Site Cleanup and Workplace Stewardship Program to prevent equipment and materials from becoming waste whenever possible, and
- funds Laboratory workers to conduct pollution prevention projects that are expected to reduce creation of waste or have some other significant environmental benefit.

What is green chemistry and green procurement?

Green chemistry is the design and use of chemicals and chemical processes in a way that avoids the creation of toxins and waste.

Green procurement is the purchase of products and services that minimize environmental impacts.

In 2017, the Laboratory Pollution Prevention Award program was paused for reorganization as the Patricia E. Gallagher Environmental Awards and will return in 2018 with a renewed emphasis on sustainability and source reduction.

In fiscal year 2017, pollution prevention projects realized an estimated cost avoidance of $4.5 million. Activities and outcomes included the following:

- Recycled more than 615 tons of mixed paper, cardboard, plastic bottles and cans, more than 970 tons of other metals, and more than 2420 pounds of batteries
- Eliminated offsite shipments of Sanitary Waste Water System sludge through composting and onsite use
- Prevented releases of sulfur hexafluoride (an extremely potent greenhouse gas) by repairing leaks and improving monitoring
- Protected wildlife by installing solar-powered roadside crossing warnings in high-traffic locations, installing more than 75 bear dumpsters throughout the site, and improving habitat for two endangered species: the Jemez Mountains salamander and the Mexican spotted owl
- Installed energy-efficient light-emitting diodes to replace outdoor uses of high-pressure sodium vapor lamps and mercury vapor lamps

The following are brief descriptions of some of the funded projects in fiscal year 2017.

- Replace mineral acids with ammonium bifluoride

  Historically, the Laboratory has used mineral acids for debris dissolution in nuclear forensics. This project explores the use of micro x-ray fluorescence spectrometry as a prescreening tool prior to sample digestion as well as the effects of using ammonium bifluoride as a digestion reagent for debris dissolution. This project has the potential to eliminate the use of hydrofluoric acid and related hazardous waste, as well as reducing the potential for worker exposure to a radiation dose.

- Determine if manipulation of water at very high pressure and temperatures can induce the precipitation of heavy metals

  Reducing the total volume, the dissolved solids content, or both in the Laboratory's liquid waste streams could significantly impact the amounts of water used, the amount of treatment needed, and disposal costs. This is true of both the radioactive liquid waste streams and those containing metals of environmental concern, such as chromium.

- Investigate the use of a filterless technology called ultrasonic separation and investigate its potential for treating water containing transuranic waste

  Wastewater that is unresponsive to standard treatment approaches is thought to contain suspensions of transuranic particles that are very hard to remove due to their small size. When waste streams are unresponsive to treatment, chemical additives such as ferric sulfate are used, which generate very large volumes of solid waste. Ultrasonic separation acts quickly to drive small particles together and create aggregates that are more easily removed, reducing waste volumes and costs.

Site Sustainability

The Laboratory is taking action to prepare for future mission work, replace aging infrastructure, and meet its growing demand for electricity. We are focused on using new technology and deep analysis to implement sustainable solutions. Major initiatives include replacement of the current steam plant with a new, more energy efficient plant that will produce both heat and power; developing a 10-megawatt photovoltaic system; and implementing the Smart Labs program to enhance our energy efficiency in existing laboratory spaces. Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*, and the DOE Strategic Sustainability Performance Plan detail sustainability goals for the Department, including the following:

- Planning, executing, evaluating, and continually improving operations to maximize sustainable use of energy and water
- Developing cost-effective energy efficiency and renewable energy projects
- Improving the performance of existing facilities and planning for net-zero energy, water, and waste in facilities

- Replacing existing energy sources with energy sources that emit low levels of greenhouse gases
- Preventing pollution and reducing or eliminating the generation of waste
- Planning for climate resiliency

LANL prepared the fiscal year 2018 Site Sustainability Plan (LANL 2017a) to describe progress toward the goals established in this Executive Order and the DOE Site Sustainability Performance Plan. We focus on three primary strategies: make targeted investments, transparently track our progress through metrics, and engage employees and programs at all levels in the organization. The intent of the Sustainability Program is to include energy and water conservation and cleaner production measures into everyday business practices.

Successes and Challenges

The 2018 Site Sustainability Plan builds on fiscal year 2017 accomplishments and outlines fiscal year 2018 actions that enable the Laboratory to continue progress toward DOE's sustainability goals and reporting requirements. Successes from 2017 include the following:

- The Laboratory has 34 facilities that are High Performance Sustainable Building candidates with an average of 90 percent compliance with guiding principles. Eleven of these buildings are 100 percent compliant with the guiding principles.
- We upgraded building automation systems from old pneumatic control systems to digital controls in three facilities.
- We completed recommissioning efforts in five facilities.
- The Sanitary Effluent Recovery Facility sent over 27 million gallons of reclaimed wastewater to the Strategic Computing Complex for reuse within its cooling towers.
- SkySpark software was implemented in six additional buildings to maintain energy savings by identifying issues needing attention.
- We continued working on the Smart Labs Program for safety and energy efficiency in Laboratory space. We added more buildings to the program and performed assessments to identify useful upgrades.
- We piloted new tablet software for energy and water audits called EMAT.
- We continued work on the new 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 was able to maintain steady energy intensity performance even though an additional 400 employees were hired. Although we did not meet the annual target of a 5 percent energy intensity reduction, we placed major emphasis on implementing the Smart Labs, building automation systems, and recommissioning programs. Developing long-term initiatives supports meeting the DOE fiscal year 2025 greenhouse gas emission reduction goals and will better position the Laboratory to adapt and compete for future mission work. Our sustainability investments are designed to reduce growth in energy demand while supporting hiring and mission growth.

Through investments in the smart lab buildings, building automation systems, lighting, and other efficiency projects, the Laboratory plans to achieve the following goals in fiscal year 2018:

- Maintain, at least, the energy intensity levels
- Reduce water use below 2017 water usage

More information on the Laboratory's Site Sustainability Plan is available at http://www.lanl.gov/environment/sustainability/goals/index.php.

Site Cleanup and Workplace Stewardship Program

Materials and equipment abandoned after projects are completed, programs end or staff retire are a recurring institutional problem. The Laboratory has established the Site Cleanup and Workplace Stewardship Program to assist with the disposition of these items and to prevent similar issues from occurring in the future. The program partners with the responsible organizations to develop work plans, clean indoor and outdoor spaces, and consult on sustainable housekeeping practices. They also develop tools and processes to implement cleanup efficiently and to prevent future issues.

In 2017, the Site Cleanup and Workplace Stewardship Program

- continued the initiative to improve management of storage structures at LANL, including
  - validating the owning organization and location of approximately 1400 storage structures,
  - attaching bar codes to the storage structures and assigning an individual owner in the Laboratory's property management system,
  - adding a point-of-contact sign to each storage structure,
  - working with the owning organizations to clean out and remove unneeded storage, and
  - cleaning out and removing over 30 structures in fiscal year 2017 as part of this initiative; and
- funded approximately 25 cleanup projects across the Laboratory, including
  - established a controlled staging area for shielding materials at the Los Alamos Neutron Science Center and moved 250,000 tons of shielding into this area;
  - finalized the cleanup on Mercury Road, which included installation of a controlled gate, fencing, and signage to discourage using the area for storage and staging of material and equipment;
  - continued with Phase 3 of the Sigma Mesa (Technical Area 60) cleanup by removing unneeded maintenance material such as sheet metal, flooring, concrete and wood. Established a controlled staging area for dumpsters and sent three truckloads of broken dumpsters for metal recycle;

- drained and recycled over 25 broken refrigeration units; and
- established an official laydown yard for the packaging and transportation team. This helps ensure all equipment is co-located in a controlled and monitored area, reducing theft and increasing efficiencies for the team.

Greenhouse Gas Reduction

In fiscal year 2017, LANL achieved a 37 percent reduction in Scope 1 & 2 greenhouse gas emissions compared to the FY 2008 baseline. 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 & 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 & 2 emissions by 12,500 metric tons of carbon dioxide annually.

Integrated Project Review

Any new or modified activity or project 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 into excavation, fill, and soil disturbance permitting and permits and requirements identification. Work owners or planners enter their project information, and subject matter experts identify the applicable permits and requirements for the work. During 2017, 906 projects at the Laboratory were reviewed for excavation, fill, and soil disturbance, and 215 projects were reviewed for permits and requirements identification.

The Integrated Project Review program coordinates environmental subject matter expert reviews and interacts with work owners and planners. The goal of this program is to identify environmental requirements during the early stages of a project so that requirements can be addressed, permits can be obtained, and projects can proceed on schedule. The program is represented by subject matter experts from the following Laboratory compliance programs: Air Quality, Biological Resources, Cultural Resources, Environmental Health Physics, 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 championed the integration of project review processes and improvements into the Integrated Review Tool. Beginning in 2016, an environmental requirements summary is generated for all reviewed projects to improve communication of environmental requirements to workers in the field. Improvements to the excavation portion of the tool and process continued in 2017, including expanding the allowable number of areas to be mapped and reviewed in a single project. This significant improvement has meant that those who submit up to 20–30 review requests per year in order to capture activities such as mowing along established roadways at LANL or fire roads mitigation across LANL 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 efficiency for repeat users of the tool.

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 and 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 routine reporting.

We are authorized to operate air-emission sources 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, degreasing, data destruction (paper shredder), and a small asphalt batch plant. Each source type has its own emission limits for both criteria pollutants (nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter and volatile organic compounds), 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. In addition, the New Mexico Environment Department inspects the Laboratory annually for compliance.

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. During 2017, 26 stacks were continuously sampled for the emission of radioactive materials to the air.

What is a stack?

A *stack* is the vertical chimney or pipe that releases the gas products of industrial processes to the environment.

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. During 2017, we operated 43 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 (discussed further in Chapter 2). The Laboratory conducts environmental surveillance monitoring on base flow, storm water flow, and deposited sediments (Chapter 6).

In 2017, we continued the process for renewal of the individual permit for storm water discharges. The individual permit renewal application was submitted to the U.S. Environmental Protection Agency on March 27, 2014. A draft permit was issued on March 19, 2015. The current permit has been administratively continued until a new final permit is issued.

What is an outfall?

An *outfall* is the location where a pipe releases the liquids produced from industrial processes to the environment.

During 2017, the Laboratory conducted work pursuant to four 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, and injection of treated groundwater into the aquifer through six underground injection control wells.

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, and we continued operation of the Buckman Direct Diversion project early notification system for storm water flows through Los Alamos Canyon into the Rio Grande. Additionally, canyon performance reports for the Los Alamos/Pueblo Canyon watershed and the Sandia Canyon wetland were submitted to the New Mexico Environment Department to document effectiveness of installed sediment-control measures.

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 at the Technical Area 46 Sanitary Waste Water System Compost Facility. Full-scale operations began in late 2014. The final 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 40 Code of Federal Regulations Part 503. As a result of this project, sewage biosolids will no longer be transported offsite for landfill disposal.

In 2017, the facility produced 12 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 November 2017, we submitted a revised compost registration request and notification of process change. 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 for prehistoric and historic cultural resources, resulting in the identification of more than 1,800 sites. Nearly 79 percent of the Laboratory's cultural resources are Ancestral Puebloan sites that date from the thirteenth, fourteenth, and fifteenth centuries. Ancestral Puebloan sites, Homestead period sites, and Laboratory buildings used during Manhattan Project and Cold War periods (1943–1990) are potentially eligible for the National Register of Historic Places. Eligible sites and buildings, whether or not they are listed on the register, and those yet to be evaluated are protected under federal law.

Current cultural resources management initiatives include

- completing the survey of DOE land and
- completing eligibility evaluations of the Laboratory's historic buildings.

Cultural resources staff prepared a revised Cultural Resources Management Plan to implement the requirements in the updated Programmatic Agreement for the management of cultural resources at the Laboratory. The State Historic Preservation Office, the Advisory Council on Historic Preservation, and the National Nuclear Security Administration Los Alamos Field Office concurred on the Programmatic Agreement in August 2017.

During 2017, cultural resource staff conducted archaeological site recording and marking for a wide variety of ground-disturbing projects and completed archaeological site assessment reports for the Environmental Restoration Operable Unit 1144 and the Technical Area 49 Training Facility Expansion project, wildfire hazard reduction projects, and a Laboratory paleoseismic trenching project on U.S. Forest Service land. The condition of Nake'muu Pueblo was assessed and photographed in September 2017. Cultural resource staff supported monthly technical meetings with the Pueblo de San Ildefonso and with Santa Clara Pueblo and joint quarterly environmental meetings with the Pueblo de San Ildefonso, Santa Clara Pueblo, Cochiti Pueblo, and Jemez Pueblo. Five cultural resource staff members received Wildland Fire Red Card training and certification to support emergency operations in case of wildfire on Laboratory property. Cultural resource staff conducted seasonal monitoring of recreational use trails in Technical Areas 70 and 71 and of DOE preservation easements in Pueblo Canyon.

In 2017, historic buildings specialists supported decontamination and decommissioning projects in several technical areas. They completed the Technical Area 46 assessment report for a decontamination and decommissioning project and the report for reevaluation of two buildings at Technical Area 16, conducted archival photography of buildings in Technical Area 16, and completed interior archival photography of the Pulsed High-Energy Radiographic Machine Emitting X-Ray facility prior to electrical power and utilities being cut. They continued working with the Bradbury Science Museum to integrate the Laboratory's historic artifacts into the museum's catalog system.

Manhattan Project National Historical Park

Legislation creating the Manhattan Project National Historical Park was passed on December 19, 2014. The Manhattan Project Park consists of units at Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. As of 2017, park resources at Los Alamos consist of 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), and the "Fat Man" weapon (the bomb detonated over Nagasaki). Eight additional Laboratory buildings and structures, identified in the park legislation, are considered "park-eligible" properties.

This year, cultural resources staff worked with NNSA Site Representatives and National Park Service staff on various assessment and repair projects at park and park-eligible properties under an Interagency Agreement. LANL cultural resources staff also facilitated site visits for National Park Service and DOE Legacy Management.

Repair and interpretive projects were top priorities. Routine surveillance and maintenance inspections were conducted at all park and park-eligible properties, and repair work was carried out at Technical Area 22's Quonset Hut and at Technical Area 16's V-Site. A historic railroad gate at Technical Area 8's Gun Site was restored using new lumber and original hardware, and additional research and survey work was conducted as part of the continuing documentation of Manhattan Project-era implosion firing sites at the Laboratory and in nearby Bayo Canyon. A new history exhibit entitled "Manhattan on the Mesa: Manhattan Project Park Properties at Los Alamos" was developed in conjunction with New Mexico Highlands University's program in interactive cultural technology and was installed in the Bradbury Science Museum.

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 and operations 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, live on the site and are monitored annually.

2017 Accomplishments

Biologists annually inform and educate the Laboratory workforce about timing and location restrictions on activities to protect threatened and endangered species from disturbance. They also provide information on impacts to migratory birds from vegetation removal projects and other known hazards such as open pipes and bollards.

Laboratory biologists annually conduct surveys for the presence of threatened and endangered species that have habitat on LANL property. Surveys for the Mexican spotted owl confirmed pairs of owls in Mortandad and Three-mile Canyons; however Southwestern willow flycatchers were not confirmed in 2017. Jemez Mountains salamander surveys are generally very limited to avoid damaging their habitat.

Throughout 2017, biological resources staff attended or presented at conferences, workshops, and meetings for professional and educational development, collaboration, and outreach, including The Wildlife Society's national conference, the Avian Electrocution and Collision Prevention Workshop, the New Mexico Avian Conservation Partners Meeting, the Sangre de Cristo Audubon Chapter Meeting, and the New Mexico Ornithological Society Meeting.

LANL biologists supported many projects across the Laboratory. Biologists worked with the U.S. Fish and Wildlife and various Laboratory staff to finalize the consultation and conservation measures for the paleoseismic trenching project. To better understand the fire history of the last 300–500 years, Laboratory biologists collaborated with staff from the United States Geological Survey to get cross-sections from fire-scarred stumps around the Pajarito Plateau. A wetland delineation was completed in Mortandad Canyon to support the supplemental environmental projects described in Chapter 2.

Two mitigation efforts were completed as conservation measures from biological assessments for projects potentially affecting the Mexican spotted owl and the Jemez Mountains salamander. Biologists and other Laboratory staff planted 150 native trees and shrubs in Mortandad Canyon to improve habitat for the Mexican spotted owl. Fences were installed in Los Alamos Canyon above and below the Los Alamos County ice rink to protect occupied Jemez Mountains salamander habitat.

2017 Biological Resources Program Reports and Publications

Reports and publications included the following:

- "2016 Results for Avian Monitoring at the TA-36 Minie Site, TA-39 Point 6, and TA-16 Burn Ground at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-20359 (April 2017).
- "Biological Assessment of the Continued Operation and Expansion of the Water Monitoring Programs at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-20753 (February 2017).
- "Biological Assessment of Changing Habitat Boundaries in Lower Water Canyon and for the Construction of a New Building at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-20797 (February 2017).
- "Floodplain Assessment for the Middle Los Alamos Canyon Aggregate Area Investigations in Technical Area 02 at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-21756 (March 2017).

- "Floodplain and Wetland Assessment for the Mortandad Wetland Enhancement and the DP Dissipater Projects at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-22373 (March 2017).
- "Floodplain Assessment for the North Ancho Canyon Aggregate Area Cleanup in Technical Area 39 at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-22996 (April 2017).
- "Floodplain Assessment for the Upper Cañon de Valle Watershed Enhancement Project in Technical Area 16 at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-27572 (August 2017).
- "Floodplain Assessment for the North Ancho and Lower Sandia Controls Supplemental Environmental Projects at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-30209 (November 2017).
- "Floodplain Assessment for the Non-potable Water Line from the Los Alamos Canyon Reservoir to the Los Alamos Townsite," Los Alamos National Laboratory document LA-UR-17-30141 (November 2017).
- "Wetland Delineation Report for Middle Mortandad Canyon Wetland adjacent to Technical Areas 35, 48, and 55 at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-17-27767 (August 2017).

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 collocated at the Technical Area 49 Interagency Fire Center with members from the U.S. Forest Service and National Park Service. The LANL Wildland Fire Program collaborates with the Los Alamos Fire Department, National Park Service, U.S. 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 fuels 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.

Wildland fire fuel mitigation projects planned or completed in 2017 included the following:

- Mowing grass and shrubs adjacent to major roads around the Laboratory, including New Mexico State Road 4, East and West Jemez Roads, and Pajarito Road
- Conducting tree thinning for defensible space and power line protection at Technical Areas 11 and 16
- Blading to mineral soil and re-contouring 12 miles of fire breaks approximately 60 feet wide
- Grading and repairing approximately 60 miles of fire roads
- Treating a total of 1,500 acres around 202 occupied structures for defensible space
- Retreating approximately 700 acres of fuel treatment units designated for annual maintenance

Waste Management

The Laboratory produces several types of regulated wastes as part of its operations, including low-level radioactive wastes, mixed hazardous and low-level radioactive wastes, transuranic wastes, New Mexico special wastes, and others. Enduring mission wastes at the Laboratory are separate from the legacy wastes (wastes generated before 1999). Legacy wastes became the responsibility of the DOE Office of Environmental Management on October 1, 2015, and legacy wastes are discussed as part of environmental remediation.

Waste minimization efforts have eliminated many sources of radioactive and hazardous waste. Offsite shipping to government and commercial treatment, storage, and disposal facilities has minimized onsite waste disposal. A Transuranic Waste Facility was constructed that allows the staging of transuranic waste for offsite shipment. Replacement of the aging Radioactive Liquid Waste Treatment Facility was approved, and planning and construction have begun on low-level radioactive and transuranic liquid waste facilities.

During 2017, disposal pathways and funding were identified for problematic low-level waste products that have remained at the Laboratory, in some cases for decades. These include radioactive sources, radioactive animal tissues, Culligan water filtration bottles with detectable radioactivity, and a tritium-containing glovebox. Efforts are underway to resolve safety, handling, and disposal issues associated with flanged tritium waste containers.

Remediated Nitrate Salts and Shipments to the Waste Isolation Pilot Plant

During 2017, the Laboratory successfully treated the 60 containers of remediated nitrate salt wastes that were located at Technical Area 54 at the Waste Characterization, Reduction, and Repackaging Facility. This is the waste type that was involved in the radiological release at the Waste Isolation Pilot Plant in 2014. 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 resume transuranic waste shipments to the Waste Isolation Pilot Plant. In 2017, the first transuranic waste was shipped following the new protocols.

Environmental Remediation

In accordance with the 2016 Compliance Order on Consent, the Environmental Remediation Program at the Laboratory 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.) 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 the Laboratory 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 3-2 presents a summary of the reports submitted and site investigations conducted in 2017 under the Environmental Remediation Program in support of the Compliance Order on Consent.

Table 3-2
Summary of Reports Submitted and Site Investigations Conducted in 2017 under the Environmental Remediation Program

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Cañon de Valle TA-14 supplemental investigation report (LANL 2016a)	14	18	The 2012 investigation data for 18 sites proposed for Phase II investigation were reevaluated under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.
Conclusions/Recommendations: There are no potential unacceptable risks or doses to humans under the industrial, construction worker, and residential scenarios; no potential ecological risks for any species evaluated; and the nature and extent of contamination is defined or no further sampling for extent is warranted for 17 sites. The sites are appropriate for corrective actions complete without controls. Delayed investigation is recommended for one active firing site for which no further sampling is currently warranted and which poses no potential unacceptable human health risk under the industrial, construction worker, and residential scenarios and no unacceptable ecological risk. A Phase II investigation work plan will be developed based on the conclusions and recommendations presented.			
Former Los Alamos Inn Property Sites within the Upper Los Alamos Canyon Aggregate Area, investigation report revision 1 (LANL 2017b)	01	10	The former Los Alamos Inn property contains all or parts of 16 solid waste management units and areas of concerns located at former Technical Area 01 within the Upper Los Alamos Canyon Aggregate Area. Of these 16 sites, six have received certificates of completion or no further action designation. Solid waste management units 01-006(b), 01-006(c), 01-006(n), 01-007(a), and 01-007(b) were evaluated in their entirety in this report, while the portions of solid waste management units 01-001(d), 01-001(s), 01-002(a)-00, and 01-006(h) and area of concern 01-003(b) within the former Los Alamos Inn property were evaluated.
Conclusions/Recommendations: There are no potential unacceptable risks or doses to humans under the industrial, construction worker, and residential scenarios; no potential ecological risks for any species evaluated; and the nature and extent of contamination is defined or no further sampling for extent is warranted for 10 sites. The sites are appropriate for corrective actions complete without controls.			
TA-57 Aggregate Area supplemental investigation work plan (LANL 2017c)	57	5	The Technical Area 57 Aggregate Area, located on U.S. Forest Service property west of Los Alamos National Laboratory, includes a total of 10 areas of concern. Of these 10 sites, three sites have previously been approved for no further action and two sites were investigated in 2015. This investigation work plan identifies and describes the activities needed to complete the investigation of the remaining five areas of concern. The objective of this supplemental investigation work plan is to evaluate the historical data and, based on that evaluation, propose sampling to define the nature and extent of contamination associated with the five areas of concern within the Technical Area 57 Aggregate Area.
Lower Sandia Canyon Aggregate Area supplemental investigation report (LANL 2017d)	20, 53, 72	17	The 2011 investigation data for 17 sites proposed for Phase II investigation were reevaluated under the Compliance Order on Consent framework agreement (January 2012), and the results are presented in this supplemental investigation report.
Conclusions/Recommendations: There are no potential unacceptable risks or doses to humans under the industrial, construction worker, and residential scenarios; no potential ecological risks for any species evaluated; and the nature and extent of contamination is defined or no further sampling for extent is warranted for 13 sites. The sites are appropriate for corrective actions complete without controls. Additional sampling is needed to define the extent of contamination at four sites, but pose no potential unacceptable human health risk under the industrial, construction worker, and residential scenarios and no unacceptable ecological risk. A Phase II investigation work plan will be developed based on the conclusions and recommendations presented.			
North Ancho Canyon Aggregate Area accelerated corrective action report (LANL 2017e)	39	3	The accelerated corrective action report presents the result of the investigation and cleanup activities conducted in the North Ancho Canyon Aggregate Area in accordance with the Phase II Investigation work plan.

<table>
<tr><th>Document/Activity</th><th>Technical Area</th><th>Number of Sites</th><th>Sampling and Remediation</th></tr>
<tr><td colspan="4">Conclusions/Recommendations: Analytical data from confirmation sampling indicate PCB concentrations were below 1.0 milligrams per kilogram at the former waste stockpile areas at solid waste management units 39-001(a) and 39-001(b), the former capacitor staging areas at solid waste management unit 39-001(a), and at solid waste management unit 39-007(a). In addition, lead concentrations and uranium-238 activities were below the residential soil screening level for lead and the screening action level for uranium, respectively, at the former waste stockpile area at solid waste management unit 39-001(a); and semivolatile organic compound concentrations are below residential soil screening levels at the former waste stockpile area at solid waste management unit 39-001(b). All cleanup objectives were met and no further corrective actions are required at these sites.</td></tr>
<tr><td>Upper Los Alamos Canyon Aggregate Area sampling and remediation</td><td>01</td><td>7</td><td>Sampling and remediation of sites within the Upper Los Alamos Canyon Aggregate Area, particularly sites associated with the former Los Alamos Inn property, were conducted. Approximately 133 cubic yards of plutonium-239/240-contaminated soil was excavated at solid waste management units 01-001(g), 01-006(b), 01-007(a), and 01-007(b). In addition, 98 surface and subsurface samples and 10 treated lumber samples were collected from six solid waste management units and one area of concern.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: Remediation was designed to result in no potential unacceptable risk/dose to human health (all scenarios) and the environment. The activities of plutonium-239/240 remaining at the sites within the relevant depth intervals are below the screening action levels and indicate no potential unacceptable dose to human receptors. An “as low as reasonably achievable” analysis for three sites located within the former Los Alamos Inn property indicated the radiation exposures to the public are as low as reasonably achievable and further soil removal is not warranted. The radiation exposures to the public at the other sites within the former Los Alamos Inn property are less than 3 millirem per year and are as low as reasonably achievable per the Laboratory’s As Low As Reasonably Achievable program description. The activities remaining also do not pose a potential risk to plants or wildlife. Details and results of the sampling and remediation were presented in an investigation report on the sites within the former Los Alamos Inn property or will be presented in the Phase II investigation report for the Upper Los Alamos Canyon Aggregate Area. The investigation report on the sites within the former Los Alamos Inn property was submitted to the New Mexico Environment Department in 2017 (LANL 2017b).</td></tr>
</table>

Note: TA = Technical Area

Environmental Health Physics Program

The Environmental Health Physics Program is responsible for providing technical and scientific support for radiation protection of the public and the environment, as outlined in DOE Order 458.1, *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.

What is health physics?

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

DOE Order 458.1 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. We provide 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 Soils, Foodstuffs, and Biota program samples garden and farm products, native vegetation, animals, and soils to determine whether they have detectable levels of radionuclides, inorganic chemicals, or organic chemicals resulting from Laboratory operations. The items sampled include surface soils; locally grown fruits and vegetables; locally-produced eggs, honey, and milk; native plants; game animals; road-killed animals; other animals from terrestrial and aquatic ecosystems; and sediments from the Rio Grande. This data is used in public and biota dose estimates and risk assessments and to monitor for any new releases. The program assesses indicators of ecosystem health by comparing chemical levels in soils, in native plants, and in animals to background levels, screening levels, and effects levels, and by looking at animal population and community characteristics. Most types of samples are collected from onsite, perimeter, and regional background locations, and the results are compared among these locations. The program is described in detail in Chapter 7.

2017 Accomplishments

We assessed aquatic ecosystem health for the Rio Grande. Information on benthic macroinvertebrate communities, sediment and fish chemical concentrations, and sediment toxicity was collected from the Rio Grande upstream and downstream of its confluence of Los Alamos Canyon. Upstream results were compared to downstream results. Additionally, chemical levels in fish collected from Abiquiu and Cochiti reservoirs were evaluated.

Thirteen soil and tree samples were collected around the perimeter of Area G. Soil, sediment, nonviable bird eggs, and deceased nestlings were collected around the Dual-Axis Radiographic Hydrodynamic Test Facility. Small mammals, such as wild mice, were collected upstream of the sediment retention structures in Los Alamos and Pajarito canyons. We submitted tissue samples from 22 animals that were killed by vehicles or other accidents. These included mule deer (*Odocoileus hemionus*), Rocky Mountain elk (*Cervus elaphus nelson*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), black bear (*Ursus americanus*), bullsnake (*Pituophis catenifer sayi*), and birds of prey such as red-tailed hawk (*Buteo jamaicensis*), western screech owl (*Megascops kennicottii*), and great horned owl (*Bubo virginianus*).

The Soils, Foodstuffs, and Biota program conducted three special studies in 2017: aquatic life surveys across the Pajarito Plateau, chemical concentrations in soil and small mammals in the Middle Los Alamos Canyon Aggregate Area at Technical Area 02, and chemical concentrations in nonviable bird eggs and deceased nestlings around firing sites and burn grounds at the Laboratory. Results from 2017 sampling and studies are reported in Chapter 7.

Meteorology Program

DOE Order 458.1, *Radiation Protection of the Public and the Environment,* and DOE Order 151.1D, *Comprehensive Emergency Management System,* state that DOE facilities must measure site meteorological variables. The variables measured are determined by the level of radiological activities, the topography of the site, and distances to critical receptors. The 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, demonstrating regulatory compliance in the areas of air quality, water quality, and waste management, and supporting monitoring programs for surface water and environmental radiation. Weather data can be accessed internally at http://weather.lanl.gov or externally at https://envweb.lanl.gov/weathermachine/. No new weather stations were added in 2017.

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 2017. An updated seismic hazard analysis of the Pajarito fault system around the Laboratory is currently underway and expected to be complete before 2019.

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. To date, 20 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.

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. In 2017, accomplishments included the following:

- Work continued to complete the conveyance of Tracts A-16-b in DP Canyon, A-15-2 (a segment of DP Road), and A-18-2 in Bayo Canyon to Los Alamos County.
- Three tracts (A-16-a, A-5-2, A-5-3) totaling nearly 90 acres were conveyed to Los Alamos County (finalized in January 2018).

AWARDS AND RECOGNITION

The Laboratory was the recipient of a DOE gold-level GreenBuy Award for 2017. 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" that extends beyond minimum compliance requirements. The Laboratory's success was the result of joint efforts from the Acquisition Services Management Division and the Environmental Stewardship Group in Environmental Protection & Compliance Division. Previously, the Laboratory won gold-level recognition in 2016 and 2012 and bronze in 2011, the year the award was launched.

LANL won a pollution prevention award from the National Nuclear Security Administration for a new field method to dissolve solid uranium oxides. Instead of using strong mineral acids for sampling surfaces, LANL scientists discovered that a commercially-available solution of ammonium bifluoride could be used. This development supports nuclear non-proliferation work because it is now easier to detect misuse of nuclear materials around the world.

LABORATORY ENVIRONMENTAL DATA PROCESS

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

The 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. Email notifications are sent to the Sample Management Office indicating the data are ready for us to review and process. 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 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.

Nonanalytical 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 manually applied by LANL.

We treat data collected at locations owned by third parties in accordance with supplementary agreements between the Laboratory and the land owners. 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 via email to the landowners for their information and review. During the review process, the data are withheld from release to IntellusNM. Once the landowner has finished review or the agreed-upon holding time frame has elapsed, the 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. The performing analytical laboratories are required to have a documented quality assurance/quality control program and to participate in 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.

The audits cover data quality and defensibility and ensure the integrity of the analytical laboratory in functional areas such as quality assurance management systems and general laboratory practices, radiochemistry, organic analysis, inorganic and wet chemistry analysis, laboratory information management systems, and hazardous and radioactive material management. The audit rating system documents Priority I Findings (deficiencies from a requirement), Priority II Findings (deviations from a requirement), and Observations (opportunities for improvement). The analytical laboratory is responsible for corrective actions resulting from audit findings. All corrective actions are in the laboratories' documented responses and are evaluated based upon root cause analysis, correction, and prevention from recurrence by the next scheduled audit.

The DOE Consolidated Audit Program's audit reports and corrective actions plans are available through their SharePoint electronic data system. DOE employees and DOE contractor personnel may request access to the electronic data system and receive authorization from the DOE Office of Science, Office of Information Technology and Services.

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. Audits also ensure that quality and reliable data are available for decision-making to support ongoing mission-critical operations and functions, environmental remediation, cleanup projects, and environmental surveillance at the Laboratory.

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LANL 2017c: "Supplemental Investigation Work Plan for Technical Area 57 Aggregate Area (Fenton Hill)," Los Alamos National Laboratory report LA-UR-17-24144 (June 2017).

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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 2017, the emissions from Laboratory operations were far below the applicable regulatory limits.

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).

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, Espanola, 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 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	0 ± 1
Uranium-234	aCi/m^3	7700	11 ± 4
Uranium-235	aCi/m^3	7100	1 ± 1
Uranium-238	aCi/m^3	8300	12 ± 5

pCi/m^3 = Picocuries per cubic meter.

aCi/m^3 = Attocuries per cubic meter.

Air-monitoring Network

During 2017, the Laboratory operated 38 environmental air-monitoring stations to sample radionuclides in airborne particulate matter (Figures 4-1 and 4-2). Sampling locations are categorized as regional, perimeter, onsite, or waste site (TA-54, Area G). 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 40 Code of Federal Regulations 61, Appendix B, Method 114 (EPA 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.

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 2017, tritium concentrations were similar to recent years and well below U.S. Environmental Protection Agency and DOE guidelines (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.

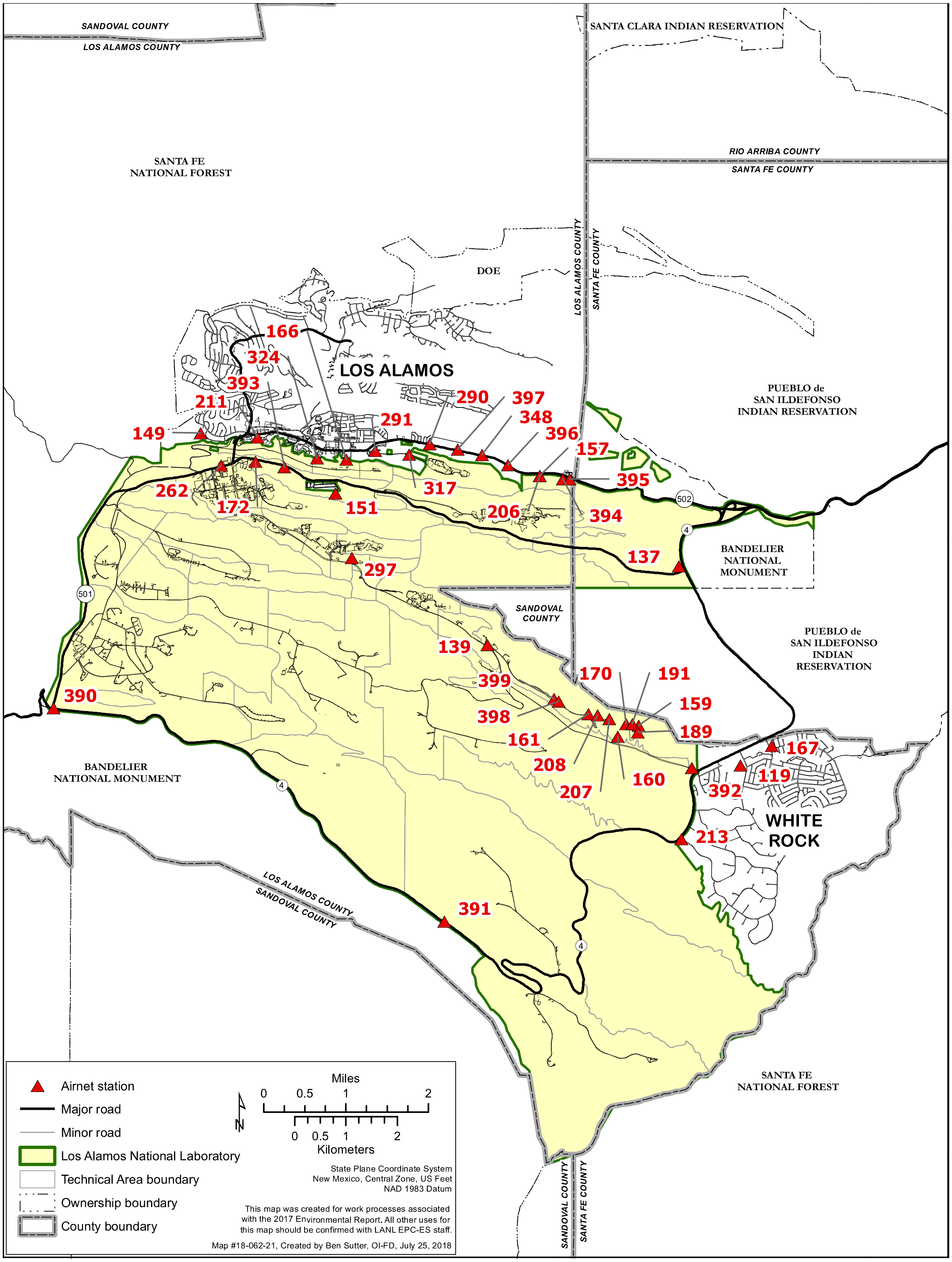
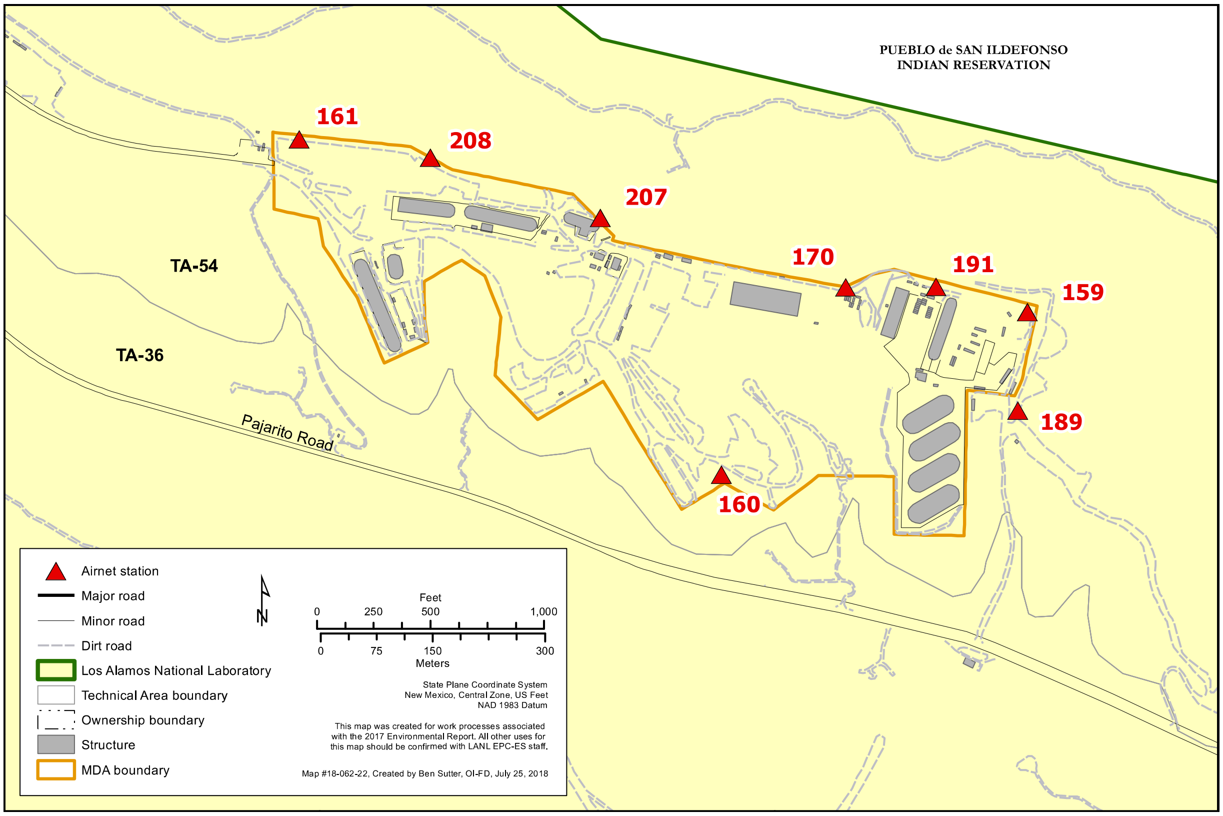


Figure 4-1 Environmental air-monitoring stations at and near the Laboratory



MDA = Material disposal area
TA = Technical area

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

Table 4-2
Airborne Tritium as Tritiated Water Activities for 2017—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	± 2	1	1500
Perimeter	25	2	± 2	4	1500
Onsite	2	7	N/A	13	1500
Waste site	1	610	N/A	610	1500

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 40 Code of Federal Regulations 61, Appendix B, Method 114 (EPA 1989).

Americium-241

Table 4-3 summarizes the 2017 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 2017—Group Summaries

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

Plutonium

Plutonium from global fallout occurs worldwide at low levels. Table 4-4 summarizes the LANL plutonium-238 and plutonium-239/240 data for 2017, which are similar to recent years.

Table 4-4
Airborne Plutonium-238 and Plutonium-239/240 Activities for 2017—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m^3)		Maximum Annual Station Activity (aCi/m^3)	
		Plutonium-238	Plutonium -239/240	Plutonium -238	Plutonium -239/240
Regional	3	0 ± 1	0 ± 1	0	1
Perimeter	25	0 ± 1	2 ± 15	2	39
Onsite	2	0 ± 1	1 ± 1	0	1
Waste site	8	0 ± 1	4 ± 16	2	24

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, 39 attocuries per cubic meter, is 2 percent of the EPA limit. During 2017, the hillside was remediated (Haagenstad 2017) and as a result, future concentrations are expected to be smaller.

Near the historical plutonium facility at Technical Area 21, the plutonium-239 activity was 2 attocuries per cubic meter, which is 0.1 percent of the public dose limit.

Uranium

The isotopes uranium-234, uranium-235, and uranium-238 are found in nature. In natural uranium, uranium-238 activity is generally equal to uranium-234 activity (Walker et al. 1989). Uranium that has been enriched by processing (enriched uranium) has higher levels of uranium-235, and uranium that has been depleted by processing (depleted uranium) has higher levels of uranium-238. Only natural uranium was detected and the activities (Table 4-5) were similar to previous years.

Table 4-5
Airborne Uranium-234, -235, and -238 Activities for 2017—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m^3)		
		Uranium-234	Uranium -235	Uranium -238
Regional	3	11 ± 9	1 ± 1	12 ± 10
Perimeter	25	8 ± 10	1 ± 1	8 ± 11
Onsite	2	6 ± 1	1 ± 1	6 ± 1
Waste site	8	7 ± 6	1 ± 1	6 ± 6

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 facilities 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 40 Code of Federal Regulations 61, Subpart H (EPA 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 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 (EPA 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 discussed in Chapter 8 and amount to less than 1 percent of the regulatory limits.

Table 4-6
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2017. Values are expressed in scientific notation.

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		8.8×10^{-8}	5.6×10^{-7}	2.1×10^{-6}	7.0×10^{-8}		
TA-16-205/450	8.2×10^{1}						
TA-48-001				6.7×10^{-9}		1.9×10^{-2}	
TA-50-001			1.7×10^{-8}	2.9×10^{-7}			
TA-50-069			2.2×10^{-10}		2.8×10^{-10}		
TA-53-003	1.8×10^{1}					2.2×10^{-4}	5.4×10^{1}
TA-53-007	3.7					2.1×10^{-3}	9.4×10^{1}
TA-54-375				2.6×10^{-8}			
TA-54-231/412				1.2×10^{-8}			
TA-55-004	1.7		3.0×10^{-10}	2.2×10^{-7}	2.4×10^{-8}		
Total	1.1×10^{2}	8.8×10^{-8}	5.8×10^{-7}	2.6×10^{-6}	9.4×10^{-8}	2.1×10^{-2}	1.5×10^{2}

Table 4-7
Detailed Results of Activation Product Sampling from LANL Stacks in 2017

Building No.	Nuclide	Emission (curies)[a]	
TA-48-001	Arsenic-73	0.000018	1.8×10^{-5}
TA-48-001	Bromine-76	0.00044	4.4×10^{-4}
TA-48-001	Bromine -77	0.000041	4.1×10^{-5}
TA-48-001	Gallium-68	0.0089	8.9×10^{-3}
TA-48-001	Germanium-68	0.0089	8.9×10^{-3}
TA-48-001	Mercury-197	0.00035	3.5×10^{-4}
TA-48-001	Mercury-197m	0.00035	3.5×10^{-4}
TA-48-001	Selenium-75	0.000029	2.9×10^{-5}
TA-53-003	Argon-41	2.1	2.1×10^{0}
TA-53-003	Beryllium-7	0.000063	6.3×10^{-5}
TA-53-003	Bromine -76	0.0000075	7.5×10^{-6}
TA-53-003	Bromine -77	0.0000025	2.5×10^{-6}
TA-53-003	Bromine -82	0.00011	1.1×10^{-4}
TA-53-003	Carbon-11	52	5.2×10^{1}
TA-53-003	Mercury-197	0.000015	1.5×10^{-5}
TA-53-003	Mercury-197m	0.000015	1.5×10^{-5}
TA-53-003	Sodium-24	0.0000067	6.7×10^{-6}
TA-53-007	Argon-41	7.4	7.4×10^{0}
TA-53-007	Bromine -76	0.000075	7.5×10^{-5}
TA-53-007	Bromine -77	0.00010	1.0×10^{-4}
TA-53-007	Bromine -82	0.0015	1.5×10^{-3}
TA-53-007	Carbon -10	0.27	2.7×10^{-1}
TA-53-007	Carbon -11	38	3.8×10^{1}
TA-53-007	Mercury-197	0.00021	2.1×10^{-4}
TA-53-007	Mercury-197m	0.00021	2.1×10^{-4}
TA-53-007	Nitrogen-13	24	2.4×10^{1}
TA-53-007	Nitrogen -16	0.35	3.5×10^{-1}
TA-53-007	Oxygen-14	0.47	4.7×10^{-1}
TA-53-007	Oxygen -15	23	2.3×10^{1}

[a] 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	6569 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. Thermoluminescent dosimeters are deployed at every environmental air-monitoring station. Additional dosimeters are located at Technical Areas 53 and 54. Neighborhood environmental watch network stations are situated near these areas. The locations are listed in Supplementary Table S4-1.

Naturally occurring gamma radiation varies from 100 millirem per year to 200 millirem per year, so it is difficult to distinguish the much smaller levels of radiation contributed by the Laboratory. Measurements are made at public locations and also close to potential Laboratory sources (McNaughton 2013). Radiation from the Laboratory is identified by higher radiation levels near the source and reduced radiation levels at greater distances.

Dosimeter Locations

Eighty dosimeters are located around the Laboratory and in the surrounding communities. Dosimeters are located at the environmental air stations shown in Figure 4-1, and additional dosimeters are located around Technical Area 54, Area G, as shown in Figure 4-3.

Neutron Radiation

Neutron doses are measured near known or suspected sources of neutrons. 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 Supplementary Table S4-1. Locations with a measurable contribution from Laboratory operations are discussed below.

Los Alamos Neutron Science Center 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.

Technical Area 54, Area G

Figure 4-3 shows the locations of the dosimeters at Technical Area 54, Area G. South of the line of dosimeters from #601 to #608, Area G is a controlled-access area, so the Area G data do not represent a potential public dose.

Dosimeters #642 through #645 are in Cañada del Buey. After subtracting background, the annual neutron dose measured by these dosimeters was 2 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 (NCRP 2005), so the dose in Cañada del Buey at the dosimeters is calculated to be $2/20 \approx 0.1$ millirem per year, which is similar to previous years.

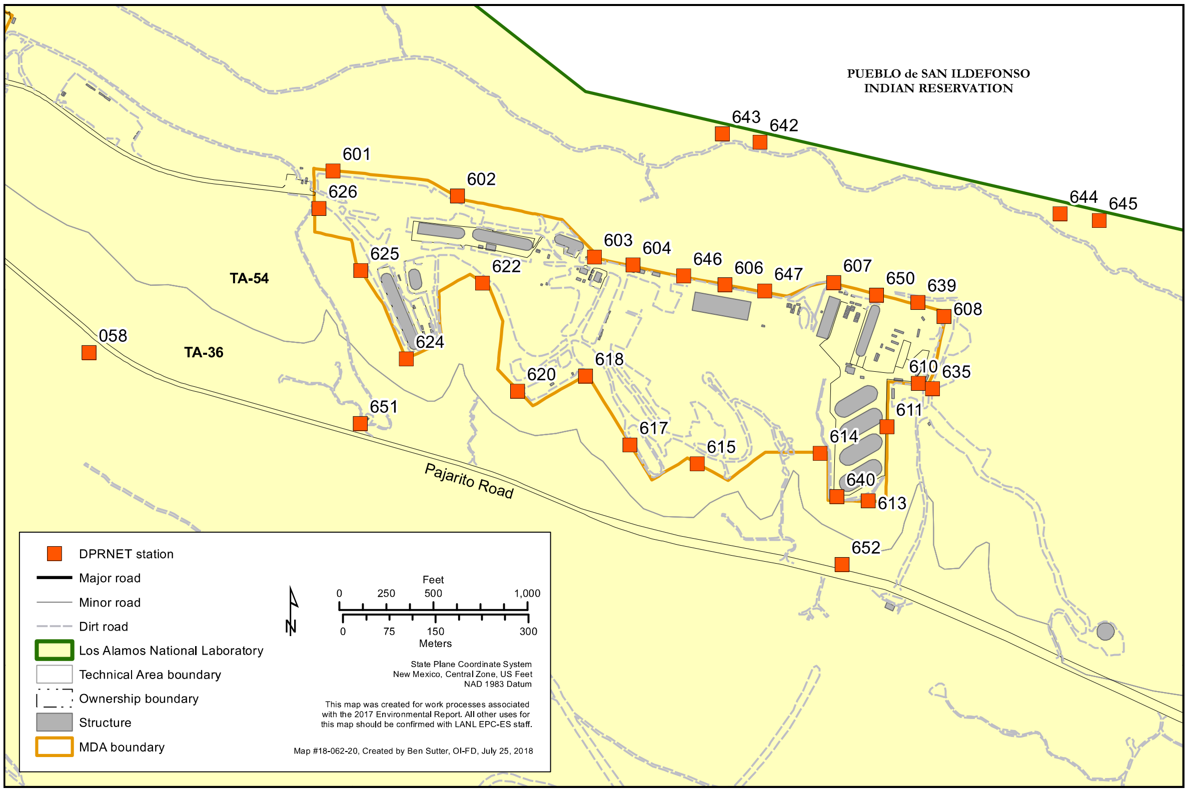


Figure 4-3 Locations of thermoluminescent dosimeters at Area G that are part of the direct-penetrating radiation monitoring network (DPRNET)

Neighborhood Environmental Watch Network

During 2017, the Neighborhood Environmental Watch Network recorded 1 microrem per hour from Technical Area 53 on three occasions: May 15, May 23, and October 20, 2017. Allowing for the possibility that smaller doses could be missed, the data show that the annual public dose from Technical Area 53 was well below 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, though it can be harmful in high concentrations.

