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Author(s): Hansen, Leslie Ann
Salzman, Sonja L.
Dewart, Jean Marie
Bruggeman, David Alan
Mcnaughton, Michael
Katzman, Danny
White, Amanda Beth
Fresquez, Philip R.

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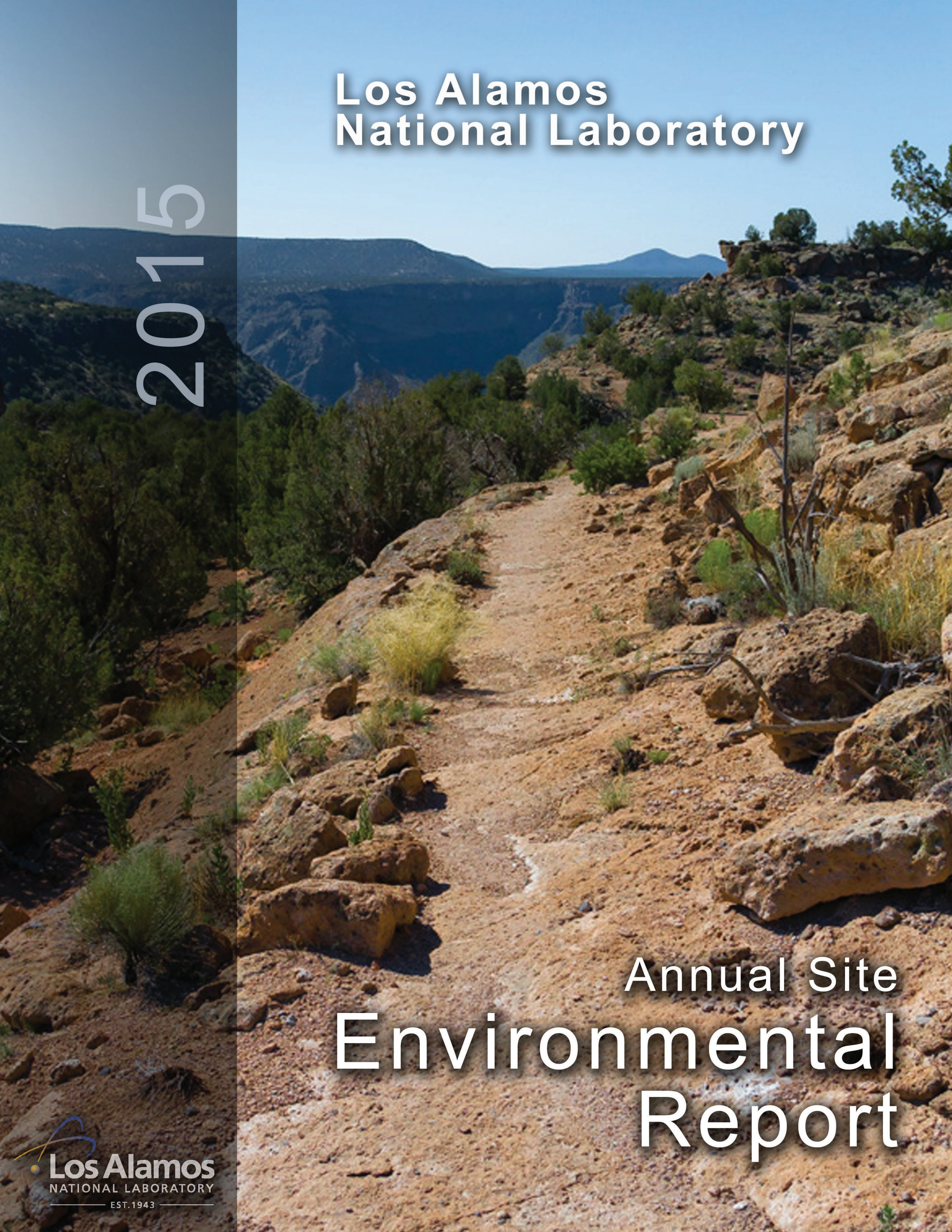
Los Alamos National Laboratory

2015



Annual Site Environmental Report

Los Alamos
NATIONAL LABORATORY
EST. 1943

Los Alamos National Laboratory Governing Policy for the Environment

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

Environmental sampling at Los Alamos National Laboratory

Cactus on Los Alamos National Laboratory property

Occupied nest box on Los Alamos National Laboratory property

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Los Alamos National Laboratory 2015 Annual Site Environmental Report

Associate Directorate for Environment, Safety, and Health
505-667-4218

Environmental Protection and Compliance Division
505-667-2211

Environmental Stewardship Services Group
505-665-8855

Environmental Compliance Programs Group
505-667-0666

Waste Management Division
505-667-2001

Associate Directorate for Environmental Management
505-606-2337

Environmental Remediation Program
505-665-3388

Los Alamos NATIONAL LABORATORY EST. 1943

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).

We have made two significant changes to the annual site environmental report this year. First, we are following 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.

Second, we have changed the content of Chapter 3 of this report to describe the Laboratory's environmental programs. However, Chapter 3 still includes information about the Laboratory's environmental remediation activities, including monitoring results for Material Disposal Area C.

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 Environmental Communication and Public Involvement at 505-667-0216.

This report, its supplemental tables, and the 2015 Annual Site Environmental Report Summary are available at http://www.lanl.gov/environment/environmental-report.php.

Additional inquiries or comments regarding these annual reports may be directed to

National Nuclear Security Administration
Los Alamos Field Office
3747 West Jemez Road
Los Alamos, NM 87544
Telephone: 505-667-5491

or

Los Alamos National Laboratory
Environmental Protection and Compliance Division
P.O. Box 1663, MS K499
Los Alamos, NM 87545
Telephone: 505-667-2211

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Sam Loftin
Brad McKown
Mike McNaughton
Jennifer Payne
Sonja Salzman
Ben Sutter

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Jessica Gillis
Elizabeth Ruedig
Jeff Whicker

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, and as such, this report does the following:

Sandia wetland at the Laboratory

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

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 more than 70-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 compliant with DOE Order 436.1, Departmental Sustainability, to accomplish this. The Laboratory has been certified to the International Organization for Standardization 14001:2004 standard for the Environmental Management System since April 2006.

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).

2015 Environmental Performance Summary

Our environmental performance can be summarized as follows:

- The Laboratory operated under 13 different types of environmental permits and legal orders (Table 2-1 in Chapter 2).
- Eight different environmental inspections or audits were conducted by external regulators (Table 2-2 in Chapter 2).
- We conducted 1174 self-assessments to determine whether the Laboratory's management of hazardous and mixed wastes meets requirements.
- We continued to respond to our past violations of the Hazardous Waste Act and the Laboratory's Hazardous Waste Facility Permit related to treatment and storage of nitrate-salt-bearing wastes.
- The Laboratory was fully in compliance with its Clean Air Act, Title V Operating Permit emission limits.
- We discharged approximately 110 million gallons of liquid effluents from permitted outfalls and had 2 of 1099 samples exceed outfall permit effluent quality limits.
- We continued to implement storm water controls at solid waste management units and areas of concern under the Laboratory's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System.
- The New Mexico Environment Department granted certificates of completion for 38 remedial sites in 2015. Of these, 28 sites were certified complete without controls, meaning no additional corrective actions or conditions are necessary. Certificates for the remaining 10 sites were for corrective actions complete with controls, which require future site use to be restricted to industrial activities.
- No radionuclides or other chemicals from current or historical Laboratory operations were detected in the wells Los Alamos County uses for its current water supply.
- Five environmental occurrences were reported under DOE Order 232.2, Occurrence Reporting and Processing of Operations Information.

- Radiological doses to the public from Los Alamos National Laboratory operations were less than 1 millirem per year, and public health risks from radioactive and chemical releases were indistinguishable from zero.

2015 Environmental Monitoring

During 2015, we found the following:

- The highest off-site annual tritium activity at any environmental air-monitoring station was 0.3% of the U.S. Environmental Protection Agency public dose limit, which is 1500 picocuries per cubic meter.
- At the Area G waste site, the highest plutonium activity detected in air was 9 attocuries per cubic meter, which is lower than previous years, because minimal amounts of soil were moved at Area G during 2015.
- The only locations with measurable gamma and neutron radiation from Laboratory operations are near the Los Alamos Neutron Science Center and Technical Area 54, Area G. The highest public radiation dose at these locations resulting from direct radiation from Laboratory operations is calculated to be 0.1 millirem per year.
- During the 2001–2010 decade, the annual average temperature increased to above 49°F, which is statistically a significantly higher value than previous decades. The annual average temperatures from 2011 to 2015 continue to demonstrate a warmer climate for Los Alamos.
- Site-wide groundwater characterization and monitoring indicates that only two substances have notable areas of groundwater contamination at the Laboratory, RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) beneath Cañon de Valle in the Technical Area 16 area and chromium beneath Sandia and Mortandad Canyons.
- 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.
- All radionuclide and most chemical concentrations in soil, plants, and wildlife from on-site and perimeter locations were either not detected, similar to background, or below screening levels.
- The lead concentration in a soil sample collected northwest of Technical Area 21 was above the low-effect ecological screening level for two types of biota. Lead in the soil was associated with the demolition of the Technical Area 21 water tower, which contained lead paint. Cleanup of the site is scheduled for 2017.
- Biota dose assessments from radionuclide data show that there are no measurable effects from Laboratory-sourced radioactive materials to Pajarito Plateau plant and animal populations.

An additional summary of this report can be found in the Los Alamos National Laboratory 2015 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.

To Read About **Turn to Page**

Los Alamos National Laboratory (the Laboratory) is committed to act as a steward of the environment to achieve its mission in accordance with all applicable environmental requirements. The Laboratory sets continual improvement objectives and 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 REPORT 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 broadened and evolved as technologies, priorities, and the world community have changed. 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, it became Los Alamos Scientific Laboratory. The U.S. Department of Energy (DOE) took ownership in 1977, and it became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. The National Nuclear Security Administration, a semiautonomous agency within the DOE, has managed the operating and management contract for the Laboratory since 2000.

From 1943 through May 2006, the Laboratory was operated by the Regents of the University of California on behalf of the DOE. In June 2006, a new organization, Los Alamos National Security, LLC, was contracted to operate the Laboratory, replacing the University of California. In 2014, the DOE decided to separate cleanup of legacy wastes at the Laboratory from the management and operating contract. This change allowed the DOE's Office of Environmental Management to increase their oversight of cleanup activities. The legacy cleanup work was transitioned to a bridge contract under the Office of Environmental Management in October 2015. A new cleanup contract will be competitively awarded in the future. Currently, both the National Nuclear Security Administration and the Office of Environmental Management maintain field offices in Los Alamos.

Report 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.

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

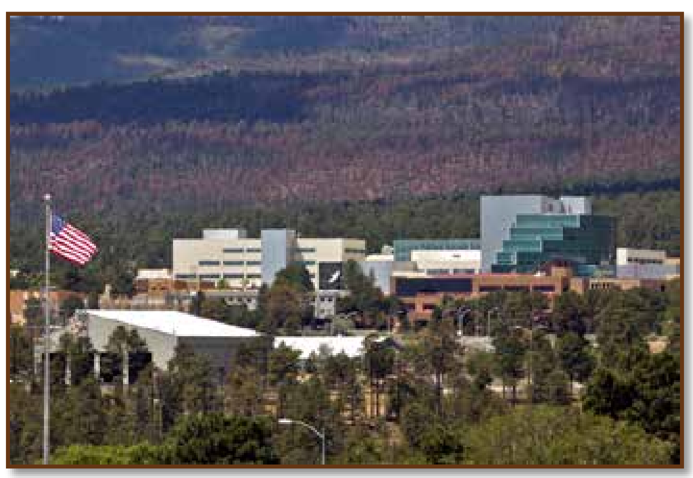
- characterize site environmental management performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials;
- summarize environmental occurrences and responses reported during the calendar year;
- confirm compliance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

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).

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 (direct distance, see Figure 1-1).



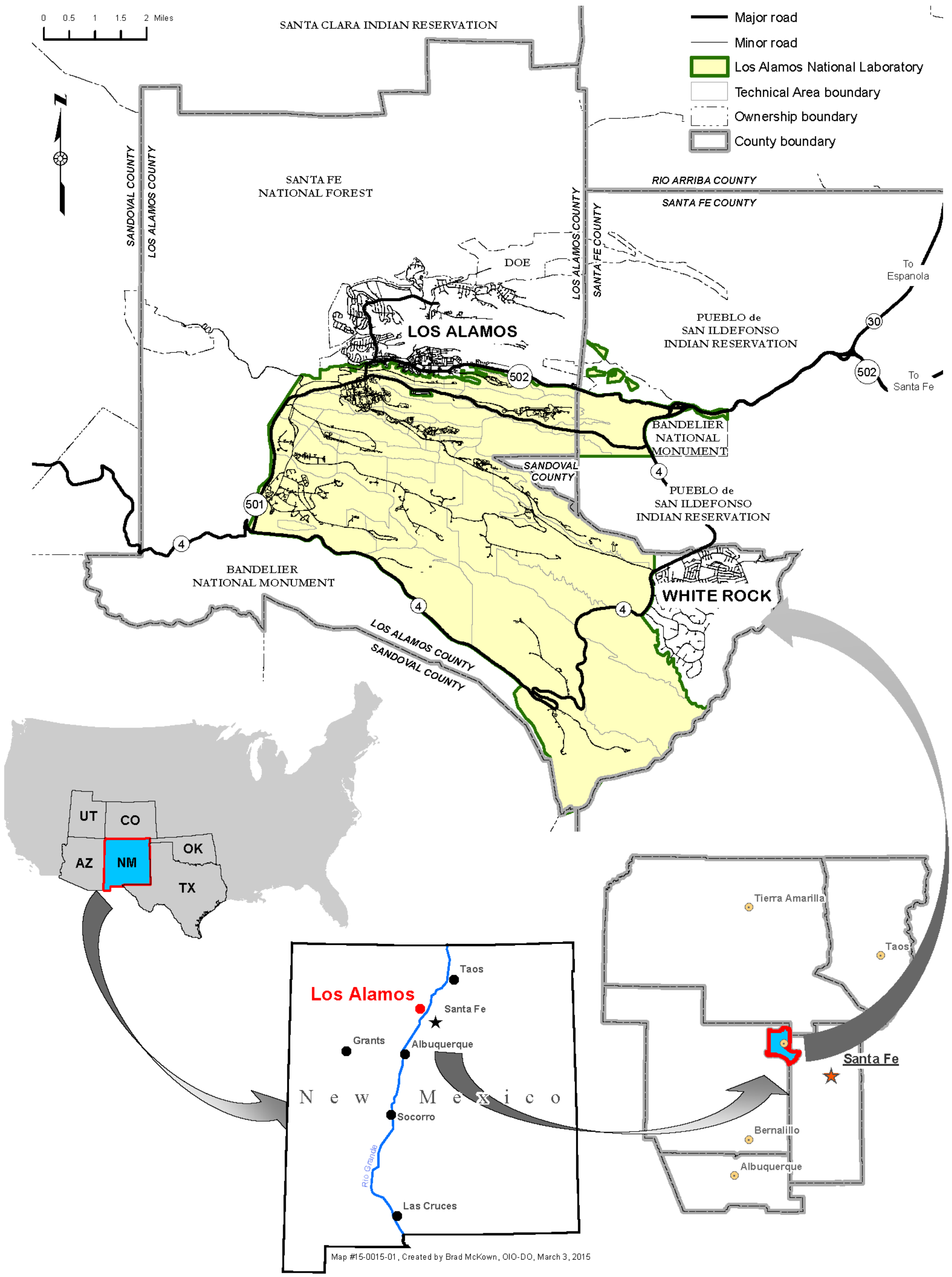


Figure 1-1 Regional location of the Laboratory

The 36-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep east-to-west-oriented canyons. 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.

The surrounding land 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 (Figure 1-2). 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.

Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. A local fault system, composed of a master fault and three subsidiary faults, constitutes the modern rift boundary in the Los Alamos area. Studies have investigated the seismic surface rupture hazard associated with these faults (LANL 2007). Most of the fingerlike mesas in the Los Alamos area are formed from Bandelier Tuff, which includes ash fall, pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains volcanic center 1.2 to 1.6 million years ago, the 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 onto the Tschicoma Formation, which consists of older volcanic deposits that form the Jemez Mountains. In the central Pajarito Plateau and near the Rio Grande, the Bandelier Tuff is underlain by the Puye Formation. The Cerros del Rio basalts interfinger with the Puye Formation along the river and extend beneath the Bandelier Tuff to the west. These formations overlie the sediments of the Santa Fe Group, which extend across the basin between the Laboratory and the Sangre de Cristo Mountains and are more than 3300 feet thick.

Surface water in the Los Alamos region occurs primarily as ephemeral or intermittent flow. Perennial springs on the flanks of the Jemez Mountains supply base flow into the upper reaches of some canyons, but the volume is insufficient to maintain surface flow across the Laboratory property before the water is lost to evaporation, transpiration, and infiltration.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) intermediate perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the regional aquifer, which is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer is under artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande and under phreatic conditions beneath most of the Pajarito Plateau (Purtymun and Johansen 1974). The source of most recharge to the regional aquifer appears to be infiltration of precipitation that falls on the Jemez Mountains. A secondary source is localized infiltration in canyons on the Pajarito Plateau (Birdsell et al. 2005). The upper portion of the regional aquifer beneath the Laboratory discharges into the Rio Grande through springs in White Rock Canyon.

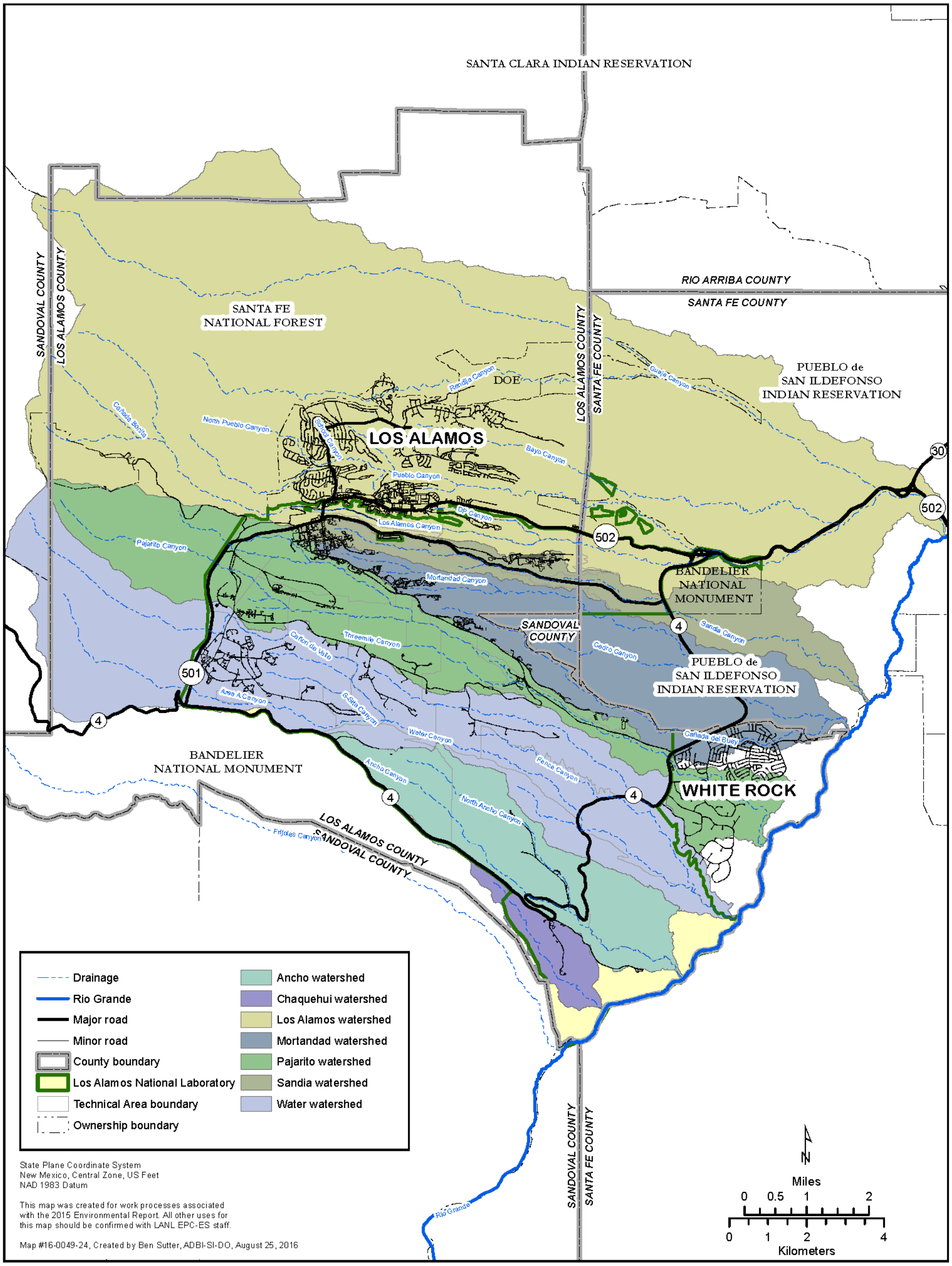


Figure 1-2 Land ownership and primary watersheds around the Laboratory

Biological Resources

The Pajarito Plateau, including the Los Alamos area, is biologically diverse. This diversity of ecosystems is partly because of the dramatic 5000-foot elevation change from the Rio Grande on the east of the plateau up to the Jemez Mountains 12 miles to the west, and partly because of the many steep canyons that dissect the area. Five major vegetative cover types are found in Los Alamos County. The juniper (*Juniperus monosperma*) savanna community is found along the Rio Grande on the eastern border of the plateau and extends upward on the south-facing sides of canyons at elevations between 5600 and 6200 feet. The piñon- (*Pinus edulis*-) juniper cover type, generally between 6200 to 6900 feet in elevation, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine (*Pinus ponderosa*) communities are found in the western portion of the plateau between 6900 and 7500 feet in elevation. These three vegetation types each occupy roughly one-third of the Laboratory site. The mixed-conifer cover type, at an elevation of 7500 to 9500 feet, overlaps the ponderosa pine community in the deeper canyons and on north-facing slopes and extends from the higher mesas onto the slopes of the Jemez Mountains. The spruce- (*Picea* spp.-) fir (*Abies* spp.) cover type is at higher elevations of 9500 to 10,500 feet. Several wetlands and riparian areas enrich the diversity of plants and animals found on the plateau.

The frequent drought conditions prevalent throughout New Mexico and Los Alamos since 1996 have resulted in the mortality of many trees. Between 2002 and 2005, more than 90% 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). Lower elevation ponderosa pine and mixed-conifer stands were also affected. More recently, large numbers of mature ponderosa pine are apparently dying of prolonged drought stress, a process 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. Following both fires, high-priority areas in the canyons were armored to protect against potential flood damage. To protect the site from future wildfire, the Laboratory operates a program to reduce wildfire fuels throughout forested areas on Laboratory and DOE property. Defensible space has been created and is maintained around facilities and other high-priority areas. Areas not designated as defensible space are managed for a combination of wildfire fuel reduction and forest health. The major roads within the facility continue to be thinned along the road easements to the fence line to provide firebreaks and protect evacuation routes.

Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 90% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1800 sites have been recorded. Nearly 73% of the sites are Ancestral Puebloan and date from the 13th, 14th, and 15th centuries. Buildings and structures from the Manhattan Project and the early Cold War period (1943–1963) are being evaluated for eligibility for listing in the National Register of Historic Places, and 164 of the more than 300 buildings that were evaluated in 2014 have been declared eligible. In addition, facilities considered to have national historic significance, dating from 1963 to the end of the Cold War in 1990, are being evaluated. Legislation creating the National Park Service Manhattan Project National Historical Park was signed by President Obama on December 19, 2014. The Los Alamos park properties listed in the legislation include historic buildings in downtown Los Alamos and 17 Laboratory properties located in eight technical areas.

Climate

Los Alamos County has a temperate, semiarid mountain climate. Large differences in locally observed temperature and precipitation exist because of the 1000-foot elevation change across the Laboratory site 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 (with a range of 23°F). 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 valley act as a barrier to wintertime arctic air masses that descend into the central United States, making the occurrence of local subzero temperatures rare. On average, summer temperatures range from 70°F to 88°F during the daytime and from 50°F to 59°F during the nighttime.

From 1981 to 2010, the average annual precipitation (which includes both rain and the water equivalent of frozen precipitation) was 18.97 inches, and the average annual snowfall amount was 58.7 inches. The months of July and August account for 34% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the Pacific Ocean and the Gulf of Mexico is convectively and/or orographically lifted by the Jemez Mountains. The 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. Lightning is most commonly observed between May and September (about 97% of the local lightning activity).

The complex topography of the Pajarito Plateau influences local wind patterns. Often a distinct diurnal cycle of winds occurs. Daytime winds measured in the Los Alamos area are predominately from the south, consistent with the typical flow of heated daytime air moving up the Rio Grande valley. Nighttime winds (sunset to sunrise) on the Pajarito Plateau are lighter and more variable than daytime winds and are typically from the west, resulting from a combination of prevailing winds from the west and downslope flow of cooled mountain air. Winds atop Pajarito Mountain are more representative of upper-level flows and primarily range from the northwest to the southwest.

The climatology of Los Alamos County is summarized in Chapter 4, Air Quality.

LABORATORY ACTIVITIES AND FACILITIES

The Laboratory is organized into technical areas used for 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 only a small part of the total land area; much of the Laboratory land provides buffer areas for security and safety or is held in reserve for future use. The Laboratory has about 976 structures, with approximately 8.2 million square feet under roof, spread over an area of approximately 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 are identified as “Key Facilities” to facilitate a logical and comprehensive evaluation of the potential environmental impacts of Laboratory operations (Table 1-1). Operations in the Key Facilities represent the majority of environmental impacts associated with Laboratory operations.

Table 1-1
Key Facilities

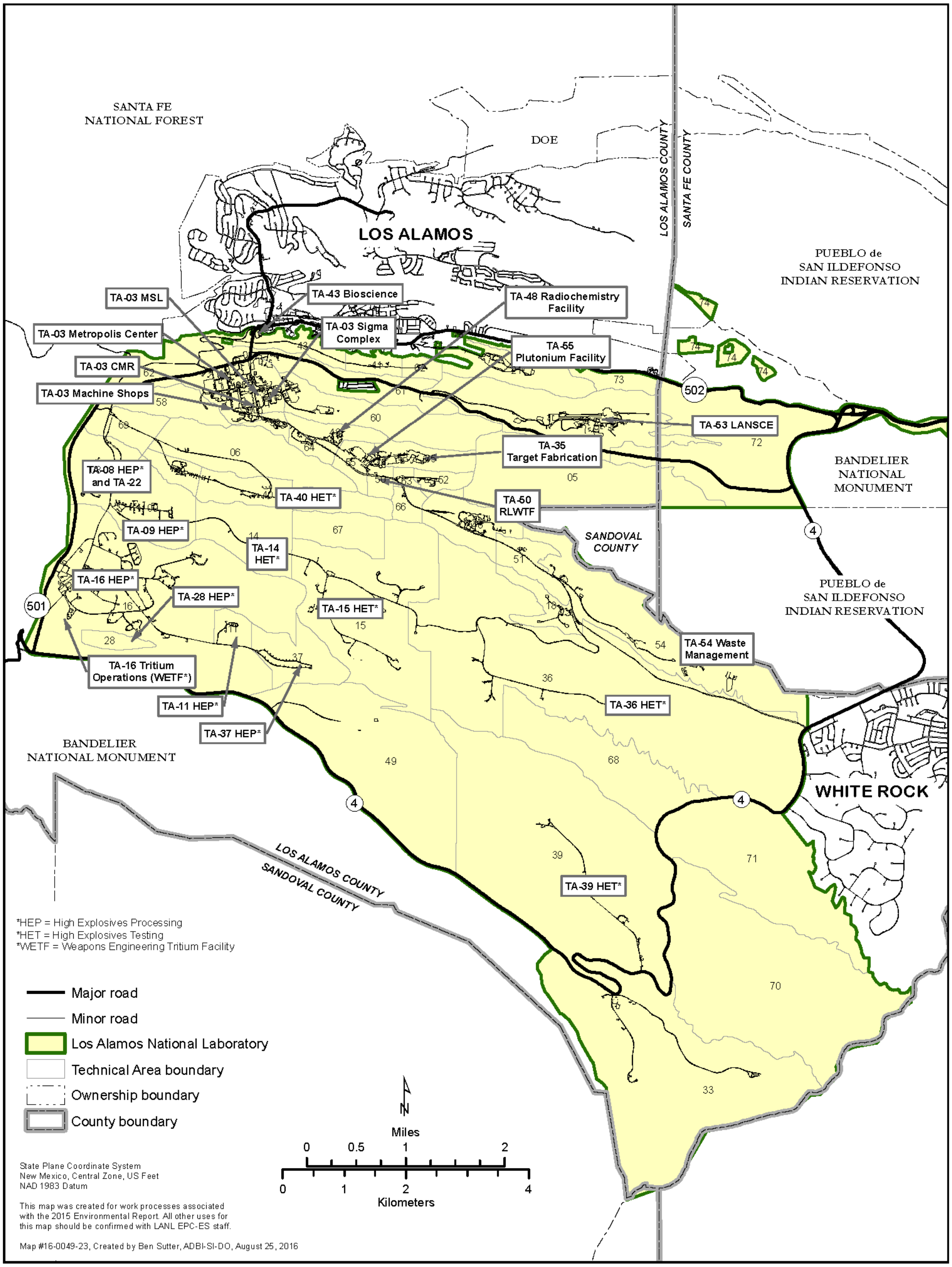
Facility	Technical Area(s)
Plutonium complex	55
Tritium facilities	16
Chemistry and Metallurgy Research (CMR) building	03
Sigma Complex	03
Materials Science Laboratory (MSL)	03
Target Fabrication Facility	35
Machine shops	03
Nicholas C. Metropolis Center for Modeling and Simulation	03
High-explosives processing	08, 09, 11, 16, 22, 37
High-explosives testing	14, 15, 36, 39, 40
Los Alamos Neutron Science Center (LANSCE)	53
Biosciences Facilities (formerly Health Research Laboratory)	43, 03, 1635, 46
Radiochemistry Facility	48
Radioactive Liquid Waste Treatment Facility (RLWTF)	50
Solid radioactive and chemical waste facilities	50, 54

Note: Data from 2008 site-wide environmental impact statement.

The facilities identified as key are those that house activities critical to meeting work assignments given to the Laboratory. These facilities also

- house operations that could potentially cause significant environmental impacts,
- are of most interest or concern to the public based on scoping comments received, or
- are the facilities most subject to change as a result of programmatic decisions.

In the 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 and employ about 74% of the total Laboratory workforce (LANL 2010). The Non-Key Facilities include such important buildings and operations as 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

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2.0 Compliance Summary

To Read About **Turn to Page**

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

Federal and state 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 environmental impact analyses of new operations. Based on these laws, Los Alamos National Laboratory (LANL or the Laboratory) operations must comply with permits, legal orders, and/or standards. The U.S. Environmental Protection Agency or the New Mexico Environment Department administers most of these laws. In addition, U.S. Department of Energy (DOE) orders have requirements for environmental protection and control of radionuclides at DOE facilities. This chapter provides a summary of our compliance with state and federal environmental regulations and permits and DOE environmental orders.

Table 2-1 presents the environmental permits and legal orders the Laboratory operated under in 2015. Table 2-2 lists the environmental inspections conducted by regulating agencies at the Laboratory during 2015. The following sections summarize our compliance performance during 2015.

Table 2-1
Environmental Permits and Legal Orders under which the Laboratory Operated during 2015

Name	Activity	Issue Date	Expiration Date	Administering Agency
Los Alamos National Laboratory Hazardous Waste Facility Permit	A permit regulating hazardous wastes at the Laboratory, including storage and treatment of the wastes. The permit also has standards for closure of indoor and outdoor areas used for hazardous waste storage or disposal. (https://www.env.nm.gov/HWB/Permit.htm)	Renewed November 2010	December 2020	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	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. (https://www.env.nm.gov/HWB/documents/LANL_10-29-2012_Consent_Order_-_MODIFIED_10-29-2012.pdf)	March 1, 2005 Revised October 29, 2012	None	New Mexico Environment Department
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)	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)	August 1, 2007 Modified May 1, 2015	September 30, 2019	U.S. Environmental Protection Agency

Table 2-1 (continued)

Name	Activity	Issue Date	Expiration Date	Administering 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. (http://int.lanl.gov/environment/_assets/docs/P100-R2-Title-V-Operating-Permit.pdf).	August 7, 2009 (initial) February 27, 2015 (current)	February 27, 2020	New Mexico Environment Department
New Mexico Air Quality Control Act Construction Permits	Permits regulating construction or modification of air emissions sources, including the following:			
	Technical Area 03 power plant (2195-B) Permit modification 2	September 27, 2000 (initial) November 1, 2011 (current)	None	New Mexico Environment Department
	1600-kilowatt generator at Technical Area 33 (2195-F) Permit revision 4	October 10, 2002 (initial) December 12, 2013 (current)	None None	New Mexico Environment Department
	Two 20-kilowatt generators and one 225-kilowatt generator at Technical Area 33 (2195-P)	August 8, 2007	None	New Mexico Environment Department
	Asphalt plant at Technical Area 60 (2195-G) Permit revision 1	October 29, 2002 (initial) September 12, 2006 (current)	None None	New Mexico Environment Department
	Data disintegrator (2195-H)	October 22, 2003	None	New Mexico Environment Department
	Chemistry and Metallurgy Research Replacement facility, Radiological Laboratory/Utility/Office Building (2195-N) Permit revision 2	September 16, 2005 (initial) September 25, 2012 (current)	None	New Mexico Environment Department

Table 2-1 (continued)

Name	Activity	Issue Date	Expiration Date	Administering Agency
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 following projects were authorized to operate under a Section 404 nationwide permit with Section 401 certification in 2015. · Water Canyon Storm Water Controls · Sandia Canyon – Technical Area 72 Firing Site Storm Water Controls · E250 Stream Gage Weir Erosion Repair in Pajarito Canyon · Pueblo Grade-Control Spurs and E060.1 Gage Revitalization · Pueblo Canyon Stabilization Project · Cañon de Valle – CDV-SMA-1.7 · Sandia Canyon Fiber Optics Installation · Threemile Canyon – 3M-SMA-4 · Sandia Canyon Wetland grade-control structure	March 19, 2012 (all current nationwide Section 404 permits)	March 18, 2017 (all current nationwide Section 404 permits)	U.S. Army Corps of Engineers and New Mexico Environment Department
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, notice of intent to discharge notifications, preparation of storm water pollution prevention plans, and other conditions. (http://www.epa.gov/sites/production/files/2015-10/documents/cgp2012_finalpermitpart1-9.pdf)	February 16, 2012	February 16, 2017	U.S. Environmental Protection Agency

Table 2-1 (continued)

Name	Activity	Issue Date	Expiration Date	Administering Agency
National Pollutant Discharge Elimination System Multi-Sector General Permit for Stormwater 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 runoff. The permit provides specific conditions for the authorization, including water quality requirements, 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)	September 29, 2008 Modified June 4, 2015	June 4, 2020	U.S. Environmental Protection 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)	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 the Laboratory's sanitary wastewater system plant effluents to be discharged to groundwater	July 20, 1992 Renewed January 7, 1998 Renewal application submitted July 2, 2010 Supplemental information submitted December 20, 2012 Working Draft Permit issued by the New Mexico Environment Department on January 12, 2016	January 7, 2003, but administratively continued through 2015	New Mexico Environment Department
Groundwater Discharge Permit DP-1793	A permit authorizing the land application of treated groundwater	July 27, 2015	July 27, 2020	New Mexico Environment Department

Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2015

Date	Purpose	Performing Entity
06/06/15–06/17/15	Resource Conservation and Recovery Act compliance inspection	New Mexico Environment Department
05/11/15–05/12/15	Clean Air Act, Title V Operating Permit compliance inspection	New Mexico Environment Department
02/25/15, 04/29/15, 05/22/15, 08/01/15, 08/15/15	Petroleum storage tanks inspection	New Mexico Environment Department
08/26/15	Compliance evaluation inspection for the National Pollutant Discharge Elimination System Permit No. NM0028355 (industrial and sanitary point-source outfalls)	New Mexico Environment Department Surface Water Quality Bureau for U.S. Environmental Protection Agency Region 6
09/09/15	Compliance inspection of Technical Area 72 Firing Site Storm Water Controls and Pueblo Wetland Stabilization Project to determine compliance with Clean Water Act Section 404 permit and state water quality standards	U.S. Army Corps of Engineers and New Mexico Environment Department
09/15/15	Inspection of LANL septic tank disposal systems	New Mexico Environment Department
10/27/15	Inspection of chromium project land application sites in Mortandad Canyon	New Mexico Environment Department

MANAGEMENT OF HAZARDOUS AND MIXED WASTES

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act regulates hazardous wastes from generation to disposal. Under the law, hazardous wastes include all solid wastes that are either (1) listed as hazardous by the U.S. Environmental Protection Agency; (2) ignitable, corrosive, reactive, or toxic; (3) batteries, pesticides, lamp bulbs, or contain mercury; 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 for waste storage and treatment and was renewed in 2010. The Laboratory does not dispose of hazardous or mixed waste on-site.

The Laboratory's Hazardous Waste Facility Permit currently covers 24 hazardous waste management units (1 storage tank system, 1 stabilization unit, and 22 container storage units). The permit includes operating requirements as well as reporting and notification requirements to the New Mexico Environment Department's Hazardous Waste Bureau and the public. Nine interim status units are being managed under the Resource Conservation and Recovery Act. These include two open-detonation units, one open-burn unit, and six additional interim status units that are in the process of being closed.

Permit Modifications, Reports, and Other Activities

In 2015, we submitted seven Class 1 permit modification packages for the Laboratory's Hazardous Waste Facility Permit. The permit modifications can be summarized as follows. Three modifications included revised figures not associated with hazardous waste management and changes to text associated with the figure changes. Two modifications included updates to the contingency plan and the inspection plan of the permit. One permit modification added two temperature control units within Dome 375 on Pad 11 at Technical Area 54, Area G. Additionally, the administrative closure of TA-55-185, a unit that had never been used for hazardous waste, was approved, and the unit was removed from the permit. Notices of these modifications were mailed to members of the public on the Laboratory's facility mailing list maintained by the New Mexico Environment Department.

As required by the Laboratory's Hazardous Waste Facility Permit, one annual and four quarterly demolition activity notifications were submitted to the New Mexico Environment Department in 2015. In August 2015, we published the community relations plan on the Laboratory's environmental web page after comments from the public were incorporated, and in October 2015, the annual training session was conducted for the public on the use of the electronic public reading room. Other reporting requirements associated with the permit included the submittal of a waste minimization report in November 2015 (LANL 2015a) and a summary of instances of noncompliances and releases in December 2015 (LANL 2015b).

Inspections, Noncompliances, and Notices of Violation

Self-assessments are conducted at the Laboratory to determine whether management of hazardous and mixed wastes meets the requirements of federal and state regulations, DOE orders, and Laboratory policy. The findings from these self-assessments are provided to waste generators, waste-management coordinators, and waste managers. Between January and December 2015, we completed 1174 self-assessments.

From June 6 to 17, 2015, the New Mexico Environment Department conducted a hazardous waste compliance inspection at the Laboratory. A notice of violation for this inspection was issued on June 1, 2016. The notice of violation for the 2014 inspection was issued in March 2015 and was resolved in July 2015.

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. During 2015, the Laboratory and the New Mexico Environment Department conducted negotiations associated with this order. An approved final order was signed in January 2016.

As mentioned above, we submitted the annual report of instances of noncompliances and releases to the New Mexico Environment Department in December 2015 (LANL 2015b). The report summarizes only noncompliances with permit conditions and releases at or from a hazardous waste management unit that do not pose a threat to human health or the environment. The data are reported here by fiscal year to coincide with the Laboratory's Hazardous Waste Facility Permit reporting requirements.

From October 1, 2014, through September 30, 2015, there were no releases of hazardous waste or hazardous waste constituents at or from a permitted unit. The report detailed 421 instances of noncompliance. The majority of the occurrences of noncompliance were associated with inconsistencies in the operating record and container labeling issues. Other instances included missed notifications and correction of permit required records. Additional instances of noncompliance for the time frame, and from past activities at the facility, were previously reported in communications dated October 21, 2014 (LANL 2014); May 6, 2015 (LANL 2015c); and August 31, 2015 (LANL 2015d). These self-disclosures of noncompliance were identified as part of a site-wide assessment to discover and resolve compliance issues at permitted hazardous waste management units. None of these noncompliances resulted in any hazards to the environment or human health, and no material was lost or had to be recovered.

LANL's Nitrate-Salt-Bearing Waste Container Isolation Plan

The New Mexico Environment Department issued an Administrative Order (5-19001), dated May 19, 2014, which required the development and implementation of an isolation plan for hazardous nitrate-salt-bearing waste in storage at the Laboratory. The order also mandates regular, updated communication on the status of containers within isolation.

In 2015, the Administrative Order was revised three times: April 27, 2015; May 8, 2015; and August 12, 2015. These revisions approved the removal of unremediated nitrate-salt wastes from isolated storage, added four newly identified containers to isolated storage, and changed the frequency of technical phone calls and written update submittals from daily, to weekly, to monthly. During 2015, there were approximately 20 submittals to the New Mexico Environment Department that included information that was either requested by the New Mexico Environment Department or required by the isolation plan. There were also 108 technical update submittals provided to the New Mexico Environment Department as required by the Administrative Order and the LANL Nitrate Salt-Bearing Waste Container Isolation Plan.

The Compliance Order on Consent

The Compliance Order on Consent provides requirements for corrective actions at the Laboratory's solid waste management units and areas of concern. Examples of solid waste management units include certain septic tanks, firing sites, landfills, sumps, and areas receiving liquid effluents from outfalls. Areas of concern are not solid waste management units but are areas that may warrant investigation because of the possible migration or release of a hazardous waste or hazardous constituent. Examples include canyon bottoms downstream from historical outfalls.

The Compliance Order on Consent was issued in 2005. It directs the Laboratory to (1) define the nature and extent of chemicals released from solid waste management units and areas of concern at the Laboratory; (2) identify and evaluate, where needed, alternatives to remediate released chemicals in the environment and prevent or mitigate the migration of those chemicals; and (3) implement corrective measures selected by the New Mexico Environment Department. The Compliance Order on Consent supersedes the corrective action requirements previously specified in the Laboratory's Hazardous Waste Facility Permit. The Compliance Order on Consent does not apply to radionuclides, which are regulated by DOE under the Atomic Energy Act, and also does not apply to those solid waste management units and areas of concern that previously received "no further action" decisions from the U.S. Environmental Protection Agency.

In 2015, the Laboratory had 964 solid waste management units and 430 areas of concern listed in its Hazardous Waste Facility Permit. Of these, 155 required no further action by the Laboratory, and 240 had certificates of completion issued under the Compliance Order on Consent. The remaining solid waste management units and areas of concern had investigations and/or corrective actions either in progress or pending or had been deferred until the sites are no longer active. We submitted 5 reports and completed 2 site investigations or remediations under the Compliance Order on Consent in 2015 (see Table 3-2 in Chapter 3 of this report).

The solid waste management units and areas of concern have been grouped by geographic location into aggregate areas. Figure 2-1 shows each aggregate area boundary as defined in the Compliance Order on Consent. The figure indicates the status of Laboratory investigations and corrective actions for solid waste management units and areas of concern in these aggregate areas as (1) complete, (2) in progress, or (3) pending. For those aggregate areas presented as complete, all investigation activities have been completed, and no additional field sampling campaigns, investigation reports, or corrective measure activities are anticipated. Aggregate areas listed as in progress include sites or areas where field sampling campaigns or corrective measure activities are currently being conducted, investigation reports are being prepared or finalized, or where investigation work plans have been approved but not yet implemented. Aggregate areas listed as pending include sites or areas where work plan preparation has not yet started.

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

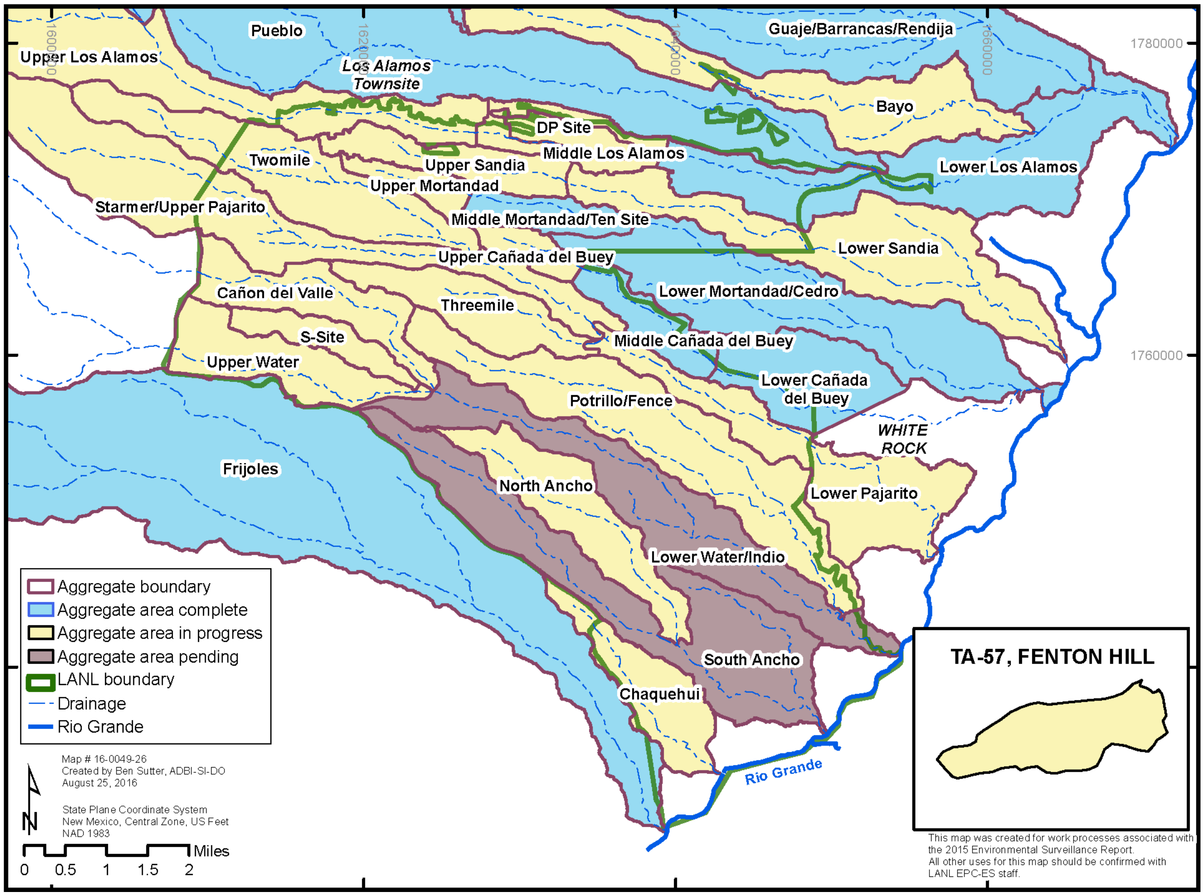


Figure 2-1 Aggregate areas as defined for the Compliance Order on Consent and their status. Status is shown as aggregrate area activities complete, activities in progress, or activities pending.

Federal Facility Compliance Order for Mixed Wastes

In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the Laboratory requiring development and implementation of a site treatment plan for mixed radioactive and hazardous wastes (mixed waste). The site treatment plan documents the use of off-site facilities for treating and disposing of mixed waste that has been stored at the Laboratory for more than 1 year. Waste data are reported here on a fiscal year basis to coincide with regulatory reporting requirements. In fiscal year 2015, Laboratory shipments of mixed low-level waste (waste containing both hazardous waste and low-level radioactive waste) and mixed transuranic waste (waste containing both hazardous waste and radioactive elements heavier than uranium) were on hold while we addressed safety basis concerns. All shipments of mixed transuranic waste to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, were suspended in May 2014 because of the plant's shutdown. The New Mexico Environment Department has determined that the removal of mixed transuranic waste from the Laboratory's site treatment plan will be deferred until more information becomes available and it is determined that the waste currently stored above grade at the off-site facilities will not be returned to the Laboratory.

Solid Nonhazardous Waste Disposal

We send sanitary solid waste, construction debris, and demolition debris to the Los Alamos County Eco Station for transfer to municipal landfills. Los Alamos County operates this transfer station and is responsible for obtaining all related permits for this activity from the state. Laboratory solid nonhazardous waste sent to the transfer station in 2015 totaled 2930 cubic meters, or 1,931,490 kilograms.

RADIATION PROTECTION AND MANAGEMENT OF RADIOLOGICAL WASTES

DOE Order 458.1, Radiation Protection of the Public and the Environment

DOE Order 458.1 establishes requirements for DOE facilities to protect the public and the environment from undue risk from radiological releases. The order requires DOE facilities to ensure the radiological dose to the public from their activities does not exceed 100 millirem in any given year. It also provides dose limits for wildlife and plants. The order requires DOE facilities to keep radiological doses to the public and the environment as low as reasonably achievable and to monitor for routine and nonroutine releases of radioactive materials. Property released from the facility (for example, surplus property, off-site waste for disposal, or transferred land parcels) cannot exceed dose limits of 25 millirem per year above background for real estate or 1 millirem per year above background for moveable items.

During 2015, the estimated maximum radiological dose to a member of the public from Laboratory operations was less than 1 millirem. Details of the Laboratory's annual radiological dose estimates for the public are presented in Chapter 8, and estimates for wildlife and plants are presented in Chapter 7.

DOE Order 435.1, Radioactive Waste Management

Laboratory operations generate four types of wastes containing radioactive materials: low-level radiological waste (low-level waste), mixed low-level waste, transuranic waste, and mixed transuranic waste. The Laboratory disposes of some low-level waste on-site; all other radiological and mixed wastes are shipped off-site for disposal. All aspects of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1 Chg 1 and DOE Manual 435.1-1. We had no DOE Order 435.1 Chg 1 compliance violations in 2015.

All Laboratory operations that generate, store, treat, or dispose of radioactive waste must have a radioactive waste management basis document approved by DOE's Los Alamos Field Office. The document describes the process and requirements for managing radioactive wastes at the facility or operation and identifies the physical and administrative controls that ensure protection of workers, the public, and the environment. Generated radioactive waste must (1) meet the acceptance requirements for its disposal facility, (2) meet Laboratory on-site storage requirements, and (3) meet requirements for transportation. Currently, the Los Alamos Field Office is reviewing four radioactive waste management basis documents from the Laboratory's Associate Directorate for Environmental Management.

Low-Level Radioactive Waste Disposal

The Laboratory disposes of some low-level waste at the Nevada National Security Site and at several commercial sites, including EnergySolutions, located in Clive, Utah, and the Waste Control Specialists site in Andrews, Texas. Disposal of minimal amounts of low-level waste on-site at Area G is being considered on a case-by-case basis. DOE Order 435.1 Chg 1 requires the Laboratory to have an approved operational closure plan and performance assessment/composite analysis. The Technical Area 54 Area G performance assessment/composite analysis analyzes the probability that the potential doses to representative future members of the public and potential releases from the facility will not exceed performance objectives during a 1000-year period after closure. Operations at Area G have been on hold, and direct off-site disposal has been conducted at other technical areas at the Laboratory.

During 2015, we disposed of a total of 1,767,836 kilograms of low-level waste (Figure 2-2). No low-level waste was placed in the Area G shafts in 2015. The Laboratory continues to implement the strategy of shifting to off-site low-level waste disposal where feasible and cost-effective but continues to store some low-level waste at Area G.

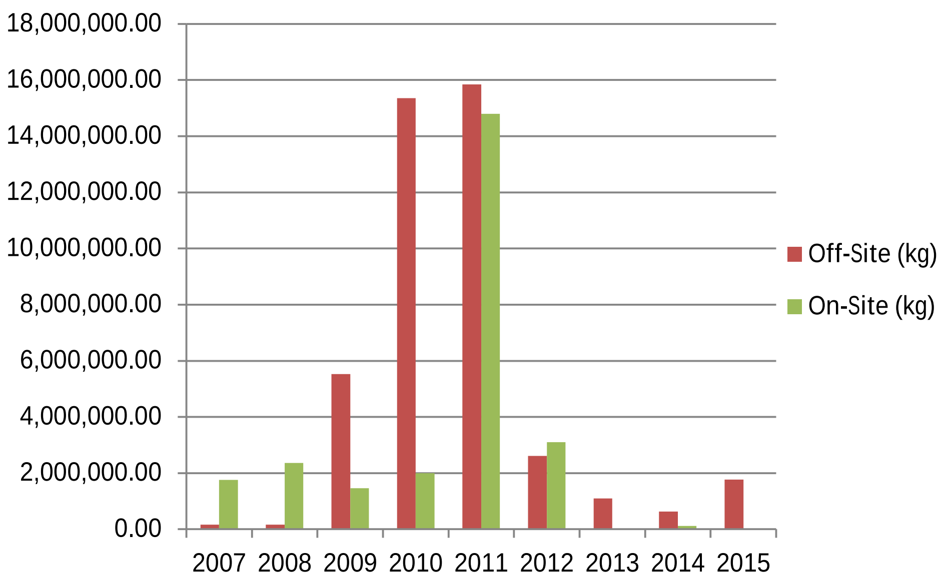


Figure 2-2 LANL low-level waste disposal

Transuranic Waste Disposal

The Laboratory's Waste Disposition Division manages disposal of stored and newly generated transuranic waste. The division is also responsible for ensuring that appropriate facilities and equipment are available to prepare legacy and current transuranic waste for disposal at the Waste Isolation Pilot Plant.

In February 2014, there was a radiological release at the Waste Isolation Pilot Plant that resulted from an exothermic reaction in a drum containing LANL transuranic wastes. As an outcome of investigations into this event, the Accident Investigation Board and a subsequent Los Alamos National Security, LLC, corrective action plan identified a total of

58 corrective actions. The following reports about the investigation results and recommendations are available at http://www.energy.gov/em/waste-isolation-pilot-plant-wipp-recovery.

- "Accident Investigation Report, Phase 1, Radiological Release Event at the Waste Isolation Pilot Plant on February 14, 2014," U.S. Department of Energy Office of Environmental Management (April 2014).
- "Accident Investigation Report, Phase 2, Radiological Release Event at the Waste Isolation Pilot Plant, February 14, 2014," U.S. Department of Energy Office of Environmental Management (April 2015).
- "Los Alamos National Security, LLC, Corrective Action Plan, Phase 2, Radiological Release Event at the Waste Isolation Pilot Plant," Los Alamos National Laboratory document DIR-15-142 (October 2015).

Figure 2-3 presents the cumulative inventory of transuranic wastes that have been shipped from Los Alamos. The waste inventory is reported here on a fiscal year basis to coincide with other transuranic waste reporting. No transuranic waste was shipped from the Laboratory during 2015 because all shipments of transuranic waste were put on hold in May 2014 after issues with the Laboratory's transuranic nitrate-salt-bearing waste were identified. Since that time, the focus of activities has been on actions necessary for safe storage, and ultimately treatment, of the nitrate-salt-bearing waste that remains at the Laboratory and on corrective actions to prevent recurrence of such issues in the future.

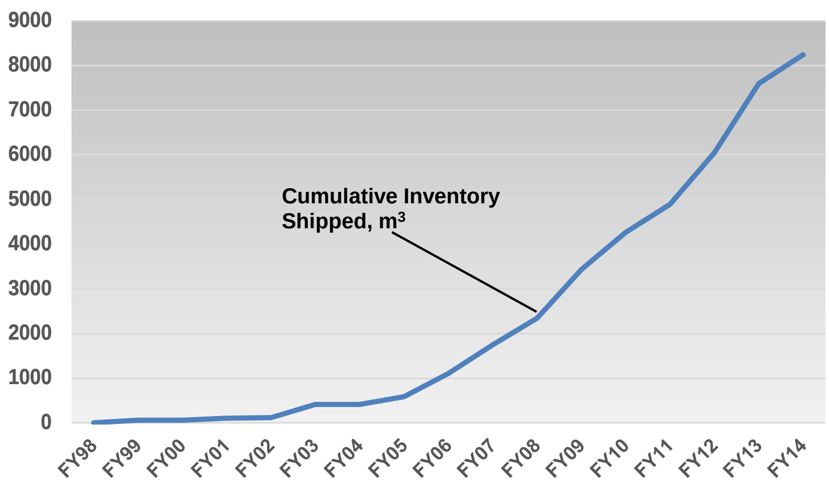


Figure 2-3 LANL transuranic waste shipping profile

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 these and other regulated pollutants below permit limits. On February 27, 2015, we received a renewal of our Title V Operating Permit (P100-R2). This permit is valid through February 27, 2020.

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 term is not met. In 2015, we had one Title V Operating Permit deviation. The deviation was associated with the requirement to only operate the combustion turbine within an 80% to 100% load. The combustion turbine operated at less than an 80% load for three days in December 2015. The operating load varied from 75% to 80% on these days. No excess emissions above permit limits occurred, and operating procedures and operator training were reviewed and updated with an emphasis on this requirement.

In 2015, the Technical Area 03 power plant as well as boilers and generators located across the Laboratory emitted nitrous oxides, carbon monoxide, and particulate matter. The Laboratory's highest levels of emissions in 2015 were significantly lower than the permit limits; for example, nitrogen oxide emissions were approximately 17% of the permit limit, carbon monoxide emissions were 13% of the permit limits, and particulate matter emissions were 3% of the permit limits. No emissions in excess of permit limits occurred from any of the permitted sources.

Table 2-3 summarizes the Laboratory's emissions data.

Table 2-3
Calculated Emissions of Regulated Air Pollutants Reported to the New Mexico Environment Department in 2015

Emission Unit	Pollutants (tons)[a]					
	NOx	SOx	PM	CO	VOCs	HAPs
Asphalt plant	0.003	0.001	0.002	0.10	0.002	0.002
Technical Area 03 power plant (3 boilers)	10.9	0.11	1.43	7.5	1.0	0.36
Technical Area 03 power plant (combustion turbine)	1.25	0.09	0.17	0.26	0.06	0.03
Research and development chemical use	n/a[b]	n/a	n/a	n/a	9.1	4.4
Degreaser	n/a	n/a	n/a	n/a	0.006	0.006
Data disintegrator	n/a	n/a	0.06	n/a	n/a	n/a
Stationary standby generators[c]	4.71	0.20	0.24	1.20	0.24	0.003
Miscellaneous small boilers[c]	20.75	0.13	1.67	16.62	1.19	0.40
Permitted generators (7 units)	1.48	0.10	0.10	0.88	0.12	<0.001
Permitted boilers	3.00	0.02	0.32	1.72	0.21	0.06
TOTAL	**42.1**	**0.65**	**4.0**	**28.3**	**11.93**	**5.26**
Title V Permit Limits	**245**	**150**	**120**	**225**	**200**	**24**

[a] NOx = nitrous oxides; SOx = sulfur oxides; PM = particulate matter; CO= carbon monoxide; VOCs = volatile organic compounds; HAPs = other hazardous air pollutants.

[b] n/a = Not applicable.

[c] Emission units in these categories are exempt from construction permitting and annual emission inventory reporting requirements and are not included in Figure 2-4.

Figure 2-4 depicts a 5-year history of pollutant emissions. Emissions from 2011 through 2015 are very similar and remain relatively constant.

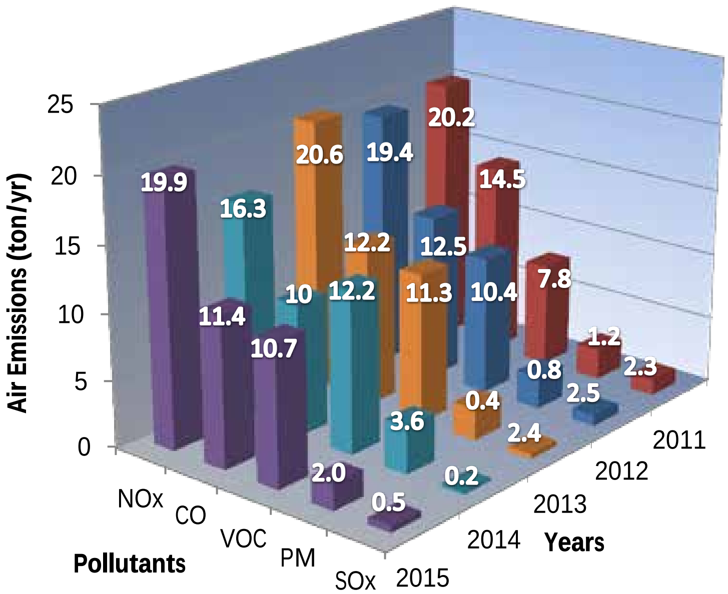


Figure 2-4 Laboratory criteria pollutant emissions from 2011 through 2015 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.

Management of Ozone-Depleting Substances under Title VI

Title VI of the Clean Air Act regulates ozone-depleting substances such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting or otherwise releasing any refrigerant or refrigerant substitute during maintenance, repair, service, or disposal of halon fire-suppression systems and air-conditioning or refrigeration equipment. All technicians who work on refrigerant systems must be certified by the U.S. Environmental Protection Agency and must use certified recovery equipment. The Laboratory is required to maintain records of all work involving refrigerants, including their purchase, use, and disposal. We continue to eliminate Class I and Class II ozone-depleting substances. In 2015, the Laboratory removed approximately 718 kilograms of Class II ozone-depleting substances.

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 2015 via air emissions was 0.13 millirem, 1.3% of the limit (see Chapter 8, Radiological Dose Assessment for the Public section).

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 to identify air quality compliance requirements. We submitted two exemption notifications during 2015: one for a research project studying the Waste Isolation Pilot Plant drum breach and one for 10 small gas-fired comfort heaters and boilers. We did not submit any “no permit required” determination requests in 2015.

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. It also requires that facilities conducting activities involving asbestos mitigate visible airborne emissions and properly package and dispose of all asbestos-containing wastes.

We continued to perform renovation and demolition projects in accordance with the requirements for asbestos management and disposal. In 2015, 38 large renovation and demolition projects were completed. The New Mexico Environment Department was provided advance notice for each of these projects. All waste was properly packaged and disposed of at approved landfills. The Laboratory conducted internal inspections of job sites and asbestos packaging approximately once a month.

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 establishes requirements for 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, issues 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 evaluation inspections and monitoring on behalf of the U.S. Environmental Protection Agency.

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

As of 2015, there are a total of 11 outfalls on the Laboratory's National Pollutant Discharge Elimination System Industrial and Sanitary Outfall Permit (Outfall Permit) (Table 2-4). Nine of the outfalls are conventional cooling tower and sanitary discharges. The Laboratory's current Outfall Permit requires weekly to yearly 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 at the end of the monitoring period for each respective outfall category.

Table 2-4
Volume of Effluent Discharged from Permitted Outfalls in 2015

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2015 Discharge (gallons)
03A048	53-963/978	Los Alamos Neutron Science Center cooling tower	Los Alamos	20,184,800
051	50-1	Technical Area 50 Radioactive Liquid Waste Treatment Facility	Mortandad	0
04A022[a]	3-2238	Sigma emergency cooling system	Mortandad	567,240
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	319,288
03A181	55-6	Plutonium facility cooling tower	Mortandad	1,890,061
13S	46-347	Sanitary wastewater treatment plant	Sandia	see outfall 001[b]
001	3-22	Power plant (includes treated effluent from outfall 13S)	Sandia	68,023,800
03A027	3-2327	Strategic Computing Complex cooling tower	Sandia	10,664,600
03A113	53-293/952	Los Alamos Neutron Science Center cooling tower	Sandia	267,403
03A199	3-1837	Laboratory Data Communications Center	Sandia	8,472,000
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2015 Total:	110,389,192

[a] 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 treatment plant collection system).

[b] The discharge amount for Outfall 13S is included in the total for Outfall 001. Beginning October 1, 2014, compliance monitoring is required only if discharge to Cañada del Buey occurs. Discharge to Cañada del Buey did not occur in October, November, or December of 2014.

Outfalls listed on the Outfall Permit that did not discharge in 2015 included Outfalls 05A055, 051, and 13S. During 2015, 2 of the 1099 samples collected from industrial outfalls exceeded effluent limits.

The following is a summary of the corrective actions the Laboratory took during 2015 to address the Outfall Permit exceedances.

- *Outfall 03A048, September 8, 2015, total residual chlorine = 0.05 milligrams per liter (mg/L), permit limit = 0.011 mg/L.* The chlorine neutralizer ran out over the 3-day Labor Day weekend.

Corrective actions:

1. The immediate action was to add chlorine to the 55-gallon drum that was empty.
2. The facility's procedure for cooling tower and water treatment operations was revised to include additional inspections to verify the adequacy of the chlorine neutralizer quantity before holidays and extended weekends.
3. The bulk 55-gallon barrel was replaced with an approximately 85-gallon barrel that will provide sufficient volume of chlorine neutralizer for typical operations over several days.

- *Outfall 001, September 22, 2015, total polychlorinated biphenyls (PCBs) = 0.00257 micrograms per liter (µg/L).* Analysis of a second aliquot of the same sample verified the original result.

Corrective actions:

1. The cause of the exceedance is unknown. On-going operational PCB sampling by the facility at several locations did not predict the result of 0.00257 µg/L at the outfall.
2. The facility has increased the operational sampling frequency and number of sampling locations to determine the source of elevated PCB levels.
3. A pilot study has been initiated at the sanitary wastewater treatment plant (May 2016) to determine the effectiveness of granulated activated carbon in reducing PCB levels in the treated sanitary effluent being pumped to the Sanitary Effluent Reclamation Facility and Outfall 001.

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 before construction 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 2015, the Laboratory had 27 storm water pollution prevention plans for construction sites. We performed 620 storm water inspections. Of those, 98.8% of the inspection items were in compliance. Most noncompliant items involved not completing corrective actions within the allowed time.

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 Program regulates storm water discharges from specific industrial activities and their associated facilities. The types of industrial activities conducted at the Laboratory covered under the National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities (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 permitted sites. Compliance with the requirements for these sites is achieved primarily by implementing the following activities:

- Identifying potential contaminants and activities that may impact surface water quality and identifying and providing structural and nonstructural controls to limit their impact
- Developing and implementing facility-specific storm water pollution prevention plans
- Implementing corrective actions identified during inspections throughout the year
- Monitoring storm water runoff at facility stand-alone samplers for industrial sector-specific benchmark parameters, impaired water constituents, and effluent limitations
- Visually inspecting storm water runoff to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution

The Laboratory implemented and maintained 12 storm water pollution prevention plans covering 14 facilities in 2015. Exceedances of benchmarks or limits for the Multi-Sector General Permit in 2015 are as follows:

- At Technical Area 03, Building 0038, the average concentration of zinc from three quarterly benchmark monitoring samples was mathematically certain to exceed the benchmark value at monitored discharge point 3-MFS-1. The zinc was present at a concentration solely attributable to natural background. A background study was provided as part of the 2010 annual report submitted to the U.S. Environmental Protection Agency on November 4, 2010 (LANL 2010).
- At Technical Area 54, Area G, the average chemical oxygen demand associated with three quarterly benchmark monitoring samples was mathematically certain to exceed the benchmark value at monitored discharge point 54-G-4. A screen was added to reduce the amount of vegetation (organic material) and slow the storm water flowing through the trench drain.

- At the Technical Area 54 Maintenance Facility West, aluminum and copper exceeded the State of New Mexico water quality criteria at discharge point 54-MFW-1. Per Part 6.2.4.2 of the 2008 Multi-Sector General Permit, “this monitoring requirement does not apply after one year if the pollutant for which the waterbody is impaired is not detected above natural background levels in your storm water discharge, and you document, as required in Part 5.4 (Additional Documentation Requirements), that this pollutant is not expected to be present above natural background levels in your discharge.” The Laboratory has met this documentation requirement and will no longer monitor for aluminum or copper at this discharge point.
- The 30-day average for total suspended solids at the Technical Area 60 Asphalt Batch Plant exceeded the numeric effluent limit at discharge point 6-ABP-1. The average from storm events on July 7, 15, and 20, 2015, was 72 mg/L. An additional sample was collected on August 8, 2015, which exceeded the daily maximum effluent limit for total suspended solids. However, this sample was collected before corrective action was completed. On September 29, 2015, the rock and liner were removed from the pond, and on September 30, 2015, the depth of the pond was dug 2 feet deeper to help increase the holding capacity and retention time of storm water to allow sediment to settle to the bottom of the pond before storm water discharges to the storm water sampler.

The U.S. Environmental Protection Agency issued a new Multi-Sector General Permit on June 4, 2015. We submitted our notice of intent to discharge under the 2015 Multi-Sector General Permit in September 2015 and received coverage in October 2015. The Laboratory’s permit tracking number under the 2015 Multi-Sector General Permit is NMR053195. Next year, storm water monitoring will be solely in accordance with the 2015 Multi-Sector General Permit.

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. Site-specific storm water controls that reflect best industry practices are applied at each of the 405 sites to minimize or eliminate discharges of pollutants in storm water. These controls prevent or reduce storm water run-on or runoff at the sites or address the movement of soil from or to the sites. The controls are routinely inspected and maintained as needed.

For purposes of monitoring, sites are grouped into 250 site monitoring areas, based on proximity and discharge to a common drainage point. The most representative storm water sampling locations are identified for each site monitoring area. Any storm water samples collected from these locations are analyzed for water quality parameters to determine the effectiveness of the storm water controls. Storm water samples are only collected when a particular site monitoring area is affected by a storm with sufficient rainfall to cause surface runoff, which does not happen every year. When target action levels for chemicals, based on New Mexico water quality standards, are exceeded in the samples, additional corrective actions are required by the Individual Permit. 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 2015, we completed the following tasks:

- Published the 2014 update to the Site Discharge Pollution Prevention Plan, Revision 1, that (1) identifies pollutant sources, (2) describes the control measures, and (3) describes the monitoring at all regulated sites
- Completed 1794 inspections of storm water controls at the 250 site monitoring areas
- Completed 1531 sampling equipment inspections
- Conducted storm water control maintenance at 122 site monitoring areas
- Collected storm water samples at 7 site monitoring areas without enhanced controls
- Collected storm water samples at 7 site monitoring areas with enhanced controls
- Activated samplers at 35 site monitoring areas with enhanced controls
- Completed installation of enhanced controls at 35 site monitoring areas
- Submitted certification that 10 sites were complete because the sites had no exposure to storm water
- Completed recovery activities from the September 13, 2013, flood event
- Continued negotiations on the permit renewal application for the Individual Permit
- Submitted alternative compliance requests for 77 sites
- Held 2 public meetings
- Completed website updates and public notifications
- Collected 17 Individual Permit samples at site monitoring areas; 10 site monitoring area samples had 22 target action level exceedances (see Table 2-5).

As a follow-up to the New Mexico Environment Department's 2014 compliance evaluation inspection, we submitted a response to the U.S. Environmental Protection Agency on February 25, 2015, stating certain corrective actions to be taken to address the findings. DOE and Los Alamos National Security, LLC, staff worked with New Mexico Environment Department staff during 2015 to develop criteria and language for the new Individual Permit that would address many of the findings. For more information on the Laboratory's Individual Permit, visit http://www.lanl.gov/environment/protection/compliance/individual-permit-stormwater/index.php.

For more information on surface water quality at the Laboratory, see Chapter 6, Watershed Quality.

Table 2-5 summarizes the exceedance of water quality parameter limits, benchmarks, guidelines, or target action levels (depending on the type of permit) for the Laboratory's National Pollutant Discharge Elimination System permits.

Table 2-5
2015 Exceedances of Limits, Benchmarks, Guidelines, or Target Action Levels for LANL's National Pollutant Discharge Elimination System Permits

Outfall, Discharge Point, or Site Monitoring Area	Date(s) Sampled	Parameter	Result	Limit, Benchmark, or Target Action Level	Reporting Units	Exceedance of Permit Limit?
Industrial and Sanitary Outfall Permit						
Outfall 03A048	09/08/15	Chlorine	0.05	0.011	mg/L	Yes
Outfall 001	09/22/15	Total PCBs	0.00257	0.00064	µg/L	Yes
Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities						
3-MFS-1	04/26/15 06/16/15 08/17/15	Zinc	0.18	0.13	mg/L	No
54-G-4	04/18/15 06/06/15 08/11/15	Chemical oxygen demand	240	120	mg/L	No
54-MFW-1	05/15/15	Aluminum	13,400	1699	µg/L	No
	05/15/16	Copper	21	6	µg/L	No
6-ABR-1	07/07/15 07/15/15 07/20/15	Total suspended solids	72	15	mg/L	Yes
Individual Permit Authorization to Discharge (from Solid Waste Management Units and Areas of Concern)						
2M-SMA-1.42	07/20/15	Gross alpha	16	15.0	pCi/L*	No
	07/20/15	Aluminum	1900	750	µg/L	No
CDB-SMA-0.15	07/20/15	Aluminum	1250	750	µg/L	No
	07/20/15	Copper	6.66	4.3	µg/L	No
CDV-SMA-2.3	07/20/15	Gross alpha	54.4	15.0	pCi/L	No
M-SMA-12	07/07/15	Total PCBs	0.00427	0.00064	µg/L	No
	07/07/15	Aluminum	1510	750	µg/L	No
	07/07/15	Copper	4.41	4.3	µg/L	No
M-SMA-12.9	07/20/15	Gross alpha	276	15.0	pCi/L	No
	07/20/15	Copper	25.1	4.3	µg/L	No
PJ-SMA-14.3	07/20/15	Arsenic	9.21	9.0	µg/L	No
	07/20/15	Gross alpha	160	15.0	pCi/L	No
	07/20/15	Aluminum	59100	750	µg/L	No
	07/20/15	Copper	70	4.3	µg/L	No
	07/20/15	Lead	104	17	µg/L	No
	07/20/15	Zinc	362	42	µg/L	No

Table 2-5 (continued)

Outfall, Discharge Point, or Site Monitoring Area	Date(s) Sampled	Parameter	Result	Limit, Benchmark, or Target Action Level	Report Units	Exceedance of Permit Limit?
S-SMA-3.72	07/20/15	Copper	4.59	4.3	µg/L	No
S-SMA-6	10/21/15	Aluminum	1540	750	µg/L	No
	10/21/15	Copper	5.87	4.3	µg/L	No
STRM-SMA-5.05	08/02/15	Aluminum	12600	750	µg/L	No
	08/02/15	Total PCBs	0.00226	0.00064	µg/L	No
W-SMA-10	08/01/15	Gross alpha	77.8	15.0	pCi/L	No

*pCi/L = Picocuries per liter.

Aboveground Storage Tank Program

The Laboratory's Aboveground Storage Tank Program is responsible for ensuring compliance with the requirements established by 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 aboveground storage tanks under the New Mexico regulations. Two tank systems were permanently closed in 2015.

During 2015, we were in full compliance with Clean Water Act requirements for aboveground storage tanks. The Petroleum Storage Tank Bureau conducted inspections of 12 aboveground storage tank systems at the Laboratory in 2014. The Bureau issued "Lists of Compliance Concerns" for 10 of the tank systems. The New Mexico regulations require any repair work on aboveground storage tanks to be completed by New Mexico–certified tank installers. The compliance concerns for three of the tank systems were addressed in 2014, but notices of violations were received for four of the systems in 2015 because repairs were not completed in a timely fashion. Repairs were subsequently completed on five tank systems, and two systems were permanently closed. A total of seven tank systems were brought into compliance during 2015. In 2015, five tank systems were inspected by the Petroleum Storage Tank Bureau after completion of corrective actions, and all were found to be in compliance.

The U.S. Environmental Protection Agency requires spill prevention, control, and countermeasure plans for facilities with aboveground storage tank systems. The Laboratory received approval for seven modifications to spill prevention, control, and countermeasure plans and is implementing those modifications. In 2015, we conducted 25 annual inspections of facilities with spill prevention, control, and countermeasure plans.

Clean Water Act Section 404/401 Permits

Section 404 of the Clean Water Act requires the Laboratory to obtain permit verification from the U.S. Army Corps of Engineers to perform work within perennial, intermittent, or ephemeral watercourses. 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. During 2015, Section 404/401 permits were issued or active for the following construction projects at the Laboratory:

- Sandia Canyon–Technical Area 72 firing site storm water controls
- E250 stream gage weir erosion repair in Pajarito Canyon
- Pueblo grade-control spurs and E060.1 gage revitalization
- Pueblo Canyon stabilization project
- Cañon de Valle at CDV-SMA-1.7
- Fiber optics installation in Sandia Canyon
- Threemile Canyon at 3M-SMA-4

The following permits were issued in 2012 and 2013 and remain open because of an annual monitoring requirement established in the permit verification:

- Water Canyon storm drain reconstruction project
- Sandia Canyon Wetland grade-control structure

On September 21, 2015, the U.S. Army Corps of Engineers and the New Mexico Environment Department conducted a compliance inspection of the Technical Area 72 firing site storm water control project and the Pueblo Canyon stabilization project. On September 29, 2015, the U.S. Army Corps of Engineers issued a Notice of Non-Compliance for the Technical Area 72 firing site project for violations related to ammunition fire remaining in the water course and damage to the soil cement channel caused by ammunition fire. On October 29, 2015, we responded by issuing a corrective action plan, which outlined the immediate removal of ammunition from the water course and contained a plan for continued removal until corrective actions are completed by September 30, 2016.

GROUNDWATER QUALITY AND PROTECTION

Safe Drinking Water Act

In 2015, we collaborated with Los Alamos County to conduct monitoring of water-supply wells owned by the county. Monitoring conducted in wells the county uses for its current water supply did not detect chemicals or radionuclides from current or historical Laboratory operations.

New Mexico Water Quality Control Commission Groundwater Discharge Regulations

The New Mexico Water Quality Control Commission regulates liquid discharges onto or below the ground surface to protect groundwater in New Mexico. The New Mexico Environment Department determines the applicability of the regulations and may require a facility that discharges effluents to submit a discharge plan and obtain a permit. The discharges must comply with the terms and conditions of the permit. In 2015, we had two discharge permits and three discharge permit applications pending.

Technical Area 46 Sanitary Wastewater Plant Discharge Permit

On July 20, 1992, the Laboratory was issued discharge permit DP-857 for the Technical Area 46 sanitary wastewater plant. The permit was renewed on January 7, 1998, and modified on October 1, 2002. We submitted an application for renewal and modification of the permit in 2010 at the request of the New Mexico Environment Department and provided supplemental information in 2012. Issuance of a final modified discharge permit was pending at the end of 2015, and the current permit has been administratively continued until the new permit is issued.

The permit requires quarterly sampling of the sanitary wastewater plant's treated water product, Outfalls 001 and 03A027 (outfalls that can discharge water from the sanitary wastewater plant), and alluvial groundwater well CDBO-6 in Cañada del Buey, near the plant. During 2015, none of the samples collected exceeded the New Mexico Water Quality Control Commission groundwater standards with the exception of the following two anomalous results:

- A total dissolved solids result on March 31, 2015, of 1220 mg/L in the Technical Area 46 sanitary wastewater plant reuse wet well exceeded the New Mexico groundwater standard of 1000 mg/L. A confirmation sample collected on April 30, 2015, reported a total dissolved solids concentration of 454 mg/L, consistent with the average total dissolved solids concentration from 2010 to 2015 of 456 mg/L.
- Nitrate (as nitrogen) results collected on November 23, 2015, of 10.5 mg/L from Outfall 001 and 19.3 mg/L from the Technical Area 46 sanitary wastewater plant reuse wet well exceeded the New Mexico groundwater standard of 10 mg/L. Confirmation samples collected on January 21, 2016, reported nitrate (as nitrogen) results of 2.62 mg/L at Outfall 001 and 1.93 mg/L at the Technical Area 46 sanitary wastewater plant reuse wet well. These confirmation results are consistent with historical concentrations at these locations; from 2010 to 2015, the average nitrate (as nitrogen) concentration at Outfall 001 was 1.0 mg/L, and the average concentration at the Technical Area 46 sanitary wastewater plant reuse wet well was 1.5 mg/L.

No inspection of the Technical Area 46 sanitary wastewater plant was conducted by the New Mexico Environment Department in 2015.

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

On August 20, 1996, at the request of the New Mexico Environment Department, 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 2015, the Laboratory and the New Mexico Environment Department held four negotiation sessions on the draft discharge permit. Some citizen groups, specifically Communities for Clean Water and Concerned Citizens for Nuclear Safety, participated in three of the four sessions. In addition, the New Mexico Environment Department and Communities for Clean Water and Concerned Citizens for Nuclear Safety participated in a tour of the Technical Area 50 Radioactive Liquid Waste Treatment Facility in 2015. Issuance of a final discharge permit was pending at the end of 2015.

Since 1999, we have voluntarily conducted quarterly sampling of the Radioactive Liquid Waste Treatment Facility's effluent and of alluvial groundwater monitoring wells MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon for nitrate (as nitrogen), fluoride, total dissolved solids, and perchlorate. During 2015, none of the quarterly groundwater samples exceeded the New Mexico Water Quality Control Commission groundwater standards for these analytes. No samples were collected from alluvial well MCO-3 in 2015 because the well was damaged beyond repair during the flood event in September 2013. No effluent samples were collected in 2015 because the Radioactive Liquid Waste Treatment Facility did not discharge any treated effluent to Mortandad Canyon; all treated water was evaporated on-site. The New Mexico Environment Department did not conduct an inspection of the Radioactive Liquid Waste Treatment Facility in 2015 but did tour the facility on April 14, 2015.

Domestic Septic Tank/Leach Field Systems Discharge Plan and Permit Application

On April 27, 2006, at the request of the New Mexico Environment Department, the Laboratory submitted a discharge plan application for the discharge of domestic wastewater from 21 septic 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 plant's collection system is not practicable. On April 6, 2010, the New Mexico Environment Department requested that the Laboratory submit an updated septic tank/leach field systems discharge plan and permit application. Accordingly, on June 25, 2010, we submitted an updated discharge plan and permit application for 15 septic tank/leach field systems. The discharge plan application was amended on January 17, 2012, reducing the number of active septic tank/leach field systems from 15 to 12. Issuance of a final discharge permit was pending at the end of 2015.

Land Application of Treated Groundwater from a Pumping Test at Well R-28 Discharge Plan and Permit Application

On December 20, 2011, the Laboratory submitted a discharge plan and permit application for the discharge of treated groundwater produced during a 10-day pumping test at regional aquifer monitoring well R-28. Subsequently, on January 7, 2014, we submitted an application amendment to broaden the scope of the original discharge plan. The plan's scope was broadened to capture activities beyond the R-28 pumping test and includes, but is not limited to, pumping tests, aquifer tests, and well rehabilitation and tracer studies.

Included in the plan is handling of produced groundwater that requires treatment prior to discharge. On July 27, 2015, the New Mexico Environment Department issued Discharge Permit DP-1793 for the land application of treated groundwater from the Laboratory's groundwater projects. Under the permit, individual work plans must be submitted for New Mexico Environment Department approval for each groundwater project. The New Mexico Environment Department conducted an inspection of chromium project land application sites in Mortandad Canyon on October 27, 2015.

Compliance Order on Consent Groundwater Activities

The Laboratory performed groundwater protection activities in 2015 as directed by the New Mexico Environment Department under the Compliance Order on Consent. Activities included sampling and testing groundwater from wells for general monitoring of groundwater quality, investigating the chromium and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) groundwater plumes, and installing new wells. In 2015, we installed three new regional aquifer monitoring wells, completed one new monitoring well in perched-intermediate groundwater, and installed three regional aquifer piezometers. A multi-well tracer injection test was also initiated in three wells in the RDX groundwater project area at Technical Area 09 and Technical Area 16. Details of the Laboratory's 2015 groundwater work and results can be found in Chapter 5.

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 and associated Supplement Analyses. The most recent Site-Wide Environmental Impact Statement was issued in May 2008 (DOE 2008).

We review proposed projects to determine whether they are covered under the existing Site-Wide Environmental Impact Statement or other existing National Environmental Policy Act documents issued by DOE. Laboratory staff reviewed 1040 proposed projects for National Environmental Policy Act coverage in 2015. If projects or activities are not covered under existing documents, new National Environmental Policy Act–compliant analyses are conducted.

DOE prepared an Environmental Assessment in 2015 to evaluate an interim measure to control chromium plume migration in groundwater. The objective of the interim measure is to maintain chromium levels outside of Laboratory boundaries at less than 50 parts per billion while long-term corrective action remedies are evaluated and implemented (DOE 2015a). DOE determined the proposed interim measure to control the chromium plume migration would not result in any significant adverse effect (DOE 2015b).

A Supplement Analysis to the Final Environmental Impact Statement for the Chemistry and Metallurgy Research Building Replacement Project was issued in January 2015 (DOE 2015c). The analysis was performed to determine if the Environmental Impact Statement adequately bounds the proposed relocation of analytical chemistry and materials characterization capabilities at the Laboratory from the Chemistry and Metallurgy Research building to other existing Laboratory facilities. DOE/the National Nuclear Security Administration concluded in the Supplement Analysis that the Environmental Impact Statement analysis bounds the proposed relocation of analytical chemistry and materials characterization capabilities to existing facilities.

Four projects were approved to proceed under existing DOE categorical exclusions: Pueblo Canyon Grade Control Structure Revitalization and Wetlands Stabilization, Technical Area 74 (DOE 2015d); Lease Extension for the Operation of a Telecommunications Tower at Los Alamos (DOE 2015e); Domestic Source Recovery Fiscal Year 2016 (DOE 2015f); and Foreign Location Source Recovery – Fiscal Year 2016 (DOE 2015g). Approved LANL National Environmental Policy Act documents are available at http://nnsa.energy.gov/aboutus/ouroperations/generalcounsel/nepaoverview/nepa/lafo.

National Historic Preservation Act

The National Historic Preservation Act requires federal agencies to consider the effects projects and activities may have on historic properties, including archaeological sites and resources and historic buildings. The act requires evaluation of historic properties that may be impacted by a project and mitigation of any adverse effects. A cultural resources management plan, available at http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-04-8964 (LANL 2006), describes the Laboratory's process for implementing the National Historic Preservation Act.

In fiscal year 2015, we conducted 20 projects that required field verification of previous historic property surveys. Five new archaeological sites were identified. Forty-three archaeological sites were determined eligible for the National Register of Historic Places.

We continued to conduct an annual inspection of the Museum of Indian Arts and Culture in Santa Fe, New Mexico, which houses artifacts from 39 archaeological sites excavated during 2002 through 2006 for the land conveyance and transfer project, along with artifacts from other earlier Laboratory projects.

We conducted archival documentation for three projects involving several historic buildings. Buildings included in these projects are located at Technical Areas 03, 16, 46, 48, 54, and 57. This work included field visits to the buildings (including interior and exterior inspections), digital and archival photography, and architectural documentation. Research on the historical uses of the buildings was conducted using source materials from the Laboratory archives and records center, historical photography, the Laboratory's public reading room, and previously conducted oral interviews.

We continue to consult 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, including their habitats. We implement these requirements through our biological resources management plan (LANL 2007), sensitive species best management practices source document (Hathcock et al. 2015a, updated March 2015) and habitat management plan (LANL 2015e).

The Laboratory contains habitat for three federally listed species: the southwestern willow flycatcher (*Empidonax traillii extimus),* the Jemez Mountains salamander (*Plethodon neomexicanus),* and the Mexican spotted owl (*Strix occidentalis lucida).* Two other federally listed species occur near the Laboratory: the New Mexico meadow jumping mouse (*Zapus hudsonius luteus)* and the western distinct population segment of the yellow-billed cuckoo (*Coccyzus americanus)*. The southwestern willow flycatcher, yellow-billed cuckoo, and New Mexico meadow jumping mouse have not been observed on Laboratory property. In addition, several federal species of concern and state-listed species potentially occur within the Laboratory (Table 2-6).

We review proposed projects to determine if projects have the potential to impact federally listed species or their habitats. During 2015, we reviewed 751 excavation permits, 204 project profiles in the permits and requirements identification system, and 5 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 2015, one to update the habitat management plan (LANL 2015f) and one for the demolition of the Fenton Hill facility (LANL 2015g).

We also conducted surveys for the Mexican spotted owl, southwestern willow flycatcher, and Jemez Mountains salamander (Hathcock et al. 2015b). Mexican spotted owls and Jemez Mountains salamanders were found on Laboratory property again in 2015. Two Mexican spotted owl nesting locations were discovered on Laboratory property during 2015, and a total of 7 owlets were fledged. Southwestern willow flycatchers were not found during surveys, though encounters of willow flycatchers of unknown subspecies do sometimes occur during spring and fall migrations.

Table 2-6
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	High
Zapus hudsonius luteus	New Mexico meadow jumping mouse	E, NME	Low
Haliaeetus leucocepahlus	Bald eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed hummingbird	NMT	Low
Amazilia violiceps	Violet-crowned hummingbird	NMT	Low
Gila pandora	Rio Grande chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains salamander	E, NME	High
Falco peregrinus anatum	American peregrine falcon	NMT, FSOC	High
Falco peregrinus tundrius	Arctic peregrine falcon	NMT, FSOC	Moderate
Accipiter gentiles	Northern goshawk	NMS, FSOC	High
Lanius ludovicianus	Loggerhead shrike	NMS	High
Vireo vicinior	Gray vireo	NMT	Moderate
Myotis ciliolabrum melanorhinus	Western small-footed myotis bat	NMS	High
Myotis volans interior	Long-legged bat	NMS	High
Euderma maculatum	Spotted bat	NMT	High
Corynorhinus townsendii pallescens	Townsend's pale big-eared bat	NMS, FSOC	High
Nyctinomops macrotis	Big free-tailed bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red fox	NMS	Moderate
Ochotona princeps nigrescens	Goat peak pika	NMS, FSOC	Low
Lilium philadelphicum var. andinum	Wood lily	NME	High
Cypripedium calceolus var. pubescens	Greater yellow lady's slipper	NME	Moderate
Speyeria nokomis nitocris	New Mexico silverspot butterfly	FSOC	Moderate
Mentzelia springeri	Springer's blazing star	NMSOC, SOC, FSS	Moderate

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

[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.

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 2015, we continued annual breeding season and winter surveys in all major habitat types (Hathcock and Keller 2012) and continued monitoring avian nest boxes. In addition, biologists completed a sixth year of bird mist-netting during fall migration in Pajarito Canyon (Thompson and Hathcock 2016). In 2015, a mist-netting effort was continued in the Sandia Canyon wetland.

Floodplain and Wetland Executive Orders

We comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands. Two floodplain assessments were prepared during 2015 for the chromium project (LANL 2015h) and storm water protection in Technical Area 18 (LANL 2015i). No violations of the DOE floodplain/wetland environmental review requirements were recorded in 2015.

Toxic Substances Control Act

The Toxic Substances Control Act addresses the production, importation, use, and disposal of specific chemicals, including PCBs. The Laboratory's responsibilities under the Toxic Substances Control Act involve record-keeping and reporting related to disposal of PCB-containing substances, including dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills, and the import or export of small quantities of chemicals used in Laboratory research activities.

During 2015, the Laboratory shipped 18 containers of PCB-containing wastes off-site for disposal or recycling. The total mass of PCB waste was 1050.6 kilograms. PCB wastes were sent to a U.S. Environmental Protection Agency–authorized treatment and disposal facility in Veolia, Colorado. We maintain an annual PCB record and document log on file for inspection. During 2015, the U.S. Environmental Protection Agency did not perform a PCB site inspection. Only one Toxic Substances Control Act import/export review was conducted in 2015 for chemicals at the Laboratory's Property Management Group Customs Office.

We have been tracking the removal of PCB-contaminated equipment and components for more than 17 years. Items such as transformers, capacitors, and other components using PCB-containing dielectric oil have been identified and tracked to disposal. In 2015 there are seven remaining items that are being stored at the Laboratory's Chemistry and Metallurgical Research facility pending final disposition.

Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act regulates the protection of workers who use these chemicals. Sections of this act that apply to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the act. 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. Herbicide and pesticide usage was reported to the

U.S. Environmental Protection Agency in accordance with the National Pollutant Discharge Elimination System Pesticide General Permit.

Table 2-7 shows the amounts of pesticides and herbicides the Laboratory used in 2015.

Table 2-7
Herbicides and Pesticides

Herbicide	Amount (gallons)
Velossa	195.82
Insecticide	**Amount (pounds)**
Maxforce Granular Insect Bait	0.6875
Advion Ant Gel	0.0625
Tempo Ultra WP	0.003
Wasp Freeze	1.08 gallons
Water Treatment Chemical	**Amount**
Garrett Callahan Formula 314 T	665 pounds
Garratt-Callahan Formula 316	124.2 ounces
Houghton Chemical Purobrom Tablets	7775 pounds

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

DOE Order 231.1B, Environment, Safety, and Health Reporting, requires the timely collection 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 and/or performance measures programs; and
- summarize property clearance activities.

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

DOE Order 232.2, Occurrence Reporting and Processing of Operations Information

DOE Order 232.2, Occurrence Reporting and Processing of Operations Information, requires that off-normal 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 2015 are listed in Table 2-8. The applicable categories for the environmental occurrences are described below.

Table 2-8
2015 Environmental Occurrences

<table>
<tr><th>Group, Subgroup, and Significance Category</th><th>Title</th><th>Action(s)</th></tr>
<tr><td>2E(3),5A(2), 10(2c)</td><td>Chemical Release into the Environment during Warranty Work Activities</td><td>Immediate Actions
1. Work was paused.
2. Environmental personnel placed absorbent pads where water had pooled.
3. On 01/07/15, environmental personnel verbally notified the New Mexico Environment Department and followed up with 7- and 15-day written reports.
Corrective Action
1. In the future, the subcontractor technical representative will ensure the Science and Technology Operations work execution manager and superintendent are contacted for scoping, scheduling, and execution activities. Others may be added to notifications by the subcontractor technical representative as necessary.
2. The Logistics Division – Maintenance Subcontract Management group leader will brief subcontractor technical representatives on AP-MSM-001 protocol as it relates to work organization and planning and communication during the work planning process.</td></tr>
<tr><td>5A(2)</td><td>Force Main Leak Exceeds New Mexico Environment Department Permit at TA-18 Sewage Collection System</td><td>Synopsis
On 09/26/15, an assumed potable water leak was spotted at Technical Area 18, Building 0252. Further investigation determined the leak was sanitary wastewater. Workers from the Utilities and Infrastructure Wastewater Department isolated the lift station until the leak was repaired.
Immediate Actions
1. The Utilities and Infrastructure Wastewater Department isolated leak.
2. The Utilities and Infrastructure Wastewater Department created a plan to mitigate the flow from the affected lift station.
Corrective Action
1. The incident was reported to the New Mexico Environment Department and the U.S. Environmental Protection Agency. The New Mexico Environment Department subsequently approved the corrective actions.</td></tr>
<tr><td>5A(2)</td><td>National Pollution Discharge Elimination System Permit Limit Total Suspended Solids Exceeded at Outfall</td><td>Synopsis
The 30-day average for total suspended solids at the Technical Area 60 Asphalt Batch Plant exceeded the numeric effluent limit in the 2008 National Pollutant Discharge Elimination System Multi-Sector General Permit.
Regulatory Reporting
On 09/17/15, Environmental Compliance Program Group personnel notified the U.S. Environmental Protection Agency of the permit exceedance pursuant to the Laboratory's National Pollutant Discharge Elimination System Permit.
Corrective Actions
1. The liner and rock were removed from the retention pond.
2. The retention pond was dug 2 feet deeper.</td></tr>
</table>

Table 2-8 (continued)

Group, Subgroup, and Significance Category	Title	Action(s)
5A(2)	Total Residual Chlorine Permit Limit Exceedance at Outfall 03A048	Regulatory Reporting On 09/08/15, at 1656 and 1657, respectively, Environmental Compliance Program Group personnel verbally notified the U.S. Environmental Protection Agency and the New Mexico Environment Department Surface Water Quality Bureau of the permit exceedance pursuant to the Laboratory's National Pollutant Discharge Elimination System Permit. The required 5-day written report was submitted on 09/10/15 to both agencies. Immediate Actions 1. Los Alamos Neutron Science Center facility operations personnel replenished the container with the neutralizing chemical and took a sample with results showing a total residual chlorine result of 0.00 mg/L. Later that day, Environmental Compliance Programs Group personnel collected a follow-up compliance sample that also showed a total residual chlorine result of 0.00 mg/L. Corrective Actions 1. Workers will inspect and verify the adequacy of the neutralizer quantity in the container during holidays and/or extended weekends. Los Alamos Neutron Science Center management will formalize this inspection and verification process. This process will be incorporated into the Los Alamos Neutron Science Center Facility Operations Cooling Tower and Water Treatment Operations Procedure (LFO-PR-940-008). 2. The Los Alamos Neutron Science Center Facilities Operations maintenance coordinator issued a work ticket to have maintenance personnel install an 85-gallon container for the neutralizer. 3. The maintenance coordinator will work with management to reevaluate the feasibility of installing an automatic detection system to the cooling tower.
5A(2)	National Pollutant Discharge Elimination System Permit Exceedance at TA-3 Power Plant, Outfall 001	Synopsis On 11/16/15, the Utilities and Institutional Facilities Operations Director received PCB analytical results from Laboratory environmental personnel that indicated the National Pollutant Discharge Elimination System permit limit of 640 picograms per liter for PCBs had been exceeded for Outfall 001. The sample result was 2570 picograms per liter from a compliance sample collected 09/22/15. The source of the exceedance is under investigation. Regulatory Reporting: On 11/17/15, at 1151, Laboratory environmental personnel notified the U.S. Environmental Protection Agency and the New Mexico Environment Department of the National Pollutant Discharge Elimination System permit exceedance from the sample collected 09/22/15. The required 5-day written report was submitted to both agencies on 11/18/15. Corrective Actions; 1. The Utilities and Infrastructure Facilities Operations Group will develop a sampling methodology to validate the current method used for determining PCB-compliant discharge scenarios at Outfall 001. Personnel will adjust or continue with this method based on the results.

Group 2, subgroup E, significance category 3. Any failure to follow a prescribed hazardous energy control process (e.g., lockout/tagout, hazardous energy control program).

Group 5, subgroup A, significance category 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 5, subgroup A, significance category 3. Any release (on-site or off-site) that exceeds 100 gallons of oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Group 10, significance category 2c. An event, condition, or series of events that does not meet any of the other reporting criteria but is determined by the facility manager or line management to be of safety significance or of concern for that facility or other facilities or activities in the DOE complex.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act requires emergency plans for more than 360 hazardous substances if they are present at a facility in amounts above specified thresholds. We are required to notify state and local emergency planning committees (1) if any changes at the Laboratory might affect the local emergency plan or (2) if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2015.

The act also requires facilities to provide notification of leaks, spills, and other releases of listed chemicals into the environment if these releases exceed specified quantities. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. No leaks, spills, or other releases of chemicals into the environment required reporting under the Emergency Planning and Community Right-to-Know Act during 2015.

Under the act, facilities must provide an annual inventory of the quantities and locations of hazardous chemicals above specified thresholds present at the facility. The inventory includes hazard information and the storage location for each chemical. We submitted a report to the State Emergency Response Commission and the Los Alamos County Fire and Police Departments listing 31 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2015.

Finally, all federal facilities are required to report total annual releases to the environment of listed chemicals that exceed activity thresholds. Laboratory operations exceeded the threshold for use of lead in 2015. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-9 summarizes the reported releases in 2015. There are no compliance violations associated with this use or release of lead.

Table 2-9
Summary of 2015 Total Annual Releases under Emergency Planning and Community Right-to-Know Act, Section 313

Reported Release	Lead (pounds)
Air emissions	5.38
Water discharges	0.26
On-site land disposal	4123
Off-site waste transfers	2094

CLIMATE CHANGE ADAPTATION

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 adapt to a changing climate. In 2014, we began a formal effort to track local climate changes. During 2015, the Laboratory developed a model of how climate change might be expected to impact LANL facilities/operations (Dewart 2016). The model identified the types of climate changes that can impact the Laboratory, such as increasing temperatures and increasing wildland fire risk, and the types of facilities/operations that could be impacted.

Also during 2015, LANL subject matter experts identified a need for consistent climate change measurements (indices) for the Laboratory. These indices track how the climate is changing and how the natural system is responding at Los Alamos and will assist us in identifying when actions will be necessary to protect facilities and operations. An initial set of climate change indices were identified in 2015:

Temperature

- Annual average (in comparison with historical 30-year averages)
- Summer average minimum and maximum
- Winter average minimum and maximum
- Annual heating degree days
- Annual cooling degree days

Precipitation

- Annual average (in comparison with historical 30-year averages)
- Number of days with greater than 0.5 inches of rain
- Number of days with greater than 0.75 inches of rain
- Number of days with greater than 1.0 inch of rain
- Average annual snowfall

Wind

- Annual average wind speed
- Annual peak gust wind speed
- Number of red flag days

Indicator Species

- Benthic macroinvertebrates
- Breeding bird phenology

- Vegetative community composition and elevation range

Storm Water Flow

- Volume of water flowing off Laboratory property, normalized to precipitation
- Volume of water flowing onto Laboratory property, normalized by precipitation
- Number of days each boundary storm water gage flows during the year

Not all of these 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 2015.

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 2-5. 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 2011–2015 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 2-6) demonstrate the strongest increasing trend from 1990 onward (an increase of approximately 5°F).

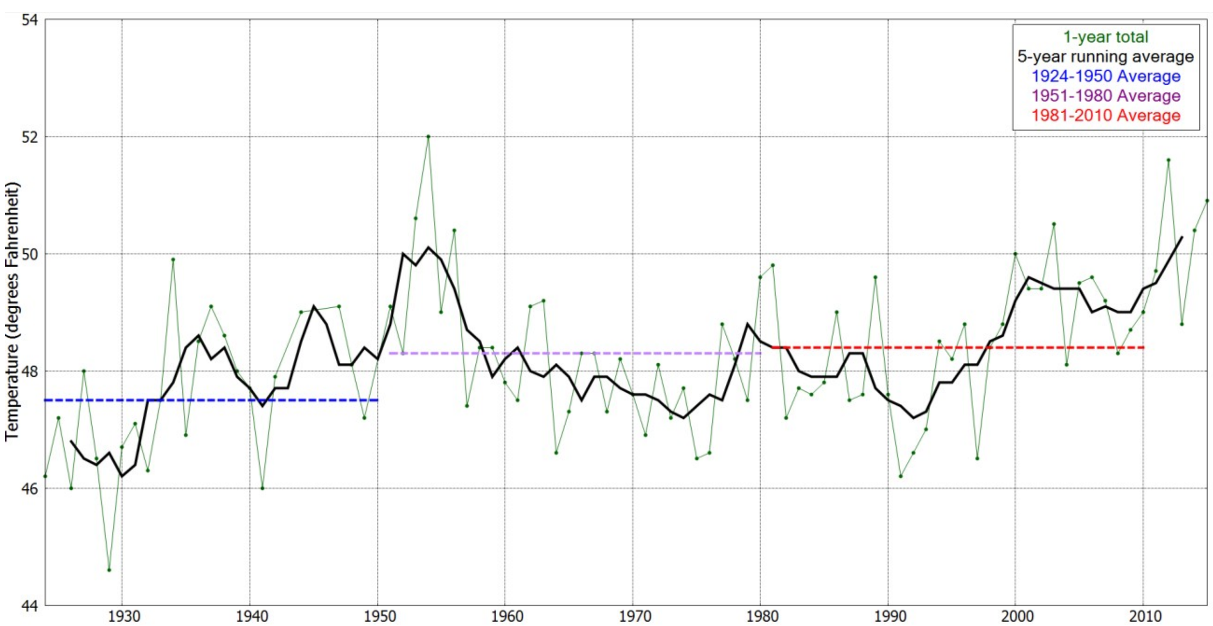
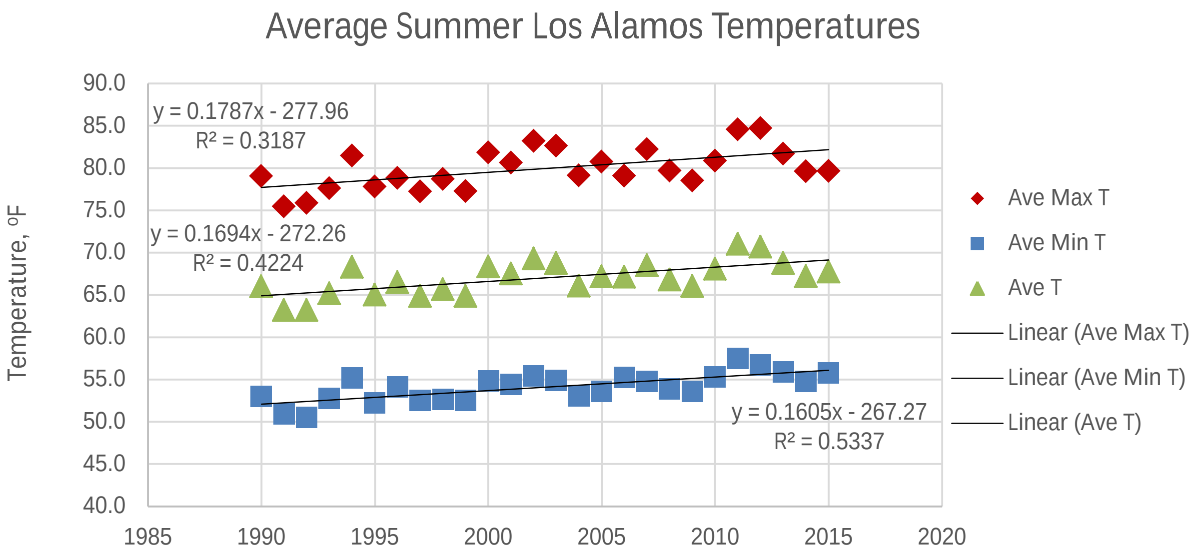


Figure 2-5 Annual average temperatures for Los Alamos



Ave = average; Min = minimum; Max = maximum; T = temperature.

Figure 2-6 Average summer (June, July, August) Los Alamos temperatures

Changes in temperature can also be assessed by changes in the number of heating and cooling degree days. Heating and cooling degree days are the yearly sums of the number of degrees per day that the average temperature is either below (for heating degrees) or above (for cooling degrees) 65°F. 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.

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 2-7) have increased and heating degree days (Figure 2-8) have decreased.

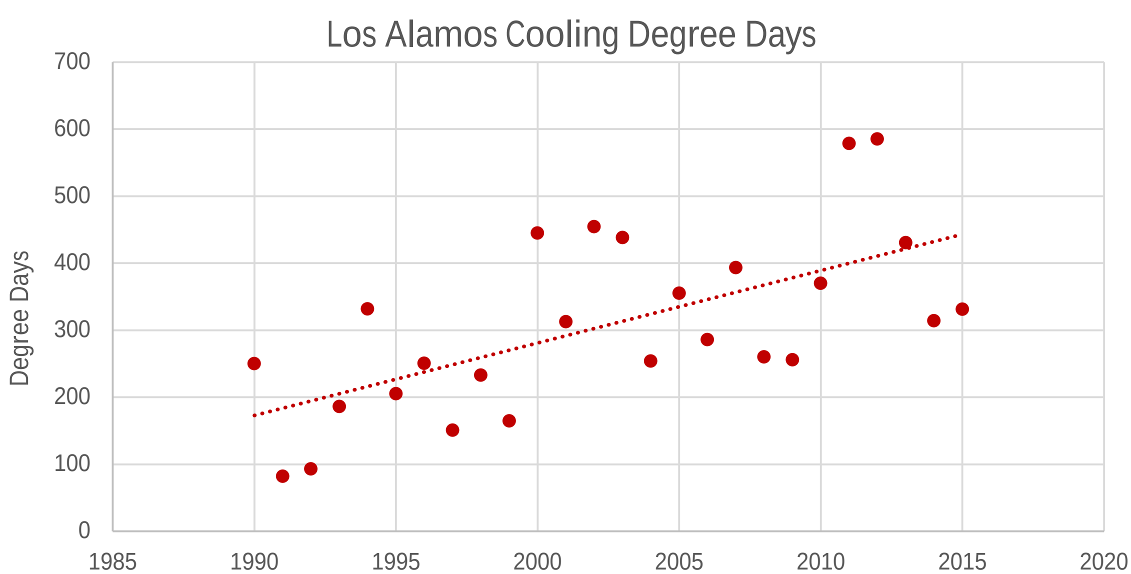


Figure 2-7 Los Alamos cooling degree days

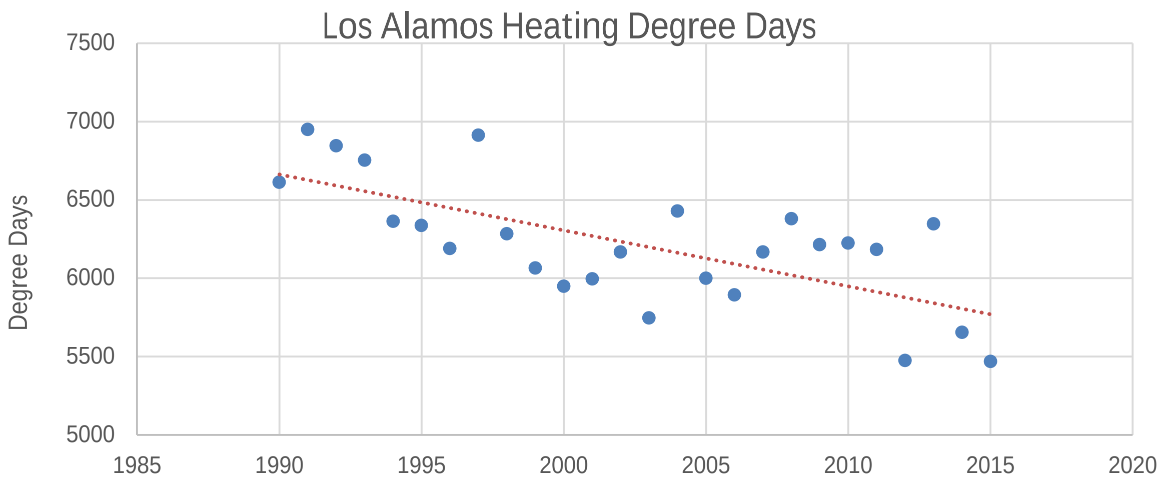
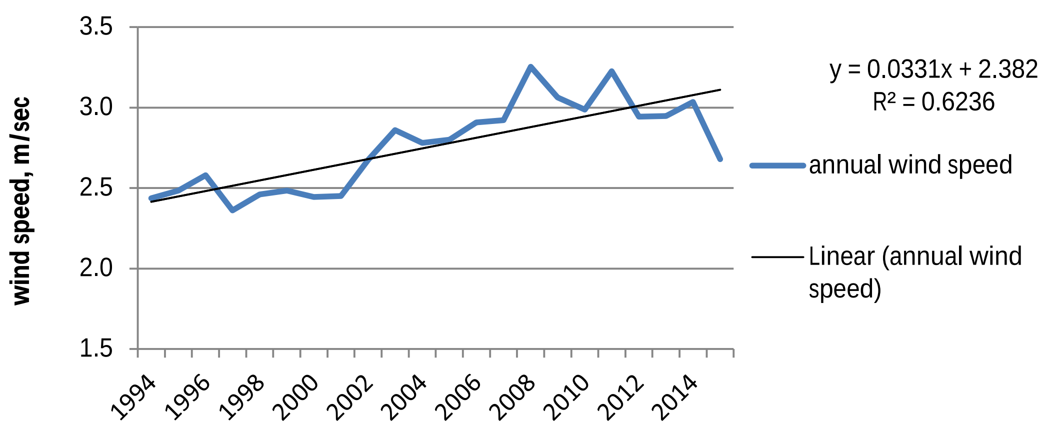


**Figure 2-8	Los Alamos heating degree days**

Wind Speed

The annual average wind speed measured at the Laboratory's meteorological tower of record at Technical Area 06 has increased approximately 20% over the past 20 years (Figure 2-9). 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). Because several factors influence wind speeds, our data do not specifically answer the question of whether climate change is impacting average wind speeds. Our current hypothesis is that the extensive loss of trees in the local area caused by wildfires, forest thinning, 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 06 since 1990 (Kelly et al. 2015).



m/sec = Meters per second.

**Figure 2-9	Technical Area 06 annual average wind speed at 12 meters**

Annual Red Flag Warnings

The National Weather Service began counting the number of red flag warnings per year for the Los Alamos area in 2012 (Figure 2-10). A red flag warning is established when the National Fire Danger Rating System is high to extreme, and the following weather conditions are forecast for the coming day:

- sustained wind average of 15 miles per hour or greater,
- relative humidity less than or equal to 25%, and
- temperature greater than 75°F.

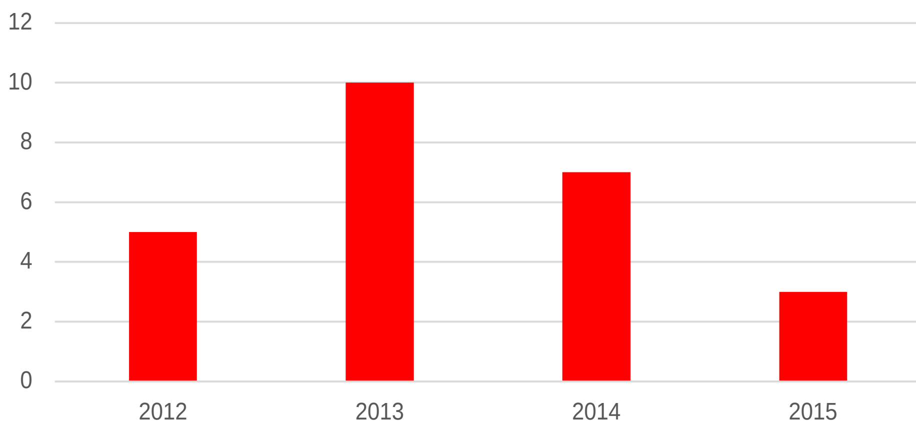


Figure 2-10 Number of National Weather Service red flag warning days for zone 102 (Los Alamos)

We will continue to track numbers of red flag warnings as a possible indicator of effects of climate change. Some Laboratory operations, including explosives testing, are restricted on days with red flag warnings.

Precipitation

We have analyzed the annual average precipitation and the number of days per year with heavy rain events. Long-term trends in annual average precipitation are presented in the Meteorological Monitoring section of Chapter 4 and are shown in Figure 2-11. 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 between 2000 and 2003 and again in 2011 and 2012. Annual precipitation values were as low as 10 inches in 2003 and 2012.

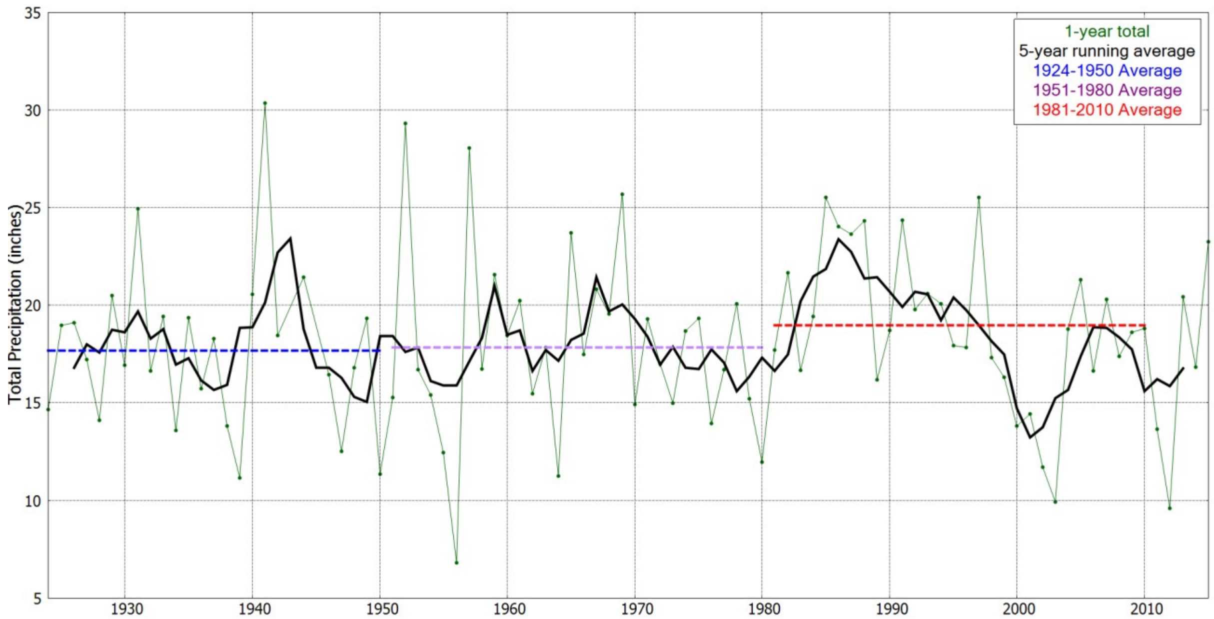


Figure 2-11 Annual precipitation totals for Los Alamos

The frequency of heavy rain events (Figure 2-12), defined as precipitation greater than 0.5 inches in one day, has no trend over the past 50 years. There is also no trend in the heaviest events (precipitation >0.75 inches or >1.0 inch per day) in the past 50 years.

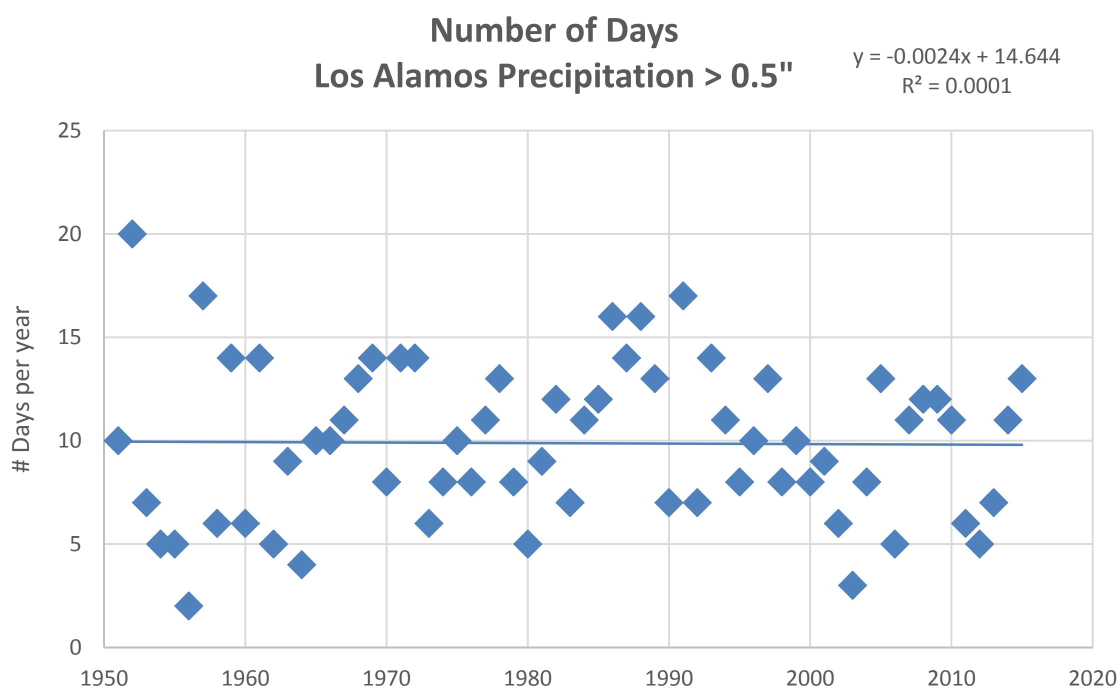


Figure 2-12 The number of days per year with precipitation >0.5 inches

Annual average snowfall (Figure 2-13) 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).

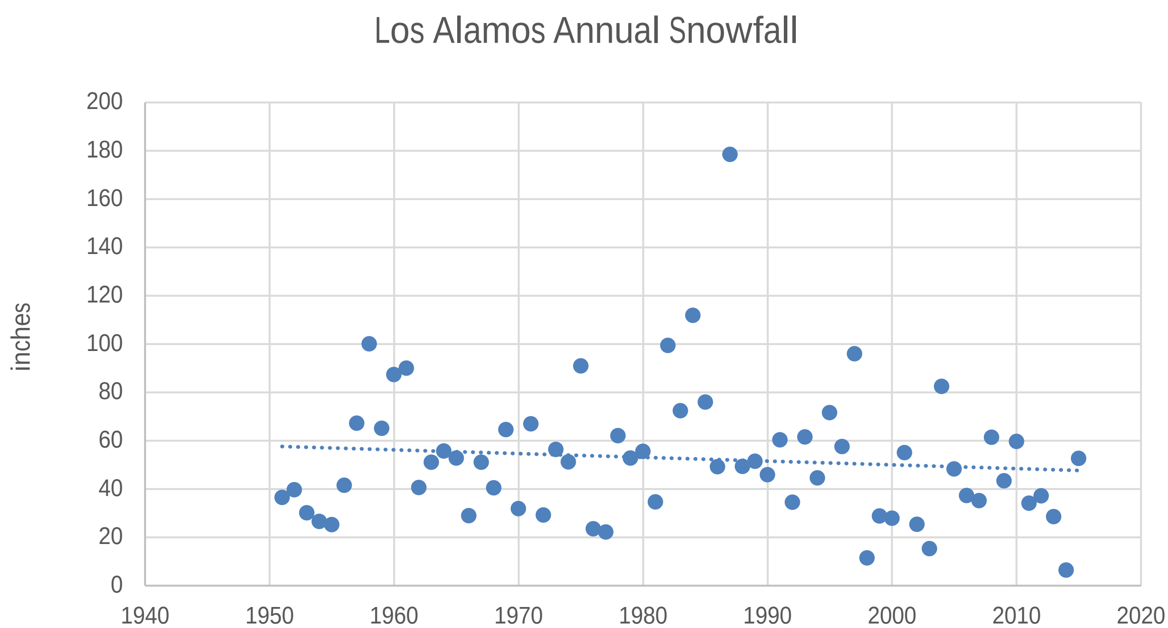


Figure 2-13 Annual average Los Alamos snowfall

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 2015j). 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 2-10. There is no apparent trend in 3 years of sampling.

Table 2-10
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, kicknet, 12 sites	173	3.2	1.4
2014, kicknet, 15 sites	84	5.7	3.5

Climate Adaptation Planning

Since 1998, we have experienced two major wildland fires, bark beetle infestation, drought-related tree mortality, and several flood events (Figures 2-14 and 2-15). Most of these events have been driven by local long-term drought conditions, which were worsened by increasing temperatures. After the Cerro Grande fire in 2000, the Laboratory established both a multi-agency emergency operations center and an interagency fire center.

Figure 2-14 Wildfire near the Laboratory

Figure 2-15 Flooding on Laboratory property

One current Laboratory program supporting the adaptation of Laboratory facilities and operations to changing climate is Wildland Fire Management (LANL 2015k). Annual tactical plans are developed to address the highest risk areas of the Laboratory, and various types of forest thinning and fuel reduction operations are conducted. These types of activities have been in place since 1998 and have reduced the risks of wildland fire to Laboratory facilities and operations.

During 2015, we moved selected high-explosives operations from Technical Area 15 to Technical Area 36. This eliminated the need to clear-cut forests at Technical Area 15. The preservation of this forest supports wildlife habitat and reduces soil erosion potential.

Climate Change 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 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 increasing summer air-conditioning costs and reductions in 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 18 years, with below-average snowfall in 83% of the years. The National Climate Assessment does not make a specific prediction for the southwest for heavy precipitation events. At this time, there is no trend in heavy precipitation events in Los Alamos.

The National Climate Assessment predicts increasing wildland fires in the southwest because 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 and thinning activities.

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 2015.

Liquid Releases

No unplanned releases of radioactive liquids occurred on Laboratory property in 2015.

There were 17 reports made to the New Mexico Environment Department pursuant to Section 20.6.2.1203 of the New Mexico Administrative Code. Fifteen unplanned releases of nonradioactive liquids in 2015 were reported to the New Mexico Environment Department as required by the New Mexico Water Quality Control Commission regulations (Table 2-11). Two instances of groundwater detections in excess of the New Mexico groundwater quality standards were also reported to the New Mexico Environment Department.

Table 2-11
2015 Unplanned Water Releases

Material Released	Number of Instances	Approximate Total Release (gallons)
Potable water	7	1,977,144
Storm water	1	350,000
Steam condensate	1	3500
Sanitary wastewater	3	2375
Heating, ventilation, and air conditioning cleaner/potable water	1	72
Fire suppression water	1	475
Groundwater	1	58,000

We investigated all unplanned releases of liquids. Following cleanup, the New Mexico Environment Department's DOE Oversight Bureau inspected the unplanned release sites. Potable water discharge volumes 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.

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To Read About **Turn to Page**

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 public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

INTRODUCTION

At Los Alamos National Laboratory (LANL or the Laboratory), good environmental performance means compliance with all applicable environmental laws, regulations, and policies. 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 environmental remediation. In addition, we have deployed staff and resources to support environmental performance within all Laboratory organizations. This chapter describes the processes and programs that the Laboratory uses to manage its environmental performance and 2015 accomplishments.

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 18 targets for 2015:

Clean the Past

- Continue to comply with the requirements of the Compliance Order on Consent with the New Mexico Environment Department
- Protect surface water runoff through implementation of the Individual Permit for Storm Water with the U.S. Environmental Protection Agency
- Design and commence implementation of remediation activities for the chromium plume in groundwater beneath Sandia and Mortandad Canyons
- Implement the institutional Facility Footprint Reduction Plan

Control the Present

- Maintain and improve the Laboratory's environmental compliance programs
- Fully integrate environmental controls with safety controls through Integrated Work Management requirements and standard work practices
- Implement sustainable acquisition
- Implement pollution prevention across all environmental media
- Implement an enduring waste management program
- Implement and maintain a site cleanout and workplace stewardship program
- Implement and maintain an integrated green infrastructure and maintenance program
- Design and implement integrated site planning management

Create a Sustainable Future

- Implement an energy and water conservation program
- Implement an institutional plan for distributed server rooms and data centers
- Reduce greenhouse gas emissions
- Implement the institutional high-performance sustainable buildings program
- Develop and deploy new environmental sustainable technologies
- Execute the long-term strategy for environmental stewardship and sustainability

INSTITUTIONAL PROCESSES

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

The Laboratory is certified to the International Organization for Standardization's 14001:2004 standard, Environmental Management System. Certification is maintained through a regular program of self-assessments and external audits. We have retained independent, third-party certification for the International Organization for Standardization's 14001:2004 standard since April 2006. Certification must be renewed at 3-year intervals and was successfully renewed in 2009, 2012, and 2015. More information about the Environmental Management System Program is available at http://www.lanl.gov/environment/protection/environmental-management-system.php.

The Laboratory maintains and annually updates an institutional list of the significant environmental aspects that may be associated with activities on site. Table 3-1 lists and describes the environmental aspects identified for 2015, 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 2015, we developed and tracked 401 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 energy consumption
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
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). This does not include isolated septic systems.	· 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
Work within or near floodplains and wetlands	Construction of structures or impoundments in a floodplain or wetland, or activities that release or have the potential to release material onto or into a floodplain, wetland, or area of overland flow.	· Monitoring well operations · Construction of roads or structures in a floodplain · Construction and operation of sediment transport controls
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.	· Removal of trees or brush · Installation and operation of night 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.	· Handling of some wastes · Human exposure to wild animals · Management of medical materials and by-products
Interaction with soil resources	Activities that release or have the 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.	· Aboveground or belowground transmission lines (water, sewer, gas, or wastewater) · Ground-disturbing activities, for example, construction, utility line repair, or maintenance of dirt roads
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
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.	· Expansion of existing, established areas (trails, walkways, clearings, roads) · Ground-disturbing activities on belowgrade or surface areas · Maintenance, modification, or demolition of potential or designated historic structures
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 · Security or after-hours lighting

Table 3-1 (continued)

Environmental Aspects	Description	Examples
Hazardous or radioactive material waste packaging and transportation	Activities that handle, package, or transport hazardous waste or radioactive material.	· 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.	· Research and development procedures using or generating radioactive material · Clean up of historical waste disposal areas
Hazardous or mixed-waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) hazardous or mixed waste.	· Research and development procedures using or generating hazardous materials · Disposal of unused, unspent laboratory chemicals
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) · All objects that are potentially waste that are not hazardous or radioactive
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
Chemical (industrial and laboratory) use and storage	Activities resulting in the purchase, use, management, or storage of chemicals.	· Chemical use in research laboratories · Vehicle operation and maintenance (fuels, coolants, lubricants, etc.)
Radioactive material use and storage	Activities that handle or store radioactive material.	· Radioactive material machining or processing · Change in location of activities or operations involving work with radioactive materials
Surplus properties and material management	Activities that manage (handle or store) 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
Resource use and conservation	Activities or practices that impact resource use and affect conservation; may increase or reduce demand or generation of 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 · Reusing and repurposing materials, equipment, and supplies
Storage of materials in tanks	Activities that handle or store materials in tanks.	· Operating or maintaining aboveground tanks in accordance with the Laboratory hazardous waste permit

Table 3-1 (continued)

Environmental Aspects	Description	Examples
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.

Findings from two external certification audits and one assessment during 2015 generated actions that supported improvements to document control, internal evaluation of compliance, and routine evaluation of effectiveness of preventive and corrective measures.