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

Ambient Air Particulate Matter Concentrations

During 2017, 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

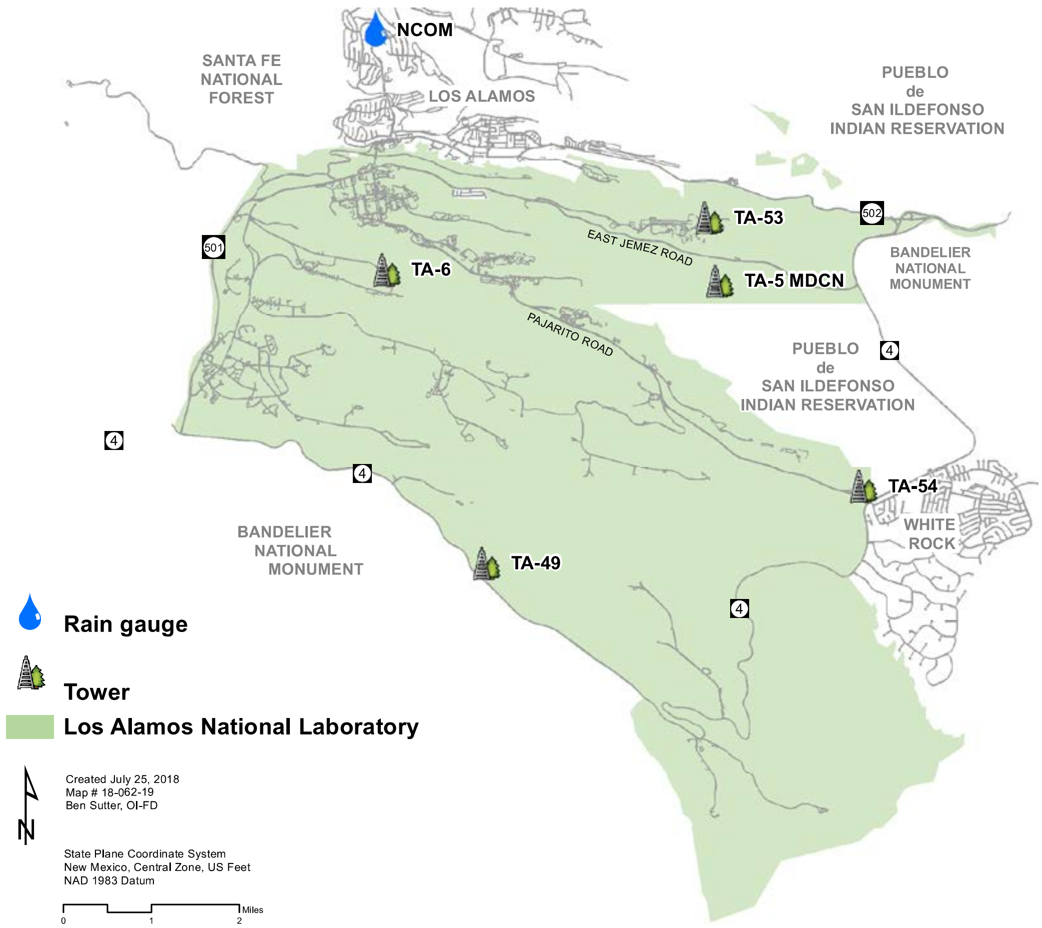
Weather data are important for many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. The meteorological monitoring program measures wind speed and direction, temperature, pressure, relative humidity and dew point, precipitation, cloud cover, and solar and terrestrial radiation, among other factors. 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 http://weathermachine.lanl.gov.

Monitoring Network

Currently, five towers are equipped to gather meteorological data at the Laboratory (Figure 4-4). 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 gauge 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.



MDCN = Mortandad Canyon.
NCOM = North community.

Figure 4-4 Locations of meteorological monitoring towers and rain gauge

Data recorders at the stations read most of the instrument results at predefined intervals (typically something like once per second), 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. 2018). 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 13 exceptions. Eight of the failures were a result of upgrading to a new data logger and a bent connection on the tower at Technical Area 06. Other failures were a result of failed instrument calibrations for wind direction at Technical Area 49 and for wind direction and vertical wind speed at Technical Area 54. These instrument issues have been addressed. Data quality and completeness are reported by Bruggeman et al. (2018).

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 and following 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 2017.

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 Los Alamos's southern latitude, 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 2017 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.

2017 in Perspective

Table 4-10 presents Los Alamos weather values during 2017. Figure 4-5 presents a graphical summary of Los Alamos temperature for 2017 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. All months had above average temperatures, except for May with less than 1 degree below average. In particular, February, March, November, and December had significantly above average temperatures with greater than 6 degrees above average. The last line of Table 4-10 summarizes the year and shows that the overall average temperature was 3.5 °F above the 1981 to 2010 averages and total precipitation was 1.9 inches below the averages. It was the second warmest year on record, 0.1 degrees shy of the record in 1954.

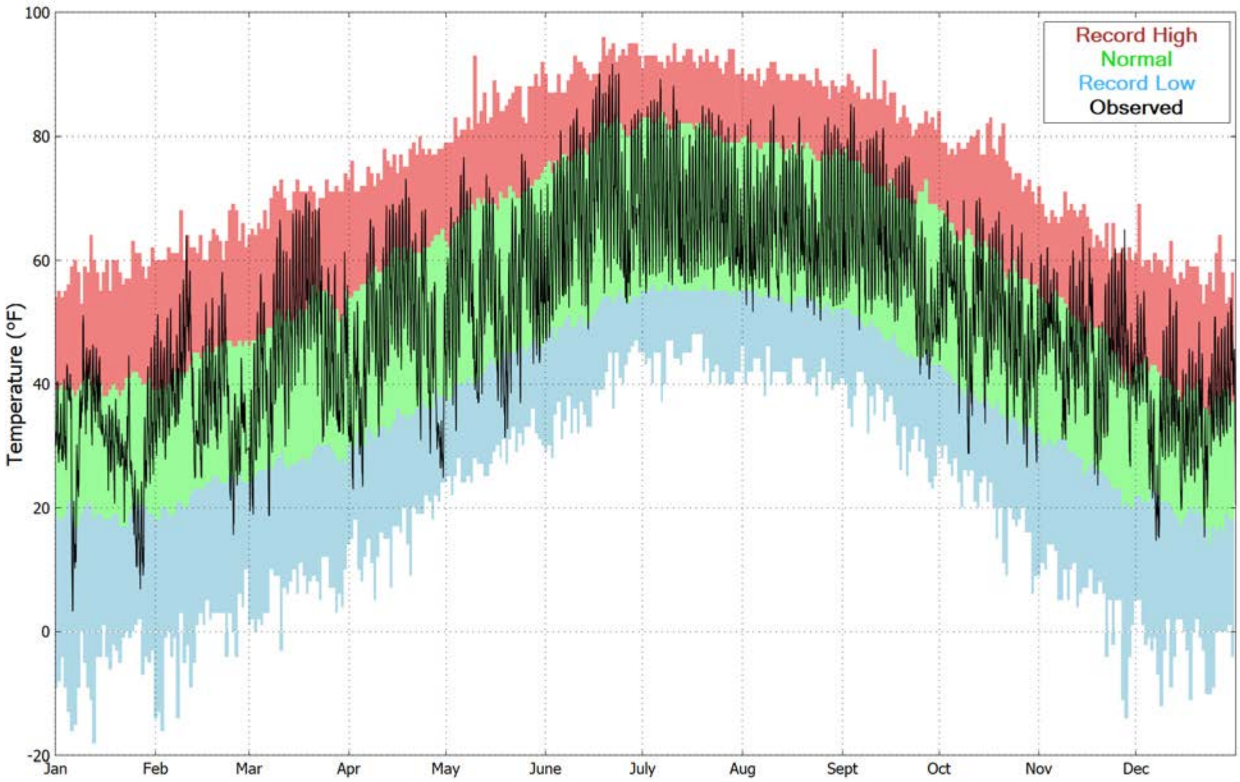


Figure 4-5 **Los Alamos 2017 temperatures in degrees Fahrenheit compared with record values and normal values**

Table 4-10
Monthly and Annual Climatological Data for 2017 at Los Alamos

Month	Temperatures (°F)[a]								Precipitation (inches)[a]				12-meter[b] Wind (miles per hour)[a]				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure[c]	Highest	Date	Lowest	Date	Total	Departure[c]	Total	Departure[c]	Average Speed	Departure[d]	Speed	From	Date
January	38.4	22.4	30.4	1.0	52	9	3	6	2.23	1.28	15.8	2.5	6.2	1.2	51	WNW	21
February	49.2	29.1	39.1	6.2	65	10	15	25	0.56	-0.30	4.3	-6.6	6.5	0.7	43	WSW	23
March	60.3	33.0	46.6	7.2	72	18	17	7	0.70	-0.50	2.3	-8.1	7.4	0.9	52	WNW	25
April	60.7	35.7	48.2	1.4	75	18	22	2	1.33	0.27	3.6	0.3	8.0	0.4	42	WNW	27
May	68.5	42.3	55.4	-0.6	78	24	31	19	0.73	-0.66	0.2	-0.1	7.8	0.4	53	W	13
June	83.3	55.9	69.6	4.5	92	21	46	1	1.91	0.40	0	0	7.7	0.6	45	WSW	5
July	83.8	57.4	70.6	2.4	91	6	54	2	2.07	-0.75	0	0	6.0	0.4	37	NE	4
August	79.1	54.3	66.7	0.9	87	10	50	25	1.55	-2.06	0	0	5.6	-0.1	40	NE	3
September	75.2	50.8	63.0	3.2	87	3	41	25	4.55	2.54	0	0	6.6	0.8	40	WSW	23
October	62.8	38.2	50.5	1.3	71	8	26	28	1.36	-0.19	0	-2.2	6.3	0.3	42	W	9
November	57.2	35.5	46.4	8.6	66	27	23	19	0.06	-0.92	0	-4.9	6.1	0.8	48	W	18
December	47.3	25.1	36.2	6.8	57	3	14	7	0.02	-0.99	0.1	-12.1	5.3	0.8	44	WNW	23
Year	63.8	40.0	51.9	3.5	92	Jun 21	3	Jan 6	17.07	-1.90	26.3	-31.2	6.6	0.6	53	W	May 13

[a] Data from Technical Area 06, the official Los Alamos weather station.

[b] Wind data measured at 12 meters above the ground.

[c] Departure column indicates positive or negative departure from 1981 to 2010 (30-year) climatological average.

[d] Departure column indicates positive or negative departure from 1990 to 2010 (21-year) climatological average.

Figures 4-6 and 4-7 are graphs of Los Alamos precipitation for 2017. Los Alamos started the year with above-average precipitation, but as summer approached, it was significantly dry through the middle of September. The end of 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 17.07 inches of precipitation (1.9 inches below average). The majority of snowfall fell at the beginning of the year from January to April, but only January and April had slightly above average snowfall. From the fall through December, Los Alamos only measured 0.1 inches of snow, the lowest snowfall from fall through December ever on record. The U.S. Drought Monitor determined Los Alamos County had no drought conditions most of the year until the end of November with abnormally dry conditions (http://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 2017 at Technical Area 06 and North Community compared to Technical Area 54.

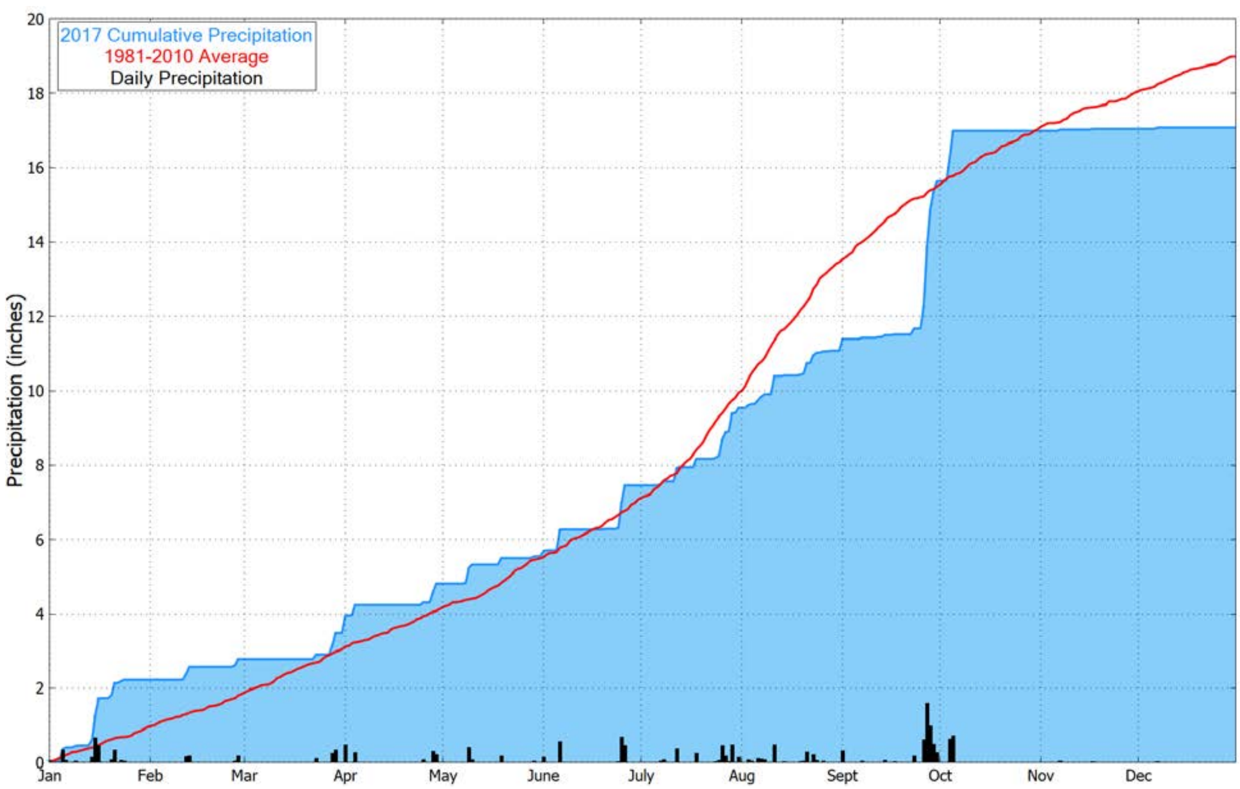


Figure 4-6 2017 Technical Area 06 cumulative precipitation versus 30-year average

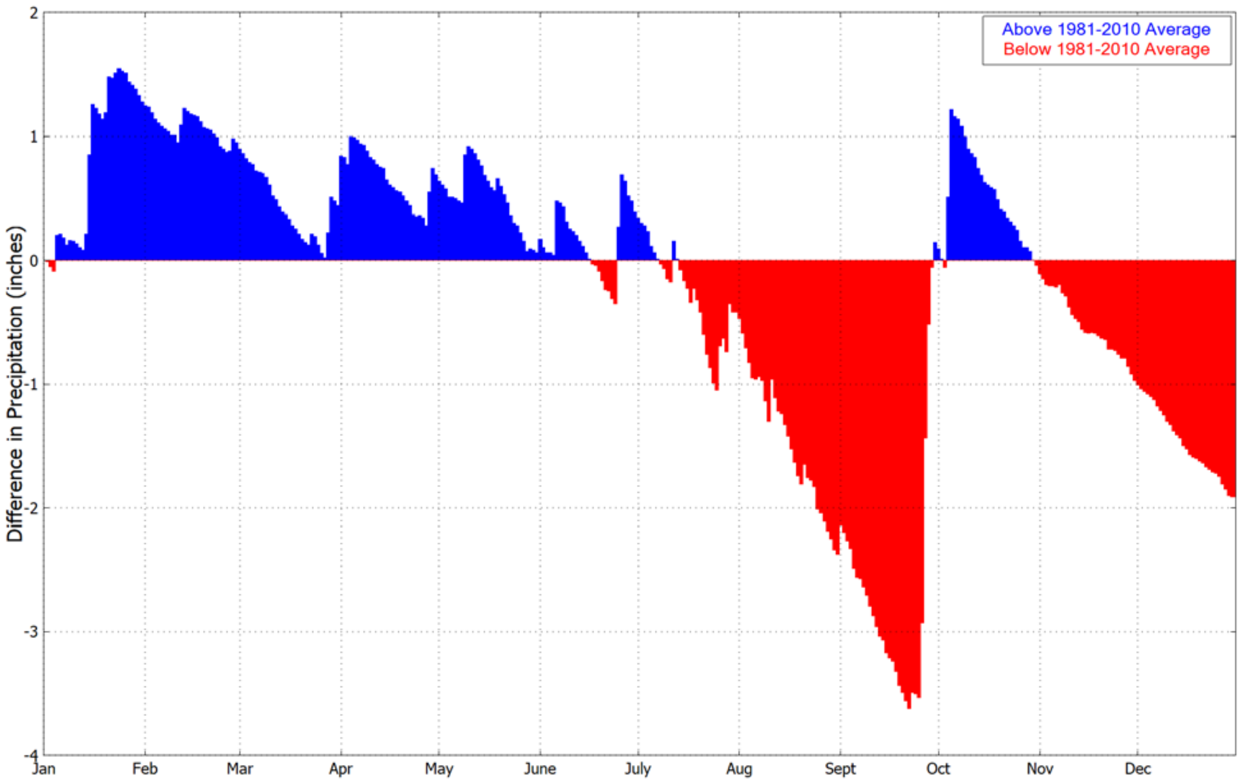


Figure 4-7 Difference between Technical Area 06 precipitation in 2017 and 1981–2010 average precipitation

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 2017 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. 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.

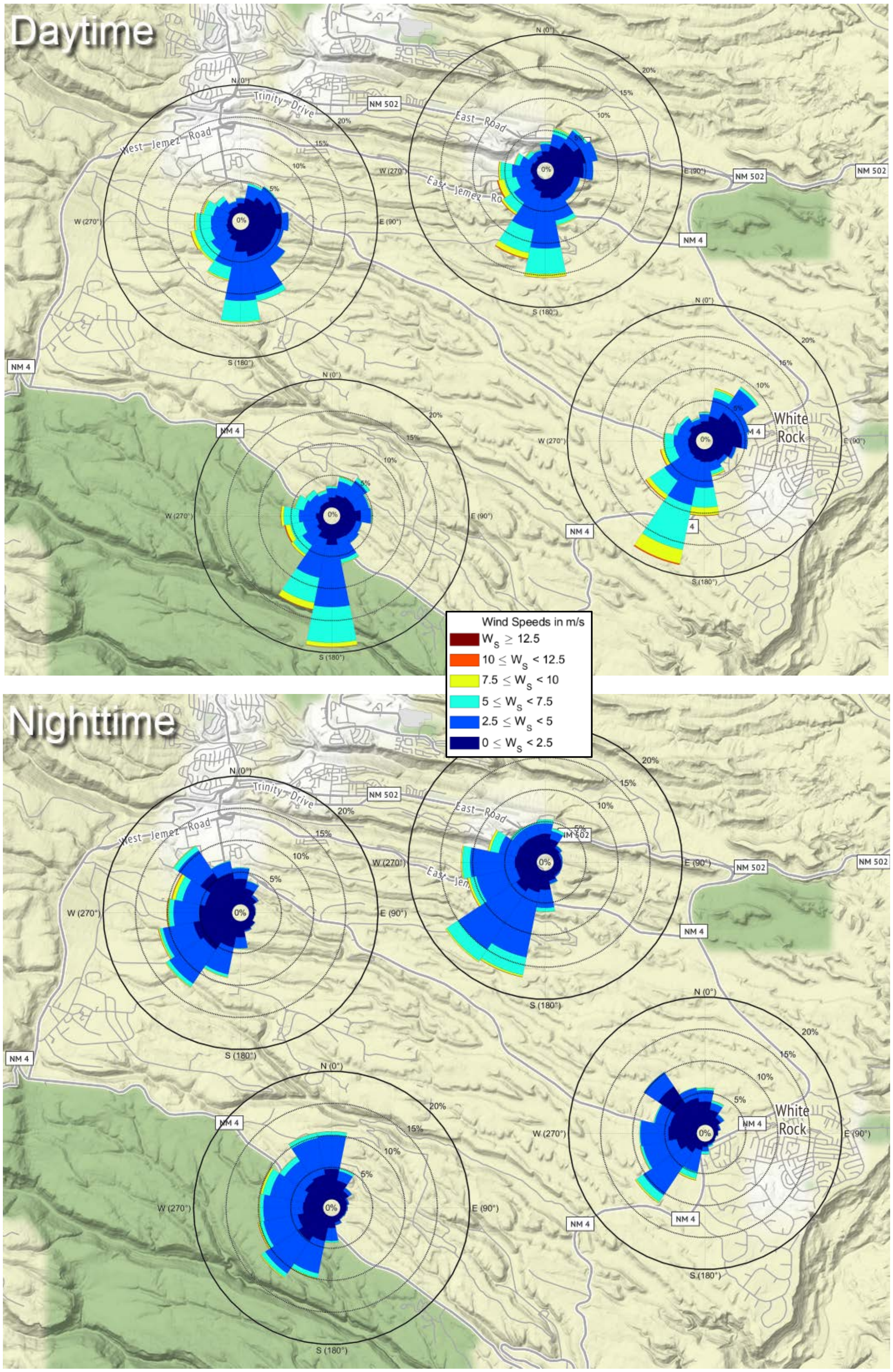


Figure 4-8 Wind roses for 2017 at the four mesa-top meteorological towers

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 2017. 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, it appears that the warm spell during the past 15 years is almost as extreme as 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.

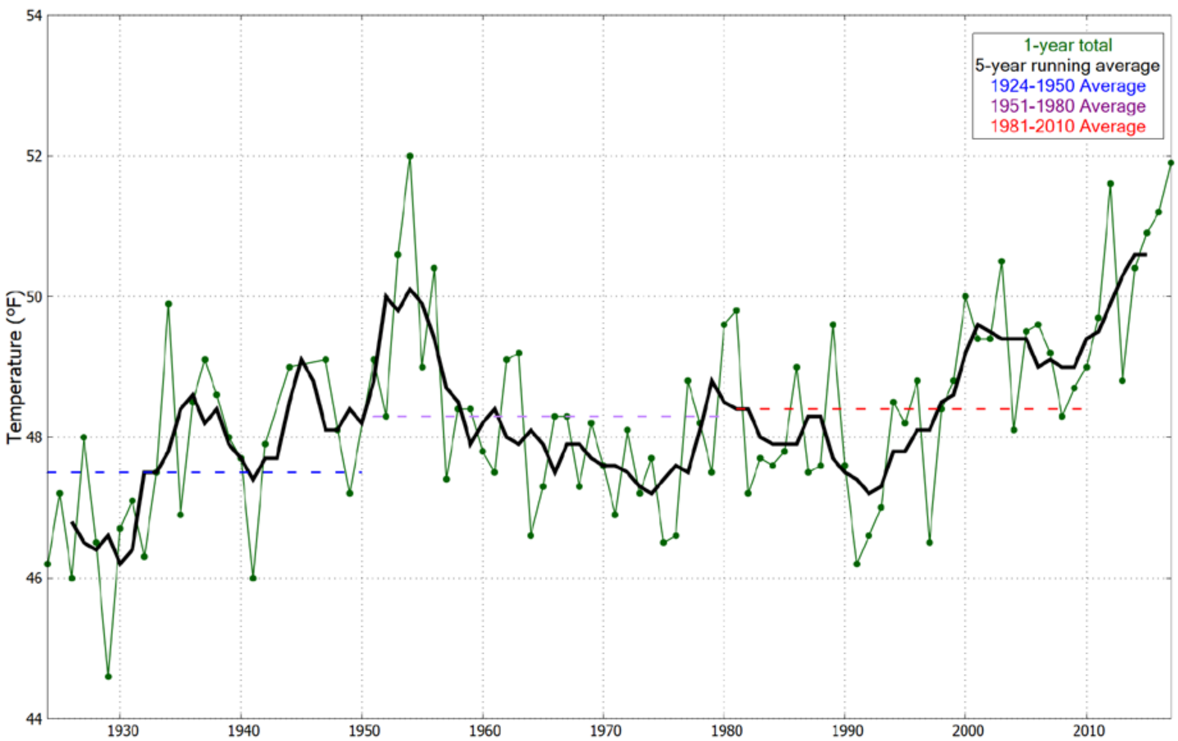


Figure 4-9 Temperature history for Los Alamos

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 2011–2017. 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 can be considered a statistically significantly higher value than previous decades. The annual average temperatures from 2011 to 2017 continue to demonstrate a warmer climate for Los Alamos. This is consistent with predictions for a warming climate in the southwestern United States (IPCC 2014).

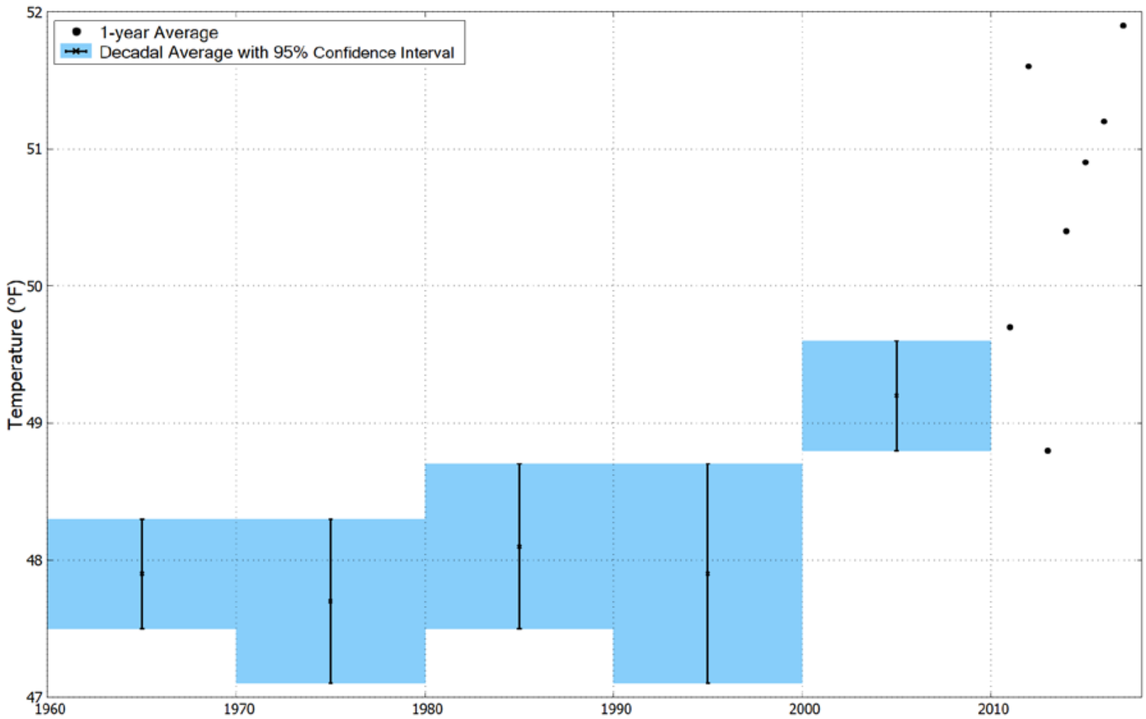


Figure 4-10 Technical Area 06 decadal average temperatures and two times the standard error

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 2017, although near-average precipitation years occurred from 2004 to 2010 and above-average precipitation occurred in 2015.

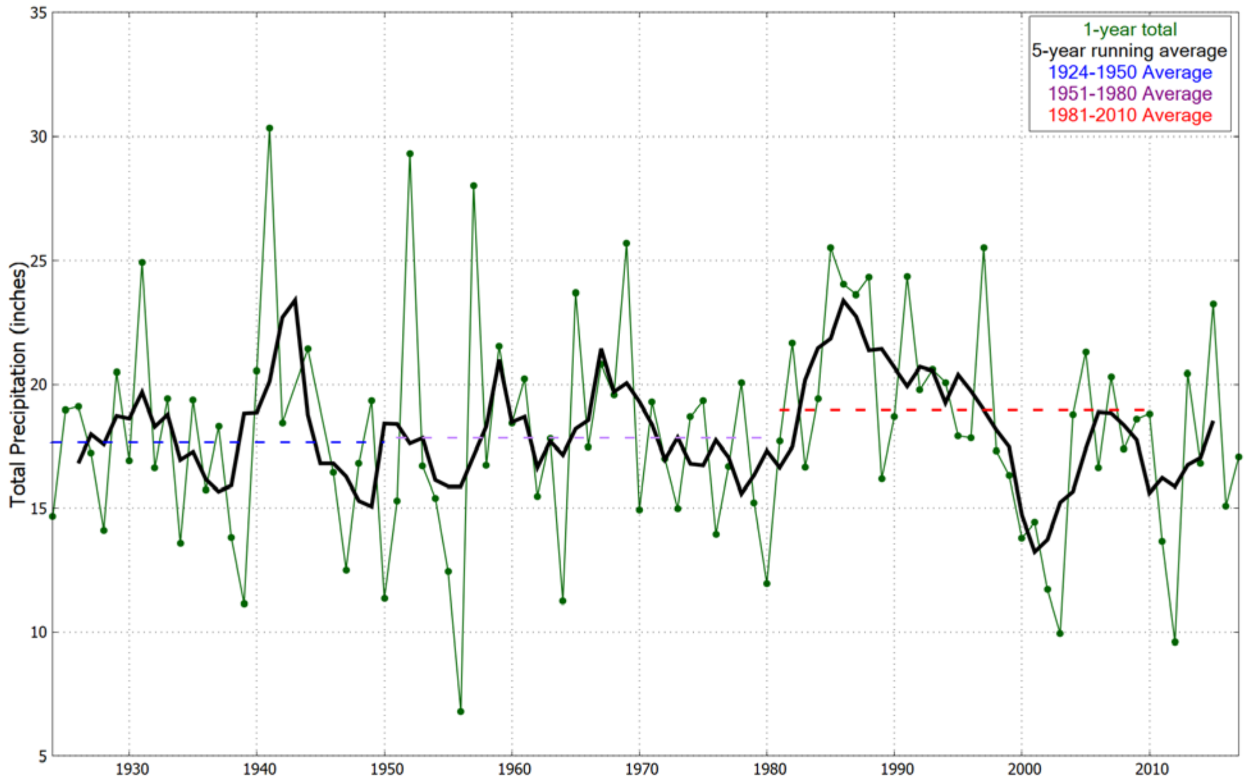


Figure 4-11 Total precipitation history for Los Alamos

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5.0 GROUNDWATER MONITORING

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Los Alamos National Laboratory (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.

Contaminants from historical Laboratory operations are present 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 contaminants and to evaluate and model changes in plume location and concentrations over time. This information guides remedial actions where 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 7.02 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 50 microgram per liter New Mexico groundwater standard.

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.

INTRODUCTION

Los Alamos National Laboratory (LANL, or the Laboratory) routinely monitors local groundwater quality. 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 contamination limits in 40 Code of Federal Regulations 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 substances tested for are updated each year in the plan.

We conducted groundwater monitoring during 2017 in accordance with the 2017 and 2018 Interim Facility-Wide Groundwater Monitoring Plans (LANL 2016, 2017a) approved by the New Mexico Environment Department. The Laboratory's Associate Directorate for Environmental Management collected groundwater samples from wells and from springs within and adjacent to the Laboratory and within nearby Pueblo de San Ildefonso land.

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 detail 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 (Figure 5-1). The Pajarito Plateau extends from the Rio Grande in the east to the Sierra de los Valles range of Jemez Mountains in the west. Rocks that compose Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from ash and other volcanic materials that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. 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 3300 feet thick.

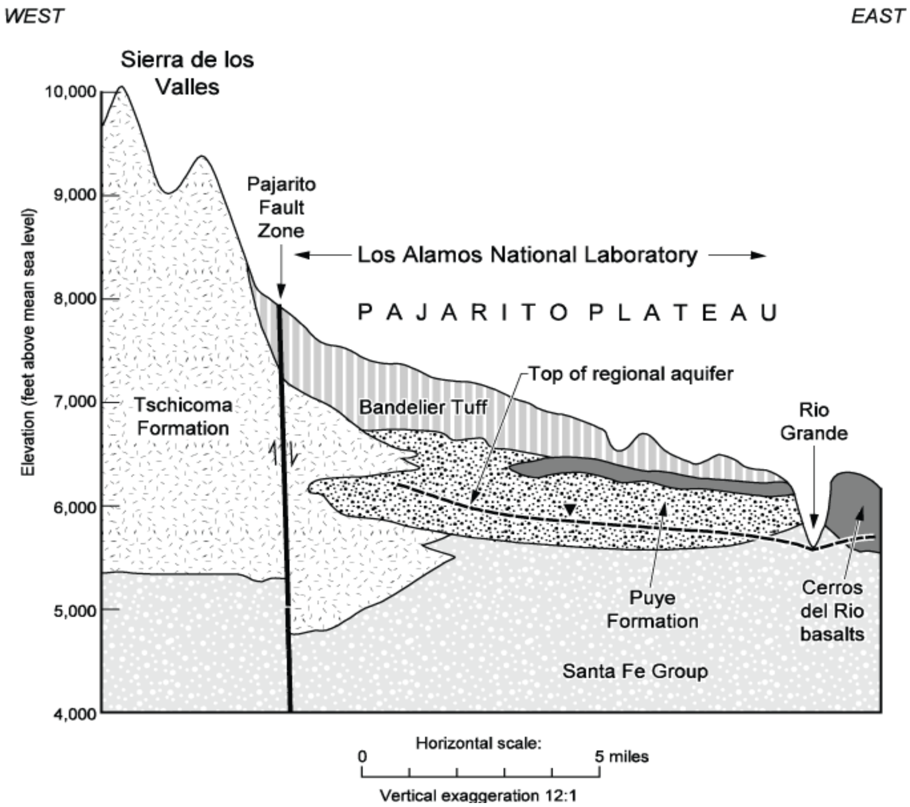


Figure 5-1 Generalized geologic cross-section of the Pajarito Plateau

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

Hydrogeologic Terms

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

Perched groundwater is a zone of saturation of limited extent and 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 the County and Laboratory.

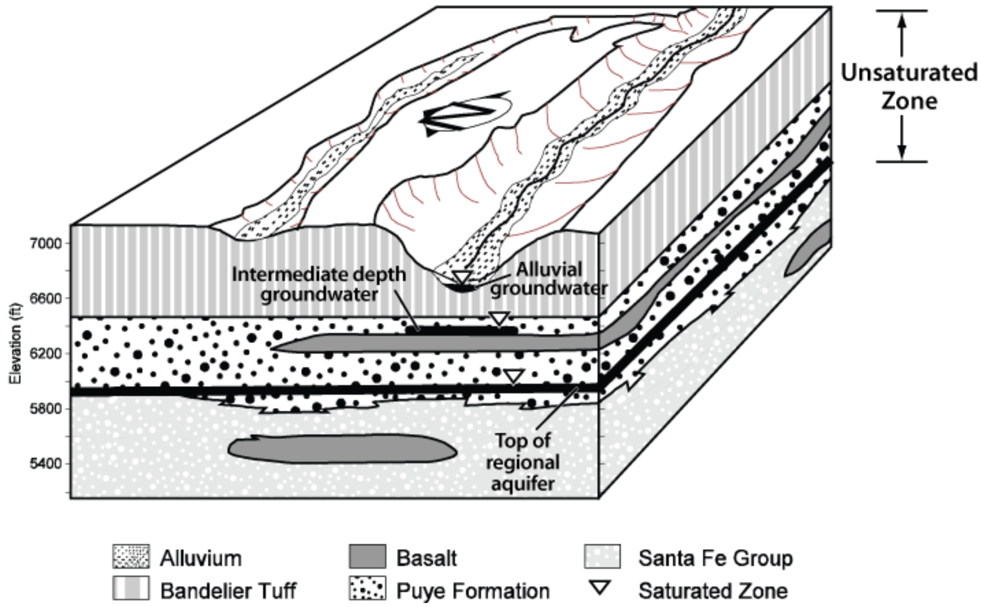


Figure 5-2 **Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence: perched alluvial groundwater, perched intermediate-depth groundwater, and groundwater within the regional aquifer.**

Perched-intermediate groundwater occurs within the lower part of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt underneath some canyons. (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by water moving downward from alluvial groundwater until the water reaches a layer of relatively impermeable rock. 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 (Figures 5-1 and 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.

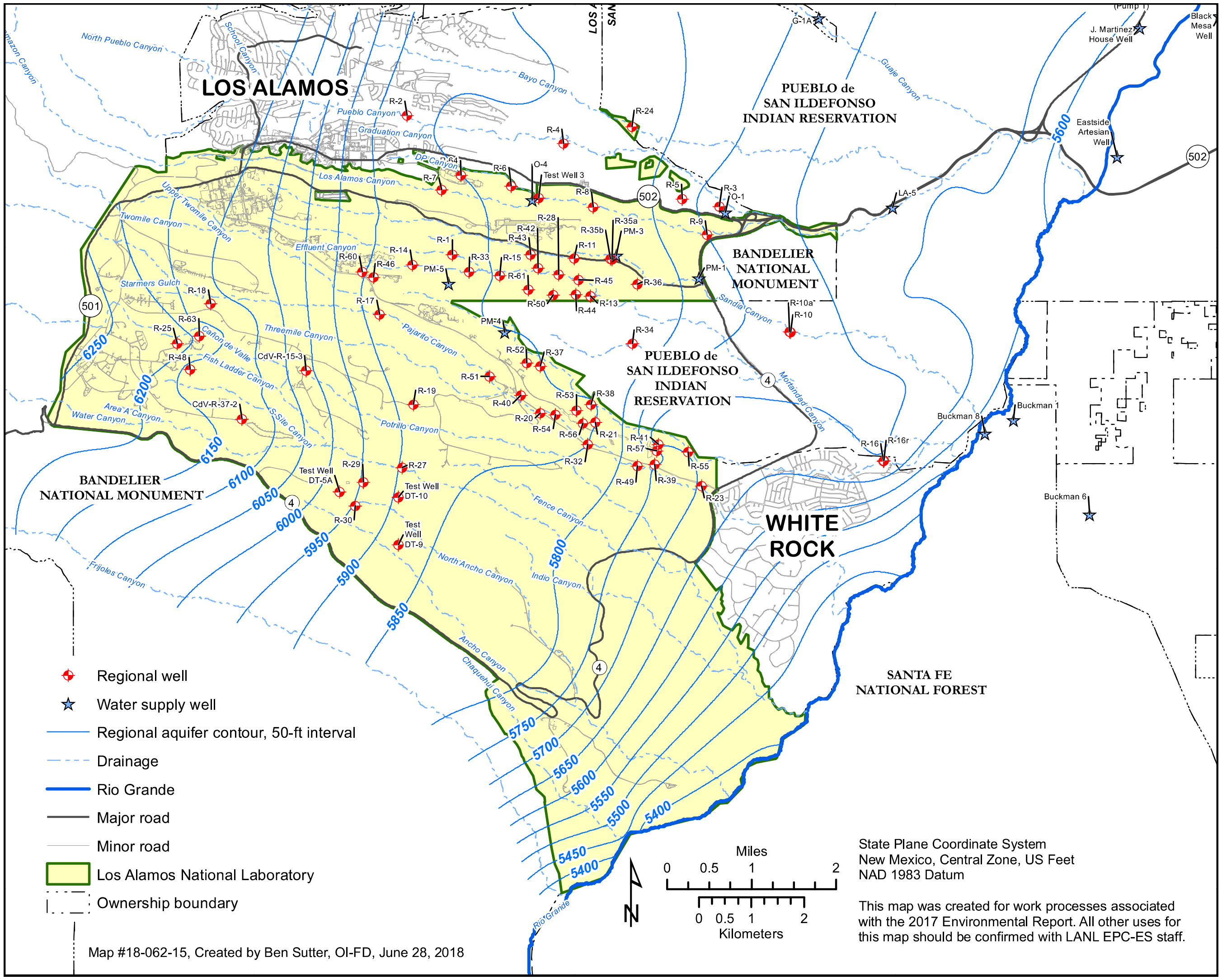


Figure 5-3 Contour map of average water table elevations for the regional aquifer. This map represents a generalization of the data.

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 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 (Part 20.6.2 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. For the toxic pollutants, numeric criteria are generally set based on the U.S. Environmental Protection Agency regional screening levels for tap water, adjusted to a risk level of more than one excess cancer per 100,000 exposed persons (10^{-5} excess cancer risk).

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; 2017 values were used to prepare this chapter.

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 apply as screening levels for groundwater. See text for explanation.

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.

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 2017 Monitoring Year, October 2016–September 2017" and the "Interim Facility-Wide Groundwater Monitoring Plan for the 2018 Monitoring Year, October 2017–September 2018" (LANL 2016, 2017a). A more detailed summary of procedures is provided in Appendix B of each monitoring plan.

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.

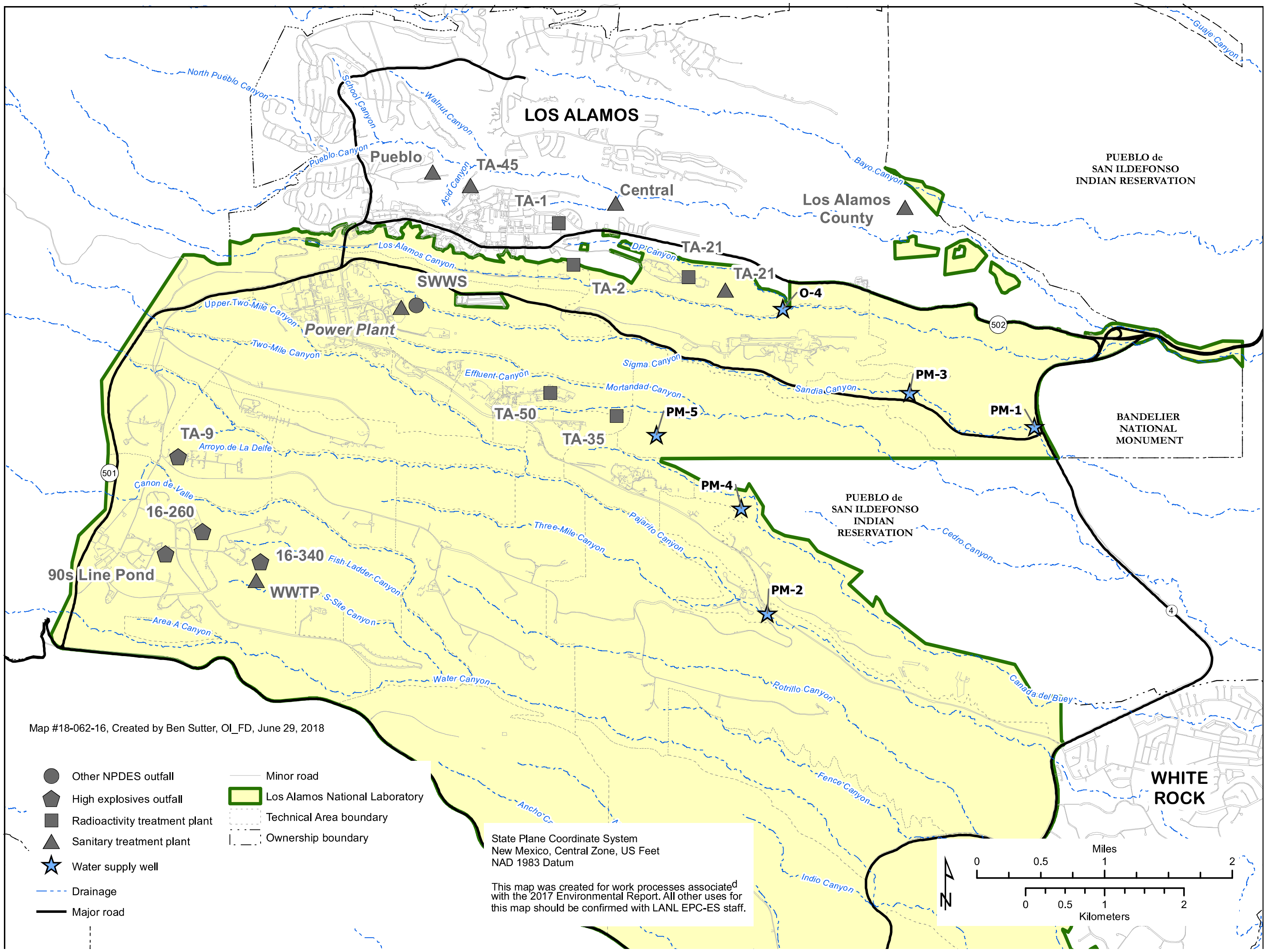
Drainages that received effluent in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize effluent discharge history at the Laboratory. Descriptions of other key effluent locations are found in Chapter 5 of the Laboratory's 2013 *Annual Site Environmental Report* (LANL 2014).

GROUNDWATER MONITORING NETWORK

We conduct monitoring at alluvial, perched-intermediate, and regional aquifer well locations and at springs that discharge perched-intermediate and regional aquifer groundwater. Monitoring is primarily organized into area-specific monitoring groups (Figure 5-5). Area-specific monitoring groups are defined for Technical Area 54, Technical

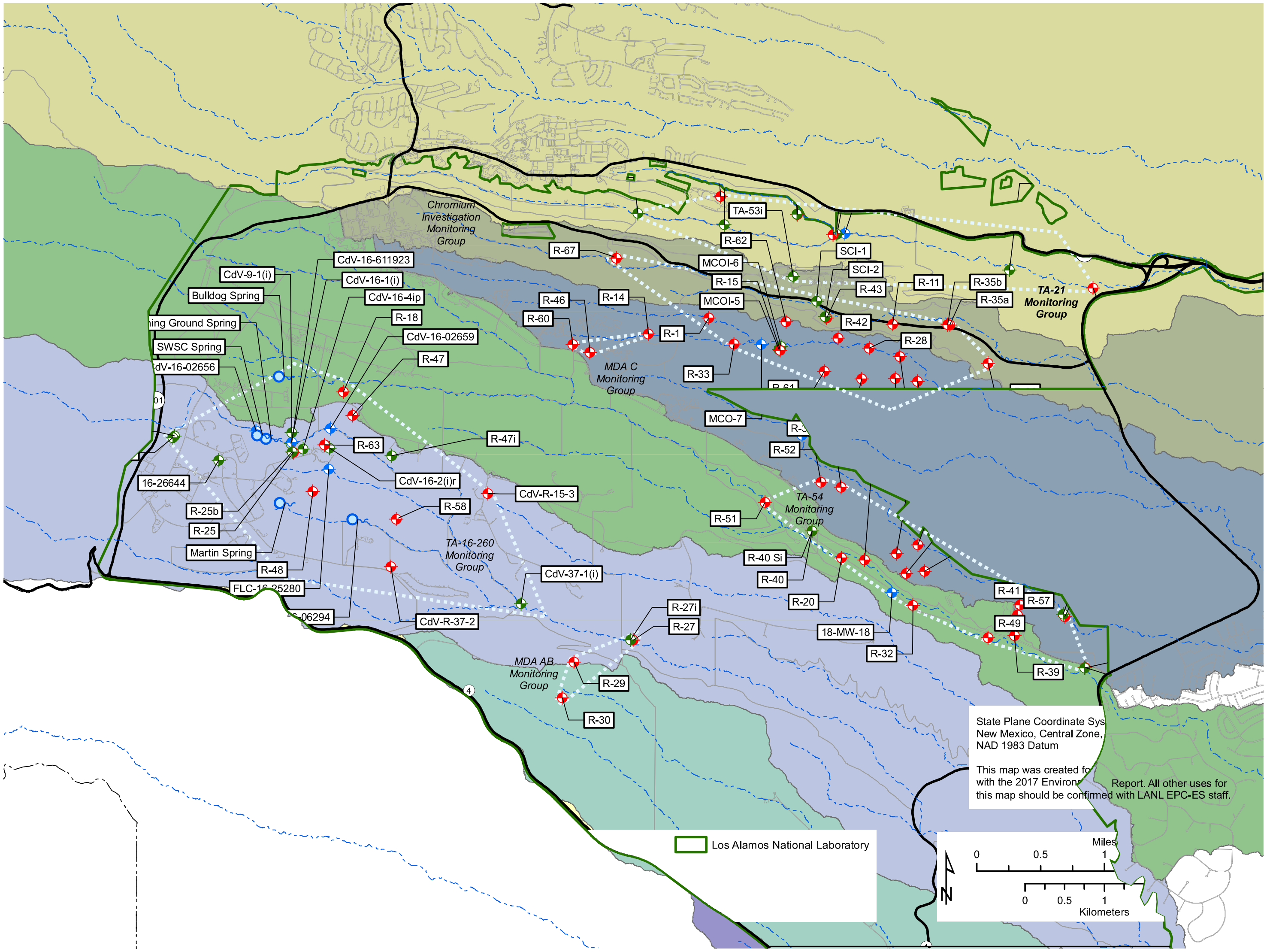
Area 21, Material Disposal Area AB, Material Disposal Area C, the Chromium Investigation, and the Technical Area 16 260 Outfall. Locations that are not included within one of these six area-specific monitoring groups are assigned to the General Surveillance monitoring group (Figure 5-6). Numerous springs 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 stations at Pueblo de San Ildefonso are shown in Figure 5-7; they mainly sample the regional aquifer. Vine Tree Spring (near former sampling location Basalt Spring) and Los Alamos Spring represent perched-intermediate groundwater, and wells LLAO-1b and LLAO-4 represent alluvial groundwater.



NPDES = National Permit 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



MDA = Material disposal area.