More information is available at http://www.lanl.gov/environment/protection/environmental-management-system.php.

The Long-Term Strategy for Environmental Stewardship and Sustainability

The Long-Term Strategy for Environmental Stewardship and Sustainability was created to help plan for a sustainable future at the Laboratory. The strategy defines six Grand Challenges to minimize the impact of Laboratory operations on the environment. The published strategy is available at http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-12-24845_SglPgs. The Grand Challenges are aspirational in nature and are described in Figure 3-1.

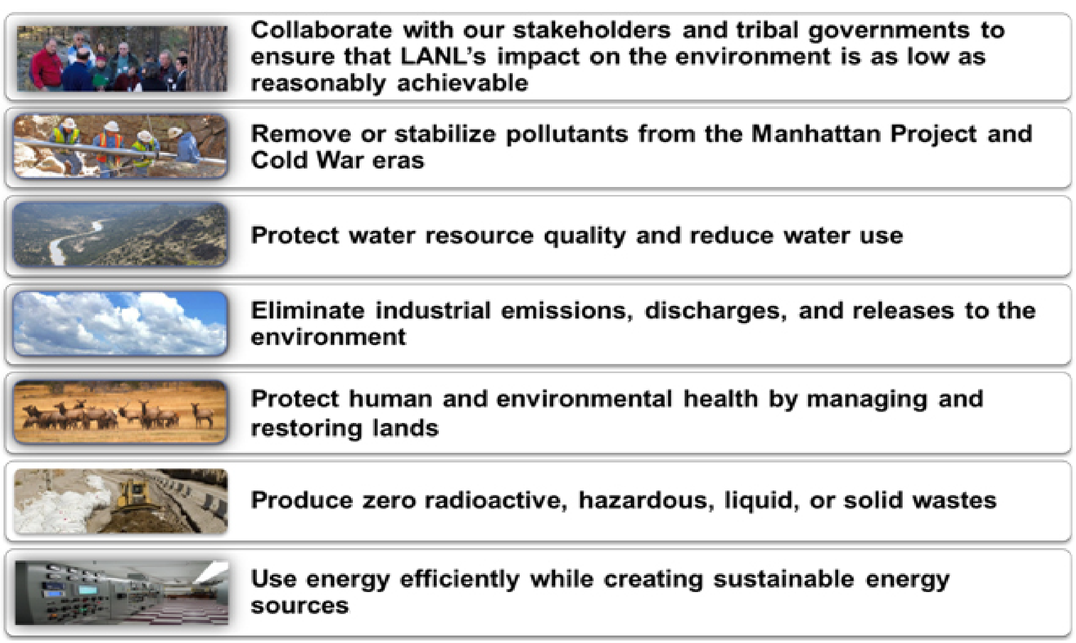

Figure 3-1 Environmental Grand Challenges—The Laboratory's goals for a sustainable future

The Long-Term Strategy for Environmental Stewardship and Sustainability core team evaluates our progress against the Grand Challenges, supports production of the annual site environmental report, and undertakes otherwise unaddressed tasks to improve environmental performance. Members of the Long-Term Strategy for Environmental Stewardship and Sustainability core team pursued the following initiatives in 2015:

- Integrated Long-Term Strategy for Environmental Stewardship and Sustainability actions into Laboratory directorates' environmental action plans for 2015
- Reviewed existing geographic information system services at the Laboratory and developed a plan for Laboratory-wide integration of services and data
- Revised and began implementation of the Enduring Mission Waste Management Plan
- Developed a conceptual model of impacts of predicted climate changes on the Laboratory and proposed Laboratory-specific climate change indices
- Launched a zero-waste pilot project for gatherings and expanded the recycling program to include all types of plastic
- Implemented a pilot program for issuing environmental work permits, based on an Integrated Project Review (see below) for projects at the Laboratory
- Began to implement the Laboratory's Forest Management Plan by updating our vegetation cover type map

2015 Accomplishments under the Grand Challenges

Collaborate with our stakeholders and tribal governments to ensure that LANL's impact on the environment is as low as reasonably achievable

- The social media hashtag, #mysmallact, developed for the Laboratory's 2015 Earth Day campaign, reached many U.S. Department of Energy (DOE) sites and was included in events by DOE Secretary Ernest Moniz and the White House. The campaign won the DOE Sustainability Award for Sustain*ABLE* Communication.
- We responded to over 300 outreach or information requests from stakeholders. Top subjects were remediation (23%); cultural, biological, and historic resources (23%); and waste management (13%).
- We actively supported establishment of the Manhattan Project National Historical Park with preservation activities, communication support, and visitor access and experience planning.

Remove or stabilize pollutants from the Manhattan Project and Cold War Eras

- Teams focused on planning for the remediation of nitrate salt wastes and completed over half of the corrective actions associated with the Waste Isolation Pilot Plant event.

Protect water resource quality and reduce water use

In addition to accomplishments listed under the Site Sustainability section later in this chapter, the Laboratory achieved the following:

- We completed a National Environmental Policy Act review for actions to mitigate the effects of chromium contamination in groundwater that allowed us to obtain permits to implement interim groundwater remediation measures and install infrastructure for injection wells in Mortandad Canyon.
- We obtained a groundwater discharge permit to facilitate chromium remediation.

Eliminate industrial emissions, discharges, and releases to the environment

- Elimination of sources of greenhouse gases produced lower emissions levels (see Greenhouse Gas Reduction section below).
- In 2015, we operated with zero exceedances under a new National Pollutant Discharge Elimination System Outfall Permit, zero permit limit exceedances in the Title V Operating Permit, and a 79% decrease in Construction General Permit noncompliance.

Protect human and environmental health by managing and restoring lands

- Measures to support climate adaptation and resiliency were added into the Site Sustainability Plan.
- In 2015, we received approval for revisions to our Threatened and Endangered Species Habitat Management Plan from the U.S. Fish and Wildlife Service. We also began implementation of the Forest Management Plan and conducted wildfire mitigation activities such as forest thinning around at-risk facilities and mowing of roadsides and firing sites.

Produce zero radioactive, hazardous, liquid, or solid wastes

- These achievements are listed in the Pollution Prevention section later in this chapter.

Use energy efficiently while creating sustainable energy sources

- These achievements are listed in the Site Sustainability section later in this chapter.

Pollution Prevention

The Laboratory's pollution prevention program develops institutional initiatives that support the Grand Challenges, reduce costs, and reduce environmental liabilities. Specific target areas for projects include zero waste, green chemistry and chemical use reduction, sulfur hexafluoride use reduction, green procurement, the Site-Wide Clean-Up and Workplace Stewardship Program, and green maintenance and infrastructure. The program also

- compiles the Hazardous Waste Minimization Report required by the New Mexico Environment Department Hazardous Facility Operating Permit,
- holds the annual Laboratory pollution prevention awards competition, and

- directly funds (i.e., within the Laboratory) waste generators to conduct pollution prevention projects.

The 2015 Laboratory pollution prevention award ceremony recognized 32 projects involving more than 200 individuals from across the Laboratory.

In fiscal year 2015, pollution prevention projects realized an estimated cost avoidance of $5.6 million. These projects prevented the generation of about 2500 pounds of hazardous waste and 1600 cubic meters of mixed low-level waste. Additionally, about 750 tons of metal and 200 tons of concrete were recycled, and approximately 100,000 pounds of lead bricks were reused.

In fiscal year 2015, the Laboratory funded 13 pollution prevention projects. The following are brief examples.

- Reduced Use of Solvents

  This team purchased a planetary ball mill (a type of grinder used to grind and blend materials), which allows them to synthesize custom compounds without using solvents, acids, or concentrated peroxides.

- Light-Emitting Diode (LED) Bulbs in Glove Boxes

  Traditional light bulbs in glove boxes were replaced with LED bulbs. Because LED bulbs last longer, they generate waste less frequently. Because they do not contain lead, the bulbs in radioactive areas become low-level radiological waste instead of mixed low-level waste.

- Releasing Suspect Metals from Radiological Areas

  Two projects were funded by the pollution prevention program to continue the Laboratory's progress towards developing verified procedures to identify scrap metals from radiological areas that are safe for re-use by the public. These suspect metals potentially contain activated materials or surface contamination through exposure to radiological operations. Activation is the process of inducing radioactivity in a material through exposure to neutrons.

  Procedures were developed and approved internally with the intent to demonstrate assessment capabilities in fiscal year 2014. In fiscal year 2015, these procedures were verified by personnel from DOE Headquarters, the Stanford Linear Accelerator, and Sandia National Laboratories. DOE's Los Alamos Field Office also performed independent verification for specific shipments. Approximately 605 tons of metal were recycled through this effort.

Site Sustainability

Executive Order 13693, Planning for Federal Sustainability in the Next Decade, and the DOE Strategic Sustainability Performance Plan provide sustainability goals for DOE, including

- 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;
- using low greenhouse gas-emitting energy sources to replace existing grid energy;
- preventing pollution and reducing or eliminating the generation of waste; and
- planning for climate resiliency.

The Laboratory's annual Site Sustainability Plan focuses on three objectives: (1) make targeted investments that improve resource use efficiency, (2) transparently track progress through metrics, and (3) engage employees and programs at all levels. The goals of the Site Sustainability Plan are fully integrated into our institutional environmental objectives.

Successes and Challenges

In fiscal year 2015, the Laboratory invested $3.3 million in the Site Sustainability Program. Additionally, we invest $3.2 million per year to fund the operation of the Sanitary Effluent Reclamation Facility. Significant 2015 successes include the following:

- An average of 87% of high-performance and sustainable building guiding principles were completed in 11 existing high-performance sustainable buildings, and an average of 86% of the guiding principles were completed in 29 high-performance and sustainable building candidate facilities (for more information on guiding principles for high-performance and sustainable buildings at DOE sites, see http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-23347.pdf).
- We completed upgrading building automation systems for heating and cooling from pneumatic to digital control systems in three large facilities.
- We completed heating, ventilation, and air conditioning recommissioning efforts in five facilities.
- The Sanitary Effluent Reclamation Facility sent over 30 million gallons of reclaimed wastewater to the Strategic Computing Complex for use within its cooling towers.
- We implemented SkySpark software in two buildings to continuously analyze energy use and equipment data.
- We increased storage for the green and yellow computing networks for infrastructure on demand (putting applications in a more energy-efficient cloud computing system).
- We reduced energy intensity (energy use per square foot of building) by almost 16% compared with fiscal year 2003 and reduced water consumption by 17% compared with fiscal year 2007.

- We reduced water intensity (water use per square foot of building) by 40% compared with fiscal year 2011.

Through investments in building automation systems, lighting, and other efficiency projects, the Laboratory plans to achieve the following goals in fiscal year 2016:

- Reduce energy intensity by 2.5% compared with the fiscal year 2015 baseline
- Maintain water use at or below fiscal year 2015 levels

We have made significant improvements in energy and water efficiency; however, the needs of future mission-related activities are projected to result in increasing levels of energy and water use. For example, the Laboratory is forecasted to double its use of energy in high-performance computing facilities and significantly increase its water use in cooling towers. We cannot reasonably continue to meet the sustainability goals without innovating to address the challenges ahead.

Laboratory management acknowledges the conflict in forecast mission growth and the energy, water, and greenhouse gas reduction goals. We are focusing on efficiency measures that can contribute to meeting energy and water-reduction goals while allowing us to successfully compete for mission growth opportunities. Specifically, to make progress toward the water-reduction goals, we will continue to operate the Sanitary Effluent Reclamation Facility and implement small water-reduction projects. More information on the Laboratory's Site Sustainability Plan is available at http://www.lanl.gov/environment/sustainability/goals/index.php.

Greenhouse Gas Reduction

The 2015 Greenhouse Gas Emission Report was submitted to the U.S. Environmental Protection Agency on March 23, 2016. The Laboratory emitted approximately 46,312 metric tons of carbon dioxide equivalents of carbon dioxide, methane, and nitrous oxide in 2015. Relative to emissions in 2008, we achieved a 19% reduction in both direct greenhouse gas emissions and indirect greenhouse gas emissions from use of purchased electricity, heat, or steam. This was achieved mainly through reductions in electricity usage and purchase of renewable energy credits. In fiscal year 2015, the Laboratory purchased over 105,000 megawatt hours of renewable energy credits.

The Laboratory achieved a 35% reduction in indirect emissions from other sources, primarily from cars and airplanes, relative to emissions in 2008. This resulted from a reduction in air and ground travel and employee commuting. We recently completed a pilot telecommuting program and are currently evaluating the feedback and results from the pilot program.

Integrated Project Review

Any new or modified activity or project conducted at the Laboratory must be reviewed to identify environmental compliance and other requirements. We have created a web-based Integrated Project Review Tool, where work managers can enter their project information, and subject matter experts can identify permits and requirements associated with the work or the geographic location. The Integrated Project Review Tool is a gateway website for Laboratory excavation permits and the permits and requirements identification process. During 2015, 741 projects at the Laboratory were reviewed for excavation permits, and 201 projects were reviewed for permits and requirements identification.

The Integrated Project Review Program coordinates environmental subject matter expert reviews and interacts with work managers. The goal of this program is to identify environmental requirements for managers early in the planning stages of a project so that requirements can be addressed, permits can be obtained, and projects can proceed as scheduled. The program is represented by subject matter experts from the following Laboratory organizations who meet biweekly: Air Quality, Biological Resources, Clean Fill Management, Cultural Resources, National Environmental Policy Act Compliance, Waste & Materials Management, and Water Quality.

Over the last several years, the Integrated Project Review Program has championed the integration of project review processes as well as improvements in the Integrated Project Review Tool. In fiscal year 2015, the Environmental Work Permit was created and launched as a pilot program. The Environmental Work Permit will be implemented for all projects needing permits and requirements identification in fiscal year 2016 to improve communication of environmental requirements to workers in the field. During 2015, the Environmental Surveillance and Assessments Program, which supports radiological assessments, became the newest program to comment on projects. Improvements to excavation permits during 2015 included automating parts of the process. This means the screening and posting of excavation permit requests is faster, with less potential for human error. Also, the screening questions of the Integrated Project Review Tool were reviewed and clarified.

DEDICATED “CORE” PROGRAMS

Air Quality Program

The Laboratory maintains a rigorous air quality compliance program for the emissions of both radionuclide and nonradionuclide air pollutants. The air-monitoring and compliance efforts consist of three main parts: compliance and permitting, stack monitoring, and ambient air monitoring.

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

The Laboratory is authorized to operate air-emission sources per the terms and conditions defined in its Title V Operating Permit. The permitted sources include a steam plant, combustion turbine, boilers and heaters, emergency generators, beryllium operations, chemical use, degreasing, data destruction (paper shredder), and a small asphalt batch plant. As part of compliance with the Title V Operating Permit, we report emissions and provide monitoring records from 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 potential for impacts of stack emissions on the public and the environment. Twenty-six stacks were continuously sampled for the emission of radioactive material to the air.

- During 2015, the off-site dose impact from Laboratory stack emissions was about 1.3% of the Clean Air Act standard for radionuclide emissions.

Ambient Air Monitoring: The Laboratory operates an extensive network of ambient air quality monitoring stations to detect other possible radioactive emissions (Chapter 4). The network includes stations located on site, in adjacent communities, and in regional locations. During 2015, we operated 40 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 four National Pollutant Discharge Elimination System permits: the outfall permit, the individual permit for storm water discharges, the construction general permit, and the multi-sector general permit (Chapter 2). The Laboratory conducts environmental surveillance monitoring on surface water base flows (Chapter 5), storm water flows, and sediments (Chapter 6). In addition, we manage solids produced through operation of the sanitary wastewater treatment facility.

In 2015, the Laboratory 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. Comments on a draft of the permit included language crafted in collaboration with the New Mexico Environment Department Surface Water Quality Bureau and representatives of the nongovernmental organization Communities for Clean Water. A final individual permit is expected from the U.S. Environmental Protection Agency in 2016. We now operate under a new multi-sector general permit, which became effective on October 3, 2015.

The Laboratory also continued activities in preparation of an U.S. Environmental Protection Agency municipal separate storm sewer system permit. On June 30, 2014, the nongovernmental organization Amigos Bravos petitioned the U.S. Environmental Protection Agency to issue municipal separate storm sewer system permits to the Laboratory, Los Alamos County, and the New Mexico Department of Transportation. On March 6, 2015, the U.S. Environmental Protection Agency issued a preliminary designation that designated all of the Laboratory and portions of Los Alamos County as meeting the requirements for the permit.

The Laboratory maintained its site-wide storm water gage station network 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 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. In 2015, the facility produced over 40 tons of composted biosolids. The final compost will be land-applied at the Laboratory for beneficial use. This includes landscaping, postconstruction 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 off-site for landfill disposal.

In 2015, finished compost was stockpiled at the Sanitary Wastewater System Compost Facility. In 2016, 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.

Cultural Resources Management

Approximately 90% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, resulting in the identification of more than 1800 sites. Nearly 73% of the Laboratory's cultural resources are Ancestral Puebloan sites that date from the 13th, 14th, and 15th centuries. Ancestral Puebloan sites, Homestead period sites, and Laboratory buildings used during Manhattan Project and early Cold War periods (1943–1963) are potentially eligible for the National Register of Historic Places. Eligible sites and buildings, whether or not they are listed on the register, are protected under the National Historic Preservation Act.

Current cultural resources management initiatives include

- surveying the remaining unsurveyed DOE land,
- completing eligibility evaluations of the Laboratory's historic buildings, and
- completing the revision of the Laboratory's Cultural Resources Management Plan.

Revisions to the Cultural Resources Management Plan include a streamlined approach to compliance with Section 106 of the National Historic Preservation Act and identification of specific objectives for historic preservation, including National Historic Landmark nominations, a site-wide monitoring plan, and identification of a Cold War period preservation district.

In 2015, cultural resource staff conducted archaeological site recording or marking for a wide variety of ground-disturbing projects. The condition of Nake'muu Pueblo was assessed and photographed in August 2015. Cultural resource staff supported separate monthly technical meetings with the Pueblo de San Ildefonso and with Santa Clara Pueblo and supported 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 2015, specialists knowledgeable about historic buildings supported decontamination and decommissioning projects in several technical areas. They completed the 1950s guard station historical context report, the Technical Area 54 West decontamination and decommissioning report, and the Phase II Technical Area 46 decontamination and decommissioning report. Historic building staff continued to support proposed modifications and improvements to several historic buildings, including painting, window installation, and lighting restoration. They also worked with the Bradbury Museum to incorporate 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 signed by President Obama on December 19, 2014. This new national park consists of units at Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. The Los Alamos unit includes buildings used during the Manhattan Project in downtown Los Alamos and 17 Laboratory sites. The Laboratory sites include buildings and structures 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). Cultural resources staff supported the development of a memorandum of agreement between the Secretary of the Interior and the Secretary of Energy regarding park properties under DOE jurisdiction and worked to develop a Manhattan Project National Historical Park brochure.

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.

2015 Accomplishments

Biologists annually inform and educate the Laboratory work force 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. Peer-reviewed research on bird deaths in uncapped metal posts and open pipes at the Laboratory (Hathcock and Fair 2014) was presented at the New Mexico Ornithological Society's 2015 annual meeting. Biologists and student interns also assisted with programs to bring primary school students to visit a fall migration bird banding station. The Laboratory foundation provided a small grant to a local science education center and nearby Bandelier National Monument for this effort.

In 2015, two pairs of federally threatened Mexican spotted owls on Laboratory property fledged a combined seven baby owls, and two Jemez Mountains salamanders were found during surveys on Laboratory property.

2015 Biological Resources Program Reports and Publications

- "Floodplain Assessment for the Construction of a Parking Lot in Los Alamos Canyon," Los Alamos National Laboratory report LA-UR-15-20766.
- "Sensitive Species Best Management Practices Source Document (Updated March 2015)," Los Alamos National Laboratory report LA-UR-15-20981.
- Hathcock, C.D. and Painter, C.W., 2015, "Distribution Note. *Arizona elegans* (Glossy Snake)," *Herpetological Review* 46(1):60-61.
- "Floodplain Assessment for Enhanced Storm Water Controls in Threemile Canyon at Technical Area 18 at Los Alamos National Laboratory," Los Alamos National Laboratory report LA-UR-15-23666.
- "Biological Assessment for the Addition of the Western Distinct Population Segment of the Yellow-billed Cuckoo and the New Mexico Meadow Jumping Mouse to the Los Alamos National Laboratory Habitat Management Plan," Los Alamos National Laboratory report LA-UR-15-23445.
- "Biological Assessment of the Effects of the Decommissioning and Removal of Infrastructure at the Technical Area 57 Fenton Hill Site at Los Alamos National Laboratory," Los Alamos National Laboratory report LA-CP-15-20378.
- Hathcock, C.D., M.A. Wright, D.S. Sias, and G.J. Gonzales, 2015, "Morphology and Sexual Dimorphism of the Many-lined Skink in North Central New Mexico," *Western North American Naturalist* 75(2):232-235.

Wildland Fire Management

In 2015, the Laboratory's Wildland Fire Management Program published an update of our Wildland Fire Management Plan (LANL 2015a). The plan provides analyses and management strategies for the prevention, mitigation, preparation, and suppression of wildland fire. Fuel mitigation actions (forest thinning and mowing) are focused on the

Laboratory perimeter, support of mission activities, and defensible space around buildings and roads.

As part of the plan, the Wildland Fire Management Program conducted hazard assessments by mapping predicted fire behavior and spread. Flame lengths, rate of spread, and crown fire activity were all modeled to determine which parts of the Laboratory have the greatest risk from wildfire. These maps are used to plan fuel mitigation projects and the replacement of infrastructure with more fire-resistant materials.

The Laboratory maintains a Wildland Fire Management web-based mapping interface that allows users to quickly query for essential information before, during, and after an incident. As part of the web-based mapping interface, the Wildland Fire Management Program maintains a set of computerized Incident Response Plans. The Incident Response Plans are a comprehensive set of maps and information designed to provide first responders with current information about facilities. The information is presented visually and in list format for quick reference.

The Laboratory Wildland Fire Management Program Office is collocated with the U.S. Forest Service and the National Park Service at the New Mexico Interagency Fire Base on the southern boundary of the Laboratory next to Bandelier National Monument. Coordination with other agencies is supported through an Interagency Wildfire Management Team, interagency agreements, the New Mexico Joint Powers Agreement, and other interorganizational councils and teams that support preservation of natural resources.

Waste Management

Enduring Mission Waste Management Plan

The Laboratory produces several types of regulated wastes as part of its operations, including low-level radiological wastes, mixed hazardous and low-level radioactive wastes, transuranic wastes, New Mexico special wastes, and others. The Enduring Mission Waste Management Plan was developed in 2015 and is the Laboratory's latest update to plans for managing wastes produced from mission-related activities.

The two February 2014 incidents that resulted in the indefinite suspension of waste acceptance at the Waste Isolation Pilot Plant has placed a new urgency on defining and implementing clear disposal pathways for each of the wastes produced by the Laboratory's national security science missions. The Enduring Mission Waste Management Plan describes the strategies and implementation path for management of newly generated waste of all types.

The plan describes for each waste type a management strategy; key requirements; expected waste generation rates; facilities and their conditions; short-term (1 to 2 years), mid-term (2 to 5 years), and long-term (>5 years) initiatives; and finally, the risks and opportunities presented. Highlights of these strategies are summarized below.

Nine overarching strategies are described in the Enduring Mission Waste Management Plan that address the most urgent needs for managing waste:

1. remediate nitrate salt drums;
2. store newly generated transuranic waste on-site pending Waste Isolation Pilot Plant reopening;
3. treat, store, and dispose of any newly generated waste off-site;
4. collocate waste management facilities with generation sources in the Pajarito corridor;
5. keep aging radioactive liquid waste facilities safely and compliantly operating until new facilities can be placed into service;
6. implement a permitting strategy in support of the overall waste strategy;
7. centralize management of waste, including prevention, characterization, certification, and transportation;
8. minimize the generation of waste of all types; and
9. address site cleanup and moratorium metals.

Legacy Waste and Nitrate-Salt-Containing Drums

Legacy transuranic waste is generally defined as all transuranic waste that currently resides at Technical Area 54, Area G, including 60 remediated and 29 unremediated nitrate salt waste containers.

Once the Waste Isolation Pilot Plant resumes operations, the mid- and long-term strategy for operations at Technical Area 54 is to resume shipments of transuranic waste to the Waste Isolation Pilot Plant until all aboveground and belowground transuranic waste is dispositioned and Area G can be closed.

In September 2014, the Secretary of Energy announced a decision to transfer oversight of the Laboratory's legacy environmental cleanup work, including legacy waste, from the National Nuclear Security Administration to DOE's Office of Environmental Management. This decision has been implemented in 2015 by

- establishment of an Office of Environmental Management–Los Alamos Field Office;
- removal of the Office of Environmental Management–funded environmental cleanup work scope from the Los Alamos National Security, LLC, management and operating contract for the Laboratory; and
- award by Office of Environmental Management of a legacy cleanup bridge contract to Los Alamos National Security, LLC, that took effect on October 1, 2015.

During the bridge contract period, Los Alamos National Security, LLC, must maintain safe facilities and operations at the three nuclear facilities used for managing legacy waste: Technical Area 54, Area G; the Radioassay and Nondestructive Testing Facility located at Technical Area 54 West; and the Waste Characterization, Reduction, and Repackaging

Facility located at Technical Area 50. The prime legacy waste goal is disposition of the 60 remediated nitrate salt and 29 unremediated nitrate salt waste containers stored at the Laboratory as soon as safely achievable.

Future corrective actions include cleanup of low-level radioactive wastes stored at Area G that resulted from past remediation of transuranic waste and identification of containers of legacy waste (other than nitrate salt wastes) stored at Area G that can be remediated and made ready for Waste Isolation Pilot Plant characterization by the Central Characterization Program in Carlsbad, New Mexico.

Newly Generated Transuranic Waste

Newly generated transuranic waste, mainly from the Plutonium Facility, the Chemistry and Metallurgy Research Facility, and the Radioactive Liquid Waste Treatment Facility, is being stored at Technical Area 55 until construction of the Transuranic Waste Facility at Technical Area 63 is completed, sometime in late fiscal year 2016 or early fiscal year 2017. After construction is completed, newly generated transuranic waste will be staged at the Transuranic Waste Facility. Large items, namely gloveboxes removed from the Plutonium Facility, are a special waste form, for which an independent management and disposition strategy will be developed. Upon resumption of Waste Isolation Pilot Plant acceptance of transuranic waste from the Laboratory, the long-term strategy is to disposition all newly generated transuranic waste at the Waste Isolation Pilot Plant within 12 months of generation.

Low-Level Radiological Waste and Mixed Low-Level Waste

The strategy for both low-level radiological waste and mixed low-level waste is to minimize its generation and to dispose of all newly generated waste off-site. Existing low-level radiological waste is being prepared for disposal in the remaining space at Area G (Pit 38 and the remaining shafts) by October 1, 2017. No new, on-site disposal capacity will be developed.

Radioactive Liquid Waste

The overall radioactive liquid waste strategy pursues a combination of near- and long-term initiatives that keep current facilities safely and compliantly operating until new facilities can be placed into service. Replacement of the Radioactive Liquid Waste Treatment Facility with a low-level radioactive liquid waste plant is on schedule to be completed by October 2017, and a transuranic liquid waste plant is scheduled to come online by October 2021.

Hazardous Waste

The strategy for hazardous waste is to minimize both the volume and toxicity of any waste generated. Hazardous waste that is generated is managed in controlled storage areas and shipped to off-site treatment, storage, and disposal facilities. In the short term, until October 2017, hazardous waste will be managed at Technical Area 54, Area L. However, the strategy is to turn all Technical Area 54 activities over to the new Environmental Management contractor at termination of the legacy cleanup bridge contract on October 1, 2017. The mid-term strategy is to plan for a consolidated hazardous waste and mixed low-level waste facility in the Pajarito corridor outside of Technical Area 54.

Waste Minimization

A critical strategy for all Laboratory waste types is to minimize the generation of waste to levels as low as reasonably achievable. Reduction in the amount of waste generated reduces long-term liabilities and reduces the potential for the disruption of critical mission work from waste disposal capacity issues. To achieve this goal, the following implementation steps will be executed:

- resume systematic forecasting of waste volumes using a graded approach focused on priority waste streams,
- establish Laboratory-wide waste-reduction goals,
- develop and fund projects to target priority waste streams,
- expand the site cleanup and metals program, and
- expand the Green is Clean program to reduce low-level radiological waste volumes.

Natural Phenomena Hazard Assessment

DOE Order 420, 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, the occurrence of natural phenomena hazards (earthquakes, floods, winds, etc.) are reviewed every 10 years to determine if major modifications to nuclear facilities are required by significant increases in risk from natural phenomena. During 2015, we reviewed the return period peak winds, rainfall, and snowfall values based on current Laboratory site meteorology data (Kelly et al. 2015). The data evaluation did not identify increases in return period weather phenomena that would require modifications to nuclear facility design.

Environmental Remediation (formerly Corrective Actions) Program

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 pose an unacceptable risk or dose to human health or the environment. Sampling is conducted to characterize sites and determine if releases have occurred and, if so, whether the nature and extent of the release are known or if further sampling is needed. Using the 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 or the environment. 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 needed to determine nature or extent of the release, and that the chemicals and radionuclides present do not pose an unacceptable risk or dose to humans, animals, or plants.

The New Mexico Environment Department granted certificates of completion for 38 sites in 2015. Of these, 28 sites were certified complete without controls, meaning no additional corrective actions or conditions are necessary. Certificates for the remaining 10 sites were for corrective actions complete with controls, which require future site use to be restricted to industrial activities. Table 3-2 presents a summary of the reports submitted and site investigations conducted in 2015 under the Environmental Remediation Program. Below is a brief summary of the annual vapor monitoring at Material Disposal Area C for 2015.

Table 3-2
Summary of Reports Submitted and Site Investigations Conducted in 2015 under the Environmental Remediation Program

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Technical Area 57 Aggregate Area (Fenton Hill) Investigation Report, Revision 1 (LANL 2015b)	57	2	Approximately 1.5 cubic yards of arsenic-contaminated soil was excavated at Area of Concern 57-007.
Conclusions/Recommendations: There are no potential unacceptable risks or doses under the industrial, construction worker, and residential scenarios; no potential ecological risks for any receptor; and the nature and extent of contamination is defined or no further sampling for extent is warranted. The Laboratory recommended the sites for corrective actions complete without controls.			
Upper Los Alamos Canyon Aggregate Area High-Angle Remediation Project	32	1	Approximately 158 cubic yards of mercury-contaminated soil was excavated and 22 confirmation samples were collected from 11 locations at Solid Waste Management Unit 32-002(b2). Additional samples were collected for an earthworm bioaccumulation study.
Conclusions/Recommendations: Site remediation was designed to result in no potential unacceptable risk to human health (all scenarios) and the environment. The maximum concentration of mercury remaining at the site is below the soil screening levels and indicates no potential unacceptable risk to human receptors. The remaining mercury concentrations also do not pose a potential risk to wildlife receptors and plants. The earthworm bioaccumulation study found no effect of mercury on survival and growth and confirmed the mercury left at the site was not an ecological risk. Details and results of the remediation will be presented in the Phase II investigation report for the Upper Los Alamos Canyon Aggregate Area.			
Sampling of solid waste management units and areas of concern within the Upper Los Alamos Canyon Aggregate Area	01, 43	6	A total of 206 surface and subsurface samples were collected from Solid Waste Management Units 01-001(g), 01-003(a), 01-003(b), 01-006(b), and 01-007(b) and Area of Concern C-43-001 to determine if remediation is warranted, and, if appropriate, to delineate area(s) to be remediated. Based on the 2015 sampling results, the area of concern does not require remediation, while the five solid waste management units will be remediated.
Upper Sandia Canyon Aggregate Area Supplemental Investigation Report, Revision 1 (LANL 2015c)	03, 60, 61	42	The 2009 investigation data for 41 sites proposed for Phase II investigation and data from an additional site remediated in 2005–2006 were reevaluated using the revised process under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.
Conclusions/Recommendations: The Laboratory recommended no further investigation or remediation activities are warranted for 31 sites; 17 sites are appropriate for corrective actions complete without controls, and 14 sites are appropriate for corrective actions complete with controls. Additional sampling is needed to define the extent of contamination at 10 sites. A revised Phase II investigation work plan will be developed based on the conclusions and recommendations presented in this supplemental investigation report.			
Potrillo/Fence Canyons Aggregate Area Supplemental Investigation Report (LANL 2015d)	15, 36	16	The 2010 investigation data for 16 sites proposed for Phase II investigations were reevaluated using the revised process under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.
Conclusions/Recommendations: The Laboratory recommended no further investigation or remediation activities are warranted for seven sites; six sites are appropriate for corrective actions complete without controls, and one site is appropriate for corrective actions complete with controls. Additional sampling is needed to define the extent of contamination at eight sites, and three sites are recommended for remediation. A Phase II investigation work plan will be developed based on the conclusions and recommendations presented in this supplemental investigation report.			

Table 3-2 (continued)

<table>
<tr><th>Document/Activity</th><th>Technical Area</th><th>Number of Sites</th><th>Sampling and Remediation</th></tr>
<tr><td>S-Site Aggregate Area Supplemental Investigation Report (LANL 2015e)</td><td>11, 13, 16</td><td>63</td><td>The 2009–2010 investigation data for 61 sites proposed for Phase II investigation were reevaluated using the revised process under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: The Laboratory recommended no further investigation/remediation activities are warranted for 44 sites; 43 sites are appropriate for corrective actions complete without controls, and 1 site is appropriate for corrective actions complete with controls. No further sampling or corrective action are warranted for 2 investigation areas. Because 9 sites could not be sampled completely or at all because of historical property preservation constraints, characterization is delayed but will be performed in the future, if possible. Additional sampling is needed to define the extent of contamination at 8 sites. A Phase II investigation work plan will be developed based on the conclusions and recommendations presented in this supplemental investigation report.</td></tr>
<tr><td>Upper Mortandad Canyon Aggregate Area Supplemental Investigation Report (LANL 2015f)</td><td>03, 35, 42, 48, 50</td><td>31</td><td>The 2009 investigation data for 31 sites proposed for Phase II investigation were reevaluated using the revised process under the framework agreement (January 2012), and the results are presented in this supplemental investigation report.</td></tr>
<tr><td colspan="4">Conclusions/Recommendations: The Laboratory recommended no further investigation or remediation activities are warranted for 25 sites; 24 sites are appropriate for corrective actions complete without controls, and 1 site is appropriate for corrective actions complete with controls. Additional sampling is needed to define the extent of contamination at 4 sites, and 6 sites are recommended for remediation. A revised Phase II investigation work plan will be developed based on the conclusions and recommendations presented in this supplemental investigation report.</td></tr>
</table>

Material Disposal Area C Subsurface Vapor Monitoring

Pore gas, or subsurface vapor, is the gas stored within pore spaces of soils or rocks. Subsurface vapor monitoring was conducted during 2015 beneath and in the area surrounding Material Disposal Area C. Subsurface vapor samples have been collected at the site since 2004. Monitoring data indicate volatile organic compounds and tritium are present in the pore gas (LANL 2012a). Although there is no current risk to humans from the volatile organic compounds and tritium in the subsurface vapor, the pore gas beneath Material Disposal Area C continues to be monitored to assess any changes in conditions. The analytical data are available online at the IntellusNM website: http://www.intellusnm.com.

Subsurface vapor monitoring at Material Disposal Area C was conducted twice during calendar year 2015 at 80 sampling ports within 18 vapor-monitoring wells. Figure 3-2 presents the 18 vapor-monitoring wells sampled during 2015 at Material Disposal Area C. The sampling locations and frequency were specified by the New Mexico Environment Department (2011). The first sampling event was conducted during March and April 2015, and the second sampling event was conducted during October and November 2015.

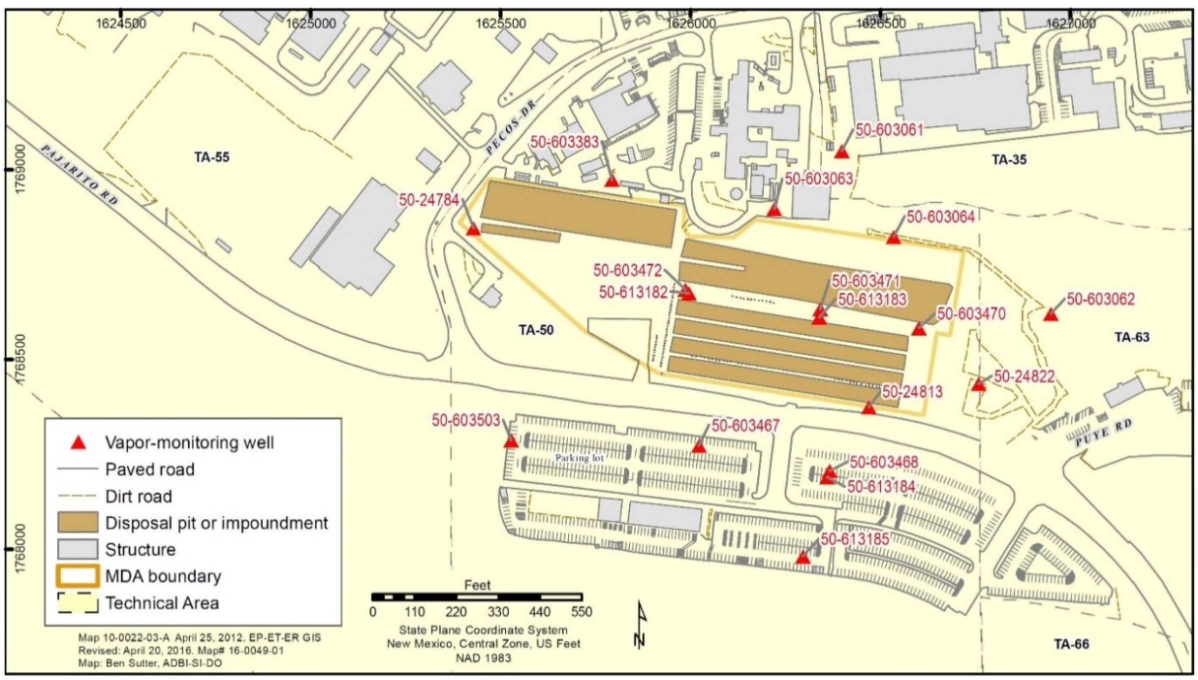

Figure 3-2 2015 Material Disposal Area C vapor-monitoring well locations

Because no regulatory criteria currently exist for substances in pore gas, the Laboratory evaluated the volatile organic compound pore-gas data using a Tier I and Tier II screening analyses for human health risk (LANL 2012a). A Tier I screening analysis uses conservative exposure assumptions and simple modeling for human health risk assessment. A Tier II screening analysis uses more realistic exposure assumptions and more detailed modeling. The Tier I screening analysis has routinely been used to evaluate the concentrations of substances in pore water (water held in pore spaces of soil or rock) that would be in equilibrium with the maximum pore-gas concentration of each volatile organic compound detected. The Tier II screening analysis expands on the Tier I screening analysis by considering the migration (dilution and attenuation) of volatile organic compounds to the water table and subsequent mixing with groundwater (LANL 2012a). The Tier II screening levels, therefore, are more representative of conditions at Material Disposal Area C. The Tier II screening levels vary with depth because they are a function of the depth to groundwater.

A total of 16 volatile organic compounds and tritium were detected in pore gas beneath Material Disposal Area C during the first 2015 sampling event, and 20 volatile organic compounds and tritium were detected in pore gas during the second 2015 sampling event. Trichloroethene was the only volatile organic compound detected at concentrations above the Tier II screening levels in 2015. Tier II screening levels for trichloroethene were exceeded in samples collected at monitoring well 50-24813 during March and April 2015. Tier II screening levels for trichloroethene were exceeded in samples collected at monitoring wells 50-24813 and 50-603471 during October and November 2015. The locations with the highest trichloroethene concentrations were consistent with previous monitoring data (LANL 2012b, 2013, 2014, 2015g).

At most locations, the tritium activity decreased with depth. A Tier II screening level for tritium (288,800 picocuries per liter) has been calculated as the product of the Tier I screening level (20,000 picocuries per liter) and an aquifer dilution factor of 14.44 (LANL 2012a). Most tritium activities (>85%) were below the Tier II screening level. However, the Tier II screening level for tritium does not account for transport in the unsaturated zone. Tritium activities exceeded the Tier II screening level at monitoring wells 50-603470, 50-603383, and 50-603472 for both sampling events. These results are consistent with previous sampling data.

The vapor plume of volatile organic compounds and tritium is associated with disposal trenches and shafts near the eastern end of Material Disposal Area C. Although the vapor plume is presently located more than 800 feet above the regional aquifer, there is some uncertainty associated with the future transport of vapor-phase substances through the fractured dacite rock layer beneath the plume. Therefore, soil vapor extraction has been recommended as a remedy to decrease subsurface vapor concentrations of volatile organic compounds, particularly trichloroethene. Vapor monitoring at Material Disposal Area C will continue on a semiannual basis to support remedy selection.

Land Transfer Program

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, 15 tracts have been conveyed to Los Alamos County, 3 tracts have been conveyed to the Los Alamos County School District, and 3 tracts have been transferred to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso.

The Land Conveyance and Transfer Project Office continues to work with the Los Alamos Field Office to complete the outstanding compliance activities and requirements needed to convey the remaining tracts. In 2015, accomplishments included the following:

- Confirmatory sampling was done for several tracts proposed for conveyance to Los Alamos County, in accordance with DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment.
- Environmental Baseline Survey Reports were prepared for seven tracts.
- The radiological warning signs on the remediated Material Disposal Area B fence in Tract A-16-a were removed, but the existing durable fence will remain for the foreseeable future to prevent dumping and unauthorized access.
- Demolition of the sewage treatment plant in Tract A-16-d was done in October 2015.
- Several field meetings were held with Los Alamos County and the U.S. Forest Service to discuss erosion issues associated with the new trail segment through Tract A-14-C.

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 analytical data collection process starts with sample planning. Field collection forms and chains of custody are created to support the process. Upon completion of field sampling, samples are delivered to the analytical laboratory through the Laboratory's Sample Management Office following standardized procedures. Documentation of the transfer is stored for sample and invoice tracking.

Once analytical laboratories have completed their analyses, they electronically upload the results into the Laboratory's Environmental Information Management system. Email notifications are sent to the Sample Management Office indicating the data are ready for the Laboratory to review and process.

Staff review and auto validate the electronic data files. If errors 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 Laboratory processing (such as incorrect location identification), the Sample Management Office fixes the issue and auto validates the data. 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 processed to the final data tables in the Environmental Information Management system.

Once data are in the final tables, they are available to the Laboratory environmental programs for review, analysis, and reporting. Data transit time from the holding tables to final tables is typically less than a day during business hours.

Field data (such as soil type or texture) may be collected in conjunction with analytical sample data. Field data are imported directly into the 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 sent to the final database tables.

Once data (field and analytical) are released to the final database tables, they are automatically released to the IntellusNM website (http://www.intellusnm.com) on a nightly basis. This is true for all data except for data associated with third parties and selected data with hold flags manually applied by the Laboratory.

The Laboratory treats 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 Laboratory locations. The only exception to the normal data management process is the delay of the release of third-party data to the IntellusNM website. Instead of direct nightly release to the database, 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 default holding window has elapsed, the data are then automatically released to the IntellusNM website.

AWARDS AND RECOGNITION

- On November 24, 2015, the White House announced that the Laboratory received the GreenGov Presidential Climate Champion Award for implementing comprehensive and proactive strategies to mitigate the long- and short-term effects of climate change.
- The Laboratory's 2015 Presidential Migratory Bird Stewardship Award nomination received "Honorable Mention" by DOE Headquarters.

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LANL 2014: "Los Alamos National Laboratory 2013 Annual Site Environmental Report," Los Alamos National Laboratory report LA-UR-14-27564 (September 2014).

LANL 2015a: "Wildland Fire Management Plan: Synopsis 2015," Los Alamos National Laboratory report LA-UR-15-27838 (2015).

LANL 2015b: "Investigation Report for Technical Area 57 Aggregate Area (Fenton Hill), Revision 1," Los Alamos National Laboratory document LA-UR-15-29322 (December 2015).

LANL 2015c: "Supplemental Investigation Report for Upper Sandia Canyon Aggregate Area, Revision 1," Los Alamos National Laboratory document LA-UR-15-26598 (September 2015).

LANL 2015d: "Supplemental Investigation Report for Potrillo and Fence Canyons Aggregate Area," Los Alamos National Laboratory document LA-UR-15-27131 (September 2015).

LANL 2015e: "Supplemental Investigation Report for S-Site Aggregate Area," Los Alamos National Laboratory document LA-UR-15-28016 (November 2015).

LANL 2015f: "Supplemental Investigation Report for Upper Mortandad Canyon Aggregate Area," Los Alamos National Laboratory document LA-UR-15-28015 (December 2015).

LANL 2015g: "Los Alamos National Laboratory 2014 Annual Site Environmental Report," Los Alamos National Laboratory report LA-UR-15-27513 (September 2015).

NMED 2011: "Approval, Phase III Investigation Report for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50," New Mexico Environment Department letter to G.J. Rael (DOE-LASO) and M.J. Graham (LANL) from J.E. Kieling (NMED-HWB), Santa Fe, New Mexico (December 2011).

To Read About **Turn to Page**

The purpose of Los Alamos National Laboratory's (the Laboratory's) air-quality surveillance program is to protect the environment and public health and to 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 interrelated programs: (1) radiological ambient air sampling at locations used by people, plants, or animals; (2) sampling of radioactive emissions from air-emission stacks at Laboratory facilities; (3) gamma and neutron radiation monitoring near sources and near locations used by people, plants, and animals; (4) nonradiological ambient air monitoring for particulate matter concentrations, and (5) monitoring of local climate and weather. The specific objectives are to measure radiological airborne materials to calculate the doses to humans, plants, and animals. We compared measured and calculated results with U.S. Department of Energy and U.S. Environmental Protection Agency standards. In this report, the results of the 2015 measurements are presented, with the conclusion that the results were far below the U.S. Department of Energy and U.S. Environmental Protection Agency limits.

AMBIENT AIR SAMPLING

Introduction

Los Alamos National Laboratory's (LANL's or the Laboratory's) radiological air-sampling network measures activities of airborne radionuclides, such as plutonium, americium, uranium, and tritium. Regional airborne radioactivity from global fallout and naturally occurring radioactive materials is summarized in Table 4-1. The typical standard deviation of 2 picocuries per cubic meter (pCi/m^3) for tritium and 1 attocurie per cubic meter (aCi/m^3) for radioactive particulate matter results from uncertainties in the analytical processes and variation in local geology and weather. Particulate matter in the atmosphere is primarily caused by soil suspended in the air by wind. Windy, dry days increase the amount of soil suspended in the air, and there are seasonal variations based on weather.

We compare ambient air activities greater than background with the U.S. Environmental Protection Agency's 10-millirem (mrem) annual dose limit (EPA 1989) and the U.S. Department of Energy's (DOE's) 100-mrem annual dose limit (DOE 2011).

Table 4-1
Average Background Radionuclide Activities in the Regional Atmosphere

Analyte	Units	U.S. Environmental Protection Agency Limit	Average Background Concentrations
Tritium	pCi/m^3	1500	0 ± 2
Am-241	aCi/m^3	1900	0 ± 1
Pu-238	aCi/m^3	2100	0 ± 1
Pu-239	aCi/m^3	2000	0 ± 1
U-234	aCi/m^3	7700	9 ± 6
U-235	aCi/m^3	7100	1 ± 1
U-238	aCi/m^3	8300	8 ± 5

Air-Monitoring Network

During 2015, the Laboratory operated 40 environmental air-monitoring stations to sample radionuclides by collecting particulate matter (Figures 4-1 and 4-2). Sampling locations are categorized as regional (>10 kilometers from the Laboratory), perimeter, waste site (Area G), or on-site. We review the locations regularly to ensure good coverage of Laboratory operations. During 2015, locations of six stations were adjusted to improve coverage of potential sources and receptors (Figure 4-1). The station at Technical Area 41 (210) was removed because this historical area is no longer a potential source. In Santa Fe, station 299 was removed because station 226 provides better coverage. The station at Technical Area 21 (169) was removed because stations 290, 317, and 348 provide better coverage. In White Rock, station 121 was removed because stations 119, 167, 213, and 392 provide better coverage. Stations 393, 394, and 395 were added to improve coverage of the northern boundary of the Laboratory (Bruggeman et al. 2014).

These stations are operated continuously; filters are changed out every 2 weeks and sent to an analytical laboratory for analysis.

Quality Assurance

We maintain a quality assurance program that 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.

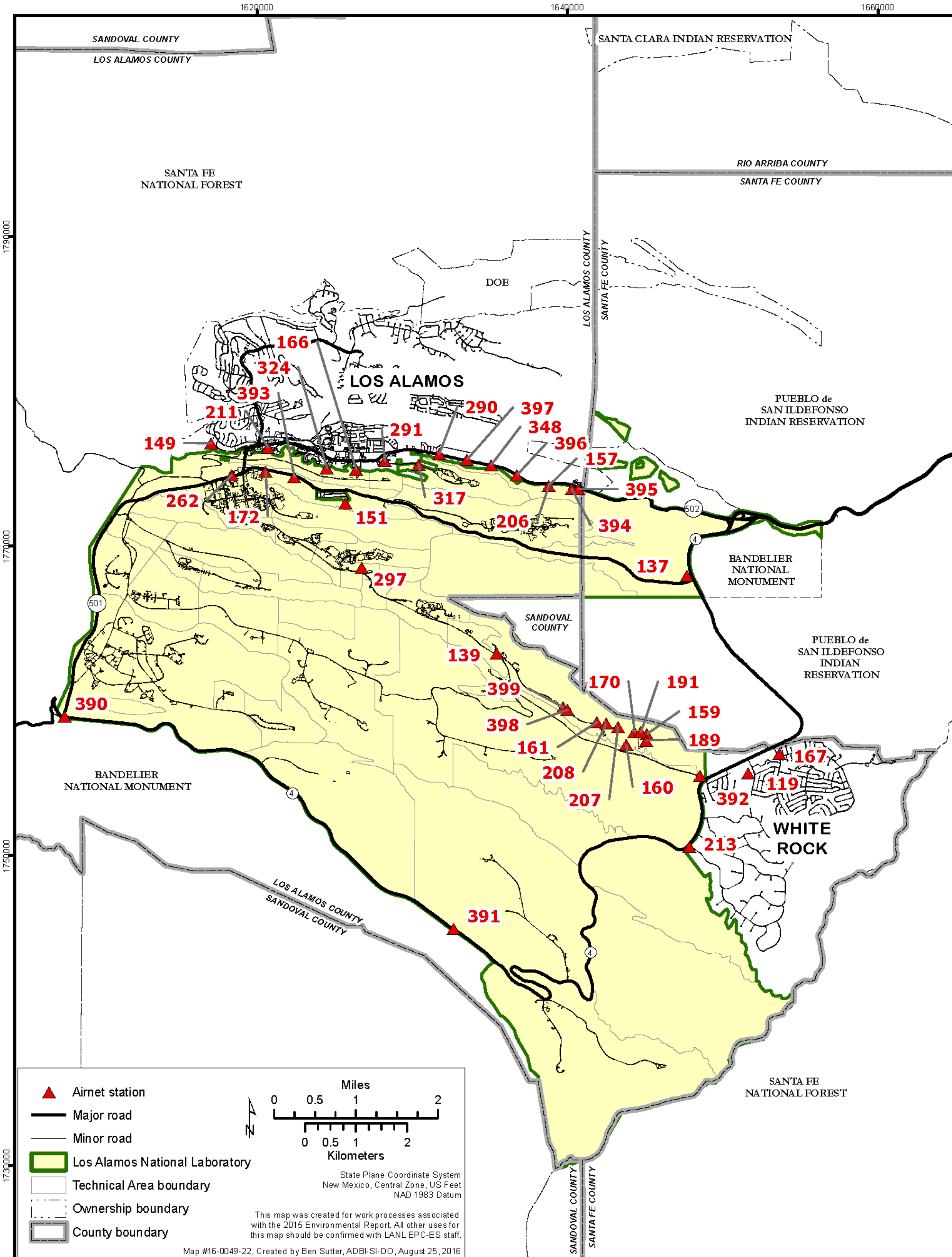


Figure 4-1 Environmental air-monitoring stations at and near the Laboratory

Ambient Air Activities

Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and natural processes by which high-energy cosmic rays interact with atoms, causing protons and neutrons to be expelled from the atom (Eisenbud and Gesell 1997). We measure the levels of tritiated water suspended in air because the dose impact from tritiated water is 25,000 times higher than from gaseous tritium (ICRP 1978). Water-vapor concentrations in the air and tritium activities in the water vapor are used to calculate ambient levels of tritium, which are corrected for blanks, bound water in the silica gel, and isotopic distillation effects.

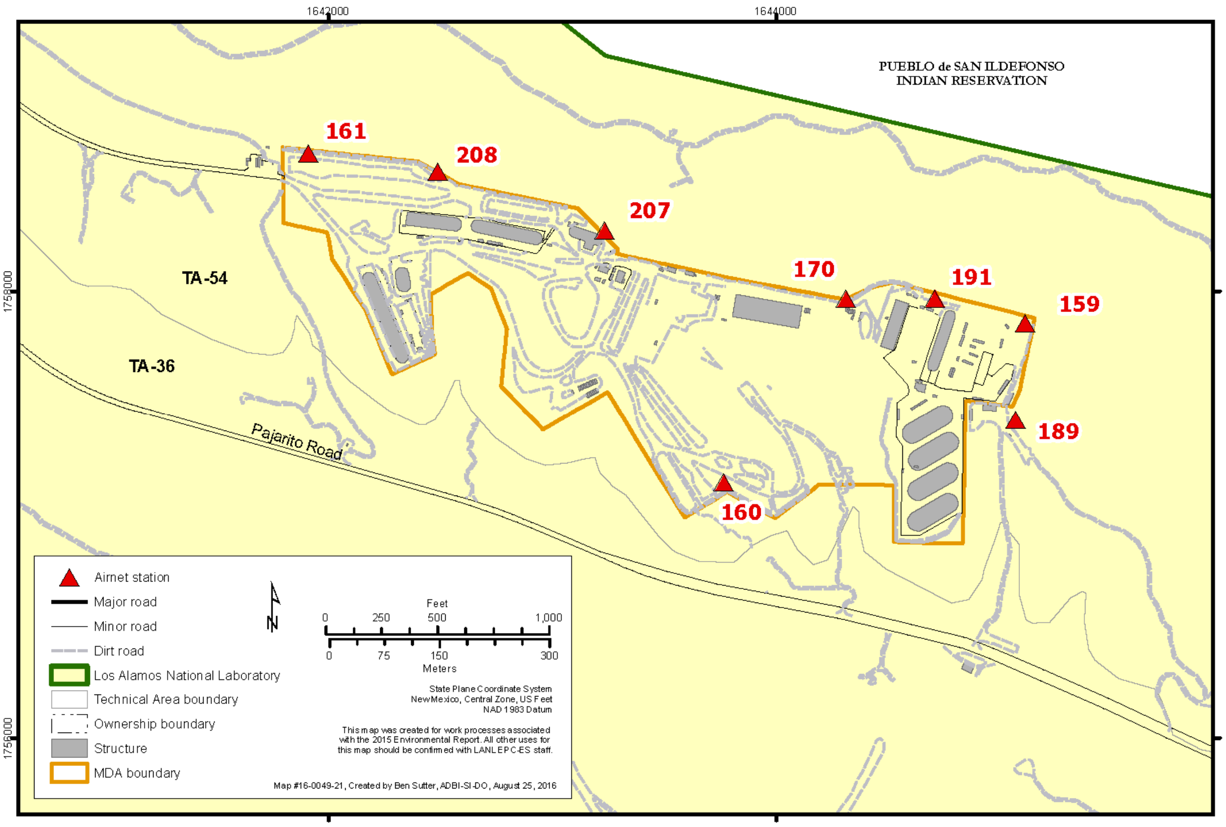
During 2015, annual mean activities were similar to recent years and well below U.S. Environmental Protection Agency and DOE guidelines (Table 4-2). The highest off-site annual tritium activity at any station was 0.3% of the U.S. Environmental Protection Agency public dose limit, which is 1500 pCi/m^3.

Table 4-2
Airborne Tritium as Tritiated Water Activities for 2015—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (pCi/m^3)		Maximum Annual Station Activity (pCi/m^3)
Regional	3	0	±2	1
Perimeter	27	1	±2	4
On-site	4	3	±8	9
Waste site	1	451		451

The waste site data are measured at a location at the southern boundary of Area G (station 160; Figure 4-2), which is a controlled area and not publicly accessible. Since 2001, the tritium activities at this location have decreased as shown in Figure 4-3, primarily because of radioactive decay.

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



MDA = Material disposal area.
TA = Technical area.

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

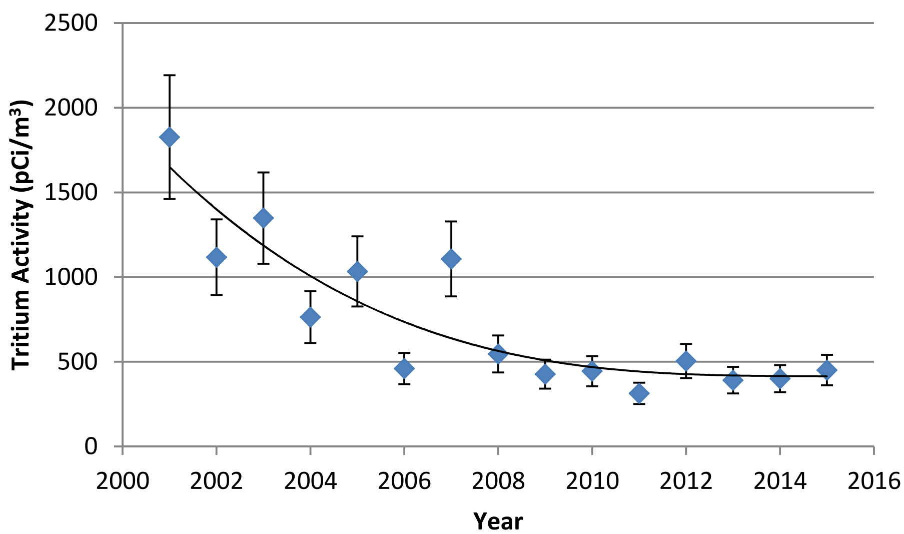


Figure 4-3 Tritium activities at the waste site, Area G, station 160

Americium-241

Table 4-3 summarizes the 2015 sampling data, which are similar to recent years, less than 0.1% of the regulatory limits, and not significantly different than zero.

Table 4-3
Airborne Americium-241 Activities for 2015—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (aCi/m³)		Maximum Annual Station Activity (aCi/m³)
Regional	3	0	±1	0
Perimeter	27	0	±1	1
On-site	2	0	±1	0
Waste site	8	0	±1	1

Plutonium

Plutonium from global fallout occurs worldwide, in low activities. Table 4-4 summarizes the plutonium-238 and plutonium-239/240 data for 2015, which are similar to recent years.

Table 4-4
Airborne Plutonium-238 and Plutonium-239/240 Activities for 2015—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m³)		Maximum Annual Station Activity (aCi/m³)	
		Pu-238	Pu-239/240	Pu-238	Pu-239/240
Regional	3	0 ±1	0 ±1	0	0
Perimeter	27	0 ±1	1 ±3	1	7
On-site	2	0 ±1	1 ±3	0	2
Waste site	8	0 ±1	2 ±6	1	9

South of the original Manhattan Project Technical Area 01, soil in Los Alamos Canyon has elevated plutonium-239 activities. Resuspension of soil from the steep canyon walls causes detectable air activities with an average plutonium-239 activity of 7 aCi/m^3. Near the historical location of the plutonium facility at Technical Area 21, the plutonium-239 activity was 4 aCi/m^3. These activities are much less than 1% of the regulatory limits and standards.

At the Area G waste site, the highest plutonium activity was 9 aCi/m^3, which is lower than previous years, because minimal amounts of soil were moved at Area G during 2015.

Uranium

Uranium-234, -235, and -238 are found in nature, and the highest airborne activities are at dusty locations. Natural uranium has constant and known relative isotopic abundances, and uranium-238 activity is generally equal to uranium-234 activity (Walker et al. 1989). Only natural uranium was detected in 2015. The uranium activities (Table 4-5) were similar to previous years and below 0.5% of the U.S. Environmental Protection Agency guidelines.

Table 4-5
Airborne Uranium-234, -235, and -238 Activities for 2015—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m³)		
		U-234	U-235	U-238
Regional	3	9 ±6	1 ±2	8 ±5
Perimeter	27	6 ±5	0 ±1	5 ±6
On-site	2	7 ±1	0 ±1	6 ±1
Waste site	8	7 ±6	0 ±1	7 ±6

Gamma Spectroscopy Measurements

For gamma screening, we analyze for the following: actinium-228, americium-241, beryllium-7, bismuth-212 and -214, cobalt-60, cesium-134 and -137, iodine-131, potassium-40, sodium-22, protactinium-234m, lead-212 and -214, thorium-234, and thallium-208. Only naturally occurring radionuclides were detected.

Special Monitoring

Los Alamos County fire department and Santa Fe National Forest personnel completed a prescribed burn in Acid Canyon on September 28, 2015. Pre-fire calculations estimated that the dose would be less than 0.1 mrem, which was confirmed by two high-volume air samplers operated from September 25 through October 5. One sampler was placed on the north side near Orange Street and the other on the south side at the Pajarito Environmental Education Center. All results were below the detection limits, and there was no measurable difference between airborne radionuclide activities before, during, and after the controlled burn.

Conclusion

Near the Laboratory, activities of airborne radioactive material were far below all regulatory limits.

STACK SAMPLING FOR RADIONUCLIDES

Introduction

Laboratory facilities using radioactive materials may be vented to the environment through a stack or other release point. The Laboratory's stack monitoring team evaluates these releases using engineering calculations and radioactive materials usage information. Every stack that may potentially result in a public dose greater than 0.1 mrem in a year is sampled in accordance with 40 Code of Federal Regulations 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities (EPA 1989).

Sampling Methodology

We categorize radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products.

For each of these emission types, the Laboratory employs an appropriate sampling method, as described below.

We sample emissions of radioactive particulate matter using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. Samples are collected weekly and shipped to an off-site analytical laboratory.

Charcoal cartridges are used to sample emissions of vapors and volatile compounds generated by operations at the Los Alamos Neutron Science Center, in shielded nuclear radiation containment chambers 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.

We measure gaseous mixed activation products emissions from Los Alamos Neutron Science Center activities using real-time monitoring data. A sample of stack air 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).

Particulate Matter

Each week, the glass-fiber filters are collected, shipped to an off-site analytical laboratory, and analyzed using alpha, beta, and gamma spectrometry to identify specific radionuclides. These data are used to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. We compare the results of the isotopic analysis with gross-activity measurements to ensure that the requested analyses (e.g., uranium-234, -235, and -238; plutonium-238 and -239/240; etc.) identify all significant radiological activity.

Vaporous Activation Products

The Laboratory removes and replaces the charcoal canisters weekly and ships the samples to the off-site analytical laboratory where gamma spectroscopy identifies and quantifies the presence of vaporous radioactive isotopes.

Tritium

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

Gaseous Mixed Activation Products

To record and report gaseous mixed activation products emissions, we use continuous monitoring, rather than off-site analysis, for two reasons. First, standard filter paper and charcoal filters will not collect the radionuclides of interest because of the nature of the emissions. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-site. The gaseous mixed activation products monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total gaseous mixed activation products emissions are measured with the ionization chamber. 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 emissions. Using decay curves and energy spectra to identify the various radionuclides, the relative composition of the emissions is determined.

Analytical Results

Measurements of Laboratory stack emissions during 2015 totaled approximately 126 curies (compared with 380 curies in 2014). Of this total, tritium emissions contributed approximately 38 curies (compared with 290 curies in 2014), and gaseous mixed activation products from Los Alamos Neutron Science Center stacks contributed 88 curies (compared with 90 curies in 2014). Los Alamos Neutron Science Center diffuse emissions contributed another 54 curies of gaseous mixed activation products. Combined airborne emissions of particulate materials such as plutonium, uranium, americium, and thorium were about 0.00001 curies. Emissions of particulate matter plus vapor activation products were about 0.05 curies (short-lived progeny are included in the sum).

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. During 2015, the Los Alamos Neutron Science Center facility nonpoint source emissions of gaseous mixed activation products comprised approximately 41 curies of carbon-11 and 13 curies of argon-41.