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

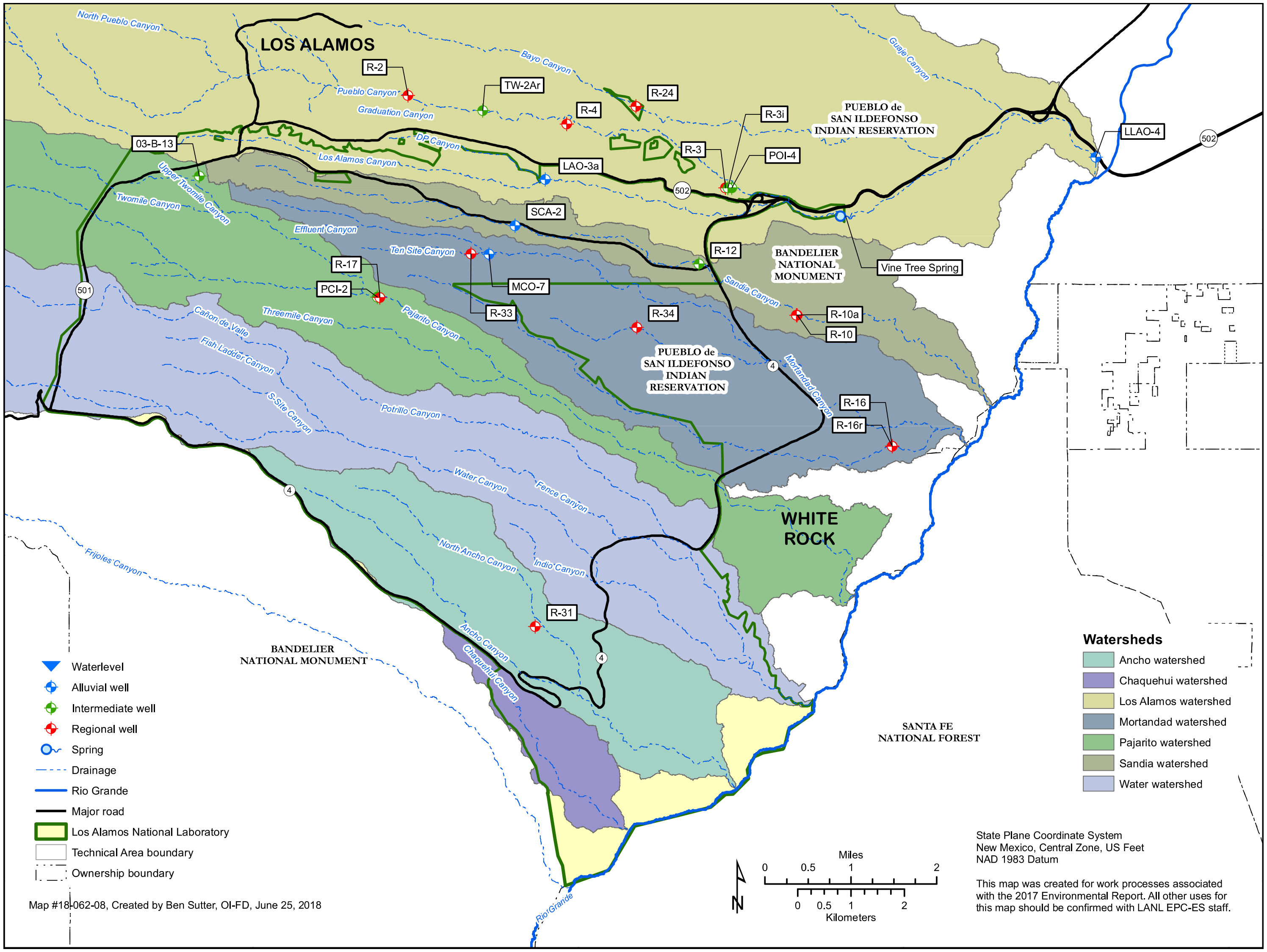


Figure 5-6 Groundwater monitoring wells and springs assigned to watershed-specific portions of the General Surveillance monitoring group

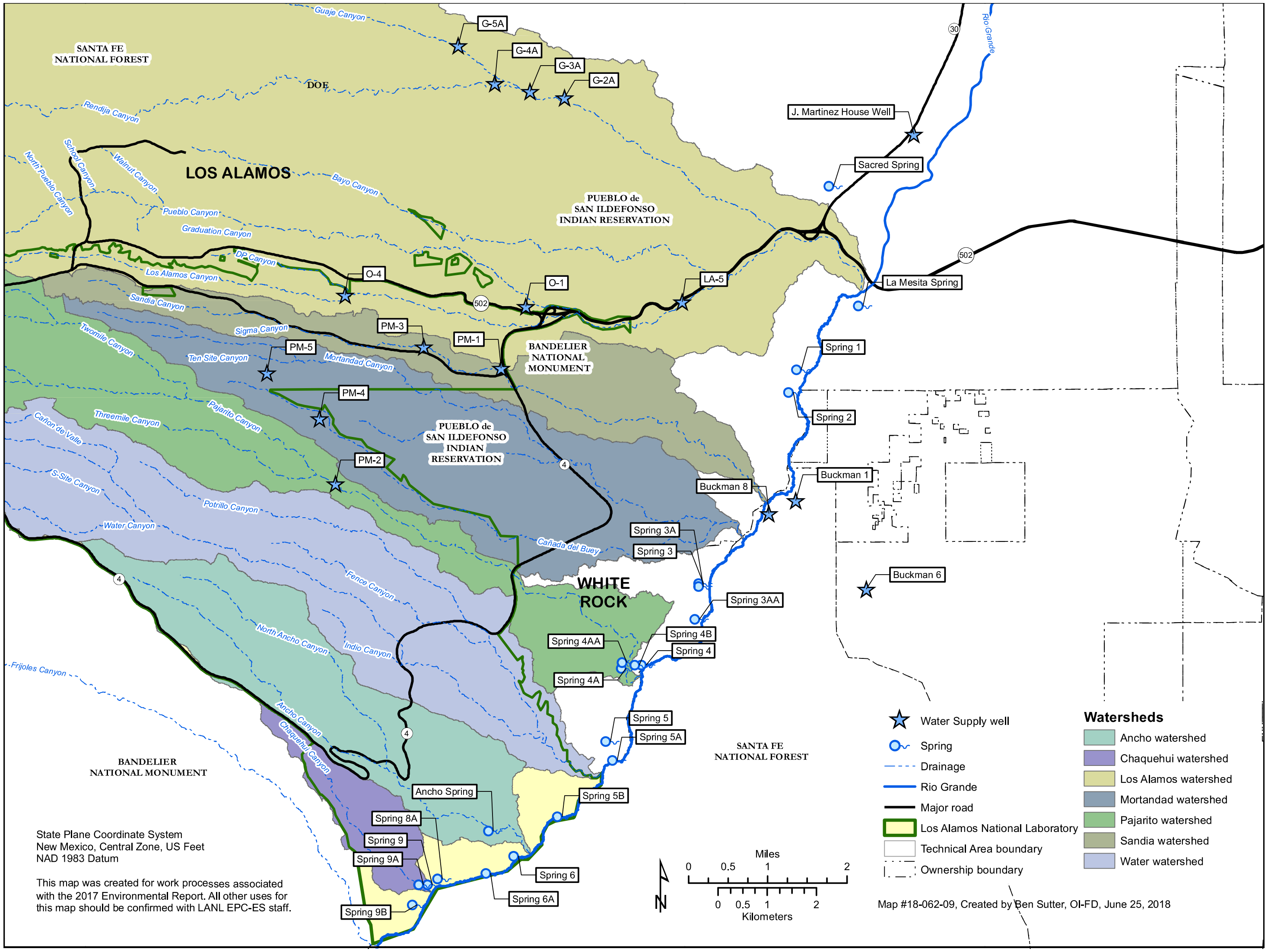


Figure 5-7 **Water supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon**

GROUNDWATER DATA INTERPRETATION

The groundwater monitoring data for 2017 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. LANL 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). The Laboratory 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, general 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://indd.adobe.com/view/50b3a008-30c5-4666-b37e-2390168c2a44). 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 an applicable drinking water standard.

City of Santa Fe

In 2017, we sampled three 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 former 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 TA-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 2017 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 2017 is 1,750 picocuries per liter in R-6i, down from 1,990 picocuries per liter in 2016. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter.

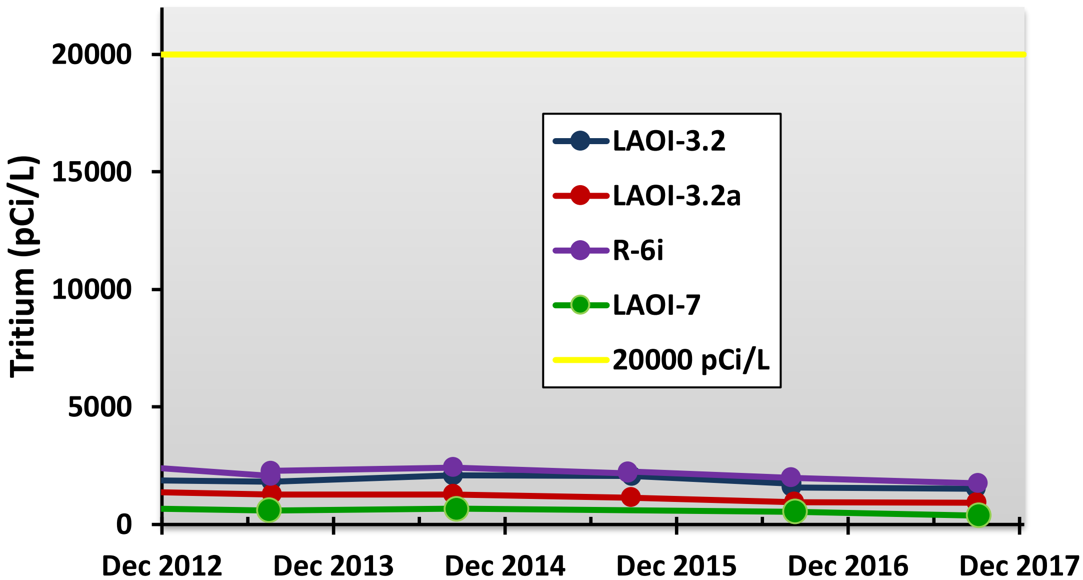


Figure 5-8 Tritium concentrations in sampled perched-intermediate groundwater from wells in the Technical Area 21 monitoring group in Los Alamos Canyon. The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter (pCi/L).

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 and 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 2018b). 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 2017 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 1 mile in length and about 0.5 mile wide (Figure 5-9). This chromium is found within 50 to 100 feet of the surface of the regional aquifer (LANL 2009a, 2012b, 2017b, 2018a). The 2017 chromium concentrations exceeded the New Mexico groundwater standard of 50 micrograms per liter in six regional aquifer wells: R-28, R-42, R-62, R-50 screen 1, R-45 screen 1, and R-43 screen 1 (Figure 5-10).

Although having high annual variability, wells within the center of the plume (for example, R-42 and R-28) show a relatively flat long-term chromium trend (Figure 5-11), whereas three wells along the edge of the plume (R-43 screen 1, R-45 screen 1, and R-50 screen 1) have increasing concentrations of chromium (Figure 5-12).

Two perched-intermediate wells also had chromium concentrations above the standard: SCI-2 and MCOI-6. The trend for chromium in these two wells is shown in Figure 5-13.

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 that occurred from 1963 until March 2002. Perchlorate is present in two perched-intermediate wells, MCOI-5 and MCOI-6 (Figure 5-14). In perched-intermediate well MCOI-6, the perchlorate concentration trends are relatively stable, but increasing concentrations are observed at MCOI-5. Perchlorate is present in the regional aquifer, specifically at R-61 and R-15, but is below the 2016 Compliance Order on Consent screening level of 13.8 micrograms per liter. We continue to monitor to evaluate whether the elimination of the source of perchlorate will result in decreasing concentrations in 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 5-15). The trend is flat at MCOI-6 but shows a continued increasing trend in MCOI-5 over the last year. Concentrations of 1,4-dioxane are not present above the screening level of 4.59 micrograms per liter in the regional aquifer.

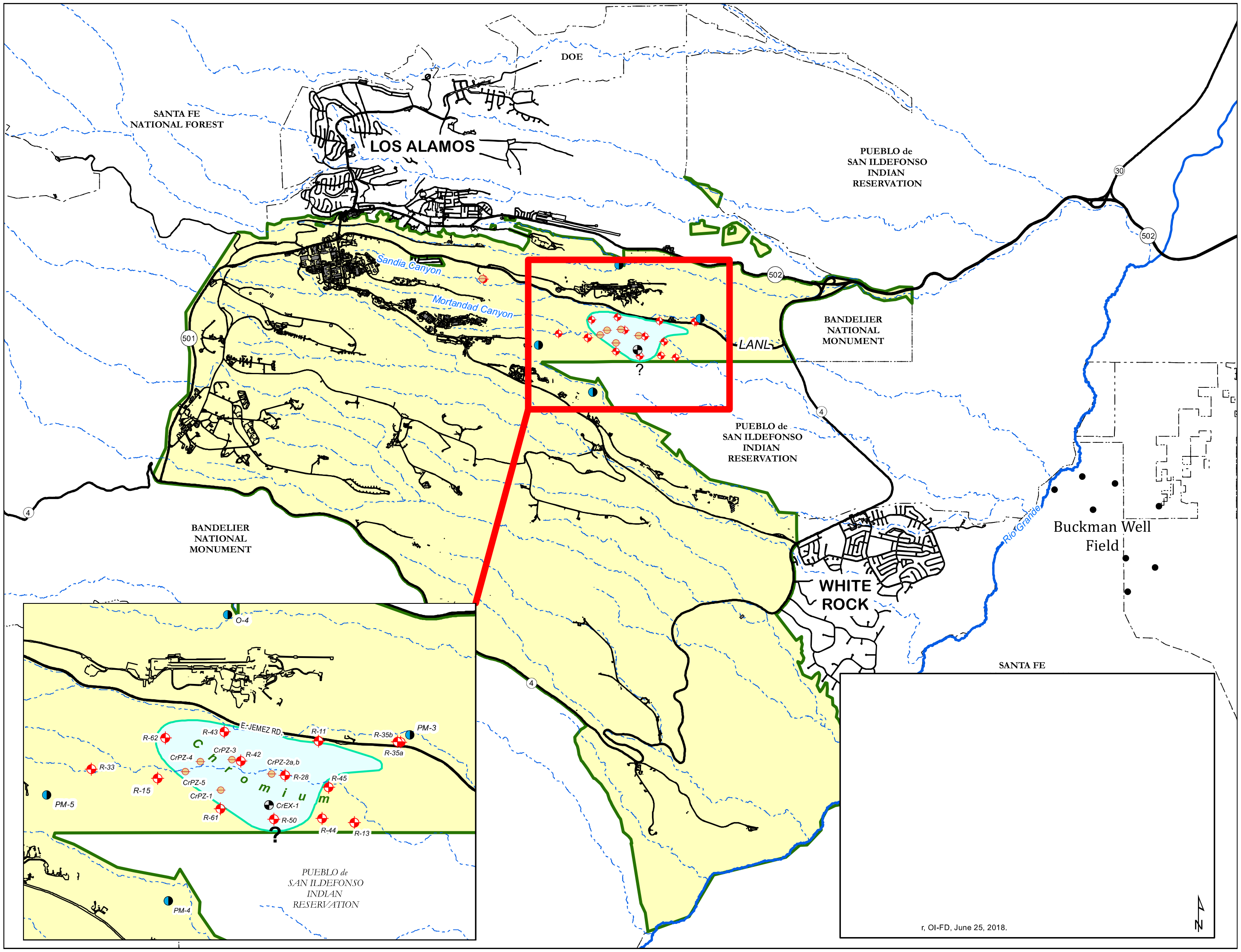


Figure 5-9 Approximation of chromium plume footprint in the regional aquifer as defined by the 50 microgram per liter New Mexico Environment Department groundwater standard

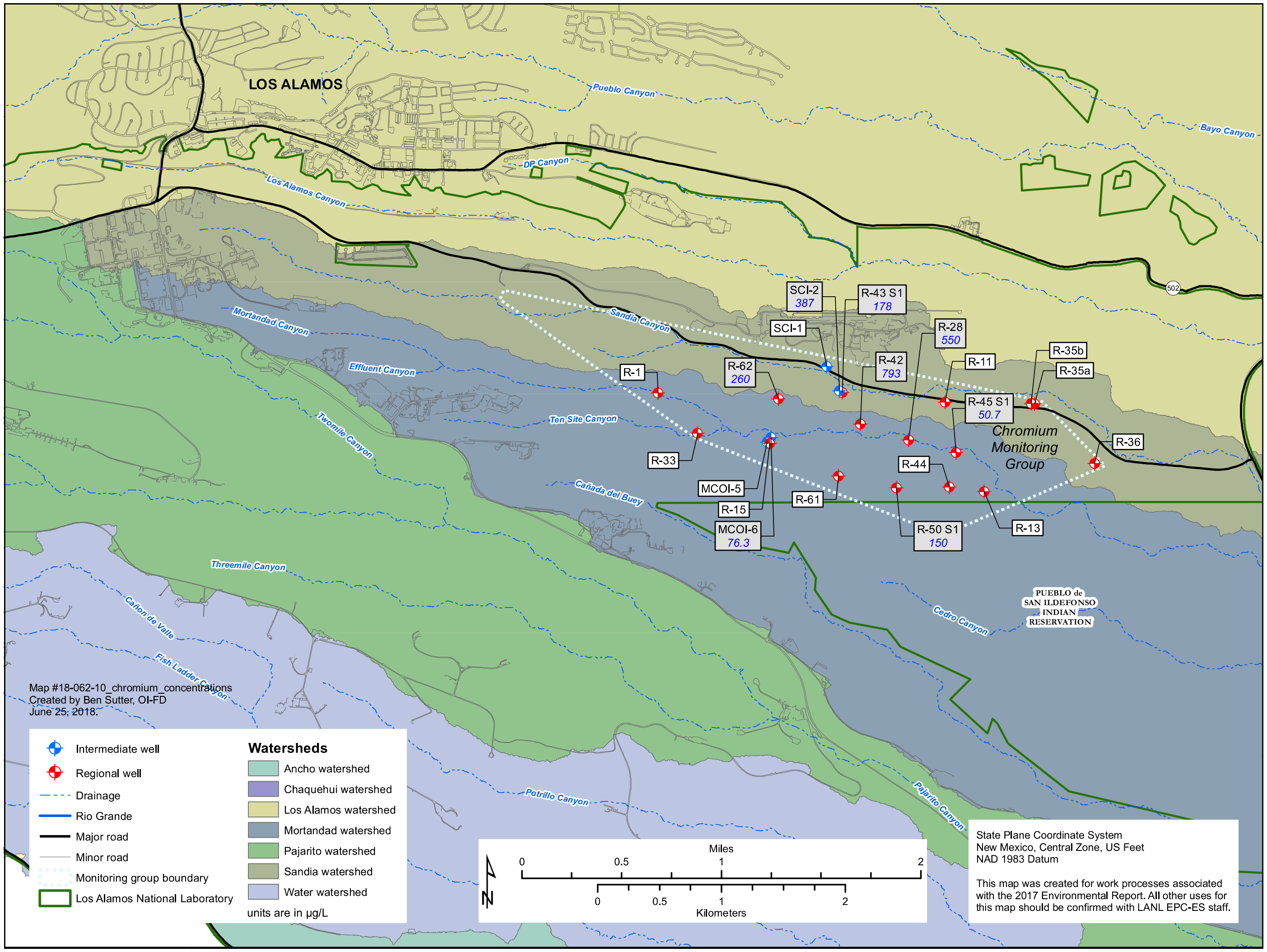


Figure 5-10 **The Chromium Investigation monitoring group perched-intermediate and regional aquifer monitoring wells. The white dashed outline encompasses the wells included in the monitoring group. Labels for the wells include maximum chromium concentrations in 2017 at wells with recorded concentrations greater than the New Mexico groundwater standard of 50 micrograms per liter.**

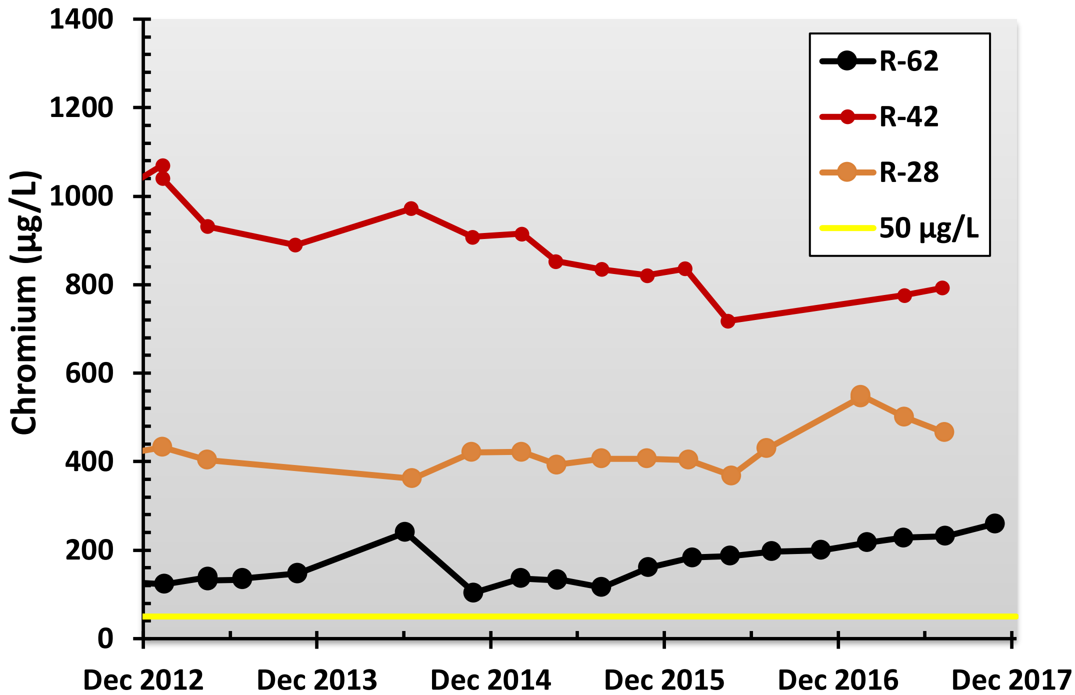


Figure 5-11 Trends in chromium concentrations for three of the regional aquifer wells in the middle of the chromium plume that exceeded the chromium standard of 50 micrograms per liter (µg/L)

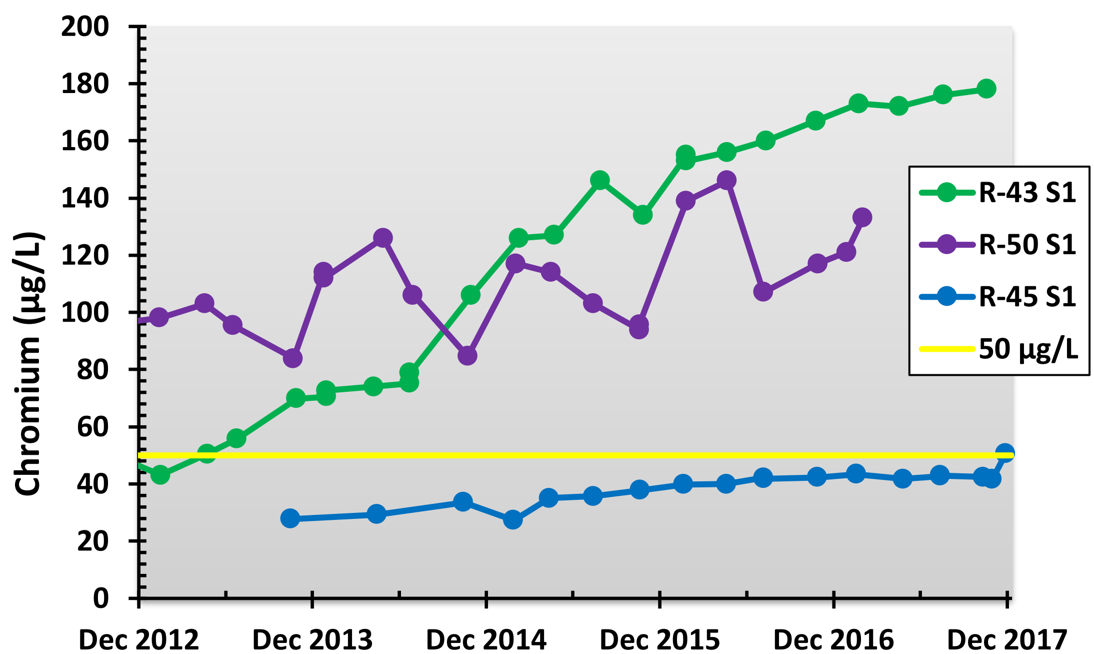


Figure 5-12 Trends in chromium concentrations for three of the regional aquifer wells along the edge of the chromium plume that exceeded the chromium standard of 50 micrograms per liter (µg/L)

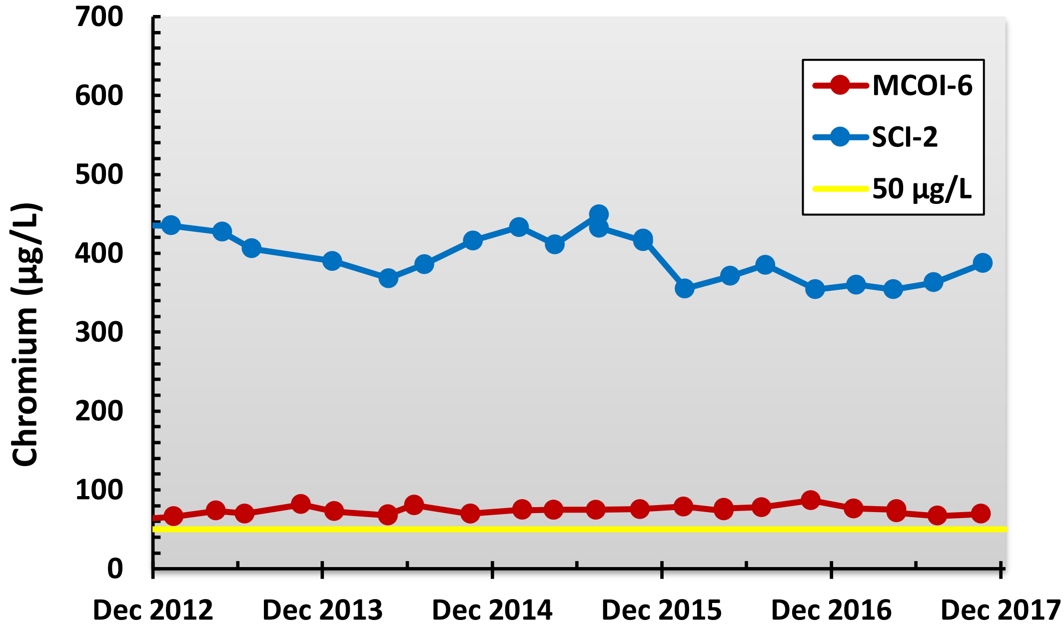


Figure 5-13 Trend in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with chromium concentrations that exceeded the chromium standard of 50 micrograms per liter (µg/L)

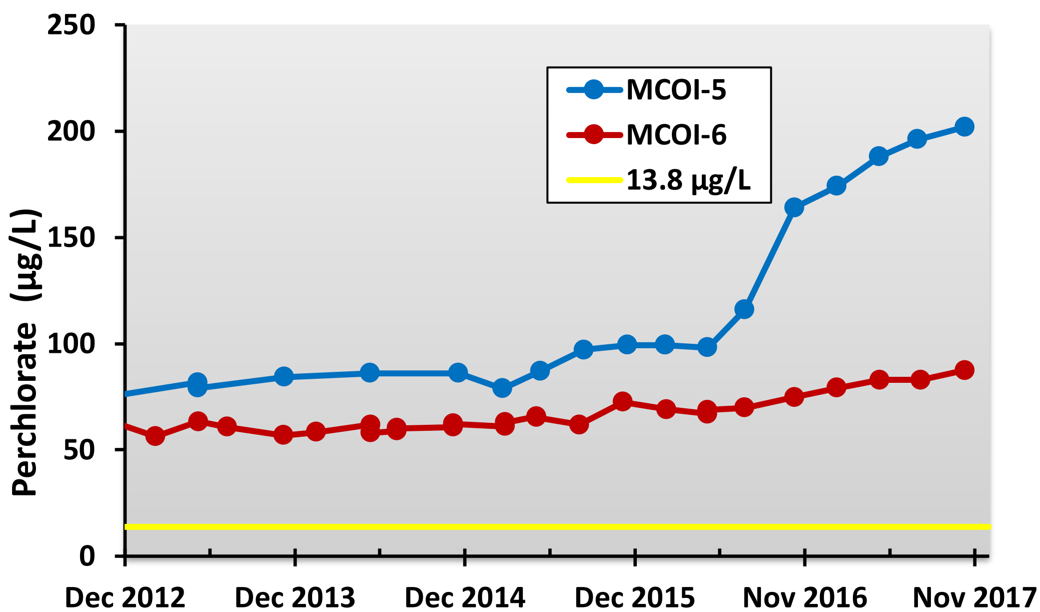


Figure 5-14 Trend in perchlorate concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with perchlorate detections above the New Mexico tap water screening level of 13.8 micrograms per liter (µg/L)

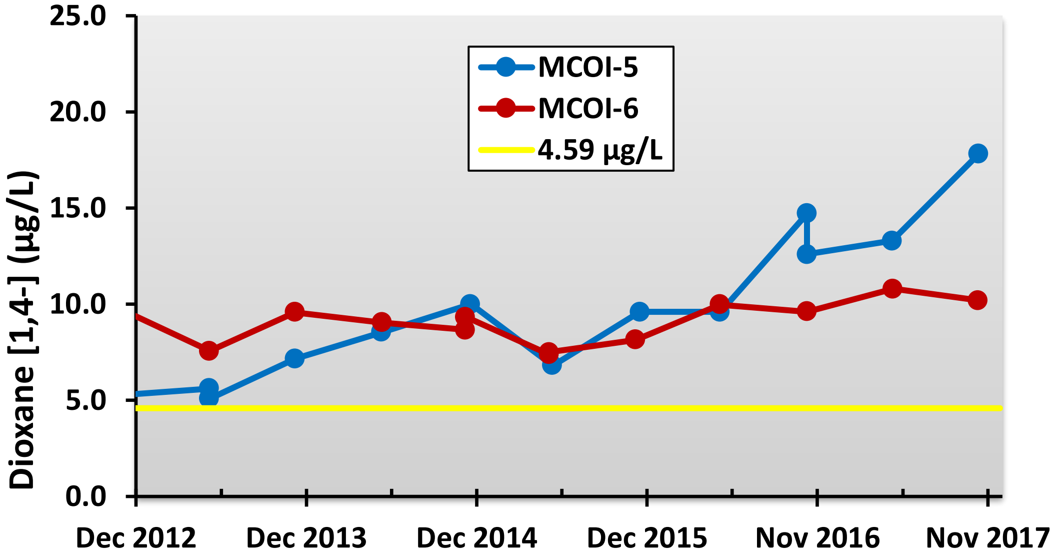


Figure 5-15 **Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells with detections of 1,4-dioxane in the Chromium Investigation monitoring group. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L).**

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 5-16). Tritium concentrations in the regional aquifer are generally less than 200 picocuries per liter.

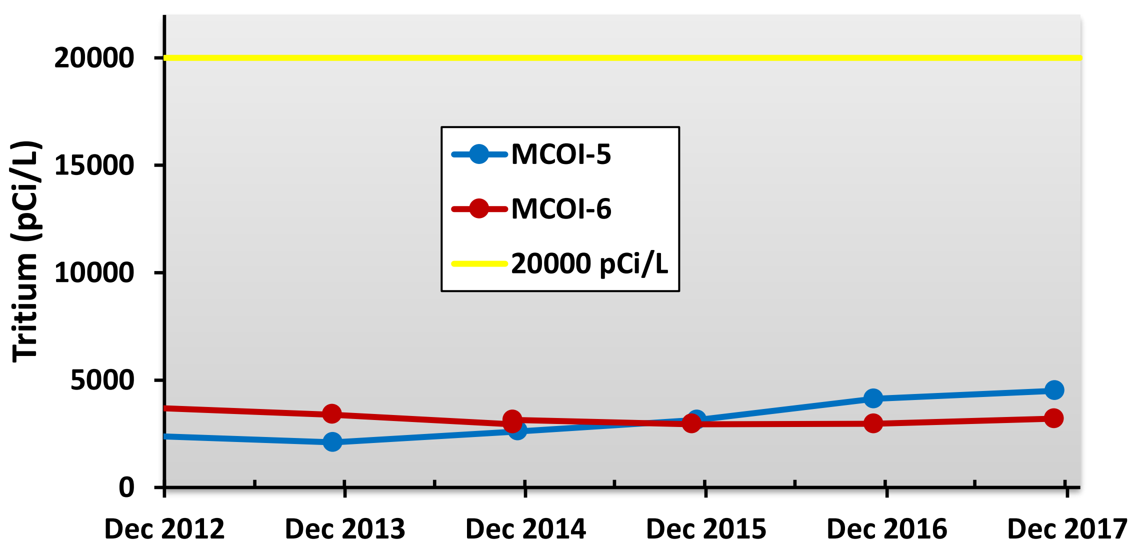


Figure 5-16 **Tritium concentrations in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter (pCi/L).**

The situation with increasing chromium concentrations observed in monitoring wells along the downgradient portion of the plume led the Laboratory to propose and implement a mitigation to address potential plume migration. An Interim Measures Work Plan for Chromium Plume Control (LANL 2015a) presents an approach that uses extraction wells and injection wells to control plume migration. The approach was analyzed in the Environmental Assessment for Chromium Plume Control Interim Measure and Plume-Center Characterization (DOE 2015). The approach will use one or more extraction wells and a series of injection wells to control plume migration and establish a 50-micogram-per-liter plume edge within the Laboratory boundary. The process involves extraction of contaminated groundwater from specific extraction wells, piping to an above-ground ion exchange treatment system, and injection of treated water back into the regional through piping and injection wells located in the downgradient portion of the area of contamination. Limited pumping and injection took place in late 2017 because of construction of additional portions of the interim-measure infrastructure, and the interim measure is expected to be more fully operational in 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 2018b).

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 vapor-phase constituents beneath are trichloroethene and tritium. 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 and disposal 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 5-17 and 5-18). 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 of effluent from the Technical Area 16 260 Outfall mixed with seasonally variable amounts of naturally occurring surface water and alluvial groundwater in Cañon de Valle 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 (7.02 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 in early 2017 are likely associated with RDX that was carried down during drilling of the well. More stable concentrations recorded during the remainder of 2017 represent the actual concentrations present in the aquifer at the R-68 location during that period. With the exception of the initial post-drilling spike, the maximum RDX concentration in R-68 during 2017 was 17.1 micrograms per liter (Figure 5-17). RDX concentrations in regional monitoring wells R-63 and R-18 were below the groundwater standard, but are exhibiting somewhat increasing trends (Figure 5-18).

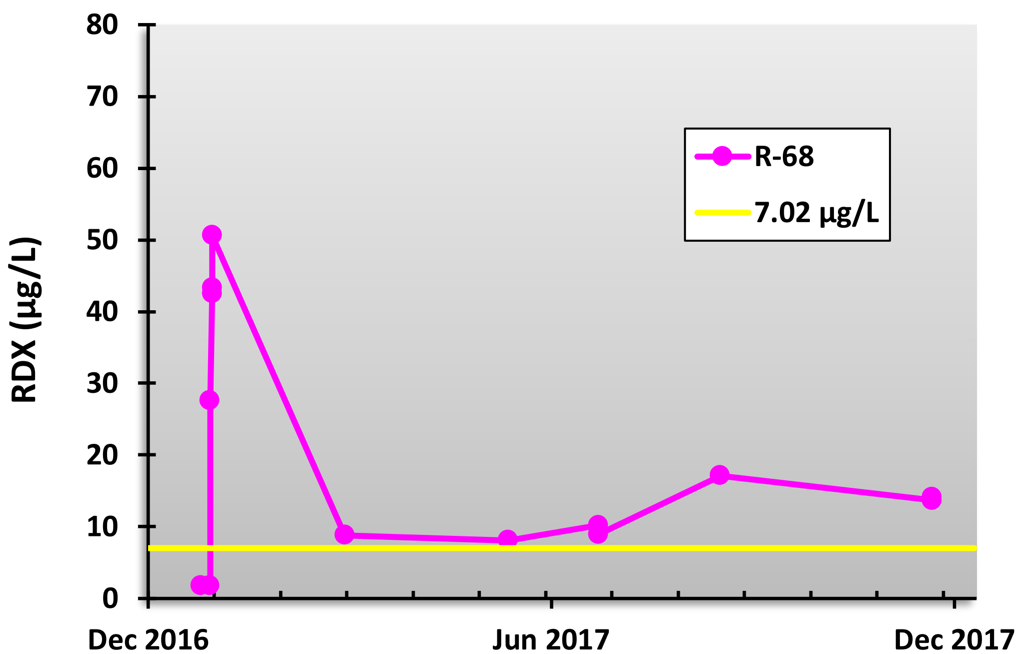


Figure 5-17 RDX concentrations in regional aquifer well R-68. The New Mexico groundwater standard for RDX is 7.02 micrograms per liter (µg/L).

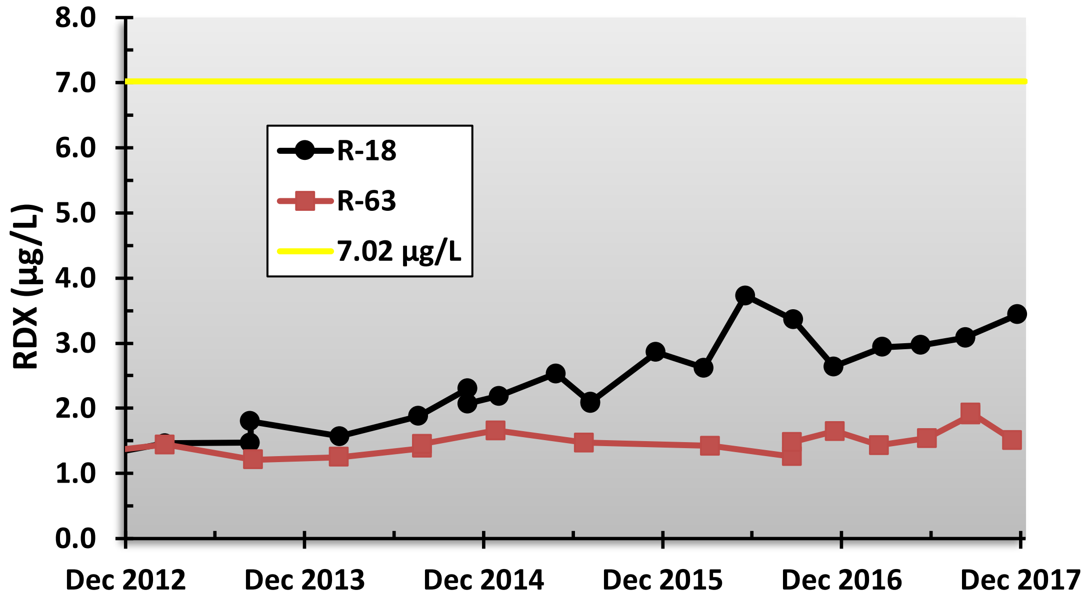


Figure 5-18 RDX concentrations in regional aquifer wells R-18 and R-63. The New Mexico groundwater standard for RDX is 7.02 micrograms per liter (µg/L).

Figures 5-19, 5-20, and 5-21 show RDX concentrations in springs, alluvial wells, and perched-intermediate wells. The springs discharge from perched-intermediate groundwater zones.

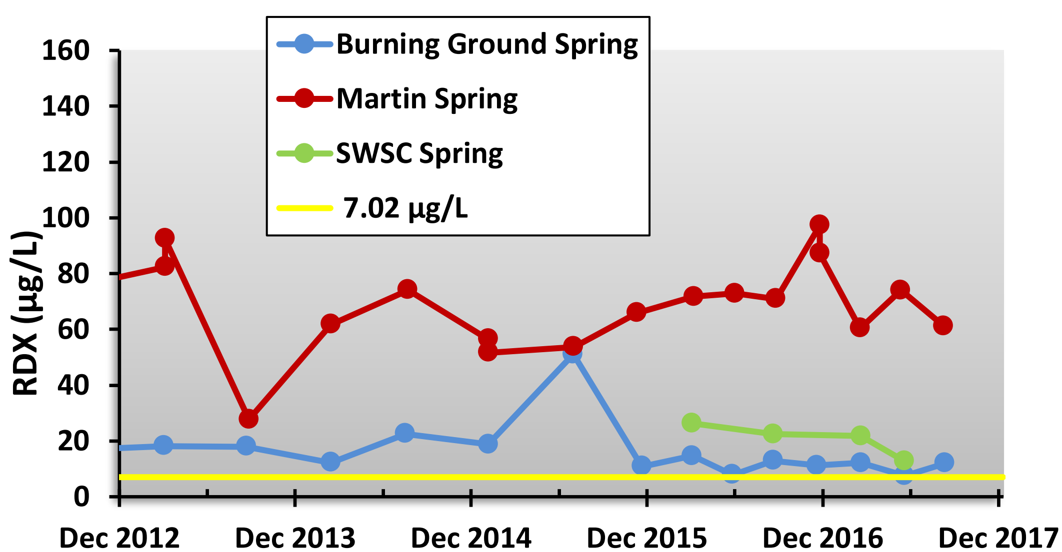


Figure 5-19 RDX concentrations in two springs in Cañon de Valle and one spring in Martin Spring Canyon in Technical Area 16 (see locations in Figure 5-5). The New Mexico groundwater standard for RDX is 7.02 micrograms per liter (µg/L).

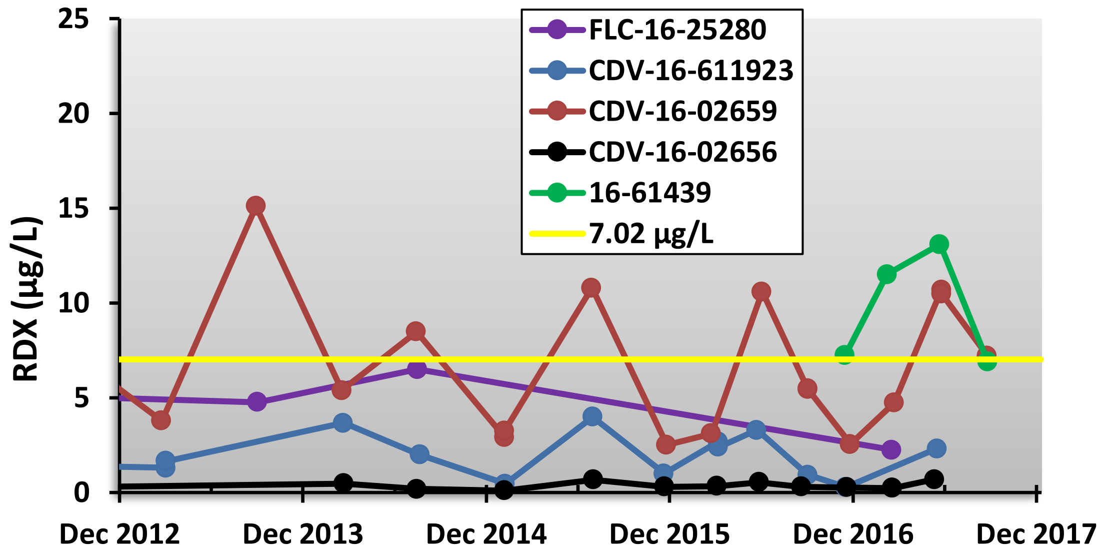


Figure 5-20 RDX concentrations in alluvial groundwater wells in Cañon de Valle and Fishladder Canyon. The New Mexico groundwater standard for RDX is 7.02 micrograms per liter (µg/L).

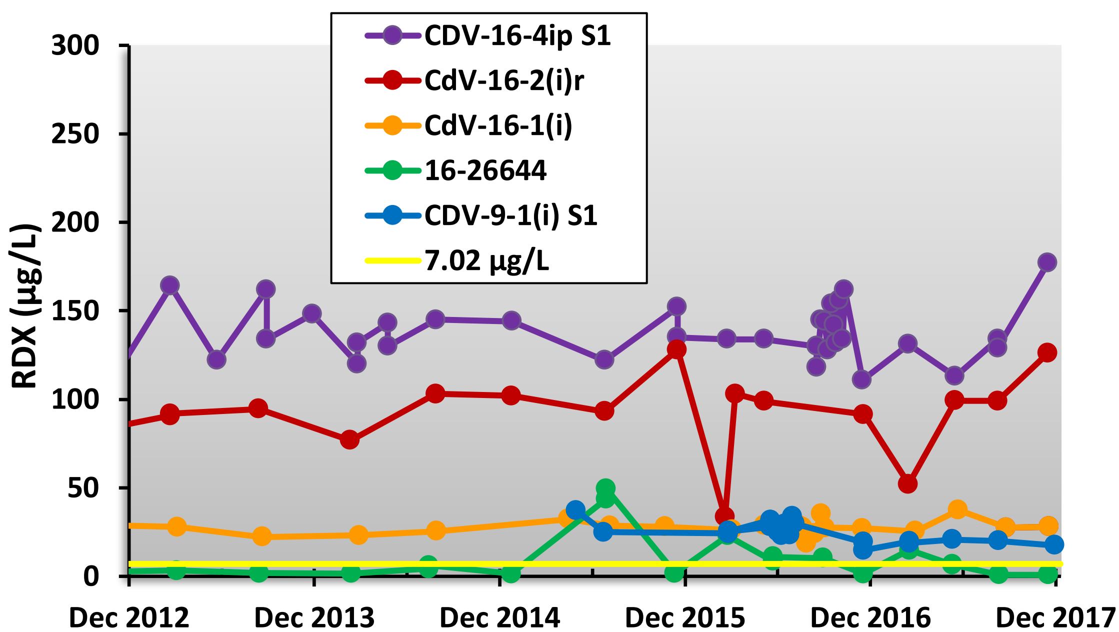


Figure 5-21 RDX concentrations in perched-intermediate groundwater wells. The New Mexico groundwater standard for RDX is 7.02 micrograms per liter (µg/L).

Of the springs sampled, the concentrations of RDX are highest in Martin Spring (Figure 5-19). RDX concentrations at Burning Ground Spring have been relatively steady over the last five years (Figure 5-19), with the exception of one sample collected in July 2015. SWSC Spring, near the former location of the Technical Area 16 260 outfall, had not flowed in recent years but began to flow again in 2016 and was sampled in 2017.

RDX concentrations in alluvial monitoring wells show significant variability because of seasonal influences, but remain relatively low (Figure 5-20). RDX concentrations in each of the perched-intermediate wells show some variability (Figure 5-21). A group of springs and alluvial wells are part of a long-term monitoring plan that is now being conducted as part of the annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2018c).

Other trace contaminants, including tetrachloroethene, trichloroethene, boron, and barium, are present in all groundwater zones but are well below applicable standards in the regional aquifer. The investigation 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 recent Laboratory reports (LANL 2010a, 2010b).

In 2016, 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 2017.

General Surveillance Monitoring Group

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 8 picocuries per liter U.S. Environmental Protection Agency maximum contaminant level for drinking water (Figure 5-22). 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).

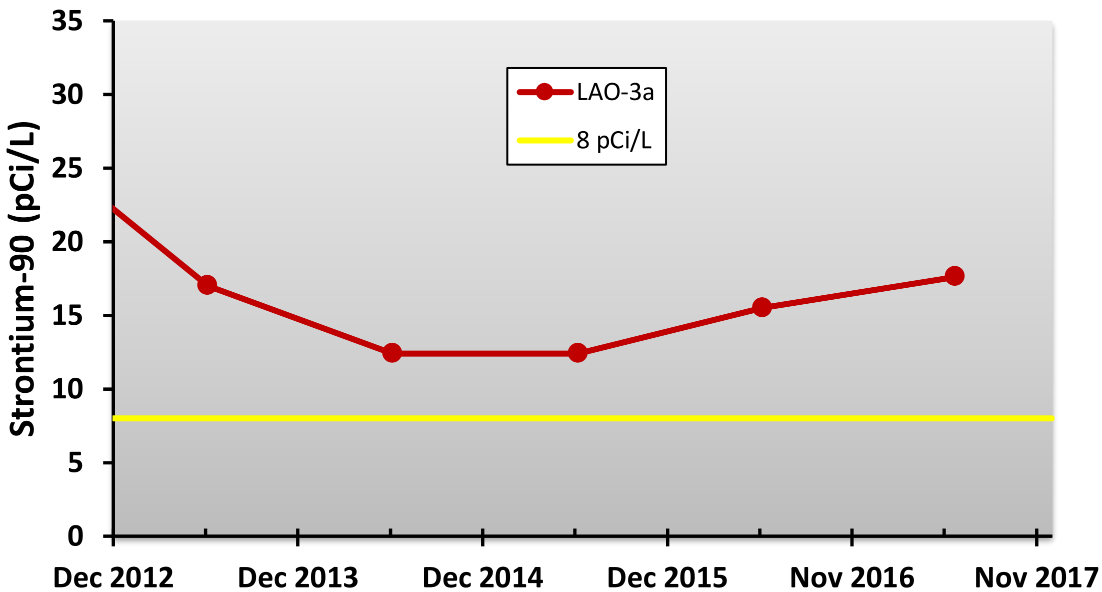


Figure 5-22 Strontium-90 concentrations at alluvial monitoring well LAO-3a. The U.S. Environmental Protection Agency maximum contaminant level for strontium-90 in drinking water value is 8 picocuries per liter (pCi/L).

Lower Los Alamos Canyon

Vine Tree Spring on Pueblo de San Ildefonso land represents discharge of perched-intermediate groundwater. Vine Tree Spring began to be sampled 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 2017 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 5-23). The screening level for perchlorate is determined according to a hierarchical data-screening process required under the 2016 Consent Order.