Table 4-6
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2015

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		3.2E-07	4.1E-06	7.8E-06	6.6E-07		
TA-16-205/450	2.4E+01						
TA-48-001				1.3E-08		5.3E-02	
TA-50-001		5.2E-08	2.4E-07	4.0E-07	6.1E-08		
TA-50-069			2.4E-10	1.0E-08	6.6E-10		
TA-53-003	1.0E+01					2.1E-04	3.0E+01
TA-53-007	2.6E+00					1.3E-03	5.8E+01
TA-54-375					1.5E-08		
TA-54-231/412				1.0E-08	3.0E-09		
TA-55-004	1.5E+00		5.2E-09	4.6E-08	1.1E-07		
Total	3.8E+01	7.5E-08	4.4E-06	8.3E-06	8.5E-07	5.5E-02	8.8E+01

Table 4-7
Detailed Results of Activation Product Sampling from LANL Stacks in 2015

Building No.	Nuclide	Emission (curies)
TA-48-0001	As-73	4.6E-05
TA-48-0001	As-74	9.7E-05
TA-48-0001	Br-77	4.2E-03
TA-48-0001	Br-82	5.8E-05
TA-48-0001	Ga-68	1.7E-03
TA-48-0001	Ge-68	1.7E-03
TA-48-0001	Hg-197	4.7E-02
TA-48-0001	Se-75	1.9E-04
TA-53-0003	Ar-41	1.2E+00
TA-53-0003	Be-7	4.9E-05
TA-53-0003	Br-76	1.4E-05
TA-53-0003	Br-77	3.1E-06
TA-53-0003	Br-82	1.3E-04
TA-53-0003	C-11	2.9E+01
TA-53-0003	Hg-197	1.1E-05
TA-53-0003	Na-24	2.3E-06
TA-53-0007	Ar-41	5.7E+00
TA-53-0007	Br-76	6.4E-05
TA-53-0007	Br-77	2.1E-06
TA-53-0007	Br-82	1.0E-03
TA-53-0007	C-10	1.0E-01
TA-53-0007	C-11	2.8E+01
TA-53-0007	Hg-197	2.0E-04
TA-53-0007	N-13	1.4E+01
TA-53-0007	N-16	2.1E-01
TA-53-0007	O-14	1.5E-01
TA-53-0007	O-15	9.6E+00
TA-53-0007	Os-191	7.3E-07
TA-53-0007	Se-75	1.4E-07

Table 4-8
Radionuclide Half-Lives

Nuclide	Half-Life
H-3	12.3 years
Be-7	53.4 days
C-10	19.3 seconds
C-11	20.5 minutes
N-13	10.0 minutes
N-16	7.13 seconds
O-14	70.6 seconds
O-15	122.2 seconds
Na-22	2.6 years
Na-24	14.96 hours
Ar-41	1.83 hours
Co-60	5.3 years
As-73	80.3 days
As-74	17.78 days
Br-76	16 hours
Br-77	2.4 days
Br-82	1.47 days
Se-75	119.8 days
Sr-90	28.6 years
Cs-134	2.06 years
Cs-137	30.2 years
Os-191	15.4 days
Hg-197	2.67 days
U-234	244,500 years
U-235	703,800,000 years
U-238	4,468,000,000 years
Pu-238	87.7 years
Pu-239	24,131 years
Pu-240	6569 years
Pu-241	14.4 years
Am-241	432 years

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 microcurie range. Recent maintenance on the Technical Area 16 emission-control systems resulted in reduced tritium emissions: 38 curies in 2015 compared with 280 curies in 2014. In summary, the 2015 air emissions were generally lower than most previous years.

GAMMA AND NEUTRON RADIATION MONITORING

Introduction

The objectives of the direct penetrating radiation monitoring network and of the neighborhood environmental watch network are to monitor gamma and neutron radiation in the environment, as required by DOE Order 458.1 Chg 3, and to demonstrate compliance with the DOE all-pathway dose limit of 100 mrem/yr.

Short-lived airborne radionuclides cannot be measured by the radiological air-sampling network, so thermoluminescent dosimeters are deployed at every environmental air-monitoring station to monitor short-lived radioactivity as well as radioactive material above the breathing height. In addition, neighborhood environmental watch network stations are situated at key locations. Radiation from the Los Alamos Neutron Science Center depends on whether the accelerator is on or off, and short-lived activation products such as carbon-11 are only detected when the wind is directed from the source to the detector. These fluctuations are apparent in the real-time neighborhood environmental watch network station displays at http://environweb.lanl.gov/newnet/, and the results are consistent with the measurements of Los Alamos Neutron Science Center emissions reported in the Stack Sampling for Radionuclides section of this chapter.

In northern New Mexico, naturally occurring gamma radiation varies from 100 mrem/yr to 200 mrem/yr, so it is difficult to measure the much smaller radiation dose from the Laboratory. To meet the objectives, measurements are made both at public locations and close to potential sources, and the data are compared with models of radiation levels as a function of distance (McNaughton 2013). Thus, radiation from the Laboratory is distinguished by higher levels close to the sources and also from the trend of the radiation levels with distance from the source.

Dosimeter Locations

Eighty thermoluminescent 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 thermoluminescent dosimeters are located around Technical Area 54, Area G, as shown in Figure 4-4.

Neutron Dosimeters

Neutron doses are monitored by all thermoluminescent dosimeters and are measured more accurately at 47 thermoluminescent dosimeter locations near known or suspected sources of neutrons at the Los Alamos Neutron Science Center and at Technical Area 54, Area G.

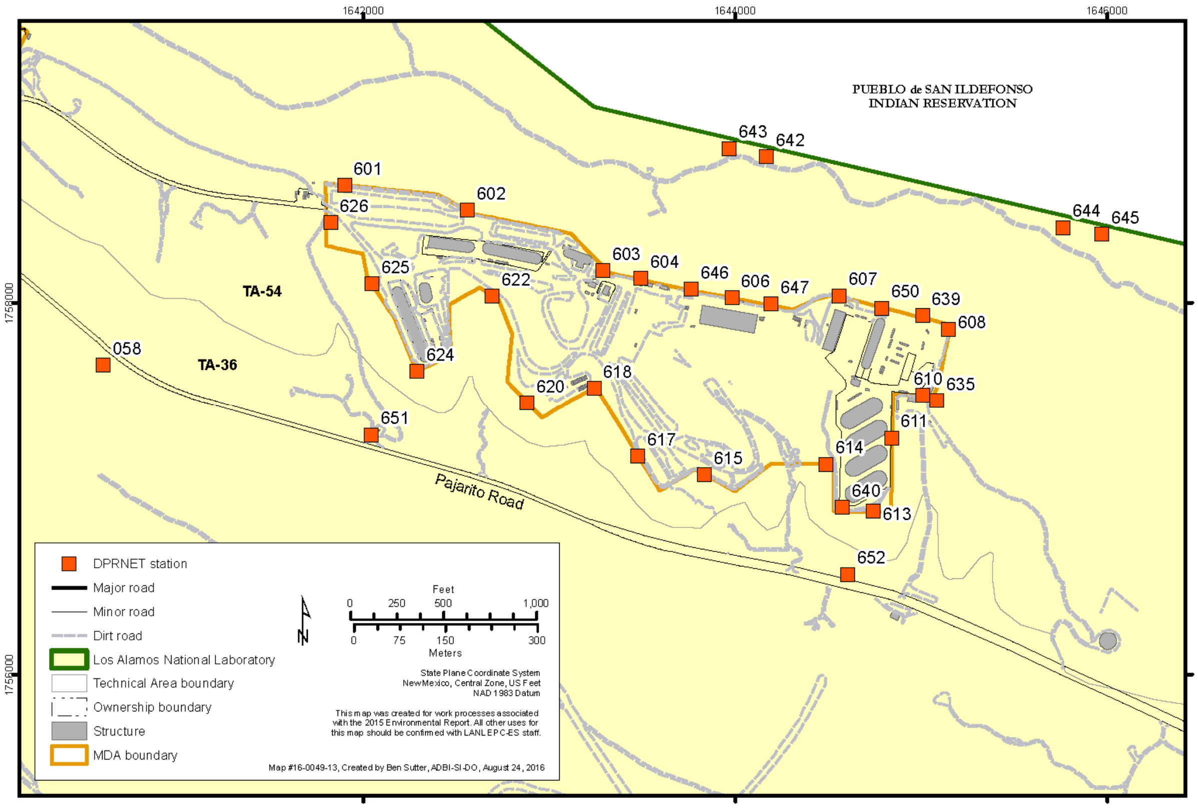


Figure 4-4 Thermoluminescent dosimeter locations at Technical Area 54, Area G, as part of the direct penetrating radiation monitoring network (DPRNET)

Neutron Background

The neutron background is measured at a location where it is isolated from human-produced neutrons. These background data are supplemented by data from other locations far from Laboratory sources.

Quality Assurance

The Radiation Protection Division calibration laboratory at LANL calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited these dosimeters, and the Radiation Protection Division provides quality assurance for the dosimeters. The uncertainty in the thermoluminescent dosimeter data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall uncertainty (one standard deviation) is 8%.

Results

The annual dose equivalents at all locations except those within the Los Alamos Neutron Science Center or near Area G are consistent with natural background radiation and with previous measurements. The only locations with a measurable contribution from Laboratory operations are near the Los Alamos Neutron Science Center and Technical Area 54, Area G, as discussed below.

Los Alamos Neutron Science Center at Technical Area 53

DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, requires determination of the doses to a hypothetical maximally exposed individual member of the public, both on-site and off-site. The only on-site location where a member of the public could receive a measurable dose is along Jemez Road as it passes by the Los Alamos Neutron Science Center (McNaughton 2013), so thermoluminescent dosimeters at the Los Alamos Neutron Science Center are used to determine this dose.

Away from the Los Alamos Neutron Science Center complex, the only thermoluminescent dosimeter at Technical Area 53 that measures an above-background gamma dose is at a location 100 meters from the tanks at the east end, where the dose was 166 mrem/yr, 36 mrem/yr above the background of 130 mrem/yr. Jemez Road is in Sandia Canyon, so it does not receive direct radiation. However, Jemez Road receives photons that are scattered from the air, known as “sky shine.” The Monte Carlo N-Particle program calculates that the dose at Jemez Road, 500 meters south of the tanks, is 0.2% of the dose at the location 100 meters north of the tanks (McNaughton 2013). Therefore, during 2015, the gamma dose at Jemez Road from the tanks was 0.2% of 36 mrem/yr, which is 0.1 mrem/yr. This is the dose that would be received by a person who is at this location 24 hours per day, 365 days per year. There are no public facilities near this location, so the occupancy factor is less than 1%, and the gamma dose to a member of the public is less than 0.001 mrem/yr.

The annual neutron dose on the mesa overlooking Jemez Road at the Los Alamos Neutron Science Center was 4 mrem above background. Jemez Road is in Sandia Canyon, so it only receives neutrons that are scattered from the air. Monte Carlo N-Particle calculations show that the annual dose at Jemez Road, 350 meters south of the Line D targets, is 10% of the 4-mrem dose on the mesa (McNaughton 2013). After adjusting for occupancy, the potential neutron dose to a member of the public is less than 0.01 mrem.

Technical Area 54, Area G

Figure 4-4 shows the locations of the thermoluminescent dosimeters at Technical Area 54, Area G. Situated south of the line of dosimeters 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 thermoluminescent dosimeters was 1.6 mrem. 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 1/16 is applied (NCRP 1976), so the public dose in Cañada del Buey at the dosimeters is calculated to be 1.6/16 = 0.1 mrem/yr, which is similar to previous years.

For the past 10 years, neutron radiation has been a significant contributor to the all-pathway hypothetical maximally exposed individual near Area G. From 2010 to 2013, the dose rate near Area G decreased significantly (Figure 4-5) as waste was shipped off-site to the Waste Isolation Pilot Plant. During 2014, Waste Isolation Pilot Plant shipments ceased. The transuranic radionuclide inventory at Area G has remained essentially constant, and the neutron dose rates have not changed significantly.

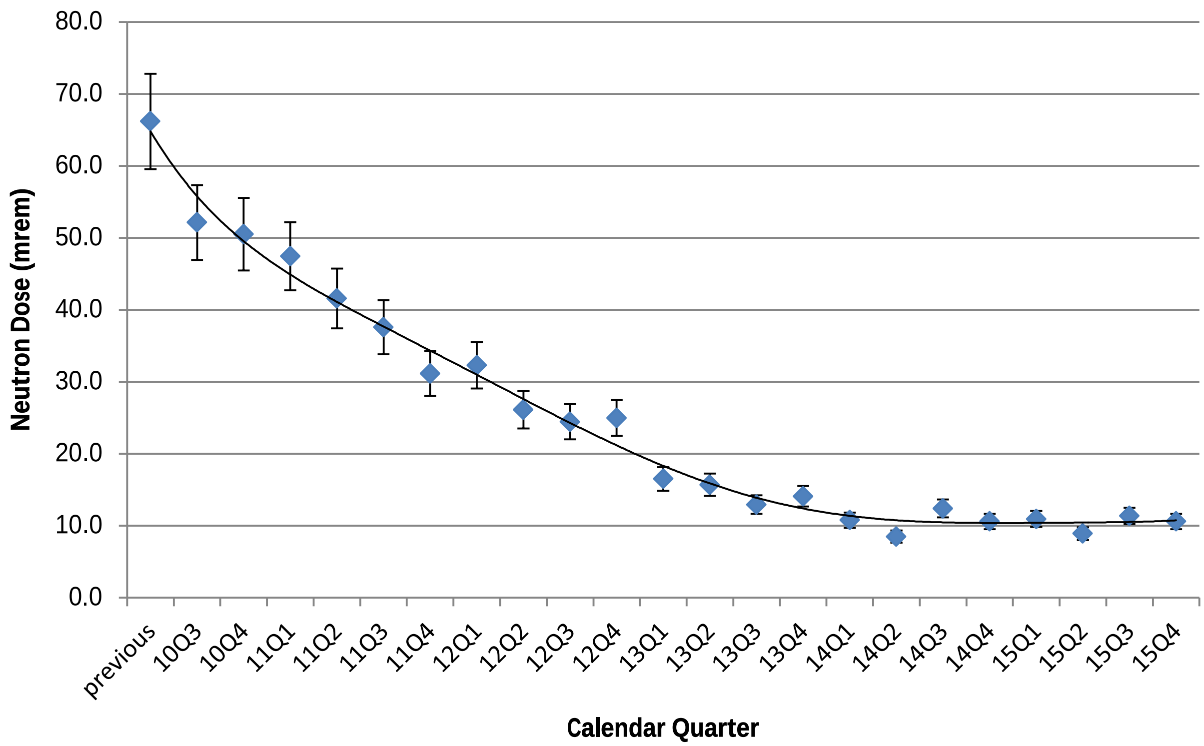


Figure 4-5 **Average quarterly neutron doses around the perimeter of Area G for the past 22 calendar quarters. The first point, at 66 mrem, is the average of the previous 14 calendar quarters. Natural background contributes less than 1 mrem to each point.**

Neighborhood Environmental Watch Network

During 2015, the neighborhood environmental watch network did not record any doses above the normal background, which indicates that the public dose from gamma-emitting radionuclides was well below 1 mrem/yr.

Conclusion

Generally, the data are similar to previous years. The results are far below the applicable limits; when an occupancy factor is included, the largest doses at public locations are all less than 1 mrem/yr, and no further action is required to address radiological exposure to the public from Laboratory operations.

NONRADIOLOGICAL AIR MONITORING

Introduction

We monitor particulate matter smaller than 2.5 micrometers at two locations: the old White Rock Fire Station on Rover Boulevard and the Los Alamos Medical Center.

Ambient Air Particulate Matter Concentrations

During 2015, the particulate matter concentrations remained well below the U.S. Environmental Protection Agency standard: 35 micrograms per cubic meter (µg/m^3)

for particulate matter smaller than 2.5 micrometers. Typical concentrations (>95% of the time) were less than 10 µg/m^3. The highest concentrations occurred during the spring from windblown dust and during the summer from wildfires in Arizona and New Mexico. During 2015, the maximum concentration for particulate matter smaller than 2.5 micrometers in a 24-hour period was 20 µg/m^3.

METEOROLOGICAL MONITORING

Introduction

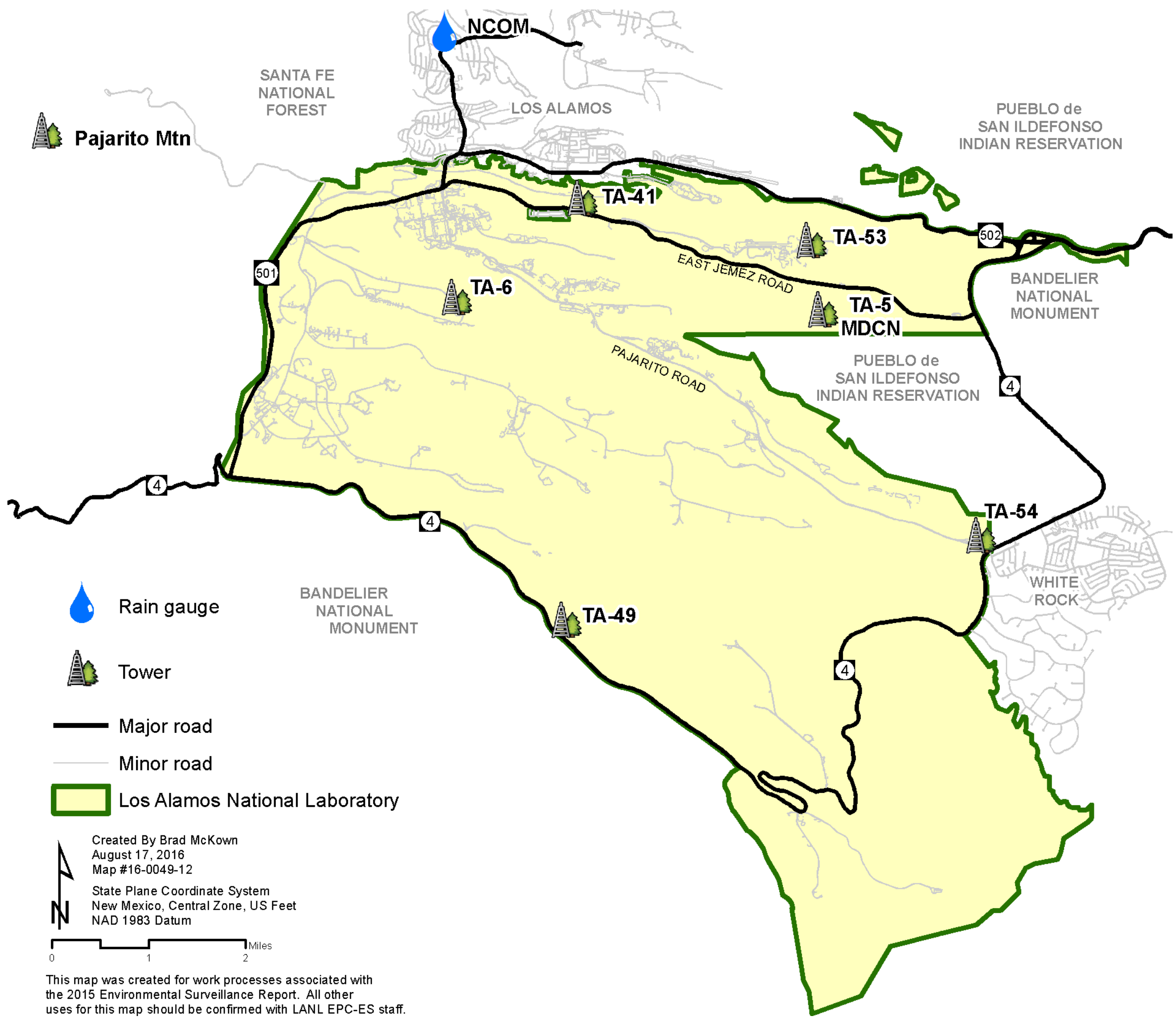
Weather data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. The meteorology program measures wind speed and direction, 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://weather.lanl.gov/.

Monitoring Network

Currently, a network of five stations gathers meteorological data at the Laboratory (Figure 4-6). The station in Los Alamos Canyon at Technical Area 41 was decommissioned on September 30, 2015. Four of the stations are located on mesa tops (Technical Areas 06, 49, 53, and 54), and one is in Mortandad Canyon (Technical Area 05). A precipitation gauge is also located in North Community of the Los Alamos townsite. The Technical Area 06 station is the official meteorological measurement site for the Laboratory.

Sampling Procedures, Data Management, and Quality Assurance

We place instruments in the meteorological network in areas with good exposure to the elements being measured, usually in open fields, to avoid effects 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 boundary layer flow and stability conditions. The multiple levels also provide redundant measurements that support data quality checks. The boom-mounted temperature sensors are shielded and aspirated to minimize solar-heating effects. The Mortandad Canyon station includes a 10-meter tripod tower that measures wind at a single level (tower top). In addition, 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 4-6 Locations of meteorological monitoring towers and rain gauges

Analog to digital conversion data loggers at the stations sample most of the meteorological variables at a frequency of 0.33 hertz, store the data, average the samples over a 15-minute period, and transmit the data by network connection, telephone modem, or cell phone to a UNIX workstation. The workstation automatically edits measurements that fall outside of realistic ranges (Dewart et al. 2016). Time-series plots of the data are also generated for a meteorologist's data quality review. Daily statistics of certain meteorological variables (e.g., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. For more than 50 years, we have provided these daily weather statistics to the National Weather Service. In addition, cloud type and percentage cloud cover are logged daily.

Calibration frequency varies by instrument, following manufacturers' recommendations and operational considerations. All wind instruments are calibrated every 6 months. All other sensors are calibrated annually, with the exception of solar radiation sensors, which are calibrated every 5 years according to manufacturer's specifications. An external audit of the instrumentation and methods is performed periodically. An external subcontractor inspects and performs maintenance on the station network structures and hoists on an annual basis.

The meteorology program met American National Standards Institute 2010 standards for data completeness with seven exceptions. Four of the failures were a result of a lightning strike at Technical Area 53 on May 21, 2015. Two of the failures were because of calibration failures of Technical Area 54 level 1 wind direction and level 2 vertical speed instruments. The last failure was the result of rewiring the longwave sensors and a battery failure at Technical Area 54. These instrument issues have been addressed. Data quality and completeness are reported by Dewart et al. (2016).

Climate

Los Alamos has a temperate, semiarid mountain climate. Atmospheric moisture levels are low, and clear skies are present about 75% 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 meteorology program and following Bowen (1990 and 1992).

The current climatological standard normal is defined as the time period from 1981 to 2010. Table 4-9 presents the temperature and precipitation records set for Los Alamos from 1924 to 2015.

Table 4-9
Records Set between 1924 and 2015 for Los Alamos

Type of Measurement	Record	Date
Low temperature	-18°F	January 13, 1963
High temperature	95°F	June 29, 1998, and June 27, 2013
Single-day rainfall	3.52 inches	September 13, 2013
Single-day snowfall	39 inches	January 15, 1987
Single-season snowfall	153 inches	1986–1987

December and January are the coldest months. The majority (90%) of minimum temperatures during December and January range from 4°F to 31°F. Minimum temperatures are usually reached shortly before sunrise. Ninety percent of maximum temperatures, which are usually reached in midafternoon, range from 25°F to 55°F. Wintertime arctic air masses that descend into the central United States tend to have sufficient time to heat before they reach Los Alamos’s southern latitude, so the occurrence of local subzero temperatures is infrequent. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. Ninety percent of maximum temperatures range from 67°F to 89°F. During the summer months, 90% of minimum temperatures range from 45°F to 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 of the storms by the high terrain.

Precipitation in July and August accounts for 34% of the annual precipitation and encompasses the bulk of the rainy season, which typically begins in early July and ends in mid-September. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convectively and/or 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 upslope along the ground. This is called anabatic flow. During the night, cool air that forms close to the ground tends to flow downslope and is known as katabatic flow. As the daytime anabatic breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerlies of the Pajarito Plateau. Nighttime katabatic flow 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 as katabatic flow 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 faster surface winds. At night, there is little mixing, so wind at the surface receives less boosting from aloft.

2015 in Perspective

Table 4-10 presents a tabular perspective of Los Alamos weather during 2015, including snowfall and wind data. Figure 4-7 presents a graphical summary of Los Alamos temperature for 2015 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 present. Figure 4-7 shows that 2015 was warmer than normal because more days had temperatures above average than below. The last line of Table 4-10 summarizes the year and shows that the overall average temperature and total precipitation were 2.5°F and 4.28 inches above the 1981–2010 averages.

Table 4-10
Monthly and Annual Climatological Data for 2015 at Los Alamos

Month	Temperatures (°F)[a]								Precipitation (inches)[a]				12-meter Wind (miles per hour)[a]				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure[b]	Highest	Day	Lowest	Day	Total	Departure[b]	Total	Departure[b]	Average Speed	Departure[c]	Speed	From	Day
January	41.7	22.6	32.2	2.8	57	26	9	3	1.28	0.33	14.8	1.5	4.7	-0.3	28	SW	30
February	47.8	25.4	36.6	3.7	61	8	9	23	0.84	-0.02	15.9	5.0	5.6	-0.2	37	W	20
March	58.2	33.6	45.9	6.5	73	16	16	5	0.84	-0.36	1.7	-8.7	6.3	-0.2	46	W	2
April	62.0	37.0	49.5	2.7	75	30	26	17	0.85	-0.21	3.6	0.3	8.3	0.7	45	WSW	15
May	64.7	41.7	53.2	-2.8	77	1	31	10	2.80	1.41	0	-0.3	7.0	-0.4	40	SE	18
June	80.7	55.3	68.0	2.9	93	21	48	14	2.12	0.61	0	0	6.2	-0.9	44	WSW	6
July	78.2	55.8	67.0	-1.2	88	1	50	10	6.68	3.86	0	0	5.3	-0.3	35	NW	12
August	80.1	56.4	68.2	2.4	86	14	50	20	2.66	-0.95	0	0	5.6	-0.1	45	NNW	18
September	78.6	52.8	65.7	5.9	85	13	48	23	0.35	-1.66	0	0	5.8	0	38	W	2
October	64.4	42.8	53.6	4.4	82	1	32	28	3.15	1.60	0	-2.2	5.6	-0.4	47	WSW	20
November	49.9	28.5	39.2	1.3	65	2	21	18	0.80	-0.18	2.0	-2.9	6.3	1	56	WNW	11
December	39.9	22.4	31.2	1.8	55	7	8	16	0.88	-0.13	14.7	2.5	5.7	0.8	47	N	26
Year	62.2	39.6	50.9	2.5	93	Jun 21	8	Dec 16	23.25	4.28	52.7	-4.8	6.0	-0.1	56	WNW	Nov 11

[a] Data from Technical Area 06, the official Los Alamos weather station. Wind speed is measured at 12 meters above ground level.
[b] Departure column indicates positive or negative departure from 1981 to 2010 (30-year) climatological average.
[c] Departure column indicates positive or negative departure from 1990 to 2010 (21-year) climatological average.

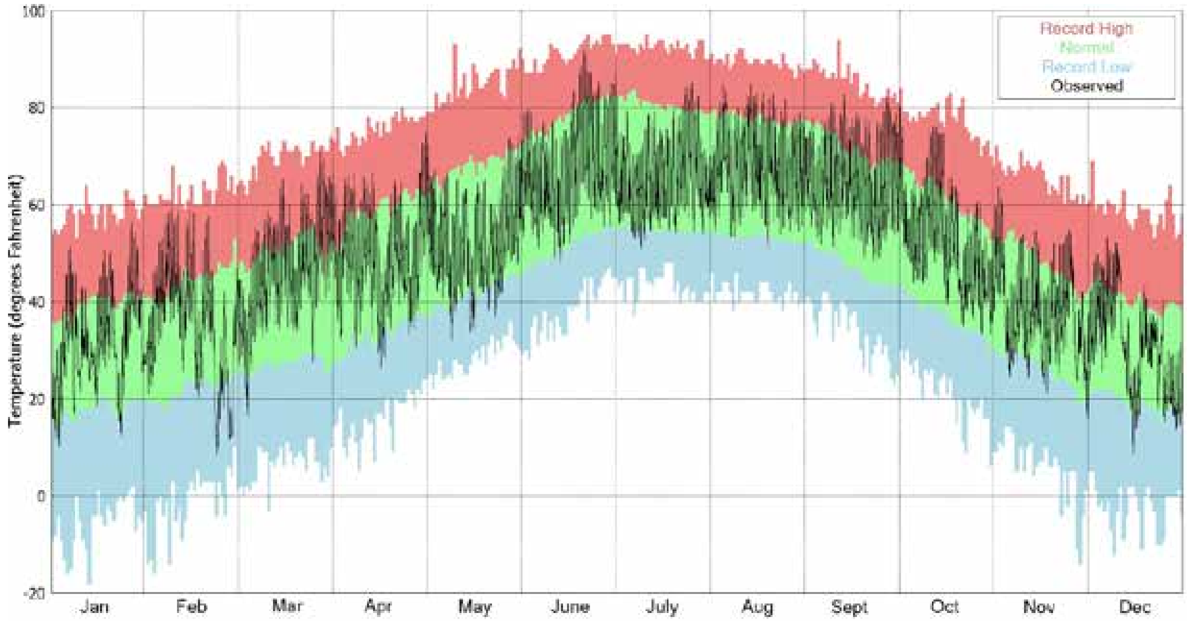


Figure 4-7 **Los Alamos 2015 temperatures in degrees Fahrenheit compared with record values and normal values**

Figures 4-8 and 4-9 present graphical summaries of Los Alamos precipitation for 2015. The year began with near-average precipitation until May. From May to July, Los Alamos measured above-average precipitation, particularly in July with 3.86 inches above average. The total precipitation from January 1 to August 3 was 6.39 inches above the 1981–2010 average. The monsoon season, July through September, had a total precipitation of 9.69 inches in comparison with the 30-year average of 8.45 inches. The main winter months (December, January, February) had above average snowfall, while the other months recorded near or below average snowfall resulting in 52.7 inches (4.8 inches below average). For the year, Los Alamos received 23.25 inches of precipitation, the most in the past 18 years and 23% above normal. The U.S. Drought Monitor determined Los Alamos started 2015 in a moderate drought, had abnormally dry conditions in May, and ended with drought-free conditions from November to the end of the year (https://www.drought.gov/drought/).

Figure 4-10 presents the annual and monsoon (based on the National Weather Service definition of June 15 to September 30) precipitation in 2015 at the Laboratory's monitoring stations across Los Alamos and at stations in the Valles Caldera provided by the Desert Research Institute and the U.S. Climate Reference Network. Generally, stations at higher elevations measure more precipitation than at lower elevations. The annual precipitation at Technical Area 53 was 19.88 inches, the most since the tower was installed in 1992.

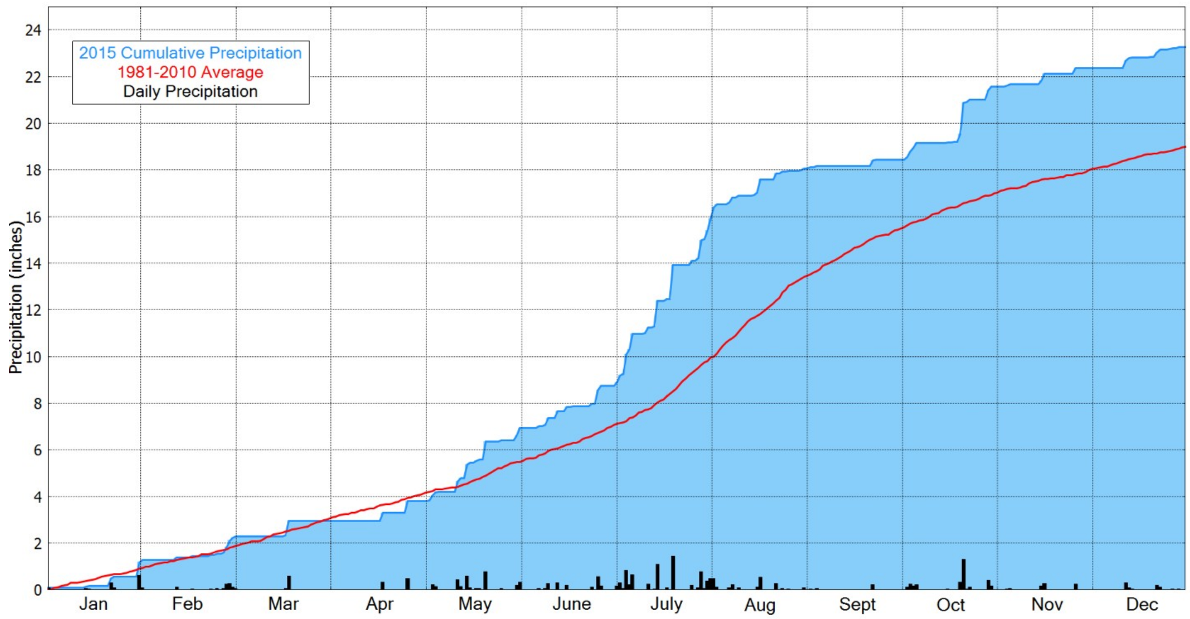


Figure 4-8 2015 Technical Area 06 cumulative precipitation versus 30-year average

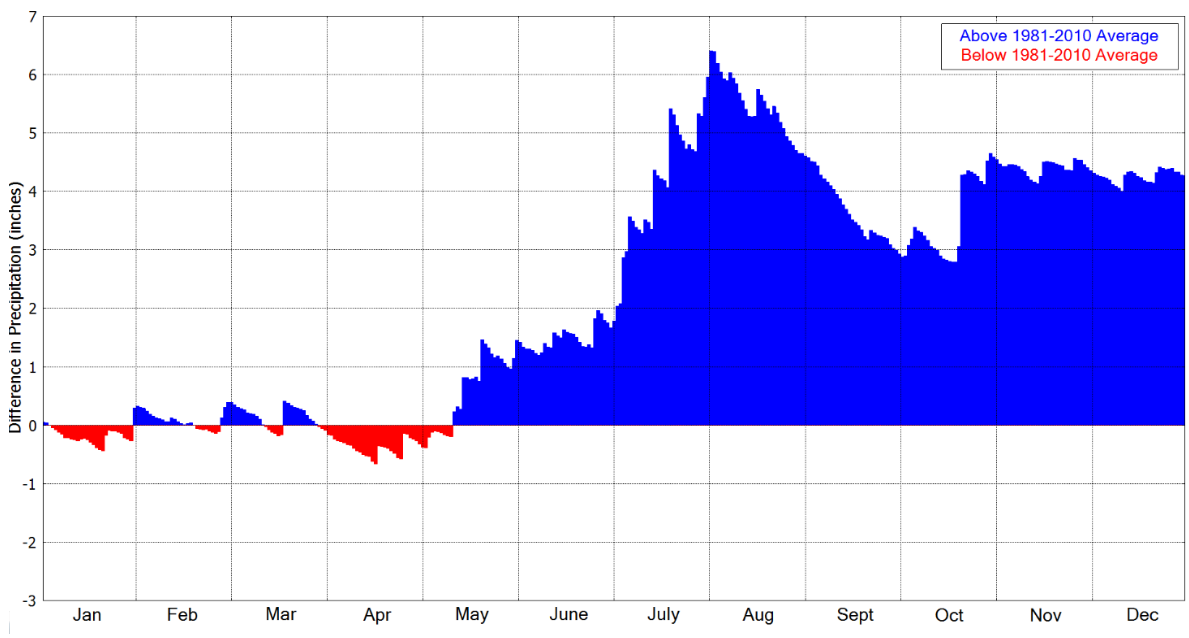


Figure 4-9 Difference between Technical Area 06 precipitation in 2015 and 1981–2010 average precipitation

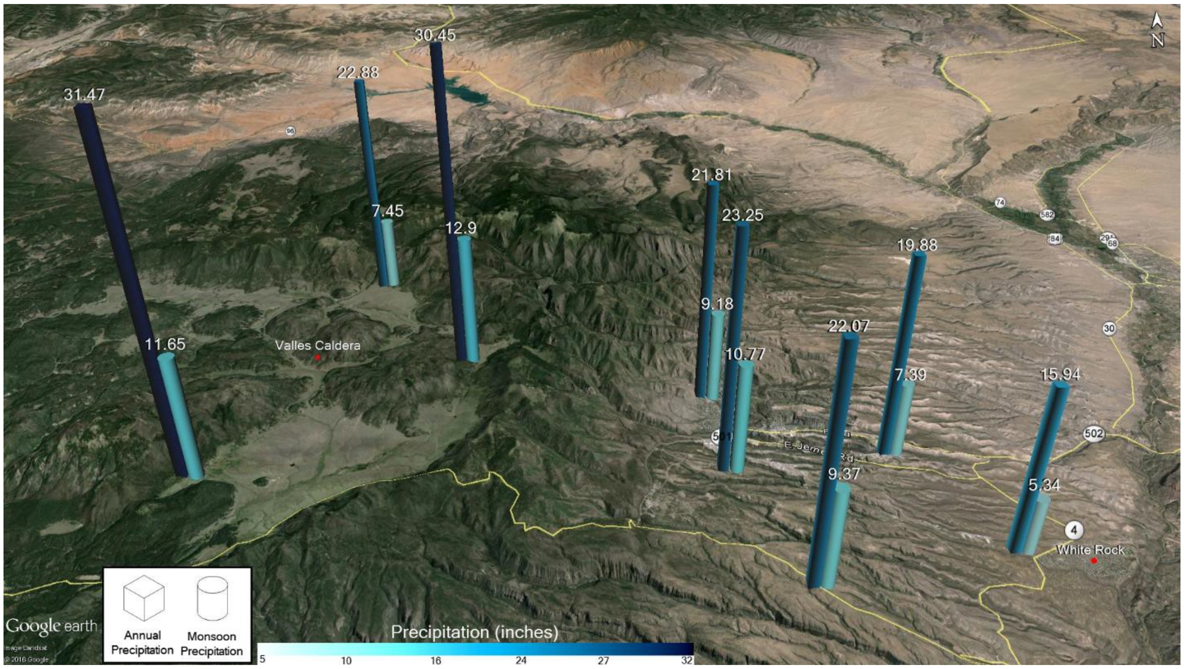


Figure 4-10 Annual and monsoon precipitation in 2015 across Los Alamos and the Valles Caldera

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-11. The wind roses are based on 15-minute-averaged wind observations for 2015 at the four mesa-top stations. Wind roses depict the percentage of time that wind blows from each of 16 direction bins and the distribution of wind speed. For example, the Technical Area 06 daytime wind rose can be interpreted as displaying calm winds 0.8% of the time. Technical Area 06 has winds directly from the south over 12% of the time. The wind speeds range from 2.5 to 5 meters per second under 8% of the time, 5 to 7.5 meters per second over 2% of the time, and exceed 7.5 meters per second only a fraction of 1% of the time. 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.

Long-Term Climate Trends

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-12 shows the historical record of temperatures in Los Alamos from 1924 through 2015. The annual average temperature is not the average temperature per se, but the midpoint between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-12. To aid in showing longer-term trends, the 5-year running mean is also shown in black. With 5-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 average temperature on record was 71.1°F, recorded during 2011.

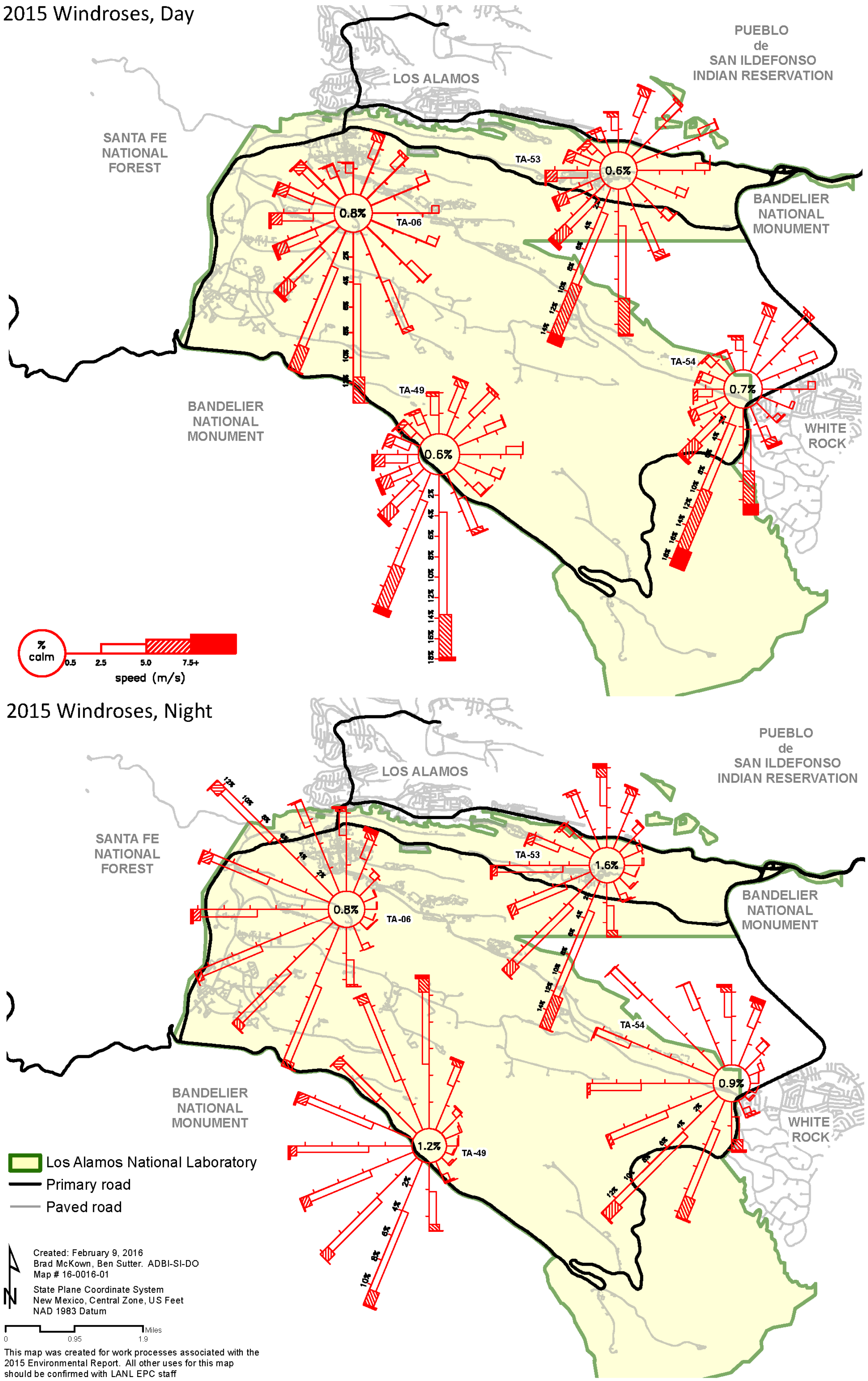


Figure 4-11 Wind roses for 2015

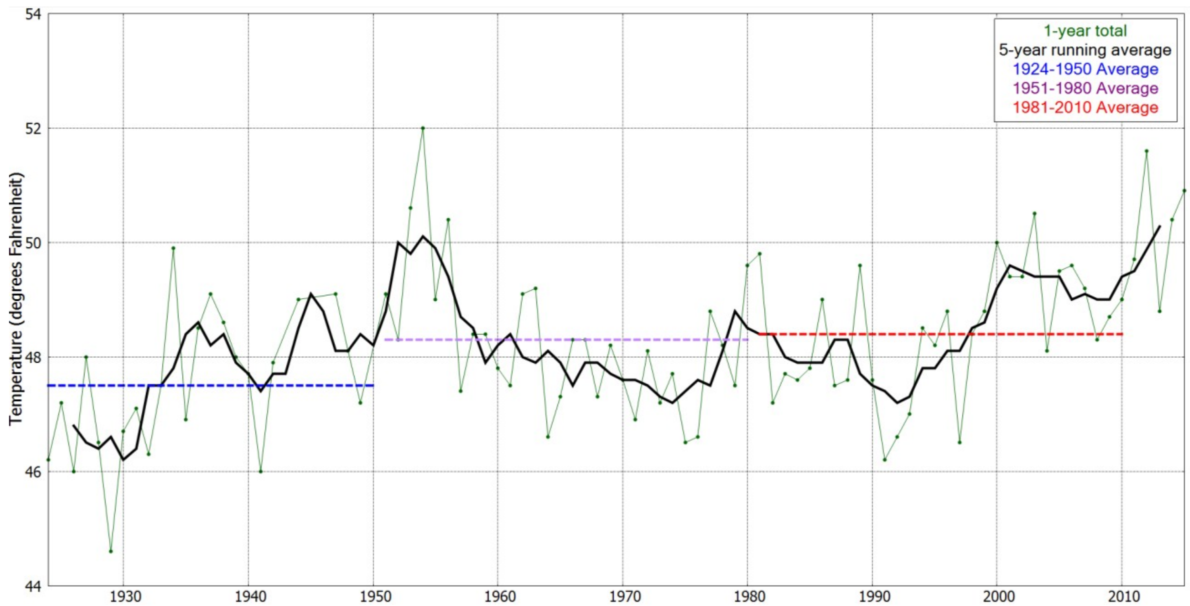


Figure 4-12 Temperature history for Los Alamos

The average temperatures per decade, recorded at Technical Area 06, along with two times the standard error, are plotted in Figure 4-13 with the annual average temperatures for 2011–2015. 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 vary 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 2015 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).

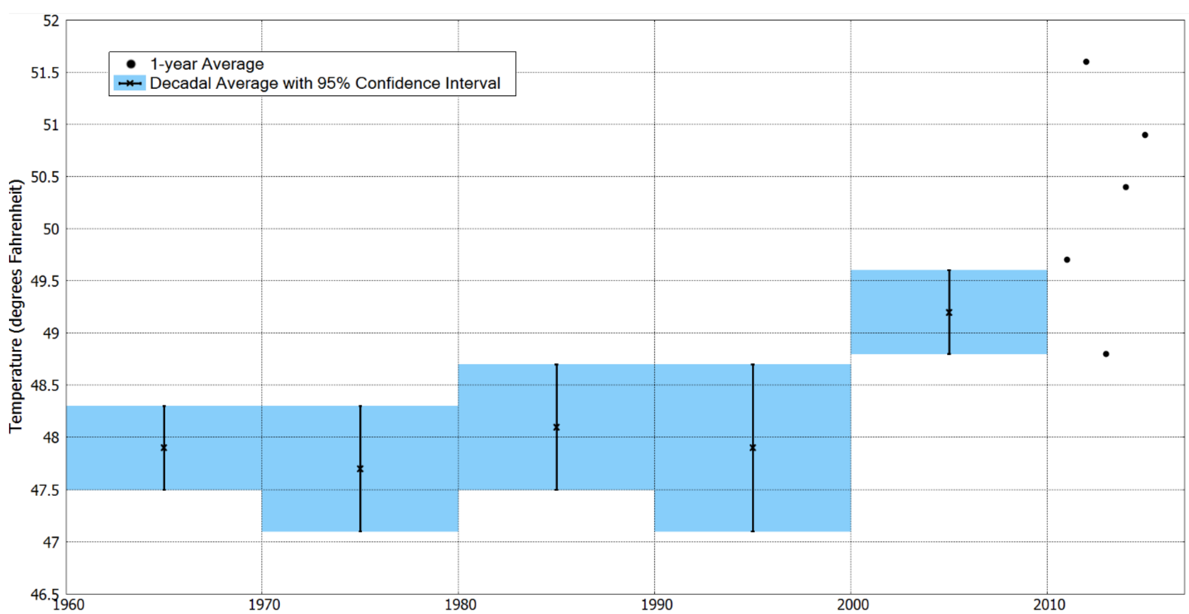


Figure 4-13 Technical Area 06 decadal average temperatures and two times the standard error

Figure 4-14 presents the historical record of the annual precipitation at Technical Area 06. The most recent drought has essentially spanned the years 1998 through 2014, although near-average precipitation years occurred from 2004 to 2010. As with the historical temperature profile, the 5-year running mean and the 30-year normal values are also shown.

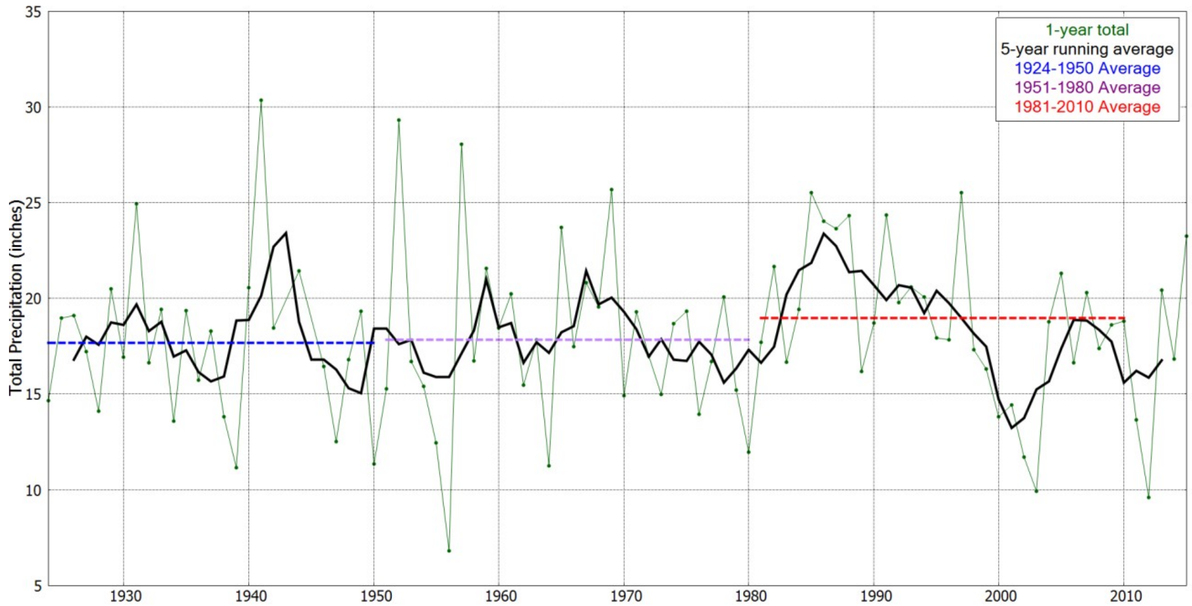


Figure 4-14 Total precipitation history for Los Alamos

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5.0 GROUNDWATER MONITORING

To Read About | **Turn to Page**

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. The Laboratory also implements measures to control contaminant migration.

Contaminants from historical Laboratory operations are present in perched-intermediate groundwater zones and in the regional aquifer. These contaminants are associated with past liquid effluent releases from Laboratory outfalls (the discharge point of a liquid waste stream into the environment). We characterize groundwater to define the nature and extent of known contaminants and to determine their fate and transport. This information guides remedial actions where needed. We use other wells to monitor for releases. Data produced from these activities 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 indicates that only two substances have notable areas of groundwater contamination at the Laboratory, RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) beneath Cañon de Valle in the Technical Area 16 area and chromium beneath Sandia and Mortandad Canyons.

RDX, primarily associated with historical machining of high explosives at Technical Area 16, has infiltrated into perched-intermediate groundwater beneath Cañon de Valle and locally exceeds the U.S. Environmental Protection Agency regional screening level for tap water (7.0 micrograms per liter [µg/L]).

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-µg/L New Mexico groundwater standard.

The regional aquifer is the source of drinking 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 analyzes groundwater samples to monitor local groundwater quality. A regional-scale aquifer is present below the Laboratory at depths ranging from 600 to 1200 feet below ground surface. Groundwater protection efforts at the Laboratory focus on the regional aquifer but also include small bodies of shallow perched groundwater found locally within canyon-floor alluvium (sediment and gravel deposits in canyon bottoms) and in rocks and sediments at intermediate depths between the canyon bottoms and 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 discharging or releasing liquids containing radionuclides to conduct monitoring and characterization 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 2005, DOE, the University of California (the Laboratory's Management and Operating Contractor at that time), and the New Mexico Environment Department signed a Compliance Order on Consent that specifies the process for groundwater monitoring at the Laboratory. The Compliance Order on Consent requires the Laboratory to annually submit an Interim Facility-Wide Groundwater Monitoring Plan to the New Mexico Environment Department. The monitoring locations, analytical suites, and frequency of monitoring are updated each year in the plan.

Most of the groundwater monitoring conducted during 2015 was carried out in accordance with the 2015 and 2016 Interim Facility-Wide Groundwater Monitoring Plans (LANL 2014a, 2015a) approved by the New Mexico Environment Department. The Laboratory's Associate Directorate for Environmental Management collects groundwater samples from wells and from springs within or adjacent to the Laboratory and the nearby Pueblo de San Ildefonso.

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 http://eprr.lanl.gov.

The Laboratory is located in northern New Mexico on the Pajarito Plateau (Figure 5-1). Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from volcanic deposits that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1000 feet thick in the western part of the plateau and thins eastward to about 260 feet adjacent 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 conglomerate underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows, which originate primarily from a volcanic center east of the

Rio Grande, interfinger with the Puye Formation beneath the Laboratory. These formations all overlie the sediments of the Santa Fe Group, which extend across the Rio Grande valley and are more than 3300 feet thick.

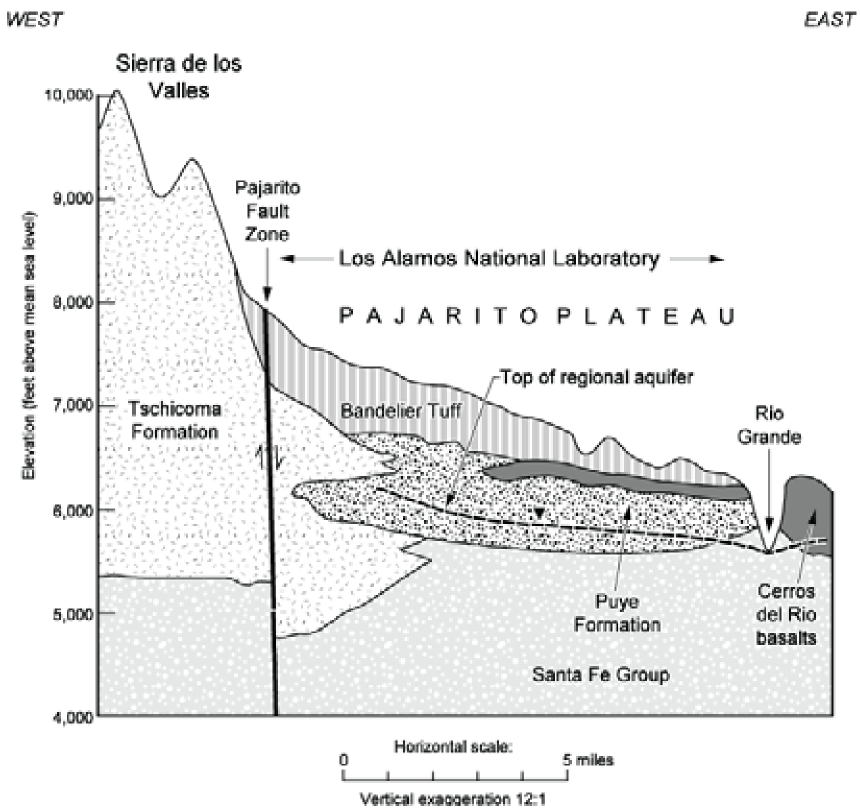


Figure 5-1 Generalized geologic cross-section of the Pajarito Plateau

The Laboratory land sits atop a thick zone of mainly unsaturated rock and sediments, with the regional aquifer found 600 to 1200 feet below the ground surface. Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2) above the regional aquifer. Perched groundwater is a zone of saturation with limited extent held in place by less permeable rock layers that restrict the downward movement of water. Perched groundwater is separated from underlying groundwater by layers of unsaturated rock.

The three modes of groundwater occurrence are (1) perched alluvial groundwater in the bottom of some canyons, (2) discontinuous zones of intermediate-depth perched groundwater, and (3) the regional aquifer beneath the Pajarito Plateau.

Most of the canyons on the Pajarito Plateau have little and infrequent surface water flow and, therefore, little or no alluvial groundwater. A few canyons have limited segments of saturated alluvium in the western portion of the plateau supported by runoff from the Jemez Mountains. Surface water is also supplemented or maintained by effluent discharges from Laboratory outfalls in a few locations. In some canyons, runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rock, maintaining shallow bodies of perched groundwater within the alluvium. These perched alluvial groundwater zones have limited extent; evapotranspiration and percolation into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

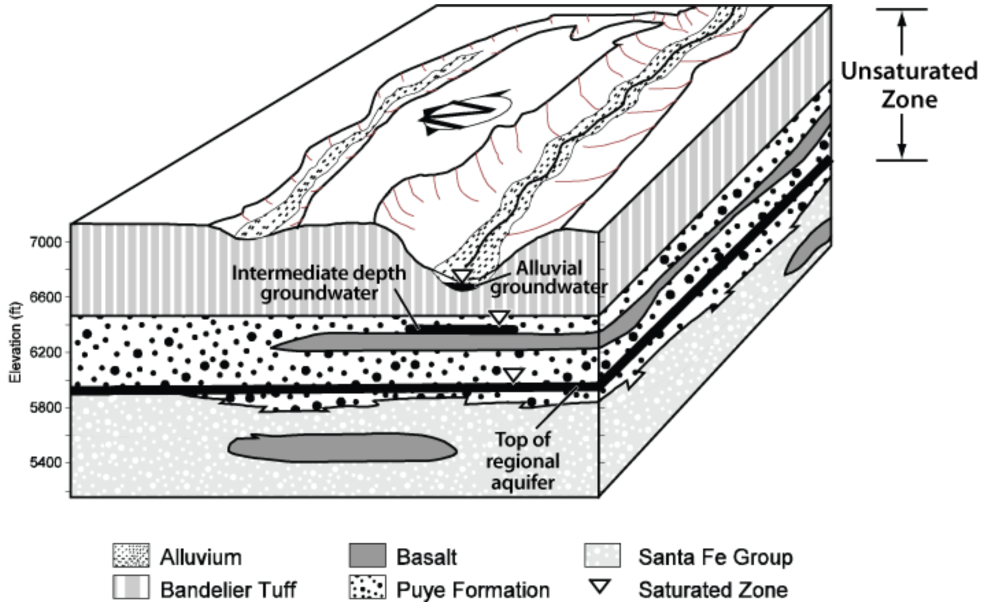


Figure 5-2 Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, perched-intermediate groundwater occurs within the lower part of the Bandelier Tuff and the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by water moving downward from the overlying perched alluvial groundwater. The intermediate groundwater zones are limited in area but may extend beneath adjacent mesas. Depths of the perched-intermediate groundwater zones vary. For example, the depth to perched-intermediate groundwater is approximately 120 feet in Pueblo Canyon, 450 feet in Sandia Canyon, and 500 to 750 feet in Mortandad Canyon.

The regional aquifer water table occurs at a depth of 1200 feet below ground level along the western edge of the plateau and 600 feet below ground level along the eastern edge (Figures 5-1 and 5-3). In the central part of the plateau, the regional aquifer water table lies about 1000 feet beneath the mesa tops. Groundwater in the regional aquifer generally flows east or southeast. Studies indicate that subsurface movement of water from the Sierra de los Valles is the main source of regional aquifer recharge (LANL 2005a). Groundwater flow velocities vary spatially but are typically on the order of 30 feet per year.

The regional aquifer is separated from alluvial and perched-intermediate groundwater by approximately 350 to 600 feet of unsaturated tuff, basalt, and sediments with generally low moisture content (<10%). Water seeps from alluvial and perched-intermediate groundwater zones through the underlying rock. 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.

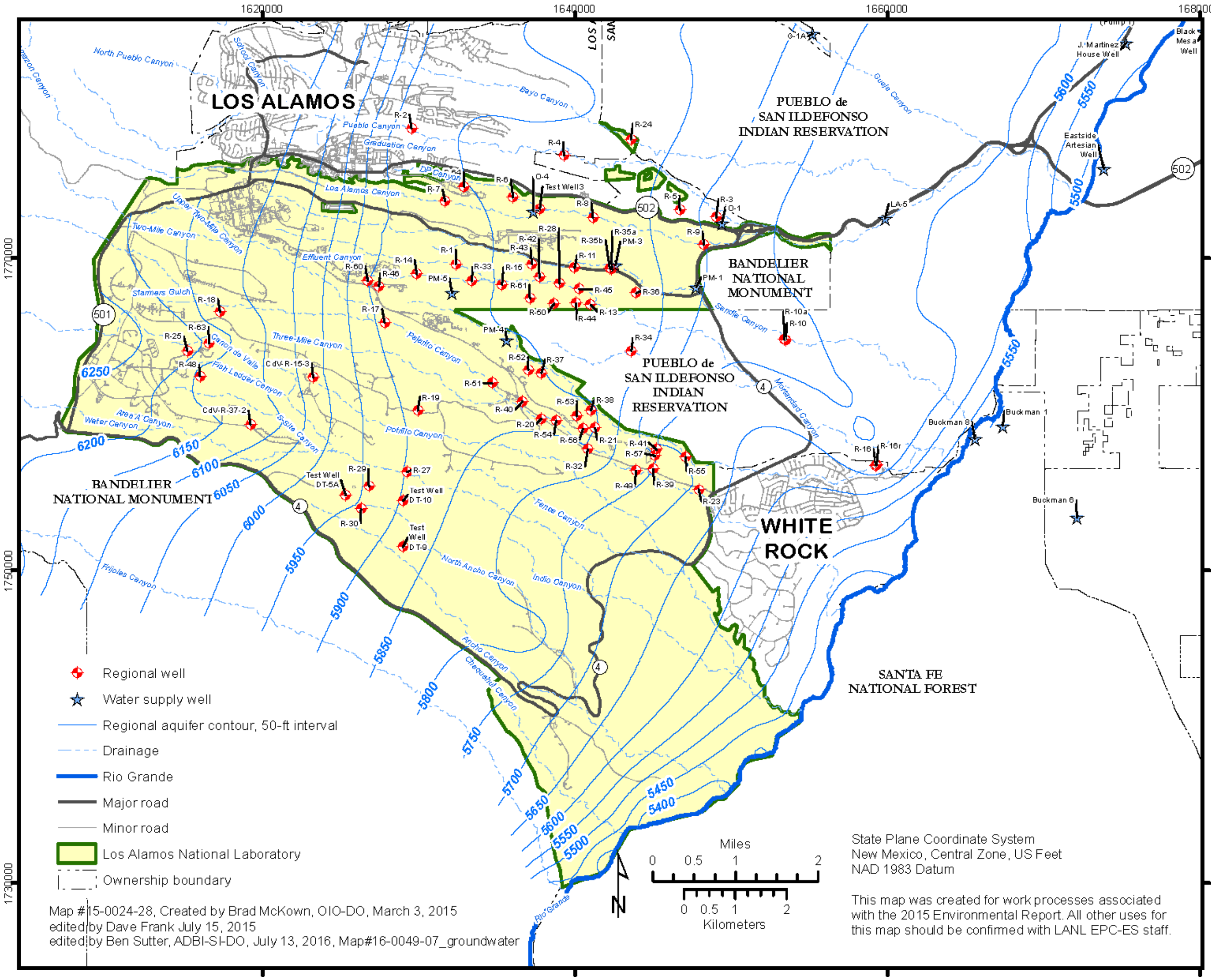


Figure 5-3 Contour map of average water table elevations for the regional aquifer. This map represents a generalization of the data.

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 (42 U.S. Code, Sections 2011 to 2259) to establish standards governing possession and use of 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 radionuclides in air and water that are based on the dose 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 (mrem/yr) drinking-water dose limit.

Public drinking-water systems are regulated by the U.S. Environmental Protection Agency under the Safe Drinking Water Act and by states and tribes when authority is delegated by the U.S. Environmental Protection Agency. 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 (Section 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 (mg/L) or less. These standards include numeric criteria for many contaminants. 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 VIII.A.1 of the Compliance Order on Consent requires that if no New Mexico Water Quality Control Commission standard or U.S. Environmental Protection Agency maximum contaminant level has been established for a specific substance for which toxicological information is published, the U.S. Environmental Protection Agency regional screening level for tap water, adjusted to a 10^{-5} excess cancer risk, is used. The groundwater screening level for perchlorate is 4 micrograms per liter (µg/L), established in Section VIII.A.1.a of the Compliance Order on Consent.

The U.S. Environmental Protection Agency updates the regional screening levels for tap water several times each year; the November 2014 values were used to prepare this chapter.