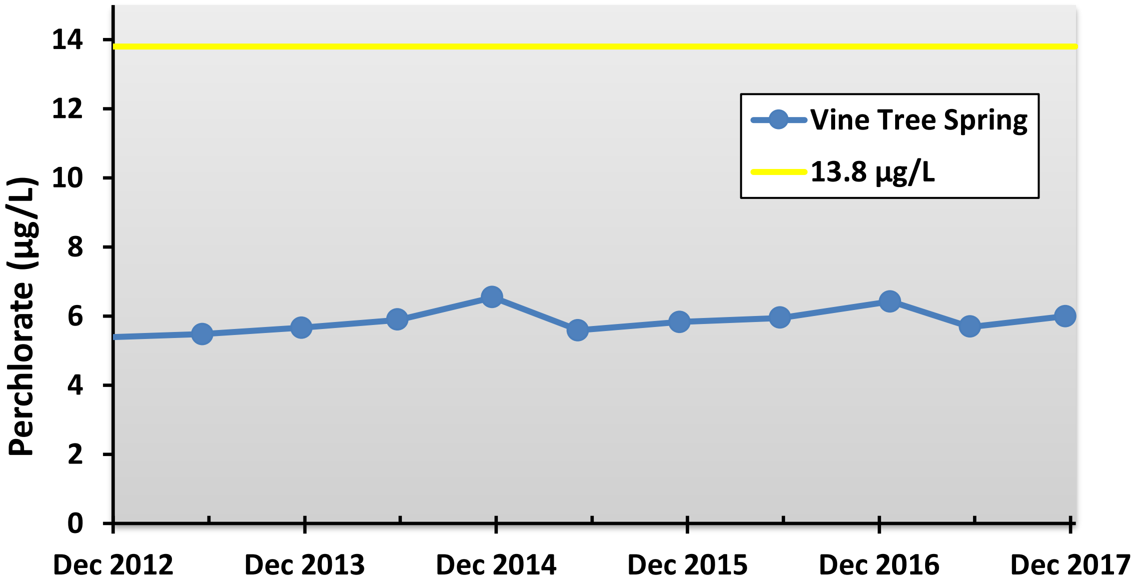


Figure 5-23 **Perchlorate concentrations at Vine Tree Spring. The New Mexico risk-based screening level for perchlorate is 13.8 micrograms per liter (µg/L).**

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 2017.

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 2017.

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 5-24). Effluent treatment at Radioactive Liquid Waste Treatment Facility was upgraded in 2002, and 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.

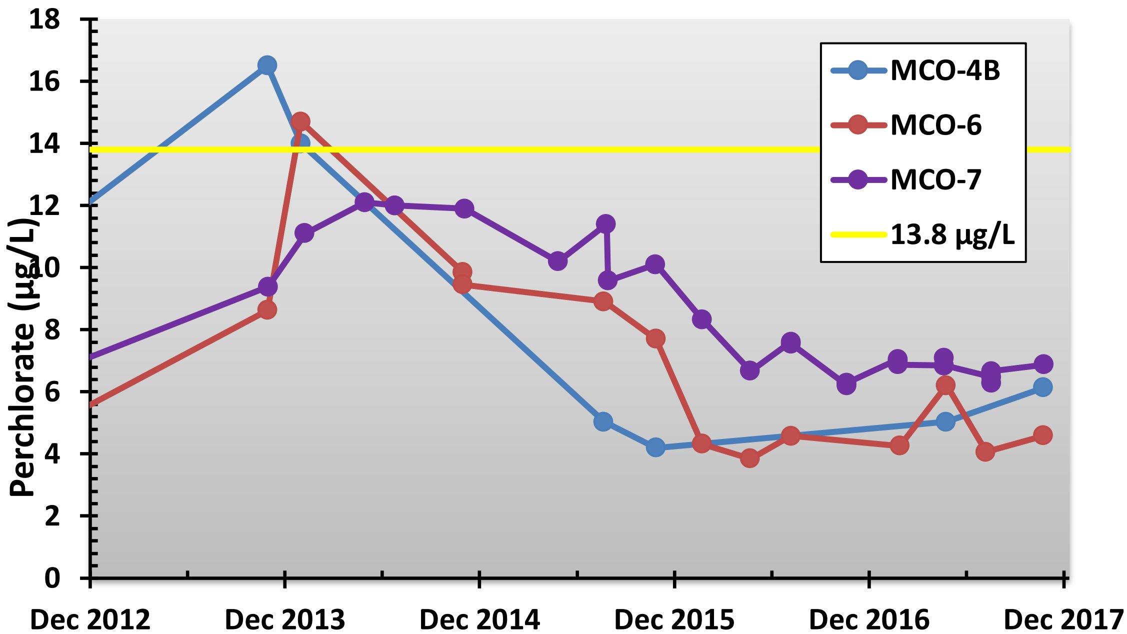


Figure 5-24 **Perchlorate concentrations at General Surveillance monitoring group and groundwater discharge plan monitoring wells MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon alluvial groundwater. The New Mexico tap water screening level for perchlorate is 13.8 micrograms per liter (µg/L).**

Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was dry in 2017 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 eastern Laboratory 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 2017, samples from this well contained 1,1,1-trichloroethane at concentrations lower than in previous years (Figure 5-25). Concentrations of 1,4-dioxane in 03-B-13 were also lower than in 2016 (Figure 5-26). Neither of these constituents are present above the lowest applicable standard of 60 micrograms per liter for 1,1,1-trichloroethane or 4.59 micrograms per liter for 1,4-dioxane in any nearby regional aquifer wells.

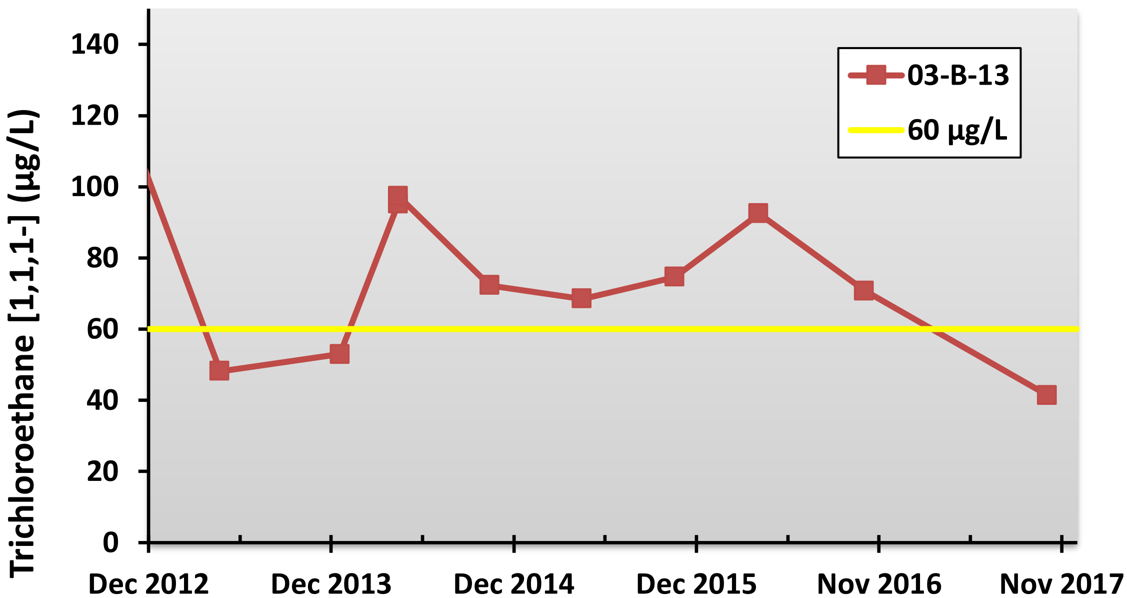


Figure 5-25 Concentrations of 1,1,1-trichloroethane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,1,1-trichloroethane is 60 micrograms per liter (µg/L).

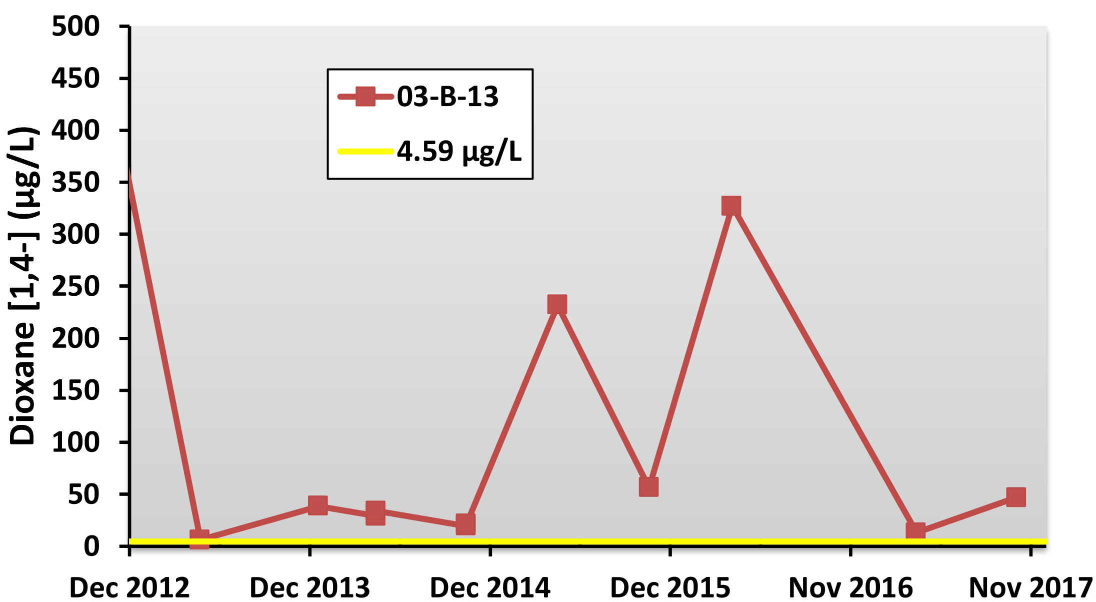


Figure 5-26 Concentrations of 1,4-dioxane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L).

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 2017.

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 2017.

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 2018 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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Los Alamos National Laboratory (the Laboratory) collects and analyzes storm water runoff 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 also analyze newly deposited sediment samples each year for chemical and radionuclide levels. We compare surface water sampling results with New Mexico water quality standards, target action levels, and radiological dose guidelines. We compare sediment sampling results with human and ecological health screening criteria. 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.

Human health and ecological risk assessments were performed as part of investigations of each of the canyons conducted 2004 through 2011 by the Laboratory's environmental remediation program. The human health risk assessments found that the chemicals and radionuclides that were present were below levels that would impact human health. The sediment and water data collected in 2017 and presented in this chapter are used to verify that during 2017 storm water–related transport of chemicals or radionuclides did not cause levels of those substances to exceed the levels found during the canyons investigations.

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 than previously existed because of the deposit of new sediments. The results of the sediment and surface water data collected in 2017 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 segments, as defined by the New Mexico Environment Department. Laboratory industrial outfalls are regulated to help minimize these impairments.

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 (LANL 2017a, 2017b)
- The annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2016a, 2017c), 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)

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 Part 20.6.4 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) (NMWQCC 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.

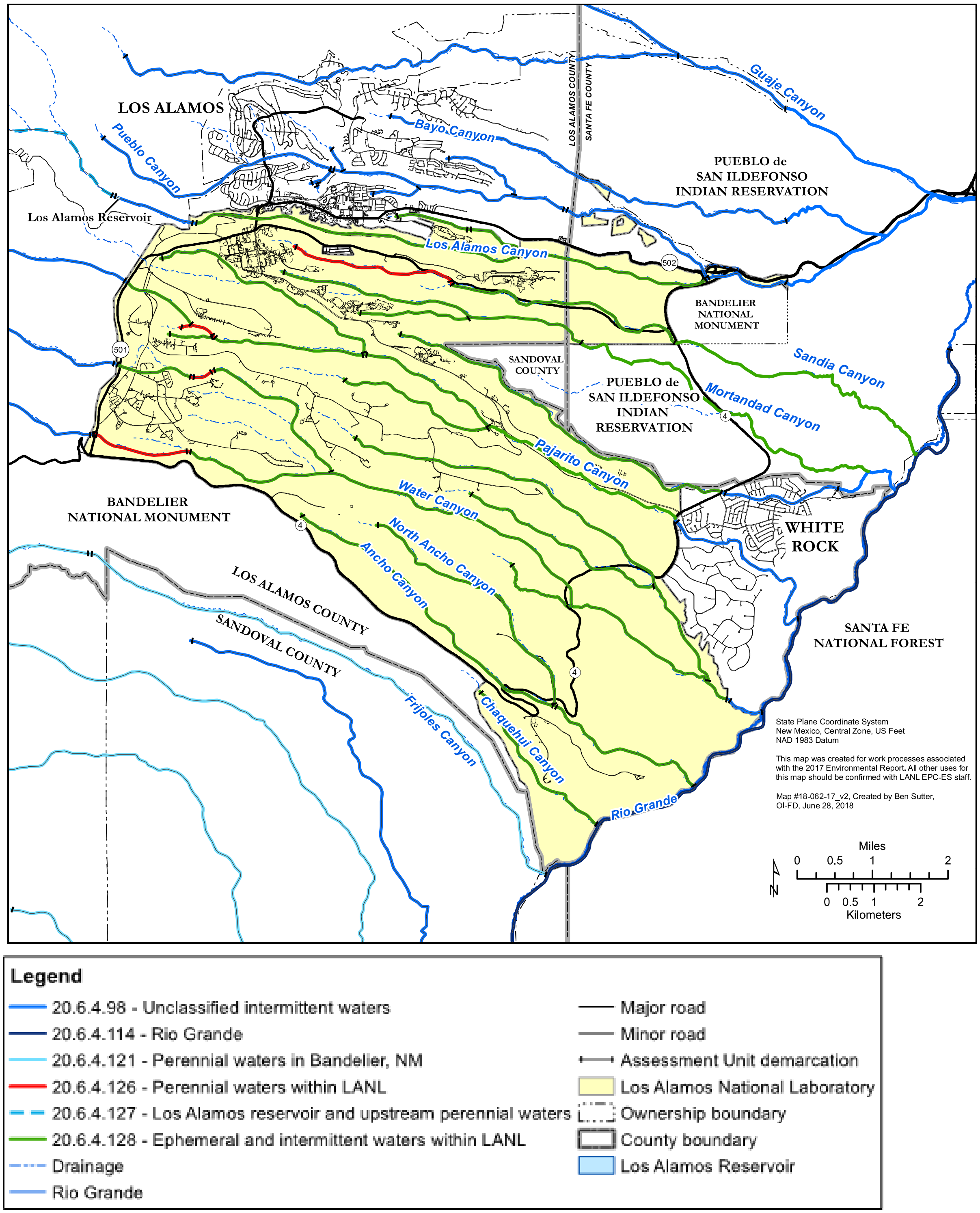


Figure 6-1 **Stream reaches within and around the Laboratory. Map shows the classifications of streams from Part 20.6.4 of the New Mexico Administrative Code (NMWQCC 2013)**

Table 6-1
New Mexico Water Quality Control Commission Classifications (Classified Water of the State) and Designated Uses for LANL Streams

Stream Segment Description	Designated Use	Description of Associated Users
Perennial stream segments on Laboratory property, including parts of Cañon de Valle, Pajarito, Water, and Sandia Canyons	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact.
	Cold water aquatic life	Fish, aquatic invertebrates, etc. Chronic aquatic life standard applies.
Ephemeral and intermittent stream segments on Laboratory property	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Limited aquatic life	Aquatic invertebrates, etc. Acute aquatic life standard applies.
	Secondary contact	Recreational or other water use in which human contact with the water may occur and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, wading, commercial and recreational boating, and any limited seasonal contact.
Intermittent segments not on Laboratory property, i.e., Acid and Pueblo Canyons	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Marginal warm water aquatic life	Limited ability for stream to sustain a natural aquatic life population on a continuous annual basis.
	Primary contact	Recreational or other water use in which there is prolonged and intimate human contact with the water, such as swimming and water skiing. Primary contact also means any use of surface waters of the state for cultural, religious, or ceremonial purposes in which there is intimate human contact with the water, including but not limited to ingestion or immersion.

Surface Water Standards and Screening Levels

The New Mexico Water Quality Control Commission establishes surface water quality standards for New Mexico in Part 20.6.4 of the New Mexico Administrative Code. The current standards were approved by the U.S. Environmental Protection Agency on June 5, 2013 and can be found online at https://www.env.nm.gov/swqb/Standards/20.6.4NMAC.pdf (NMWQCC 2013). We use the protocol employed by the New Mexico Environment Department for assessing surface water quality standard attainment (NMED 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 (EPA 2006a, NMWQCC 2013). Storm water background values from developed and undeveloped areas near the Laboratory are used for reference (LANL 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 emphasis of the radiological assessment of surface water is on 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.

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 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 (LANL 2017d).

Sediment Screening Levels

We compare sediment results for chemicals with the New Mexico Environment Department's risk-based soil screening levels (NMED 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 (EPA 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 6-2. 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.

Table 6-2
LANL Assessment Units, Impairment Cause, and Designated Use(s) that Are Supported, Not Supported, or Not Assessed

Assessment Unit Name	Water Type	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Acid Canyon (Pueblo to headwaters)	Ephemeral	PCBs[a], copper[b], aluminum	None	Wildlife habitat, livestock watering, marginal warm water aquatic life	Primary contact
Ancho Canyon (North Fork to headwaters)	Ephemeral	PCBs	Wildlife habitat	Limited aquatic life	Secondary contact, livestock watering
Ancho Canyon (Rio Grande to North Fork Ancho)	Ephemeral	Aluminum, gross alpha[c], PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Arroyo de la Delfe (Pajarito Canyon to headwaters)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Cañada del Buey (within LANL)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life	Secondary contact, wildlife habitat
Cañon de Valle (below LANL gage E256)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Cañon de Valle (LANL gage E256 to Burning Ground Spring)	Perennial	Gross alpha, aluminum, PCBs	None	Livestock watering, cold water aquatic life, wildlife habitat	Secondary contact
Cañon de Valle (upper LANL bnd[d] to headwaters)	Intermittent	Gross alpha, aluminum, PCBs	Wildlife habitat	Marginal warm water aquatic life, livestock watering	Primary contact
Cañon de Valle (within LANL above Burning Ground Spring)	Ephemeral	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Chaquehui Canyon (within LANL)	Ephemeral	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)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
DP Canyon (Los Alamos Canyon to grade control)	Intermittent	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Fence Canyon (above Potrillo Canyon)	Ephemeral	Not assessed	None	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Graduation Canyon (Pueblo Canyon to headwaters)	Ephemeral	Copper[b], aluminum, PCBs	Livestock watering	Wildlife habitat, marginal warm water aquatic life	Primary contact

Table 6-2 (continued)

Assessment Unit Name	Water Type	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Indio Canyon (above Water Canyon)	Ephemeral	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Kwage Canyon (Pueblo Canyon to headwaters	Ephemeral	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 bnd)	Ephemeral	Aluminum, gross alpha, total mercury, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Los Alamos Canyon (NM-4 to DP Canyon)	Ephemeral	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Mortandad Canyon (within LANL)	Ephemeral	Aluminum, copper[b], gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
North Fork Ancho Canyon (Ancho Canyon to headwaters)	Ephemeral	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Pajarito Canyon (Arroyo de La Delfe to Starmers Spring)	Perennial	Aluminum	Livestock watering, wildlife habitat	Cold water aquatic life	Secondary contact
Pajarito Canyon (lower LANL bnd to Two Mile Canyon)	Ephemeral	Aluminum, PCBs	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
Pajarito Canyon (Two Mile Canyon to Arroyo de La Delfe)	Intermittent	PCBs, copper[b], gross alpha	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
Pajarito Canyon (upper LANL bnd to headwaters)	Perennial	PCBs, selenium, gross alpha, arsenic, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pajarito Canyon (within LANL above Starmers Gulch)	Intermittent	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Potrillo Canyon (above Water Canyon)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Pueblo Canyon (Acid Canyon to headwaters)	Ephemeral	PCBs, gross alpha, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Canyon to Los Alamos WWTP)	Ephemeral	PCBs, gross alpha, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos WWTP to Acid Canyon)	Ephemeral	PCBs, gross alpha	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Sandia Canyon (Sigma Canyon to NPDES outfall 001)	Perennial	PCBs, dissolved thallium, copper[b], aluminum, gross alpha	None	Wildlife habitat, livestock watering, cold water aquatic life	Secondary contact

Table 6-2 (continued)

Assessment Unit Name	Water Type	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Sandia Canyon (within LANL below Sigma Canyon)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
South Fork Acid Canyon (Acid Canyon to headwaters)	Ephemeral	Zinc[b], copper[b], PCBs, gross alpha	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Ten Site Canyon (Mortandad Canyon to headwaters)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Threemile Canyon (Pajarito Canyon to headwaters)	Ephemeral	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Twomile Canyon (Pajarito to headwaters)	Ephemeral	PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Walnut Canyon (Pueblo Canyon to headwaters)	Ephemeral	Copper[b], PCBs	Wildlife habitat, livestock watering	Marginal warm water aquatic life	Primary contact
Water Canyon (Area-A Canyon to NM 501)	Perennial	Aluminum	Wildlife habitat, livestock watering	Cold water aquatic life	Secondary contact
Water Canyon (within LANL above NM 501)	Intermittent	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Water Canyon (within LANL below Area-A Cyn)	Ephemeral	Aluminum, gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

[a] PCBs are total PCBs in the water column.

[b] Levels of these metals are considered an impairment for acute aquatic life standards.

[c] 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.

[d] bnd = boundary

HYDROLOGIC SETTING

Laboratory lands contain all or parts of seven primary watersheds that drain into the Rio Grande (Figure 6-2). 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 2017, there was no snowmelt runoff that crossed the downstream (eastern) boundary of the Laboratory. Total storm water runoff for 2017 measured at the downstream Laboratory boundary is estimated at 44.5 acre-feet. Most of this runoff occurred in Los Alamos and Ancho Canyons; minimal runoff (less than 1.0 acre-feet) occurred in Pueblo, Sandia, and Water Canyons and Cañada del Buey; and no runoff occurred in Pajarito, Potrillo, and Chaquehui Canyons. No effluent from the Los Alamos County Waste Water Treatment Facility reached the gaging station in lower Pueblo Canyon during storm events in 2017. Figure 6-3 shows the precipitation and storm water runoff volume for the Laboratory for the monsoonal period of June through October during the years 1995 to 2017.

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 39 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 seven additional stream channel locations without active gaging stations. The number of gaging stations and sample locations remains fairly constant from year to year. 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 2017 was the thirteenth 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 2-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 6-3). 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.

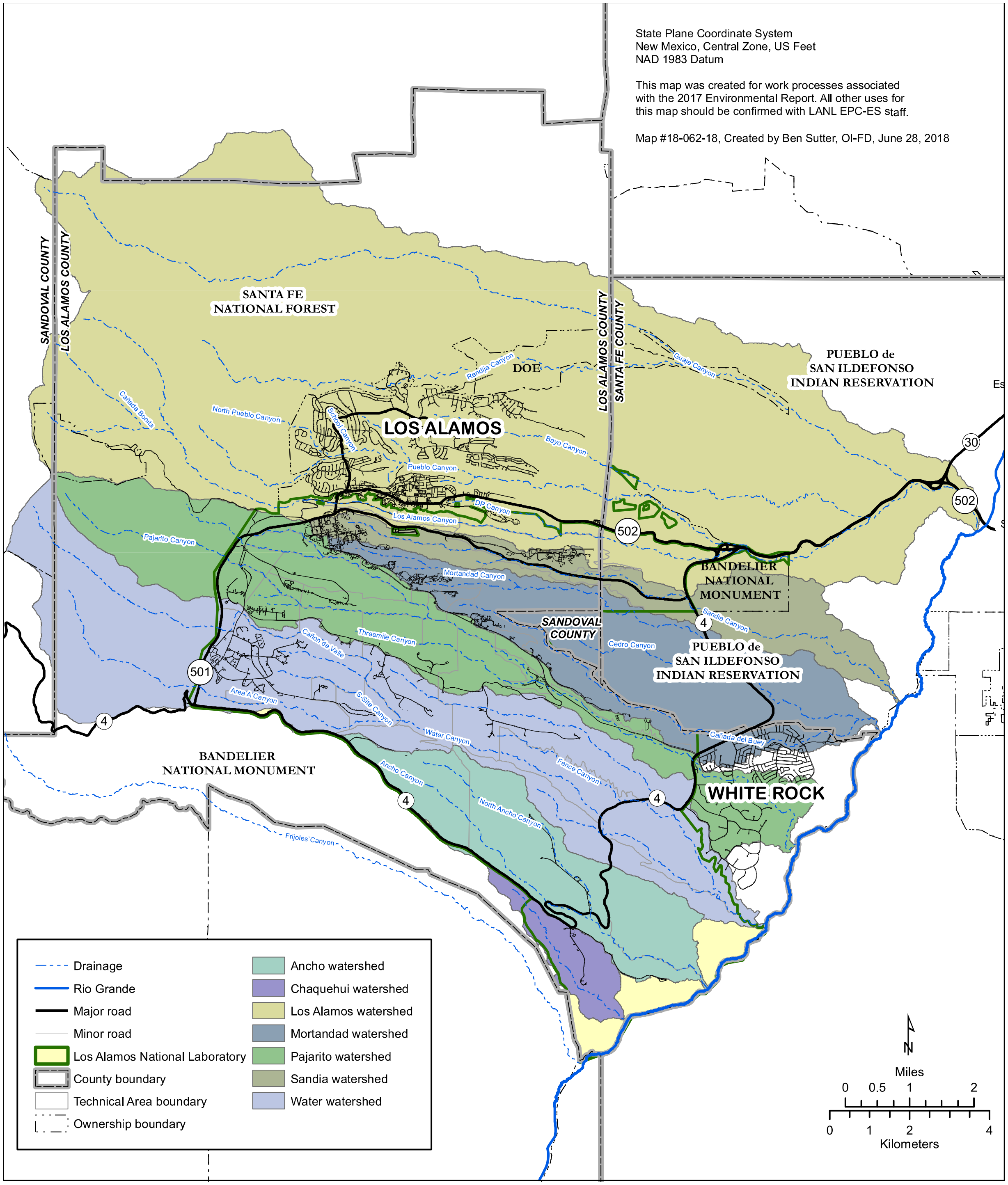


Figure 6-2 Primary watersheds at the Laboratory

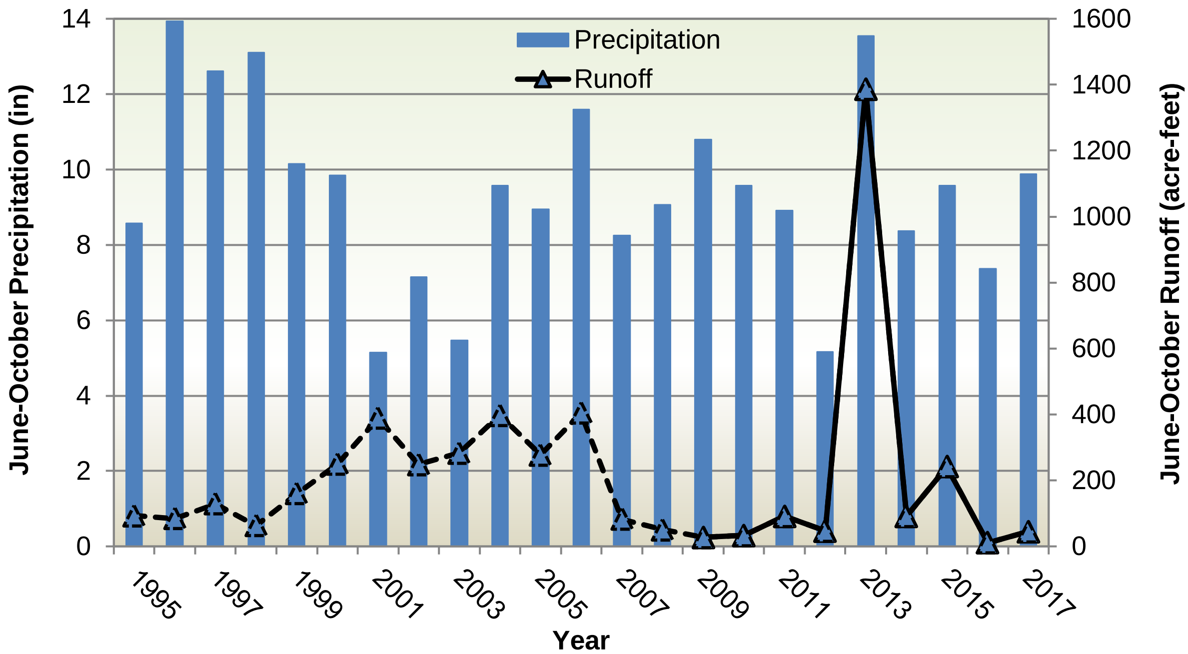


Figure 6-3 **Total June–October precipitation from 1995 to 2017, averaged across the Laboratory's meteorological tower network (Technical Area 06, Technical Area 49, Technical Area 53, Technical Area 54, and northern community), and estimated June–October storm water runoff volume in Laboratory canyons from 1995 to 2017. 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 2017 Monitoring Year, October 2016–September 2017" and the "Interim Facility-Wide Groundwater Monitoring Plan for the 2018 Monitoring Year, October 2017–September 2018" (LANL 2016a, 2017c).

Figure 6-4 shows locations sampled in 2017 for storm water at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs. Figure 6-5 shows locations of Individual Permit site monitoring areas where storm water runoff samplers collected compliance samples in 2017.

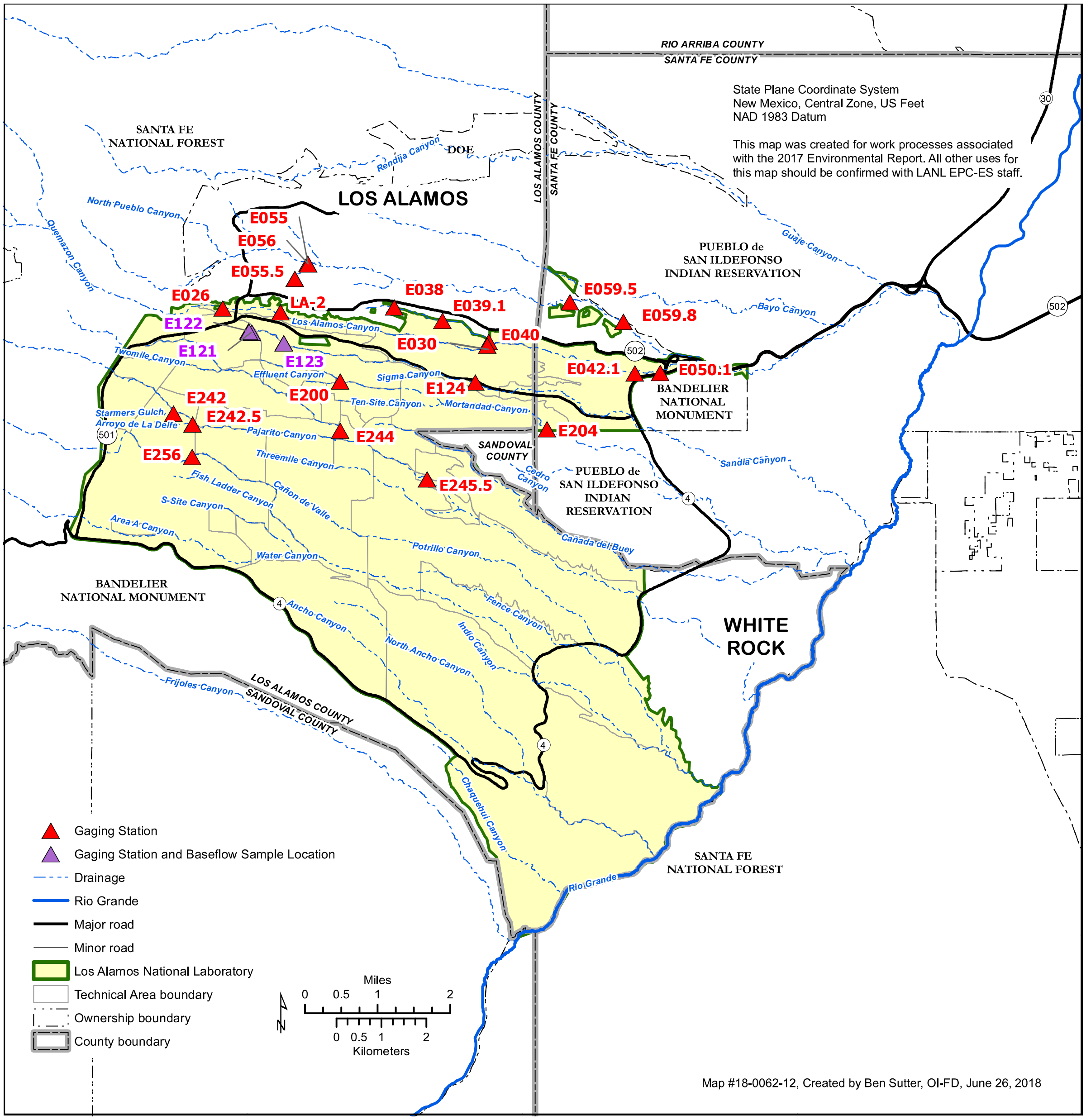


Figure 6-4 Locations sampled for storm water in 2017 at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs

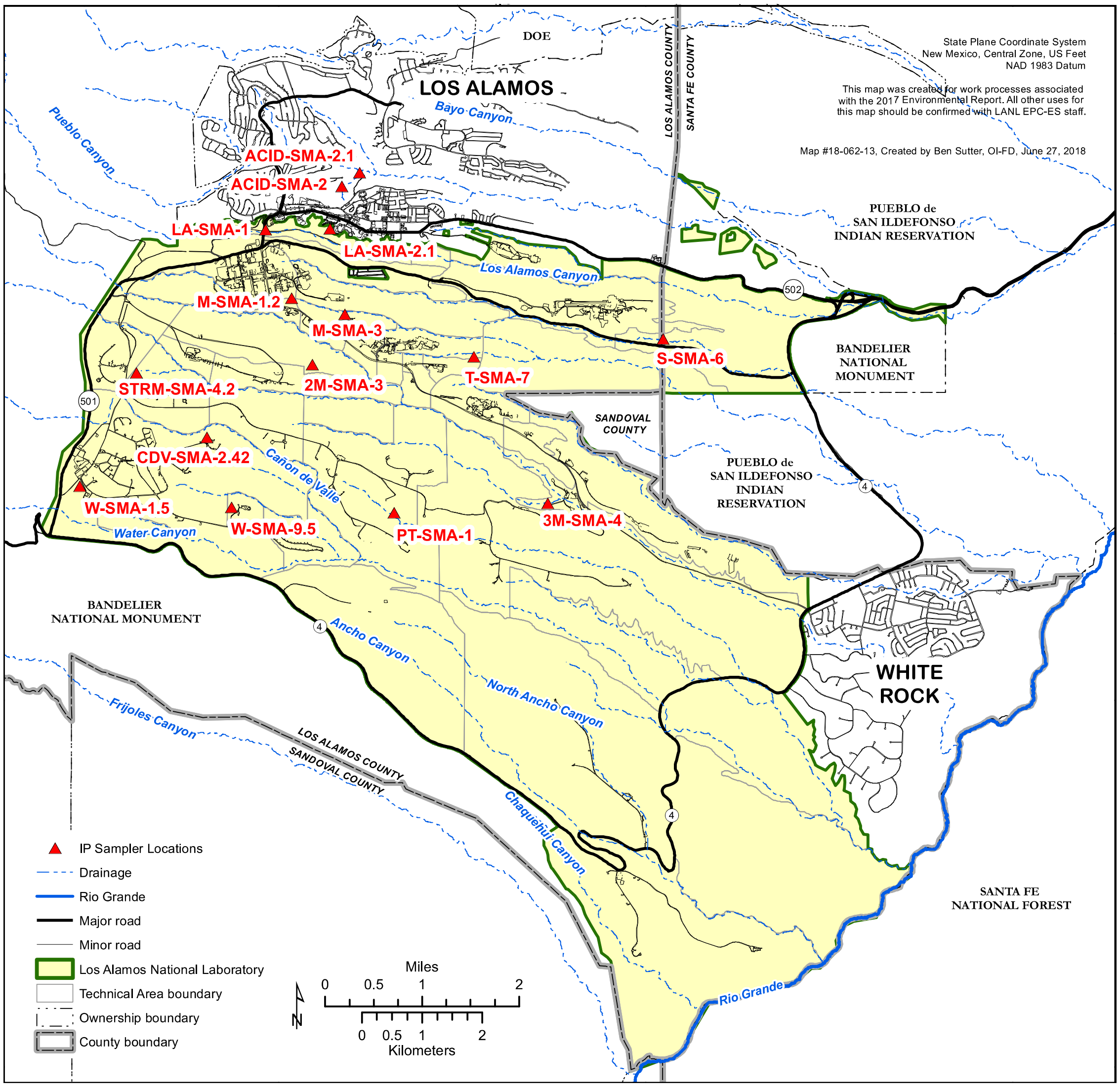


Figure 6-5 **Individual Permit site monitoring areas where automated samplers collected compliance storm water samples in 2017**

Sediment Sampling Locations and Methods

Figure 6-6 shows locations sampled for sediment in 2017 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 flood plains where new sediment was deposited during 2017. For streams with flowing water, sediment samples were collected near the edge of the main channel adjacent to, but not in, the water. During 2017, storm water runoff flowed in every canyon on Laboratory property except for Fence and Indio Canyons in the Water Canyon watershed; therefore, sediment samples were collected from most watersheds.

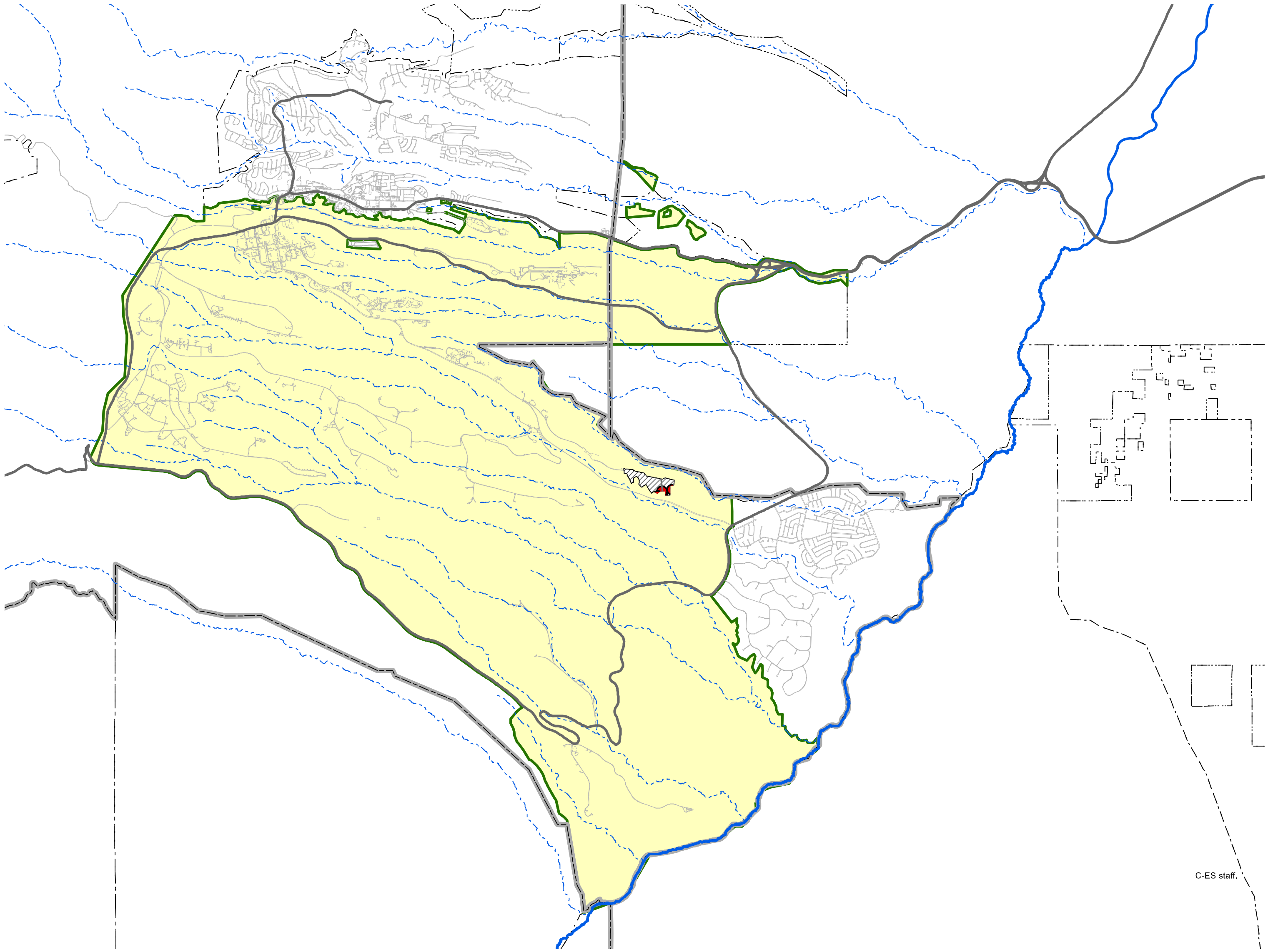


Figure 6-6 Locations sampled in 2017 for sediment as part of the annual environmental surveillance program

Quality Assurance

Sampling of storm water runoff is performed according to written quality assurance and quality control procedures and protocols identified in the following Laboratory standard operating procedures and guides: Installing, Setting Up, and Operating 3700 ISCO Samplers (EP-DIV-SOP-10008); Inspecting ISCO Storm Water Samplers and Retrieving Samples (ER-SOP-10013); and Processing Surface Water Samples (EP-DIV-SOP-20217). Measuring stream flow is performed according to Operation and Maintenance of Gage Stations for Storm Water Projects (EP-DIV-SOP-10005) and Managing Electronic Stage and Discharge Data from Stream Gage Stations (EP-DIR-SOP-10022). Base flow is sampled according to Spring and Surface Water Sampling (SOP-5224). Sediment is sampled according to Geomorphic Characterization (ER-GUIDE-20237) and Soil, Tuff, and Sediment Sampling (ER-SOP-20069). Current versions of all procedures and guides are listed at http://www.lanl.gov/environment/plans-procedures.php and are available in the Laboratory's electronic public reading room at http://eprr.lanl.gov.

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. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting. We collect all samples under full chain-of-custody procedures. Once collected, sediment samples are hand-delivered to the Laboratory's Sample Management Office, which ships the samples via express delivery directly to an external laboratory. Storm water samples are collected in the field, hand-delivered to the Laboratory's storm water processing facility where samples are preprocessed, then hand-delivered to the Laboratory's Sample Management Office, which ships the samples via express delivery directly to an external laboratory. Upon receipt of data from the analytical laboratory, an automated quality assessment of the data is performed where sample completeness and other variables are assessed.

Sampling Results

Table 6-3 summarizes inorganic chemical results for 2017 storm water and base flow samples for locations that had at least one sample result that exceeded screening levels. Table 6-4 summarizes organic chemical and radionuclide results for 2017 storm water and base flow samples for locations that had at least one sample result that exceeded screening levels. Table 6-5 summarizes results for radionuclides and chemicals in 2017 sediment samples for substances that had at least one sample result that exceeded screening levels.

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 2017 are available in the Storm Water Individual Permit Annual Report (LANL 2017d). 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.

Table 6-3
2017 Storm Water and Base Flow Locations for Inorganic Chemicals Where At Least One Sample Result Exceeded Screening Levels

Location Description	Stream Gage Number	Aluminum			Copper			Lead			Mercury			Selenium			Zinc		
		Analyses[a]	Detects[b]	Exceedances[c]	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
Acid above Pueblo	E056	4	4	4	4	4	4	4	4	4	—[d]	—	—	—	—	—	4	4	1
Ancho below SR-4	E275	1	1	1	—	—	—	—	—	—	1	1	1	1	1	1	—	—	—
DP above Los Alamos Canyon	E040	8	8	4	8	8	2	—	—	—	—	—	—	—	—	—	—	—	—
DP above TA-21	E038	4	4	3	4	4	2	—	—	—	—	—	—	—	—	—	—	—	—
DP below grade control structure	E039.1	4	4	2	4	4	2	—	—	—	—	—	—	—	—	—	—	—	—
E059.5 Pueblo below LAC WWTF	E059.5	1	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—
E059.8 Pueblo below Wetlands	E059.8	2	2	1	2	2	1	—	—	—	—	—	—	—	—	—	—	—	—
La Delfe above Pajarito	E242.5	2	2	2	2	2	1	—	—	—	—	—	—	—	—	—	—	—	—
Los Alamos above DP Canyon	E030	4	4	2	4	4	2	—	—	—	—	—	—	—	—	—	—	—	—
Los Alamos above low-head weir	E042.1	4	4	2	4	4	1	—	—	—	4	4	2	4	2	2	—	—	—
Los Alamos below low-head weir	E050.1	6	6	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mortandad below Effluent Canyon	E200	3	3	2	3	3	3	—	—	—	—	—	—	3	1	1	—	—	—
Pajarito above Threemile	E245.5	3	3	3	3	3	1	—	—	—	—	—	—	3	2	1	—	—	—
Pueblo above Acid	E055	4	4	4	4	4	4	4	4	4	—	—	—	—	—	—	—	—	—
Sandia above Firing Range	E124	2	2	2	2	2	1	—	—	—	2	2	2	2	2	1	—	—	—
Sandia below Wetlands[e]	E123	12	6	5	12	5	5	12	5	4	—	—	—	—	—	—	—	—	—
Sandia left fork at Asph Plant	E122	4	4	4	4	4	4	—	—	—	—	—	—	—	—	—	4	4	2
Sandia right fork at Pwr Plant	E121	13	5	4	13	7	4	13	2	2	—	—	—	—	—	—	13	13	4
South fork of Acid Canyon	E055.5	3	3	3	3	3	3	3	3	3	—	—	—	—	—	—	3	3	1
Starmers above Pajarito	E242	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—
Twomile above Pajarito	E244	2	2	2	2	2	1	—	—	—	—	—	—	—	—	—	—	—	—

[a] Analyses are the number of samples analyzed for that constituent.
[b] Detects are the number of samples in which that constituent was detected.
[c] Exceedances are the number of results that were detected above the screening level.
[d] A dash (—) indicates either analysis was not performed for the chemical or there were no exceedances of screening levels.
[e] Gray highlighting indicates base flow sampling locations, while no gray highlighting indicates storm water sampling locations.

Table 6-4
2017 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[a]	Detects[b]	Exceedances[c]	Analyses	Detects	Exceedances
Acid above Pueblo	E056	4	4	4	4	4	4
Ancho below SR-4	E275	1	1	1	1	1	1
DP above Los Alamos Canyon	E040	4	4	4	4	3	3
DP above TA-21	E038	4	4	4	4	4	4
DP below grade control structure	E039.1	4	4	4	4	4	3
E059.5 Pueblo below LAC WWTF	E059.5	2	1	1	1	1	1
E059.8 Pueblo below Wetlands	E059.8	4	4	4	—[d]	—	—
La Delfe above Pajarito	E242.5	2	2	2	—	—	—
Los Alamos above DP Canyon	E030	2	2	2	2	2	2
Los Alamos above low-head weir	E042.1	8	8	8	4	4	4
Los Alamos below low-head weir	E050.1	6	6	6	3	3	3
Mortandad below Effluent Canyon	E200	3	3	3	3	3	2
Pajarito above Threemile	E245.5	3	3	3	3	3	3
Pueblo above Acid	E055	2	2	2	2	2	1
Sandia above Firing Range	E124	2	2	2	1	1	1
Sandia below Wetlands[e]	E123	11	11	11	6	3	1
Sandia left fork at Asph Plant	E122	4	4	4	—	—	—
Sandia right fork at Pwr Plant	E121	12	11	11	—	—	—
South fork of Acid Canyon	E055.5	3	3	3	3	3	3
Starmers above Pajarito	E242	1	1	1	1	1	1
Twomile above Pajarito	E244	2	2	2	2	2	2

[a] Analyses are the number of samples analyzed for that constituent.
[b] Detects are the number of samples in which that constituent was detected.
[c] Exceedances are the number of results that were detected above the screening level.
[d] A dash (—) indicates either analysis was not performed for the chemical or there were no exceedances of screening levels.
[e] Gray highlighting indicates base flow sampling locations, while no gray highlighting indicates storm water sampling locations.

Table 6-5
2017 Sediment Locations for Radionuclides and Chemicals Where at Least One Sample Result Exceeded Screening Levels

Location ID	Canyon	Reach Name	2,3,7,8-TCDD TEQ			Cesium-137			Chromium			Manganese			PCB-126		
			Analyses[a]	Detects[b]	Exceedances[c]	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
CH-61316	Chaquehui	CHQ@RG	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—
LA-61568	Los Alamos	LA Ret Pond	1	1	1	—	—	—	—	—	—	—	—	—	1	1	1
MO-61262	Mortandad	M-2W	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—
PU-61505	Pueblo	AC-3	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—
SA-61613	Sandia	S-2	—	—	—	—	—	—	1	1	1	1	1	1	—	—	—
SA-61614	Sandia	S-2	—	—	—	—	—	—	1	1	1	1	1	1	—	—	—
WA-61529	Water	WA-4	—	—	—	—	—	—	—	—	—	1	1	1	—	—	—

[a] Analyses are the number of samples analyzed for that constituent.
[b] Detects are the number of samples in which that constituent was detected.
[c] Exceedances are the number of results that were detected above the screening level.
[d] A dash (—) indicates either analysis was not performed for the chemical or there were no exceedances of screening levels.

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 (EPA 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 2017 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 2017, there were minimal exceedances of screening levels. The residential screening action level for cesium-137 was exceeded in one sediment samples collected in Mortandad Canyon. Residential soil screening levels were exceeded for PCB-126 and 2,3,7,8-TCDD TEQ in one sediment sample collected in the upper sediment detention ponds in Los Alamos Canyon, and for chromium in two sediment samples collected below the wetland in Sandia Canyon. Construction soil screening levels for manganese were exceeded in four sediment samples: one each in Pueblo, Sandia, Water, and Chaquehui Canyons.

For radionuclides in storm water and base flow samples collected in 2017, no aquatic or terrestrial biota concentration guides for water were exceeded. For chemicals in storm water and base flow, Table 6-6 presents a summary of locations where New Mexico water quality standards or background values were exceeded in at least one location for each chemical.