Table 5-1
Application of Standards or Screening Levels to LANL Groundwater Monitoring Data

Sample Type	Constituent	Standard	Screening Level	Reference	Notes
Water-supply wells	Radionuclides	New Mexico groundwater standards	DOE 4-mrem/yr derived concentration technical standards, U.S. Environmental Protection Agency maximum contaminant levels	40 Code of Federal Regulations 141–143, DOE Order 458.1 Chg 3, 20.6.2 New Mexico Administrative Code	The 4-mrem/yr derived concentration technical standards 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	40 Code of Federal Regulations 141–143, 20.6.2 New Mexico Administrative Code	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	DOE 4-mrem/yr derived concentration technical standards, U.S. Environmental Protection Agency maximum contaminant levels	20.6.2 New Mexico Administrative Code, DOE Order 458.1 Chg 3, 40 CFR 141–143	New Mexico groundwater standards apply to all groundwater. The 4-mrem/yr derived concentration technical standards 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, adjusted U.S. Environmental Protection Agency regional screening levels for tap water	40 Code of Federal Regulations 141–143, 20.6.2 New Mexico Administrative Code, 2005 Compliance Order on Consent	New Mexico groundwater standards apply to all groundwater. U.S. Environmental Protection Agency maximum contaminant levels are for comparison only.

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.

Because many metals are either chemically bound to or components of material that makes up suspended sediment in water samples, the unfiltered concentrations of these substances can be higher than the filtered concentrations. The U.S. Environmental Protection Agency maximum contaminant levels and regional screening levels for tap water are intended for application to water-supply samples that generally have low levels of suspended solids.

Procedures for Collecting Groundwater and Surface Water Samples

The Laboratory implements several standard operating procedures to collect groundwater and base-flow (the portion of perennial surface water stream flow that is not storm water or snow melt runoff) samples and samples from springs. These procedures are listed in Table 5-2. These procedures (or their equivalent used by sampling subcontractors) are used in accordance with the "Interim Facility-Wide Groundwater Monitoring Plan for the 2015 Monitoring Year, October 2014–September 2015" and the "Interim Facility-Wide Groundwater Monitoring Plan for the 2016 Monitoring Year, October 2015–September 2016" (LANL 2014a, 2015a). A more detailed summary of procedures is provided in Appendix B of each monitoring plan. Current versions of the procedures 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.

Table 5-2
Procedures Used to Collect Groundwater, Base-Flow, and Spring Samples

Procedure Identifier	Procedure Title	Applicability
Collection of Groundwater Samples		
ER-SOP-20032	Groundwater Sampling	Procedure for sampling groundwater using various types of pumps. Procedure also addresses sampling of water-supply wells and domestic wells.
SOP-5225	Groundwater Sampling Using the Westbay multiport system	Procedure for sampling groundwater using the Westbay multiport system
EP-ERSS-SOP-5061	Field Decontamination of Equipment	Procedure for field decontamination of equipment
Collection of Surface Water and Spring Samples		
SOP-5224	Spring and Surface Water Sampling	Procedure for sampling springs and surface water
Sample Preparation, Preservation, and Transportation		
ER-SOP-20235	Sample Containers, Preservation, and Field Quality Control	Procedure specifying sample containers, collection and preservation techniques, holding times, and collection of field quality control samples, which include field duplicates, equipment rinsate blanks, and trip blanks.
ER-SOP-20236	Handling, Packaging, and Transporting Field Samples	Procedure for sample packaging and shipping
OIO-TP-222	Shipping/Receiving of Environmental Samples by the Sample Management Office	Procedure for receiving, packaging, and shipping samples to analytical laboratories

Evaluation of Groundwater 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 4-mrem/yr drinking-water derived concentration technical standards, 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 groundwater other than drinking water.

POTENTIAL SOURCES OF CONTAMINATION

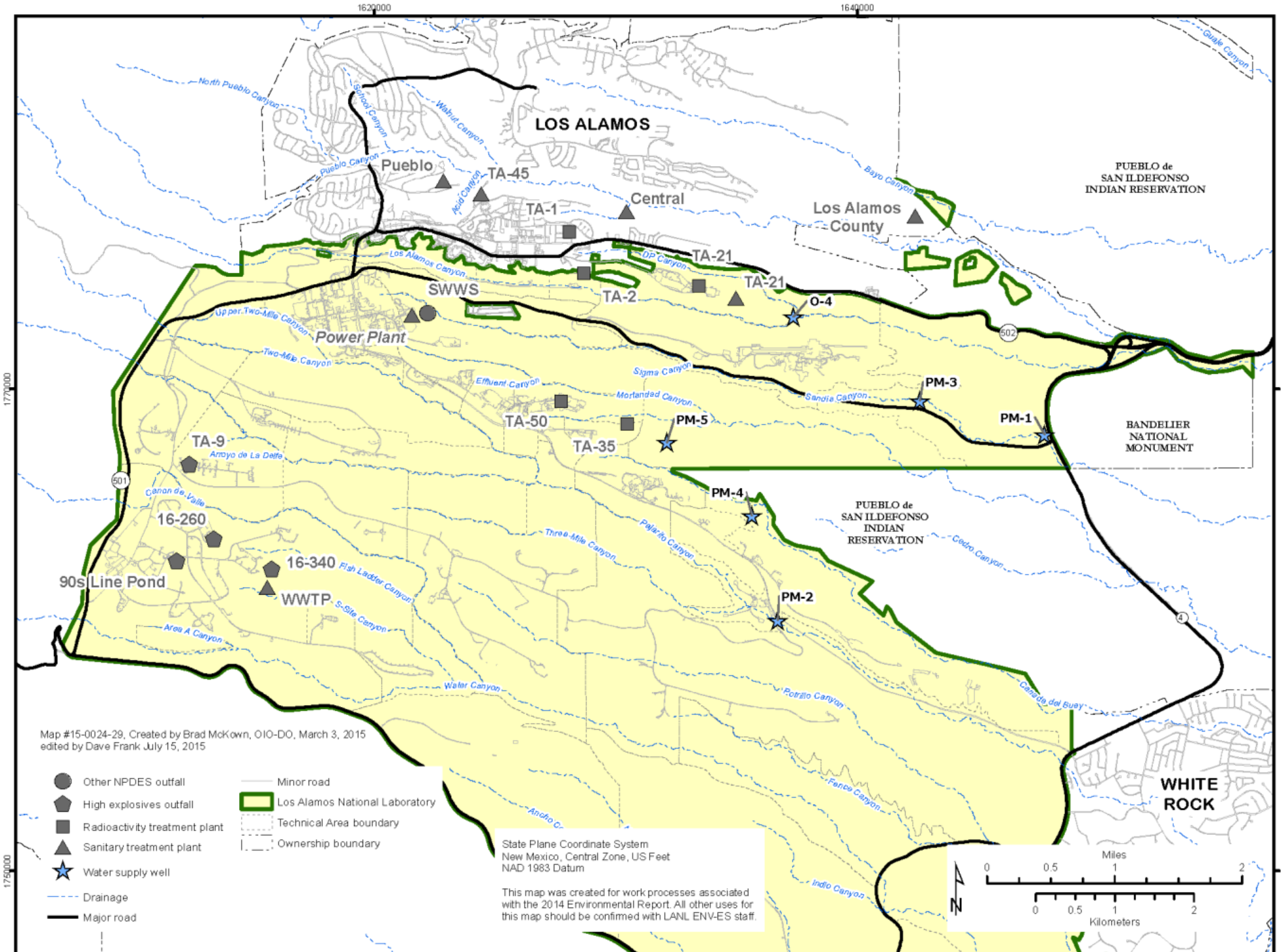
Historical discharges have affected all three groundwater zones. Figure 5-4 shows the key locations where effluent that may have affected groundwater was historically discharged.

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 2014b).

GROUNDWATER MONITORING NETWORK

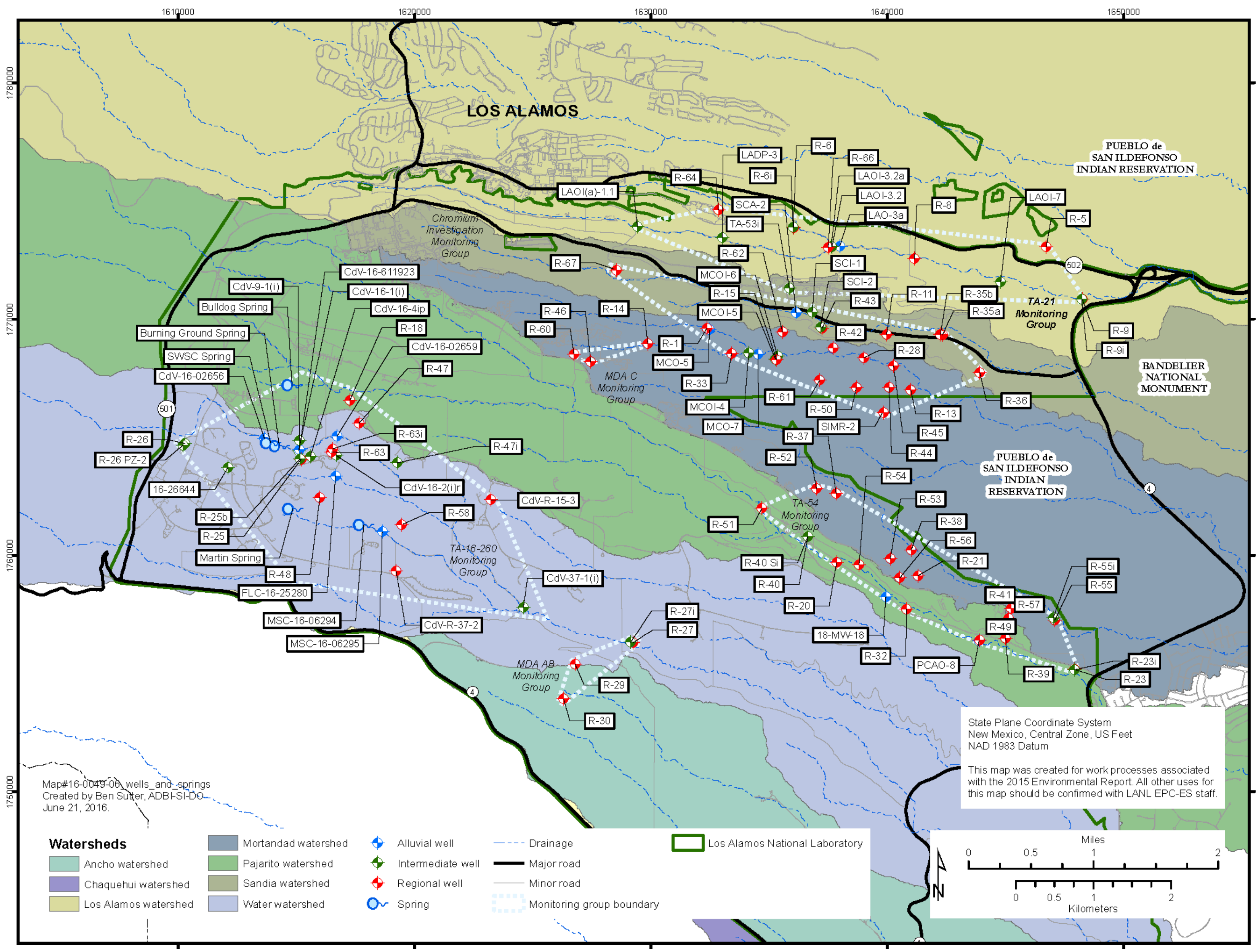
We conduct monitoring at base-flow surface water locations, at alluvial, perched-intermediate, and regional aquifer well locations, and at springs that discharge perched-intermediate and regional aquifer groundwater. Monitoring is primarily organized into area-specific monitoring groups (Figure 5-5). 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 in 3 well fields (Figure 5-7). Additional samples are collected from wells located on Pueblo de San Ildefonso lands and from the Buckman wellfield operated by the City of Santa Fe. Groundwater monitoring stations at Pueblo de San Ildefonso are shown in Figure 5-7 and 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. WWTP = Wastewater treatment plant.

Figure 5-4 Major liquid release outfalls (effluent discharge) potentially affecting groundwater; most outfalls shown are currently inactive



MDA = Material disposal area. TA = Technical area.

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

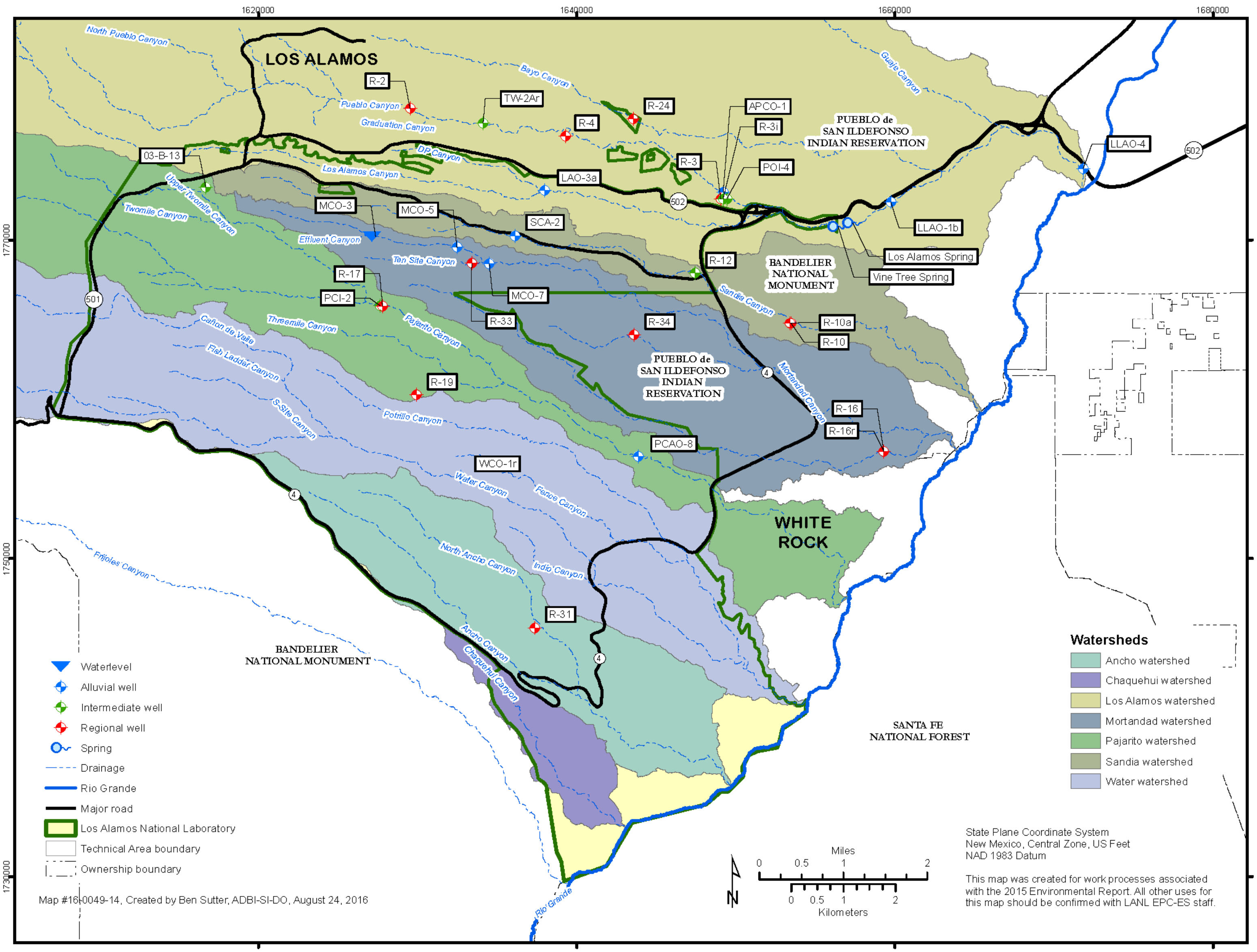


Figure 5-6 **Groundwater monitoring wells and springs assigned to watershed-specific portions of the General Surveillance monitoring group**

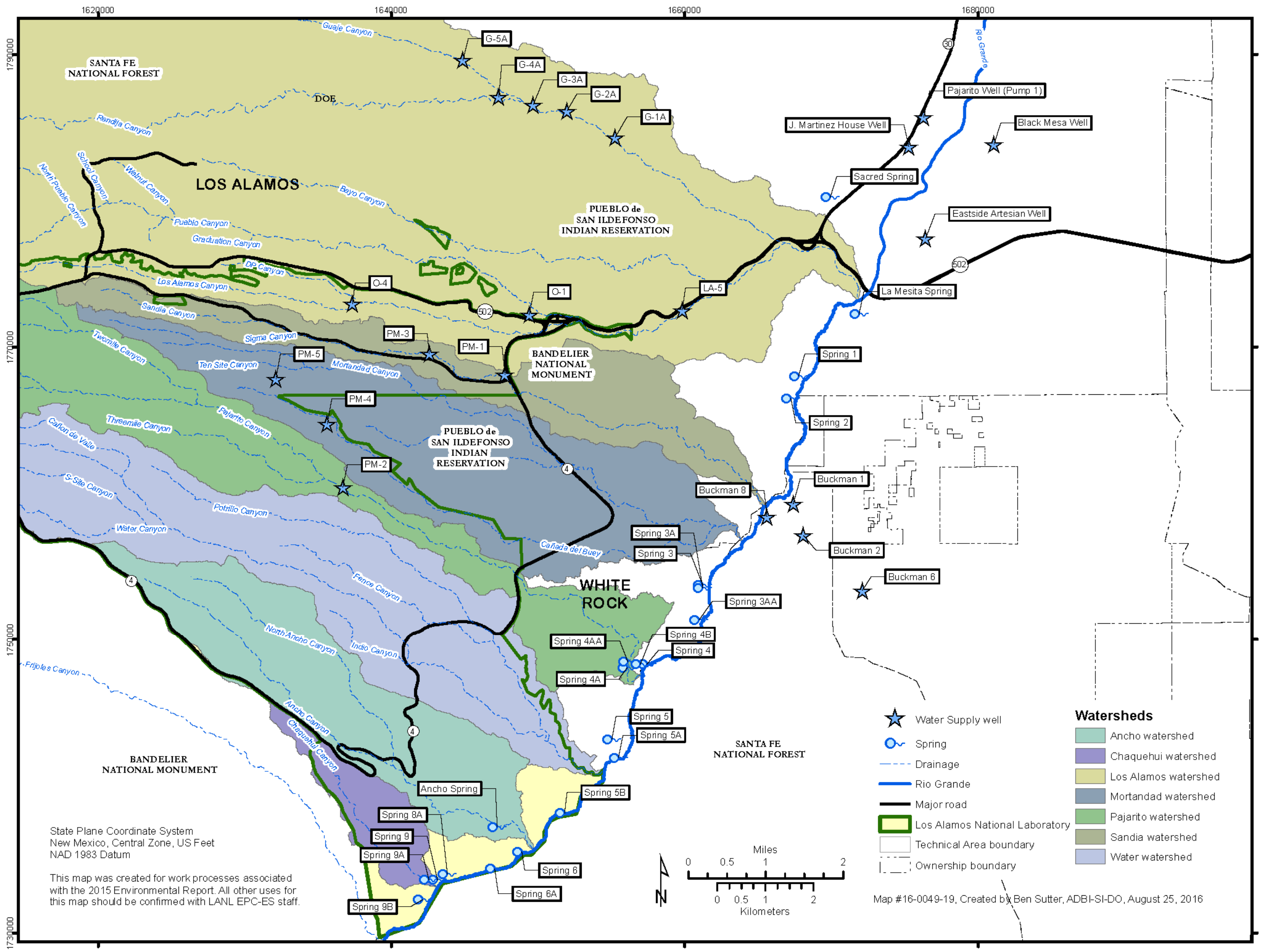


Figure 5-7 Water-supply wells used for monitoring at Los Alamos County, City of Santa Fe Buckman well field, and Pueblo de San Ildefonso and springs used for groundwater monitoring in White Rock Canyon

GROUNDWATER DATA INTERPRETATION

The groundwater quality monitoring data for 2015 are available at http://www.intellusnm.com.

Analytical laboratory results are reported relative to several defined limits based on the method used to detect and quantify analyte concentrations. The method detection limit is the minimum concentration of a substance that can be detected with 99% confidence that the analyte concentration is greater than zero. The method detection limit is determined from analysis of a set of samples in a given matrix containing the analyte (40 Code of Federal Regulations Part 136, Appendix B).

A second limit used by analytical laboratories, the practical quantitation limit, does not have a standard definition. The practical quantitation limit is intended to be a concentration that can be consistently measured within 30% of the true analyte concentration in the sample. 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" flag in the analytical report.

A nondetect indicates that the analytical laboratory did not detect the analyte in the sample. Results for nondetects are reported at the practical quantitation limit; estimated concentrations are not. This convention means that detected but estimated results (results between the method detection limit and the practical quantitation limit) are reported with a lower 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 from radioactive counting statistics. To be considered a detected concentration, 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 substances 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, 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 collect samples from 12 Los Alamos County water-supply wells in 3 well fields that produce water for the Laboratory and the community (Figure 5-7). These samples supplement Los Alamos County's monitoring for safe drinking water 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 (Los Alamos County 2016). The water-supply wells have long screens (the slotted portion of a well that allows water to enter the well) up to 1600 feet deep within the regional aquifer. Water-quality samples collected from these wells therefore sample water over a large depth range. This section reports on supplemental sampling of those wells by the Laboratory.

Water-supply well G-1A, located in the Guaje well field, has historically shown occasional detections of naturally occurring arsenic above the U.S. Environmental Protection Agency's maximum contaminant level of 10 µg/L. The Guaje well field is located northeast of the Laboratory. In 2015, arsenic measurements were below 10 µg/L. No other water-supply wells showed detections above an applicable drinking water standard.

Perchlorate has historically been present below the 4-µg/L Compliance Order on Consent screening level in water-supply well O-1 and has been steadily declining. The 2015 data show that the trend is maintained (Figure 5-8).

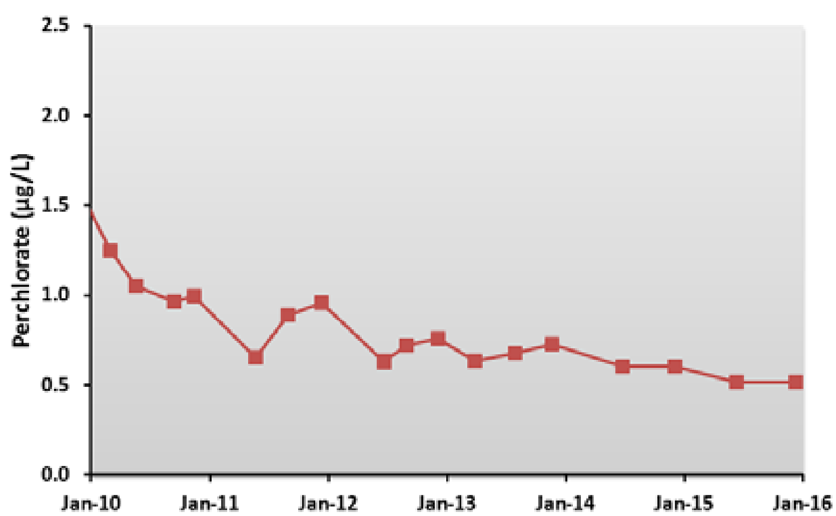


Figure 5-8 Perchlorate at water-supply well O-1 in Pueblo Canyon

City of Santa Fe

In 2015, we sampled three wells, Buckman-1, -6, and -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 collected to supplement the City of Santa Fe's compliance monitoring requirements and specifically address monitoring for potential Laboratory contaminants. No Laboratory constituents were present above standards for these locations. The City of Santa Fe published an annual water quality report that provides additional information (City of Santa Fe 2016).

Technical Area 21 Monitoring Group

Technical Area 21 is located on a mesa north of Los Alamos Canyon (Figure 5-5). 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 contaminants 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 monitoring objectives for the Technical Area 21 monitoring group are based in part on the results and conclusions presented in the “Los Alamos and Pueblo Canyons Investigation Report” (LANL 2004) as well as on the New Mexico Environment Department–approved “Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1” (LANL 2008). The Technical Area 21 monitoring group includes monitoring wells in perched-intermediate groundwater and in the regional aquifer. In 2015, perched-intermediate groundwater samples from wells R-6i and LAOI-3.2 continued to have perchlorate detections above the Compliance Order on Consent screening level of 4 µg/L (Figure 5-9). LAOI-3.2a had perchlorate detections, but they were below the screening level of 4 µg/L. Other constituents, including nitrate, are present in these same wells but at levels below applicable standards. Perchlorate is not present above the screening level in regional aquifer wells within the Technical Area 21 monitoring group. No action is being taken to address the perchlorate in the perched-intermediate zones at this time.

In 2014, gross alpha was detected above the 15-picocuries per liter (pCi/L) maximum contaminant level for drinking water in well LAOI(a)-1.1 (Figure 5-10). The 2015 result is substantially lower and is below the 15-pCi/L level. The gross-alpha measurements are related to naturally occurring uranium and its decay products.

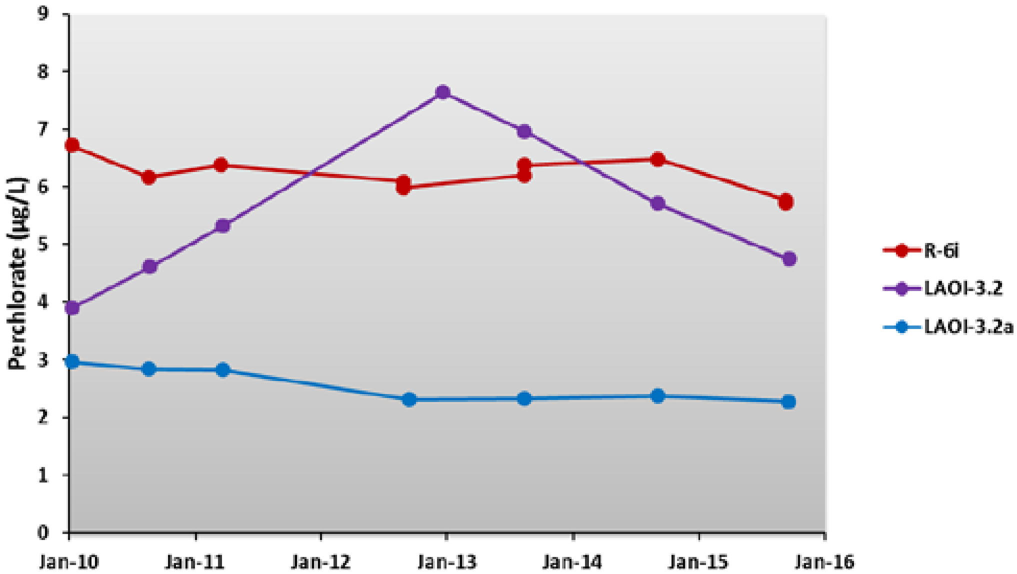


Figure 5-9 **Perchlorate in perched-intermediate groundwater in the Technical Area 21 monitoring group in Los Alamos Canyon. The 2015 Compliance Order on Consent screening level is 4 µg/L.**

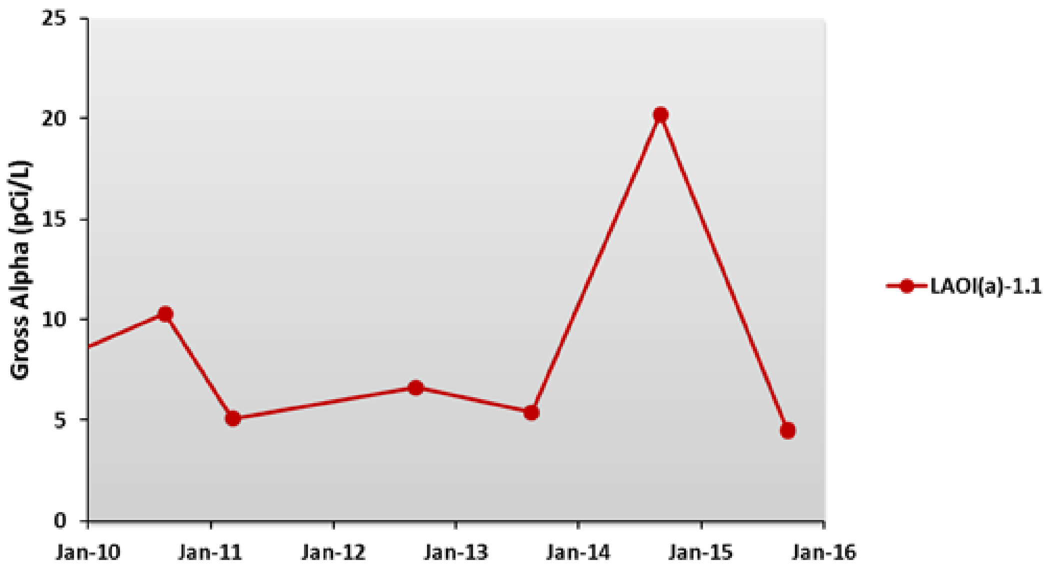


Figure 5-10 **Gross alpha in perched-intermediate well LAOI-1.1**

Several perched-intermediate wells have tritium present in groundwater samples (Figure 5-11) that is likely from the liquid-waste treatment plant and/or the Omega West Reactor. Samples from perched-intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 2250 pCi/L of tritium in 2015 and generally remain consistent with data from recent years. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 pCi/L.

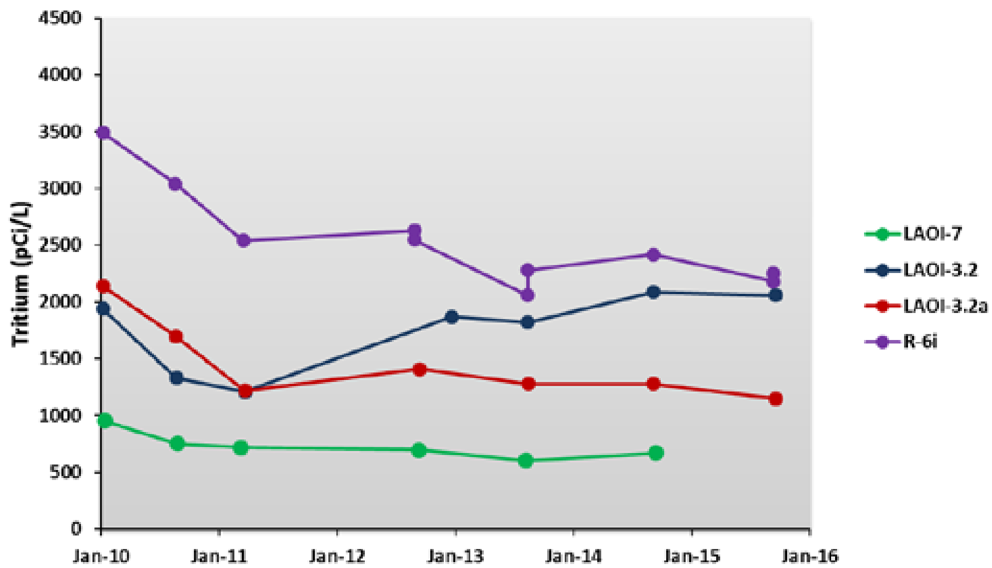


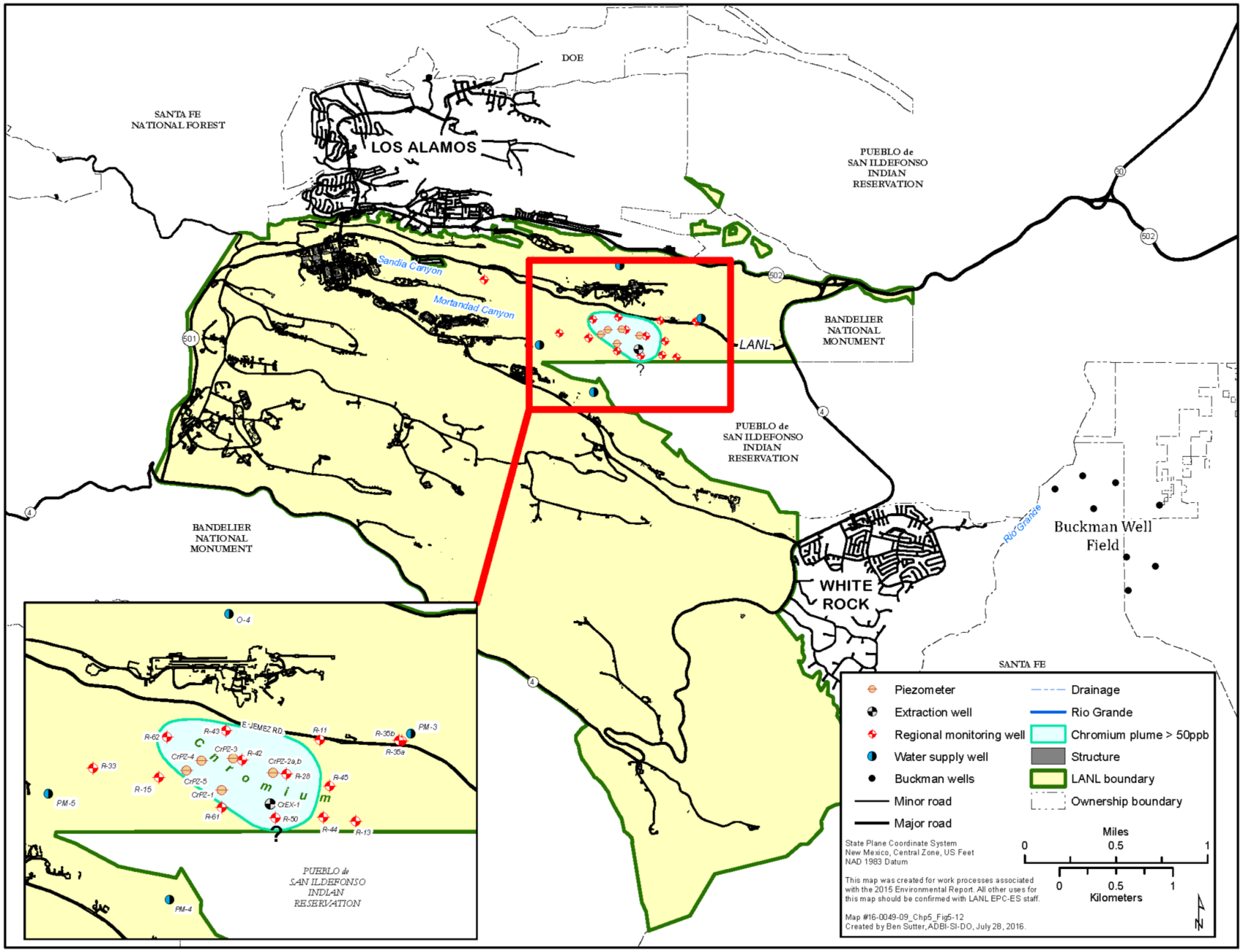
Figure 5-11 Tritium in the Technical Area 21 monitoring group in Los Alamos Canyon perched-intermediate groundwater. The U.S. Environmental Protection Agency maximum contaminant level for drinking water is 20,000 pCi/L.

Chromium Investigation Monitoring Group

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons (Figure 5-5). Monitoring in this group focuses on characterizing and understanding the fate and transport of chromium and related contaminants in perched-intermediate groundwater and within the regional aquifer.

Sandia Canyon has a small drainage area that heads at Technical Area 03. Through Outfall 001, 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. From 1956 to 1972, potassium dichromate was used as a corrosion inhibitor in the cooling system at the power plant (LANL 1973) and was also discharged through Outfall 001. 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.

The Laboratory detects chromium in the regional aquifer above the 50-µg/L New Mexico Environment Department groundwater standard in an area that is approximately 1 mile in length and about 0.5 mile wide (Figure 5-12). Contaminants in this area are found within the top 50 feet of the regional aquifer, as demonstrated by a series of two-screen wells that monitor the plume (LANL 2009a, 2012b). The 2015 chromium concentrations exceeded the New Mexico groundwater standard of 50 µg/L in five regional aquifer wells: R-28, R-42, R-62, R-50 screen 1, and R-43 screen 1 (Figure 5-13). The trend in chromium concentrations for these wells is shown in Figure 5-14.



Note: ppb = parts per billion

Figure 5-12 Approximation of chromium plume footprint at the Laboratory as defined by 50-µg/L New Mexico Environment Department groundwater standard

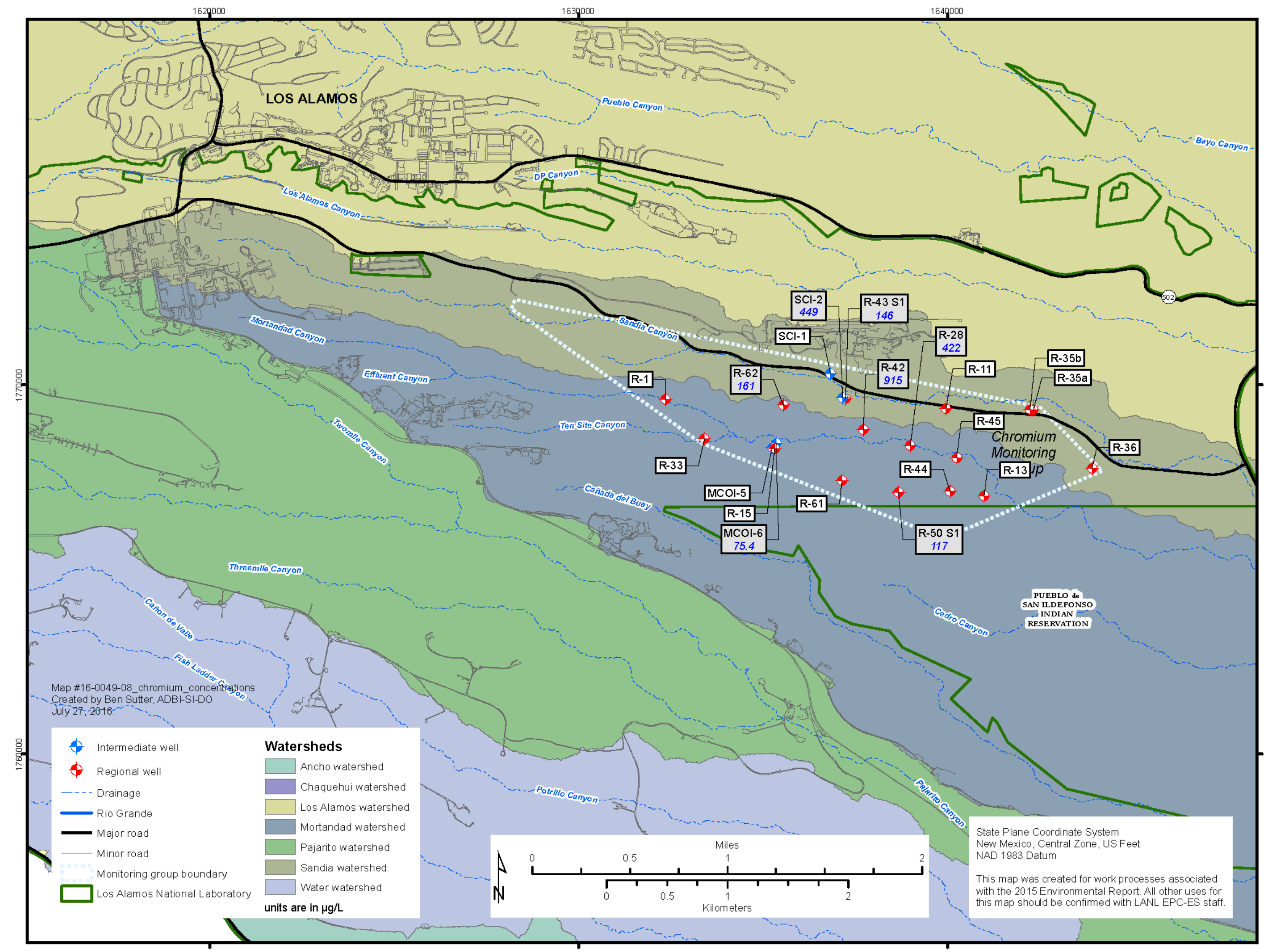


Figure 5-13 **The Chromium Investigation monitoring group perched-intermediate and regional aquifer monitoring wells. Labels for the wells also show maximum chromium detected in 2015 for values greater than the New Mexico groundwater standard of 50 µg/L.**

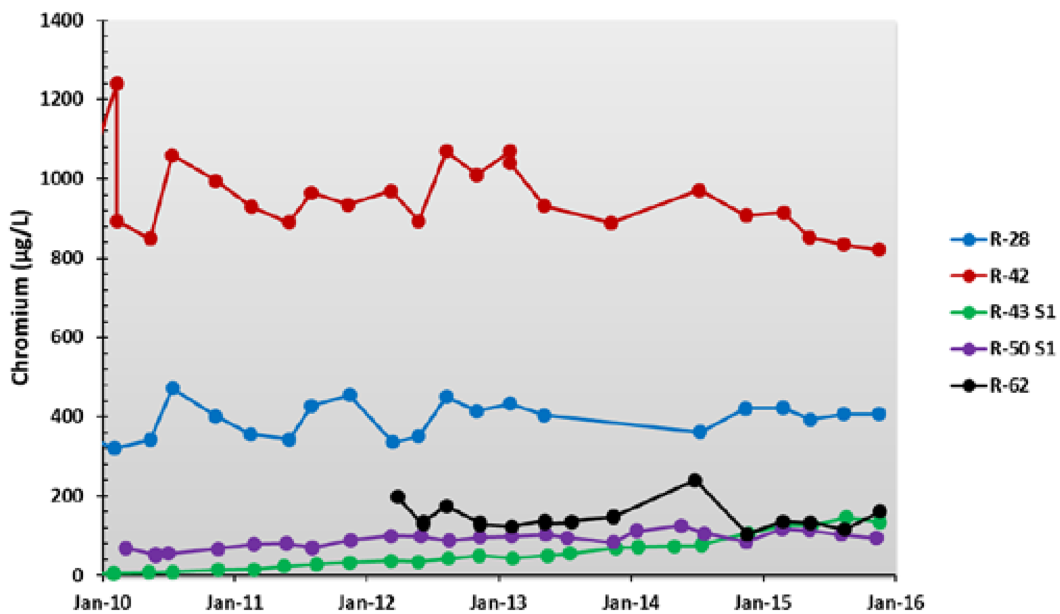


Figure 5-14 Trends in chromium concentrations at five regional aquifer wells that exceeded the chromium standard of 50 µg/L within the Chromium Investigation monitoring group

Although showing high annual variability, the wells within the center of the plume, R-42 and R-28, show a relatively flat chromium trend, whereas three wells along the edge of the plume (R-45 screen 1, R-43 screen 1, and R-50 screen 1) are showing gradually increasing concentrations of chromium (Figure 5-15). Two perched-intermediate wells also had chromium concentrations above the standard: SCI-2 and MCOI-6. The trend for chromium in these wells is shown in Figure 5-16.

A smaller area with perchlorate contamination is also present in groundwater beneath Mortandad Canyon. Perchlorate exceeded the Compliance Order on Consent screening level of 4 µg/L in one actively monitored regional aquifer well within the monitoring group, R-15, and in perched-intermediate wells MCOI-5 and MCOI-6. The perchlorate concentration trend in regional well R-15 shows variability but is generally flat (Figure 5-17). In the perched-intermediate wells MCOI-5 and MCOI-6, the perchlorate concentration trends are also generally not increasing over time (Figure 5-18). The primary source of perchlorate was effluent discharges from the Radioactive Liquid Waste Treatment Facility that occurred from 1963 until implementation of improvements in perchlorate treatment in March 2002. Ongoing monitoring will be used to evaluate whether the elimination of the source of perchlorate will result in decreasing concentrations in perched-intermediate wells and eventually in the regional aquifer. Another constituent detected at concentrations above screening levels in the Chromium Investigation monitoring group is 1,4-dioxane in perched-intermediate wells MCOI-5 and MCOI-6 (Figure 5-19).

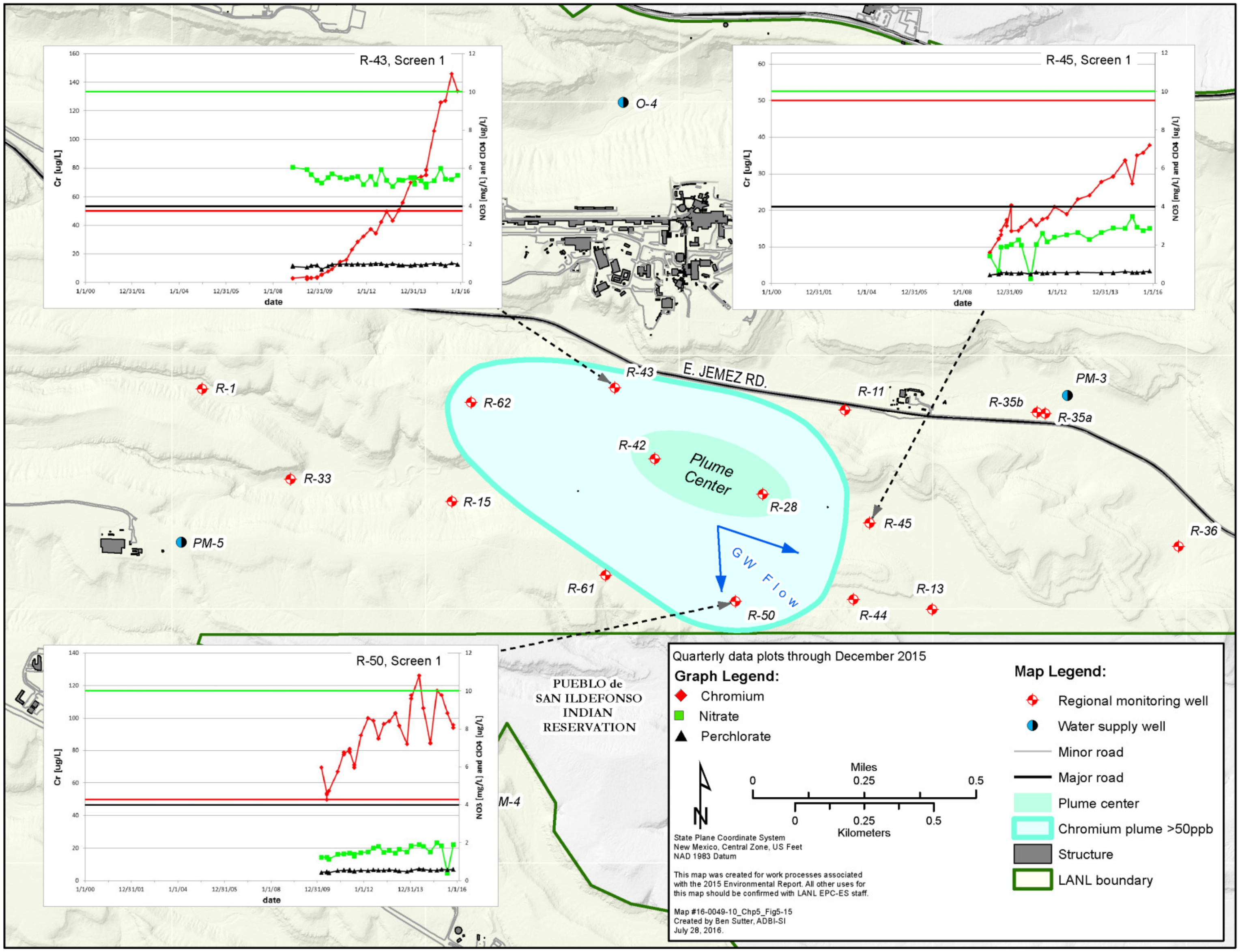


Figure 5-15 Time-series plots of three regional aquifer wells within the Chromium Investigation monitoring group. Plots show trends for chromium (red), nitrate (green), and perchlorate (black).

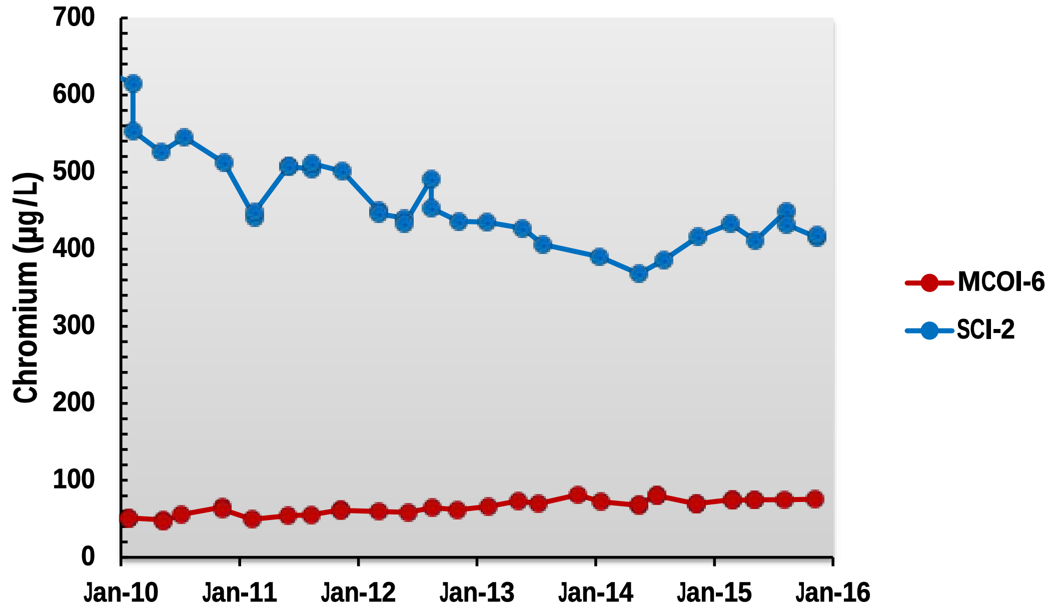


Figure 5-16 Trends in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The New Mexico Environment Department groundwater standard is 50 µg/L.

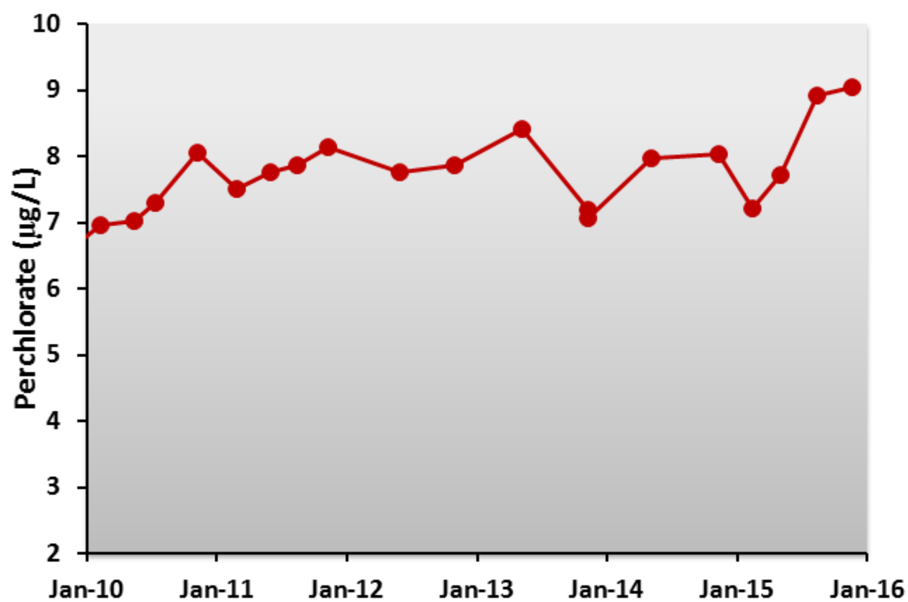


Figure 5-17 Perchlorate at regional aquifer well R-15 in the Chromium Investigation monitoring group. The 2015 Compliance Order on Consent screening level is 4 µg/L.

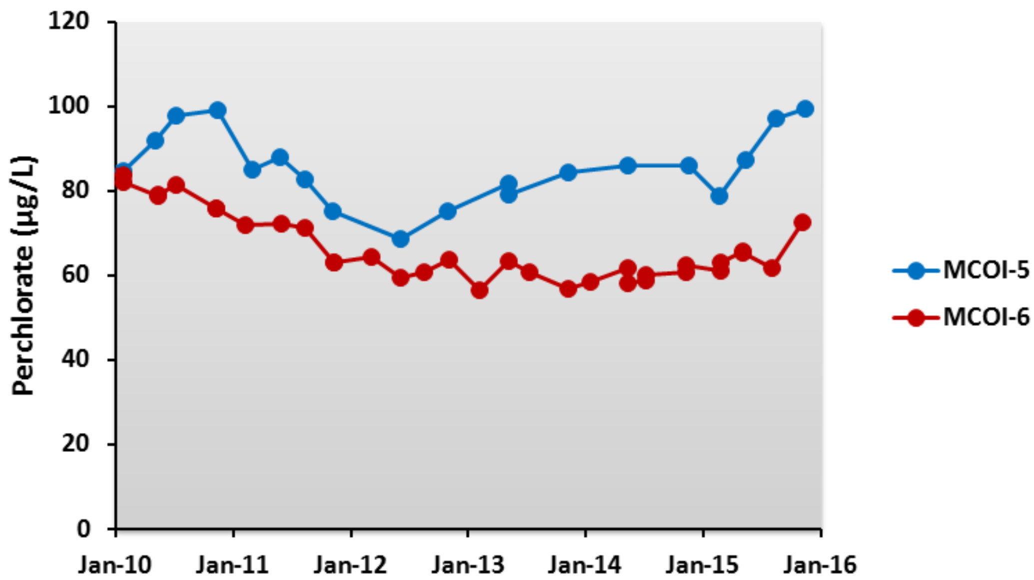


Figure 5-18 **Perchlorate in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The 2015 Compliance Order on Consent screening level is 4 µg/L.**

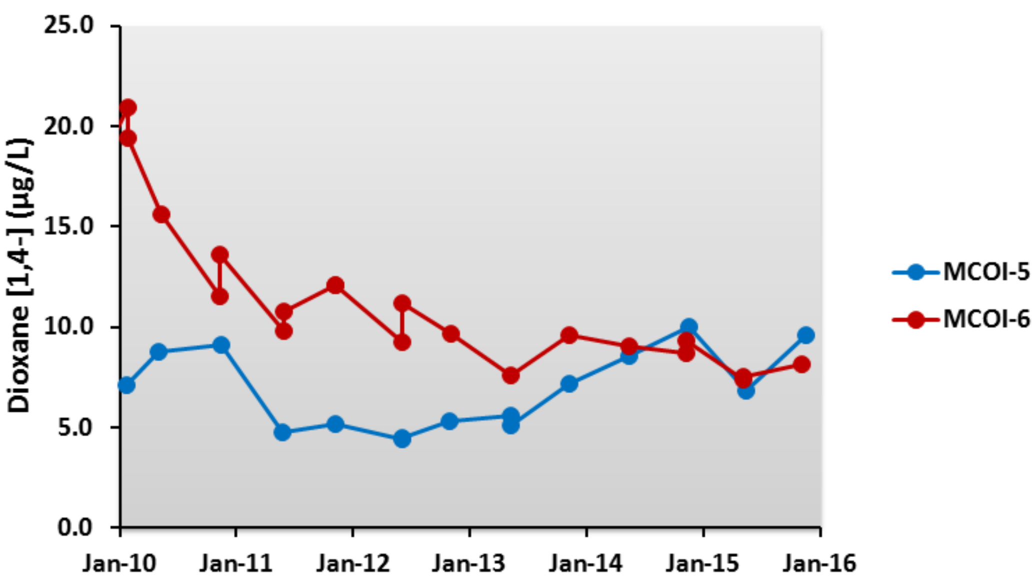


Figure 5-19 **Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The U.S. Environmental Protection Agency maximum contaminant level for 1,4-dioxane in drinking water is 7.8 µg/L.**

Perched-intermediate wells MCOI-5 and MCOI-6 have tritium activities that have continued to decline since 2007, reflecting significant improvements in water quality from Outfall 051. These activities are far below the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water of 20,000 pCi/L (Figure 5-20).

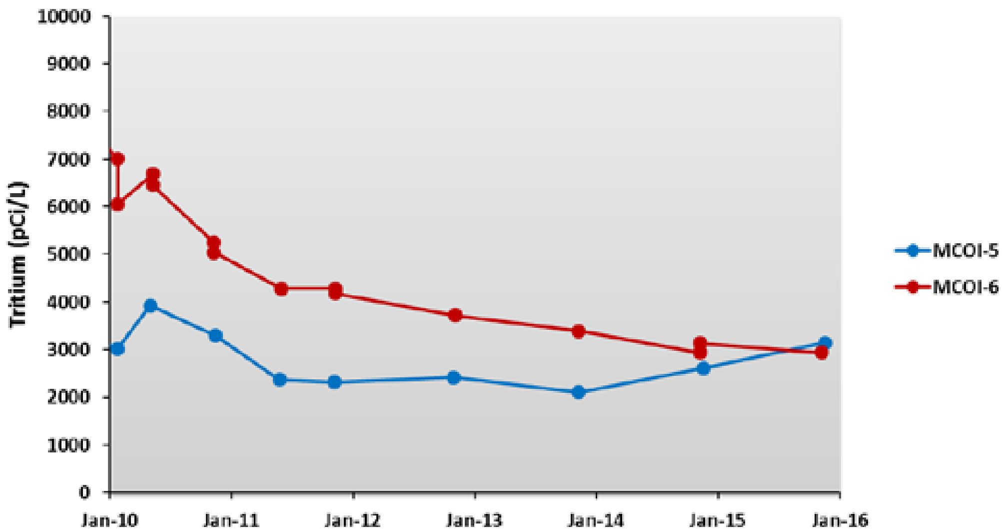


Figure 5-20 Tritium in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 pCi/L.

A conceptual model for the sources and spatial distribution of these contaminants is presented in the Investigation Report for Sandia Canyon and in the Phase II Investigation Report for Sandia Canyon (LANL 2009a, LANL 2012b). The conceptual model shows that chromium originated from releases into Sandia Canyon and may have migrated in the subsurface along geologic perching horizons to locations in the aquifer beneath Mortandad Canyon. For this reason, perched-intermediate and regional wells beneath Mortandad Canyon are included in the Chromium Investigation monitoring group. Other areas of contamination beneath Sandia and Mortandad Canyons may be associated with Mortandad Canyon sources (LANL 2009a, LANL 2012b).

In 2015, the Laboratory submitted work plans for two sets of actions for the chromium plume and received approval from the New Mexico Environment Department for both. The “Interim Measures Work Plan for Chromium Plume Control” presents an approach for controlling movement of chromium-contaminated groundwater along the downgradient portions of the plume (LANL 2015b). The approach uses one or more extraction wells and a series of injection wells to establish a capture zone to maintain the downgradient edge of chromium in groundwater, as defined by the 50-µg/L level, within the Laboratory boundary. Contaminated groundwater will be extracted, treated at the surface using ion exchange, and returned to the aquifer using injection wells. In 2015, most of the effort was placed on obtaining all necessary permits and reviews to enable implementation of the interim measure beginning in 2016.

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 2015c). 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.

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. Material Disposal Area C 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 zone beneath Material Disposal Area C (LANL 2011a). The primary vapor-phase constituents beneath Material Disposal Area C are trichloroethene and tritium. The Material Disposal Area C monitoring group includes nearby regional aquifer monitoring wells on the mesa top and in Mortandad Canyon (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. Results from monitoring of vapor-phase substances at Material Disposal Area C are presented in Chapter 3, Environmental Programs.

Technical Area 54 Monitoring Group

Technical Area 54 is situated in the east-central portion of the Laboratory on Mesita del Buey. Technical Area 54 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 Resource Conservation and Recovery Act Hazardous Waste Facility Permit. The Technical Area 54 monitoring group includes both perched-intermediate and regional wells in the near vicinity (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, 2007a).

Data from the groundwater monitoring network around Technical Area 54 show scattered detections of a variety of substances, including several volatile organic compounds. However, no constituents were detected above applicable standards or screening levels. Tritium is not detected in any of the regional aquifer groundwater monitoring wells in the Technical Area 54 monitoring group. The temporal and 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 organic and inorganic constituents detected 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) traverse the southern portion of the Laboratory where the Laboratory develops and tests explosives. In the past, the Laboratory released wastewater into both canyons from several high-explosives-processing sites in Technical Areas 16 and 09 (Figure 5-4). In 1997, the Laboratory consolidated individual outfalls into one outfall at the High Explosives Wastewater Treatment Facility. This outfall has evaporated all treated effluent since June 2007. 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 is the Technical Area 16 260 Outfall, and other sites at Technical Area 16. The Technical Area 16 260 Outfall discharged high-explosives-bearing water from a high-explosives-machining facility to Cañon de Valle during 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 and R-63. In addition, the volatile organic compounds tetrachloroethene and trichloroethylene have been detected in springs, alluvial groundwater, and perched-intermediate groundwater. Low concentrations of tetrachloroethene have also 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 strata to perched-intermediate groundwater zones and ultimately into the regional aquifer.

The Laboratory submitted an initial corrective measures evaluation report for perched-intermediate and regional groundwater in the watershed in July 2007 (LANL 2007b). In April 2008, the New Mexico Environment Department issued a notice of disapproval on the report and required that additional work be conducted to evaluate the feasibility of the remedial alternatives proposed and to further characterize the extent of contamination. We are currently conducting additional characterization, including cross-hole aquifer tests and tracer tests, and refining the conceptual model for the groundwater system. Groundwater monitoring data collected from the Technical Area 16 260 monitoring group will be used to support a revised corrective measures evaluation report. The following discussion presents ongoing results for the area.

RDX is the primary groundwater contaminant. RDX concentrations exceed the adjusted U.S. Environmental Protection Agency regional screening level for tap water (7.0 µg/L) in two springs (Burning Ground Spring and Martin Spring), in one alluvial well (CdV-16-02659), and in five perched-intermediate zone wells [CdV-16-4ip screen 1, CdV-16-2(i)r, CdV-16-1(i), CdV-9-1(i), and 16-26644 (Figure 5-21)].

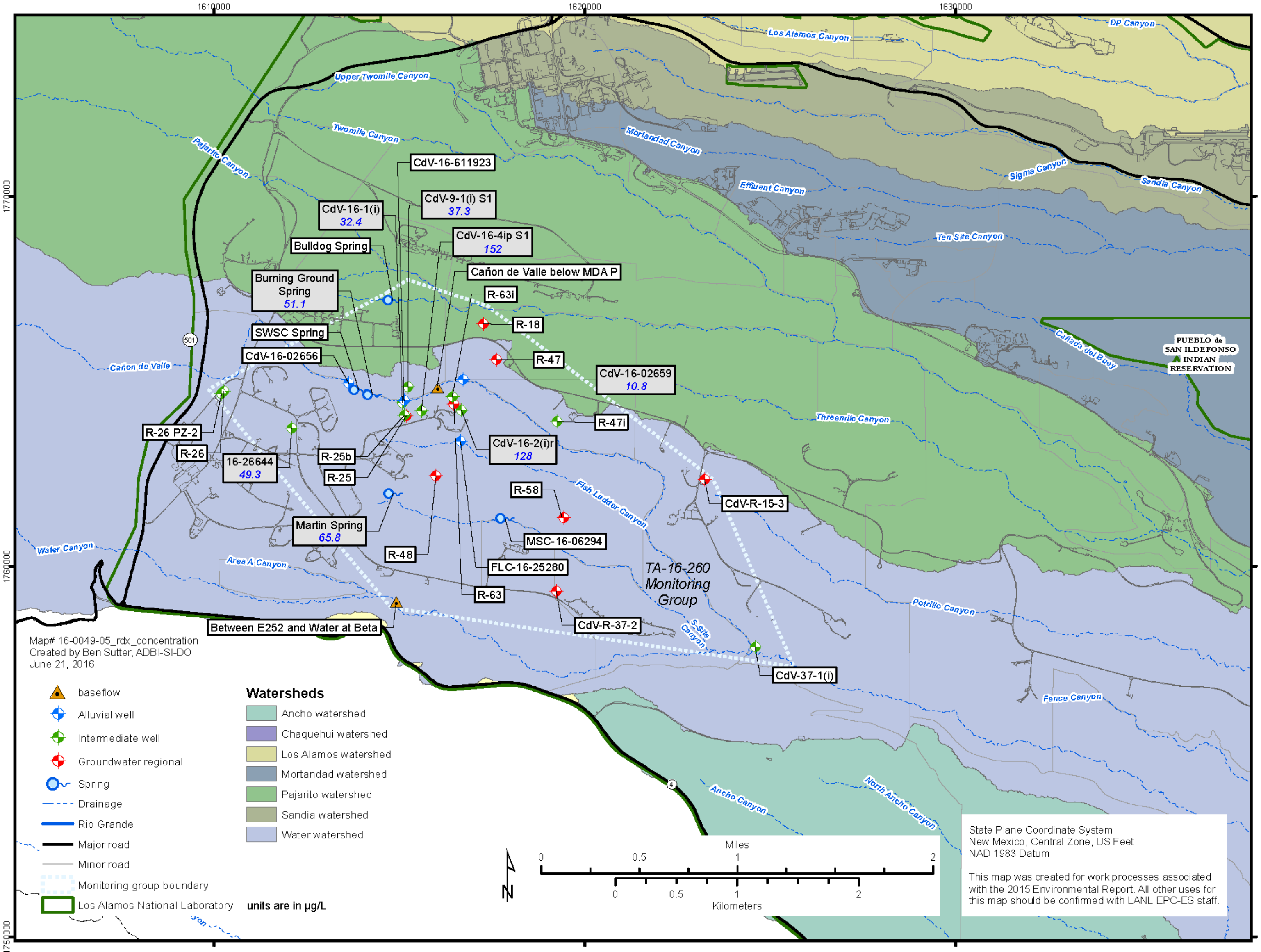


Figure 5-21 Wells and springs with 2015 RDX concentrations above the 7.0-µg/L U.S. Environmental Protection Agency tap water screening level. Maximum concentration for the year (in blue) is in µg/L.