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 good enough 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 6-6
Number of Locations where New Mexico Water Quality Standards or Background Values were Exceeded for Storm Water or Base Flow Results in 2017 for Constituents with at Least One Exceedance

Analyte[1]	Livestock Watering	Wildlife Habitat	Acute Aquatic Life	Chronic Aquatic Life	Human Health-Organism Only	Undeveloped Area Background	Developed Area Background
Aluminum (T)	—	—	31	20	—	2	5
Copper (D)	—	—	19	20	—	17	0
Lead (D)	—	—	0	16	—	0	1
Mercury (T)	—	5	0	0	—	—	—
Selenium (T)	0	6	—	0	—	—	—
Zinc (D)	—	—	2	6	—	1	0
Gross alpha	39	—	—	—	—	11	33
Total PCB	—	57	1	57	78	65	21

(T) = total and (D) = dissolved
A dash indicates there is no standard for this chemical or radionuclide in this category.

Constituents Related to Background Sources

Several constituents observed in storm water, base flow, and sediment are associated with both naturally occurring sources in soils and rock and human-derived sources upstream of the Laboratory on the Pajarito Plateau. 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 2017 at a particular location for storm water or base flow samples are shown in Figures 6-7 through 6-10 for the watersheds in which the exceedances occurred. No chemicals from human sources, with the potential exception of chromium in Sandia Canyon, exceeded screening levels more than once at a particular location in sediment samples.

In Figures 6-7 through 6-10, the y-axis is reversed to represent the Rio Grande to the east of the Laboratory. Values are plotted from upstream sampling locations on the left of each figure to downstream locations on the right, with the Rio Grande at zero. Plotted results are from the canyons investigation reports, the annual environmental surveillance program, or the Individual Permit. All results are plotted relative to their along-channel distance from the Rio Grande. Canyon confluences, stream reaches of interest, and particular Laboratory areas are labeled for spatial reference. Pre-2017 results are identified using a unique color for each subwatershed. Results obtained in 2017 are in green. In the surface water figures, results associated with the Individual Permit are identified with a circle, and gaging station results are identified with a triangle.

Aluminum. Filtered storm water samples collected on the Pajarito Plateau in 2017 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 is not known to be derived from Laboratory operations in any significant quantity. As shown in Table 6-6, while there is a large number of exceedances of the aquatic life water quality standards, there are only two exceedances of the undeveloped area background value, indicating that the major source of aluminum is likely the Bandelier Tuff formation. There were four exceedances of the target action limit for filtered aluminum concentrations in nine Individual Permit–related runoff samples in 2017. Twenty-six of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for aluminum (Table 6-2). 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 (NMED 2009).

Aluminum concentrations in sediment samples collected during 2017 were not detected above the residential soil screening level, and there were no results above the sediment background value for aluminum.

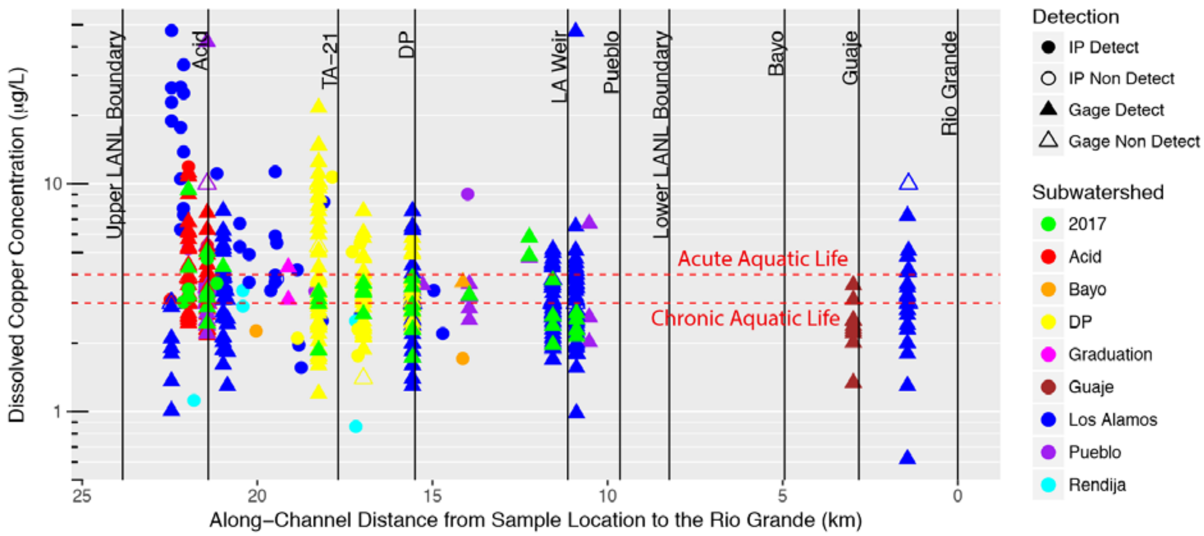
Arsenic. Gaseous emissions from coal-fired power plants are associated with arsenic pollution. While the Four Corners Generating Station coal-fired power plant has contributed to arsenic contamination in the surrounding areas, the Laboratory also operated coal-fired power plants historically. However, arsenic is also a significant component of the local volcanic geologic formations. In 2017, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for arsenic, and while 11 results exceeded the developed area background value, no results exceeded the undeveloped area background value, thus indicating that the source of the arsenic is most likely naturally occurring. None of the nine Individual Permit-related samples exceeded the target action level for arsenic in 2017. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for arsenic (Table 6-2), and it is located in upper Pajarito Canyon upstream of the Laboratory.

In 2017, no sediment samples exceeded screening levels for arsenic and only two sediment samples exceeded the background value for arsenic.

Copper. Copper is naturally occurring and it is also associated with 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 2017, copper concentrations in filtered storm water were detected above the acute aquatic life standard in 19 samples, above the chronic aquatic life standard in 20 samples, but above the developed area background value in none of the samples, indicating that the major sources of copper are likely those associated with developed areas.

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 6-2). 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 2017, there were six exceedances of the target action limit for filtered copper concentrations in nine Individual Permit-related runoff samples. Figures 6-7a and 6-7b show copper concentrations in filtered storm water and base flow for Los Alamos and Sandia Canyons.

In 2017, copper concentrations in sediment were not detected above the residential soil screening level, and there were only eight of 77 sample results above the sediment background value for copper.



Note: TA = Technical area; LA = Los Alamos; km = kilometers; µg/L = microgram per liter.

Figure 6-7a Los Alamos Canyon watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017

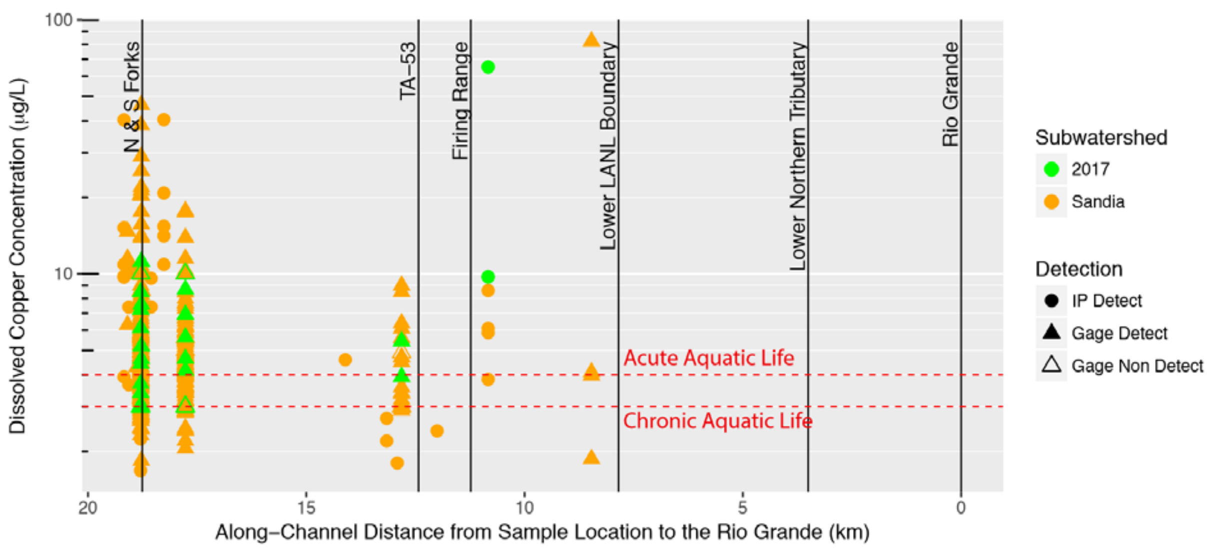


Figure 6-7b Sandia Canyon watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017

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 2017 were detected above the chronic aquatic life standard in 16 samples, but lead concentrations above the developed area background value were found in only one sample, indicating that the major source of lead is likely developed areas. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for lead (Table 6-2). There was one exceedance of the target action limit for filtered lead concentrations in the nine Individual Permit-related runoff samples in 2017. Figures 6-8a and 6-8b show lead concentrations in filtered storm water and base flow for Los Alamos and Sandia Canyons.

In 2017, lead concentrations in sediment were not detected above the residential soil screening level, and there were only twelve of 77 sample results above the sediment background value for lead.

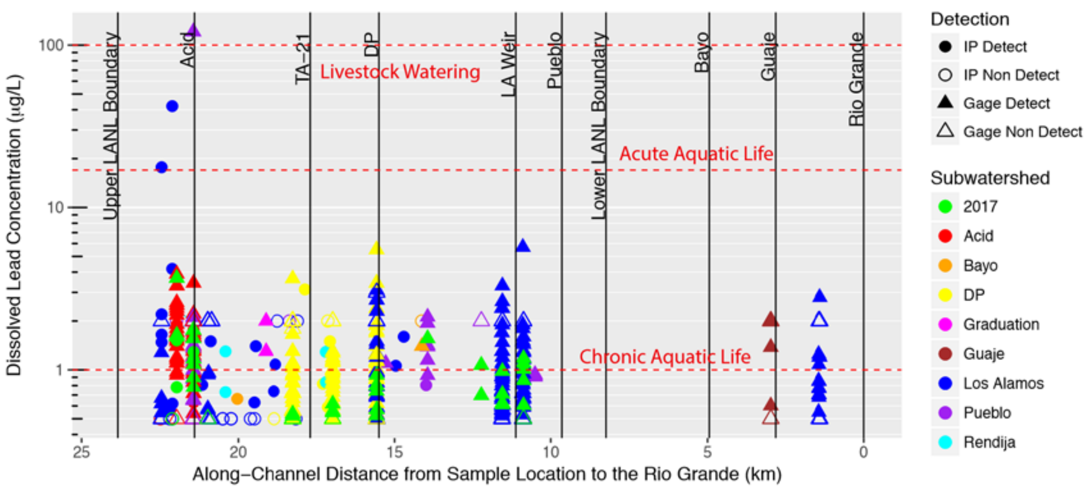


Figure 6-8a **Los Alamos Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017**

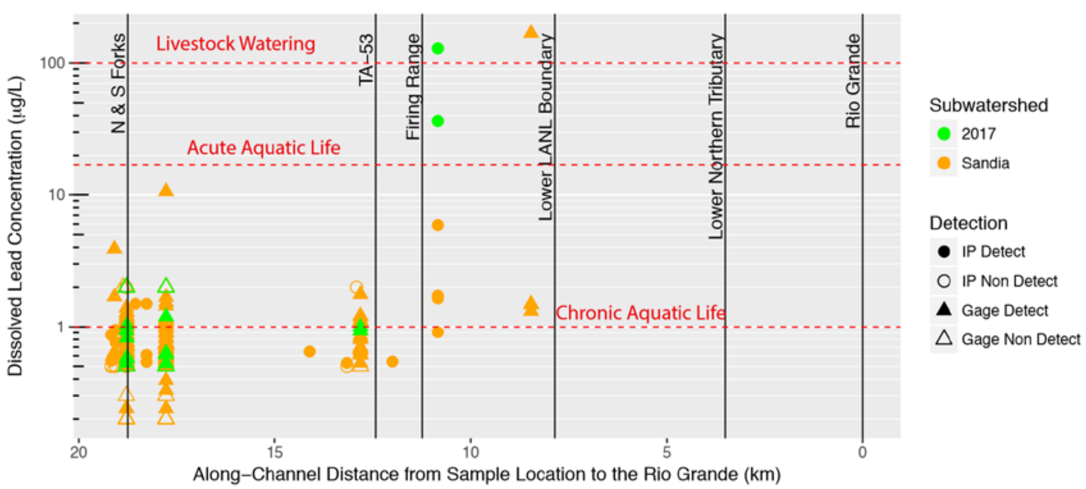


Figure 6-8b **Sandia Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017**

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 2017. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for manganese (Table 6-2).

In 2017, manganese concentrations in sediment were detected above the construction soil screening level (which is lower than the residential soil screening level) in five of 77 samples and above the background value in only five of 77 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). Total selenium concentrations were detected above the wildlife habitat standard in six storm water samples collected in 2017. Total selenium concentrations exceeded the Individual Permit target action level in none of the Individual Permit-related storm water samples collected in 2017. Only one of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for selenium (Table 6-2), and it is located in upper Pajarito Canyon directly upstream of the Laboratory boundary to the watershed headwaters.

In 2017, 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 2017, 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 six samples, but were not detected above the developed area background value, indicating that the major source of zinc is most likely developed areas. Only one of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for zinc (Table 6-2) 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 2017 there were no Individual Permit exceedances for zinc. Figure 6-9 shows zinc concentrations in filtered storm water and base flow for Sandia Canyon.

In 2017, zinc concentrations in sediment were not detected above the residential soil screening level, and there were only 11 of 77 sample results above the sediment background value for zinc.

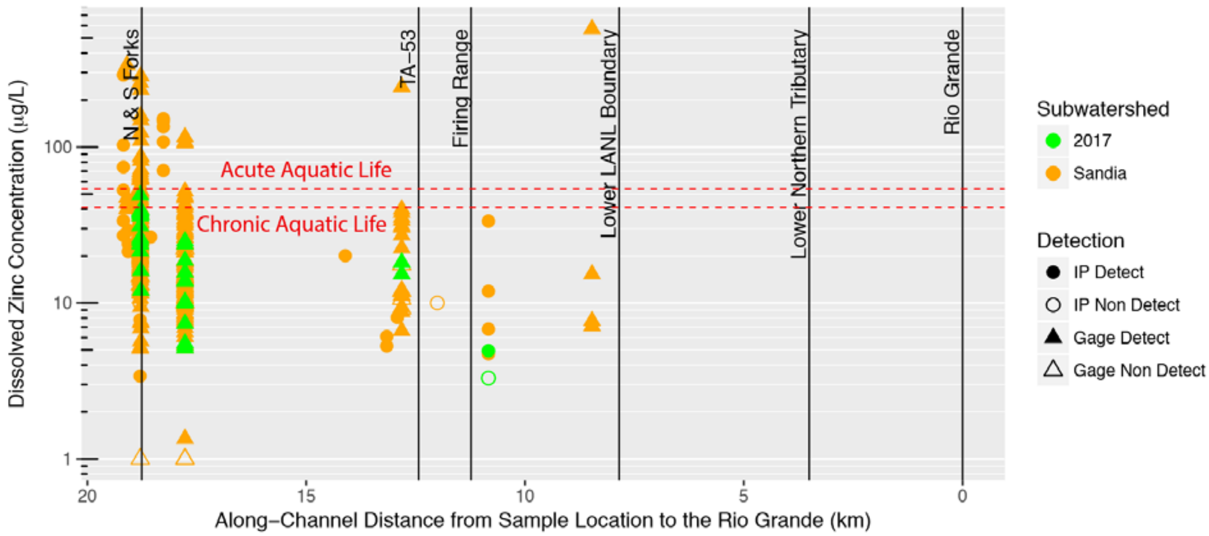


Figure 6-9 Sandia Canyon watershed zinc concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017

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 2017, 39 unfiltered storm water samples had gross alpha activities above the livestock watering standard, but only 11 results exceeded the undeveloped area background value, indicating that the Bandelier Tuff formation is most likely the major source of the gross alpha exceedances. 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, the gross alpha activities were particularly high in runoff samples from the large September 2013 flood event. For sampling under the Individual Permit in 2017, gross alpha activity was above the target action level in six of nine 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 6-2). However, the analytical results from 2017 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 (e.g., 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 relate to 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 2017 storm water and sediment samples. Chemical results that exceeded screening levels or standards more than once in 2017 at a particular sample location for storm water and base flow are shown in the figures associated with each chemical below.

Cesium-137. Cesium-137 is a radionuclide that is a byproduct of nuclear fission processes in nuclear reactors and nuclear weapons testing. In 2017, 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.

Cesium-137 activity in sediment samples collected in 2017 exceeded the residential screening action level in one of five samples and exceeded the background value in three of five samples in Mortandad Canyon; therefore, the source is most likely related to historical Laboratory activities associated with Technical Area 50 and Effluent Canyon within the Mortandad Canyon watershed. In addition, two sediment samples in Los Alamos Canyon and one in DP Canyon had cesium-137 activities above the background value; thus, the source is potentially related to historical Laboratory activities in these canyons.

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 2017 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 6-2).

In 2017, sediment results in Sandia Canyon in the reach below the wetlands exceeded the chromium residential soil screening level in two of two samples. Five of 77 samples exceeded the sediment background value for chromium, two in the reach below the Sandia Canyon wetlands, two in the reach above the Sandia Canyon firing range, and one in Chaquehui Canyon at the Rio Grande.

Dioxins/Furans. Dioxins/furans are associated with the incineration of medical, industrial, municipal, and private wastes; municipal wastewater treatment sludge; coal-fired boilers; and diesel fuel emissions (EPA 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/furans and are more meaningful than reporting the number of grams of dioxins/furans because toxic equivalents provide information on toxicity (EPA 2010). In addition, there are surface water quality standards for a total dioxin toxic equivalent, whereas there are no standards for individual dioxins/furans. In 2017, 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/furans (along the Rio Grande at the Otowi Bridge and Mortandad Canyon), 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 6-2).

In 2017, sediment was analyzed for dioxins/furans in 14 samples, 12 of which had detects of one of the 17 types of dioxins/furans. Detects were found throughout Los Alamos and

Pajarito Canyons, including in background locations upstream of Laboratory lands. The more toxic dioxin compounds (2,3,7,8-tetrachlorodibenzodioxin and 1,2,3,7,8-pentachlorodibenzodioxin) were not detected in sediment samples collected in 2017.

Mercury. Natural sources of mercury include forest fires and fossil fuels such as coal and petroleum, and 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 2017, seven 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 the surface water quality standard for mercury, and none of the filtered or unfiltered baseflow results exceeded the surface water quality standard for mercury. One of the nine Individual Permit–related samples exceeded the target action level for mercury in 2017. 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.

In 2017, no sediment results exceeded screening levels for mercury, and at two locations the sediment results exceeded background values, one in the reach below the Sandia wetlands and one in Acid Canyon.

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 the former asphalt batch plant in Sandia Canyon.

PCBs were detected in 79 of 80 gaging station storm water and base flow samples collected in 2017. Of 80 samples, 78 had concentrations above the human health–organism only standard, 57 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. There were 65 exceedances of the undeveloped area background value for total PCBs but only 21 exceedances of the developed area background value, indicating that the major source of PCBs is likely developed areas with minor sources of PCBs associated with Laboratory-related releases. In 2017, three of nine 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 6-2). Figures 6-10a through 6-10c show total PCB concentrations in unfiltered storm water and base flow for Los Alamos, Pajarito, and Sandia Canyons.

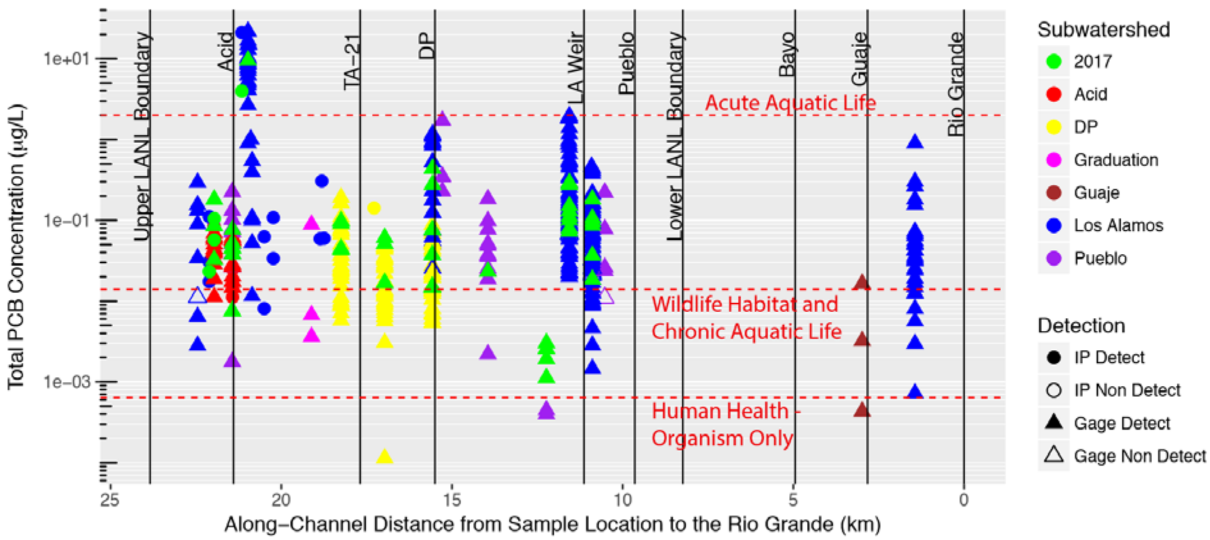


Figure 6-10a Los Alamos Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017

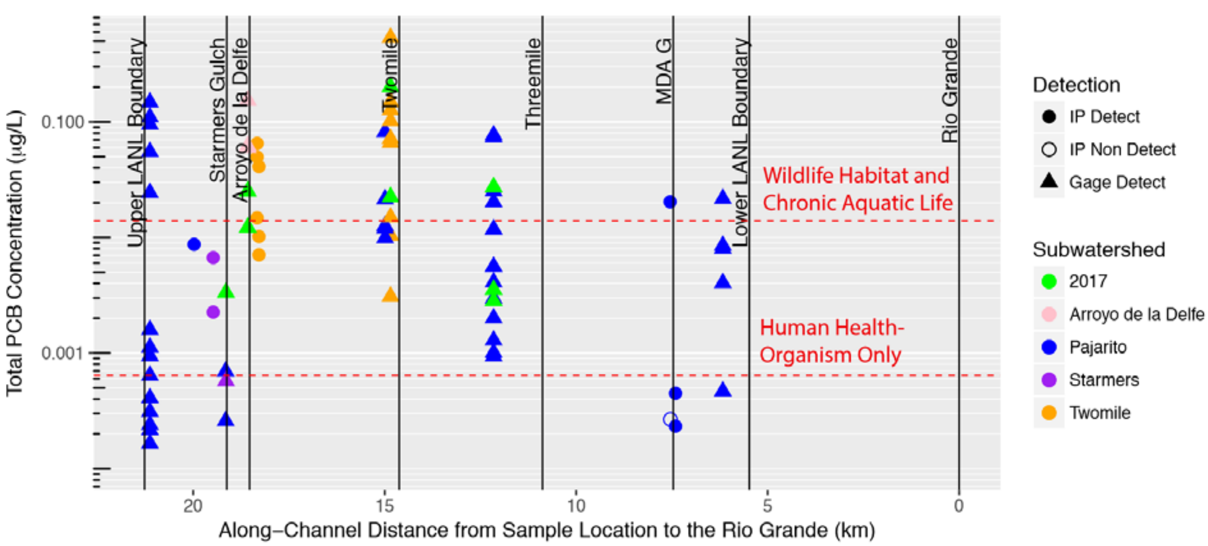


Figure 6-10b Pajarito Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017

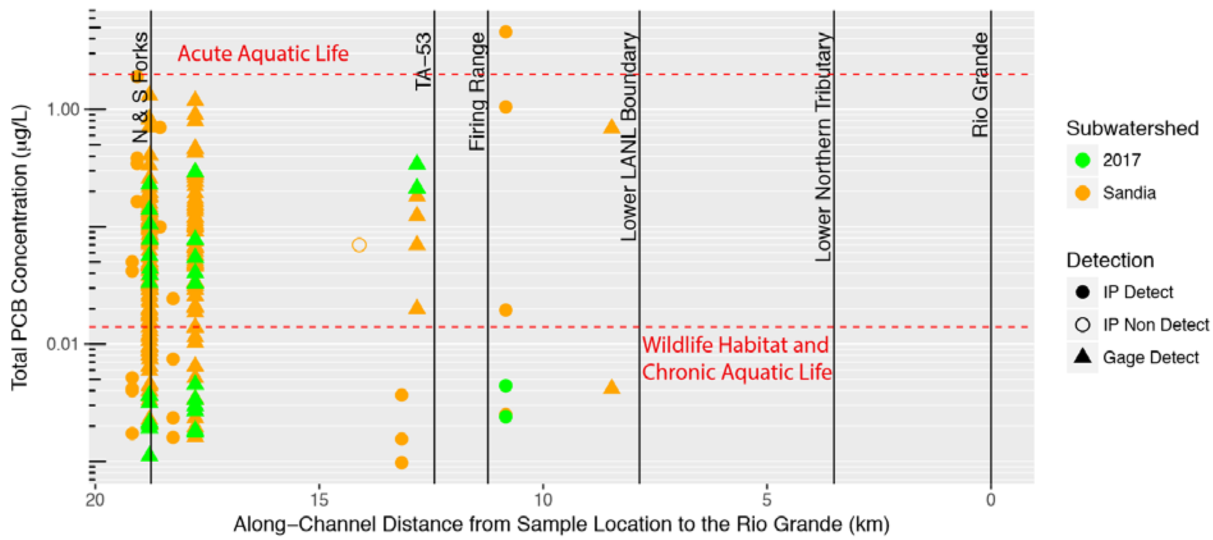


Figure 6-10c Sandia Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2010 to 2017

In sediment, PCBs were detected in 75 of 82 samples; the only samples with no detection of PCBs were along the Rio Grande (at all the Rio Grande locations except below Mortandad, Ancho, and Chaquehui Canyons), and in Cochiti Lake. The residential soil screening level for PCB-126 (a specific congener of PCBs) was exceeded in one sediment sample 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 2017 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 2017, no storm water results at the gaging stations or base flow results exceeded the water quality standards. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for polycyclic aromatic hydrocarbons (Table 6-2).

For the 12 of 18 polycyclic aromatic hydrocarbon compounds that have screening levels, none of the sediment results from 2017 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 2017, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for thallium. None of the nine Individual Permit-related samples exceeded the target action level for thallium in 2017. Only 1 of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands is listed as impaired for thallium (Table 6-2). 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 2017.

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 results of the storm water, base flow, and sediment data comparisons from samples collected in 2017 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 2017, these transient events do not significantly affect human or biota health.

One notable aspect of the sampling in 2017 is that there was only one location where a sediment sample had a chemical result that exceeded soil screening levels downstream of a surface water sampling location where the same chemical had a result that exceeded surface water quality standards—PCBs in the upper Los Alamos Canyon detention ponds.

Storm water and base flow results from 2016 and 2017 were used by the New Mexico Environment Department to reassess the impairment status of each assessment unit, or stream reach, on Laboratory and former Laboratory lands. Once finalized, this reassessment will be used to inform updates to the Laboratory's National Pollutant Discharge Elimination System permits that regulate industrial activities, specifically the effluent outfalls.

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7.0 Ecosystem Health

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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 and chemicals (e.g., metals, other inorganic elements, PCBs, dioxins, furans, and high explosives). We also complete dose assessments for plants and animals occupying areas around specific Laboratory facilities and 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 2017, soil and vegetation samples were collected around the perimeter of Material Disposal Area G at Technical Area 54. Soil, wild bird eggs that did not hatch, and nestlings that died of natural causes were collected at the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15. Mice and vegetation were collected upstream of sediment control structures within Los Alamos and Pajarito canyons. Deceased animals (primarily from vehicle strikes) including mule deer, rocky mountain elk, black bear, coyote, gray fox, great horned owl, western screech owl, red-tailed hawk, and bullsnake were collected from various areas of the Laboratory and were analyzed. We completed an aquatic ecosystem health assessment of the Rio Grande near the Laboratory, including sampling and testing fish and sediment downstream and upstream of the Laboratory, evaluating benthic macroinvertebrate communities, and conducting sediment biotoxicity assays. We also report the results from surveys of bird abundance and diversity, as well as surveys for threatened and endangered species.

Most radionuclide activities and chemical concentrations in soil, sediment, plants, and animals from on-site, perimeter, or background locations were either not detected, similar to background, or below screening levels, which we know to be protective of biota. On the Rio Grande, benthic macroinvertebrate community assemblages and results from the sediment biotoxicity assay were similar between downstream and upstream locations. There were no effects on bird populations and diversity around open firing sites at Technical Areas 36 and 39 and one open-burn site at Technical Area 16 compared with control areas. Biota dose assessments show that the radiation doses are far below the levels where adverse effects to plants and animals have been observed.

INTRODUCTION

An ecosystem includes living organisms, such as plants, animals, and microorganisms, and nonliving physical environmental factors, such as soil, air, and water, and also 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 the Laboratory's Ecosystem Health Monitoring Program is to determine if past or current releases of radionuclides and chemicals from LANL 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 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 on-site at the Laboratory, from perimeter locations, and from regional background locations. Specifically, the terrestrial health assessment reports on (1) facility-specific results, including monitoring around Area G, the Dual-Axis Radiographic Hydrodynamic Test Facility, and around two sediment retention structures; (2) chemical levels in mammals, birds, and snakes that were collected opportunistically; and (3) bird population monitoring. Aquatic ecosystem health was also monitored in the Rio Grande and at two reservoirs (Cochiti Lake, downstream from the Laboratory, and Abiquiu Reservoir, upstream from the Laboratory). We report on (1) chemical levels in fish, (2) benthic macroinvertebrate community assemblages, (3) chemical levels in aquatic sediments, and (4) sediment biotoxicity assays. Finally, an overall biota radiation dose was calculated for organisms occupying mesa tops, canyon bottoms, and Rio Grande waters. Results are compared with background levels, screening levels, and federal dose standards to assess any effects of Laboratory releases on surrounding ecosystems.

TERRESTRIAL HEALTH ASSESSMENT

Soil and Biota Comparison Levels Related to Ecosystem Health

The soil monitoring program directly measures the long-term trends in levels of radionuclides and chemicals around nuclear facilities (DOE 2015). Soil receives substances that are released in air emissions, particles that are transported by wind, and substances carried in irrigation water, in the case of agricultural fields. Therefore, soil data can provide information about several modes of chemical and radionuclide transport.

Chemical levels in soil biota collected at and near the Laboratory are compared with levels collected at background locations. Radionuclides and chemicals in soil collected from these 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. 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 1991). Figure 7-1 shows the on-site, perimeter, and regional (background) soil-sampling locations.

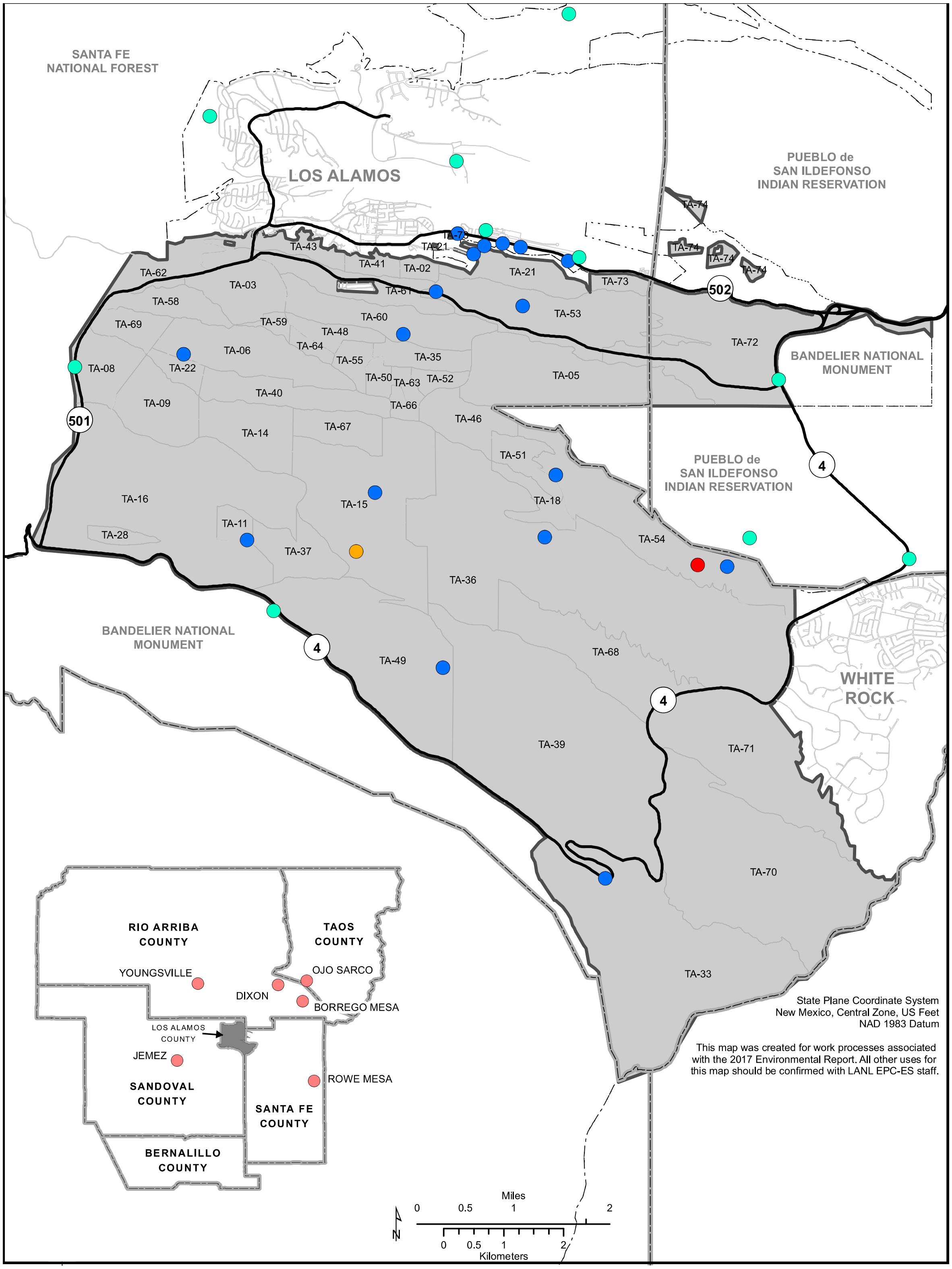
Individual results from samples collected on-site and near the Laboratory are compared with regional statistical reference levels. Regional statistical reference levels are the levels below which 99 percent of all background samples occur and are statistically calculated. Additionally, we perform statistical tests to evaluate differences between sites and trends over time. Examples of these tests include *t*-tests, linear regressions, and generalized linear models. These statistical tests are used to test a null hypothesis for each set of data, typically that there are no differences among groups, or that there are no trends over time. These statistical tests have an associated p-value, for example $p < 0.05$ or $p > 0.05$. The p-value refers to the likelihood that the test result would occur if our null hypothesis is true. A p-value of less than 5 percent ($p < 0.05$) is used as our threshold to reject the null hypothesis of no difference or no trend. If the p-value greater than 5 percent ($p > 0.05$), we accept the null hypothesis of no difference or no trend.

Only samples collected within the last ten years are used in these statistical tests because the samples were analyzed with similar methods and instruments and had similar detection limits.

Levels of chemicals in soil are also compared with ecological screening levels (LANL 2017). 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 2017). 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. Soil ecological screening levels also exist for the following aquatic ecological receptors: algae—representing aquatic autotrophs; aquatic community organisms; aquatic snails—representing aquatic herbivores; daphnids—representing aquatic herbivores and omnivores; and fish—representing intermediate aquatic carnivores (LANL 2017).

Levels of chemicals in 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 (EPA 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://web.ead.anl.gov/resrad/home2/biota.cfm), 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).



Note DARHT = Dual-Axis Radiographic Hydrodynamic Test (Facility).

Figure 7-1 On-site, perimeter, and regional (background) soil-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.

Institutional Soil and Vegetation Monitoring

Surface soil and vegetation samples are collected from 17 on-site, 11 perimeter, and six regional background locations every third year. The last comprehensive soil and vegetation survey occurred in 2015 (Fresquez et al. 2016). The next large-scale soil and vegetation sampling will occur in 2018.

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 7-2). Tritium, plutonium, americium, and uranium are the main radionuclides in waste materials at Area G. 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).

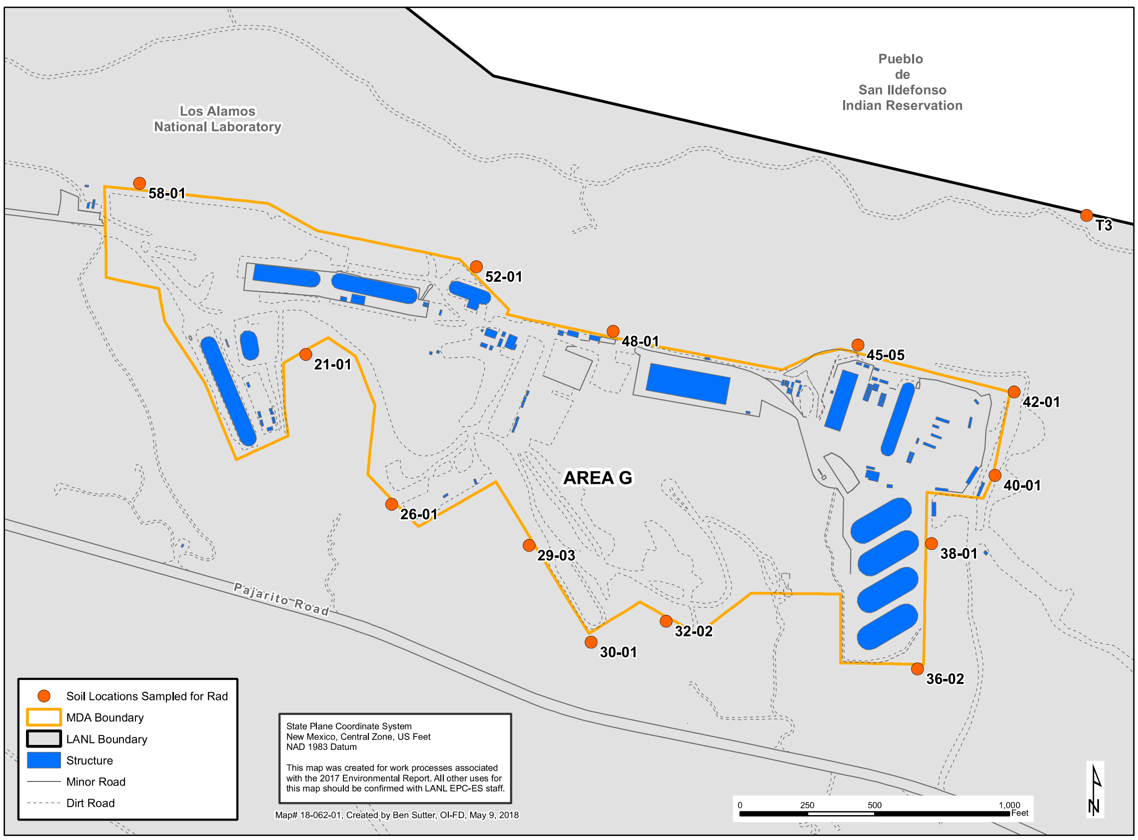


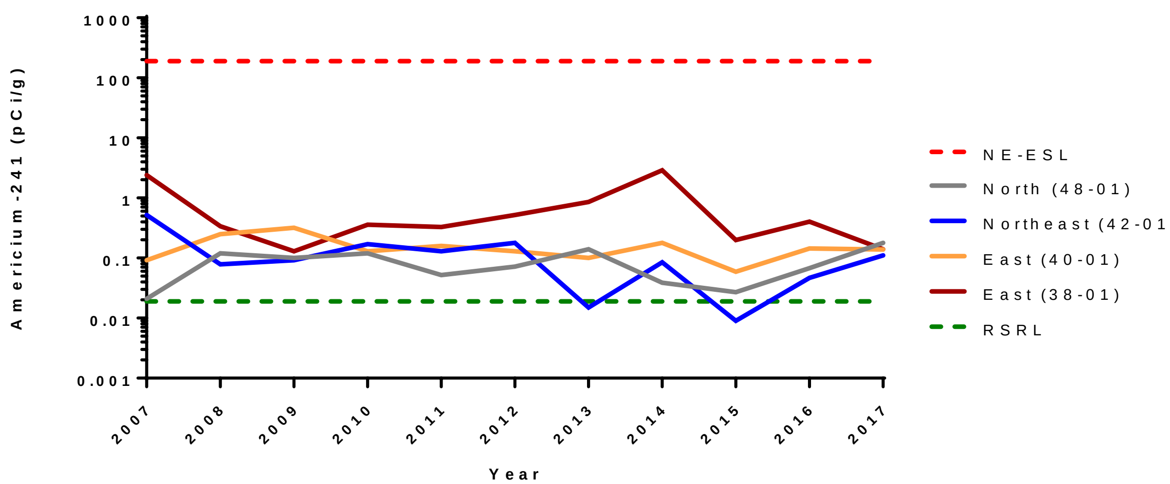
Figure 7-2 Locations of soil and vegetation samples collected around Area G in 2017.

Surface soil grab samples (0- to 6-inch depth) and composite tree samples, primarily of one-seed juniper (*Juniperus monosperma*), were collected in April and June 2017, respectively, at 13 designated locations around the perimeter of Area G. One soil sample and one tree sample were collected at the bottom of Cañada del Buey near the boundary between the Laboratory and the Pueblo de San Ildefonso (site T3; Figure 7-2). All samples were analyzed for tritium, americium-241, plutonium-238, plutonium-239/240, cesium-137, strontium-90, uranium-234, uranium-235/236, and uranium-238.

Radionuclides in Soil and Vegetation at Area G

In 2017, tritium results in soil from Area G were rejected because of quality control issues at the analytical laboratory (see the Analytical Laboratory Quality Assessment section at the end of this chapter). Cesium-137, strontium-90, 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 in 2017. Similar to previous years, americium-241, plutonium-238 and plutonium-239/240 were detected above regional statistical reference levels in many soil locations around the perimeter of Area G in 2017 (Supplemental Table S7-1) (Supplemental tables can be found online accompanying this document at http://www.lanl.gov/environment/environmental-report.php).

These levels and the locations of detections in soil (americium-241, plutonium-238, and plutonium-239/240 on the north, northeastern, and eastern side of Area G) were consistent with data from previous years and are not statistically increasing over time ($p > 0.05$; Figures 7-3 through 7-5).



Note: pCi/g = picocuries per gram.

Figure 7-3 Americium-241 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 2007 to 2017 compared with the regional statistical reference level (RSRL) and the lowest no-effect ecological screening level (NE-ESL; for earthworm). Note the logarithmic scale on the vertical axis.

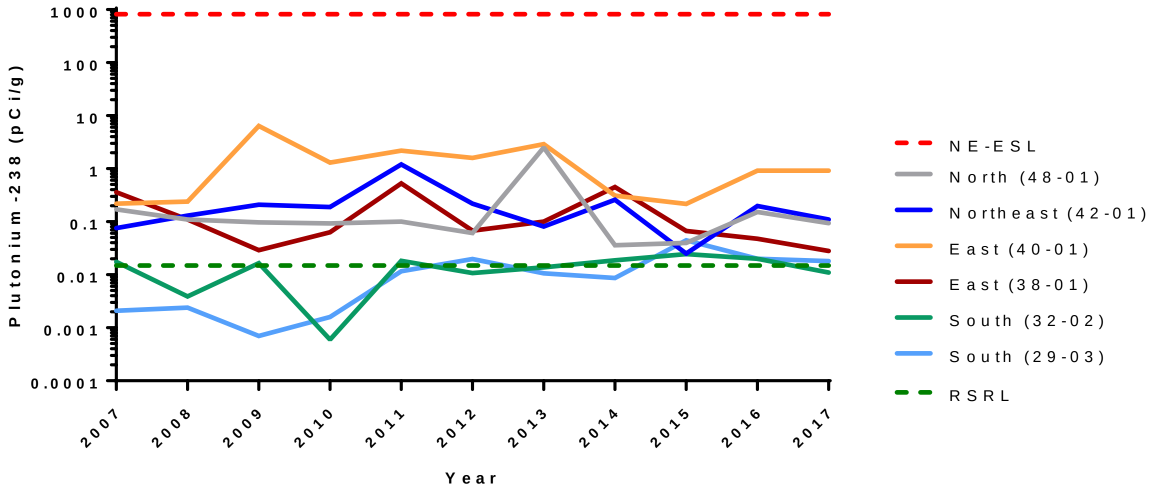


Figure 7-4 **Plutonium-238 activities in surface soil collected from the northern, northeastern, eastern, and southern portions of Area G at Technical Area 54 from 2007 to 2017 compared with the regional statistical reference level (RSRL) and and the lowest no-effect ecological screening level (NE-ESL; for earthworm). Note the logarithmic scale on the vertical axis.**

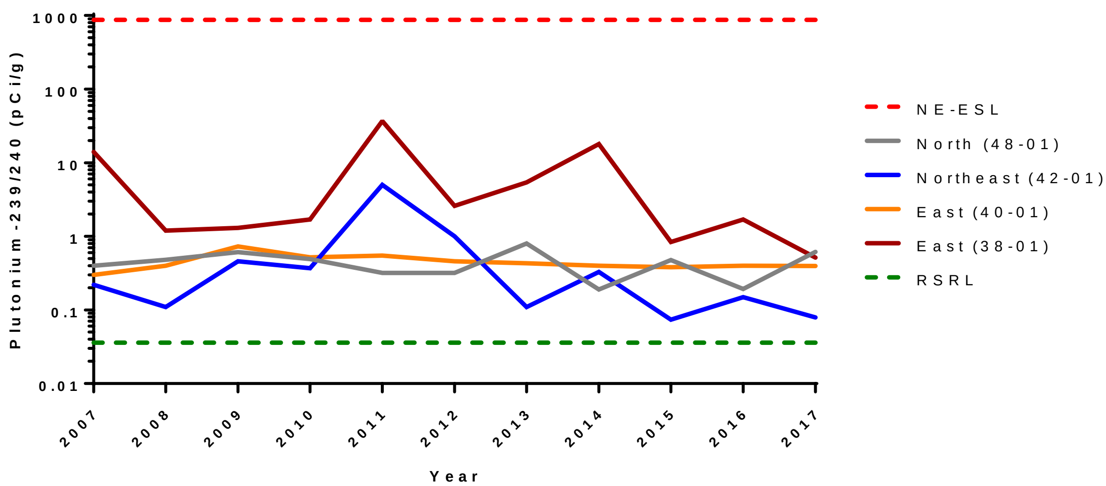


Figure 7-5 **Plutonium-239/240 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 2007 to 2017 compared with the regional statistical reference level (RSRL) and the lowest no-effect ecological screening level (NE-ESL; for earthworm). Note the logarithmic scale on the vertical axis.**

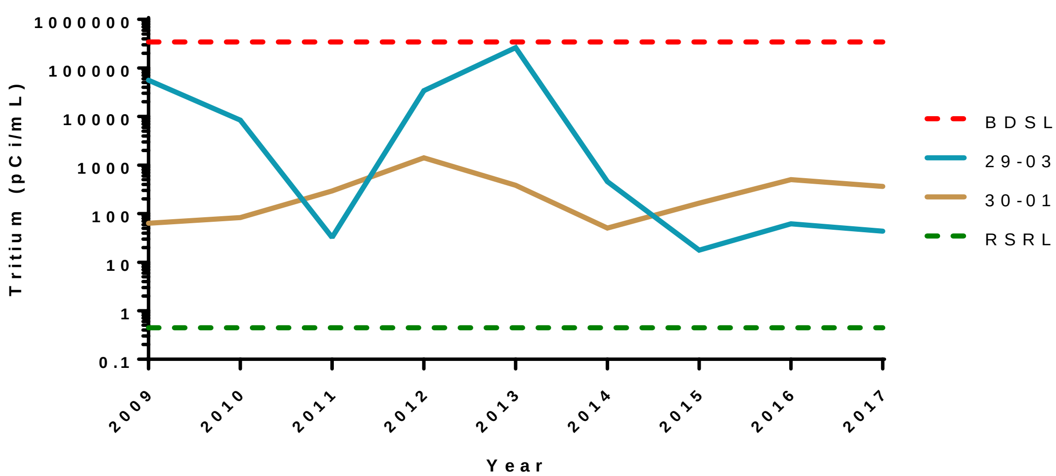
Plutonium-238 activities increased during the period between 2007 and 2017 at two locations on the south side of Area G ($p < 0.05$; 29-03 and 32-02; Figure 7-4); however, these levels are comparable to the regional statistical reference level and are below plutonium-238 activities observed on the north, northeastern, and eastern sides of Area G (Figure 7-4).

Most importantly, all radionuclide activities in soil samples from the perimeter of Area G were below all of the no-effect ecological screening levels for plant, animals, and invertebrates

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 7-2). However, because of a firebreak along the fence line, the trees are located more than 30 feet away from the fence around Area G. Results for tritium in vegetation are reported on a picocuries per milliliter basis, and results for the other radionuclides are reported on a picocuries per gram ash weight basis.

Cesium-137 was not detected in any of the vegetation samples from the perimeter of Area G, and americium-241 was only detected in one sample (Table S7-2). Uranium-238 and strontium-90 were detected in all of the vegetation samples (Table S7-2). Some plants contained radionuclide levels which exceeded the regional reference statistical reference level; however, all concentrations were well below the biota dose screening levels for overstory vegetation (Table S7-2).

Tritium was detected above background in almost all tree samples collected around the perimeter of Area G, with the highest amounts (up to 364.0 picocuries per milliliter) occurring 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. Tritium levels have not been significantly increasing over time ($p > 0.05$; Figure 7-6).



Note pCi/mL = picocuries per milliliter.

Figure 7-6 Tritium activities in composite tree samples collected from the southern portions of Area G at Technical Area 54 (sites 29-03 and 30-01) from 2009 to 2017 compared with the regional statistical reference level (RSRL) and the biota dose screening level (BDSL) for overstory vegetation. Note the logarithmic scale on the vertical axis. Sample locations can be found in Figure 7-3.

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.

No radionuclide activities in trees are increasing over time ($p > 0.05$). These data suggest that radionuclide activities observed here are not expected to cause adverse effects to the vegetation.

Radionuclides in Soil and Vegetation near the Laboratory/Pueblo de San Ildefonso Boundary in Cañada del Buey

The sample location (T-3) is on Laboratory property at the bottom of Cañada del Buey, approximately 194 feet south of the Pueblo de San Ildefonso fence line and northeast of Area G (Figure 7-2).

The level of americium-241 detected in a soil sample collected at this location in 2017 was higher than past years. However, the trend during 2007 to 2017 is not statistically significant ($p > 0.05$; Figure 7-7). The landscape near the T-3 point has been altered in the recent past which included shredding and removing trees to reduce risks from wildfire to Area G. The changes in the landscape could in part explain the variation in soil americium-241 levels. Additional soil sampling is warranted around T-3 to further characterize americium-241 in soil, and this sampling is scheduled to occur during the spring of 2018.

Plutonium-238 was not detected in the soil sample collected at this site in 2017 (Table S7-1). Levels of both plutonium-238 and plutonium 239/240 are not changing over time ($p > 0.05$; Figure 7-8 and 7-9). All levels of these radionuclides are far below the no-effect ecological screening levels for plant and animal receptors.

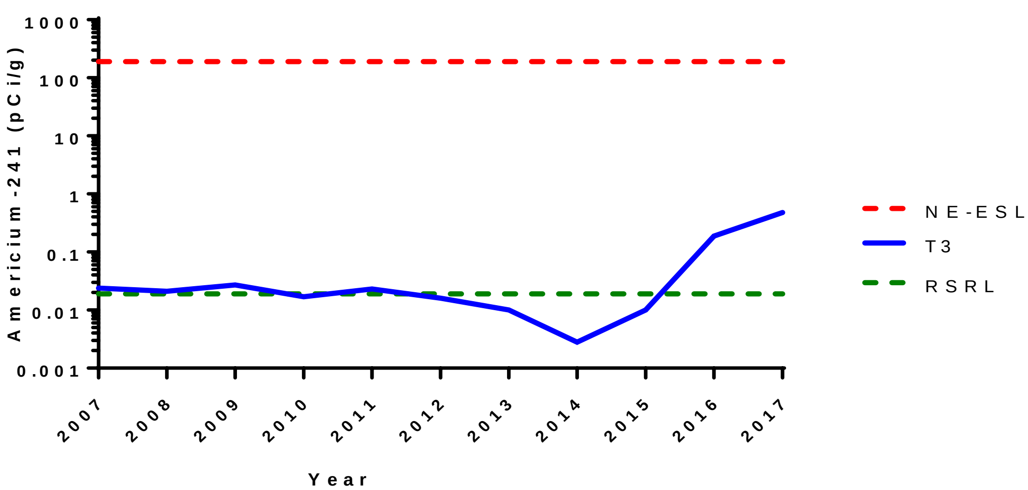


Figure 7-7 Americium-241 (detected and nondetected) activities in surface soil collected near the Laboratory/Pueblo de San Ildefonso boundary (site T3) northeast of Area G at Technical Area 54 from 2007 to 2017 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.

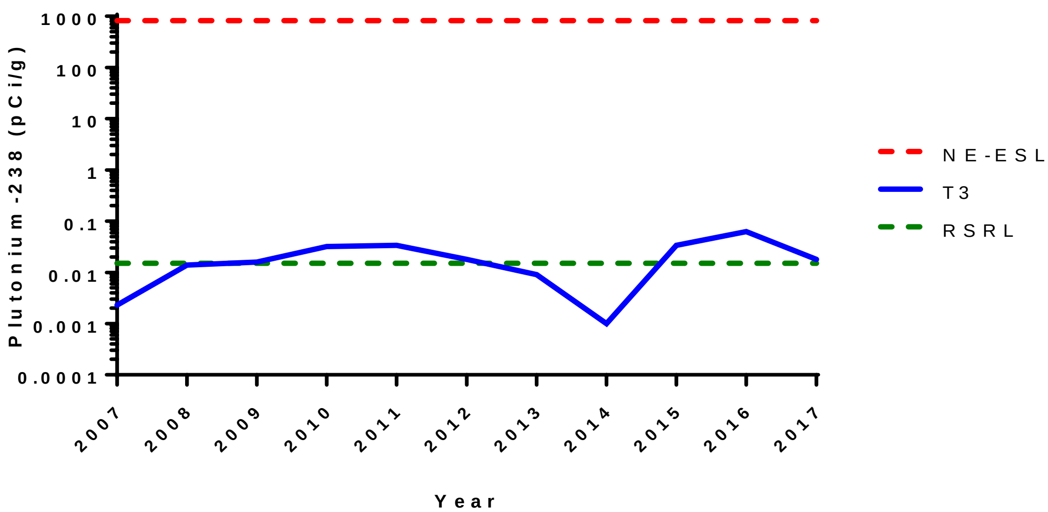


Figure 7-8 **Plutonium-238 (detected and nondetected) activities in surface soil collected near the Laboratory/Pueblo de San Ildefonso boundary (site T3) northeast of Area G at Technical Area 54 from 2007 to 2017 compared with the regional statistical reference level (RSRL) and the lowest no-effect ecological screening level (NE-ESL) for earthworm. Note the logarithmic scale on the vertical axis.**

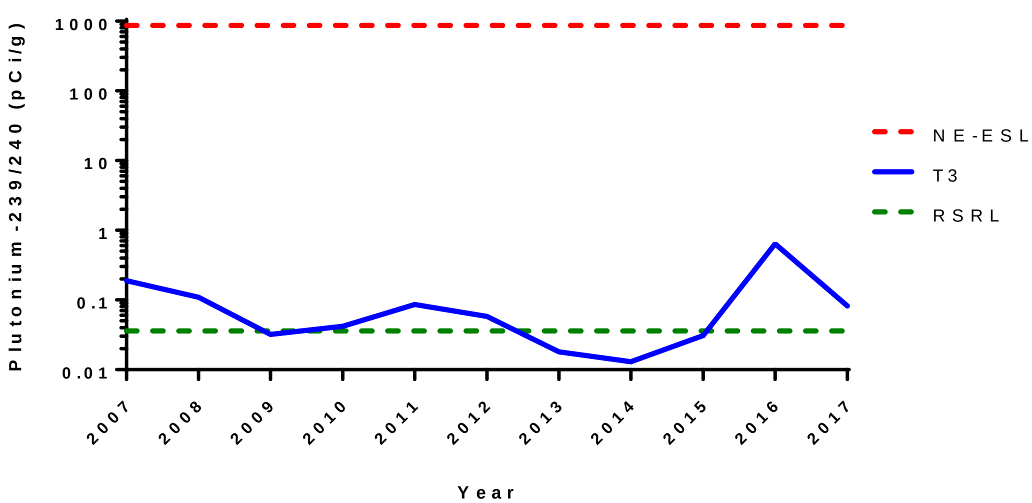


Figure 7-9 **Plutonium-239/240 (detected and nondetected) activities in surface soil collected near the Laboratory/Pueblo de San Ildefonso boundary (site T3) northeast of Area G at Technical Area 54 from 2007 to 2017 compared with the regional statistical reference level (RSRL) and the lowest no-effect ecological screening level (NE-ESL; for earthworm). Note the logarithmic scale on the vertical axis.**

In vegetation, all radionuclides except for tritium were below the regional statistical reference level. All radionuclides are far below the biota dose screening level protective of biota, and no radionuclides are increasing over time in vegetation (Table S7-2).

Soil Samples Collected from Pueblo de San Ildefonso

In 2017, two soil samples were collected from Pueblo de San Ildefonso property. One was collected on Pueblo de San Ildefonso Sacred Area lands on the north side of the fence line across from Area G; the other was collected further north near Tsankawi. Americium-241 (-0.002 picocuries per gram at the Sacred Area), tritium, and strontium-90 were not detected in either of the soil samples; all other radionuclides were either not detected, were below the regional statistical reference level, or below the no-effect ecological screening levels protective of biota (Table S7-3). Additionally, all inorganic elements tested for were below the regional statistical reference level and below the no-effect ecological screening levels protective of biota (Table S7-4).

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 and sediment from drainages, plants, and animals are monitored at the facility to determine whether levels of constituents are affecting plants or animals and are consistent with our expectation of radionuclide or chemical uptake. This 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 metals), and organic chemicals such as high explosives, dioxins, and furans. The biota samples collected at the Dual-Axis Radiographic Hydrodynamic Test Facility have included tree branches, small mammals, bees, birds, and bird eggs. Starting in 2014, soil plus one type of biota were collected per year, with the biota type being rotated annually.

Composite soil samples (five subsamples per location) were collected in May 2017 on the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter along the fence line (Figure 7-10). 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 were collected on the north, east, south, and southwest sides (Figure 7-10). All soil and sediment samples were analyzed for the radioactive elements tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235/236, uranium-238; for the inorganic elements aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, potassium, magnesium, manganese, mercury, selenium, silver, sodium, thorium, vanadium, and zinc; and for high explosives. The sample nearest the firing point was also analyzed for dioxins and furans.

In 2017, eggs that did not hatch and nestlings that died were collected from nest boxes near perimeter of Dual-Axis Radiographic Hydrodynamic Test Facility and were analyzed for the same inorganic elements as the soil and sediment. The nestling sample was also analyzed for uranium isotopes.

Results of most chemical analyses were compared with the baseline statistical reference levels. The baseline statistical reference level for the Dual-Axis Radiographic

Hydrodynamic Test Facility is based on samples collected at the facility during 1996 to 1999, before the beginning of firing site operations. The baseline levels for each measure are 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.

Radionuclides and Chemicals in Soil, Sediment, and Bird Eggs and Nestlings at the Dual-Axis Radiographic Hydrodynamic Test Facility

All radionuclides in soil and sediment collected from within and around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility were either not detected (most results), similar to baseline or regional statistical reference levels, or far below the lowest no-effect ecological screening level (Table S7-5). No radionuclides are increasing over time in soil or sediment around the Dual-Axis Radiographic Hydrodynamic Test Facility ($p > 0.05$).

The only radionuclides in soil and sediment around the Dual-Axis Radiographic Hydrodynamic Test Facility site that have been consistently measured above the baseline or regional statistical reference levels over the years are the uranium isotopes, primarily uranium-238. Based on the ratio of uranium-234 to uranium-238, most of these samples represent depleted uranium (uranium from testing activities) rather than natural uranium.

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 7-11), though the trend is not statistically significant ($p > 0.05$). Uranium-238 activity in soil collected from the south side of Dual-Axis Radiographic Hydrodynamic Test Facility has significantly decreased ($p < 0.05$) since 2007.

All soil and sediment samples contained thallium and vanadium that exceeded the lowest no-effect screening level protective of biota. Additionally, most samples also contained barium concentrations and one sample contained lead concentrations that exceeded the lowest no-effect screening level (Table S7-6). However, all concentrations of these elements were below the regional statistical reference level and baseline statistical reference level.

The majority of samples contained selenium concentrations that exceeded the no-effect ecological screening level for the generic plant (0.52 milligrams per kilogram) and the no-effect ecological screening level for the montane shrew (0.70 milligrams per kilogram) but were below the regional statistical reference level, and most values were also below the baseline statistical reference level (Table S7-6). The maximum selenium value recorded was 0.75 milligrams per kilogram.

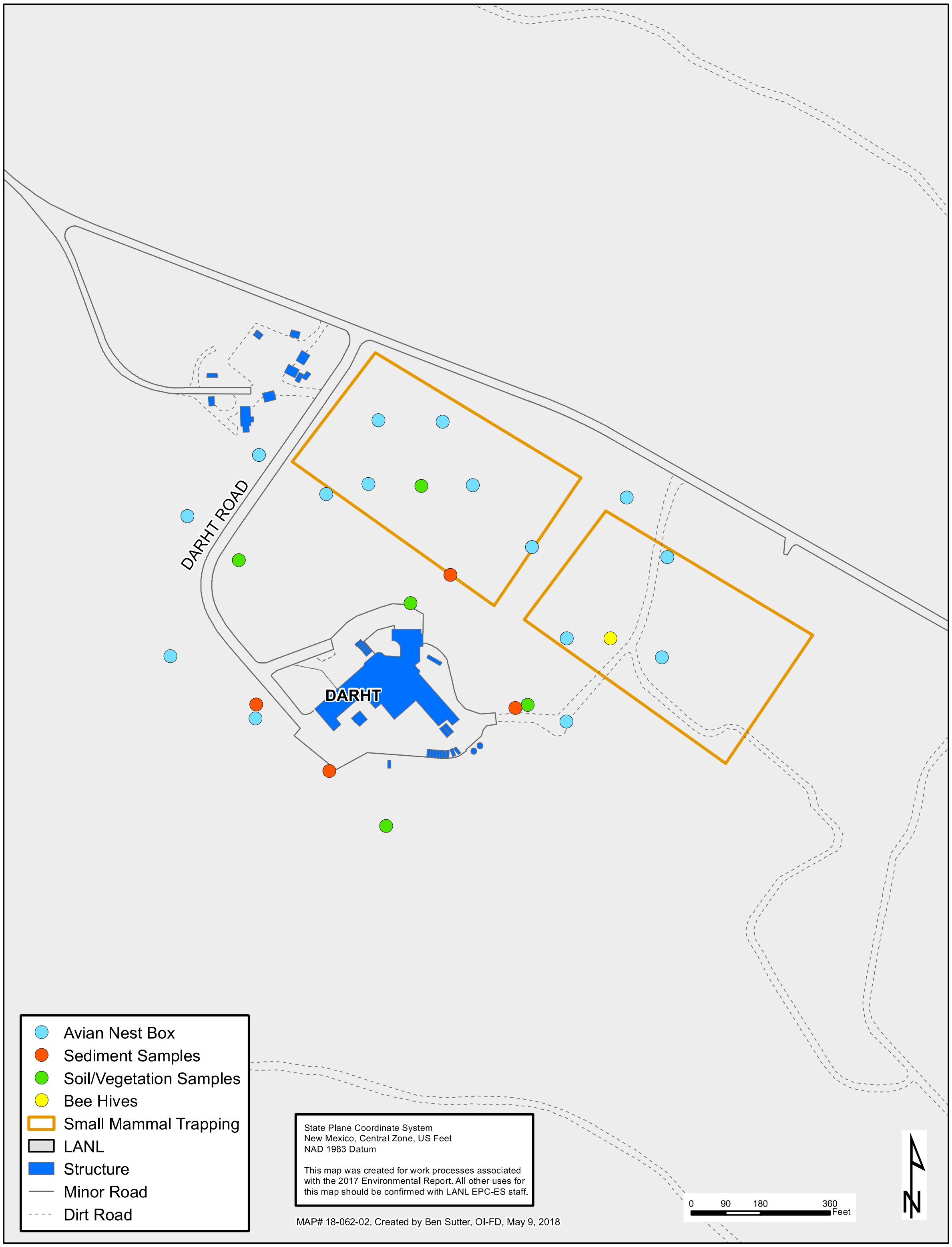


Figure 7-10 Soil, sediment, and biota sample locations at the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15.

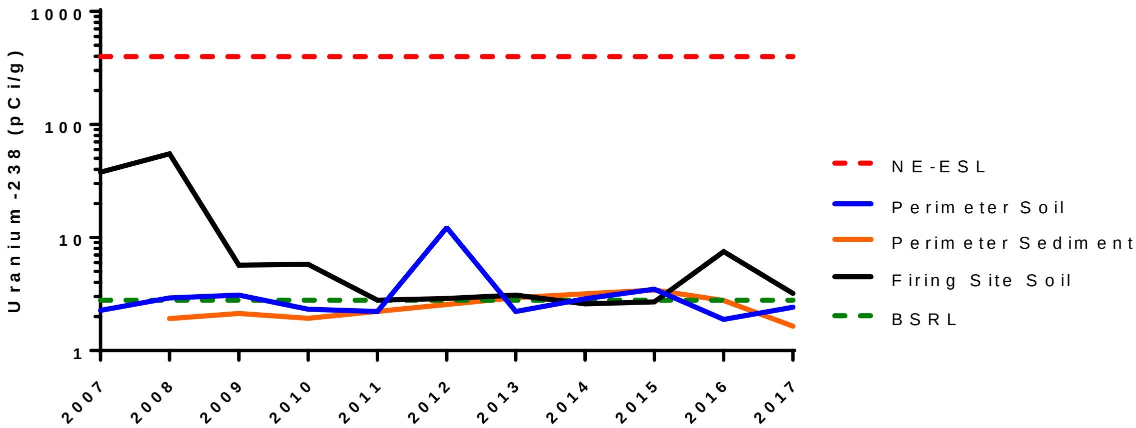
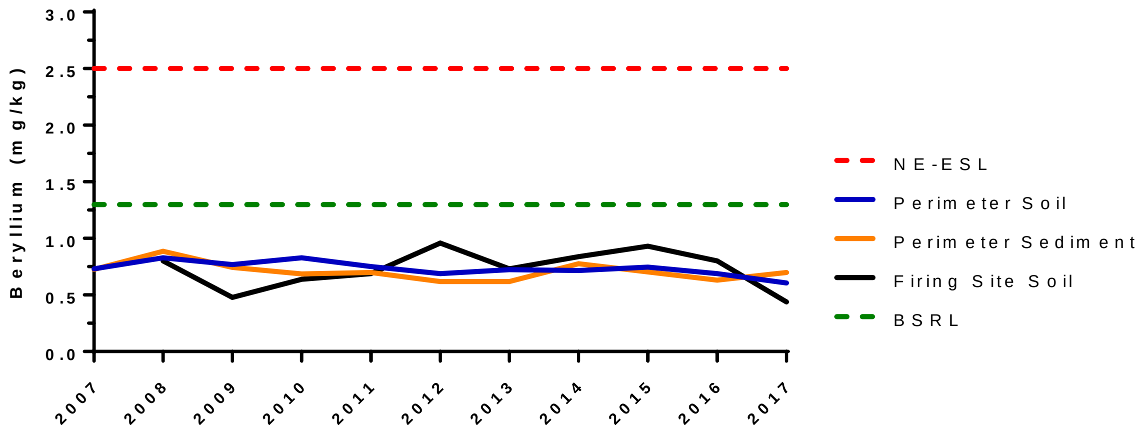


Figure 7-11 Uranium-238 activities in surface soil collected near the firing point and average uranium-238 activities in surface soil and sediment collected around the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter at Technical Area 15 from 2007 to 2017 compared with the baseline statistical reference level (BSRL; mean plus three standard deviations of soil uranium-238 preoperations) and the lowest no-effect ecological screening level (NE-ESL; for lowest no-effect ecological screening level for the plant). Note the logarithmic scale on the vertical axis.

Selenium has significantly increased over time at all soil and sediment sampling locations, including the firing site ($p < 0.05$). Arsenic has also increased in soil collected from the south and the east, and antimony has increased in soil from the east of the Dual-Axis Radiographic Hydrodynamic Test Facility. These trends will be monitored closely in future sampling.

The soil sample collected from the firing site in 2017 contained a silver concentration (0.33 milligrams per kilogram) that was higher than the regional statistical reference level (0.26 milligrams per kilogram). However, this concentration was below the baseline statistical reference level (2.1 milligrams per kilogram) as well as below the lowest no effect screening level (2.6 milligrams per kilogram, American robin; LANL 2017; Table S7-6) protective of biota. All other inorganic elements in the sample collected at the firing site were below the regional statistical reference level, the baseline statistical reference level, and the lowest no-effect screening level (Table S7-6). Barium and selenium concentrations in the soil collected near the firing site have increased over time ($p < 0.05$) and will be closely monitored.

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 2017. Beryllium concentrations in all soil and sediment samples from 2007 to 2017 have been below the baseline statistical reference level (Figure 7-12). Additionally, beryllium concentrations have significantly decreased in the soil samples collected from the west and south and from the sediment sample collected from the east of the Dual-Axis Radiographic Hydrodynamic Test Facility ($p < 0.05$).



Note mg/kg = milligrams per kilogram.

Figure 7-12 Beryllium concentrations in surface soil collected near the firing point and average beryllium concentrations in surface soil and sediment collected around the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter at Technical Area 15 from 2007 to 2017 compared with the baseline statistical reference level (BSRL; mean plus three standard deviations of soil beryllium preoperations) and the lowest no-effect ecological screening level (NE-ESL; for lowest no-effect ecological screening level for the plant). Note the logarithmic scale on the vertical axis.

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, including the sample closest to the firing point (Table S7-7). Most dioxins, including 2,3,7,8-tetrachlorodibenzodioxin (TCDD), and furans were not detected in the sediment sample collected at the firing site (Table S7-8). The only dioxins 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 0.000000715 and 0.00000483 milligrams 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.

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 (Figure 7-10). A total of four egg samples consisting of an individual western bluebird egg (*Sialia mexicana*), an individual mountain bluebird egg (*Sialia currucoides*), an individual ash-throated flycatcher egg (*Myiarchus cinerascens*), and a composite of four western bluebird eggs were collected and submitted for inorganic element analyses. Additionally, one western bluebird composite of three nestlings was collected and analyzed for inorganic elements and uranium isotopes. Several elements were not detected in bird eggs, including aluminum, antimony, arsenic, beryllium, cadmium, cobalt, lead, nickel, silver, and vanadium. Potassium concentrations in eggs were slightly above (range 2040–2460 milligrams per kilogram) the regional statistical reference level of 1916 milligrams per kilogram. Potassium is an essential macronutrient, so the concentrations observed here are not of concern. All other detectable concentrations of elements were similar or below the regional statistical reference level (Table S7-9). Similarly, several elements were not detected in the nestling sample, including uranium-235/236. The nestling sample did contain detectable concentrations of uranium-234 or uranium-238. 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 (Fresquez et al. 2016, Fresquez et al. 2015). These results suggest that uranium is bioavailable and is being incorporated into nestling tissues. Although uranium was detected, it was far below the biota dose screening level, which is 10 percent of the U.S. Department of Energy limit for radiation doses to biota (DOE 2002). For additional discussion on egg and nestling results from around the Dual-Axis Radiographic Hydrodynamic Test Facility, see Gaukler (2017).

Biota Monitoring at Sediment and Flood-Retention Structures

The Laboratory has constructed flood- and sediment-retention structures to reduce flood risk or to stop or slow the movement of sediments and associated chemicals and radionuclides off of 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. Los Alamos Canyon received wastes from early operations at Technical Areas 01 and 21 and from the Los Alamos town site.

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 impact 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.

We submitted the following samples from each location: (1) a composite understory vegetation sample for radionuclide and inorganic element analyses, (2) a composite sample of seven 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 2017 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 that was built in Los Alamos Canyon near the northeastern boundary of the

Laboratory (Figure 7-13). The retention basin upstream of the weir covers over 1 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.

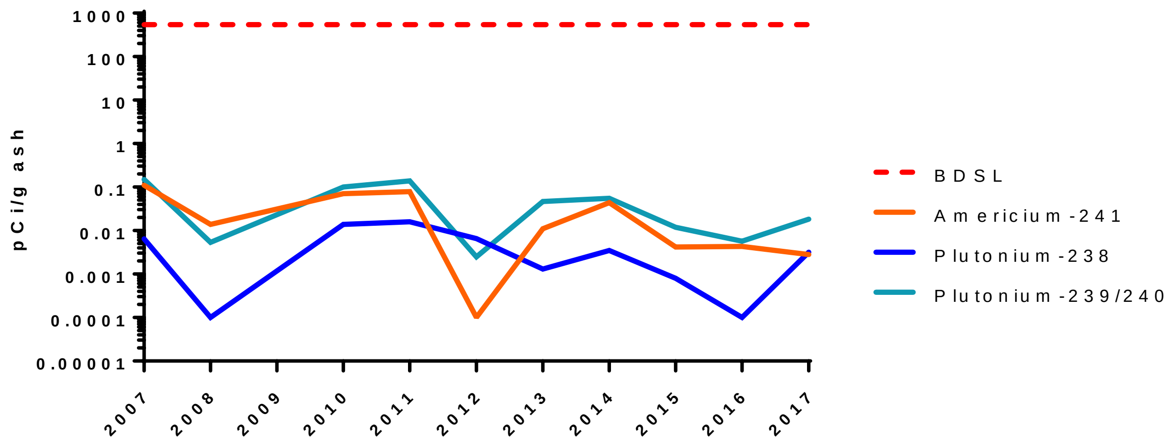
A composite understory vegetation sample was collected within the retention basin and submitted for radionuclide and inorganic element analyses in May 2017. Several inorganic elements were not detected in understory vegetation (Table S7-10). Antimony concentrations were similar to the regional statistical reference level and all other concentrations of elements were below the regional statistical reference level. Levels of inorganic elements in vegetation are not increasing over time ($p > 0.05$).

All radionuclides in the understory vegetation sample either were not detected or were similar to regional statistical reference levels, and all activities were far below biota dose screening levels (Table S7-11). Americium-241, plutonium-238, and plutonium-239/240 appear to vary from year to year but they are not increasing (Figure 7-14). Americium-241 has significantly decreased in vegetation over time ($p < 0.05$). 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 alter radionuclide results.

Small mammals were also collected from the retention basin in May 2017. Small mammals were captured by utilizing Sherman® live traps and all handling procedures were approved by LANL's Institutional Animal Care and Use committed. Several radionuclides were not detected in small mammals collected upstream of the Los Alamos Canyon Weir, including americium-241. Plutonium-239/240 was the only radionuclide that was detected at levels (0.0195 picocuries per gram ash) above the regional statistical reference level (0.0078 picocuries per gram ash). However, it was well below the biota dose screening level (42 picocuries per gram ash). All other detected activities were below both the regional statistical reference levels (Fresquez 2015) and biota dose screening levels (Table S7-12). Uranium isotopes 234, 235/236, and 238 are significantly decreasing ($p < 0.05$) in whole-body wild mice collected upstream of the Los Alamos Canyon Weir. No changes were observed in the remaining radionuclides analyzed ($p > 0.05$; Figure 7-15).

Results of inorganic element analyses in whole-body small mammals are in Table S7-13. Zinc concentrations in two samples (170 and 220 milligrams per kilogram wet) exceeded the regional statistical reference level (159 milligrams per kilogram); as this is an essential macronutrient, no adverse effects are expected at the concentrations observed here. All other inorganic elements were below the regional statistical reference level or not detected (Table S7-13). Most inorganic elements are not changing overtime; however, a significant increase in calcium, potassium, sodium, chromium and zinc was observed in small mammals ($p < 0.05$) from 2007 to 2017 (Figure 7-16). Chromium and zinc levels will be monitored closely, however, at these concentrations, no adverse effects are expected (all chromium levels were below the regional statistical reference level).

Figure 7-13 Los Alamos Canyon weir before (top photo) and after (bottom photo) storm-water flows.



Note pCi/g = picocuries per gram.

Figure 7-14 Americium-241, plutonium-238, and plutonium-239/240 detectable and non-detectable activities in understory vegetation collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2007 to 2017 compared with the lowest biota dose screening level (BDSL). Note the logarithmic scale on the vertical axis.

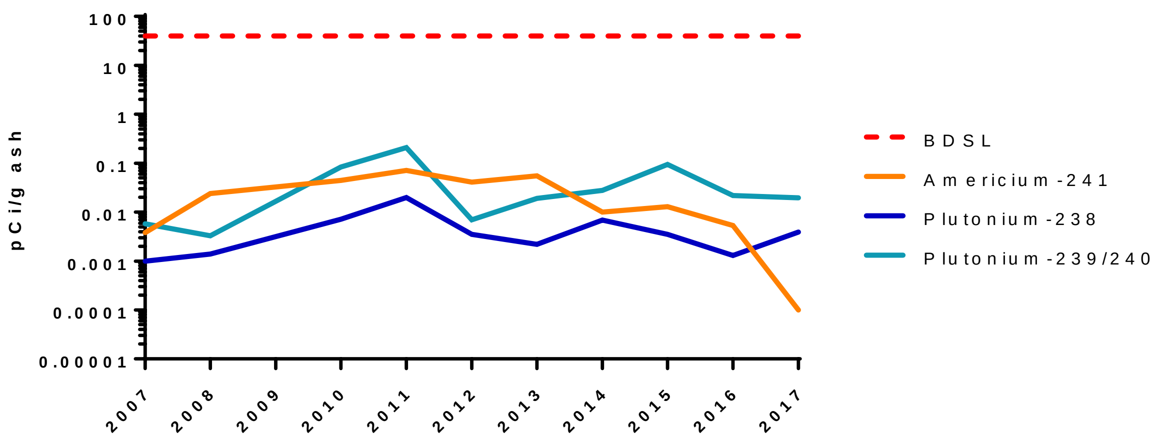
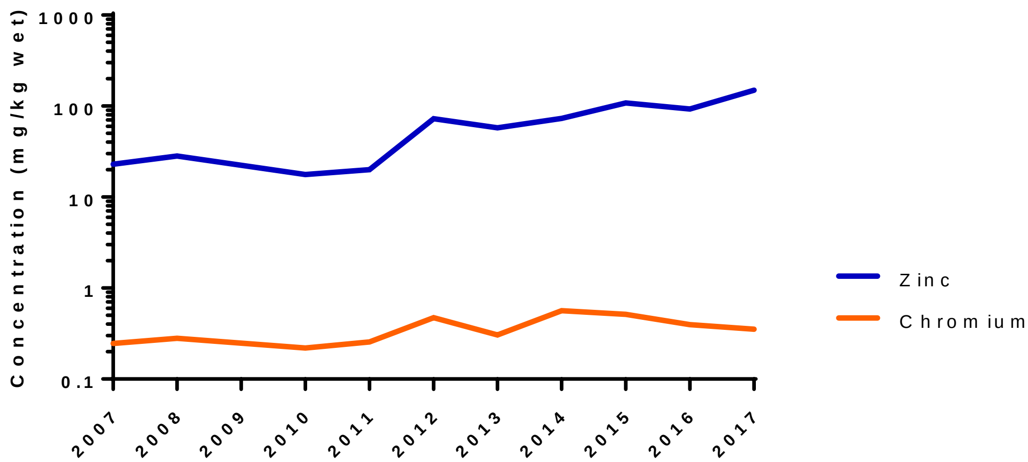


Figure 7-15 Americium-241, plutonium-238, and plutonium-239/240 detectable and non-detectable activities in composite whole-body deer mice samples collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2007 to 2017 compared with the biota dose screening level (BDSL). Note the logarithmic scale on the vertical axis.

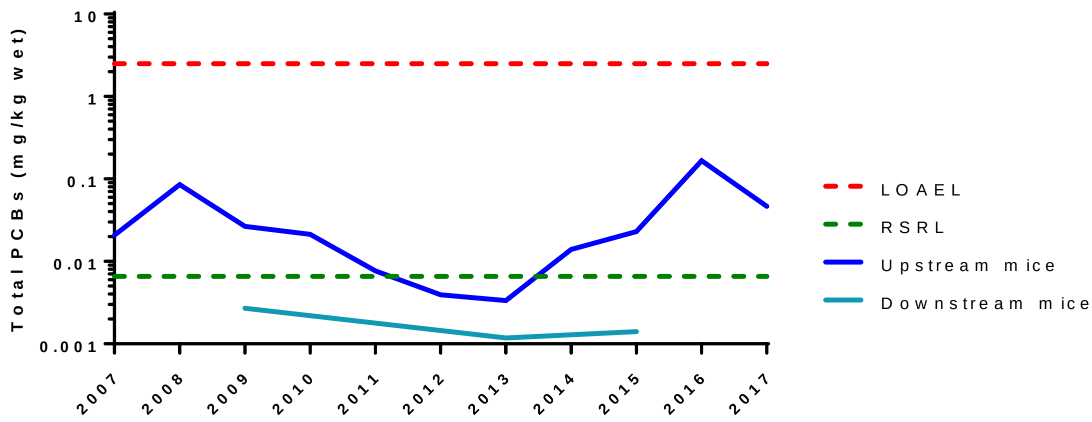


Note mg/kg = milligrams per kilogram.

Figure 7-16 Chromium and zinc concentrations (detectable and non-detectable concentrations) in a individual whole-body wild mice sample collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2007 to 2017. Note the logarithmic scale on the vertical axis.

Concentrations of total PCBs in whole-body wild mice samples collected upstream from the Los Alamos Canyon weir were significantly higher than regional background concentrations ($p < 0.0001$; Table S7-14). The highest individual total PCB concentration detected in a deer mouse sample collected from the retention basin in 2017 (0.11 milligrams per kilogram) was an order 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, even though the PCB concentrations are higher than background, these levels are not expected to negatively impact 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 but did not significantly increase or decrease between 2007 and 2017 ($p > 0.05$; Figure 7-17). The variability in PCB concentrations may be the result of sediment traps, willow plantings, and sediment removals which were implemented in Los Alamos Canyon upstream of the weir (Fresquez 2014). It may also be related to the removals of sediment from the basin between 2009 and 2014 and accumulation of sediment since that time.



Note mg/kg = milligrams per kilogram.

Figure 7-17 Mean total PCB concentrations in whole-body wild mice collected upstream (retention basin) and 4.5 miles downstream of the Los Alamos Canyon weir from 2007 to 2017 compared with the regional statistical reference level (RSRL) and the lowest observable adverse effect level (LOAEL) observed in mice (Batty et al. 1990). Note the logarithmic scale on the vertical axis.

Pajarito Canyon Flood-Retention Structure

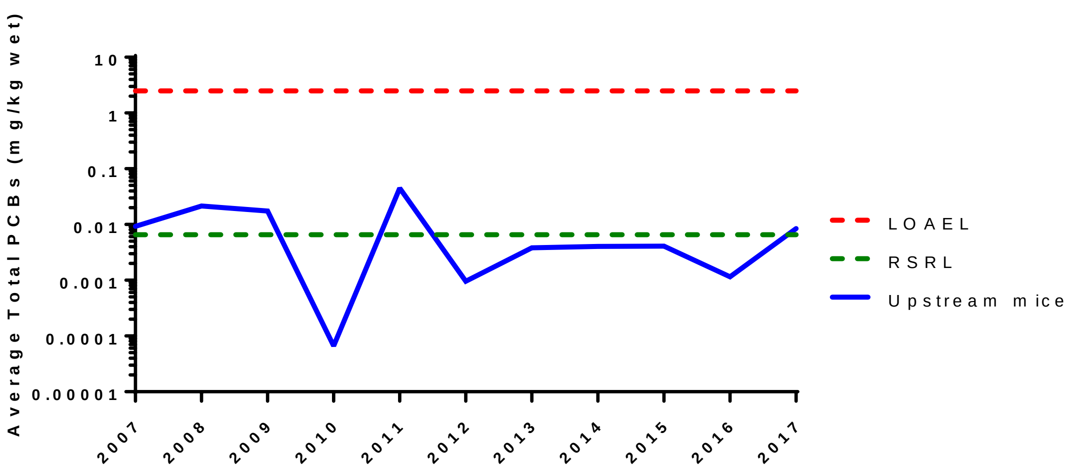
The Pajarito Canyon flood-retention structure is located upstream of Technical Area 18. The structure extends 390 feet across the canyon and is about 70 feet high. The bottom of the retention structure is equipped with one 42-inch-diameter drainage culvert, which allows storm water to drain. Accumulated water is retained no longer than 96 hours behind the retention structure; water drains naturally into the existing streambed.

In 2017, a composite understory vegetation sample and small mammals were collected on the upstream side of the Pajarito Canyon flood-retention structure. Results from analysis of the composite vegetation sample show that all radionuclides were either not detected or were below the regional statistical reference level (Table S7-15). No changes in radionuclide activities in vegetation collected upstream of the Pajarito Canyon flood-retention structure were observed from 2007 to 2017 ($p > 0.05$). Antimony was detected at 0.068 milligrams per kilogram and silver was detected at 0.015 milligrams per kilogram, which were above the respective regional statistical reference levels of 0.028 milligrams per kilogram and 0.012 milligrams per kilogram. All other inorganic elements were either not detected or were below the regional statistical reference levels (Tables S7-16). Inorganic element concentrations are not changing over time in vegetation collected upstream of the Pajarito canyon flood-retention structure ($p > 0.05$).

All radionuclides in whole-body wild mice were either not detected or were below regional statistical reference levels, and were below biota dose screening levels (Table S7-17). All inorganic element concentrations in whole body wild mice were either not detected or similar to or below the regional statistical reference level (Table S7-18). Most inorganic elements in wild mice are not changing over time and some constituents, such as aluminum, beryllium, cobalt, manganese, and silver, are significantly decreasing over time

($p < 0.05$). Similar to trends observed in wild mice at the Los Alamos weir, calcium, potassium, and zinc are significantly increasing over time in wild mice at the Pajarito Canyon flood-retention structure ($p < 0.05$). As all of these levels are similar to or below background, they are not of concern, but we will continue to monitor the trends.

The total PCB concentrations in whole-body wild mice collected upstream of the Pajarito Canyon flood-retention structure during 2007 through 2017 are significantly higher than those in wild mice collected from background locations during 2007 through 2015 ($p < 0.001$; Table S7-18). The highest individual total PCB concentration in a deer mouse sample collected in 2017 (0.0117 milligrams per kilogram) was 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, 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 significantly changing over time ($p > 0.05$; Figure 7-18).



Note mg/kg = milligrams per kilogram.

Figure 7-18 Average total PCB concentrations in whole-body wild mice collected on the upstream side of the Pajarito Canyon flood-retention structure from 2007 to 2017 compared with the regional statistical reference level (RSRL) and the lowest observable adverse effect level (LOAEL) observed in mice (Batty et al. 1990). Note the logarithmic scale on the vertical axis.

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 nelson*) from on-site, perimeter, and background sites since the 1970s (LASL 1973). To date, the program has collected and analyzed approximately 45 deer and 51 elk.

Recently, 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 aikeni*), red-tailed hawk (*Buteo jamaiciensis*), and bullsnake (*Pituophis catenifer sayi*) that were killed by vehicles or by other accidents.

Here we report radionuclide activities and chemical concentrations in tissues from six mule deer, five elk, two black bears, one coyote, three gray foxes, one great horned owl, one western screech owl, one red-tailed hawk, and two bullsnakes collected in 2016 and 2017 (Figure 7-19). The majority of animals collected were casualties of vehicle strikes, though others came from different opportunistic collections. One deer and one elk sample were donated by hunters, the bears were euthanized by law enforcement, the great horned owl died of electrocution, and the red-tailed hawk died after colliding with a breezeway.

Leg muscle and leg bone were harvested from the deer, elk, bear, coyote, and gray fox. Muscle tissue was analyzed for radionuclides, inorganic elements, and PCBs. Bone tissue was analyzed for radionuclides. Leg muscle was harvested from the owls and red-tailed hawk and analyzed for PCBs; the remaining whole body (unwashed feathers included) was analyzed for radionuclides and inorganic elements. Muscle tissue was harvested from the bullsnakes and analyzed for PCBs; while the remaining whole body was analyzed for radionuclides and inorganic elements.

Deer and Elk Monitoring

All radionuclides in deer and elk (muscle and bone) collected from on-site and perimeter locations were either below the minimum detectable activity (most results), regional statistical reference level, or biota dose screening level (Table S7-20 and S7-21). These data are similar to past years.

All inorganic elements in muscle tissues of deer collected at LANL were below the regional statistical reference levels for deer (Table S7-22). One deer collected from the perimeter of LANL contained concentrations of aluminum, antimony, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, silver, and sodium that were above the regional statistical reference levels for deer (Table S7-22).

All inorganic elements in elk muscle tissue collected at LANL and the perimeter were similar to concentrations in background elk (Table S7-23). No regional statistical reference level is available because the background elk reported here is the first to undergo inorganic element analyses.

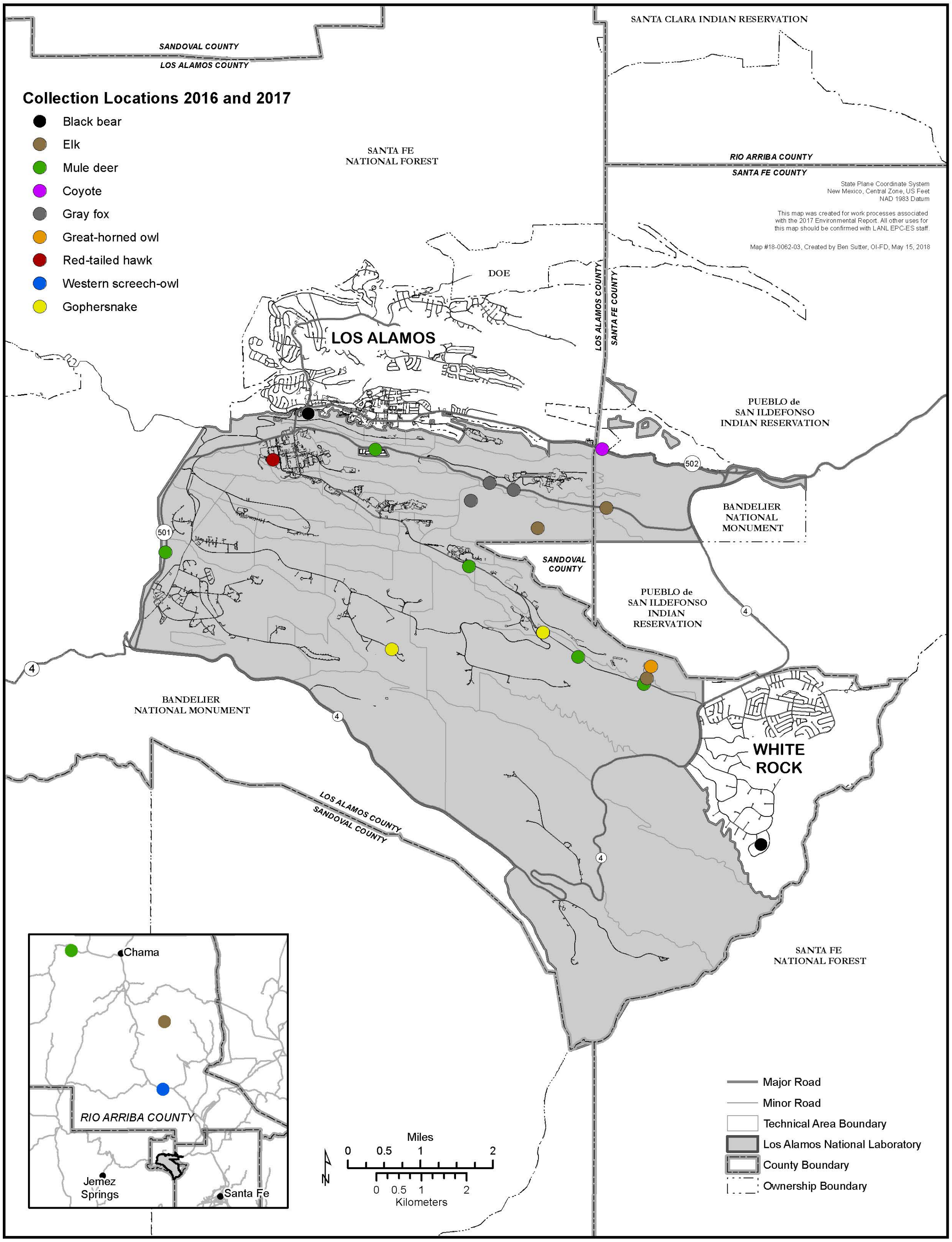


Figure 7-19 Locations of animals collected as roadkill from within and around the perimeter of the Laboratory in 2016 and 2017.

For total PCBs in mule deer muscle tissue, both the lowest and highest concentration were from deer collected at the perimeter; the range was from 3.2 picograms per gram in a deer collected on West Jemez Road to 116.0 picograms per gram in a deer collected on East Jemez Road (Table S7-24). The deer with the highest level (116 picograms per gram) contained concentrations that exceeded the regional statistical reference level of 87.8 picograms per gram; all other deer from on-site and perimeter locations were below this level. The deer collected from a background location did not contain detectable levels of PCBs.

Total PCBs in elk collected on the Laboratory ranged from 17.2 picograms per gram to 249.0 picograms per gram. The elk collected from the background location contained 2.48 picograms per gram total PCBs (Table S7-25). No regional statistical reference level is available because the background elk reported here is the first to undergo PCB analyses.

The total 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 million to 3 million picograms per gram 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 million picograms per gram for red meat consumption by humans (FDA 1987).

Black Bear, Coyote, Gray Fox, Bullsnake, Hawk, and Owl Monitoring

All radionuclides in tissues of the black bears, coyote, gray foxes (Table S7-26), bullsnakes, red-tailed hawk, great horned owl, and western screech owl (Table S7-27) were either not detected, or were below biota dose screening levels. The majority of radionuclides were below the minimum detectable activity in muscle, bone, and whole-body samples.

Currently, there are no background reference values for comparisons for these animals. While all radionuclide activities were below the biota dose screening level, the whole-body great horned owl contained 14,800 picocuries per milliliter of tritium. The great horned owl died of electrocution and was collected on the east side of Area G. The owl’s diet could have been the source of the tritium. Great horned owls are apex predators, and consume several types of prey items including small mammals. In 2015, mice that were collected near the tritium disposal shafts at Area G (sampling location 29-03; Figure 7-2) had 391 picocuries per milliliter of tritium (Fresquez et al. 2016). Botta’s pocket gophers, which burrow into the ground, were sampled at Area G in 1999 and had tritium levels as high as 168,000 picocuries per milliliter (Gonzales et al. 2000).

Inorganic elements in muscle tissue of the black bears, coyote, and gray foxes are reported in table S7-28. Currently there are no background reference values for these elements for these species, however, the pattern of nondetects and levels of constituents in muscle tissues among these species appear to be fairly consistent and concentrations do not warrant concern (Table S7-28).

Some inorganic elements in whole-body bullsnakes appeared to differ among individuals, though no statistical comparisons could be made due to small sample size. For example, the bullsnake collected at Technical Area 15 contained approximately ten times the concentration of aluminum, iron, and lead compared with the bullsnake collected near Technical Area 18 (Table S7-29). These differences may be within the natural range of variation in snakes, or the differences could be explained by different levels in the environment. Currently there are no background reference values available for comparisons.

The inorganic elements in a whole-body great-horned owl, western screech owl, and red-tailed hawk are reported in table S7-29. Currently there are no background reference values available for comparisons for each of these species.

We also conducted a pilot experiment using chest feathers from the red-tailed hawk. Chest feathers may be a useful biomonitoring tool and can be collected from live birds. The goal of this experiment was to examine the recovery rate of inorganic elements from different-sized samples of feathers; one sample weighed 0.5 gram and one sample weighed 1.0 gram. Arsenic, magnesium, and silver were not detected in the 0.5-gram sample of feathers, but were detected in the 1.0-gram sample. Otherwise, the detected and nondetected elements were the same in both samples of feathers. Beryllium, chromium, cobalt, nickel, thallium, and vanadium were not detected in either of the feather samples. The remaining elements were detected in both samples and the concentrations were fairly similar (Table S7-29). These results suggest that collecting feathers could be a useful biomonitoring tool at LANL; however, it may be challenging to obtain the minimum mass required from smaller birds.

Total PCB levels in muscle tissue of both black bears (41.1 and 33.2 picograms per gram) and one of the gray foxes (130 picograms per gram) were similar to the concentrations of total PCBs observed in deer and elk reported above (Table S7-30). The coyote contained 2,590 picograms per gram and the remaining two gray foxes contained 1,980 and 2,300 picograms per gram total PCBs (Table S7-30).

Total PCB levels in muscle tissue were 4,050 and 6,460 picograms per gram in the two bullsnakes, 39,200 picograms per gram in the great horned owl, 2,200 picograms per gram in the red-tailed hawk, and were highest in the western screech owl that was collected near Abiquiu, NM at 43,200 picograms per gram (Table S7-31). PCB concentrations are typically higher in predator species, such as the owls and the raptor reported here, because these organic chemicals are lipophilic (absorbed by fats) and because they increase in concentration as the trophic level increases (Eisler and Belisle 1996, Hornbuckle et al. 2006).

The total PCB concentrations observed in all animals monitored and reported here are overall quite low and are not expected to cause adverse effect as adverse effects are typically not observed until the 2.5 million to 3 million picograms per gram range in other species (Batty et al. 1990, Hoffman et al. 1996).

Bird Monitoring at Facility Sites

Monitoring at Open-Detonation and Open-Burn Firing Sites

In 2017, we completed bird surveys for a fifth year at two open-detonation sites (sites where explosives are set off) at Technical Areas 36 and 39 and one open-burn site (site where equipment and waste is exposed to high heat to remove explosives residues) at

Technical Area 16. The purpose of these surveys is to assess whether operations at these sites are impacting bird species richness, diversity, abundance, or composition. Results from each site are compared with the results from areas of similar habitat that do not have Laboratory operations, and are used to identify trends over time.

A total of 785 birds representing 59 species were recorded during surveys in 2017 (Hathcock et al. 2018). Bird species richness and diversity at the treatment sites were not statistically different from the control sites. Bird abundance showed more variability among sites, but treatment and control sites have similar trends over time. Results indicate some changes in the species present over time but with very little difference between treatment and control sites.

Breeding Season Capture and Banding at Sandia Canyon

We monitor bird populations that breed in specific areas of interest by banding birds during the breeding season. A banding station is currently located in the Sandia Canyon wetland and has been operating since 2014. It is composed of 12 mist nets periodically deployed in and around the wetland in upper Sandia Canyon, below the Los Alamos County landfill. This wetland contains primarily broadleaf cattail (*Typha latifolia*) and some tree species, including Rio Grande cottonwood (*Populus deltoids*) and Russian olive (*Elaeagnus angustifolia*).

A total of 814 birds representing 61 species was banded during the breeding seasons of 2014 through 2017. The number of bird captures have increased from year to year. We have captured some birds not previously documented in Los Alamos County at this station, including the golden-winged warbler (*Vermivora chrysoptera*) (Figure 7-20) and orchard oriole (*Icterus spurius*) (Figure 7-21). The bird banding operations follow a specific protocol named “Monitoring Avian Productivity and Survivorship,” which is part of a continent-wide program (DeSante and Kaschube 2009) managed by the Institute for Bird Populations in Point Reyes, California. This study supports the 2013 memorandum of understanding between the U.S. Fish and Wildlife Service and the DOE (DOE 2013).