Figures 5-22, 5-23, 5-24, and 5-25 show RDX concentrations in springs, alluvial wells, perched-intermediate zone wells, and regional wells, respectively, during 2010 through 2015. The springs represent perched-intermediate groundwater. RDX concentrations in regional monitoring wells R-63 and R-18 were below the adjusted U.S. Environmental Protection Agency regional tap water screening level.

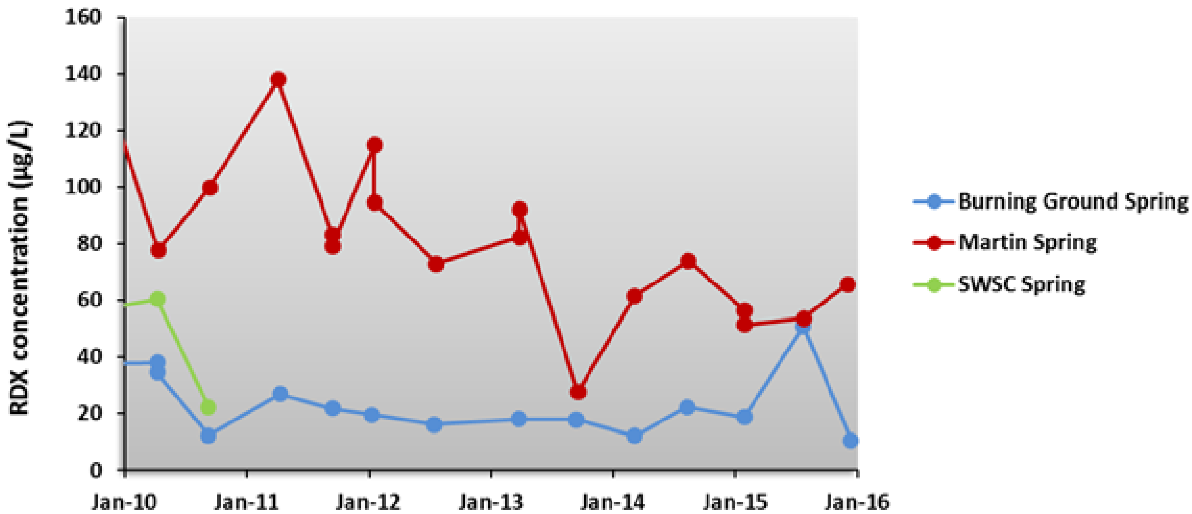


Figure 5-22 **RDX concentrations in springs in Cañon de Valle and Martin Spring Canyon. For comparison purposes, the adjusted U.S. Environmental Protection Agency regional screening level for tap water is 7.0 µg/L.**

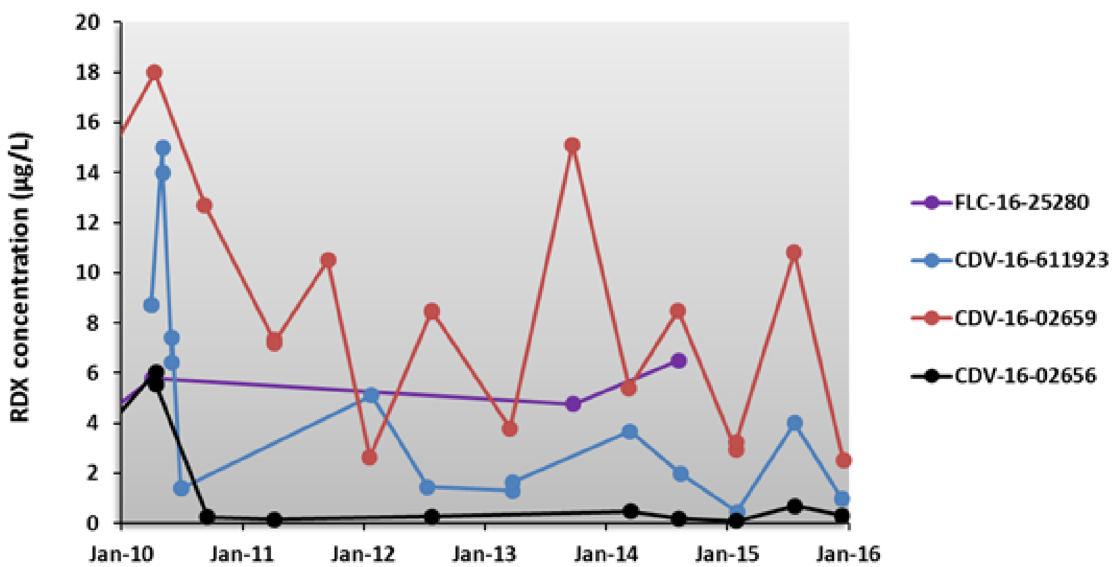


Figure 5-23 **RDX concentrations in alluvial wells in Cañon de Valle and Fishladder Canyon. For comparison purposes, the adjusted U.S. Environmental Protection Agency regional screening level for tap water is 7.0 µg/L.**

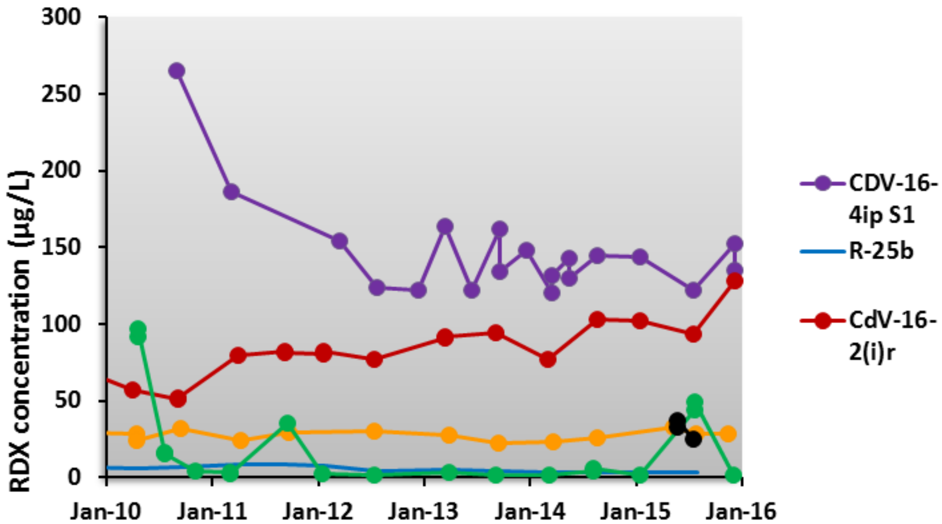


Figure 5-24 RDX in the Technical Area 16 260 monitoring group in Cañon de Valle perched-intermediate groundwater. For comparison purposes, the adjusted U.S. Environmental Protection Agency regional screening level for tap water is 7.0 µg/L.

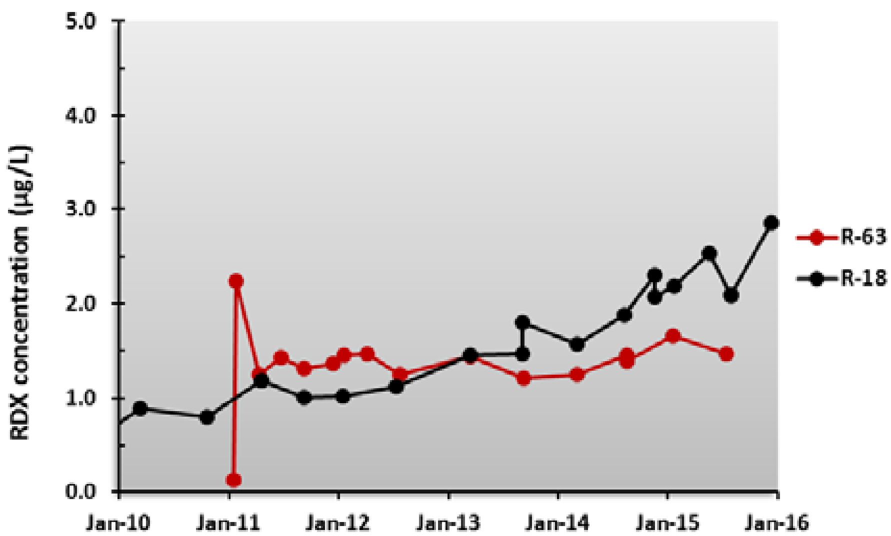


Figure 5-25 RDX in the Technical Area 16 260 monitoring group in Cañon de Valle regional groundwater. For comparison purposes, the adjusted U.S. Environmental Protection Agency regional screening level for tap water is 7.0 µg/L.

Discharge from Martin Spring and Burning Ground Spring contains RDX concentrations above the adjusted U.S. Environmental Protection Agency regional screening level for tap water (Figures 5-21 and 5-22). The concentrations are highest in Martin Spring, which shows a long-term declining trend over the last 5 years (Figure 5-22). RDX concentrations in samples from Burning Ground Spring are typically lower than concentrations in Martin Spring and have been relatively steady over the last 5 years (Figure 5-22), with the exception of one sample collected in July 2015. In the past, SWSC Spring, located near the former location of the Technical Area 16 260 Outfall, has shown elevated RDX concentrations; however, this spring has gone dry in recent years, and no samples were collected in 2015 from SWSC Spring.

RDX concentrations in alluvial monitoring well CdV-16-02659 exceeded the adjusted U.S. Environmental Protection Agency screening level for tap water, with a maximum concentration of 10.8 µg/L in 2015 (Figures 5-21 and 5-23). RDX concentrations in CdV-16-02659 fluctuate because of seasonal influences. RDX concentrations in samples from other nearby alluvial wells in Cañon de Valle were below the adjusted U.S. Environmental Protection Agency tap water screening level in 2015 (Figure 5-23).

RDX concentrations at some perched-intermediate groundwater locations are significantly higher than the current RDX concentrations in the Cañon de Valle alluvium. RDX concentrations exceeded the adjusted U.S. Environmental Protection Agency regional tap water screening level in perched-intermediate wells CdV-16-4ip screen 1, CdV-16-2(i)r, CdV-16-1(i), CdV-9-1(i) screen 1, and 16-26644 (Figures 5-21 and 5-24). Concentrations in CdV-16-1(i) and in CdV-16-4ip screen 1 have been relatively stable in recent years. However, RDX concentrations in CdV-16-2(i)r show a gradual increase with time, increasing over the last 10 years from around 50 µg/L to a maximum value of 128 µg/L in 2015.

In 2015, RDX was detected at low levels in several monitoring wells completed in the regional aquifer (Figure 5-25). RDX is persistently detected at low levels in monitoring wells R-63 and R-18 at concentrations below the 7.0-µg/L adjusted U.S. Environmental Protection Agency regional screening level for tap water. In 2015, RDX was detected in R-63 at a maximum concentration of 1.66 µg/L; RDX concentrations in R-63 have been relatively steady since the well was installed in 2011, with the exception of the first few samples collected after well construction. In 2015, RDX was detected in regional monitoring well R-18 at a maximum concentration of 2.86 µg/L. RDX concentrations in R-18 show increasing trends since the well was installed in 2006 (Figure 5-25).

Chlorinated solvents are also present in groundwater in the Technical Area 16 260 monitoring group. In 2014, the chlorinated solvents tetrachloroethene and trichloroethene were detected above the U.S. Environmental Protection Agency maximum contaminant level for drinking water of 5 µg/L in alluvial well FLC-16-25280. Concentrations of these volatile organic compounds have decreased since 2010 (Figures 5-26 and 5-27). Alluvial well FLC-16-25280 was not sampled in 2015 because the well was dry. Low concentrations of tetrachloroethene and trichloroethene continue to be detected in Burning Ground Spring and in perched-intermediate wells 16-26644, CdV-16-1(i), CdV-16-2(i)r, and CdV-16-4ip screen 1 at concentrations below the U.S. Environmental Protection Agency maximum contaminant level for drinking water. Low concentrations of tetrachloroethene were also detected in piezometer 2 of perched-intermediate well R-26. Trichloroethene also continues to be detected in Martin Spring at concentrations below the U.S. Environmental Protection Agency maximum contaminant level for drinking water. No volatile organic compounds are present above applicable groundwater standards in perched-intermediate or regional groundwater.

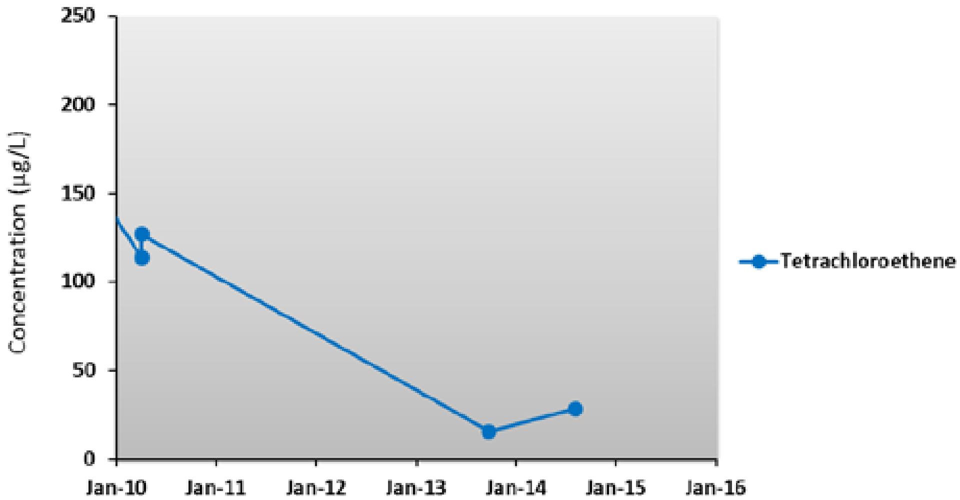


Figure 5-26 **Tetrachloroethene in the Technical Area 16 260 monitoring group in Fishladder Canyon alluvial groundwater well FLC-16-25280. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for drinking water is 5 µg/L.**

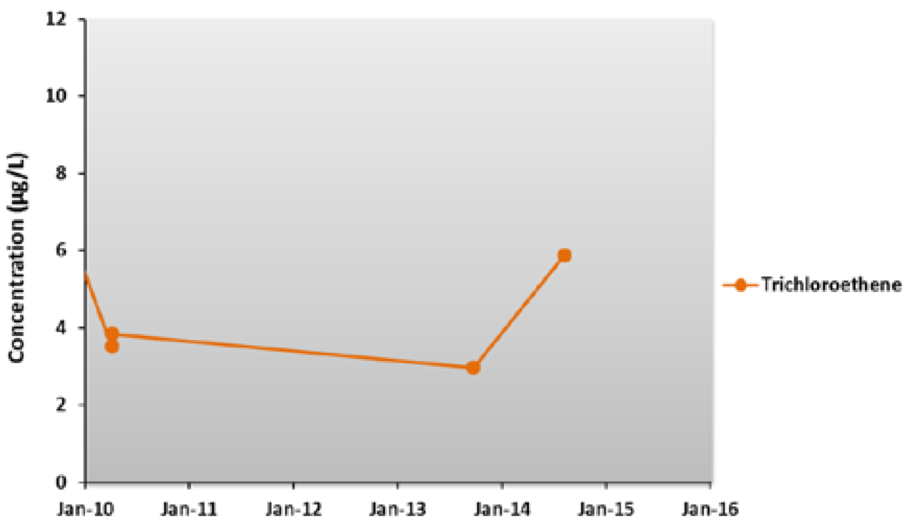


Figure 5-27 **Trichloroethene in the Technical Area 16 260 monitoring group in Fishladder Canyon alluvial groundwater well FLC-16-25280. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for drinking water is 5 µg/L.**

In 2015, boron was detected in samples from Martin Spring at concentrations above the 750-µg/L New Mexico groundwater standard for irrigation use (Figure 5-28). Discharge from Martin Spring has historically shown elevated concentrations of boron, along with RDX. Boron also exceeded the New Mexico groundwater standard for irrigation use in alluvial monitoring well MSC-16-06293 (Figure 5-29). Boron did not exceed groundwater standards in perched-intermediate or regional aquifer wells. Boron concentrations have gradually declined in discharge from Martin Spring and in the remaining alluvial wells in Martin Spring Canyon (Figures 5-28 and 5-29).

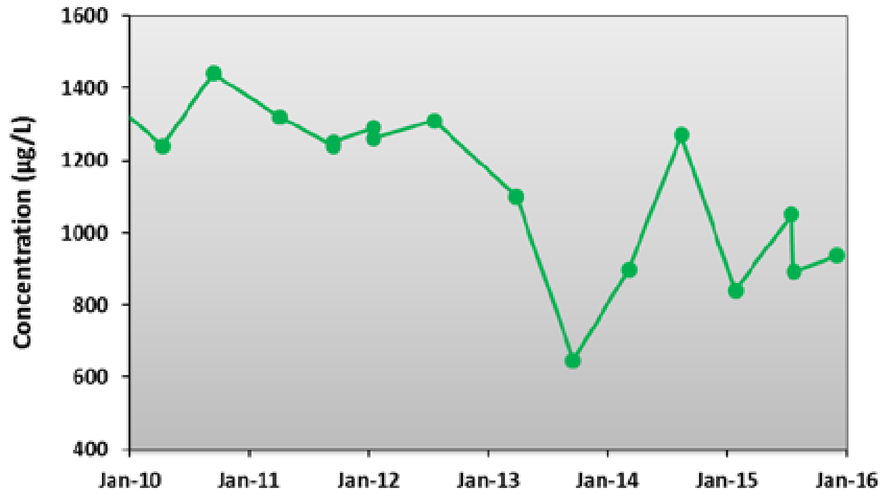


Figure 5-28 **Boron at Martin Spring in Martin Spring Canyon (a Cañon de Valle tributary). The New Mexico groundwater standard for irrigation use is 750 µg/L.**

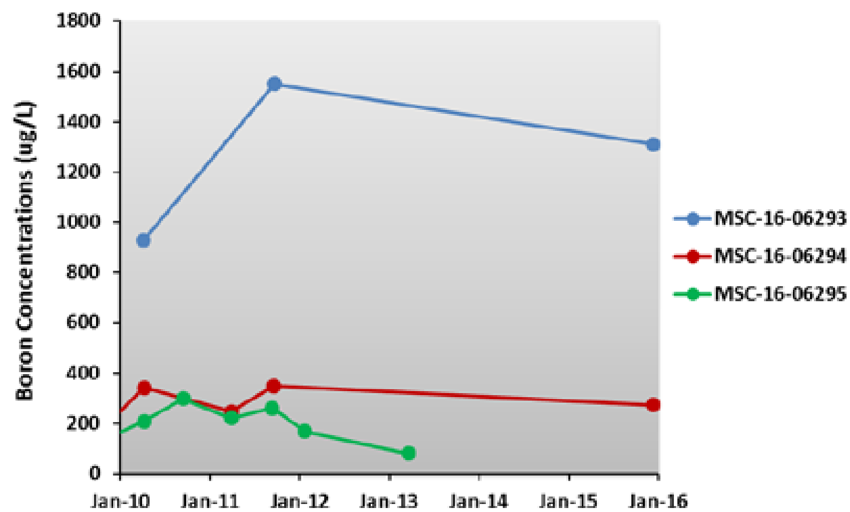


Figure 5-29 **Boron concentrations in alluvial wells in Martin Spring Canyon (a Cañon de Valle tributary). Location MSC-16-06293 is closest to Martin Spring. Location MSC-16-06295 is the farthest downgradient location. The New Mexico groundwater standard for irrigation use is 750 µg/L.**

The source of boron is thought to be the laundry detergent borax, which was used at the former laundry facility at Technical Area 16. Boron is also a component of the explosive compound Boracitol, which was processed in a limited number of facilities.

Barium exceeded the New Mexico groundwater standard of 1000 µg/L in three alluvial wells in Cañon de Valle: CdV-16-611923, CdV-16-02659, and CdV-16-02656 (Figure 5-30). Barium concentrations in these wells have been fairly steady over the last few years, although in 2010, barium concentrations in CdV-16-611923 increased for several sampling periods before dropping to current levels. Barium is associated with an explosive compound, Baratol, which is a mixture of barium nitrate and TNT.

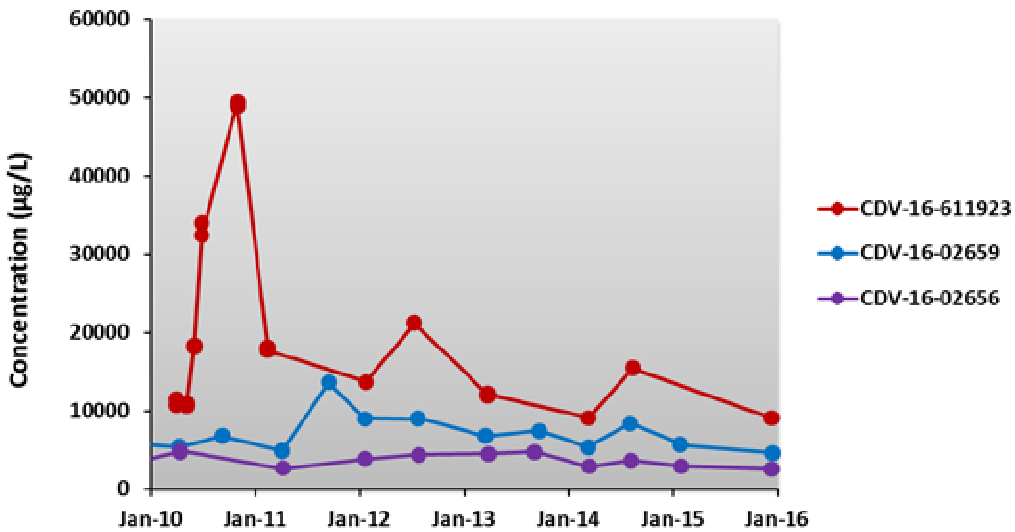


Figure 5-30 Barium in the Technical Area 16 260 monitoring group in Cañon de Valle alluvial groundwater. For comparison purposes, the New Mexico groundwater standard is 1000 µg/L

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 little alluvial 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 on 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 2015 no substances were found in Material Disposal Area AB monitoring group wells at concentrations above standards.

White Rock Canyon Monitoring Group

The springs that issue 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. The water discharging at some other springs may be 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 key 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 have any constituent concentrations that are close to the applicable groundwater standards.

General Surveillance Monitoring

Los Alamos Canyon on Laboratory Property

Alluvial well LAO-3a in Los Alamos Canyon (Figure 5-6) continues to show strontium-90 activities above the 8-pCi/L U.S. Environmental Protection Agency maximum contaminant level for drinking water (Figure 5-31). Results from filtered and unfiltered samples from the same date are typically similar in the alluvial groundwater setting. The source of 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 continues to be found in shallow alluvial groundwater samples at this location because it has been retained on the alluvium by cation exchange (LANL 2004).

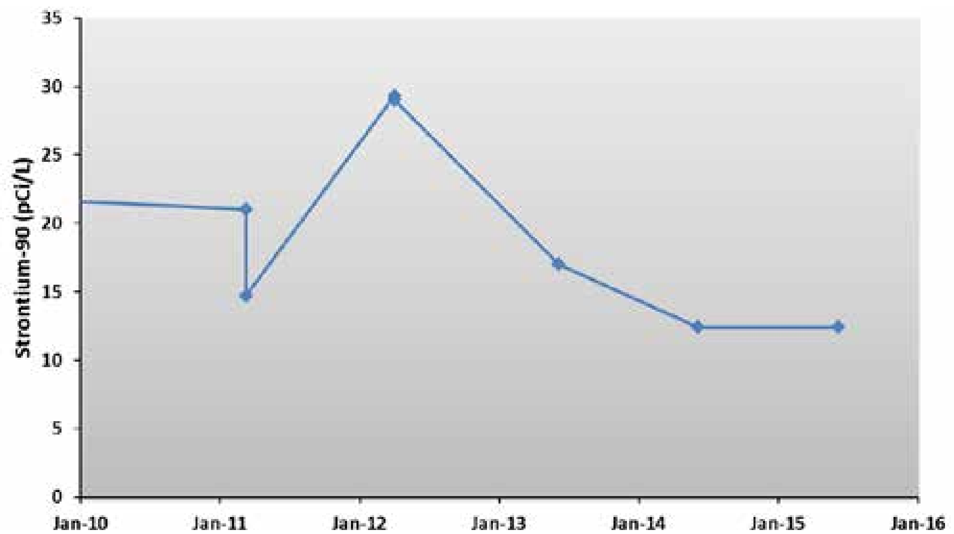


Figure 5-31 Strontium-90 at alluvial monitoring well LAO-3a. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for drinking water is 8 pCi/L.

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; R-10 and R-10a are on Pueblo de San Ildefonso land. No constituents were measured near or above standards in these wells during 2015.

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 in these wells during 2015.

Under the groundwater discharge plan application for the Technical Area 50 Radioactive Liquid Waste Treatment Facility outfall, we have collected quarterly samples 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 above the Compliance Order on Consent screening level of 4 µg/L at all three wells (Figure 5-32). The results since the 2002 Radioactive Liquid Waste Treatment Facility effluent treatment upgrades remain low relative to past perchlorate concentrations in Mortandad Canyon alluvial groundwater. Nitrate, fluoride, and total dissolved solids are far below applicable standards for these alluvial wells.

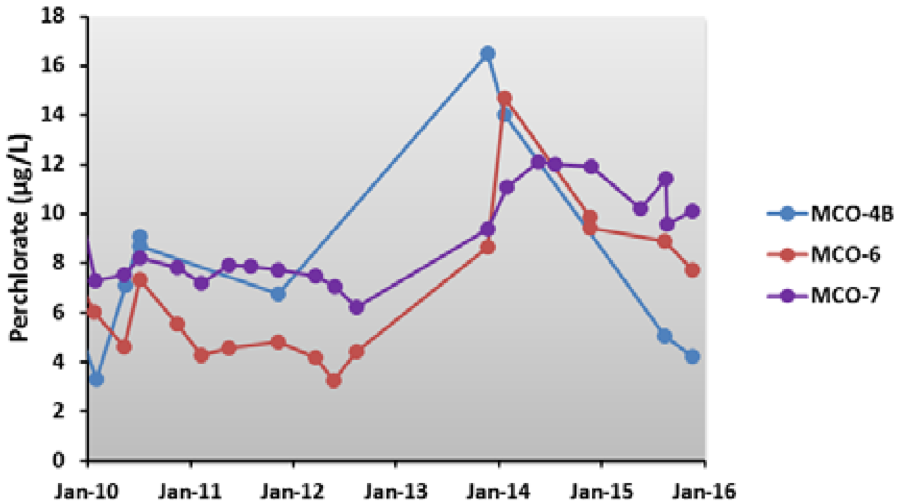


Figure 5-32 **Perchlorate at General Surveillance monitoring group and groundwater discharge plan monitoring locations MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon alluvial groundwater. The 2015 Compliance Order on Consent screening level is 4 µg/L.**

Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was dry in 2015 and therefore not sampled.

Pajarito Canyon

Pajarito Canyon has a watershed that extends down from 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 throughout portions of Pajarito Canyon, including a reach in lower Pajarito Canyon near the eastern Laboratory boundary, but does not extend beyond the boundary at NM 4. 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 in the tributary is apparently recharged by runoff from the parking lot and building roofs. This perched groundwater is sampled at a depth of approximately 21 feet by well 03-B-13.

In 2015, samples from this well contained 1,1,1-trichloroethane and 1,4-dioxane above their applicable standards. Figures 5-33 and 5-34 show the history of these two constituents, respectively.

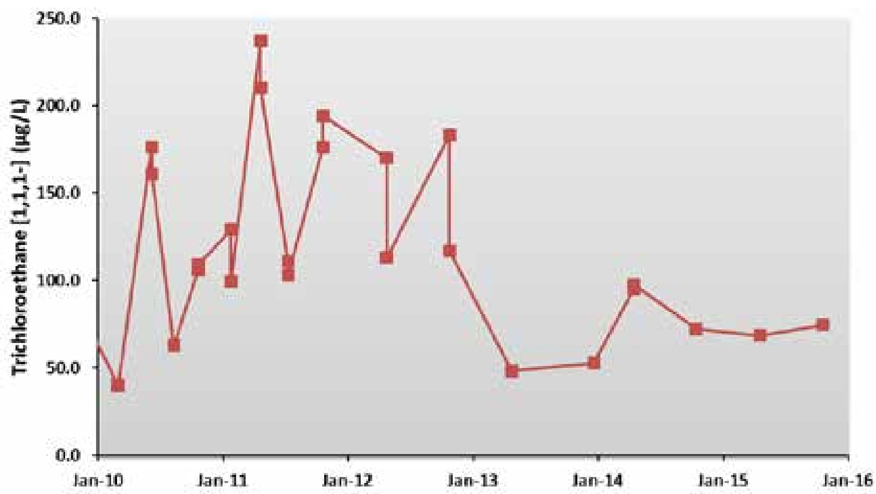


Figure 5-33 **Concentrations of 1,1,1-trichloroethane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard is 60 µg/L.**

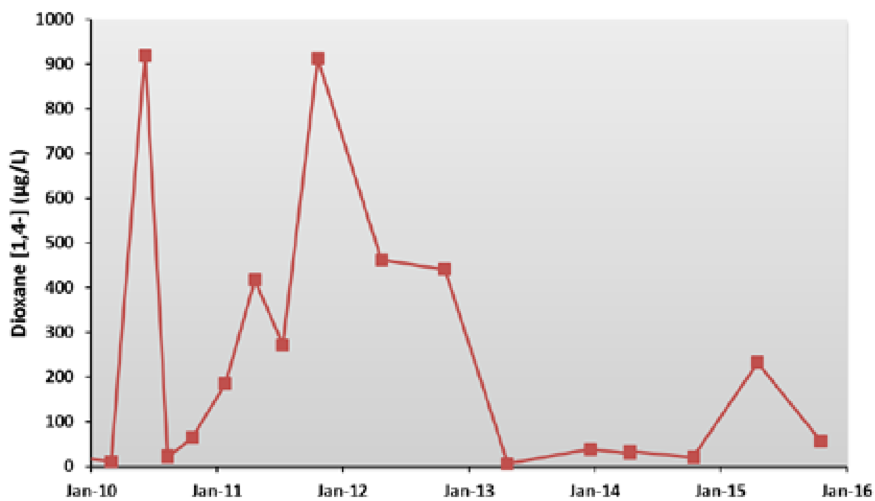


Figure 5-34 **Concentrations of 1,4-dioxane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. For comparison purposes, the U.S. Environmental Protection Agency regional screening level for tap water is 7.8 µg/L.**

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 in these wells during 2015.

Water Canyon

Water Canyon has only one General Surveillance monitoring group location, alluvial well WCO-1r. No constituents were detected above applicable standards in this well in 2015.

SUMMARY

The Laboratory has been monitoring groundwater for decades. A new focus to expand the groundwater monitoring network has taken place over the last decade. This expanded network has resulted in a significant enhancement to 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 extent to warrant interim measures, further characterization, and potential remedial actions: RDX contamination in the Technical Area 16 area and chromium contamination beneath Sandia and Mortandad Canyons. Interim measures will be implemented in the chromium plume beginning in 2016, assuming that all necessary permits are in place. Further characterization work and studies to inform an evaluation of potential remediation strategies are ongoing in both of these areas. The regional aquifer is the source of water for Los Alamos County and the Laboratory. The water-supply wells, which are owned and operated by Los Alamos County, meet all federal and state drinking-water standards.

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To Read About **Turn to Page**

Los Alamos National Laboratory (the Laboratory) collects and analyzes storm water runoff and sediment samples for a variety of substances, including radionuclides and chemicals associated with Laboratory legacy wastes and current operations. We compare sampling results with standards and various screening criteria. The results are also used to determine how different actions, such as willow plantings, are effective at meeting their mitigation goals of reducing sediment and chemical transport.

Human health and ecological risk assessments were performed as part of each of the canyons investigation reports conducted under the Compliance Order on Consent during 2005 through 2015. While some concentrations of substances present in canyons were above applicable aquatic life standards, the human health risk assessments in the canyons investigation reports concluded that concentrations of chemicals and radionuclides present were below levels that would impact human health.

The sediment and water data presented in this chapter are used to verify annually that storm-water-related transport of Laboratory-derived chemicals or radionuclides is not causing levels of those substances to exceed the levels found during the canyons investigations. Over time, storm-water-related transport of sediments is generally resulting in lower concentrations of Laboratory-derived chemical and radionuclides than previously existed in the sampled locations. The results of the sediment and storm water data collected from flood-affected canyons in 2015 agree with this conceptual model and support the idea 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.

INTRODUCTION

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

We monitor chemicals and radionuclides in storm water runoff and sediment in and around the Laboratory to (1) document the occurrence and transport of chemicals associated with legacy LANL wastes and ongoing Laboratory operations and (2) evaluate risks to human and ecosystem health. The sampling results are compared with various screening criteria and standards based on protection of human health and terrestrial and aquatic wildlife.

Annual monitoring of sediment sampled at and near the Laboratory has occurred since 1969. Currently, sediment samples are collected from active channels, overbank-flow sediment deposits on floodplains, and other settings. The sampling is intended to evaluate changes in chemical concentrations and radionuclide activities over time.

Detailed evaluations of substances in sediment across the Laboratory have indicated that chemical concentrations and radionuclide activities are below the acceptable risk and dose limits established by regulating agencies (see the canyons investigation reports: LANL 2004, 2005, 2006, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b, 2011c). Ongoing monitoring is designed to determine whether the concentrations are responding to changing conditions in the watersheds, including forest fires and floods, and to identify the source of any changes that occur. In addition, we evaluate the effects of sediment transport mitigation activities that have been undertaken in the Los Alamos/Pueblo, Sandia, and Mortandad Canyon watersheds (LANL 2013a, 2014a, 2014b, 2015a, 2015b, 2016a, 2016b).

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

- Annual environmental surveillance program
- Monitoring the effectiveness of sediment transport mitigation activities
- The National Pollutant Discharge Elimination System Individual Permit for Storm Water Program

The 2015 Interim Facility-Wide Groundwater Monitoring Plan (LANL 2014c) includes monitoring of base flow or persistent surface water in main drainages and some tributary channels. These data are not presented in this chapter; data are presented in Chapter 5, Groundwater Monitoring, of this report. In addition, sampling of storm water occurred in watersheds in urban, developed landscapes in the Los Alamos townsite in 2015. Results from the townsite sampling will be included in an upcoming report evaluating baseline concentrations of particular metals and polychlorinated biphenyls (PCBs) in developed areas.

HYDROLOGIC SETTING

Laboratory lands contain all or parts of seven primary watersheds that drain into the Rio Grande (Figure 6-1). Listed from north to south, the master 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 entirely located on Laboratory land.

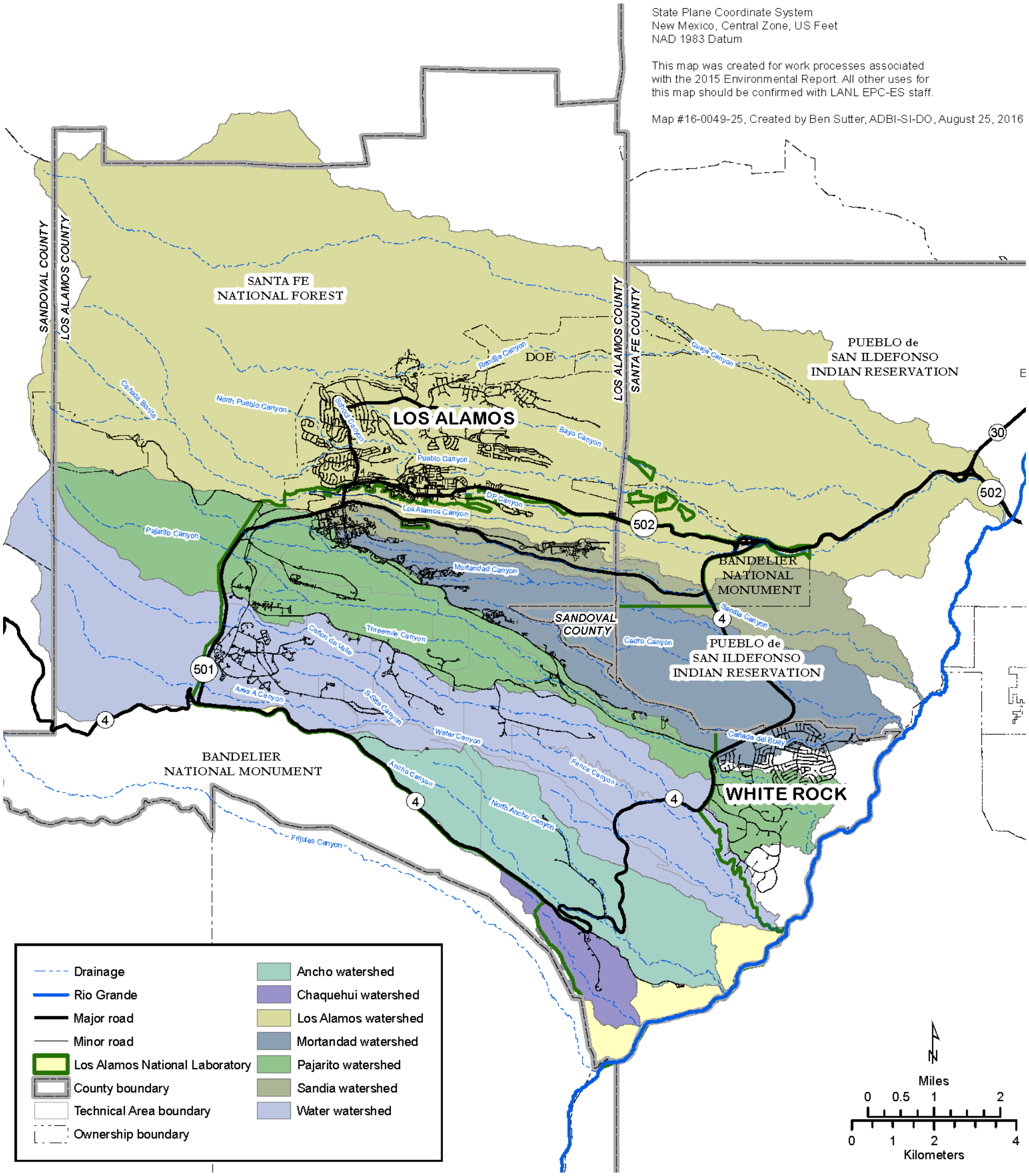


Figure 6-1 Primary watersheds at the Laboratory

In 2015, there was no snowmelt runoff that crossed the downstream (eastern) boundary of the Laboratory. Total storm water runoff for 2015 measured at the downstream Laboratory boundary is estimated at 241 acre-feet. Most of this runoff occurred in Los Alamos, Pueblo, and Water Canyons. Runoff in Sandia, Pajarito, Ancho, Mortandad, Cañada del Buey, Chaquehui, and Potrillo Canyons was minimal. Figure 6-2 shows the estimated storm water runoff volume and seasonal precipitation at the Laboratory for June through October from 1995 to 2015. Approximately 1 acre-foot of the 2015 total storm water runoff volume is attributed to effluent from the Los Alamos County Wastewater Treatment Facility that reached gaging station E060.1 during storm events in July and August.

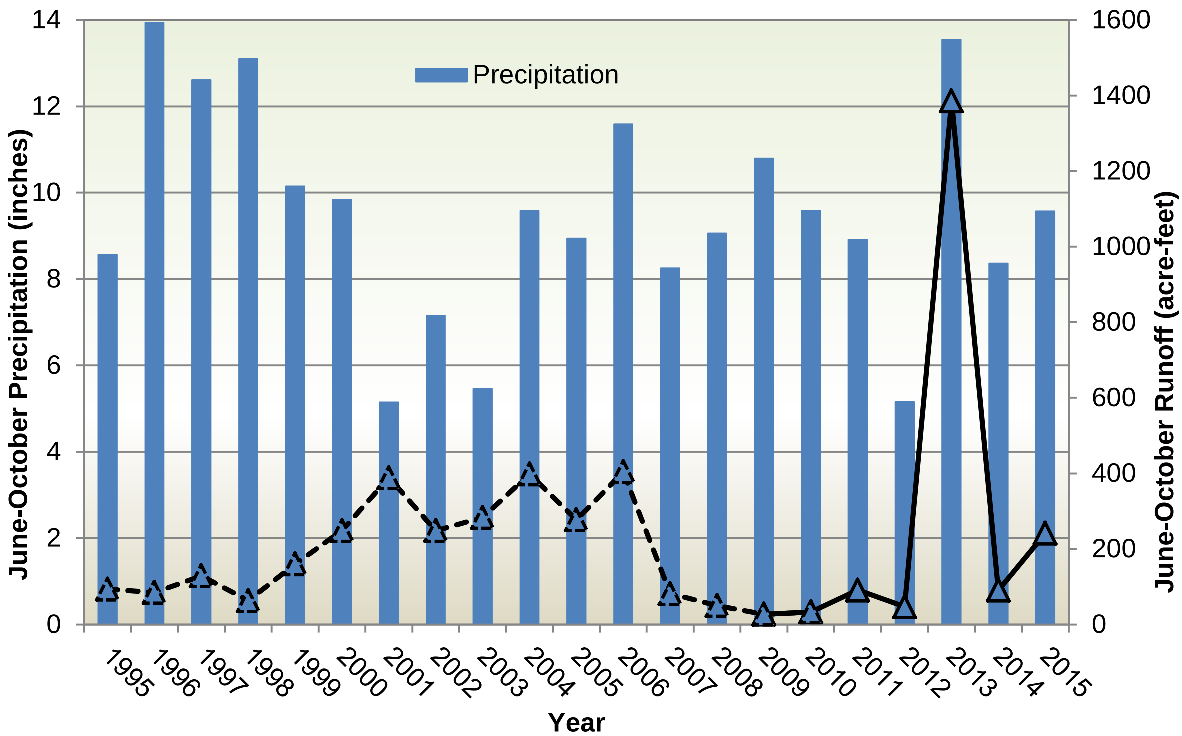


Figure 6-2 **Estimated storm water runoff volume in Laboratory canyons from 1995 to 2015 and total June through October precipitation from 1995 to 2015 averaged across the Laboratory's meteorological tower network (Technical Area 06, Technical Area 49, Technical Area 53, Technical Area 54, and northern community). Dashed line indicates data with some quality issues.**

REGULATION OF STORM WATER RUNOFF AT LANL

The Laboratory currently operates under four National Pollutant Discharge Elimination System permits. The Laboratory's National Pollutant Discharge Elimination System Industrial and Sanitary Permit regulates effluent outfalls. The National Pollutant Discharge Elimination System Individual Permit for Storm Water (Individual Permit) regulates storm water runoff from a subset of solid waste management units and areas of concern. The National Pollutant Discharge Elimination System Construction General Permit regulates storm water runoff from construction sites. The National Pollutant Discharge Elimination System Multi-Sector General Permit regulates storm water runoff from specified industrial sites.

The New Mexico Water Quality Control Commission establishes surface water standards for New Mexico, presented in Section 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 (NMWQCC 2013) and can be found at http://164.64.110.239/nmac/parts/title20/20.006.0004.pdf. Surface water within the Laboratory boundary is not a source of drinking, municipal, industrial, or irrigation water. However, wildlife may use surface waters within the Laboratory. Streamflow may extend beyond the Laboratory boundary. Under the New Mexico Administrative Code, surface waters within the Laboratory boundary are designated as perennial, intermittent, or ephemeral and are assigned specified designated uses, including coldwater aquatic life, marginal warmwater aquatic life, limited aquatic life, livestock watering, wildlife habitat, primary (human) contact, and secondary (human) contact.

Samples of storm water from site monitoring areas associated with solid waste management units and areas of concern are compared with target action levels contained in the Individual Permit. Results from storm water samples collected from established gaging stations in stream channels are compared with New Mexico Water Quality Control Commission standards.

Hardness-dependent aquatic life criteria are calculated using water hardness values of the particular sample, where available, and 30 milligrams calcium carbonate per liter (mg $CaCO_3$/L) where hardness values of the particular sample are not available (EPA 2006, NMWQCC 2013). The Laboratory uses the protocol employed by the New Mexico Environment Department for assessing water quality standards attainment for the State of New Mexico (NMED 2015).

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 in environmental media. Because of the limited streamflow, there are no drinking-water systems on the Pajarito Plateau that rely on surface water supplies. The emphasis of the radiological assessment of surface water is, therefore, on potential exposures of aquatic organisms. For protection of biota, radionuclide activities in surface water are compared with the DOE biota concentration guides (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2013). For water samples from in or near designated perennial stream segments, biota concentration guides for aquatic or riparian animals are used for evaluation, and for samples from ephemeral or intermittent segments, biota concentration guides for terrestrial animals are used. Surface water results for gross-alpha radioactivity and radium isotopes are also compared with the New Mexico Water Quality Control Commission livestock watering standards.

SEDIMENT MANAGEMENT AT LANL

There are no regulatory compliance standards for sediment. For screening purposes, chemical results from sediment are compared with the New Mexico Environment Department's risk-based soil screening levels, and radionuclide results from sediment are compared with the Laboratory's risk-based screening action levels (Table 6-1). Soil screening levels for inorganic and organic chemicals and screening action levels for radionuclides are levels considered safe for industrial, construction worker, recreational, and residential exposure scenarios. If environmental levels of substances are below screening action levels or soil screening levels, then adverse human health effects are highly unlikely.

Table 6-1
Application of Surface Water Standards and Screening Levels and Sediment Screening Levels to Monitoring Data

Substance	Standard	Screening Level	Source	Notes
Surface Water				
Gross-alpha radioactivity, radium-226, and radium-228	New Mexico water quality standards for surface water		New Mexico Water Quality Control Commission (2013)	Standards apply to surface waters in perennial, intermittent, or ephemeral stream reaches. Values are from the livestock watering standard. The New Mexico Water Quality Control Commission standards are not specific about the frequency or duration of organism exposure; therefore, single sample results are compared with the numeric values. New Mexico Water Quality Control Commission standards do not apply on pueblo land.
Radionuclides and radioactivity		Biota concentration guides	DOE (2002, 2004) and McNaughton et al. (2013)	Surface water within the Laboratory boundary is frequently ephemeral or intermittent and therefore often not available to wildlife for long-term access. Perennial water biota concentration guides are used for samples collected from perennial stream segments, and terrestrial water biota concentration guides are applied to all other locations.
Chemicals	New Mexico water quality standards for surface water		New Mexico Water Quality Control Commission (2013)	Standards apply to surface waters in perennial, intermittent, or ephemeral stream reaches. Single sample results are compared with the livestock watering, wildlife habitat, or acute or chronic aquatic life standard, depending on the classification of the stream reach. Standards for human health–organism only (for human consumption of aquatic organisms) apply to all stream segments.
Chemicals		Target action levels	LANL's National Pollutant Discharge Elimination System Individual Permit for Storm Water	Levels apply to storm water runoff from solid waste management units and areas of concern regulated under the Individual Permit.
Sediment				
Radionuclides		Biota concentration guides	DOE (2002, 2004) and McNaughton et al. (2013)	Dose limit to biota is the same as for surface water.
Radionuclides and radioactivity		Screening action levels	LANL (2015c)	Results are compared with residential screening action levels for radionuclides.
Chemicals		Soil screening levels	New Mexico Environment Department (2014)	Results are compared with residential, recreational, construction worker, and industrial soil screening levels.

For protection of biota, levels of radionuclides in sediment are compared with the DOE biota concentration guides (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2013). For screening purposes, single sample results are compared with the biota concentration guides. For sediment samples from in or near designated perennial stream segments, biota concentration guides for riparian animals are used for evaluation, and for samples from ephemeral or intermittent segments, biota concentration guides for terrestrial animals are used.

The Laboratory has installed sediment-control structures in some canyons to reduce channel erosion and to increase the deposition of sediment within Laboratory boundaries (Figure 6-3). Following the Cerro Grande fire in May 2000, a detention basin and barrier (called the low-head weir) were built in Los Alamos Canyon to trap ash, sediment, and debris during floods; the basin and barrier performed in the same manner after the Las Conchas fire in July 2011. Two detention basins were constructed in upper Los Alamos Canyon below Solid Waste Management Unit 01-001(f) to capture PCB-contaminated sediment. A pipeline was installed at this location in 2015 to divert storm water runoff from the Los Alamos townsite around Solid Waste Management Unit 01-001(f).

In Mortandad Canyon, ponding areas (called sediment traps) designed to hold water temporarily had been constructed to allow sediments to settle out of storm water runoff. These sediment traps were rebuilt in 2014. In Pajarito Canyon, a large flood-retention structure was built after the Cerro Grande fire to reduce the possibility that large flood peaks would impact downstream facilities and residences; the structure functioned in the same manner after the Las Conchas fire.

A grade-control structure is an erosion prevention measure built within the active channel of a streambed to set the elevation of the streambed, halting channel incision and sometimes slowing water flow. A grade-control structure was installed in Pueblo Canyon to prevent erosion of the stream channel at the downstream end of the Pueblo Canyon wetland and to improve the condition of the wetland. Willows were planted to help reduce flood peaks and slow flood velocities (LANL 2008a, 2008b). In DP Canyon, a grade-control structure was installed to stabilize the channel and adjacent floodplains. A grade-control structure has also been installed in Sandia Canyon.

An extremely large flood in September 2013 caused damage in Pueblo Canyon as well as other locations. After the flood, work began in 2014 to rehabilitate and mitigate damage to the Pueblo Canyon wetland and grade-control structure, including planting willows below the wetlands, revegetating disturbed areas, installing piezometer transects to record water levels and willow performance, stabilizing local banks, and armoring the north bank at gaging station E060.1. Further rehabilitation work conducted in 2015 included installing a structure to pass water to a lower elevation while controlling its velocity at the downstream end of the Pueblo Canyon wetland; installing gaging station E059.8; and redirecting the stream channel, installing spurs for bank protection, and contouring the area around gaging station E060.1. The Laboratory installed erosion protection measures at the downstream side of both the existing Pueblo Canyon grade-control structure and gaging station E060.1 and constructed an access road.

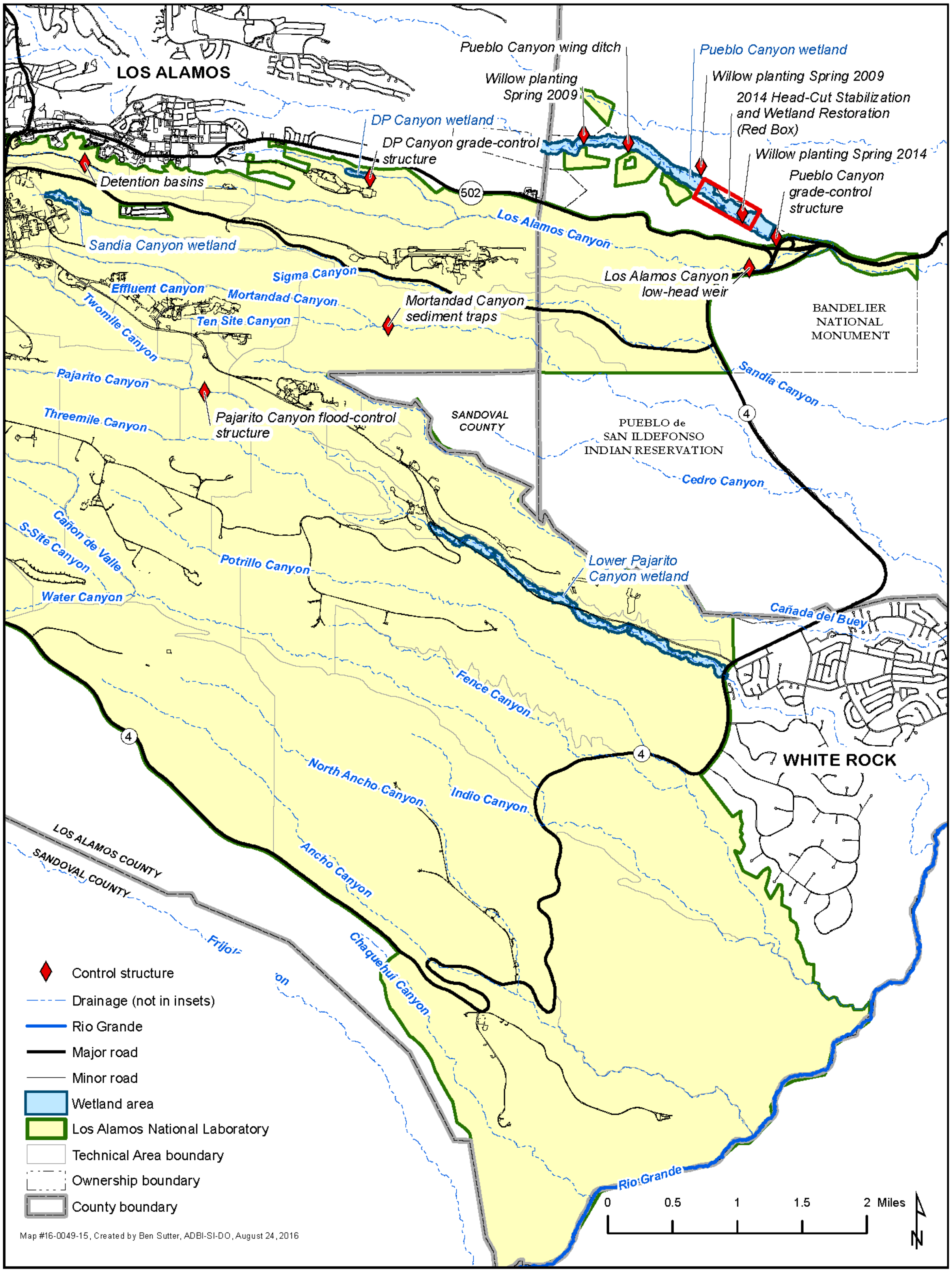


Figure 6-3 Sediment-control structures installed by the Laboratory

In addition to the sediment-control structures discussed above, approximately 1800 storm water control measures have been installed on mesa tops and hillslopes across the Laboratory near and downstream of solid waste management units under the Individual Permit. There are numerous types of control measures, including seed and mulch, natural vegetation, berms and wattles, swales, sediment-detention basins, small check dams, gabions, and ground cover caps. All of these measures reduce the amount of soil transported away from solid waste management units by storm water runoff. Many of them slow down water movement and increase local water infiltration, thereby reducing the total amount of local storm water runoff. The swales, sediment-detention basins, and check dams can reduce the peak volume of storm water runoff from larger areas, thereby reducing the energy generated by the runoff and associated erosion.

STORM WATER AND SEDIMENT SAMPLING

Surface Water Standards and Screening Levels and Sediment Screening Levels

Surface water and sediment sampling is used to monitor the effects of disturbances, including drought, construction, fire, fire suppression, global atmospheric fallout, and Laboratory operations, on chemical and radionuclide levels in storm water runoff and sediments. We compare monitoring results with published standards and screening levels. These standards and screening levels are summarized in Table 6-1. Stream segments on Laboratory property have been classified as perennial or intermittent and ephemeral and have been assigned designated uses by the New Mexico Water Quality Control Commission. The locations of these stream segments and their classification are shown in Figure 6-4, and the official description of their designated use is given in Table 6-2.

The New Mexico Water Quality Control Commission human health–organism only standard is designed to protect people that consume aquatic organisms. Although the human health–organism only standard applies on Laboratory property, there are no fish and no known human consumption of other aquatic organisms for any of the stream segments reported in this chapter.

Although the livestock watering standard applies to all stream reaches on Laboratory property, the only livestock present are a few feral cows that inhabit the bottom of White Rock Canyon, next to the Rio Grande.

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.

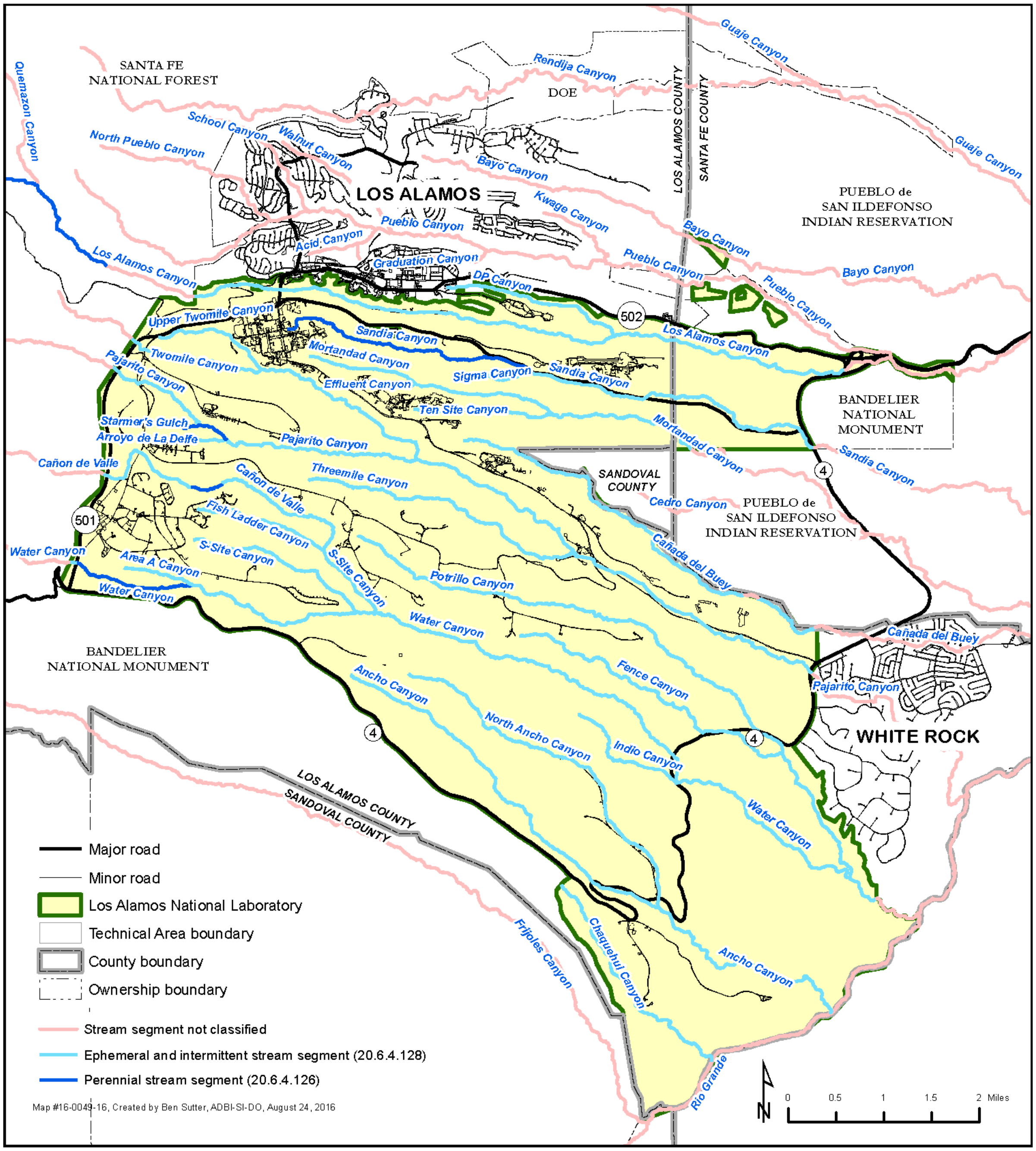


Figure 6-4 Major drainages within and around the Laboratory showing the classifications of designated stream segments

Table 6-2
New Mexico Water Quality Control Commission–Designated Classifications and Uses for LANL Surface Waters

Stream Segment Description	Designated Use	Description of Associated Users
Perennial stream segments on Laboratory property, including parts of Cañon de Valle and Pajarito, Water, and Sandia Canyons		
20.6.4.126 New Mexico Administrative Code – "Perennial portions of Cañon de Valle from LANL stream gage E256 upstream to Burning Ground spring, Sandia canyon from Sigma canyon upstream to LANL Outfall 001, Pajarito canyon from Arroyo de La Delfe upstream into Starmers gulch and Starmers spring and Water canyon from Area-A canyon upstream to State Route 501."	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
	Coldwater aquatic life	Fish, aquatic invertebrates, etc. Chronic aquatic life standard applies.
Ephemeral and intermittent stream segments on Laboratory property		
20.6.4.128 New Mexico Administrative Code – "Ephemeral and intermittent portions of watercourses within lands managed by U.S. department of energy (DOE) within Los Alamos national laboratory, including but not limited to: Mortandad canyon, Cañada del Buey, Ancho canyon, Chaquehui canyon, Indio canyon, Fence canyon, Potrillo canyon and portions of Cañon de Valle, Los Alamos canyon, Sandia canyon, Pajarito canyon and Water canyon not specifically identified in 20.6.4.126 New Mexico Administrative Code."	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		
20.6.4.98 New Mexico Administrative Code – "All intermittent surface waters of the state that are not included in a classified water of the state in 20.6.4.101 through 20.6.4.899 New Mexico Administrative Code."	Livestock watering	Horses, cows, etc.
	Wildlife habitat	Deer, elk, mice, birds, etc.
	Marginal warmwater 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.

Sampling Locations and Methods

Storm water runoff and sediment are sampled in all major canyons on current or former Laboratory lands and are also sampled along some short tributary drainages. We collect samples as part of several programs and to meet different regulatory requirements. This includes an emphasis on monitoring close to and downstream of potential sources of Laboratory-derived substances, including monitoring at the downstream Laboratory boundaries and east of NM 4.

Figure 6-5 shows locations sampled for storm water runoff in 2015 as part of the annual environmental surveillance program and to monitor the effectiveness of sediment transport mitigation measures in the Los Alamos/Pueblo Canyon and Sandia Canyon watersheds. These locations are mostly at stream gaging stations but also include storm water samples at sediment-detention basins in upper Los Alamos Canyon. Figure 6-6 shows locations of Individual Permit site monitoring areas where storm water runoff samplers were located in 2015. Note that discharge from Individual Permit site monitoring areas may or may not, depending on the storm event, reach the canyons.