Avian Nest Box Monitoring

The avian nest box network at the Laboratory was established in 1997 with 438 boxes, and now contains more than 500 boxes. The primary species monitored with the nest box network are the western bluebird and the ash-throated flycatcher. They are common around the Laboratory and readily nest in artificial nest boxes. Their eggs have been used for biomonitoring at the Laboratory since the late 1990s (Becker 2003). Western bluebird and ash-throated flycatcher eggs have been collected opportunistically across the Laboratory and have been analyzed for radionuclides, inorganic elements and organic chemicals (Gaukler et al. 2016, Gaukler et al. 2018). The results indicate that the levels of radionuclides, metals, PCBs, and organochlorine chemicals in the eggs of western bluebirds and ash-throated flycatchers are not likely to cause adverse effects in breeding bird populations.

Figure 7-20 Golden-winged warbler banded and released at the Sandia Canyon wetland in 2016.

Figure 7-21 Orchard oriole banded and released at the Sandia Canyon wetland in 2016.

Recently, there have been some additions to the nest box program. In 2016, 92 nest boxes were placed south of the Laboratory in a natural area and 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 to monitor nesting success as well as chemical levels in eggs that did not hatch and nestlings that died of natural causes.

Threatened and Endangered Species Surveys

In 2017, surveys were completed for two species protected under the Endangered Species Act: the Mexican spotted owl (*Strix occidentalis lucida*) and the southwestern willow flycatcher (*Empidonax trailii extimus*). Jemez Mountains salamander (*Plethodon neomexicanus)* surveys on LANL were very limited in 2017 because of the lack of appropriate moisture needed to conduct surveys.

Mexican Spotted Owl

The Mexican spotted owl generally inhabits mixed conifer forests and ponderosa pine–Gambel oak (*Pinus ponderosa* and *Quercus gambelii,* respectively) forests in mountains and canyons (USFWS 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). Although seasonal movements vary among owls, adults commonly remain within their breeding home ranges throughout the year.

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, Mexican spotted owl habitat at the Laboratory has been identified based on a combination of cliff habitat and forest characteristics (Hathcock et al. 2017). 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 in each Mexican spotted owl area of environmental interest each year.

During 2017, Mexican spotted owls were found in two areas of environmental interest at the Laboratory, and at least one Mexican spotted owl chick fledged from one nest. Mexican spotted owls were found at the same locations at the Laboratory as in the previous year.

Southwestern Willow Flycatcher

The Southwestern willow flycatcher is found in close association with dense stands of willows (*Salix* spp.), arrowweed (*Pluchea* spp.), buttonbush (*Cephalanthus occidentalis*), tamarisk (*Tamarix ramosissima*), Russian olive, and other riparian vegetation, often with a scattered overstory of cottonwood (*Populous* spp.) (USFWS 2002). The size of vegetation patches used by Southwestern willow flycatchers ranges from as small as 2 acres (0.8 hectares) to several hundred acres.

Southwestern willow flycatcher surveys were conducted during their breeding season within the Sandia and Pajarito Canyons wetlands. No southwestern willow flycatchers were detected.

AQUATIC HEALTH ASSESSMENT

To assess whether Laboratory operations are affecting aquatic ecosystems in the Rio Grande, we (1) evaluated levels of chemicals in fish, (2) evaluated chemical concentrations in sediment, (3) conducted a sediment biotoxicity assay, and (4) measured indices of benthic macroinvertebrate community health in river and reservoir locations upstream and downstream of the Laboratory.

Fish Monitoring

In 2017, fish were collected from Abiquiu reservoir (upstream of LANL), Cochiti reservoir (downstream of LANL), and from the Rio Grande upstream and downstream of its confluence with Los Alamos Canyon. Los Alamos Canyon is the northern-most watershed draining from Laboratory property, discharging into the Rio Grande near Otowi Bridge (Figure 7-22). Fish have been sampled and analyzed for radionuclides from these locations since the early 1980s (Fresquez et al., 2015).

Predator fish and bottom-feeding fish were collected and analyzed for radionuclides, inorganic elements, and PCB congeners. Predator fish primarily eat other fish and were only collected from the reservoirs. Collected predator fish included the northern pike (*Esox lucius*), white bass (*Morone chrysops*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and walleye (*Sander vitreus*). Bottom-feeding fish eat both plant and animal matter and feed at the bottom of lakes and rivers. Bottom-feeding fish were collected from both reservoirs as well as from the Rio Grande and included the white sucker (*Catostomus commersonii*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*).

In 2017, eleven fish samples were collected from Abiquiu reservoir, twelve samples from Cochiti reservoir, five samples from upstream Rio Grande, and five samples from downstream Rio Grande. In reservoirs, fish were collected using gill nets, and in the Rio Grande, fish were collected using hoop nets, rod and reel, and trot lines. After a fish was captured, it was euthanized using approved Institutional Animal Care and Use Committee methods. We removed the viscera and head, rinsed the fish thoroughly, and filleted both sides of the fish. One fillet (muscle plus skin) was analyzed for inorganic elements, the other fillet was analyzed for PCB congeners, and the remaining body was analyzed for radionuclides. Individual and composite samples (up to three individuals of the same species) were submitted for analyses. Some samples were composited to increase the amount of material available for laboratory analyses. All samples were labeled, sealed with chain-of-custody tape, placed into a cooler with ice, and submitted under full chain-of-custody procedures to the sample management office at the Laboratory. The sample management office sent fish samples to ALS (Australian Laboratory Services) in Fort Collins, Colorado for radionuclide and inorganic element analysis and to Cape Fear Analytical, LLC in Wilmington, North Carolina for PCB analysis.

The radionuclides analyzed were tritium, americium-241, cesium-137, plutonium-238, plutonium-239/240, radium-226, radium-228, strontium-90, uranium-234, uranium-235/236, and uranium-238. Tritium is reported on a picocuries per milliliter basis and the remaining radionuclides are reported on a picocuries per gram of ash basis. Inorganic elements analyzed included aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, sodium, silver, thallium, vanadium, and zinc. These elements are reported on a wet weight basis in milligrams per kilogram. PCBs were analyzed for 209 possible chlorinated congeners and are reported on a wet weight basis in picograms per gram.

We statistically tested our fish results from 2008 through 2017. Generalized linear models were used to assess the effects of year, location (upstream or downstream), the interaction of year by location, feeding strategy (bottom-feeding or predator) or species (in the event that all fish were from the same feeding strategy, i.e., Rio Grande captured fish were all bottom-feeding), feeding strategy/species by year, feeding strategy/species by location, and feeding strategy/species by year by location. Year and location were modeled as fixed effects and feeding strategy/species was modeled as a random effect.

Radionuclide Results

Several radionuclides were not detected in bottom-feeding fish collected from the Rio Grande and the reservoirs in 2017. Tritium, americium-241, and cesium-137 were not detected in either bottom-feeding or predator fish in 2017 (Tables S7-32 and S7-33). Evaluating results from 2008 to 2017, there were no differences in radionuclide activities in bottom-feeding fish collected from the Rio Grande between upstream and downstream locations. Levels of americium-241, uranium-234, and uranium-238 varied significantly among years, but the amount of variation did not differ based on location in the Rio Grande (Table S7-32).

In reservoir fish samples, there was no difference in either plutonium-238 or plutonium-239/240 activities between reservoirs for either predator or bottom-feeding fish (Table S7-33). The levels of two radionuclides significantly varied among years but to a similar extent in both reservoirs (Figure 7-23 and 7-24). Strontium-90 activities in fish were not significantly different between reservoirs, nor did they change significantly over time. However, there was a significant interaction of year by reservoir, suggesting that variations in strontium activities occurred independently in each reservoir (Figure 7-25).

All radionuclide activities are several orders of magnitude below the biota dose screening level and are not a health concern to the fish.

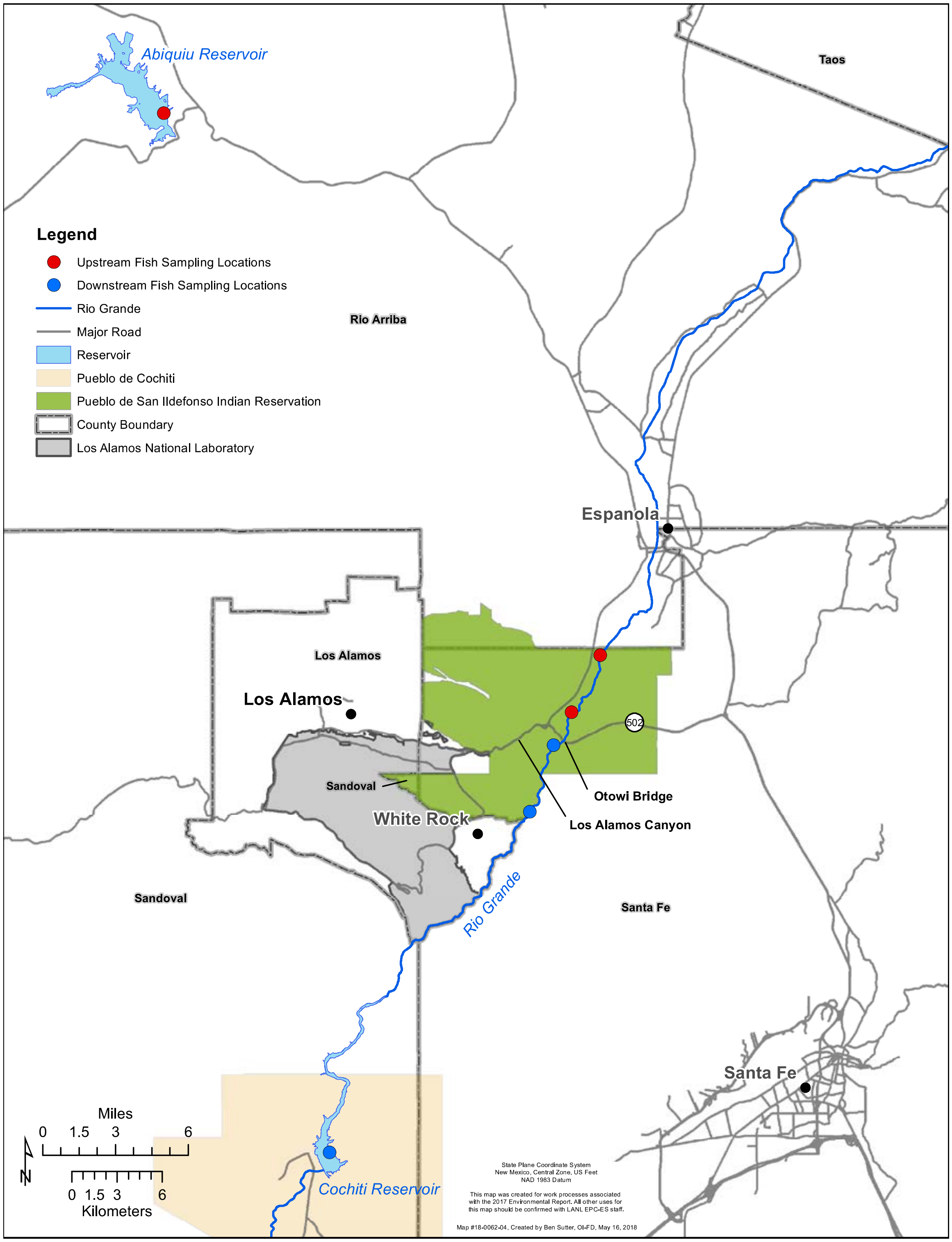
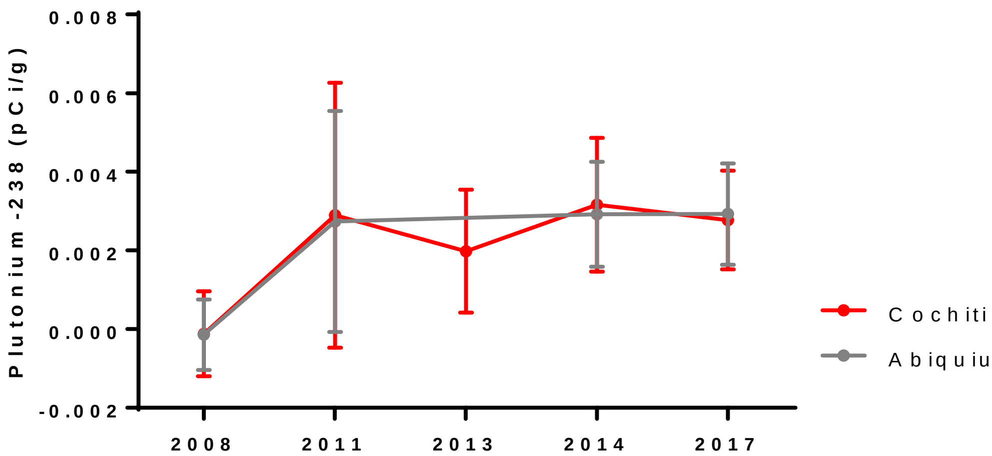
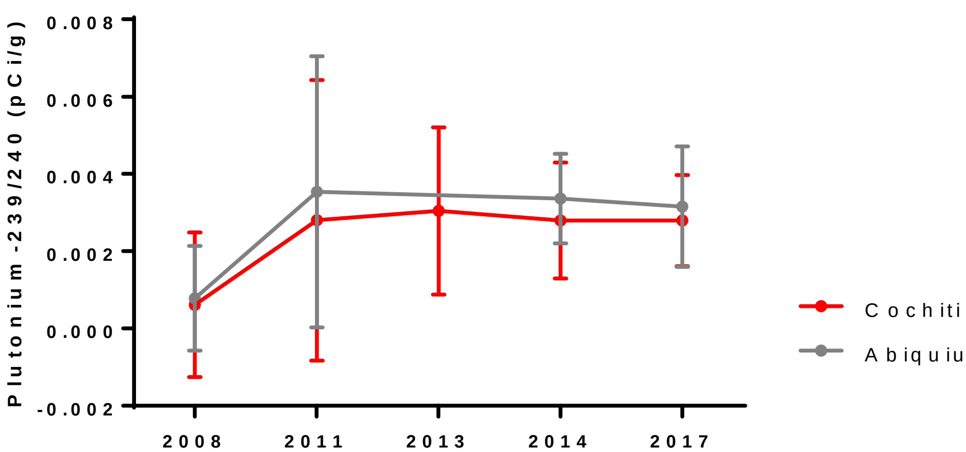


Figure 7-22 Locations of where fish were collected from locations upstream and downstream of LANL in 2017.



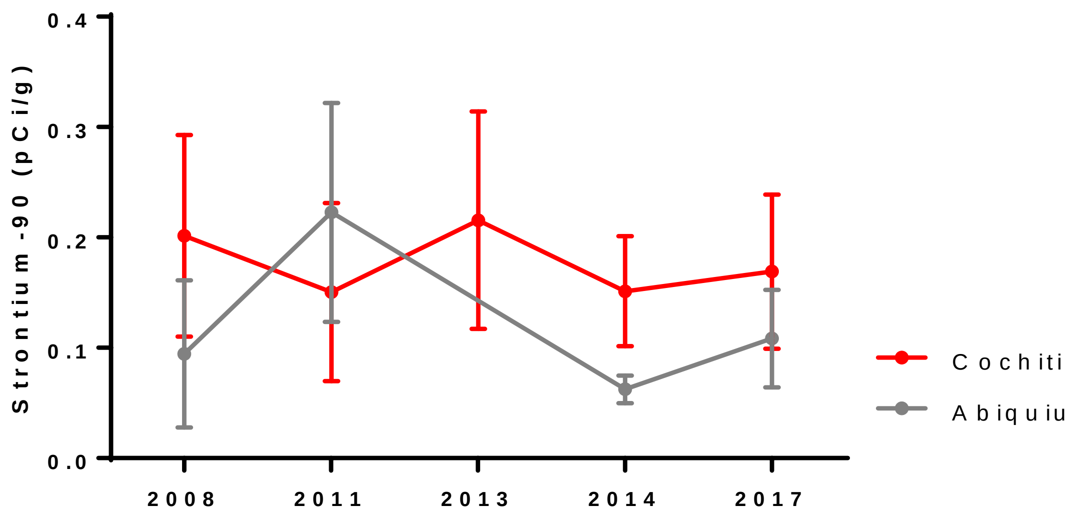
Note: pCi/g = picocuries per gram.

Figure 7-23 Plutonium-238 activities in fish (bottom-feeding and predator combined) collected from Abiquiu reservior (upstream) and Cochiti reservoir (donwstream) in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.



Note: pCi/g = picocuries per gram.

Figure 7-24 Plutonium-239/240 activities in fish (bottom-feeding and predator combined) collected from Abiquiu reservior (upstream) and Cochiti reservoir (downstream) in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.



Note pCi/g = picocuries per gram.

Figure 7-25 Strontium-90 activities in fish (bottom-feeding and predator combined) collected from Abiquiu reservior (upstream) and Cochiti reservoir (donwstream) in 2008 through 2017. Lines connect averages at each time point and error bars represent standard deviation.

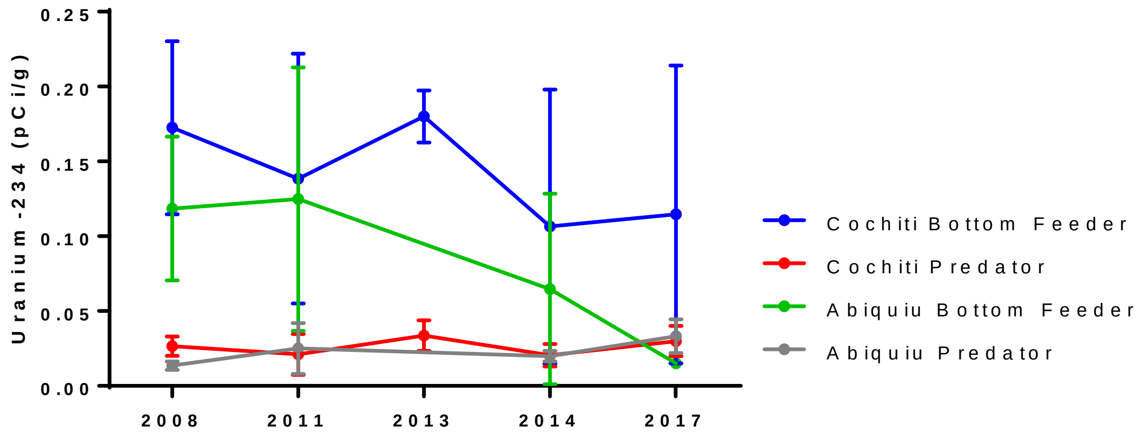
Levels of the uranium isotopes 234, 235/236, and 238 differed significantly between bottom-feeding and predator fish, but there was no difference between reservoirs (Table S7-33). Bottom-feeding fish had significantly higher activities of uranium isotopes compared with predator fish (Figure 7-26, 7-27, and 7-28). Several radionuclides readily bind to sediments, and bottom feeders are more likely to be exposed to these sediments (DOE 2015).

All radionuclide activities in fish from Abiquiu reservoir, Cochiti reservoir, and from the Rio Grande are several orders of magnitude below the biota dose screening level and not a health concern to the fish. These findings indicate that releases from the Laboratory are not affecting the levels of radionuclides in fish tissues that are collected downstream of Los Alamos Canyon.

Inorganic Element Results

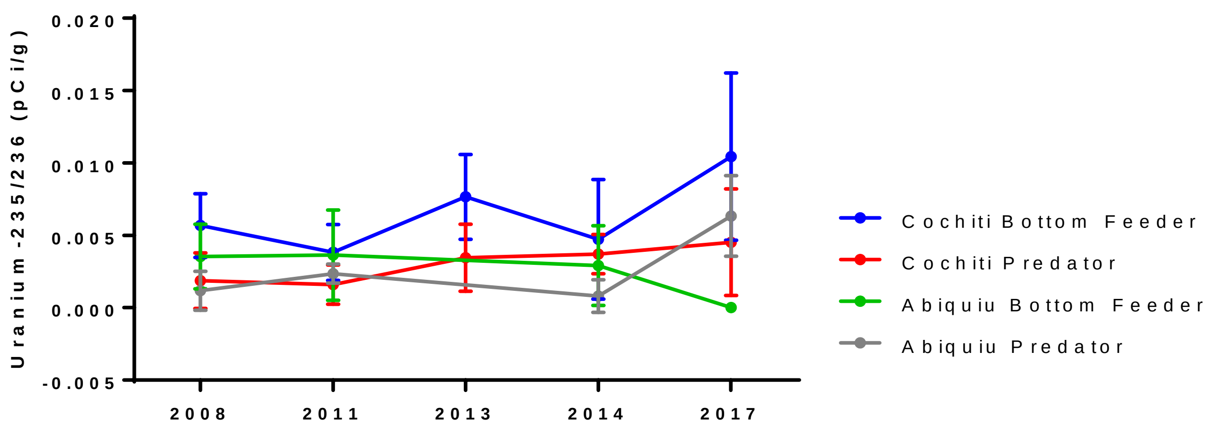
Most concentrations of inorganic elements in muscle of bottom-feeding fish collected from downstream Rio Grande did not differ from concentrations in bottom-feeding fish collected from upstream Rio Grande (Table S7-34). Antimony, silver, and thallium in bottom-feeding fish differed between upstream and downstream locations. However, these results could be an artifact of the analytical detection limits because these elements were not detected in the majority of samples (antimony = 58 percent nondetects; silver = 90 percent nondetects; thallium = 38 percent nondetects) between 2008 and 2017 (Table S7-34).

Most concentrations of inorganic elements in fish muscle collected from Cochiti reservoir did not differ from concentrations observed in fish collected from Abiquiu reservoir.



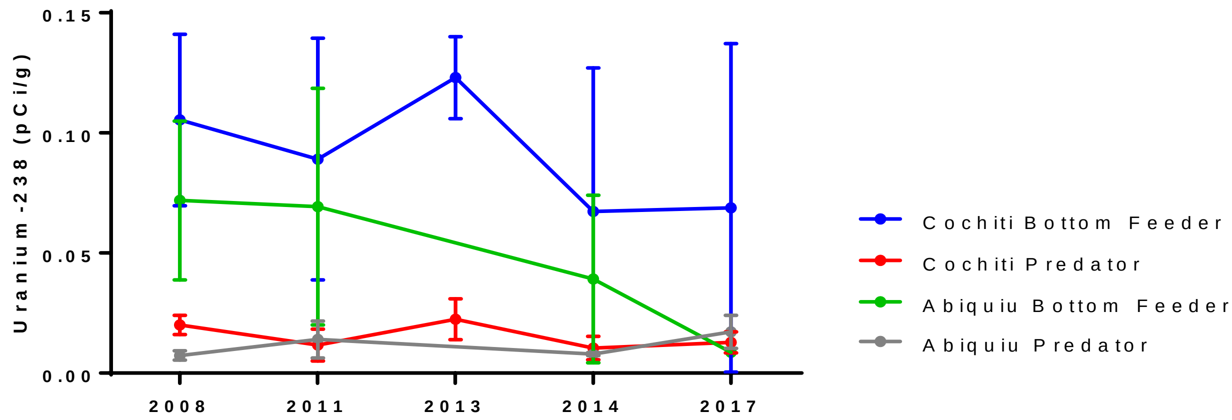
Note: pCi/g = picocuries per gram.

Figure 7-26 **Uranium-234 activities in bottom-feeding fish and predator fish collected from Abiquiu reservoir (upstream) and Cochiti reservoir (donwstream) in 2008 through 2017. Lines connect averages at each time point and error bars represent standard deviation.**



Note: pCi/g = picocuries per gram.

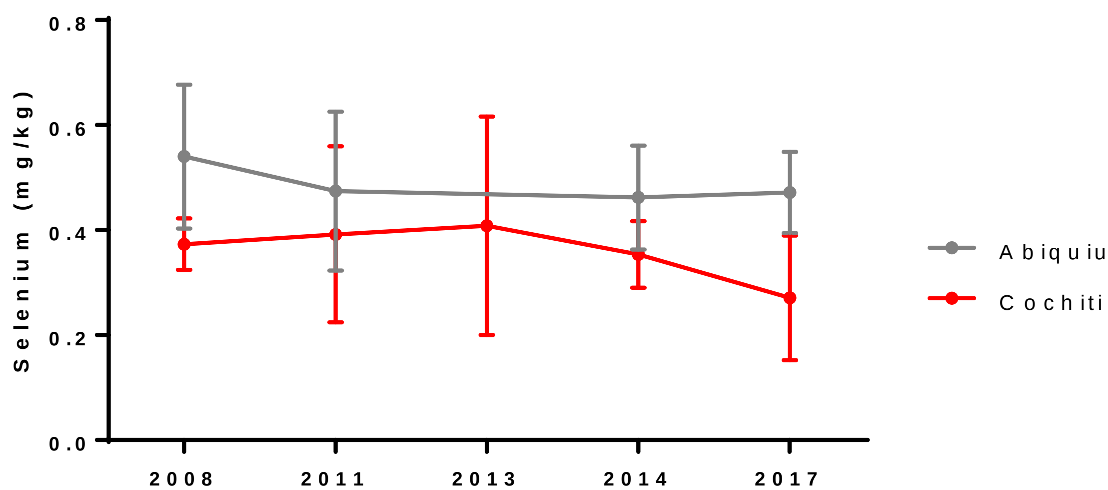
Figure 7-27 **Uranium-235/236 activities in bottom-feeding fish and predator fish collected from Abiquiu reservoir (upstream) and Cochiti reservoir (donwstream) in 2008 through 2017. Lines connect averages at each time point and error bars represent standard deviation.**



Note: pCi/g = picocuries per gram.

Figure 7-28 Uranium-238 activities in bottom-feeding and predator fish collected from Abiquiu reservoir (upstream) and Cochiti reservoir (donwstream) in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.

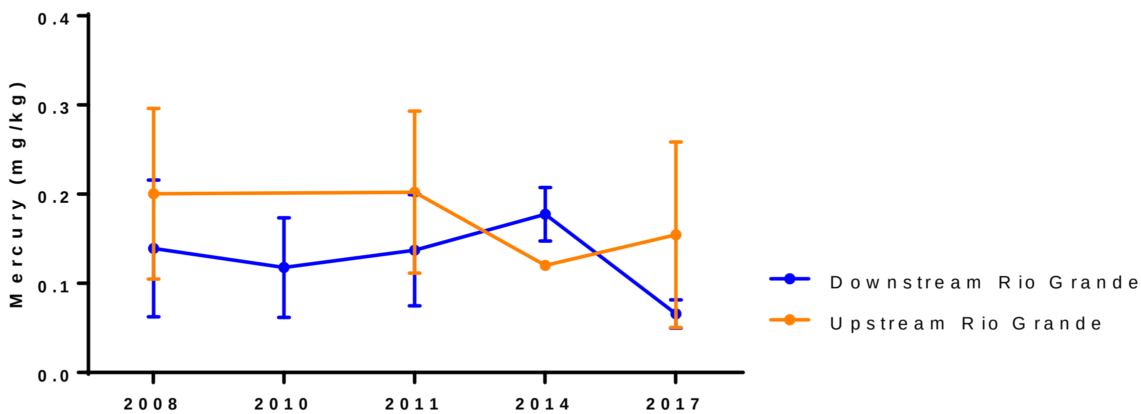
However, selenium concentrations did statistically differ between the two reservoirs (Table S7-35). Selenium concentrations are consistently higher in fish collected from Abiquiu reservoir (Figure 7-29). All selenium concentrations observed in fish collected from both reservoirs are an order of magnitude less that the lowest observable adverse effect level of 8 milligrams per kilogram in muscle tissue (Lemly, 1996).



Note: mg/kg = milligrams per kilogram.

Figure 7-29 Selenium concentrations in fish (bottom-feeding and predator combined) collected from Abiquiu reservior and Cochiti reservoir in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.

Mercury concentrations were statistically higher in bottom-feeding fish collected from upstream Rio Grande when compared with downstream fish ($p < 0.05$; Table S7-34; Figure 7-30). Concentrations of mercury varied independently year-to-year between upstream and downstream fish (Figure 7-30). In 2017, mercury concentrations in fish collected upstream were 0.15 ± 0.11 (mean ± standard deviation) milligrams per kilogram and in fish collected downstream were 0.07 ± 0.02 milligrams per kilogram. In 2017, only one fish sample out of 10 from the Rio Grande exceeded the EPA human health screening value of 0.3 milligrams per kilogram (EPA, 2018). All mercury concentrations observed in fish collected from the Rio Grande are an order of magnitude less than the lowest observable adverse effect level of 5 milligrams per kilogram in muscle tissue (Scherer et al. 1975).

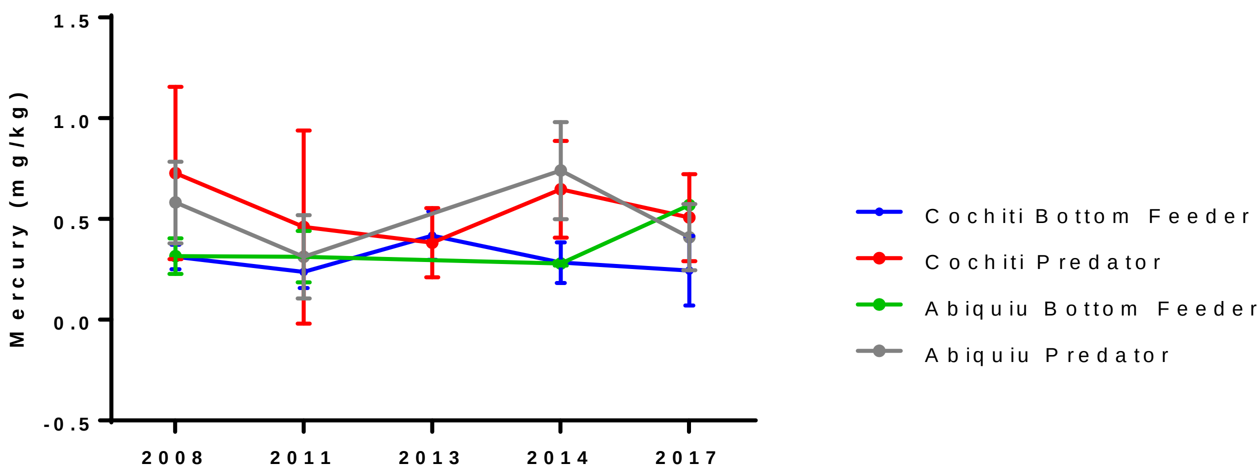


Note: mg/kg = milligrams per kilogram.

Figure 7-30 Mean total mercury concentrations in bottom-feeding fish collected from upstream and downstream Rio Grande in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.

For fish captured in reservoirs between 2008 and 2017, overall mercury concentrations were significantly higher in predator fish compared to bottom-feeding fish, but there was no difference between reservoirs. This suggests that Laboratory operations have not affected fish mercury concentrations (Table S7-35; Figure 7-31). In 2017, mercury concentrations in fish collected from Abiquiu reservoir were 0.41 ± 0.16 milligrams per kilogram in predator fish and 0.57 milligrams per kilogram in a bottom-feeding fish. Fish from Cochiti reservoir contained 0.51 ± 0.22 milligrams per kilogram in predator fish and 0.24 ± 0.18 milligrams per kilogram in bottom-feeding fish (Table S7-35). In general, predator fish are predicted to contain higher levels of mercury than bottom-feeding fish because mercury biomagnifies, or builds up, in the food chain. Also, because the conversion of inorganic mercury to methyl mercury is primarily conducted by bacteria under anaerobic conditions such as those found in bottom sediments of deeper and slower waters (Driscoll et al. 1994; Bunce 1991), we expect that higher levels of mercury in reservoir fish than in Rio Grande fish.

The majority of bottom-feeding and predator fish collected from both reservoirs since 2008 have exceeded the U.S. Environmental Protection Agency's human health consumption screening value for mercury of 0.3 milligrams per kilogram (EPA 2018). All fish from both reservoirs contained mercury concentrations that were an order of magnitude less than the lowest observable adverse effect level for fish of 5 milligrams per kilogram in muscle tissue (Scherer et al. 1975), suggesting that levels observed here are not adversely affecting the fish populations.



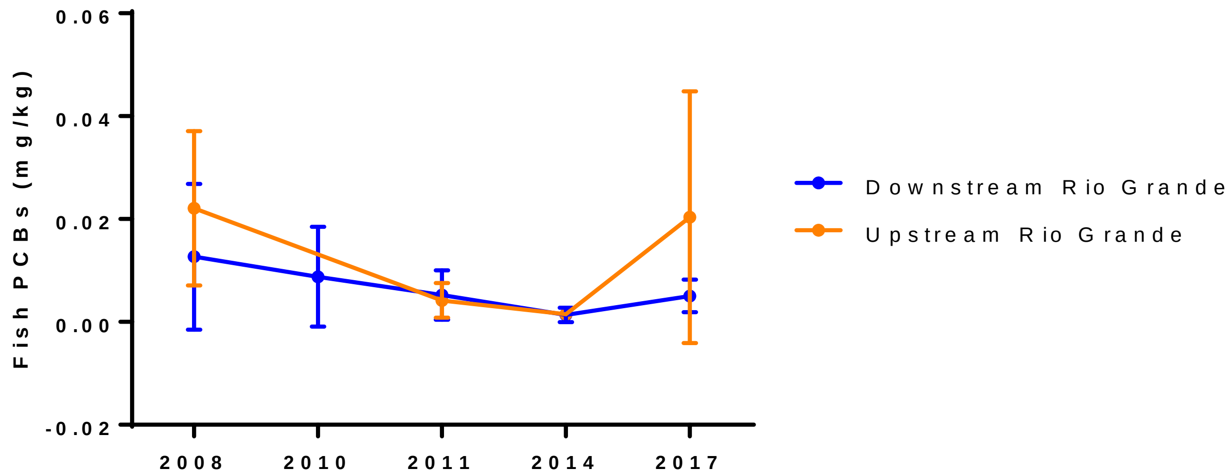
Note mg/kg = milligrams per kilogram.

Figure 7-31 Mercury concentrations in bottom-feeding and predator fish collected from Abiquiu reservoir and Cochiti reservoir in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.

PCB Analytical Results

In 2017, the average level of total PCBs in bottom-feeding fish collected from the Rio Grande were 20,360 ± 24,467 picograms per gram upstream and 5,064 ± 3,156 picograms per gram downstream (Table S7-36). Three of the five fish samples collected from upstream locations exceeded the U.S. Environmental Protection Agency human health consumption screening value of 12,000 picograms per gram (EPA 2018). All PCB levels in fish collected downstream were below the PCB consumption screening value. PCB concentrations in fish were well below the range of values associated with adverse effects on growth and reproduction (50 million to 100 million picograms per gram PCBs in fish tissue) (Niimi 1996).

PCB concentrations in fish collected from the Rio Grande changed significantly between years and there was a significant interaction between location (upstream and downstream) and year (Table S7-36). However, there was no significant difference between locations (Figure 7-32). These data suggest that PCB concentrations in bottom-feeding fish from the Rio Grande do not differ between downstream and upstream locations, but that the concentrations of PCBs in these locations are changing independently over time (Figure 7-32). No other variables or interactions of variables were significantly different (i.e., species, location, year by location, location by species, and year by location by species). Because no difference between locations was observed, these data suggest that Laboratory operations are not affecting PCB concentrations in Rio Grande fish.

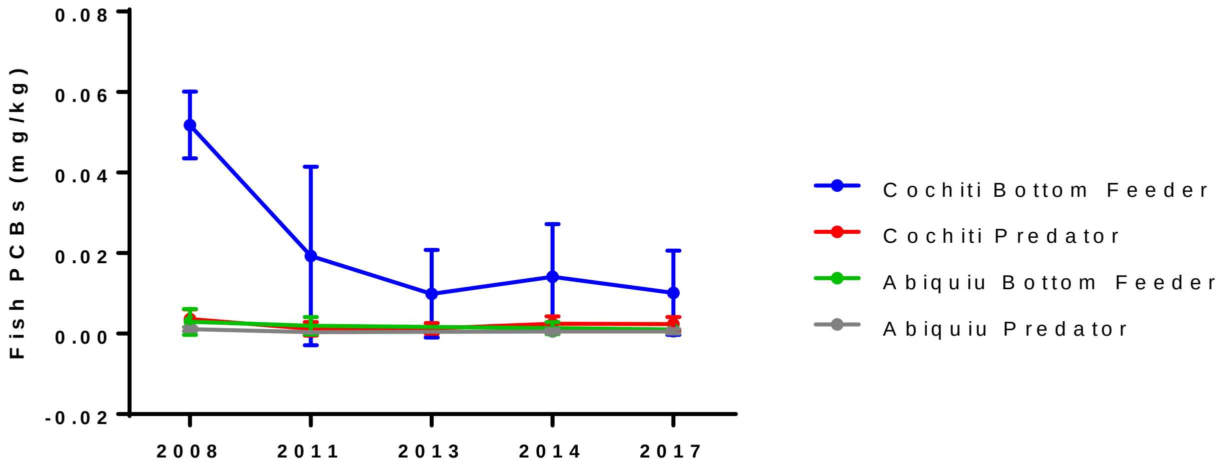


Note mg/kg = milligrams per kilogram.

Figure 7-32 PCB concentrations in bottom-feeding fish collected from the Rio Grande upstream and downstream in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.

In 2017, the average level of PCBs in fish collected from Abiquiu reservoir was 627 ± 559 picograms per gram and from Cochiti reservoir was 6,281 ± 8,215 picograms per gram (Table S7-37). Two of the 12 fish samples collected from Abiquiu reservoir exceeded the U.S. Environmental Protection Agency's human health consumption screening value of 12,000 picograms per gram (EPA 2018). Similar to the PCB concentrations in fish collected in the Rio Grande, all PCB concentrations in fish from the reservoirs were well below the range of values that are associated with adverse effects on growth and reproduction (50 million to 100 million picograms per gram PCBs in fish tissue; Niimi 1996).

PCB concentrations in fish collected from Cochiti did not differ from Abiquiu during 2008 through 2017; additionally, concentrations of PCBs in fish are not changing over time (Figure 7-33). PCBs were significantly higher in bottom-feeding fish, and this was consistent between reservoirs (Figure 7-33). PCB concentrations in bottom-feeding fish from Cochiti appear to be more variable among years than in fish from Abiquiu reservoir (Figure 7-33). This might result from the number and intensity of flooding events affecting Cochiti Lake during 2008 through 2017, the fact that Cochiti is influenced by two rivers (Rio Grande and Rio Chama), or a combination of these effects. Nonetheless, there were no significant differences in PCB concentrations between reservoirs, which suggests that Laboratory operations are not affecting PCB concentrations in these fish.



Note mg/kg = milligrams per kilogram.

Figure 7-33 PCB concentrations in bottom-feeding and predator fish collected from Abiquiu reservoir (upstream) and Cochiti reservoir (donwstream) of Los Alamos Canyon in 2008 through 2017. Lines connect means at each time point and error bars represent standard deviation.

Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrates are insects, oligochaetes (worms), leeches, mollusks, and crustaceans that live on river or lake bottoms. The types of benthic macroinvertebrates present in a community indicate the water quality within a system and the occurrence of environmental stressors such as pollutants (Hilsenhoff 1987; EPA 1998). We surveyed benthic macroinvertebrate species that were retained by a standard number 35 sieve (0.50 millimeter opening).

In October 2017, benthic macroinvertebrates were collected from the Rio Grande upstream and downstream of its confluence with Los Alamos Canyon (Figure 7-34). Benthic macroinvertebrates and sediments were collected from seven locations upstream, extending from Los Alamos Canyon to Black Mesa, and from eight locations downstream, extending from Los Alamos Canyon to Ancho Canyon (Figure 7-35).

Figure 7-34 Collecting benthic macroinvertebrates in the Rio Grande with a kick net.

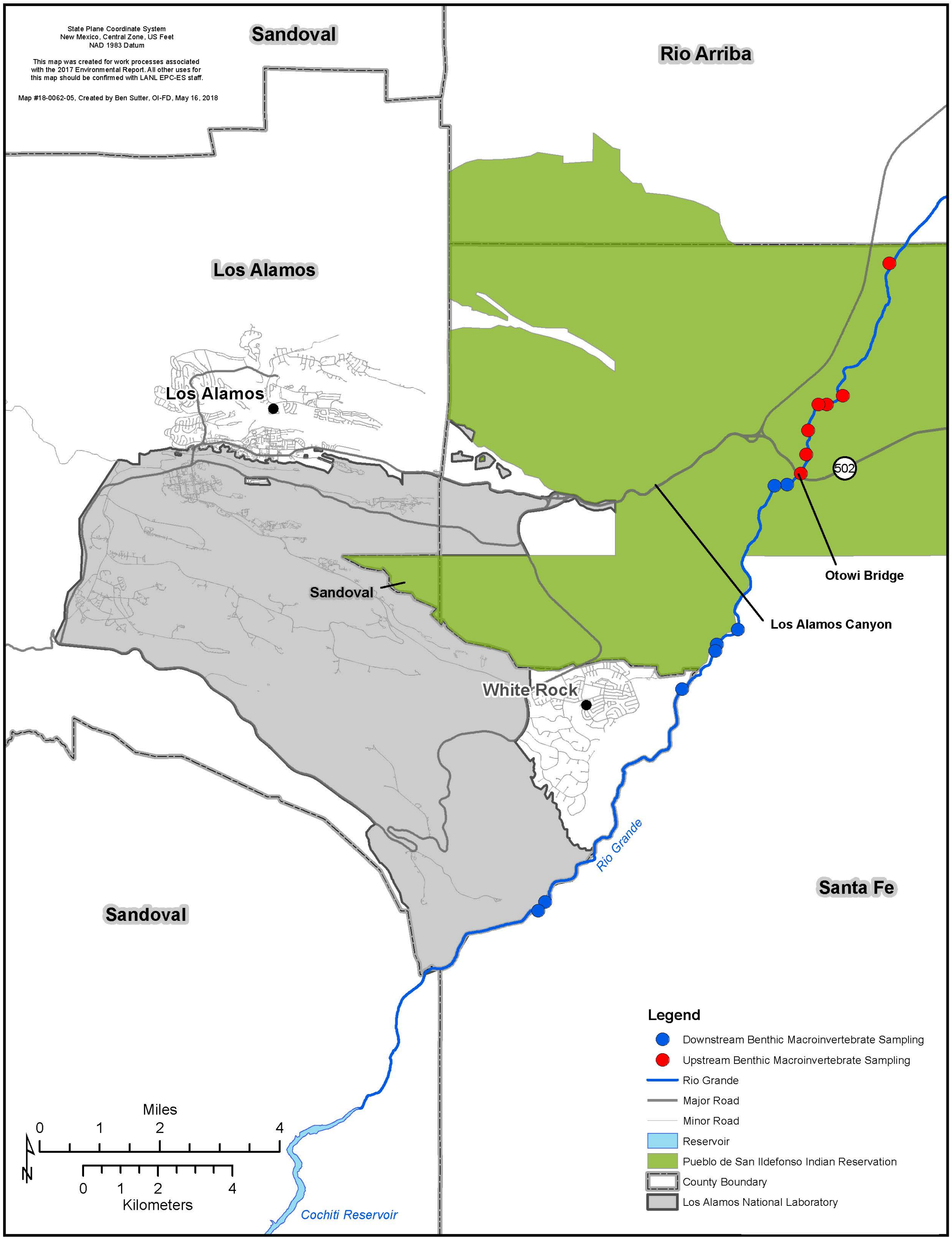


Figure 7-35 **Locations of where benthic macroinvertebrates were collected from locations upstream and downstream of LANL in 2017.**

At each sample location, benthic macroinvertebrates were collected from shallow riffle habitat (areas with fast water running over rocks) using a Turtox kick net (0.75 feet × 1.5 feet with 0.50-millimeter mesh). A sample consisted of six subsamples collected in a downstream direction along a 6-meter-long transect in water depths of 15 to 20 centimeters.

Each subsample was collected by placing the net approximately 1 meter downstream and having the sampler shuffle their feet while walking toward the net, dislodging the benthic macroinvertebrates from the sediment into the net. The area thus sampled was approximately 3 square meters. The net containing the benthic macroinvertebrates was inverted into a five-gallon bucket half filled with water, and the bucket contents were poured through the sieve. Macroinvertebrates on the sieve were transferred to a 1-liter polyethylene bottle and preserved with 95 percent ethanol. The invertebrates were then shipped to EcoAnalysts in Moscow, Idaho for identification.

We calculated benthic macroinvertebrate community metrics, including abundance (numbers of individuals captured), dominance (the taxa with the highest and second highest abundance), richness (the number of different taxa), and diversity-evenness measures (the abundance of different taxa relative to one another) as well as community composition, functional group composition (feeding guild), and biotic indices. We statistically compared these metrics between upstream and downstream locations. All taxonomic data are reported in Table S7-38, and all metrics and statistical analyses are reported in Table S7-39.

Overall abundance and abundance of larvae from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) did not differ between upstream and downstream locations ($p > 0.05$; Table S7-39) and were similar to previous years (Fresquez and Jacobi 2012; Fresquez et al. 2015).

Larvae from the family Hydropsyche (net-spinning caddisflies) were the most abundant taxon in all upstream locations and at six of the eight downstream locations. The taxon with the second highest abundance was the species *Baetis tricaudatus* (blue-winged olive mayflies) at three of the seven upstream locations and at five of the eight downstream locations (Table S7-39). These results were similar with previous years (Fresquez and Jacobi 2012; Fresquez et al. 2015). Richness measures, including species richness; Ephemeroptera, Plecoptera, and Trichoptera richness; Chironomidae (midges) richness; and Oligochaeta (worms) richness did not differ between upstream and downstream locations ($p > 0.05$; Table S7-39).

What are taxa?

Scientists use a hierarchy of classification categories to describe and name each animal and plant. Any group of organisms having the same name in a classification category is called a taxon. Multiple taxons are taxa. In this study, the authors mostly grouped organisms according to their **order** or their **family,** or the authors named organisms specifically by using italicized **genus** and **species**. Here is an example of how humans are named using this taxonomic hierarchy.

Domain: Eukarya
Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Primates
Family: Hominidae
Genus: *Homo*
Species: *sapiens*

Several community composition measures were similar between upstream and downstream locations (for example, the percent of the community composed of members of orders Plecoptera, Coleoptera, and Diptera (flies); $p > 0.05$; Table S7-39). However, this was not true of all measures. The percent of the community composed of members of the order Ephemeroptera and the family Baetidae was higher in the downstream locations than in the upstream locations ($p < 0.01$; Table 7-1). The percent of the community composed of members of the order Trichoptera and the family Hydropsychidae was lower in the downstream location than in upstream location ($p < 0.01$; Table 7-1).

Both Ephemeroptera and Trichoptera are intolerant of pollution. The differences reported here do not suggest differences in water quality between upstream and downstream locations because both taxa indicate good water quality.

Most functional group (feeding guild) composition measures were similar between upstream and downstream locations. However, the percent of filterers was lower in the downstream locations than in upstream locations, and the percent of gatherers was higher in the downstream locations than in upstream locations (Tables 7-1, S7-39). Filterers and gatherers have similar feeding strategies; they both feed primarily on decomposing fine particulate organic material.

Table 7-1

Measures of benthic macroinvertebrate community composition and functional group composition that differed in the Rio Grande upstream and downstream of its confluence with Los Alamos Canyon in 2017.

Community Composition Measures	Upstream (mean ± standard deviation)	Downstream (mean ± standard deviation)
Percent of community composed of members of order Ephemeroptera	30.1 ± 8.0%	50.8 ± 13.7%
Percent of community composed of members of family Baetidae	14.9 ± 10.1%	31.0 ± 4.1%
Percent of community composed of members of order Trichoptera	56.7 ± 7.9%	37.5 ± 14.1%
Percent of community composed of members of family Hydropsychidae	50.7 ± 10.7%	30.5 ± 8.9%
Functional group composition measures		
Percent of filterers	47.6 ± 12.8%	30.4 ± 8.6%
Percent of gatherers	31.0 ± 7.8%	50.1 ± 10.2%

Note: All measures reported are significantly different at the $p < 0.01$ level

However, filterers primarily feed from the water column and gatherers feed from the stream bottom (Cummins et al. 2008). The differences between upstream and downstream locations can be explained by greater numbers of the Ephmeroptera, which are gatherers, downstream and by greater numbers of Trichoptera, which are filterers, upstream (Fresquez and Jacobi 2012).

Several diversity indices were calculated and compared between upstream and downstream locations. There were no differences in diversity and evenness measures between upstream and downstream locations ($p > 0.05$; Table S7-39). This was similar to previous years (Fresquez and Jacobi 2012, Fresquez et al. 2015).

Biotic indices were evaluated between upstream and downstream locations. Most indices did not differ significantly between locations including the Hilsenhoff biotic index which was 4.1 ± 0.3 upstream and 3.8 ± 0.3 downstream ($p > 0.05$; Table S7-39; Hilsenhoff 1987). The Hilsenhoff biotic index is an estimate of the overall benthic macroinvertebrate community tolerance to organic pollution and is on a scale of zero to ten, with zero being the least tolerant. Both the upstream and downstream Hilsenhoff biotic index indicate very good water quality (3.76–4.25, possible slight organic pollution). These results are similar with previous years (Fresquez and Jacobi 2012, Fresquez et al. 2015). Additionally, there were no differences in the metals tolerance index ($p > 0.05$; Table S7-39; Puget Sound Stream Benthos 2018), or in the fine sediment sensitivity index ($p > 0.05$; Table S7-39; Puget Sound Stream Benthos 2018).

The Karr benthic index of biotic integrity metrics were assessed, and long-lived taxa richness was higher in the upstream locations when compared with downstream ($p < 0.05$; Table S7-39). This metric is a measure of invertebrates that require more than a year to complete their life cycle. Many species in the Hydropsychidae family complete one life cycle per year, whereas many species in the Baetidae family complete three or more life cycles per year (Huryn et al. 2008). Hence, the greater number of Hydropsychidae in the upstream locations and the greater number of Baetidae in the downstream are likely driving this observation.

A benthic index of biotic integrity score was calculated to quantify overall biological condition and is based on a scale of 10 to 50 (Puget Sound Stream Benthos 2018). Upstream metrics yielded a score of 32, while downstream metrics yielded a score of 30 (Table S7-40) and indicate that the condition of the river is fair at both upstream and downstream locations (Puget Sound Stream Benthos 2018). The biological condition was also similar between upstream and downstream locations in previous years (2009 and 2014), but reduced biological condition occurred downstream in 2011, attributed to flooding and ash flows following the Las Conchas fire (Fresquez and Jacobi 2012, Fresquez et al. 2015). These data collectively suggest that Laboratory operations are not adversely affecting benthic macroinvertebrate communities in the Rio Grande.

Rio Grande Sediment Chemistry

River sediment samples were collected near the collection sites of the benthic macroinvertebrate samples in the active channel of the Rio Grande between October 10 and October 30, 2017. The top portion of sediment (0–2-inch depth) was collected with a shovel and placed into a 5-gallon polyethylene bucket until approximately three-quarters full. The sediment was then homogenized and scooped into appropriate sampling containers. Samples were submitted to the sample management office and shipped to analytical laboratories. Sediments were analyzed for PCB congeners by Cape Fear Analytical, LLC in Wilmington, North Carolina and for radionuclides and inorganic elements by ALS in Fort Collins, Colorado.

Most radionuclide activities in sediment did not differ statistically between upstream and downstream locations (Table S7-41). Radium-226 and uranium-235/236 were significantly higher in upstream reaches when compared with downstream reaches. Specifically, radium-226 activity was 1.209 ± 0.476 (mean ± standard deviation) picocuries per gram upstream and 0.673 ± 0.284 picocuries per gram downstream ($p < 0.05$) and uranium-235/236 activity was 0.083 ± 0.019 picocuries per gram upstream and 0.049 ± 0.033 downstream ($p < 0.05$). All levels of radionuclides are far below the lowest no-effect ecological screening level. These data are similar to the data collected in 2014. However, there were no significant differences in radionuclide activities between upstream and downstream reaches at that time.

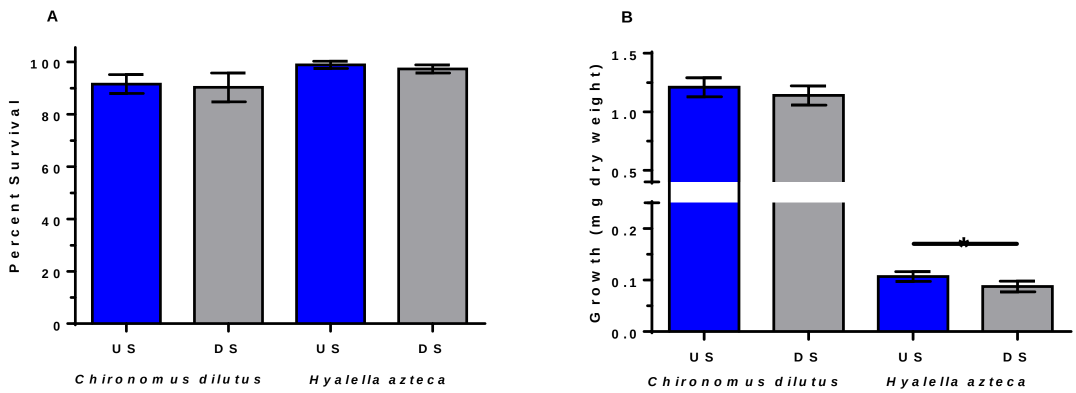
Most inorganic element concentrations did not differ statistically between upstream and downstream locations (Table S7-42). Sodium and silver were significantly higher in upstream sediments when compared with downstream sediments. Average sodium concentrations from upstream reaches was 212 ± 62 milligrams per kilogram and 129 ± 65 milligrams per kilogram from downstream reaches. Silver was not detected in several sediment samples collected from both upstream and downstream; the average silver concentrations from upstream reaches was 0.10 ± 0.05 milligrams per kilogram and 0.04 ± 0.03 milligrams per kilogram from downstream reaches. Barium and selenium concentrations exceeded the no-effect ecological screening level for aquatic community organisms at some locations in both upstream and downstream reaches. No other elements exceeded the no-effect ecological screening level. All elements were below the low-effect ecological screening level for aquatic community organisms (Table S7-42). These data are similar to the data collected in 2014.

Sediment collected from several locations, both upstream and downstream, did not contain detectable concentrations of PCBs (Table S7-43). There was no significant difference in total PCB concentrations between upstream (10.8 ± 15.4 picograms per gram) and downstream (43.8 ± 112.2 picograms per gram) sediment (Table S7-43). All PCB concentrations were far below the lowest no-effect ecological screening level. These results are similar to the data collected in 2014.

Rio Grande Sediment Toxicity Bioassay

River sediment was collected as describe above and sent to Pacific EcoRisk in Fairfield, California for sediment acute toxicity testing. The testing procedure followed U.S. Environmental Protection Agency guidelines. The toxicity assay consists of exposing two different aquatic organisms, *Chironomus dilutus* and *Hyalella azteca,* to the sediment and monitoring their growth and survival over a 10-day period (EPA 2000). The test was replicated eight times for each sediment sample and test species. Each replicate contained 100 milliliters of homogenized sediment, clean overlying water, and 10 organisms and was placed in a temperature-controlled room at 23° C for 10 days. All replicates were checked daily, and any dead animals were removed. After 10 days, percent survival and growth (determined by dry mass) of the two species was determined.

There were no significant differences in the percent survival of *Chironomus dilutus* or *Hyalella azteca* housed in sediments collected from downstream of Los Alamos Canyon when compared with organisms exposed to upstream sediments (Figure 7-36; Table S7-44). Similarly, there were no differences in growth of *Chironomus dilutus* between upstream and downstream locations (Figure 7-36; Table S7-44). However, growth of *Hyalella azteca* was significantly reduced in sediments collected downstream when compared with upstream reaches (Figure 7-36; Table S7-44; $p < 0.01$). The sediment chemistry results do not indicate that higher constituent levels downstream would be driving this effect as no constituents were higher downstream. However, silver and sodium were significantly higher in river sediments collected upstream; perhaps these constituents promoted growth in *Hyalella azteca* exposed to upstream sediments. These results are similar to the results of this experiment that was conducted in 2014.



Note: mg = milligrams.

Figure 7-36 Survival and growth of *Chironomus dilutus* and *Hyalella azteca* exposed to Rio Grande sediments collected upstream (US) and downstream (DS) of the confluence with Los Alamos Canyon in 2017. (A) No significant differences were observed in percent survivial of *Chironomus dilutus* or *Hyalella azteca* exposed to downstream sediments when compared with upstream. (B) No difference in growth of *Chironomus dilutus* was observed between upstream and downstream locations; however, *Hyalella azteca* growth was lower in downstream sediments ($p < 0.01$).

Overall Results

Our evaluation of fish chemical and radionuclide levels, benthic macroinvertebrate communities, sediment chemical and radionuclide levels, and sediment toxicity tests found that with few exceptions there were no significant differences in the Rio Grande above and below its confluence with Los Alamos Canyon. These results indicate that chemicals and radionuclides resulting from Laboratory operations that may be present in storm water and snow melt flows have not had an adverse effect on the Rio Grande aquatic ecosystem during 2008–2017. None of the chemical or radionuclide levels measured exceeded any known lowest observed adverse effect level for biota, either upstream or downstream of potential Laboratory influence. Levels of chemicals in fish that are of concern relative to human health consumption advisories—mercury and PCBs—tend to be higher above the confluence of Los Alamos Canyon with the Rio Grande, upstream of the area potentially affected by Laboratory operations.

BIOTA DOSE ASSESSMENT

Introduction

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 standard "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2002), and uses the standard DOE dose calculation program, RESRAD-BIOTA Version 1.8.

Previous biota dose assessments concluded that doses for populations of plants and wildlife 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, movement of sediment may cause an accumulation of radioactive material in areas where sediment is retained, such as the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure, so these locations are reassessed annually.

What is a rad?

"Rad" is an acronym for **r**adiation **a**bsorbed **d**ose. 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.

Mesa-Top Facilities

Area G

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. In most cases, the doses calculated from the soil data were slightly higher than the doses calculated from the vegetation and animal data. This is because the bioaccumulation factors used in RESRAD-BIOTA are upper limits so the measured biota concentrations are usually less than the model-estimated values; however, whichever results in the highest dose is used. The tritium activities in biota tissue at Area G are higher than in surface soil because plants are exposed to the higher concentrations underground in the waste burial shafts. For tritium, biota data were used instead of soil data. For plutonium-239/240, at location 58-01 near the north-west corner of Area G, the dose is higher if the vegetation data is used instead of the soil data. This is because the bioaccumulation factors are for root uptake from the soil, whereas in this case, the vegetation data include windblown dust attached to the outer surfaces of the plants. This external plutonium-239/240 does not contribute to the biota dose, but to be conservative, the vegetation data were used.

The resulting doses are reported in Tables 7-2 and 7-3.

Table 7-2
Dose to Terrestrial Animals at Area G for 2017

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Americium-241	1.4×10^{-10}	1.4×10^{-06}	4.7×10^{-07}	1.1×10^{-05}	1.2×10^{-05}
Cesium-137	1.3×10^{-08}	1.3×10^{-05}	1.7×10^{-09}	8.3×10^{-06}	1.4×10^{-05}
Tritium	3.0×10^{-03}	5.9×10^{-03}	5.9×10^{-03}	5.9×10^{-03}	2.1×10^{-02}
Plutonium-238	1.2×10^{-10}	4.7×10^{-07}	2.4×10^{-07}	1.7×10^{-05}	1.8×10^{-05}
Plutonium-239	2.8×10^{-10}	1.1×10^{-06}	1.5×10^{-07}	6.3×10^{-05}	6.4×10^{-05}
Strontium-90	1.9×10^{-07}	1.1×10^{-05}	1.5×10^{-06}	4.5×10^{-05}	5.8×10^{-05}
Uranium-234	6.2×10^{-09}	6.2×10^{-07}	4.6×10^{-06}	2.2×10^{-05}	2.3×10^{-05}
Uranium-235/236	7.1×10^{-09}	7.1×10^{-07}	1.8×10^{-07}	6.6×10^{-07}	1.6×10^{-06}
Uranium-238	4.4×10^{-07}	4.4×10^{-05}	4.2×10^{-06}	1.6×10^{-05}	6.4×10^{-05}
Total	3.0×10^{-03}	6.0×10^{-03}	5.9×10^{-03}	6.0×10^{-03}	**Overall Dose 0.021 rad per day**

Note: DOE Limit: 0.1 rad per day for terrestrial animals

Table 7-3
Dose to Terrestrial Plants at Area G for 2017

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Americium-241	1.4×10^{-10}	1.4×10^{-06}	2.1×10^{-05}	2.2×10^{-05}
Cesium-137	1.3×10^{-08}	1.3×10^{-05}	8.3×10^{-07}	1.4×10^{-05}
Tritium	3.0×10^{-03}	5.9×10^{-03}	6.3×10^{-03}	1.5×10^{-02}
Plutonium-238	1.2×10^{-10}	4.7×10^{-07}	5.2×10^{-05}	5.3×10^{-05}
Plutoniumu-239/240	2.8×10^{-10}	1.1×10^{-06}	3.0×10^{-04}	3.1×10^{-04}
Strontium-90	1.9×10^{-07}	1.1×10^{-05}	4.5×10^{-05}	5.6×10^{-05}
Uranium-234	6.2×10^{-09}	6.2×10^{-07}	1.7×10^{-05}	1.8×10^{-05}
Uranium-235/236	7.1×10^{-09}	7.1×10^{-07}	6.8×10^{-07}	1.4×10^{-06}
Uranium-238	4.4×10^{-07}	4.4×10^{-05}	1.6×10^{-05}	6.0×10^{-05}
Total	3.0×10^{-03}	6.0×10^{-03}	6.3×10^{-03}	**Overall Dose 0.016 rad per day**

Note: DOE Limit 1.0 rad per day for terrestrial plants

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 (Figure 7-4). The tritium dose reported in Table 7-1 may be compared with the dose calculated for an owl using the data listed in Table S7-27. The internal tritium dose to the great horned owl at Area G from its measured tissue concentration is 0.0043 rad per day, which is less than the estimated internal dose from tritium of 0.0059 rad per day listed in Table 7-2.

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 results in Table 7-3 show that doses are also below the limit of 1 rad per day for plants. Overall there are no measurable impacts to biota.

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 Tables 7-4 and 7-5.

Table 7-4
Dose to Terrestrial Animals at Dual-Axis Radiographic Hydrodynamic Test Facility for 2017

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Americium-241	0.0×10^{00}	2.9×10^{-09}	0.0×10^{00}	2.3×10^{-08}	2.6×10^{-08}
Cesium-137	9.7×10^{-09}	9.3×10^{-06}	1.3×10^{-09}	6.0×10^{-07}	9.9×10^{-06}
Tritium	2.5×10^{-09}	0.0×10^{00}	4.9×10^{-09}	0.0×10^{00}	7.4×10^{-09}
Plutonium-238	1.1×10^{-12}	6.6×10^{-09}	2.4×10^{-09}	2.4×10^{-07}	2.5×10^{-07}
Plutonium-239/240	1.4×10^{-12}	7.7×10^{-09}	4.7×10^{-09}	4.3×10^{-07}	4.5×10^{-07}
Strontium-90	1.6×10^{-07}	9.8×10^{-06}	1.3×10^{-06}	3.9×10^{-05}	5.1×10^{-05}
Uranium-234	1.3×10^{-08}	1.9×10^{-06}	9.4×10^{-06}	5.3×10^{-05}	6.4×10^{-05}
Uranium-235	1.8×10^{-08}	3.3×10^{-06}	4.6×10^{-07}	3.1×10^{-06}	6.8×10^{-06}
Uranium-238	1.1×10^{-06}	1.8×10^{-04}	1.1×10^{-05}	6.3×10^{-05}	2.5×10^{-04}
Total	3.8×10^{-06}	2.0×10^{-04}	2.7×10^{-05}	1.6×10^{-04}	**Overall Dose 0.00039 rad per day**

Note: DOE Limit: 0.1 rad per day for terrestrial animals

Table 7-5
Dose to Terrestrial Plants at Dual-Axis Radiographic Hydrodynamic Test Facility for 2017

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Americium-241	0.0×10^{00}	2.9×10^{-09}	4.4×10^{-08}	4.7×10^{-08}
Cesium-137	9.7×10^{-09}	9.3×10^{-06}	6.0×10^{-07}	9.9×10^{-06}
Tritium	2.5×10^{-09}	0.0×10^{00}	0.0×10^{00}	2.5×10^{-09}
Plutonium-238	1.1×10^{-12}	6.6×10^{-09}	7.4×10^{-07}	7.5×10^{-07}
Plutonium-239240	1.4×10^{-12}	7.7×10^{-09}	2.1×10^{-06}	2.1×10^{-06}
Strontium-90	1.6×10^{-07}	9.8×10^{-06}	3.9×10^{-05}	4.9×10^{-05}
Uranium-234	1.3×10^{-08}	1.9×10^{-06}	5.3×10^{-05}	5.4×10^{-05}
Uranium-235/236	1.8×10^{-08}	3.3×10^{-06}	3.1×10^{-06}	6.4×10^{-06}
Uranium-238	1.1×10^{-06}	1.8×10^{-04}	6.4×10^{-05}	2.4×10^{-04}
Total	3.8×10^{-06}	2.0×10^{-04}	1.6×10^{-04}	**Overall Dose 0.00037 rad per day**

Note: DOE Limit: 1.0 rad per day for terrestrial plants

The largest dose contribution is from uranium. Half of the uranium is from Laboratory operations and half is natural. The activities of the other radionuclides are consistent with natural background and global fallout.

Tables 7-4 and 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 from radiation at this site.

Sediment-Retention Sites in Canyons

Los Alamos Canyon Weir

The Los Alamos Canyon weir receives storm water flow from historic Technical Area 01 and Technical Areas 02 and 21. The soil and sediment trapped by the weir includes slightly elevated activities, on the order of 1 picocuries per gram of fission products and transuranic radionuclides.

Animal and plant tissue data are generally consistent with the soil data. However, the doses calculated from the soil data were higher than the tissue doses, so the soil data were used to calculate a conservative upper limit for the dose.

The largest doses resulted from naturally occurring uranium. Possible contributions from anthropogenic uranium are indistinguishable from background.

The total biota doses from soil or sediment are shown in Table 7-6 (animals) and Table 7-7 (plants). They are less than 1 percent of the DOE limits and are mostly from naturally occurring material.

Table 7-6
Dose to Terrestrial Animals in Los Alamos Canyon Weir for 2017

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Americium-241	8.6×10^{-11}	8.6×10^{-07}	2.9×10^{-08}	6.7×10^{-06}	7.6×10^{-06}
Cesium-137	4.5×10^{-08}	4.5×10^{-05}	5.8×10^{-09}	2.9×10^{-06}	4.8×10^{-05}
Plutonium-238	5.0×10^{-12}	2.0×10^{-08}	1.1×10^{-08}	7.4×10^{-07}	7.7×10^{-07}
Plutonium-239/240	2.8×10^{-11}	1.1×10^{-07}	9.7×10^{-08}	6.2×10^{-06}	6.4×10^{-06}
Strontium-90	3.5×10^{-07}	2.1×10^{-05}	2.8×10^{-06}	8.4×10^{-05}	1.1×10^{-04}
Uranium-234	1.3×10^{-08}	1.3×10^{-06}	9.9×10^{-06}	3.8×10^{-05}	4.9×10^{-05}
Uranium-235/236	9.1×10^{-09}	9.1×10^{-07}	2.3×10^{-07}	8.5×10^{-07}	2.0×10^{-06}
Uranium-238	9.3×10^{-07}	9.3×10^{-05}	8.9×10^{-06}	3.3×10^{-05}	1.4×10^{-04}
Total	1.4×10^{-06}	1.6×10^{-04}	2.2×10^{-05}	1.7×10^{-04}	**Overall Dose 0.00036 rad per day**

Note: DOE Limit: 0.1 rad per day for terrestrial animals

Table 7-7
Dose to Terrestrial Plants in Los Alamos Canyon Weir for 2017

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Americium-241	8.6×10^{-11}	8.6×10^{-07}	1.3×10^{-05}	1.4×10^{-05}
Cesium-137	4.5×10^{-08}	4.5×10^{-05}	2.9×10^{-06}	4.8×10^{-05}
Plutonium-238	5.0×10^{-12}	2.0×10^{-08}	2.3×10^{-06}	2.3×10^{-06}
Plutonium-239/240	2.8×10^{-11}	1.1×10^{-07}	3.1×10^{-05}	3.1×10^{-05}
Strontium-90	3.5×10^{-07}	2.1×10^{-05}	8.4×10^{-05}	1.1×10^{-04}
Uranium-234	1.3×10^{-08}	1.3×10^{-06}	3.7×10^{-05}	3.9×10^{-05}
Uranium-235/236	9.1×10^{-09}	9.1×10^{-07}	8.7×10^{-07}	1.8×10^{-06}
Uranium-238	9.3×10^{-07}	9.3×10^{-05}	3.4×10^{-05}	1.3×10^{-04}
Total	1.4×10^{-06}	1.6×10^{-04}	2.0×10^{-04}	**Overall Dose 0.00037 rad per day**

Note: DOE Limit: 1 rad per day for terrestrial plants

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure does not receive significant quantities of Laboratory radionuclides. Any contribution from DOE operations is too small to measure and is 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.

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 S7-20 (deer), S7-21 (elk), and S7-26 (bear, coyote, fox). 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.

Measurements of smaller animals (snakes and birds) are reported in Table S7-27. The body of a great horned owl collected from Area G contained tritium, probably from eating small mammals inside Area G. The resulting dose to the owl was 4.3×10^{-03} rad per day, which is 4.3 percent of the population dose limit of 0.1 rad per day.

Measurements of fish are reported in Tables S7-32 and S7-33, and these data are supported by sediment data reported in Table S7-41. There is no indication of any measurable radioactive material from the Laboratory and the doses to fish are less than 1 percent of the DOE limits.

Conclusion

Previous biota dose assessments have shown that biota doses at the Laboratory are far below the DOE limits. The 2017 assessment confirms the previous assessments and shows that there are no harmful effects to the biota populations at LANL from Laboratory radioactive materials.

SPECIAL STUDIES

Aquatic Life Surveys

Introduction

The objective of the aquatic life surveys supplemental environmental project is to identify the aquatic species found in perennial and ephemeral or intermittent streams on the Pajarito Plateau. This information will be used by the New Mexico Environment Department to evaluate whether the species that were used by the U.S. Environmental Protection Agency in their development of ambient water quality criteria adequately represent the species that are found here.

Methods

In October 2017, aquatic life surveys were conducted in four perennial streams. Two of the streams were naturally perennial systems in Calaveras Canyon and Rio Cebolla, off of Laboratory property, and two were effluent-fed streams, one in Sandia Canyon on Laboratory property and one in Pueblo Canyon off of Laboratory property. Two reaches were surveyed in each stream, except Sandia Canyon, which had four reaches surveyed. Surveys were conducted at nine equidistant transects along each 160-meter reach.

At each transect, we surveyed for amphibians and fish using a pond net. All captured animals were identified and released at the location of capture. We took a sample of the small invertebrates living within stream bottom sediments (called meiofauna) at three locations along each transect using a corer that collected approximately one centimeter of sediment as well as a water column sample. The three samples were combined and homogenized to create a single composite sample for each transect. Benthic macroinvertebrates were collected at each transect with the use of a D-frame kick net. To take a sample, the person operating the kick net disturbed the sediment directly upstream for 30 seconds.

Meiofauna and benthic macroinvertebrates samples were processed on a 63-micron and 500-micron sieve, respectively, and all material on the sieves were transferred to a sample container and preserved with 95 percent ethanol. Samples were then shipped to EcoAnalysts, Moscow, Idaho for taxonomic identification. A map of the sampling locations and a complete description of sampling methods are described in Berryhill and Gaukler (2017).

Preliminary Results

No amphibians were observed during the aquatic life surveys, and rainbow trout (*Oncorhynchus mykiss*) were only observed in Rio Cebolla. Meiofauna and benthic macroinvertebrates were found in all reaches in all streams (Table S7-38). There was no significant difference in the total number of meiofauna taxa across locations ($p > 0.05$). A list of the first, second, and third dominant taxa can be found in table S7-45.

Several benthic macroinvertebrate community metrics, such as abundance, dominance, diversity-evenness measures richness measures, community composition, functional group composition, and biotic indices were statistically analyzed across sampling locations. There were no differences in abundance or richness measures among locations. Within the remaining metrics, approximately 25 percent of the metrics were statistically different among the four perennial stream locations surveyed (Table S7-46); these differences are likely due differences in habitat type.

Future Direction

Aquatic life surveys will be repeated in perennial streams during the fall of 2018 and ephemeral-intermittent streams will be surveyed during the spring and summer of 2018. The results can then be used to make comparisons with the species used to develop the U.S. Environmental Protection Agency's ambient water quality criteria.

Avian Monitoring at Firing Sites and at the Burning Grounds

In 2017, chemical concentrations were evaluated in eggs and deceased nestlings that were collected at the Laboratory near the open detonation sites at Technical Areas 36 and 39 and near the Technical Area 16 open-burn site. Eggs were evaluated for inorganic elements, and nestlings from technical areas 36, 39, and 16 were evaluated for PCBs, dioxins, and furans.

Eggs collected from Technical Areas 36 and 16 contained significantly higher concentrations of copper compared to background eggs ($p < 0.05$); specifically, at Technical Area 36 eggs contained 0.85 ± 0.08 (mean ± standard deviation) milligrams per kilogram, Technical Area 16 eggs contained 0.80 ± 0.24 milligrams per kilogram, and reference eggs contained 0.56 ± 0.20 milligrams per kilogram of copper. Eggs collected at Technical Area 16 also contained significantly higher concentrations of barium, mercury, and selenium when compared with background ($p < 0.05$); specifically, eggs collected at Technical Area 16 burn grounds contained 14.01 ± 14.35 milligrams per kilogram of barium, 0.032 ± 0.016 milligrams per kilogram of mercury, and 0.88 ± 0.32 milligrams per kilogram of selenium while reference eggs contained 2.07 ± 1.58 milligrams per kilogram of barium, 0.014 ± 0.006 milligrams per kilogram of mercury, and 0.51 ± 0.22 milligrams per kilogram of selenium.

Magnesium, potassium, and sodium were higher in eggs collected at Technical Area 16, and potassium and sodium were higher in eggs collected at Technical Area 36, compared with background. These chemicals are macronutrients, which are required by living organisms in relatively large amounts. No other significant differences in levels of inorganic elements in eggs were observed, and most concentrations were below the regional statistical reference level. A full list of results, including data tables and discussion on the results can be found in Gaukler (2017).

Most dioxins and furans were not detected in nestlings collected from Technical Areas 16, 36, or 39. There were no statistical differences in dioxins, furans, or PCBs in nestlings collected from Technical Area 36 when compared with nestlings from the reference location ($p > 0.05$). For Technical Areas 16 and 39, we could not perform statistics on dioxin or furan concentrations because of small sample sizes. However, the nestling sample collected at Technical Area 16 contained 1,2,3,4,6,7,8-heptachlorodibenzodioxin at 19.0 picograms per gram, which exceeded the regional statistical reference level of 9.4 picograms per gram. PCBs were detected at 212,000 picograms per gram and also exceeded the regional statistical reference level (45,300 picograms per gram). Heptachlorodibenzofuran [1,2,3,4,6,7,8-] and 1,2,3,4,6,7,8-octachlorodibenzodioxin were detected but were below the regional statistical reference levels. Nestlings collected at Technical Area 39 contained 1,2,3,4,6,7,8-heptachlorodibenzodioxin (11.1 picograms per gram) which exceeded the regional statistical reference level of 9.4 picograms per gram; 1,2,3,4,6,7,8-octachlorodibenzodioxin and PCBs were also detected but were below the regional statistical reference level. A full list of results, including data tables and discussion on the results can be found in Gaukler (2017).

Many constituents were not detected and most constituents were below regional statistical reference level and lowest observable adverse effect levels and are therefore not of ecological concern. These data are preliminary, and more data are needed to make a robust assessment, including additional background samples (Gaukler, 2017).

Los Alamos Canyon Bioassessment

A bioassessment was conducted in the Middle Los Alamos Canyon Aggregate Area at Technical Area 02 at LANL. The study area sequentially housed a total of five experimental nuclear reactors along with ancillary facilities. The site was active from 1943 to 2003. Inorganic chemicals (barium, cadmium, copper, lead, mercury, selenium, thallium, and vanadium) and organic chemicals (PCBs, dioxins, and furans) have been identified as chemicals of potential ecological concern for the study area. The objectives of the study were to report chemical levels in soil and animal tissues and to document occupancy and density of small mammal and bird species at the site. The results of this study were used to support an ecological risk assessment that is part of the Phase II investigation of the Middle Los Alamos Canyon Aggregate Area being performed under the 2016 Compliance Order on Consent.

Six composite soil samples were collected from each of three grids within Technical Area 02 as well as from an upstream control location in Los Alamos Canyon. The upper grid contained the location of the reactors; the middle and lower grids were downstream of the upper grid. Small mammal populations were assessed by live-trapping small mammals for five consecutive nights for a mark-recapture study. At the end of the trapping, small mammals were euthanized, composited, and submitted for chemical analyses. Avian nest boxes were also placed in Technical Area 02 and monitored weekly from May to July 2017.

Most soil inorganic chemical concentrations did not differ significantly among grids, including the control grid. However, soil collected from the upper grid contained higher concentrations of mercury and total PCBs (up to 546 milligrams per kilogram of total PCBs). Soil collected from the three grids within Technical Area 02 contained PCBs and all inorganic chemicals of interest, except for barium and cadmium. Levels of some chemicals in soil exceeded ecological screening levels that are protective of biota. Concentrations of most dioxins and furans were statistically different among the grids, with the general trend that the upper grid contained higher concentrations. No ecological screening levels for dioxins or furans are available except for TCDD; TCDD was only detected in upper grid and concentrations were below the ecological screening level.

In small mammals, all detected inorganic element concentrations were below the regional statistical reference levels. PCBs were detected in all small mammal samples, and total PCB concentrations in small mammals from the upper grid exceeded the regional statistical reference level; however, those concentrations were below the lowest observed adverse effect level of PCBs in whole-body mice (Batty 1990). Most dioxins and furans were not detected in small mammals with the exception of 1,2,3,7,8-pentachlorodibenzodioxin; 2,3,4,7,8-pentachlorodibenzofuran; total pentachlorodibenzofurans; and 2,3,4,6,7,8-hexachlorodibenzofuran, which were detected mostly in the upper grid and also exceeded the regional statistical reference levels. Whole-body burdens of TCDD-like chemical concentrations were calculated using the toxic equivalent method, and whole-body burdens observed in small mammals from middle, lower, and control grids are not expected to cause adverse effects (DeVito et al. 1995); however, TCDD-induced adverse effects are possible in small mammals from the upper grid.

Small mammal density was analyzed by using spatially explicit capture-recapture models. We estimated a density of 4.59 animals per hectare (95 percent confidence interval = 3.30–7.98) and an abundance of 50 animals (95 percent confidence interval = 36–87) within the 10.9 hectares around all three grids. There was not a statistical difference in density among the three grids. Only 4 of the 16 nest boxes were used in the 2017 field season, one of which was used by a target species, the ash-throated flycatcher. That nest fledged young, and no unhatched eggs were found. Therefore, no chemical analyses could be completed.

Despite many of the chemicals of interest in this study exceeding ecological screening levels in soil, most concentrations of these chemicals in small mammal tissues were below the regional statistical reference levels or lowest observable adverse effect levels from published literature. These data, along with the small mammal population assessment, suggest that adverse effects to the population level for small mammals is unlikely. A full list of results, including data tables and discussion on the results can be found in Gaukler and Hathcock (2017).

Small Mammal and Sediment Monitoring in Sandia Canyon

Sandia Canyon contains an approximately three-acre wetland, and an effluent-fed stream reach for approximately 2.5 miles below the wetland. The effluent comes primarily from the Laboratory's sanitary waste water treatment plant and discharge from cooling towers, and is regulated under the Laboratory's outfall permit.

In 2016, a small mammal population study in the Sandia Canyon wetland was conducted and wild mice were collected and analyzed for constituents (reported in detail in Fresquez et al. 2017). In 2017, three vole samples and two shrew samples collected during the 2016 study were analyzed for PCBs. Voles contained an average of 0.009 ± 0.0056 (mean ± standard deviation) milligrams per kilogram of PCBs. Two of the three samples contained PCB concentrations that were above the regional statistical reference level (0.0066 milligrams per kilogram; Table S7-47). Shrews contained an average of 1.78 ± 0.10 milligrams per kilogram of PCBs (Table S7-47). No shrews have been collected from background location for comparison. PCB concentrations were higher in shrews than in the other small mammals collected in Sandia Canyon (average PCB concentration 0.112 milligrams per kilogram). The higher level of PCBs in shrews can likely be explained by the shrew's different feeding strategies. Shrews have an extremely high metabolic rate and primarily feed on insects, whereas other small mammals reported here have an omnivorous diet. Sandia Canyon small mammal PCB concentrations are all below the lowest observable adverse effect level of 2.5 milligrams per kilogram (Batty et al. 1990) and are not expected to adversely affect the small mammal population in Sandia Canyon.

As part of an ongoing effort to characterize ecosystem health in Sandia Canyon, in 2017 four sediment samples from the active channel in Sandia Canyon were collected over 1.6 miles starting above the wetland and working downstream. Samples were analyzed for PCBs, inorganic elements, and physical properties. Almost all inorganic element concentrations were below both the lowest no-effect and the lowest low-effect screening level for aquatic community organisms (Table S7-48). Sediment within the wetland contained selenium concentration of 0.92 milligrams per kilogram, which was above the no-effect screening level of 0.72 milligrams per kilogram. Additionally, sediment within and below the wetland contained silver concentrations of 1.66 and 0.804 milligrams per kilogram, respectively, which was above the no-effect screening level of 0.5 milligrams per kilogram. Both of these constituents were below the lowest low-effect level and are not expected to cause adverse effects to aquatic community organisms, including the plants and invertebrates that inhabit the active channel.

PCB concentrations in sediment generally decreased going downstream, although this was not statistically significant ($p > 0.05$). The highest concentration was 0.543 milligrams per kilogram at the uppermost reach and decreased to 0.00408 milligrams per kilogram at the lowermost reach (Table S7-49). PCB concentrations also decreased directly downstream of the wetland, suggesting that the wetland is filtering PCBs. PCB concentrations in sediment samples collected from the two uppermost reaches exceeded the lowest no-effect ecological screening level for aquatic community organisms for Aroclor-1260 of 0.059 milligrams per kilogram; however, all concentrations of PCBs were below the lowest low-effect ecological screening level for aquatic community organisms (0.59 milligrams per kilogram). These data suggest that the levels observed here are not likely to cause adverse effects to aquatic organisms inhabiting the active channel in Sandia Canyon.

Sand was the dominant substrate in sediments collected from the active channel of Sandia Canyon (Figure 7-37). The sediment collected from the wetland contained higher amounts of silt and total organic carbon (17,500 milligrams per kilogram) compared with other locations (Table S7-50).

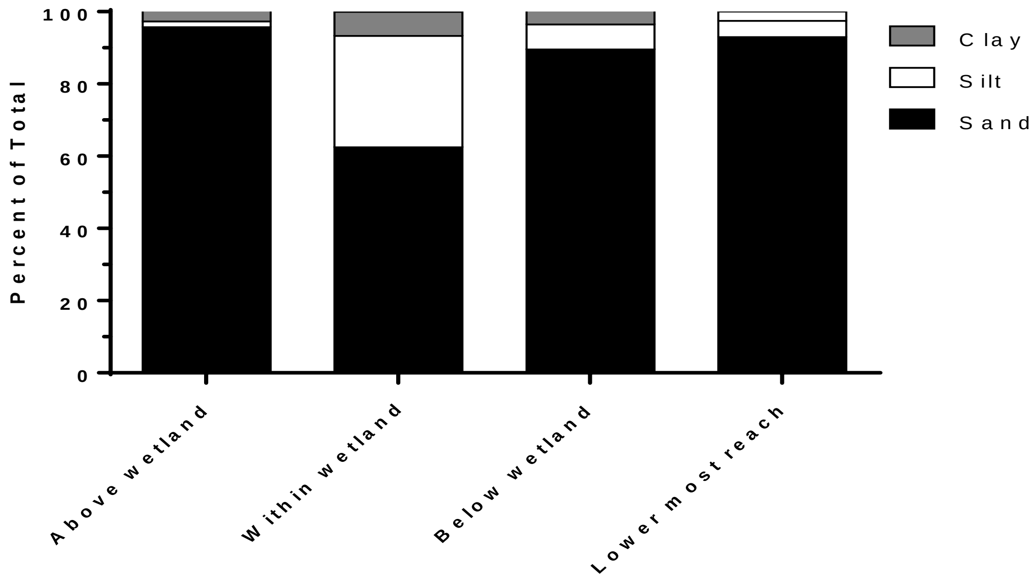


Figure 7-37 Particle size distribution in sediment collected from the active channel within Sandia Canyon in 2017.

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 *Quality Assurance Project Plan for the Soil, Foodstuffs, and Nonfoodstuffs Biota Monitoring Project* (QAPP-0001) 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)
- Collection of Crawfish in the Rio Grande (ENV-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)

Also, 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, listed on the Laboratory's public website at http://www.lanl.gov/environment/plans-procedures.php and available at https://eprr.lanl.gov/, 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 2017 was 100 percent.

Analytical Laboratory Quality Assessment

The 2017 measurements of tritium in soil at Area G were rejected because the method was not suitable for these samples. Although the method requested by LANL was EPA Method 906, the method used by the analytical laboratory was ARS-055, which does not measure the percentage of water in the sample. The percentage of moisture was listed as 0.010 for all samples; however, this was an arbitrary number that was entered in the absence of actual measurements. This means it is impossible to convert the data to units of picocuries per liter, which is required for biota dose assessment and for comparison with previous data. Furthermore, the method allowed volatile organic chemicals to transfer from the sample into the liquid scintillation apparatus, and these organics interfered with the measurements of tritium. For these reasons, the 2017 Area G soil tritium results were not suitable to use.

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U.S. Department of Energy regulations limit the total annual radiological dose to the public from Los Alamos National Laboratory (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 2017 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.

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, and standard methods are used to calculate the potential effects. The results are compared with regulatory limits and international standards.

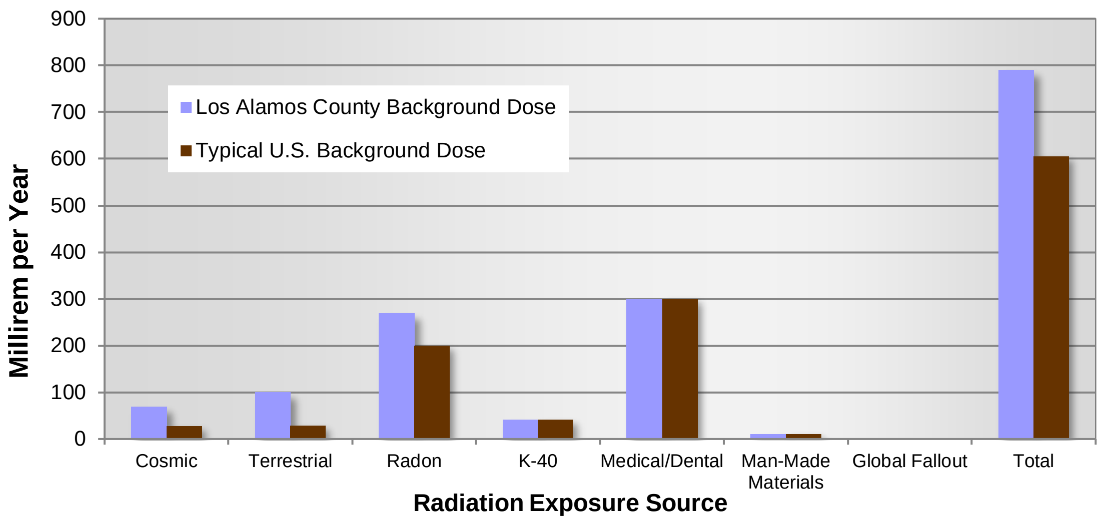
RADIOLOGICAL DOSE ASSESSMENT FOR THE PUBLIC

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; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 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 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 (EPA 1989). The annual dose from community drinking water supplies is limited by the Safe Drinking Water Act to 4 millirem (EPA 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 on page 8-3 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 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 1 kilometer of the source. At distances more than 1 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) (EPA 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 (Fuehne 2018) 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 are reported in Chapter 7 and here.

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 "2017 Annual Drinking Water Quality Report" (Los Alamos County 2018; available at https://indd.adobe.com/view/50b3a008-30c5-4666-b37e-2390168c2a44).

Local produce is tested regularly and contains no measurable radioactivity from Laboratory sources. This year, six deer and five elk were tested for radionuclides and other materials. The 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 cosmic rays, direct-penetrating radiation from terrestrial sources, radon gas, and 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 (NCRP 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 (NCRP 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 calculate doses from the Laboratory to the following members of the public:

- The total human population within 80 kilometers (50 miles) of the Laboratory
- 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 (EPA 1989)
- The onsite dose
- Other locations with measurable dose
- 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 from the roads within and adjacent to the Laboratory, including during 2017, 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 (Tables S7-20 and S7-21). 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 conclusion is that the ingestion dose 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 2017 collective population dose to persons living within 80 kilometers of the Laboratory is 0.2 person-rem (Fuehne 2018). 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 55 percent of the dose from the Laboratory, and short-lived activation products, such as carbon-11 from the Los Alamos Neutron Science Center, contributed 45 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.

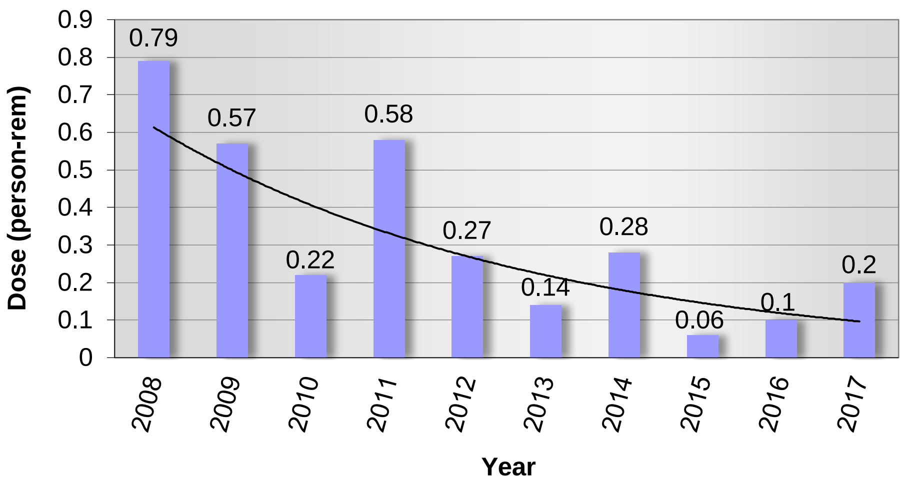


Figure 8-2 **Annual collective dose (person-rem) to the population within 80 kilometers of the Laboratory.**

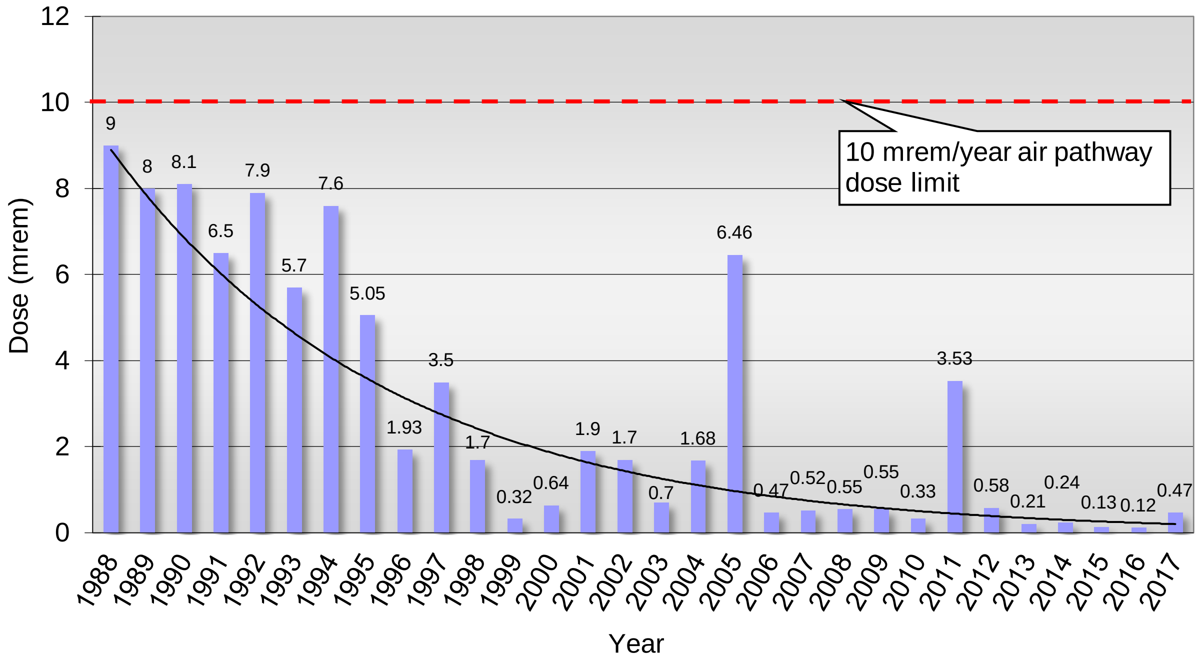
Dose to the Maximally Exposed Individual

The "maximally exposed individual" is a hypothetical member of the public who receives the greatest possible dose from Laboratory operations (EPA 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 2017

The air-pathway dose calculations are described in an annual air-emissions report (Fuehne 2018). For 2017, the offsite location of the hypothetical maximally exposed individual was at 2101 Trinity Drive, in the general area of the original Technical Area 01 (established in 1943 for the Manhattan Project) and close to environmental air-monitoring station 324 (Chapter 4, Figure 4-1). Contributions to this dose included legacy plutonium (0.2 millirem), uranium (0.01 millirem), and tritium (0.01 millirem). Additional minor sources brought the estimated potential dose to 0.47 millirem (Fuehne 2018). Doses from ingestion and direct-penetrating radiation were less than 0.01 millirem.

During 2017, the hillsides south of station 324 were remediated to recreational standards (Haagenstad 2017). At present, the plutonium activities on these hillsides are similar to those in Acid Canyon (Reneau 2002, McNaughton 2011). However, the estimated doses near station 324 are higher than those in Acid Canyon, for two reasons. First, the hillsides near station 324 are south facing, which leads them to be dry with sparse vegetation and exposed to the predominant winds from the south and south-west. In contrast, Acid Canyon is sheltered by the canyon walls and tall trees and is relatively moist for most of the year, so soil in Acid Canyon is not as likely to become suspended in the air. Second, under the compliance and reporting requirements for the National Emission Standards for Hazardous Air Pollutants (Title 40 of the Code of Federal Regulations, Part 61) the places of business near station 324 are assumed to be occupied for 8,760 hours per year, whereas Acid Canyon, used for recreation, is assumed to be occupied for less than 365 hours per year. The longer period of exposure near station 324 contributes to a higher estimated potential public dose near station 324 than in Acid Canyon.



Note: mrem = millirem.

Figure 8-3 **Annual maximally exposed individual offsite dose.**

Maximally Exposed Individual Onsite Dose for 2017

The onsite locations where a member of the public could receive a measurable dose are on or near the publicly accessible roads, and hiking trails are described in 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 during 2017 the neutron dose was 0.6 millirem and the gamma dose was 0.1 millirem for a total of 0.7 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, so the onsite dose for a maximally exposed individual is less than 1 percent of 0.7 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 during 2017 was 2 millirem. After applying the standard factor of 1/20 for occasional occupancy (NCRP 2005), the individual neutron dose during 2017 was 2/20 ≈ 0.1 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 4 attocuries per cubic meter (Chapter 4, Tables 4-3 and 4-4), so 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, during 2017, the total dose in Cañada del Buey was 0.1 millirem.

Maximally Exposed Individual Summary

At the offsite location for the maximally exposed individual (2101 Trinity Drive), the direct-penetrating radiation and ingestion doses are essentially zero, so the largest all-pathway dose for 2017 was the same as the air-pathway dose of 0.47 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 0.47 millirem in 2017 is far below the 10-millirem annual air-pathway limit (EPA 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 and do not cause measurable health effects.

Table 8-1
LANL Radiological Doses for Calendar Year 2017

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	0.47	0.47%	0.2	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	0.47	0.47%	0.2	~343,000	~268,000[b]

[a] n/a = Not applicable. Background population dose is not calculated for individual exposure pathways.

[b] Based on 780 millirem per person as shown in Figure 8-1.

NONRADIOLOGICAL MATERIALS

Introduction

This section summarizes the potential human health risk from nonradiological materials released from the Laboratory in 2017. Air emissions are reported in Chapters 2 and 4; groundwater is reported in Chapter 5; surface water and sediment are reported in Chapters 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 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 2017. 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 2018).

Additional water sampling was conducted in the City of Santa Fe's Buckman well field. No Laboratory-related constituents were present above 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 work on interim measures to control migration of this chromium plume.

Surface Water and Sediment

The concentrations of chemicals in surface water and sediment for 2017 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 compare unfiltered storm water concentrations with drinking water standards as screening levels, though storm water is not a drinking water source and there is thus 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.

Polychlorinated biphenyls (PCBs) are discussed in Chapter 6. Because of the limited number of aquatic organisms on the Pajarito Plateau, the amount of PCBs entering the food chain is small.

We conclude there is no risk to the public from exposure to surface water and sediment as a result of 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 during 2017, chemical concentrations above human-health–based screening criteria were not detected.

Conclusion

The environmental data collected in 2017 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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Reneau 2002: Reneau Steven L, "Interim Action Completion Report for the South Fork of Acid Canyon," Los Alamos National Laboratory document LA-UR-02-5785 (2002).

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Whicker 2009b: Whicker, J.J., "Work to Save Dose: Contrasting Effective Dose Rates from Radon Exposure in Workplaces and Residences Against the Backdrop of Public and Occupational Regulatory Limits," *Health Physics* 97:248-256 (2009).

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).

In 2011, DOE issued Order 458.1, which describes the current radiation protection standards for the public, now 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).

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-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 (40 Code of Federal Regulations 61, Subpart H).

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 mrem/yr.

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.

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, 40 Code of Federal Regulations 61, Subpart H. 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 mrem/yr. 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 mrem to a member of the public.

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 40 Code of Federal Regulations 141 and New Mexico Drinking Water Regulations, Sections 206 and 207. These regulations stipulate that combined radium-226 and radium-228 may not exceed 5 picocuries per liter (pCi/L). Gross-alpha activity (including radium-226 but excluding radon and uranium) may not exceed 15 pCi/L.

A screening level of 5 pCi/L for gross alpha is established to determine when analysis specifically for radium isotopes is necessary.

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 mrem/yr. 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 mrem/yr. 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 livestock watering and wildlife habitat 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 mrem or greater to an individual for radionuclides, (2) an estimated excess cancer risk of 1×10^{-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 mrem/yr 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/day for terrestrial plants and aquatic biota and 0.1 rad/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

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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).

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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 because U.S. customary units are the units in which most data and measurements are collected or measured. 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 2.0×10^3, 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 10^6	M
kilo	1000 or 10^3	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:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

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 aging vacant 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.
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.

Technical Area	Activities
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.
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.
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.

Technical Area	Activities
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, treatment, and decontamination.
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. Construction of the Radiological Laboratory/Utility/Office Building was completed in 2012. Radiological operations 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.
61 (East Jemez Site)	Technical Area 61, located in the northern portion of the Laboratory, contains physical support and infrastructure facilities, including a sanitary landfill operated by Los Alamos County, the photovoltaic array, and sewer pump stations.
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.

Technical Area	Activities
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.

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/

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

Previous reports in this series are LA-UR-17-27987, LA-UR-16-26788, LA-UR-15-27513, LA-UR-14-27564, LA-UR-13-27065, LA-14427-ENV, LA-13775-ENV, LA-13861-ENV, LA-13979-ENV, LA-14085-ENV, LA-14162-ENV, LA-14239-ENV, LA-14304-ENV, LA-14341-ENV, LA-14369-ENV, LA-14407-ENV, LA-14427-ENV, LA-14445-ENV, LA-14461-ENV.

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