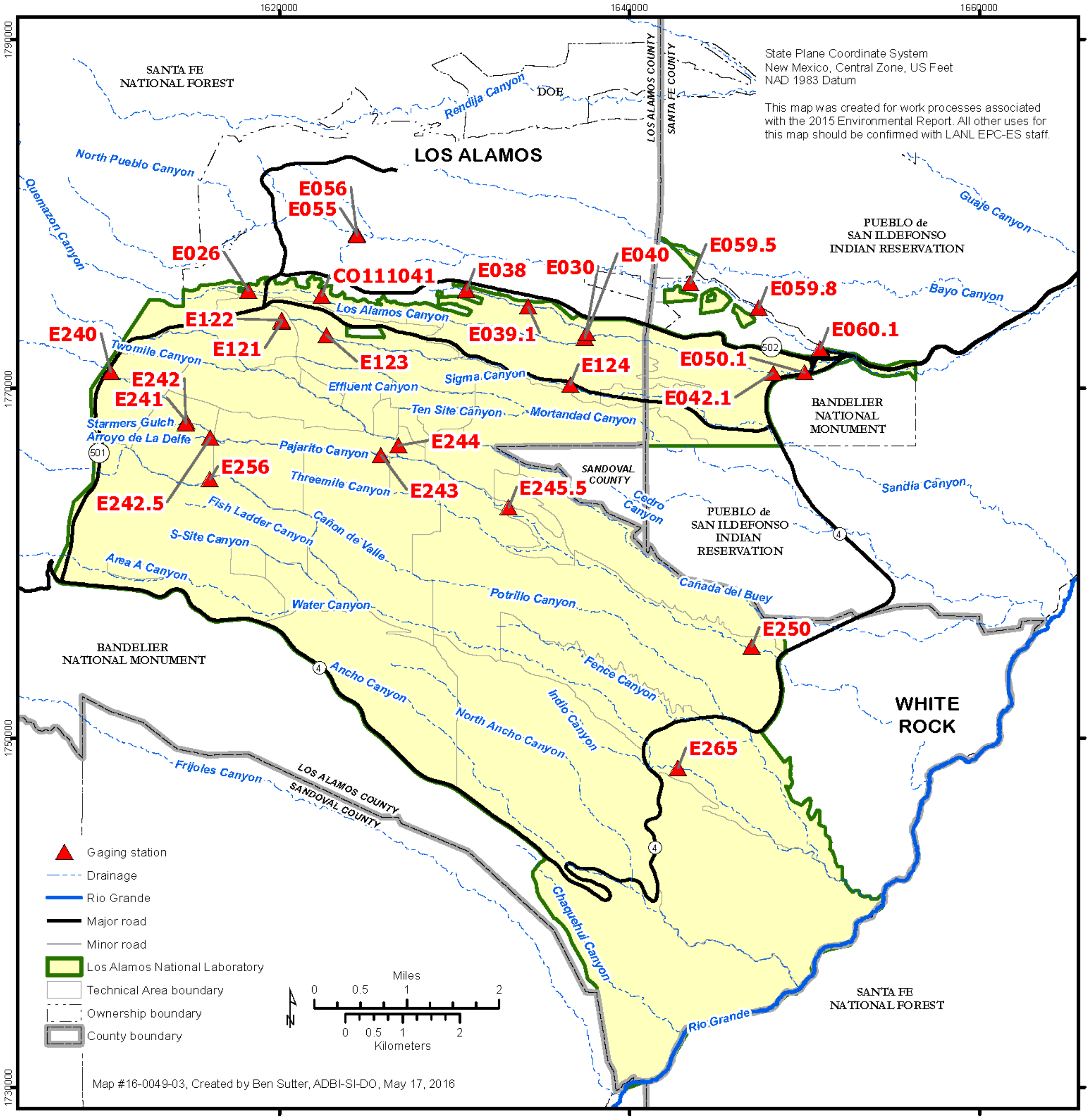


Figure 6-5 Surface water locations sampled in 2015 as part of the annual environmental surveillance program and the Los Alamos/Pueblo Canyon watershed monitoring plan

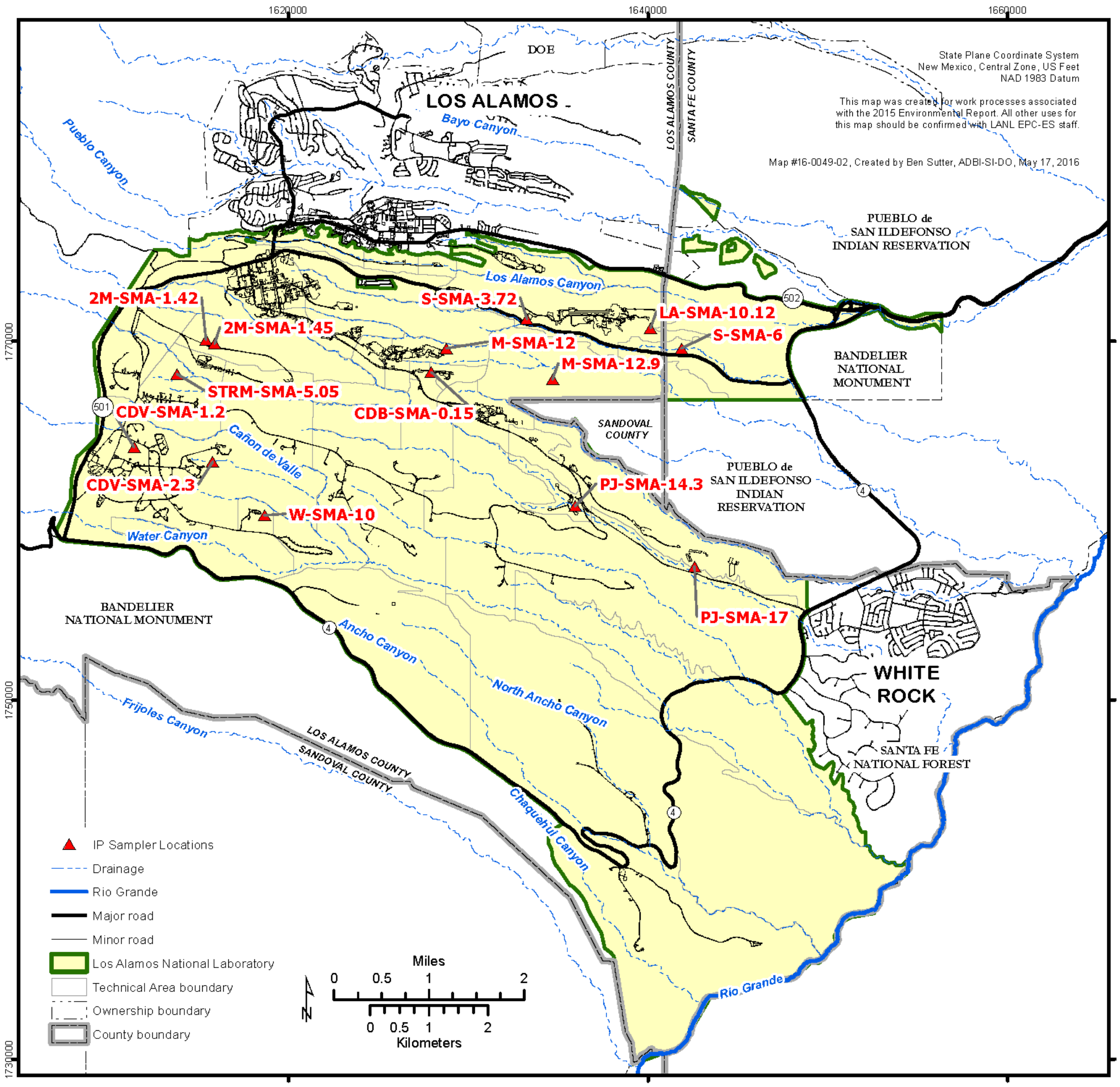
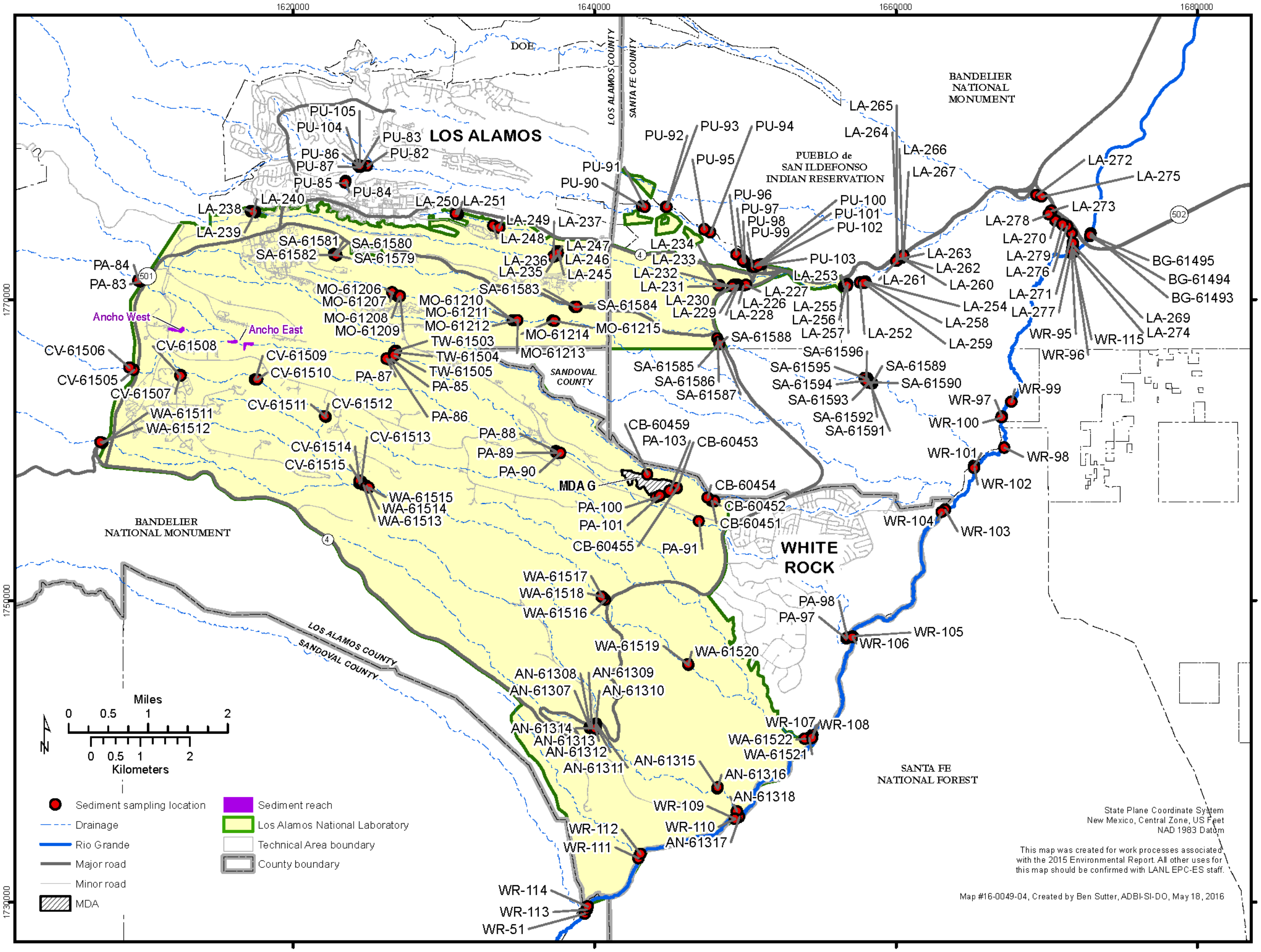


Figure 6-6 Surface water samplers in 2015 at Individual Permit site monitoring areas

Figure 6-7 shows locations sampled for sediment in 2015 as part of the annual environmental surveillance program. We collected sediment samples at a depth of 0 to 12 inches (depending on the thickness of the uppermost sediment layer) from stream channels and adjacent flood plains that had sediment deposited during 2015. For flowing streams, samples were collected from near the edge of the main channel adjacent to (not underneath) flowing water. Locations outside the main channel were also sampled to variable depths. During 2015, storm water runoff flowed in every canyon on Laboratory property except Fence, Potrillo, Indio, and Chaquehui; therefore, sediment samples were collected in almost every watershed.



MDA = Material disposal area.

Figure 6-7 Sediment locations sampled in 2015 as part of the annual environmental surveillance program

Quality Assurance

Sampling of storm water and sediment is performed according to written quality assurance and quality control procedures and protocols identified in the following Laboratory standard operating procedures (SOPs) and guides: Installing, Setting Up, and Operating ISCO Samplers (EP-DIV-SOP-10008); Inspecting Storm Water Runoff Samplers and Retrieving Samples (EP-DIV-SOP-10013); Processing Surface Water Samples (EP-DIV-SOP-20217); Operation and Maintenance of Gage Stations for Storm Water Projects (EP-DIV-SOP-10005); Geomorphic Characterization (ER-GUIDE-20237); and Soil, Tuff, and Sediment Sampling (ER-SOP-20069). 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. The sampling teams 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 mail 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 mail 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. There were no analytical laboratory data quality issues related to the storm water or sediment sampling programs during 2015.

Stream gaging stations are equipped with automated samplers that are activated at the start of storm water runoff events. All automated samplers collect water from the peak of the runoff event to sample water near the leading edge of the hydrograph, also called the "first flush." The year 2015 was the twelfth year that the first flush of storm water was sampled at many gaging stations, and it is a significant change from 2003 and earlier, when samples were collected continuously over a 2-hour period and composited. Higher suspended sediment concentrations tend to occur in the first flush compared with the average concentration over a runoff event because the suspended sediment concentration is generally greatest near the leading edge of the hydrograph (Malmon et al. 2004, 2007). As a result, current storm water data are not directly comparable with data from 2003 and earlier. Beginning in 2010, we also collected multiple storm water samples throughout individual runoff events to evaluate variations in suspended sediment and constituent concentrations within the hydrograph. All storm water samples are filtered and preserved in the Laboratory's storm water processing facility. These samples are then shipped without compositing or splitting.

Sampling Results

Tables 6-3 and 6-4 present results for radionuclides and chemicals in 2015 sediment samples for substances and locations that had at least one sample result greater than background values. Tables 6-5 and 6-6 present results for radionuclides and chemicals in 2015 storm water samples collected at gaging stations for substances that had at least one sample result exceeding a background value.

Table 6-3
2015 Sediment Results for Radionuclides for Locations with at Least One Sample Result Greater than Background Values

Major Canyon	Tributary or Subcanyon	Radionuclide	Number of Samples Tested for the Radionuclide	Number of Detections	Maximum Value (pCi/g[a])	Residential Screening Action Level (pCi/g)	Number of Samples > Residential Screening Action Level	Industrial Screening Action Level (pCi/g)	Number of Samples > Industrial Screening Action Level	Construction Worker Screening Action Level (pCi/g)	Number of Samples > Construction Worker Screening Action Level	Recreational Screening Action Level (pCi/g)	Number of Samples > Recreational Screening Action Level	Terrestrial Biota Concentration Guide for Sediment (pCi/g)	Number of Samples > Terrestrial Biota Concentration Guide for Sediment
Rio Grande	**Above Otowi Bridge**	Am-241	8	1	0.053	50	0	140	0	610	0	890	0	4000	0
Los Alamos Canyon	**Upper Los Alamos**	Am-241	33	8	0.096	50	0	140	0	610	0	890	0	4000	0
		Pu-239/240	17	12	0.298	48	0	120	0	710	0	770	0	6000	0
	DP	Am-241	15	6	0.332	50	0	140	0	610	0	890	0	4000	0
		Cs-137	8	5	2.16	7.2	0	22	0	25	0	220	0	2000	0
		Pu-239/240	8	5	0.287	48	0	120	0	710	0	770	0	6000	0
	Acid	Am-241	6	4	0.309	50	0	140	0	610	0	890	0	4000	0
		Pu-238	4	3	0.035	51	0	140	0	790	0	850	0	—[b]	—
		Pu-239/240	4	4	9.18	48	0	120	0	710	0	770	0	6000	0
	Pueblo	Am-241	41	6	0.368	50	0	140	0	610	0	890	0	4000	0
		Pu-238	21	2	0.040	51	0	140	0	790	0	850	0	—	—
		Pu-239/240	21	18	8.29	48	0	120	0	710	0	770	0	6000	0
		Tritium	1	1	0.095	1000	0	9.9E05	0	1.5E06	0	3.4E06	0	2.0E05	0
	Lower Los Alamos	Am-241	62	4	0.079	50	0	140	0	610	0	890	0	4000	0
		Pu-239/240	31	17	0.363	48	0	120	0	710	0	770	0	6000	0

Table 6-3 (continued)

Major Canyon	Tributary or Subcanyon	Radionuclide	Number of Samples Tested for the Radionuclide	Number of Detections	Maximum Detected Value (pCi/g[a])	Residential Screening Action Level (pCi/g)	Number of Samples > Residential Screening Action Level	Industrial Screening Action Level (pCi/g)	Number of Samples > Industrial Screening Action Level	Construction Worker Screening Action Level (pCi/g)	Number of Samples > Construction Worker Screening Action Level	Recreational Screening Action Level (pCi/g)	Number of Samples > Recreational Screening Action Level	Terrestrial Biota Concentration Guide for Sediment (pCi/g)	Number of Samples > Terrestrial Biota Concentration Guide for Sediment
Mortandad Canyon	**Mortandad**	Am-241	23	17	11.1	50	0	140	0	610	0	890	0	4000	0
		Cs-137	12	10	15.5	7.2	3	22	0	25	0	220	0	2000	0
		Pu-238	12	9	3.39	51	0	140	0	790	0	850	0	—	—
		Pu-239/240	12	9	7.79	48	0	120	0	710	0	770	0	6000	0
	Cañada del Buey	Am-241	14	1	0.085	50	0	140	0	610	0	890	0	4000	0
		Pu-238	7	1	0.153	51	0	140	0	790	0	850	0	—	—
		Pu-239/240	7	1	0.324	48	0	120	0	710	0	770	0	6000	0
Pajarito Canyon	**Pajarito**	Am-241	16	1	0.334	50	0	140	0	610	0	890	0	4000	0
		Pu-239/240	16	1	1.06	48	0	120	0	710	0	770	0	6000	0

[a] pCi/g = Picocuries per gram.

[b] — = Screening level does not exist.

Table 6-4
2015 Sediment Results for Inorganic and Organic Chemicals for Locations with at Least One Sample Result Greater than Background Values

Major Canyon	Tributary or Subcanyon	Chemical	Number of Samples Tested for the Chemical	Number of Detections	Maximum Detected Value (mg/kg[a])	Residential Soil Screening Level (mg/kg)	Number of Samples > Residential Soil Screening Level	Industrial Soil Screening Level (mg/kg)	Number of Samples > Industrial Soil Screening Level	Construction Worker Soil Screening Level (mg/kg)	Number of Samples > Construction Worker Soil Screening Level
Los Alamos Canyon	Upper Los Alamos	Antimony	17	8	0.85	31.3	0	142	0	519	0
		Cobalt	17	17	8.97	23	0	36.6	0	350	0
		Manganese	17	17	557	10500	0	464	1	160000	0
	DP	Antimony	8	2	0.87	31.3	0	142	0	519	0
		Copper	8	8	16.7	3130	0	14200	0	51900	0
		Lead	8	8	23.8	400	0	800	0	800	0
		Manganese	8	8	720	10500	0	464	1	160000	0
		Selenium	8	1	0.44	391	0	1750	0	6490	0
		Zinc	8	8	102	23500	0	106000	0	389000	0
		Benzo(a)pyrene	4	4	0.20	0.153	1	24	0	3.23	0
	Acid	Antimony	4	4	2.01	31.3	0	142	0	519	0
	Pueblo	Antimony	11	9	2.6	31.3	0	142	0	519	0
		Cadmium	11	5	0.71	70.5	0	72.1	0	1110	0
		Iron	11	11	14600	54800	0	248000	0	908000	0
		Selenium	11	1	0.87	391	0	1750	0	6490	0
		Vanadium	11	11	21.4	394	0	614	0	6530	0
		Zinc	11	11	63.9	23500	0	106000	0	389000	0
		Benzo(a)pyrene	6	4	0.30	0.153	1	24	0	3.23	0

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Chemical	Number of Samples Tested for the Chemical	Number of Detections	Maximum Detected Value (mg/kg[a])	Residential Soil Screening Level (mg/kg)	Number of Samples > Residential Soil Screening Level	Industrial Soil Screening Level (mg/kg)	Number of Samples > Industrial Soil Screening Level	Construction Worker Soil Screening Level (mg/kg)	Number of Samples > Construction Worker Soil Screening Level
Los Alamos Canyon (continued)	**Lower Los Alamos**	Antimony	31	21	1.33	31.3	0	142	0	519	0
		Calcium	31	31	6050	—[b]	—	—	—	—	—
		Lead	31	31	39.4	400	0	800	0	800	0
		Selenium	31	2	0.532	391	0	1750	0	6490	0
		Vanadium	31	31	21.9	394	0	614	0	6530	0
		Zinc	31	31	64.8	23500	0	106000	0	389000	0
Sandia Canyon	**Sandia**	Barium	20	20	146	15600	0	4390	0	255000	0
		Cadmium	20	2	0.815	70.5	0	72.1	0	1110	0
		Calcium	20	20	4520	—	—	—	—	—	—
		Chromium	20	20	453	96.6	2	134	1	505	0
		Cobalt	20	20	5.28	23	0	36.6	0	350	0
		Copper	20	20	40.8	3130	0	14200	0	51900	0
		Iron	20	20	16400	54800	0	248000	0	908000	0
		Lead	20	20	32.4	400	0	800	0	800	0
		Manganese	20	20	660	10500	0	464	2	160000	0
		Mercury	20	10	0.589	23.5	0	77.1	0	389	0
		Nickel	20	20	10.5	1560	0	753	0	25700	0
		Selenium	20	6	0.746	391	0	1750	0	6490	0
		Silver	20	11	12.7	391	0	1770	0	6490	0
		Vanadium	20	20	21.2	394	0	614	0	6530	0
		Zinc	20	20	163	23500	0	106000	0	389000	0

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Chemical	Number of Samples Tested for the Chemical	Number of Detections	Maximum Detected Value (mg/kg[a])	Residential Soil Screening Level (mg/kg)	Number of Samples > Residential Soil Screening Level	Industrial Soil Screening Level (mg/kg)	Number of Samples > Industrial Soil Screening Level	Construction Worker Soil Screening Level (mg/kg)	Number of Samples > Construction Worker Soil Screening Level
Mortandad Canyon	**Mortandad**	Iron	12	12	14900	54800	0	248000	0	908000	0
		Zinc	12	12	84.9	23500	0	106000	0	389000	0
	Cañada del Buey	Manganese	7	7	482	10500	0	464	1	160000	0
		Vanadium	7	7	25.6	394	0	614	0	6530	0
Pajarito Canyon	**Pajarito**	Selenium	16	2	1.59	391	0	1750	0	6490	0
		Silver	16	7	1.45	391	0	1770	0	6490	0
		Vanadium	16	16	21.7	394	0	614	0	6530	0
		Zinc	16	16	75.3	23500	0	106000	0	389000	0
Water Canyon	**Water**	Barium	13	13	199	15600	0	4390	0	255000	0
		Cobalt	13	13	4.81	23	0	36.6	0	350	0
		Magnesium	13	13	2600	—	—	—	—	—	—
		Nickel	13	13	10.2	1560	0	753	0	25700	0
		Vanadium	13	13	21.5	394	0	614	0	6530	0
	Cañon de Valle	Antimony	12	9	0.89	31.3	0	142	0	519	0
		Barium	12	12	1680	15600	0	4390	0	255000	0
		Copper	12	12	19	3130	0	14200	0	51900	0
		Iron	12	12	14600	54800	0	248000	0	908000	0
		Lead	12	12	44.3	400	0	800	0	800	0
		Manganese	12	12	502	10500	0	464	2	160000	0
		Nickel	12	12	45	1560	0	753	0	25700	0
		Silver	12	12	17.7	391	0	1770	0	6490	0

Table 6-4 (continued)

Major Canyon	Tributary or Subcanyon	Chemical	Number of Samples Tested for the Chemical	Number of Detections	Maximum Detected Value (mg/kg[a])	Residential Soil Screening Level (mg/kg)	Number of Samples > Residential Soil Screening Level	Industrial Soil Screening Level (mg/kg)	Number of Samples > Industrial Soil Screening Level	Construction Worker Soil Screening Level (mg/kg)	Number of Samples > Construction Worker Soil Screening Level
Ancho Canyon	**Ancho**	Calcium	13	13	7160	—	—	—	—	—	—
		Iron	13	13	26800	54800	0	248000	0	908000	0
		Manganese	13	13	629	10500	0	464	2	160000	0
		Selenium	13	4	1.1	391	0	1750	0	6490	0
		Vanadium	13	13	30.5	394	0	614	0	6530	0
		Zinc	13	13	107	23500	0	106000	0	389000	0

[a] mg/kg = Milligrams per kilogram.

[b] — = Standard does not exist for chemical.

Table 6-5
2015 Storm Water Results for Radionuclides in Samples Collected at Gaging Stations at Locations with Results Greater than at Least One Screening Level

Major Canyon	Tributary or Subcanyon	Sample Location	Radionuclide	Number of Tested for the Radionuclide	Number of Detections	Maximum Detected Value (pCi/L*)	Aquatic Biota Concentration Guide for Water (pCi/L)	Number of Samples > Aquatic Biota Concentration Guide for Water	Terrestrial Biota Concentration Guide for Water (pCi/L)	Number of Samples > Terrestrial Biota Concentration Guide for Water
Los Alamos Canyon	**Los Alamos**	**Los Alamos below Low-Head Weir at E050.1**	Radium-228	7	7	4.6	3	4	7000	0
	Pueblo	**Pueblo below Grade-Control Structure at E060.1**	Radium-226	2	2	6.05	4	1	8000	0
			Radium-228	2	2	15.5	3	2	7000	0

*pCi/L = Picocuries per liter.

Table 6-6
2015 Storm Water Results for Inorganic and Organic Chemicals and Gross-Alpha Radioactivity in Samples Collected at Gaging Stations at Locations with at Least One Sample Result Greater than Background Values

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of Samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Los Alamos Canyon	Los Alamos	**Los Alamos below Ice Rink at E026**	Selenium	1	1	16.6	—[c]	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	1	1	0.006	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
			Gross alpha	1	1	197	—	—	15	1	—	—	—	—	—	—	—	—
		LA-2 Ponds Run-on at CO111041	Aluminum	5	5	617	5000	0	—	—	—	—	307 to 673	2	—	—	—	—
			Copper	5	5	5.88	200	0	500	0	—	—	2.56 to 4.39	3	—	—	—	—
			Total PCB	4	4	8.68	—	—	—	—	0.014	4	2	4	—	—	0.00064	4
			Gross alpha	4	4	45.9	—	—	15	3	—	—	—	—	—	—	—	—
		Los Alamos above DP Canyon at E030	Total PCB	1	1	0.527	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
			Gross alpha	1	1	231	—	—	15	1	—	—	—	—	—	—	—	—
	DP	**DP above TA-21[d] at E038**	Aluminum	6	6	2080	5000	0	—	—	—	—	154 to 658	5	—	—	—	—
			Copper	6	6	2.69	200	0	500	0	—	—	1.59 to 4.32	1	—	—	—	—
			Total PCB	6	6	0.075	—	—	—	—	0.014	1	2	0	—	—	0.00064	6
			Gross alpha	6	6	45.7	—	—	15	5	—	—	—	—	—	—	—	—
		DP below Grade-Control Structure at E039.1	Aluminum	9	9	4880	5000	0	—	—	—	—	278 to 479	9	—	—	—	—
			Copper	9	9	3.79	200	0	500	0	—	—	2.39 to 3.48	2	—	—	—	—
			Total PCB	9	9	0.0465	—	—	—	—	0.014	2	2	0	—	—	0.00064	9
			Gross alpha	9	9	173	—	—	15	6	—	—	—	—	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Los Alamos Canyon	DP	DP above Los Alamos Canyon at E040	Aluminum	8	8	6020	5000	2	—	—	—	—	357 to 658	8	—	—	—	—
			Copper	8	8	3.8	200	0	500	0	—	—	2.8 to 4.3	0	—	—	—	—
			Total PCB	8	8	0.074	—	—	—	—	0.014	3	2	0	—	—	0.00064	8
			Gross alpha	8	8	200	—	—	15	7	—	—	—	—	—	—	—	—
	Los Alamos	Los Alamos above Low-Head Weir at E042.1	Aluminum	5	5	14600	5000	4	—	—	—	—	404 to 909	5	—	—	—	—
			Selenium	5	5	24.7	—	—	—	—	5	4	20	1	—	—	—	—
			Dioxins[e]	5	5	1.383E-05	—	—	—	—	—	—	—	—	—	—	5.1E-08	5
			Total PCB	14	13	0.254	—	—	—	—	0.014	13	2	0	—	—	0.00064	13
			Gross alpha	5	5	830	—	—	15	5	—	—	—	—	—	—	—	—
		Los Alamos Below Low-Head Weir at E050.1	Aluminum	7	7	9270	5000	5	—	—	—	—	512 to 1860	6	—	—	—	—
			Selenium	7	4	8.3	—	—	—	—	5	2	20	0	—	—	—	—
			Dioxins	7	7	2.900E-06	—	—	—	—	—	—	—	—	—	—	5.1E-08	7
			Total PCB	19	15	0.111	—	—	—	—	0.014	13	2	0	—	—	0.00064	15
			Gross alpha	13	13	173	—	—	15	11	—	—	—	—	—	—	—	—
	Pueblo	Pueblo above Acid at E055	Aluminum	1	1	6060	5000	1	—	—	—	—	—	—	151	1	—	—
			Copper	1	1	3.49	200	0	500	0	—	—	—	—	2.26	1	—	—
			Lead	1	1	1.72	5000	0	100	0	—	—	—	—	0.42	1	—	—
			Total PCB	1	1	0.072	—	—	—	—	0.014	1	—	—	0.014	1	0.00064	1
			Gross alpha	1	1	142	—	—	15	1	—	—	—	—	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Los Alamos Canyon	**Acid**	**Acid above Pueblo at E056**	Aluminum	4	4	3160	5000	0	—	—	—	—	—	—	60 to 129	4	—	—
			Copper	4	4	2.82	200	0	500	0	—	—	—	—	1.27 to 2.05	4	—	—
			Lead	4	4	1.23	5000	0	100	0	—	—	—	—	0.20 to 0.37	4	—	—
			Total PCB	4	4	0.058	—	—	—	—	0.014	4	—	—	0.014	4	0.00064	4
			Gross alpha	4	4	150	—	—	15	4	—	—	—	—	—	—	—	—
	Pueblo	**Pueblo below Los Alamos County WWTF[f] at E059.5**	Aluminum	1	1	12200	5000	1	—	—	—	—	—	—	270	1	—	—
			Arsenic	1	1	2.83	100	0	200	0	—	—	—	—	150	0	9	0
			Boron	1	1	49.6	750	0	5000	0	—	—	—	—	—	—	—	—
			Copper	1	1	3.64	200	0	500	0	—	—	—	—	3.25	1	—	—
			Lead	1	1	1.15	5000	0	100	0	—	—	—	—	0.68	1	—	—
			Selenium	1	1	15.8	—	—	—	—	5	1	—	—	5	1	—	—
			Total PCB	2	2	0.048	—	—	—	—	0.014	2	—	—	0.014	2	0.00064	2
			Gross alpha	1	1	250	—	—	15	1	—	—	—	—	—	—	—	—
		Pueblo Below Wetlands at E059.8	Arsenic	1	1	3.77	100	0	200	0	—	—	—	—	150	0	9	0
			Boron	1	1	280	750	0	5000	0	—	—	—	—	—	—	—	—
			Copper	1	1	4.74	200	0	500	0	—	—	—	—	7.95	0	—	—
			Nickel	1	1	5.34	—	—	—	—	—	—	—	—	46.23	0	4600	0
			Vanadium	1	1	8.32	100	0	100	0	—	—	—	—	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Los Alamos Canyon	**Pueblo**	**Pueblo below Grade-Control Structure at E060.1**	Aluminum	2	2	15800	5000	2	—	—	—	—	—	—	247 to 541	2	—	—
			Arsenic	2	2	2.56	100	0	200	0	—	—	—	—	150	0	9	0
			Lead	2	2	0.924	5000	0	100	0	—	—	—	—	0.629 to 1.190	1	—	—
			Selenium	2	2	16	—	—	—	—	5	2	—	—	5	2	—	—
			Dioxins	2	2	9.030E-06	—	—	—	—	—	—	—	—	—	—	5.1E-08	2
			Total PCB	3	2	0.026	—	—	—	—	0.014	2	—	—	0.014	2	0.00064	2
			Gross alpha	4	4	486	—	—	15	4	—	—	—	—	—	—	—	—
Sandia Canyon	**Sandia**	**Sandia Right Fork at Power Plant at E121**	Aluminum	9	9	1490	5000	0	—	—	—	—	—	—	76 to 215	9	—	—
			Copper	27	27	6.19	200	0	500	0	—	—	—	—	1.03 to 4.16	25	—	—
			Lead	27	10	0.619	5000	0	100	0	—	—	—	—	0.146 to 0.937	7	—	—
			Mercury	27	8	1.13	—	—	10	0	0.77	2	—	—	—	—	—	—
			Vanadium	27	27	5.94	100	0	100	0	—	—	—	—	—	—	—	—
			Zinc	27	26	44.6	2000	0	25000	0	—	—	—	—	12.1 to 53.6	9	26000	0
			Benzo(a) anthracene	47	5	0.20	—	—	—	—	—	—	—	—	—	—	0.18	1
			Benzo(b) fluoranthene	47	9	0.221	—	—	—	—	—	—	—	—	—	—	0.18	1
			Total PCB	26	26	0.198	—	—	—	—	0.014	24	—	—	0.014	24	0.00064	26

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Sandia Canyon	**Sandia**	**Sandia Left Fork at Asphalt Plant at E122**	Aluminum	1	1	669	5000	0	—	—	—	—	—	—	37	1	—	—
			Copper	1	1	2.74	200	0	500	0	—	—	—	—	0.94	1	—	—
			Zinc	1	1	25.6	2000	0	25000	0	—	—	—	—	11.0	1	26000	0
			Total PCB	1	1	0.032	—	—	—	—	0.014	1	—	—	0.014	1	0.00064	1
		Sandia below Wetlands at E123	Aluminum	7	7	1770	5000	0	—	—	—	—	—	—	76 to 235	7	—	—
			Chromium	17	6	17.4	100	0	1000	0	—	—	—	—	11.2 to 25.8	0	—	—
			Copper	17	17	17.7	200	0	500	0	—	—	—	—	1.25 to 2.98	17	—	—
			Lead	17	9	10.6	5000	0	100	0	—	—	—	—	0.2 to 0.6	8	—	—
			Vanadium	17	17	8.47	100	0	100	0	—	—	—	—	—	—	—	—
			Zinc	17	17	116	2000	0	25000	0	—	—	—	—	15 to 38	1	26000	0
			Total PCB	17	17	0.262	—	—	—	—	0.014	17	—	—	0.014	17	0.00064	17
		Sandia above Firing Range at E124	Aluminum	2	2	10600	5000	1	—	—	—	—	658 to 2200	2	—	—	—	—
			Boron	2	2	55.5	750	0	5000	0	—	—	—	—	—	—	—	—
			Chromium	2	2	6.51	100	0	1000	0	—	—	437.84	0	—	—	—	—
			Copper	2	2	3.58	200	0	500	0	—	—	4.32 to 9.93	0	—	—	—	—
			Mercury	2	2	2.05	—	—	10	0	0.77	1	—	—	—	—	—	—
			Vanadium	2	2	23.1	100	0	100	0	—	—	—	—	—	—	—	—
			Zinc	2	2	243	2000	0	25000	0	—	—	54 to 119	1	—	—	26000	0
			Total PCB	2	2	0.182	—	—	—	—	0.014	2	2	0	—	—	0.00064	2
			Gross alpha	2	2	134	—	—	15	1	—	—	—	—	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg\L[a])	Irrigation Standard (µg\L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg\L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg\L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg\L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg\L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg\L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Pajarito Canyon	**Pajarito**	**Pajarito below SR-501[g] at E240**	Aluminum	1	1	3090	5000	0	—	—	—	—	203	1	—	—	—	—
			Copper	1	1	2.07	200	0	500	0	—	—	1.92	1	—	—	—	—
			Total PCB	1	1	0.002	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
			Gross alpha	1	1	109	—	—	15	1	—	—	—	—	—	—	—	—
		Pajarito above Starmers at E241	Aluminum	3	3	19900	5000	3	—	—	—	—	248 to 3370	3	—	—	—	—
			Arsenic	3	1	2.9	100	0	200	0	—	—	340	0	—	—	9	0
			Mercury	3	3	3.87	—	—	10	0	0.77	1	—	—	—	—	—	—
			Selenium	3	3	24.6	—	—	—	—	5	2	20	1	—	—	—	—
			Total PCB	2	2	0.0007	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
			Gross alpha	2	2	428	—	—	15	2	—	—	—	—	—	—	—	—
	Starmers	**Starmers above Pajarito at E242**	Aluminum	2	2	14600	5000	2	—	—	—	—	—	—	83 to 112	2	—	—
			Antimony	2	2	25.2	—	—	—	—	—	—	—	—	—	—	640	0
			Copper	2	2	2.16	200	0	500	0	—	—	—	—	1.56 to 1.88	1	—	—
			Lead	2	2	0.662	5000	0	100	0	—	—	—	—	0.256 to 0.329	2	—	—
			Gross alpha	2	2	83.1	—	—	15	2	—	—	—	—	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Pajarito Canyon	**La Delfe**	**La Delfe above Pajarito at E242.5**	Aluminum	2	2	8280	5000	2	—	—	—	—	227 to 307	2	—	—	—	—
			Copper	2	2	2.78	200	0	500	0	—	—	2.08 to 2.56	2	—	—	—	—
			Mercury	2	2	1.34	—	—	10	0	0.77	2	—	—	—	—	—	—
			Selenium	2	2	7.72	—	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	3	3	0.154	—	—	—	—	0.014	3	2	0	—	—	0.00064	3
			Gross alpha	2	2	69.8	—	—	15	2	—	—	—	—	—	—	—	—
	Pajarito	**Pajarito above Twomile at E243**	Aluminum	3	3	25000	5000	3	—	—	—	—	388 to 1140	3	—	—	—	—
			Arsenic	3	2	3.73	100	0	200	0	—	—	340	0	—	—	9	0
			Cadmium	3	2	0.519	10	0	50	0	—	—	0.425 to 0.833	0	—	—	—	—
			Chromium	3	2	12.1	100	0	1000	0	—	—	155 to 295	0	—	—	—	—
			Copper	3	3	13.8	200	0	500	0	—	—	3.01 to 6.31	2	—	—	—	—
			Lead	3	3	18.8	5000	0	100	0	—	—	11.0 to 26.7	0	—	—	—	—
			Mercury	3	3	0.791	—	—	10	0	0.77	1	—	—	—	—	—	—
			Nickel	3	3	12.7	—	—	—	—	—	—	122 to 237	0	—	—	4600	0
			Selenium	3	2	35.8	—	—	—	—	5	2	20	1	—	—	—	—
			Silver	3	3	1.9	—	—	—	—	—	—	0.21 to 0.81	3	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Pajarito Canyon	**Pajarito**	**Pajarito above Twomile at E243 (cont.)**	Vanadium	3	3	24.1	100	0	100	0	—	—	—	—	—	—	—	—
			Zinc	3	3	52.3	2000	0	25000	0	—	—	37.7 to 77.1	0	—	—	26000	0
			Total PCB	2	2	0.022	—	—	—	—	0.014	1	2	0	—	—	0.00064	2
			Gross alpha	3	3	552	—	—	15	3	—	—	—	—	—	—	—	—
	Twomile	**Twomile above Pajarito at E244**	Aluminum	1	1	7940	5000	1	—	—	—	—	143	1	—	—	—	—
			Copper	1	1	1.67	200	0	500	0	—	—	1.52	1	—	—	—	—
			Selenium	1	1	9.08	—	—	—	—	5	1	20	0	—	—	—	—
			Total PCB	1	1	0.149	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
			Gross alpha	1	1	132	—	—	15	1	—	—	—	—	—	—	—	—
	Pajarito	**Pajarito above Threemile at E245.5**	Aluminum	4	4	24200	5000	3	—	—	—	—	200 to 446	4	—	—	—	—
			Copper	4	4	2.42	200	0	500	0	—	—	1.91 to 3.31	2	—	—	—	—
			Selenium	4	3	9.67	—	—	—	—	5	2	20	0	—	—	—	—
			Total PCB	4	4	0.077	—	—	—	—	0.014	1	2	0	—	—	0.00064	4
			Gross alpha	4	4	127	—	—	15	4	—	—	—	—	—	—	—	—
		Pajarito above SR-4 at E250	Aluminum	1	1	13500	5000	1	—	—	—	—	771	1	—	—	—	—
			Total PCB	1	1	0.009	—	—	—	—	0.014	0	2	0	—	—	0.00064	1
			Gross alpha	1	1	18.3	—	—	15	1	—	—	—	—	—	—	—	—

Table 6-6 (continued)

Major Canyon	Tributary or Subcanyon	Sample Location	Analyte	Number of Samples Tested for the Analyte	Number of Detections	Maximum Detected Value (µg/L[a])	Irrigation Standard (µg/L)	Number of Samples > Irrigation Standard	Livestock Watering Standard (µg/L)	Number of Samples > Livestock Watering Standard	Wildlife Habitat Standard (µg/L)	Number of Samples > Wildlife Habitat Standard	Acute Aquatic Life Standard (µg/L)[b]	Number of Samples > Acute Aquatic Life Standard	Chronic Aquatic Life Standard (µg/L)[b]	Number of samples > Chronic Aquatic Life Standard	Human Health–Organism Only Aquatic Life Standard (µg/L)	Number of Samples > Human Health–Organism Only Aquatic Life Standard
Water Canyon	**Cañon de Valle**	**Cañon de Valle below MDA P at E256**	Aluminum	1	1	21800	5000	1	—	—	—	—	—	—	263	1	—	—
			Total PCB	1	1	0.084	—	—	—	—	0.014	1	—	—	0.014	1	0.00064	1
			Gross alpha	1	1	380	—	—	15	1	—	—	—	—	—	—	—	—
	Water	**Water below SR-4 at E265**	Aluminum	1	1	18600	5000	1	—	—	—	—	658	1	—	—	—	—
			Copper	1	1	4.56	200	0	500	0	—	—	4.32	1	—	—	—	—
			Lead	1	1	5.57	5000	0	100	0	—	—	17.04	0	—	—	—	—
			Selenium	1	1	11.6	—	—	—	—	5	1	20	0	—	—	—	—
			Vanadium	1	1	7.24	100	0	100	0	—	—	—	—	—	—	—	—
			Total PCB	1	1	0.077	—	—	—	—	0.014	1	2	0	—	—	0.00064	1
			Gross alpha	1	1	112	—	—	15	1	—	—	—	—	—	—	—	—

[a] µg/L = Micrograms per liter. For gross alpha, strontium-90, radium-226, and radium-228, the units are picocuries per liter.

[b] Acute and chronic aquatic life standards for particular metals are hardness-dependent; thus, the standard is adjusted accordingly if a hardness value is available, and 30 mg $CaCO_3$/L is used if no hardness value is available (NMWQCC 2013). These standards are presented as a range if hardness-adjusted. In addition, acute and chronic aquatic life standards apply to different stream segments (see Table 6-2 and Figure 6-5) and thus are purposely not shown for particular streams.

[c] — = Standard does not exist for analyte.

[d] TA-21 = Technical Area 21.

[e] Dioxins are the sum of the dioxin toxicity equivalents expressed as 2,3,7,8-tetrachlorodibenzo-p-dioxin (EPA 2010). If there were no dioxin/furan results for a particular sample, 2,3,7,8-tetrachlorodibenzo-p-dioxin was not calculated.

[f] WWTF = Wastewater treatment facility.

[g] SR-501 = State route 501.

Identification of Results above Background Levels

For sediment samples, data are compared with levels in local sediments of inorganic chemicals and radionuclides that are naturally occurring or result from global atmospheric fallout on the Pajarito Plateau (Ryti et al. 1998, McDonald et al. 2003). There are no established background levels for organic chemicals in sediments on or off the Pajarito Plateau, and all detected organic chemicals in sediment are considered above background levels.

For storm water samples from gaging stations, data are compared with concentrations of inorganic chemicals and PCBs measured in storm water samples collected from reference locations in undeveloped and urban watersheds (LANL 2012, 2013b). There are no established background values for storm water samples collected at site monitoring areas under the Individual Permit.

Comparison of Results with Screening Levels and Standards

The sampling results are compared with screening levels (sediment) or standards and screening levels (storm water at gaging stations) described in Table 6-1. Storm water sampling results from the site monitoring areas that exceed target action levels under the Individual Permit, as well as some specific radionuclide results from those samples, are discussed separately. Additional details for site monitoring area results are provided in the Individual Permit annual report (LANL 2016c).

Discussion of Sampling Results

The screening levels described in Table 6-1 provide a high level of confidence in determining a low probability of adverse risk and incorporate uncertainty in a precautionary manner. 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. Human health and ecological risk assessments were performed as part of the canyons investigation reports conducted between 2005 and 2015 under the Compliance Order on Consent. The human health risk assessments in those reports concluded that levels of chemicals and radionuclides present in canyon soils and sediments are within regulator-accepted limits for the applicable exposure scenarios. Human health effects from exposure to storm water are evaluated 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 lower levels of LANL-derived substances in new sediment deposits than previously existed in a given reach. The results from 2015 verify this conceptual model and support the idea that the risk assessments presented in the canyons investigation reports represent an upper bound of potential human health risks in the canyons for the foreseeable future.

Overall, the residential screening action level for cesium-137 was exceeded in three on-site sediment samples collected in 2015 in Mortandad Canyon. Residential soil screening levels for benzo(a)pyrene were exceeded in one sediment sample in DP Canyon and one in Pueblo Canyon and for chromium in two sediment samples in Sandia Canyon. Industrial soil screening levels were exceeded for chromium in one sediment sample in Sandia Canyon and for manganese in one sediment sample in upper Los Alamos Canyon, one in DP Canyon, two in Sandia Canyon, one in Cañada del Buey, two in Cañon de Valle, and two in Ancho Canyon.

For storm water samples collected in 2015, aquatic biota concentration guides for water for radionuclides were exceeded for radium-226 in one sample in Pueblo Canyon and for radium-228 in four samples in Los Alamos Canyon and two samples in Pueblo Canyon. As discussed in Chapter 7, these data do not indicate a significant biota dose for several reasons: these are not aquatic habitats, the storm water is ephemeral, and the materials are naturally occurring in suspended sediment.

For chemicals in storm water, the following is a list of exceedances of New Mexico Water Quality Control Commission standards in at least one location: aluminum exceeded the irrigation standard; gross alpha exceeded the livestock watering standard; mercury and selenium exceeded the wildlife habitat standard; aluminum, copper, selenium, silver, and zinc exceeded the acute aquatic life standard; aluminum, copper, lead, selenium, and zinc exceeded the chronic aquatic life standard; and benzo(a)anthracene, benzo(b)fluoranthene, and dioxins exceeded the human health–organism only standard. Total PCBs exceeded the wildlife habitat standard and the acute, chronic, and human health–organism only standards.

Constituents Related to Background Sources

Several constituents observed in storm water runoff 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.

Aluminum. Filtered storm water samples collected on the Pajarito Plateau in 2015 commonly contained aluminum concentrations above New Mexico Water Quality Control Commission standards. However, most or all of this aluminum is likely naturally occurring (e.g., 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. The regional background value for aluminum in sediment is 15,400 mg/kg. Filtered storm water samples from upstream boundary gaging stations have had aluminum concentrations as high as 11,500 µg/L. 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 µg/L (the acute aquatic life standard for a hardness of 30 mg $CaCO_3$/L) in other parts of the Jemez Mountains area (NMED 2009).

Arsenic. Arsenic is also naturally occurring in storm water and sediment in this area. No filtered storm water samples collected on the Pajarito Plateau in 2015 had arsenic above the human health–organism only standard (9 µg/L). In 2015, arsenic concentrations in sediment were not detected above the residential soil screening level (3.9 mg/kg).

Copper. Copper is associated with firing sites, developed areas such as buildings and parking lots, and forest fires and is naturally occurring. In 2015, copper concentrations in filtered storm water were detected above the chronic aquatic life standard in 50 of 116 samples in Acid, Pueblo, and Sandia Canyons and Starmer's Gulch. Copper concentrations in filtered storm water were detected above the acute aquatic life standard in 15 of 116 samples of water running into the upper Los Alamos detention basins (CO111041) and in lower Water Canyon (gage E265) and DP, Pajarito, La Delfe, and Twomile Canyons. 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. Since the implementation of the Individual Permit, every watershed has had a target action level exceedance for copper in Individual Permit–related runoff samples. The highest Individual Permit result recorded to date for filtered copper was 45.5 µg/L at PT-SMA-1 in Potrillo Canyon and was associated with Laboratory operations. In 2015, the highest Individual Permit result for filtered copper was 25.1 µg/L at M-SMA-12.9 in Mortandad Canyon. Copper concentrations in sediment were not detected above the residential soil screening level of 3130 mg/kg in 2015.

Cyanide. Cyanide is observed in ash from forest fires as a result of incomplete combustion of plant materials. In general, we observe rapid declines in total cyanide concentrations as fire-affected watersheds recover from wildfires (Gallaher and Koch 2004, 2005). In 2014, cyanide was detected in 3 of 9 Chaquehui Canyon sediment samples and 2 of 7 Potrillo Canyon sediment samples, none of which exceeded the regional background value for sediment (0.83 mg/kg) or the residential soil screening level (1220 mg/kg). For comparison, in 2011, cyanide was detected above the regional background value in 41 of 58 samples collected in watersheds affected by the Las Conchas fire. Cyanide was not analyzed in gaging station storm water samples or sediment samples in 2015, as it had been more than 3 years since the Las Conchas fire. For sampling under the Individual Permit, the highest result for total cyanide in 2015 was 0.002 µg/L at CDB-SMA-0.15 in Cañada del Buey.

Manganese. Manganese is naturally occurring in this area. Filtered manganese concentrations were not detected above the acute or chronic aquatic life standards in storm water samples collected in 2015. Manganese concentrations in sediment were above the industrial soil screening level (464 mg/kg) in 9 of 167 samples. 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).

Selenium. Selenium is naturally occurring in this area. Total selenium concentrations were detected above the wildlife habitat standard (5 µg/L) in 19 of 116 gaging station storm water samples collected in 2015. Total selenium concentrations did not exceed the Individual Permit target action level (5 µg/L) in any of the 8 samples collected in 2015. The highest total selenium result detected at a gaging station in 2015 was 35.8 µg/L at Pajarito above Twomile (E243). 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).

Zinc. While naturally occurring, zinc can also be associated with developed areas. Zinc is used in tires and galvanized metals. In 2015, filtered zinc concentrations in gaging station storm water samples were above the chronic aquatic life standard in 9 of 116 samples and above the acute aquatic life standard in 1 of 116 samples. Since implementation of the Individual Permit, every watershed has had target action level (42 µg/L) exceedances of zinc concentrations at some point in time; however, in 2015 there were no Individual Permit exceedances for zinc. No 2015 zinc concentrations in sediment were above the residential soil screening level of 23,500 mg/kg.

Gross Alpha. Gross alpha is the total radioactivity of alpha particle emissions from radioactive materials. Alpha particles are released by many naturally occurring radionuclides, such as isotopes of radium, thorium, uranium, and their decay products. In 2015, unfiltered storm water samples in 68 of 116 gaging stations had gross-alpha activities above the livestock watering standard (15 pCi/L). In 2011, 2012, and 2013, the highest activities of gross alpha in storm water (6200 pCi/L, 1260 pCi/L, and 8730 pCi/L, respectively) were measured in samples containing ash and sediment from the Las Conchas fire. The activities were particularly high after the large September 2013 flood event. For sampling under the Individual Permit, the highest detected gross-alpha activity in 2015 was 276 pCi/L at M-SMA-12.9 in Mortandad Canyon. The analytical results from 2015 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).

Sum of Radium-226 and Radium-228. In 2015, gaging station storm water samples analyzed for radium-226 and radium-228 radioactivity were collected at Los Alamos below Low-Head Weir (E050.1) and Pueblo below the Grade-Control Structure (E060.1) with the sum of radium-226 and radium-228 activities between 2.94 pCi/L and 21.6 pCi/L, which are below the livestock watering standard of 30 pCi/L. In previous years, many storm water samples had the sum of radium-226 and radium-228 activities above the livestock watering standard. In 2011, 2012, and 2013, the highest activities of the sum of radium-226 and radium-228 in storm water (109 pCi/L, 122 pCi/L, and 885 pCi/L, respectively) were measured in unfiltered samples containing ash and sediment from the Las Conchas fire and were particularly high after the September 2013 flood. For sampling under the Individual Permit in 2015, the highest detected sum of radium-226 and radium-228 activity was 13.9 pCi/L at M-SMA-12.9 in Mortandad Canyon. The analytical results from 2015 support earlier conclusions that the majority of the radium-226 and radium-228 found 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).

Constituents Related to Los Alamos National Laboratory Operations

Several constituents were measured in storm water runoff and resultant sediment deposits 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 this chapter’s introduction. The following discussion describes the occurrences of key constituents in 2015 storm water and sediment samples. The two major substances of potential concern from historical activities at the Laboratory, total PCBs and plutonium, are discussed in greater detail at the end of this section.

Barium. There are no New Mexico Water Quality Control Commission standards for barium applicable to storm water runoff at the Laboratory. Barium has been released at the Laboratory during the synthesis, processing, and testing of high explosives (LANL 2011c). The highest concentration of filtered barium in gaging station storm water samples collected in 2015 was in Cañon de Valle below MDA P (E256, 498 µg/L). Storm water samples from Water Canyon below SR-4 (E256) and Sandia Canyon above the Firing Range (E124) had concentrations of 247 µg/L and 289 µg/L, respectively. Some pre-2015 barium concentrations in sediment were above the residential soil screening level of 15,600 mg/kg in Cañon de Valle; however, 2015 barium concentrations in sediment were not above the residential soil screening level anywhere at the Laboratory. Concentrations of barium in storm water and sediment generally decreased from Cañon de Valle to the confluence with the Rio Grande.

Lead. In pre-2015 storm water data, filtered lead concentrations were above the acute aquatic life standard in Pueblo, DP, and upper Los Alamos Canyons. In 2015, no samples had filtered lead concentrations above the acute aquatic life standard. Fifteen of 44 samples in Sandia Canyon (E121 and E123), 7 of 8 samples in Acid/Pueblo Canyon (E055, E056, E059.5, and E060.1), and 2 of 2 samples in Starmer's above Pajarito (E242) had filtered lead concentrations above the chronic aquatic life standard. There were no Individual Permit target action level (17 µg/L) exceedances for lead.

The highest filtered lead result at gaging stations in 2015 was 18.8 µg/L at Pajarito above Twomile (E243). Concentrations of lead in storm water collected during 2015 were highest where lead was associated with historical Laboratory operations in Acid Canyon, Pueblo Canyon below Acid Canyon, and Sandia and Pajarito Canyons (LANL 2005, 2009a). No 2015 lead concentrations in sediment were above the residential soil screening level. Lead concentrations in sediment decreased to levels near the background value by the downstream Laboratory boundary.

Mercury. In pre-2015 gaging station storm water data, total mercury concentrations were above the wildlife habitat standard (0.77 µg/L) in Cañon de Valle and Acid, Los Alamos, Pajarito, and Water Canyons. For 2015, unfiltered mercury concentrations in storm water were above the wildlife habitat standard in Sandia Canyon (two samples at Right Fork at Power Plant [E121], one sample at Sandia above Firing Range [E124]) and Pajarito Canyon (one sample at Pajarito above Starmer's [E241], two samples at La Delfe above Pajarito [E242.5], and one sample at Pajarito above Twomile [E243]). No Individual Permit samples exceeded the target action level of 0.77 µg/L.

The highest unfiltered mercury result detected at the gaging stations in 2015 was 3.87 µg/L at Pajarito above Starmer's (E241). Mercury concentrations decreased from their sources in Acid and S-Site Canyons (LANL 2005, 2011c) to below the background value in sediment collected near the downstream Laboratory boundary. One pre-2015 mercury concentration in sediment was above the residential soil screening level (23.5 mg/kg) in

Threemile Canyon (LANL 2009b). No 2015 mercury concentrations in sediment were above the residential soil screening level.

Silver. In pre-2015 gaging station storm water data, filtered silver concentrations were above the acute aquatic life standard (0.4 µg/L for a hardness of 30 mg $CaCO_3$/L) in Cañon de Valle and Acid, Pajarito, and Water Canyons. In 2015, silver concentrations in three of three filtered storm water samples collected at Pajarito above Twomile (E243) exceeded the acute aquatic life standard. Silver was not detected in any Individual Permit samples. No pre-2015 or 2015 sediment concentrations of silver were above the residential soil screening level of 391 mg/kg. Silver concentrations in sediment decreased from their Laboratory sources in Cañon de Valle and Pajarito Canyon (LANL 2009a, 2011c) to below the background value in sediment collected near the downstream Laboratory boundary.

RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine). Over the past 6 years of Individual Permit monitoring, only one sample exceeded the target action level of 200 µg/L. It was collected at CDV-SMA-1.7 (908 µg/L) in 2013. In 2015, RDX was not detected in any Individual Permit samples. At the gaging stations in 2015, RDX was detected at the following: Cañon de Valle below MDA P (E256 at 5.37 µg/L), Water below SR-4 (E256 at 1.84 µg/L), La Delfe above Pajarito (E242.5 at 0.78 µg/L and 0.419 µg/L), Starmer's above Pajarito (E242 at 0.373 µg/L), and Pajarito above Twomile (E243 at 0.135 µg/L and 0.133 µg/L). In Cañon de Valle, some pre-2015 RDX concentrations in sediment were above the residential soil screening level of 58.2 mg/kg. In 2015, RDX was not detected in any sediment samples, including canyons associated with former/current high explosives facilities (Cañon de Valle and Pajarito) or former/current firing sites (Ancho, Pajarito, Twomile, and Water Canyons).

Uranium-234 and Uranium-238. Uranium isotopes are naturally occurring on the Pajarito Plateau; however, there are also historical Laboratory sources of uranium isotopes, thus uranium-234 and uranium-238 (the two isotopes associated with historical sources) are discussed here.

No gaging station storm water samples collected on the Pajarito Plateau from 2004 to 2015 had uranium-234 or uranium-238 activities above the terrestrial biota concentration guide for water (400,000 pCi/L). In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), higher activities of uranium-234 and uranium-238 in 2011 through 2014 at the upstream Laboratory boundary stations are related to runoff from Las Conchas fire burn areas. Higher activities of uranium-234 and uranium-238 in storm water in lower Los Alamos Canyon from 2011 through 2014 were most likely associated with Guaje Canyon storm water runoff, which contained sediment from Las Conchas fire burn areas, and with uranium from historical Laboratory activities in Acid Canyon (LANL 2004, 2005). Higher activities of uranium-234 and uranium-238 at the lower boundary of Water and Pajarito Canyons during 2011 through 2014 were most likely associated with Las Conchas fire burn areas and with historical Laboratory firing sites (LANL 2011c). In 2015, no storm water samples collected at the upstream boundary stations in Los Alamos or Water Canyons or Cañon de Valle were analyzed for uranium isotopes, but Pajarito below SR-501 (E240) continued to have elevated uranium-234 and uranium-238 activities. The highest activity in storm water samples collected in 2015 of uranium-234 (17.4 pCi/L) was detected at Pajarito above Starmer's (E241), and the highest activity of uranium-238 (19.4 pCi/L) was detected at Pueblo below the Grade-Control Structure (E060.1).

In Los Alamos, Pajarito, and Water Canyons, no pre-2015 sediment samples had uranium-234 or uranium-238 activities above the Laboratory residential screening action levels (270 pCi/g and 150 pCi/g, respectively). After the Las Conchas fire, uranium-234 and uranium-238 activities in sediment samples collected in Los Alamos, Pajarito, and Water Canyons during 2011 through 2014 were below the Laboratory residential screening action levels and below to near regional background values. All post-fire uranium-234 and uranium-238 activities in sediment decreased to near background values before the downstream Laboratory boundary and the confluence of canyons with the Rio Grande. In 2015, the highest uranium-234 and uranium-238 activities in sediment (1.35 pCi/g and 1.36 pCi/g, respectively) were in Mortandad Canyon below the Ten Site confluence. All 2015 sediment samples had activities of uranium-234 and uranium-238 below background values.

Americium-214, Cesium-137, and Strontium-90. Higher levels of americium-241, cesium-137, and strontium-90 in storm water samples at the Laboratory are associated with global fallout that is concentrated in ash from wildfires and with historical Laboratory activities in Acid and DP Canyons (LANL 2004, 2005). No gaging station storm water samples collected in Los Alamos or Mortandad Canyons from 2004 to 2015 had americium-241, cesium-137, or strontium-90 activities above the terrestrial biota concentration guides for water (200,000 pCi/L, 20,000 pCi/L, and 30,000 pCi/L, respectively). Higher activities of these radionuclides were observed from 2011 through 2014 in Los Alamos Canyon and are associated with storm water runoff from the Las Conchas burn areas.

In 2015, americium-241 was detected in Acid, Pueblo, and Los Alamos Canyons in storm water runoff. Cesium-137 and strontium-90 were detected in DP, Los Alamos, and Pueblo Canyons. The highest activities of americium-241, cesium-137, and strontium-90 in storm water were 13.7 pCi/L at Los Alamos above the Low-Head Weir (E042.1), 23.9 pCi/L at Los Alamos above the Low-Head Weir (E042.1), and 11.8 pCi/L at DP above Los Alamos Canyon (E040), respectively.

In Mortandad Canyon, activities of americium-241, cesium-137, and strontium-90 in storm water samples are associated with historical Laboratory sources at Technical Area 50 and Effluent Canyon (LANL 2006). In 2015, there was no storm water runoff at the Mortandad Canyon gaging stations. In Pajarito and Water Canyons, where post–Las Conchas fire effects could be seen from 2011 through 2014, gaging station storm water samples were not analyzed for americium-241, cesium-137, or strontium-90 in 2015 because these effects diminished in 2014 and associated activities returned to near pre-fire levels.

In the Los Alamos watershed, pre-2015 sediment samples had americium-241, cesium-137, and strontium-90 activities above the Laboratory residential screening action levels (82 pCi/g, 11 pCi/g, and 15 pCi/g, respectively) in Acid, DP, Pueblo, and Los Alamos Canyons because of historical Laboratory sources (LANL 2004, 2005). These activities decreased to near or below regional background activities (0.04 pCi/g, 0.9 pCi/g, and

1.04 pCi/g, respectively) at the Laboratory boundary and before the confluence with the Rio Grande.

In Mortandad Canyon, pre-2015 sediment samples had americium-241, cesium-137, and strontium-90 activities above the Laboratory residential screening action levels in Effluent Canyon and Mortandad Canyon because of historical Laboratory sources (LANL 2006). These activities also decreased to near or below regional background activities at the Laboratory boundary and above the confluence with the Rio Grande.

In 2015, the highest activities of americium-241, cesium-137, and strontium-90 in sediment samples were 11.1 pCi/g, 15.5 pCi/g, and 0.86 pCi/g, respectively, which were all collected in Mortandad Canyon below the Ten Site Confluence. Three of five samples in Mortandad Canyon above the Ten Site Confluence had activities of cesium-137 above the residential screening action level. There are no residences near these sites. For americium-241, the following locations had activities above the background value: Rio Grande above Otowi Bridge; Los Alamos, DP, Acid, Pueblo, and Mortandad Canyons; and Cañada del Buey and Pajarito Canyon near Area G. For cesium-137, DP and Mortandad Canyons had activities above the background values. For strontium-90, only Mortandad Canyon below the Ten Site Confluence had detected values, but none were above the background value.

Total PCBs and Plutonium: Comparisons of Pre-2015 Levels with 2015 Levels

Figures in this section compare 2015 concentrations of total PCBs and activities of plutonium-239/240 in storm water and sediment samples with pre-2015 levels. All results are plotted relative to the distance of the sampling location from the Rio Grande, with the Rio Grande being represented on the right-hand side of each figure, and the upstream Laboratory boundary on the left. Confluence points of each subwatershed, stream reaches of interest, and particular Laboratory areas are labeled on the upper axis for spatial reference. Results obtained in 2015 are in green, and results from other years are in other colors. In the storm water figures, results collected as part of the Individual Permit are identified with a circle, and canyon gaging station results are identified with a triangle. In the sediment figures, results collected as part of canyons investigation reports are identified with a circle, and annual environmental surveillance results are identified with a triangle. Results from the detention basins in upper Los Alamos Canyon are uniquely presented.

Total PCBs

Storm Water Runoff. PCBs were detected in 96% of gaging station storm water samples collected in 2015; 127 of 138 samples had concentrations above the human health–organism only standard (0.00064 µg/L), and 98 of 138 samples had concentrations above the chronic aquatic life standard (0.014 µg/L) (Figures 6-8a through j; Ancho and Chaquehui Canyons are not presented because of the minimal amount of PCB congener data available for comparison). A PCB background report indicates that in storm water runoff from nonurban, nonindustrial areas on the Pajarito Plateau, atmospheric fallout of PCBs can result in concentrations in storm water that are above the human health–organism only standard (LANL 2012). For the reference locations of undeveloped watersheds and watersheds west of the Laboratory boundary, the PCB background value in storm water was 0.013 µg/L. In storm water collected from a developed urban landscape, the PCB background value was 0.098 µg/L. The reference locations and western boundary watersheds are composed primarily of weathered Bandelier tuff; the developed urban landscape is composed of light industry, streets, parking lots, and residential neighborhoods.

For 2015 Laboratory storm water results, we report PCB detections as categorized in the PCB background report:

1) *Storm water runoff from nonurban, nonindustrial areas (reference/boundary watersheds) on the Pajarito Plateau.* Seventeen of the 138 storm water samples collected at gaging stations in 2015 fall into this category. In 11 of the 17 samples, the total PCB concentrations were below the nonurban background value of 0.013 µg/L, and in the other 6 samples, the total PCB concentrations (0.0215 µg/L to 0.0842 µg/L) were above that limit.

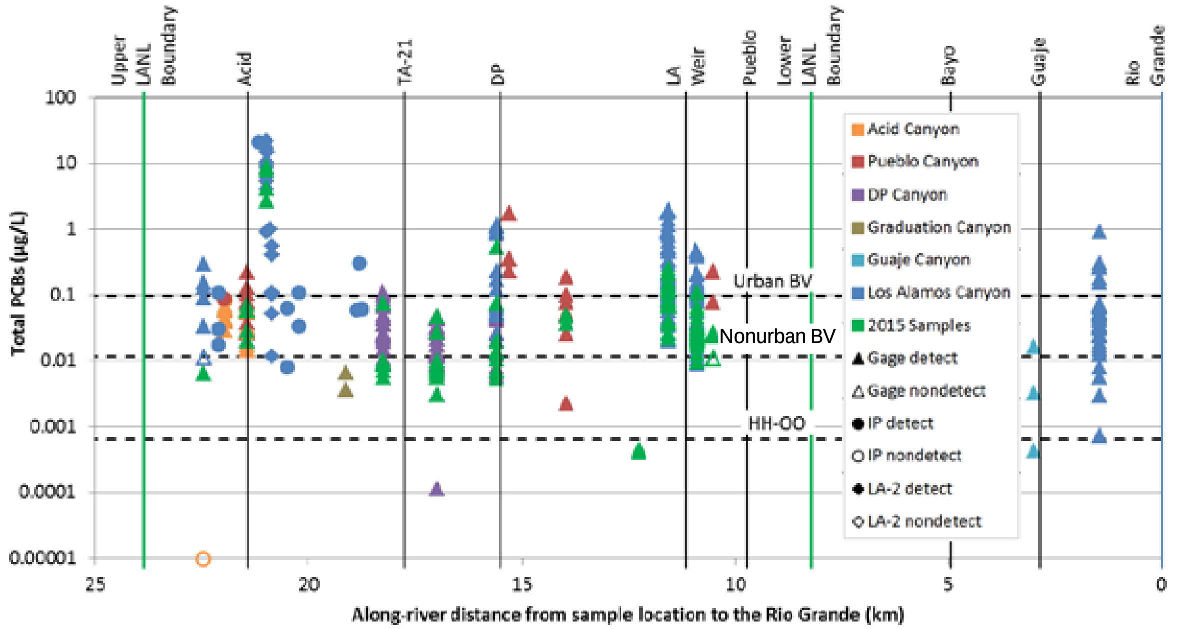
2) *Storm water runoff from Los Alamos County townsite without point sources of PCBs.* Fifty-four of the 138 storm water samples collected at gaging stations in 2015 fall into this category. These samples were collected at gaging stations that receive Los Alamos townsite runoff (Los Alamos and Pueblo Canyons). The total PCB concentrations (0.000401 µg/L to 0.0843 µg/L) for these samples were below the urban background value of 0.098 µg/L, indicating an absence of point sources of PCBs.

3) *Storm water runoff from potential point and nonpoint sources of PCBs.* Twenty-seven of the 138 storm water samples collected at gaging stations in 2015 fall into this category and had total PCB concentrations (0.105 µg/L to 8.68 µg/L) above the urban background value of 0.098 µg/L, potentially indicating a source of PCBs. These samples were collected in Los Alamos, Sandia, Twomile, and Arroyo de La Delfe Canyons. There were an additional 34 samples in this category collected in Sandia Canyon that had total PCB concentrations (0.012 µg/L to 0.0964 µg/L) below the urban background value.

4) *No detection of PCBs.* Six of the 138 storm water samples collected at gaging stations in 2015 fall into this category.

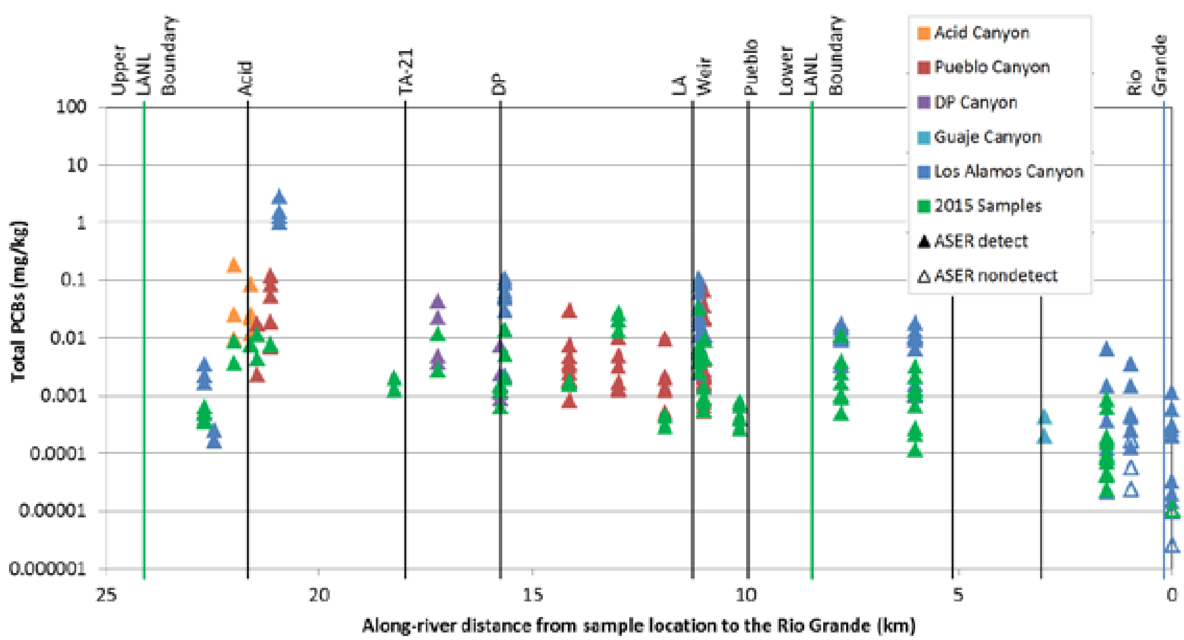
The highest total PCB concentrations were detected in storm water runoff entering the detention basins below Solid Waste Management Unit 01-001(f) in Los Alamos Canyon. These detention basins capture PCB-contaminated sediments before runoff enters the main channel in Los Alamos Canyon. In 2015, total PCB concentrations for storm water samples collected at the inlet to the upper detention basin ranged from 2.67 µg/L to 8.68 µg/L. All of the water captured in the basins in 2015 infiltrated into the ground and did not contribute to downstream runoff. The low-head weir in Los Alamos Canyon also captures sediments, with the effect of reduced PCB concentrations downstream. Above the low-head weir (E042.1), the total PCB concentrations ranged from 0.0227 µg/L to 0.254 µg/L, and below the low-head weir (E050.1), the total PCB concentrations ranged from 0.00964 µg/L to 0.111 µg/L. In 2015, three of four Individual Permit samples exceeded the target action level for total PCBs.

Sediment. In sediment, PCBs were detected in 168 of 203 samples; the only samples with no detection of PCBs were along the Rio Grande, at background locations in Pajarito Canyon and Cañon de Valle, in Cañada del Buey near the White Rock Visitor's Center, and along the main branch of Ancho Canyon.



BV = Background value.
HH-OO = Human health–organism only (numeric criteria).
IP = Individual Permit.
LA = Los Alamos.

Figure 6-8a Los Alamos Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit stations (2011–2014) and gaging stations (2009–2015). A diamond indicates the upper Los Alamos detention basins (LA-2).



ASER = Annual site environmental report.
km = Kilometer.

Figure 6-8b Los Alamos Canyon watershed total PCB concentrations in sediment from the annual environmental survillance program (2009–2015). PCB congeners were not analyzed in Los Alamos Canyon before 2011; thus, there are no canyons investion report data. There is no residential soil screening level for PCBs in sediment.

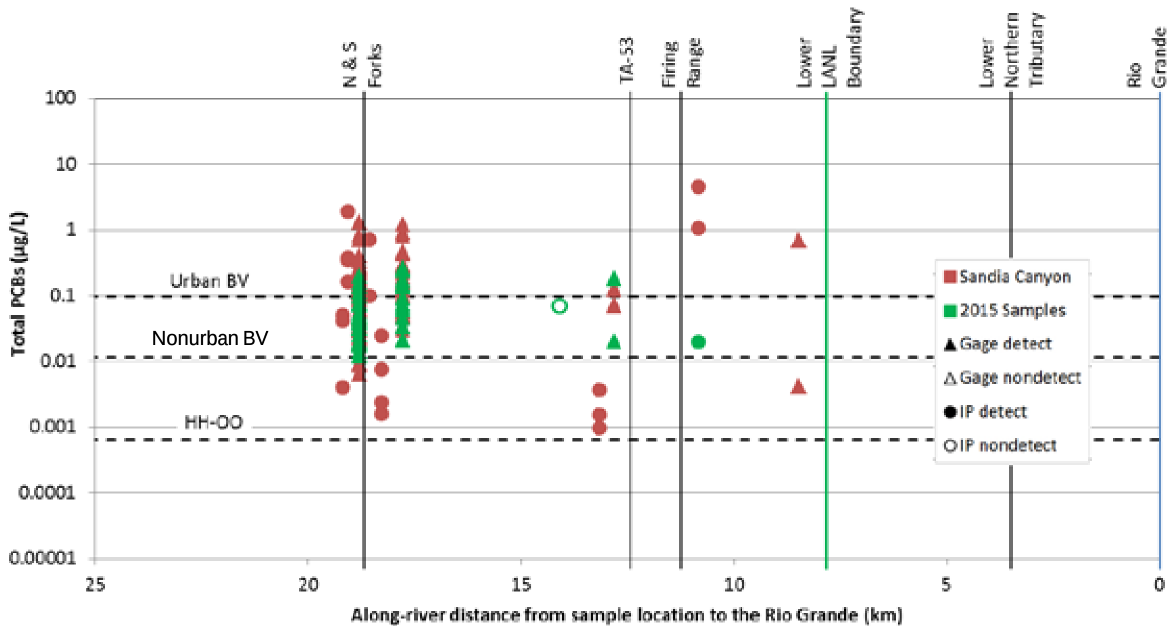


Figure 6-8c Sandia Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit stations and gaging stations (2010–2015)

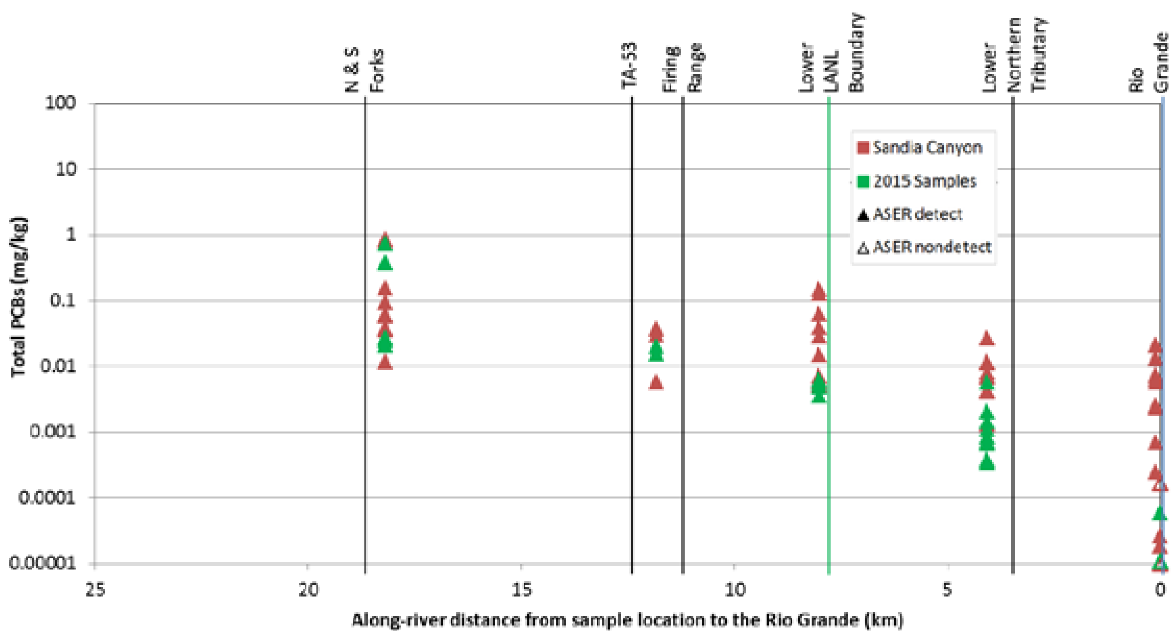
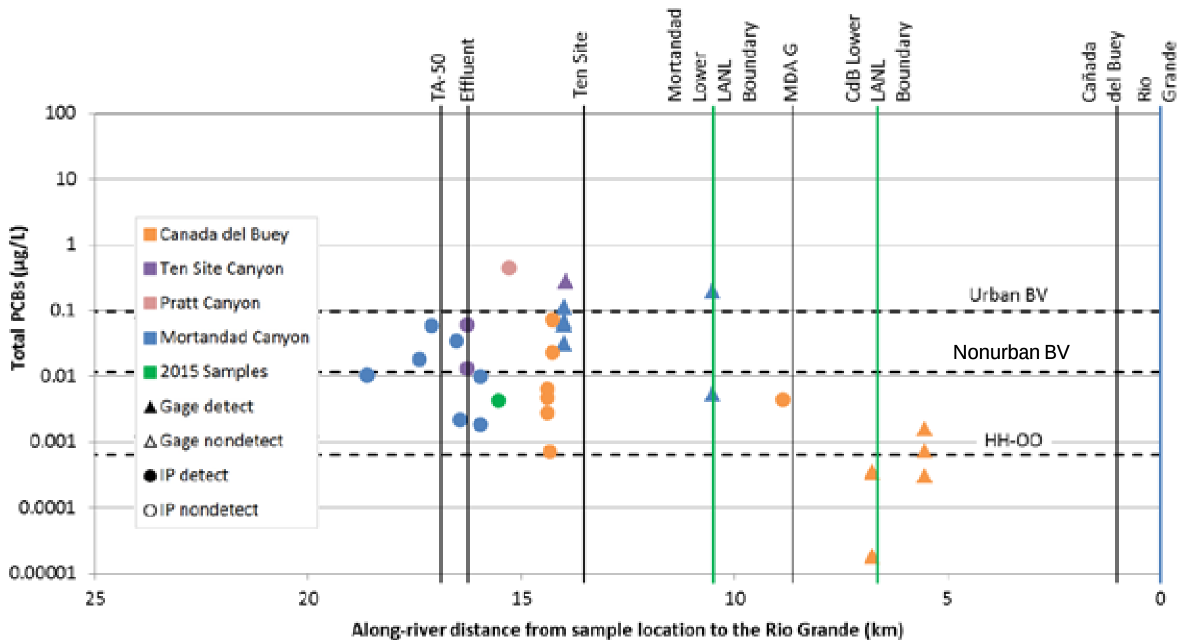


Figure 6-8d Sandia Canyon watershed total PCB concentrations in sediment from the annual environmental surveillance program (2012–2015). PCB congeners were not analyzed in Sandia Canyon before 2011; thus, there are no canyons investigation report data. There is no residential soil screening level for PCBs in sediment.



CdB = Cañada del Buey.

Figure 6-8e Mortandad Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit stations (2011–2015) and gaging stations (2009–2014)

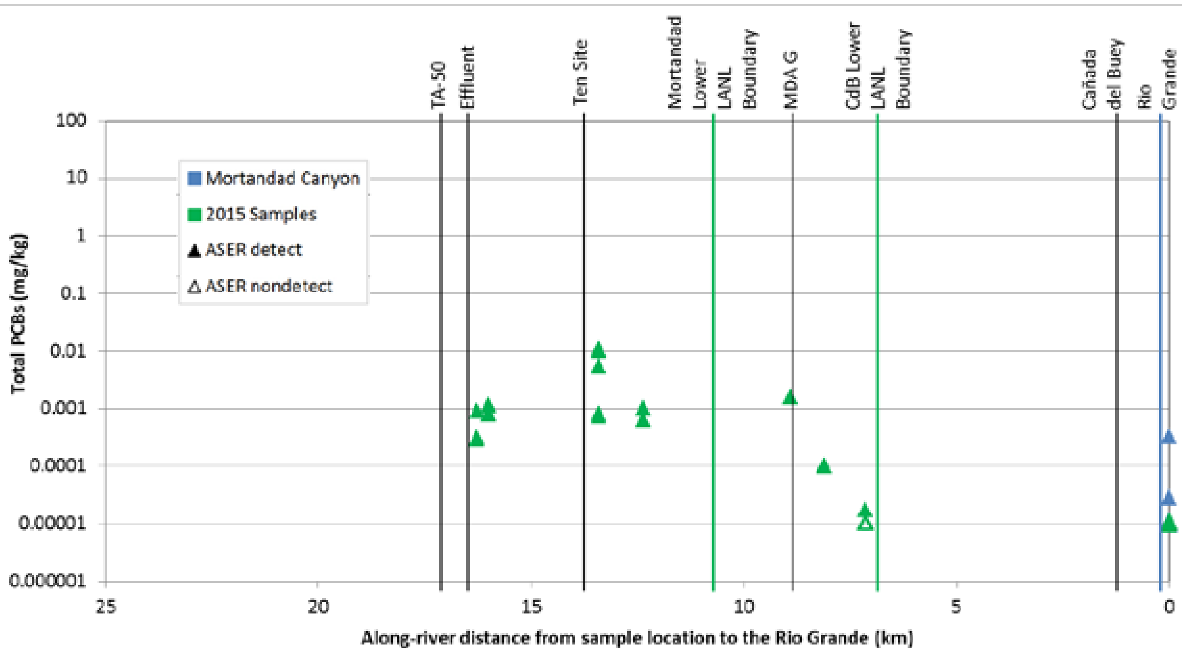


Figure 6-8f Mortandad Canyon watershed total PCB concentrations in sediment from the annual environmental surveillance program (2012–2015). PCB congeners were not analyzed in Mortandad Canyon before 2011; thus, there are no canyons investigation report data. There is no residential soil screening level for PCBs in sediment.

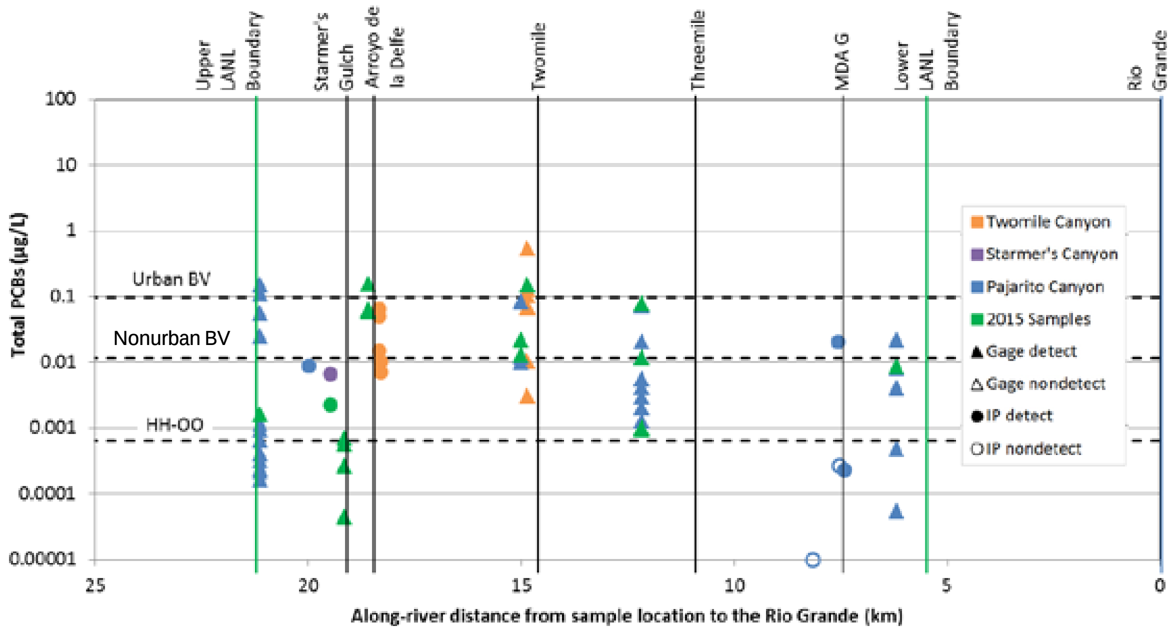


Figure 6-8g Pajarito Canyon watershed total PCB concentrations in unfiltered storm water from Individual permit stations (2011–2015) and gaging stations (2010–2015)

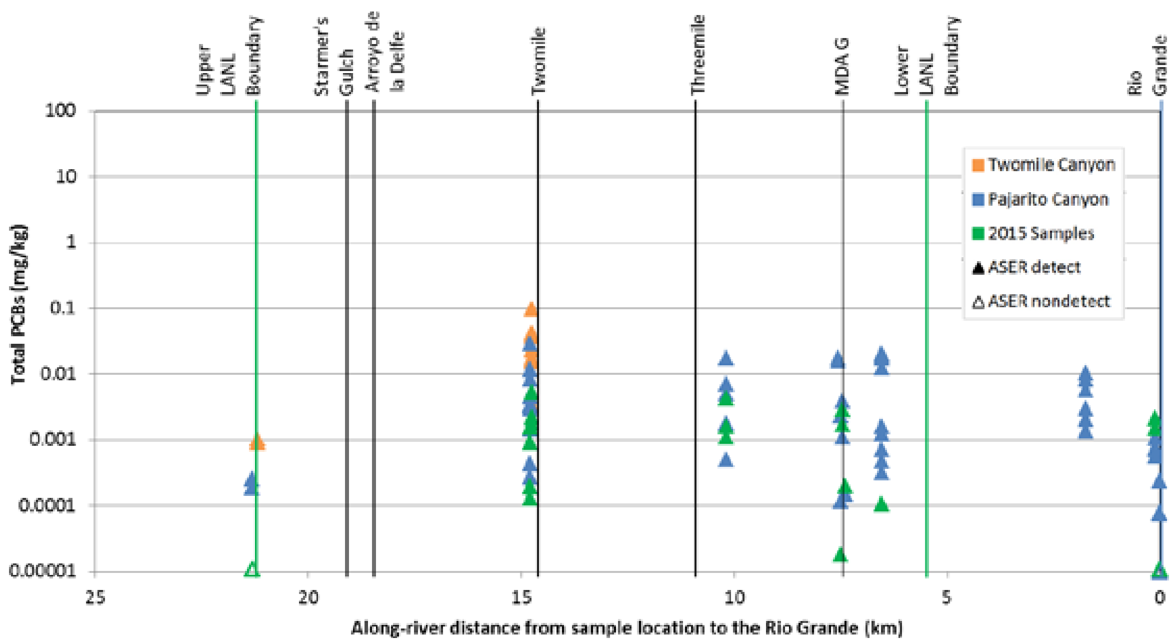
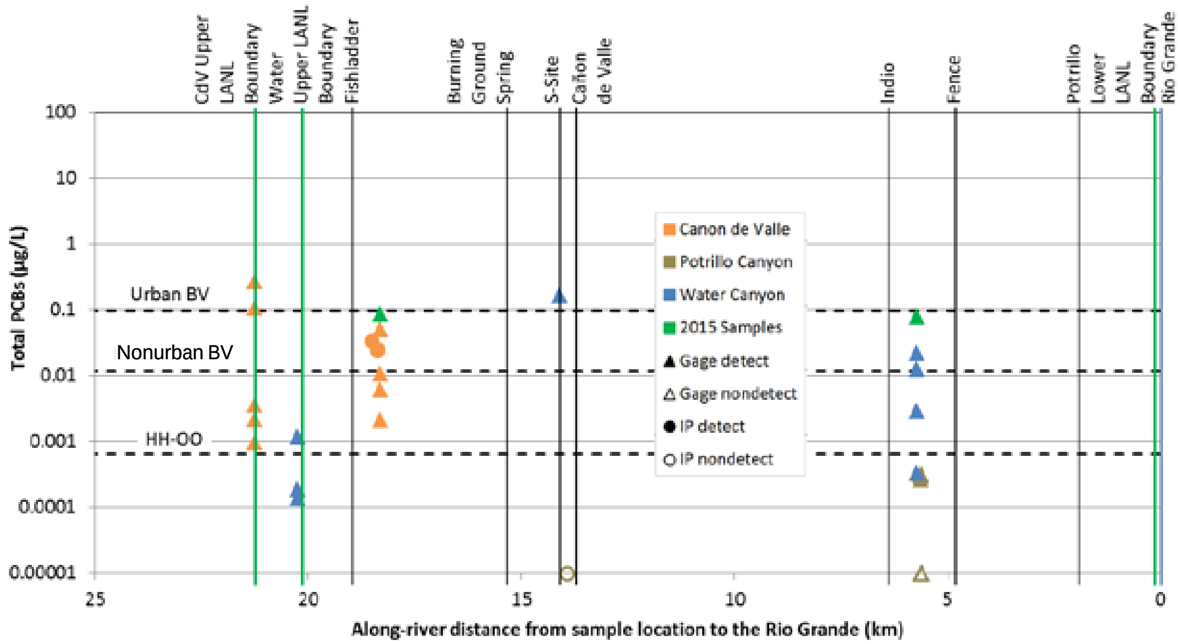


Figure 6-8h Pajarito Canyon watershed total PCB concentrations in sediment from the annual environmental surveillance program (2011–2015). PCB congeners were not analyzed in Pajarito Canyon before 2011; thus, there are no canyons investigation report data. There is no residential soil screening level for PCBs in sediment.



CdV = Cañon de Valle.

Figure 6-8i **Water Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit stations (2011–2014) and gaging stations (2010–2015)**

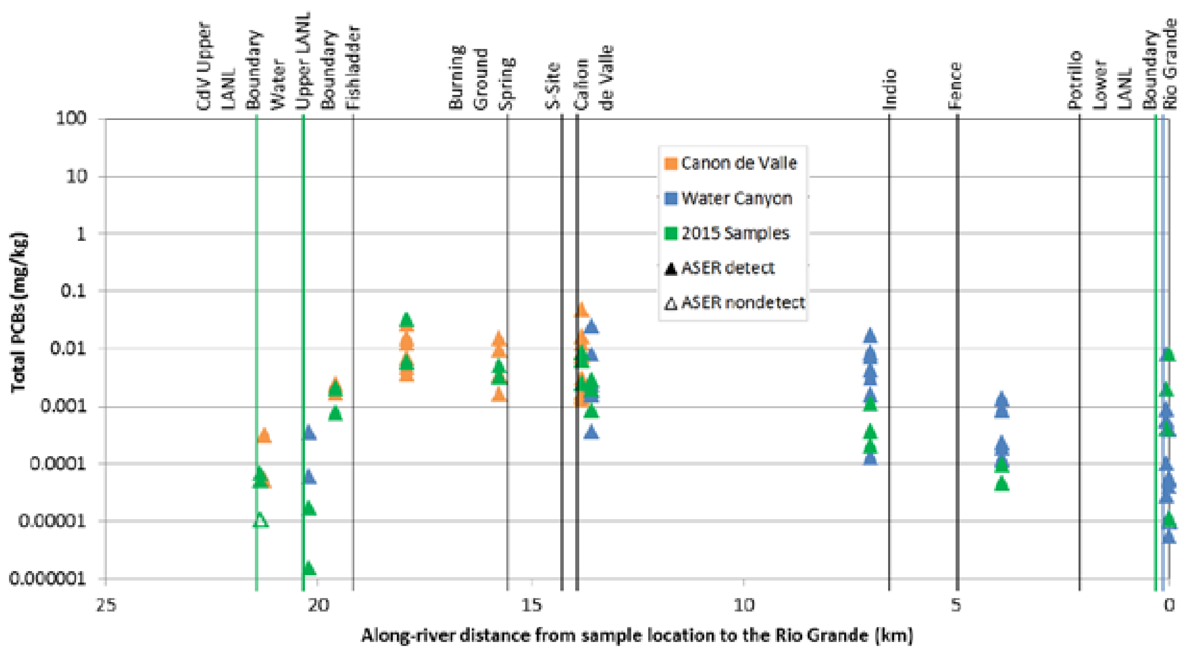


Figure 6-8j **Water Canyon watershed total PCB concentrations in sediment from the annual environmental surveillance program (2011–2015). PCB congeners were not analyzed in Water Canyon before 2011; thus, there are no canyons investigation report data. There is no residential soil screening level for PCBs in sediment.**

Plutonium-238 and Plutonium-239/240

Storm Water Runoff. No gaging station storm water samples collected on the Pajarito Plateau from 2004 to 2015 had plutonium-238 or plutonium-239/240 activities above the terrestrial biota concentration guide for water (200,000 pCi/L; Figures 6-9a through j). In 2015, the highest activity of plutonium-238 in storm water, 0.536 pCi/L, was at Los Alamos above Low-Head Weir (E042.1), and the highest activity of plutonium-239/240 in storm water, 38.8 pCi/L, was at Pueblo below the Los Alamos County WWTF (E059.5). In Los Alamos, Pajarito, and Water Canyons (including Cañon de Valle), higher activities of plutonium-238 and plutonium-239/240 in storm water at the upstream boundary stations in 2011 through 2013 are related to runoff from Las Conchas fire burn areas. Higher activities of plutonium-238 and plutonium-239/240 in storm water at the lower boundary of Los Alamos Canyon in 2011 through 2013 are potentially associated with the following: Guaje Canyon runoff that contained sediment from Las Conchas fire burn areas, elevated activities of plutonium from historical Laboratory activities in Acid Canyon, and erosion in the Pueblo Canyon wetland during the September 13, 2013, flood (LANL 2004, 2005, 2014a). In 2014 and 2015, activities of plutonium-238 and plutonium-239/240 in storm water were lower than in samples taken following the Las Conchas fire (2011–2013), indicating a decline in fire-related impacts to storm water that is consistent with observations following the Cerro Grande fire (Gallaher and Koch 2004, 2005).

Sediment. In Los Alamos Canyon, no pre-2015 sediment samples had plutonium-238 activities above the residential screening action level of 84 pCi/g. Pre-2015 plutonium-238 activities in sediment decreased from the historical Laboratory sources in Acid and DP Canyons to near regional background (0.006 pCi/g) or nondetectable activities before reaching the confluence with the Rio Grande (LANL 2005). Pre-2015 plutonium-239/240 activities in the Los Alamos Canyon watershed were above the Laboratory residential screening action level of 79 pCi/g in Acid and Pueblo Canyons, yet decreased from these historical source sites to near regional background activities (0.068 pCi/g) at the confluence with the Rio Grande. In Mortandad Canyon, pre-2015 activities of plutonium-238 and plutonium-239/240 in sediment were above the Laboratory residential screening action levels, particularly from the historical Laboratory sources at Technical Area 50 and Effluent Canyon, but decreased to below regional background or nondetectable activities at the confluence with the Rio Grande (LANL 2006). In Pajarito Canyon, no pre-2015 activities of plutonium-238 and plutonium-239/240 in sediment were above the Laboratory residential screening action levels, although Area G had activities above the regional background values. From the historical Laboratory source at Area G, the pre-2015 plutonium-238 and plutonium-239/240 activities in sediment decreased to near regional background values before the Laboratory boundary and were at nondetectable activities at the confluence with the Rio Grande (LANL 2009b).

In 2015, sediment samples collected in Los Alamos, Acid, Pueblo, DP, and Mortandad Canyons had plutonium-238 and plutonium-239/240 activities above the regional background values but below the Laboratory residential screening action levels. Activities of plutonium isotopes are present above the background values in 2015 sediment deposits below the Laboratory boundary in Los Alamos Canyon. In all of these canyons, the higher activities may be associated with historical Laboratory sources as discussed above, or there may be lingering effects from the Las Conchas fire or the September 2013 flood. One sediment sample collected near Area G in Pajarito Canyon and one near Area G in Cañada del Buey had plutonium-239/240 activities above the regional background value.

The highest plutonium-238 and plutonium-239/240 activities in 2015 sediment samples were in Mortandad Canyon below the Ten Site confluence (3.39 pCi/g) and in lower Acid Canyon (9.18 pCi/g), respectively.

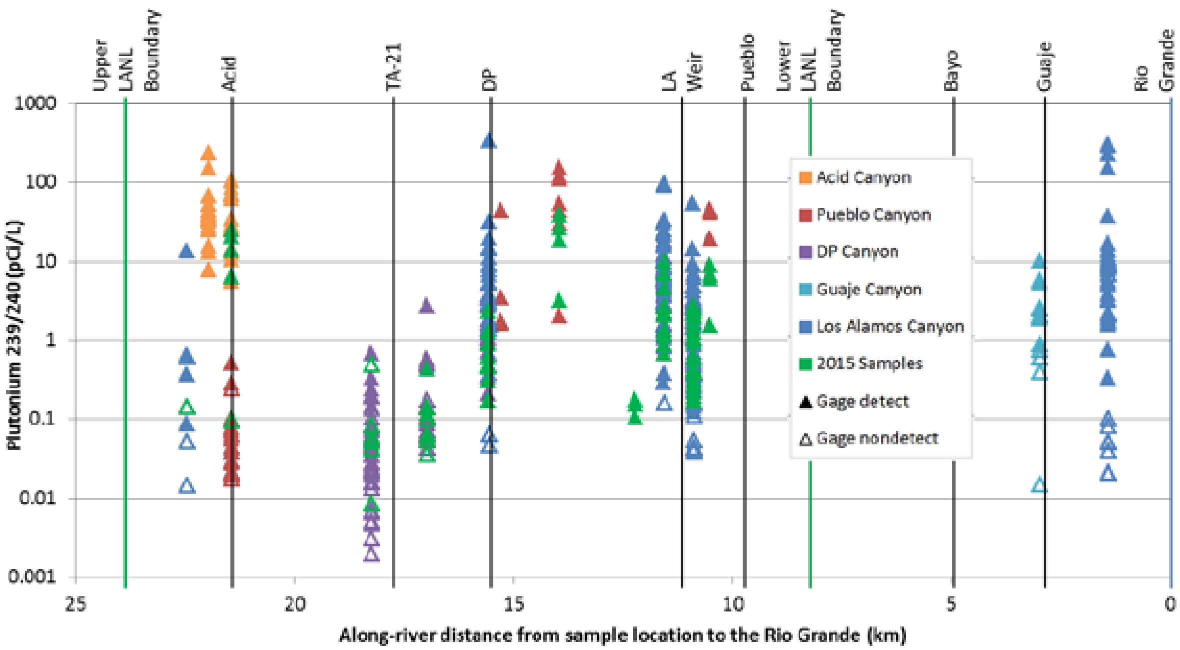
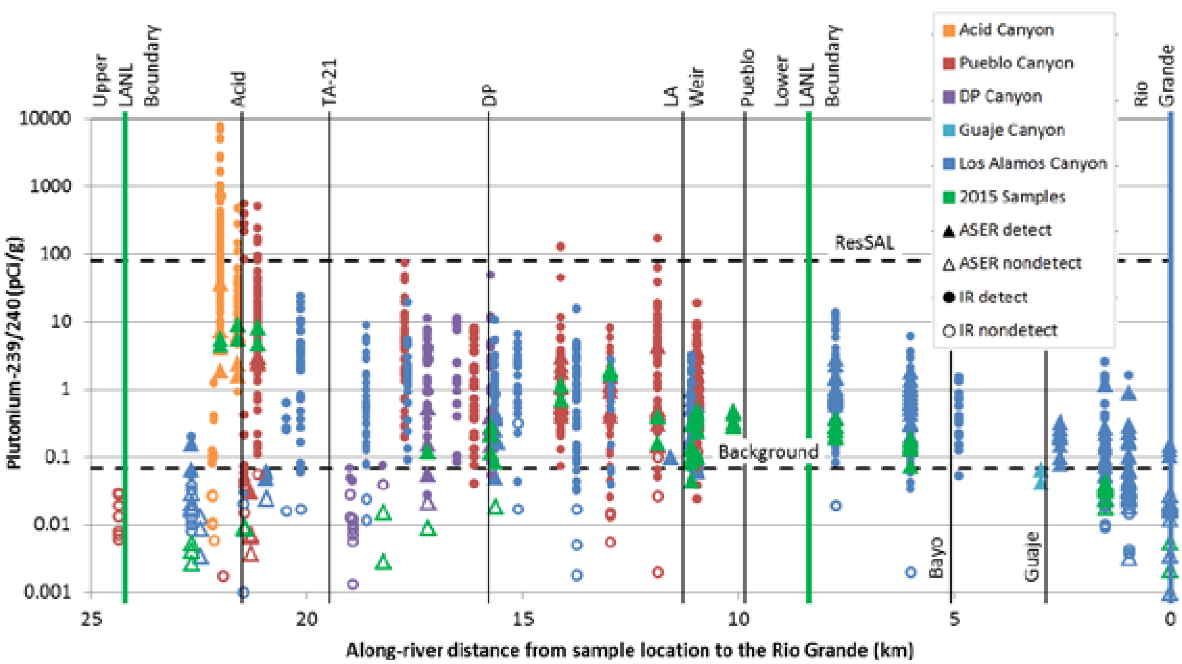


Figure 6-9a Los Alamos Canyon watershed plutonium-239/240 radioactivities in unfiltered storm water from gaging stations (2004–2015). Plutonium-239/240 was not analyzed at Individual Permit stations; the terrestrial biota concentration guide for water is 200,000 pCi/L.



ResSAL = Residential screening action level. IR = Investigation report.

Figure 6-9b Los Alamos Canyon watershed plutonium-239/240 radioactivities in sediment from the canyons investigation reports (1996–2003) and the annual environmental surveillance program (2003–2015)

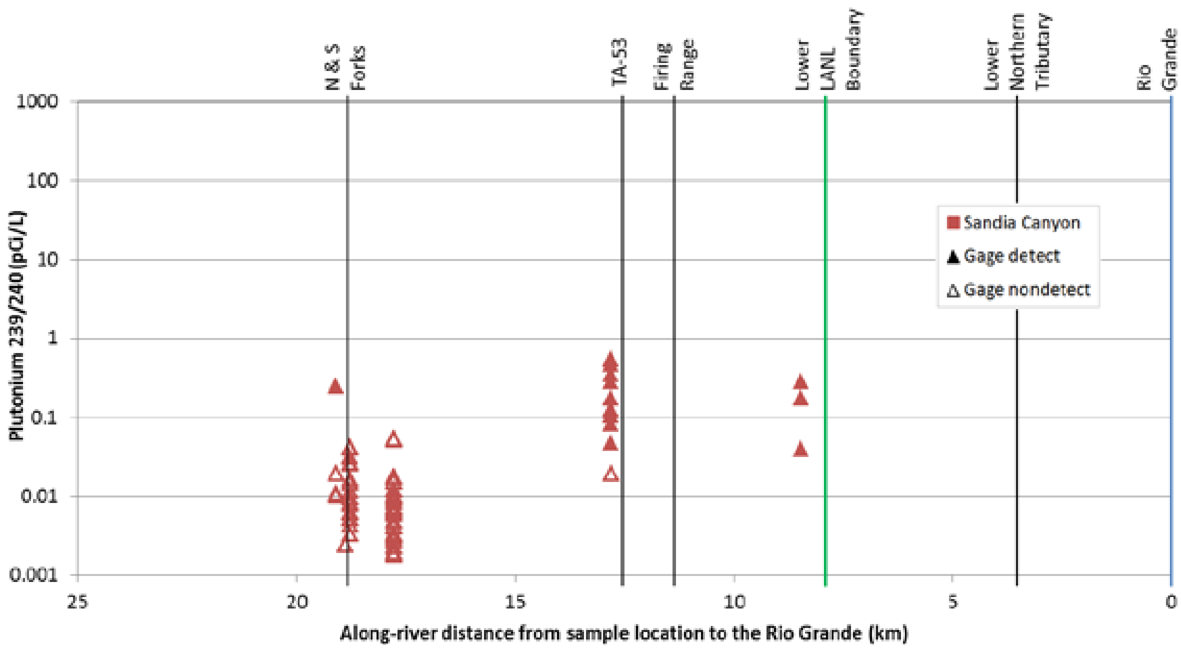


Figure 6-9c **Sandia Canyon watershed plutonium-239/240 radioactivities in unfiltered storm water from gaging stations (2004–2015); no 2015 samples collected in Sandia Canyon watershed were analyzed for plutonium-239/240. Plutonium-239/240 was not analyzed at Individual Permit stations; the terrestrial biota concentration guide for water is 200,000 pCi/L.**

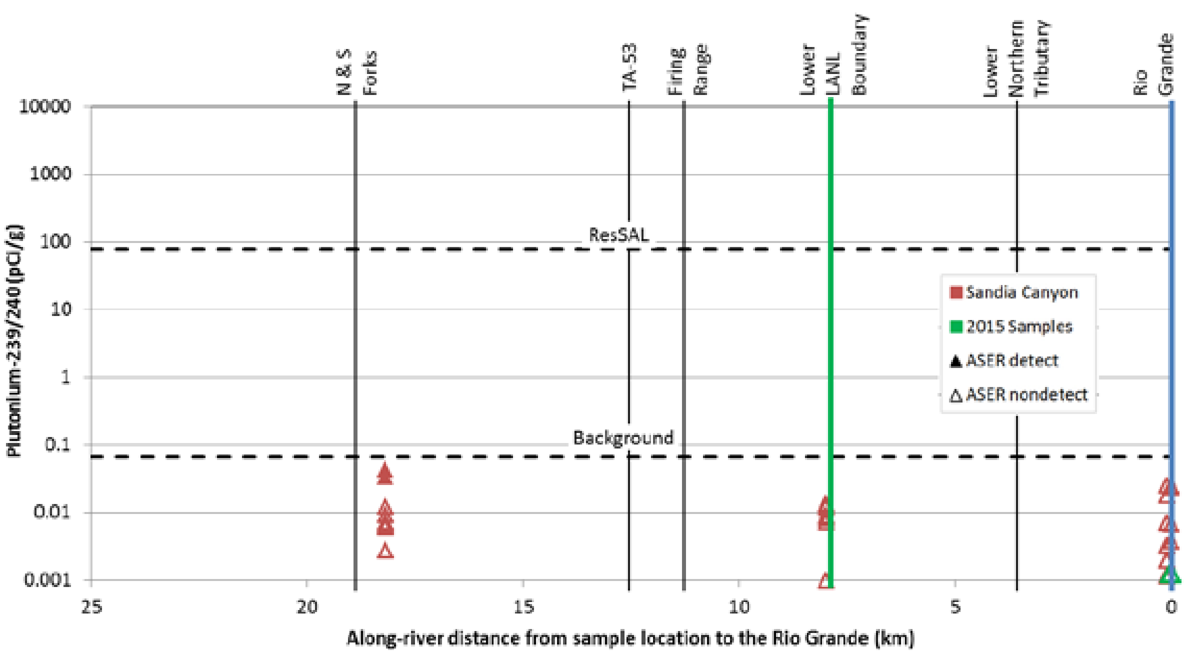


Figure 6-9d **Sandia Canyon watershed plutonium-239/240 radioactivities in sediment from the annual environmental surveillance program (2003–2015). Plutonium-239/240 was not analyzed in the canyon investigation report for Sandia.**

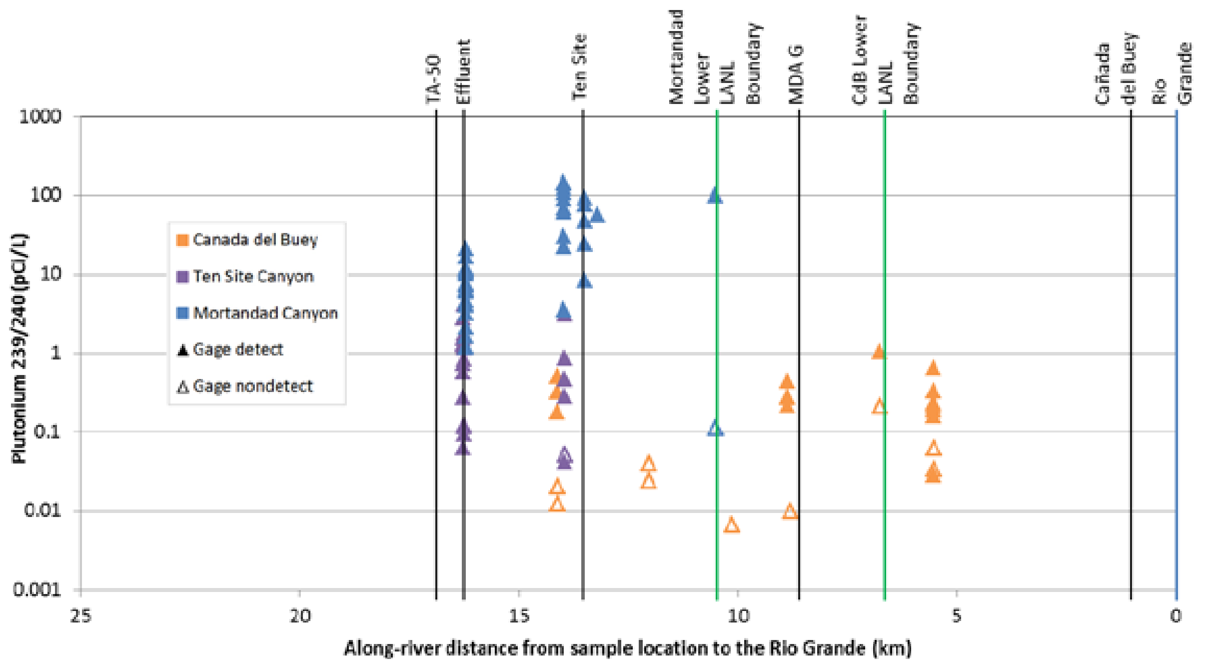


Figure 6-9e **Mortandad Canyon watershed plutonium-239/240 radioactivities in unfiltered storm water from gaging stations (2004–2015); no 2015 samples collected in Mortandad Canyon watershed were analyzed for plutonium-239/240. Plutonium-239/240 was not analyzed at Individual Permit stations; the terrestrial biota concentration guide for water is 200,000 pCi/L.**

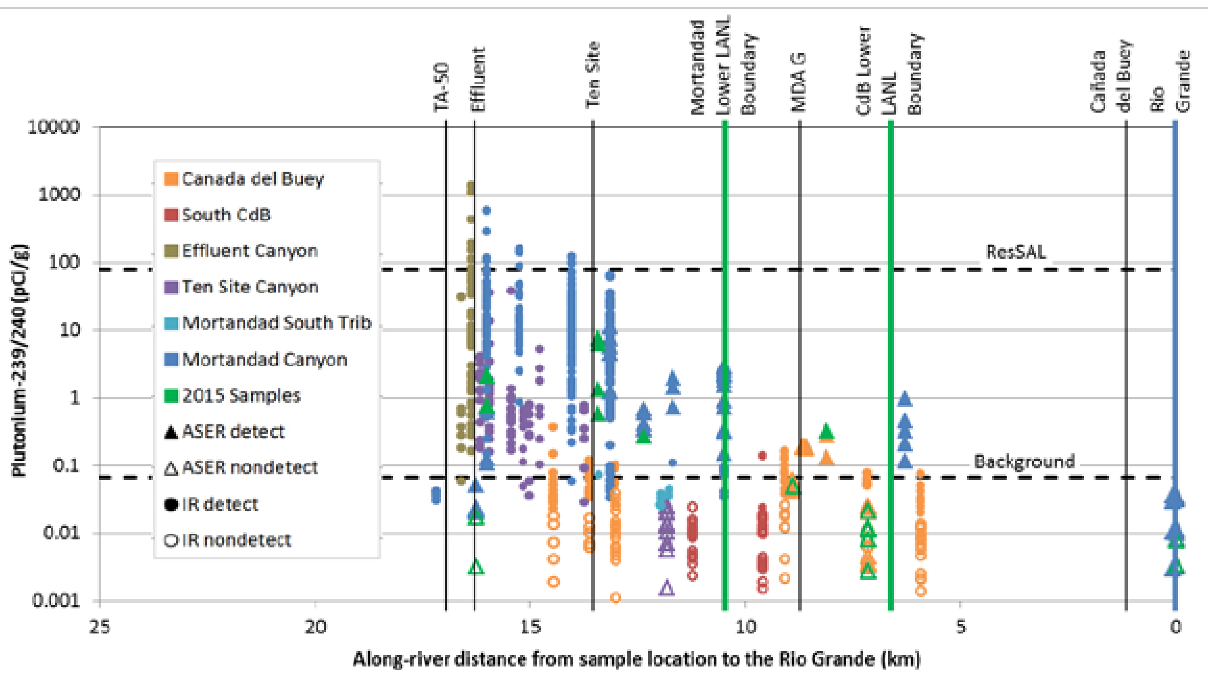


Figure 6-9f **Mortandad Canyon watershed plutonium-239/240 radioactivities in sediment from the canyons investigation reports (1998–2008) and the annual enviromental surveillance program (2003–2015)**

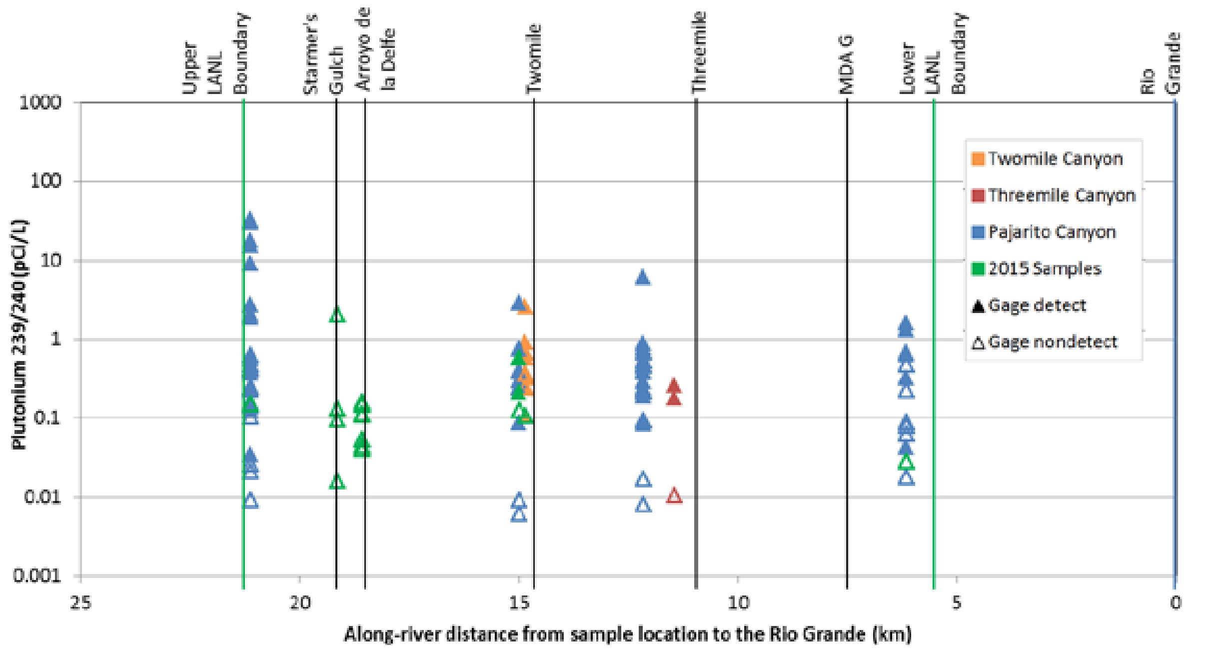


Figure 6-9g **Pajarito Canyon watershed plutonium-239/240 radioactivities in unfiltered storm water from gaging stations (2004–2015). Plutonium-239/240 was not analyzed at Individual Permit stations; the terrestrial biota concentration guide for water is 200,000 pCi/L.**

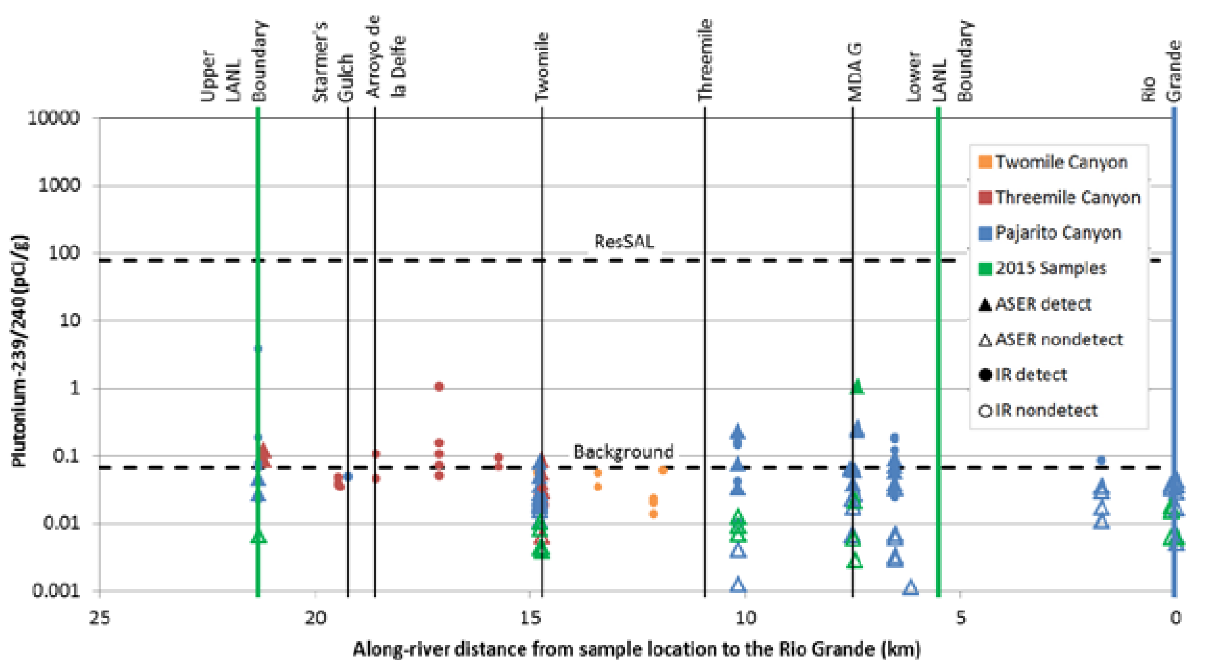


Figure 6-9h **Pajarito Canyon watershed plutonium-239/240 radioactivities in sediment from the canyons investigation reports (2000–2007) and the annual environmental surveillance program (2003–2015)**

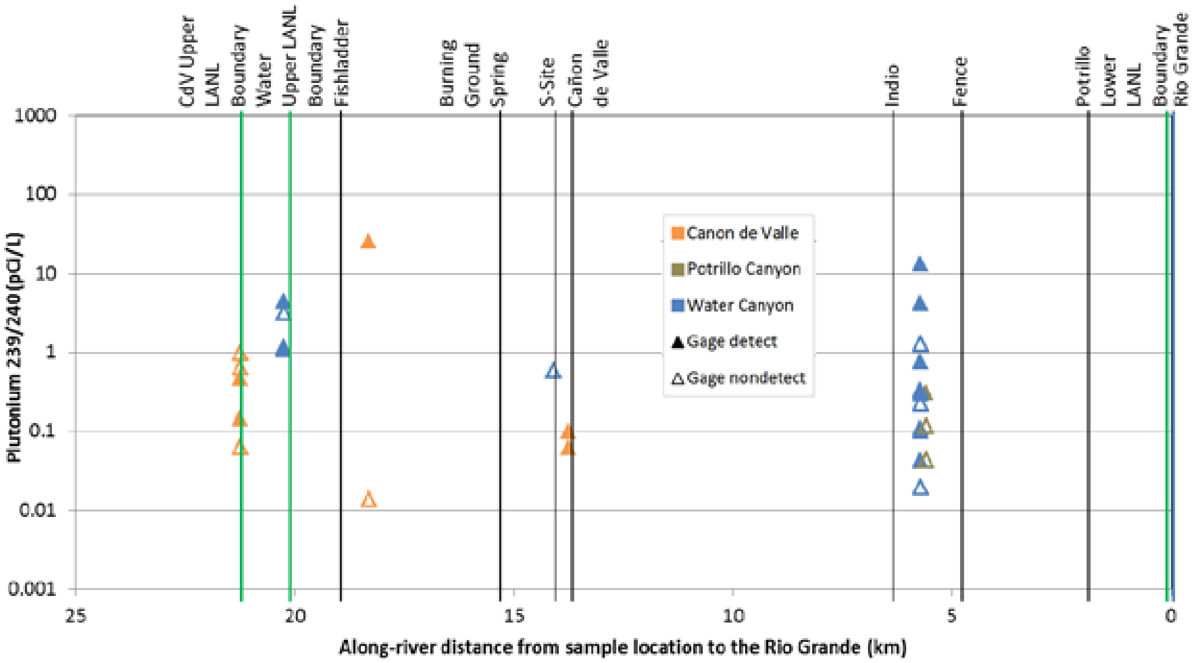


Figure 6-9i Water Canyon watershed plutonium-239/240 radioactivities in unfiltered storm water from gaging stations (2004–2015); no 2015 samples collected in Water Canyon watershed were analyzed for plutonium-239/240. Plutonium-239/240 was not analyzed at Individual Pemit stations; the terrestrial biota concentration guide for water is 200,000 pCi/L.

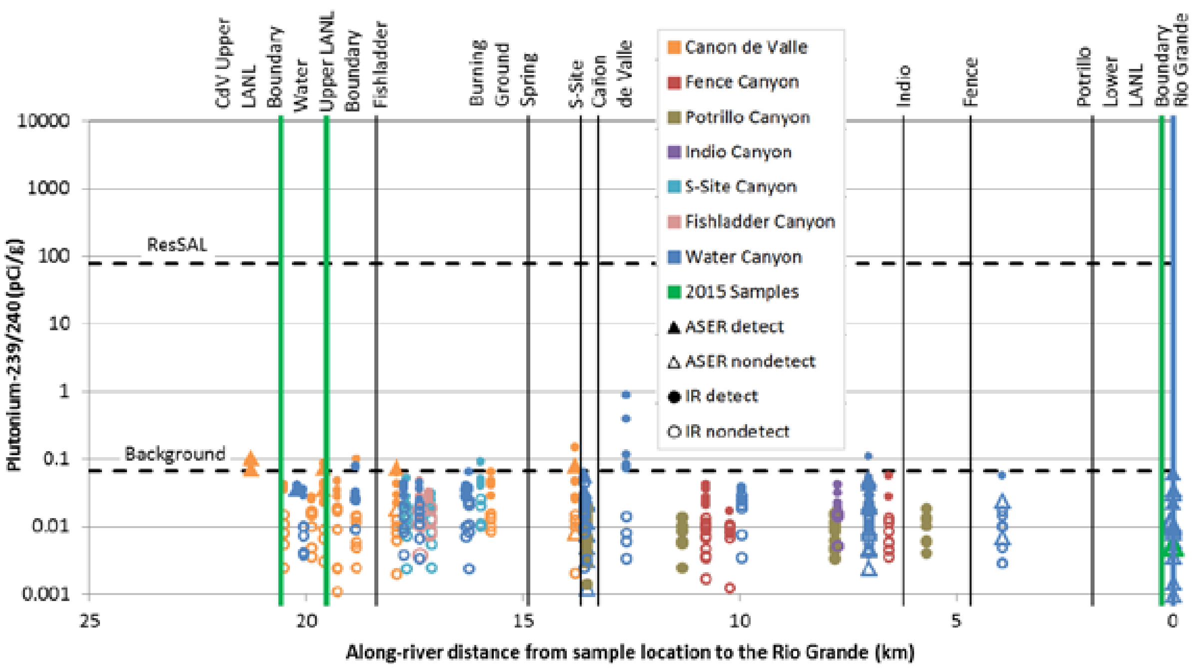


Figure 6-9j Water Canyon watershed plutonium-239/240 radioactivities in sediment from the canyons investigation reports (2000–2011) and the annual environmental surveillance program (2003–2015)

CONCLUSIONS

Human health and ecological risk assessments have been performed as part of each of the canyons investigation reports conducted under the Compliance Order on Consent. While some concentrations of Laboratory-derived chemicals present in canyon media are above applicable aquatic environment standards, the human health risk assessments in the investigation reports and the biota and human health risk assessments in Chapters 7 and 8 of this report have concluded that levels of chemicals and radionuclides present in storm water and canyon sediments are below applicable human health limits. The results of the sediment and storm water data comparisons from samples collected in 2015 verify the conceptual model that the scale of storm-water-related sediment transport observed in Laboratory canyons generally results in lower concentrations of Laboratory-derived 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 canyons investigation reports represent an upper bound of potential risks in the canyons for the foreseeable future. Risk and dose to biota are assessed in Chapter 7, and results show that the doses are far below the limits. The Las Conchas fire burned areas of Santa Fe National Forest upstream of Laboratory property, resulting in increased ash and sediment transport into Water, Pajarito, and Los Alamos Canyon watersheds from 2011 through 2014. Ash and sediment accumulate in storm water during active flooding and in floodplain deposits after monsoonal rains. Following the Cerro Grande fire in May 2000, ash and sediment transport returned to pre-fire levels in 3 to 5 years (Gallaher and Koch 2004, 2005). A similar return to pre-fire conditions is expected for the Las Conchas fire. Sediment and storm water samples collected in 2015 downstream of burned areas had levels of background and global fallout constituents close to pre-fire levels.

The sediment-control structures throughout the Laboratory performed as designed in 2015. The Pueblo Canyon wetland effectively reduced storm water discharges; gaging station E060.1, downstream of the wetland and grade-control structure, measured only four storm events throughout 2015. The Los Alamos Canyon low-head weir reduced peak discharges and storm water levels of many constituents. Ash and sediment were also trapped upstream of the Pajarito Canyon flood-retention structure, reducing sediment transport downstream. The upper Los Alamos Canyon detention basins below Solid Waste Management Unit 01-001(f) have been quite effective at reducing the total PCB concentrations in storm water runoff from the hillslope since they were constructed. During 2015, no runoff overtopped the basins. The Mortandad and Ten Site Canyon sediment traps were effective at reducing discharge and removing sediment because no storm events produced runoff that crossed the Laboratory boundary directly downstream of the sediment traps.

Although some substance levels in unfiltered storm water were above screening levels at on-site locations, these transient events do not significantly affect human or biota health. Biota dose is assessed in Chapter 7 and human dose is assessed in Chapter 8.

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7.0 ECOSYSTEM HEALTH

To Read About	Turn to Page

In this chapter, we report levels of radionuclides and chemicals in soil, plants, and animals as well as the abundance and diversity of bird populations at Los Alamos National Laboratory (the Laboratory). Also, we calculated biota radiation doses for plants and animals occupying areas around specific mesa-top 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.

This year, levels of constituents in soil and tree samples from 17 on-site, 11 perimeter, and 6 regional background locations were assessed. In addition, soil, vegetation, and small mammals were collected around the perimeter of Area G and at the Dual-Axis Radiographic Hydrodynamic Test Facility and upstream of sediment control structures within Los Alamos, Pajarito, and Pueblo Canyons.

All substances measured were compared with background levels, screening levels protective of biota, and standards. All radionuclide and most chemical concentrations in soil, sediment, and biota from on-site and perimeter locations were either not detected, similar to background, or below screening levels.

The lead concentration in a soil sample collected northwest of Technical Area 21 was above the low-effect ecological screening level for two types of biota. Lead in the soil was associated with the demolition of the Technical Area 21 water tower, which contained lead paint.

Bird populations and diversity of birds were assessed at the Dual-Axis Radiographic Hydrodynamic Test Facility, the Sandia Canyon wetland, and the Pajarito Canyon wetland complex. Bird eggs collected from the Laboratory's avian nest-box monitoring network were analyzed for organic and inorganic chemicals. Federally threatened and endangered species, including the Mexican spotted owl and the Jemez Mountains salamander, were found during annual surveys.

Biota dose assessments show that there are no measurable effects from Laboratory-sourced radioactive materials to the Pajarito Plateau plant and animal populations.

INTRODUCTION

An ecosystem is a community of living organisms (plants, animals, and microorganisms) along with the nonliving components of their environment (such as soil, air, and water) (Smith and Smith 2012). The condition of an ecosystem is affected by disturbances, including wildfire, flooding, drought, invasive species, climate change, chemical spills, and a host of other factors (Rapport 1998).

Los Alamos National Laboratory (LANL or the Laboratory) is home to many types of plants and animals (collectively called "biota"). The primary objective of the Laboratory's Ecosystem Health Program is to determine if releases of chemicals, including metals, or radionuclides from Laboratory operations are affecting local plants or animals.

We conduct both institutional (site-wide) monitoring and facility-specific monitoring. Institutional monitoring is used to determine the levels of Laboratory-produced radionuclides and chemicals outside of areas designated as 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 Laboratory-produced radionuclides and chemicals associated with specific facilities 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:

- Measuring activities of radionuclides and concentrations of other chemicals in soil, plants, and animals from areas in the Laboratory (on-site samples) and close to the Laboratory boundary (perimeter samples), and comparing these concentrations with
  - levels at sites not affected by Laboratory operations (background),
  - levels that scientists have determined should trigger further investigation (screening levels), and
  - levels that may cause harm (standards and adverse effect levels).
- Evaluating trends in radionuclide activities and chemical concentrations in soil, plants, and animals over time
- Assessing population levels and species diversity of animals in areas potentially affected by Laboratory operations
- Estimating radiation dose and chemical risk to biota based on the collected information

The Laboratory also monitors migratory bird species to meet regulatory commitments.

TERRESTRIAL HEALTH ASSESSMENT

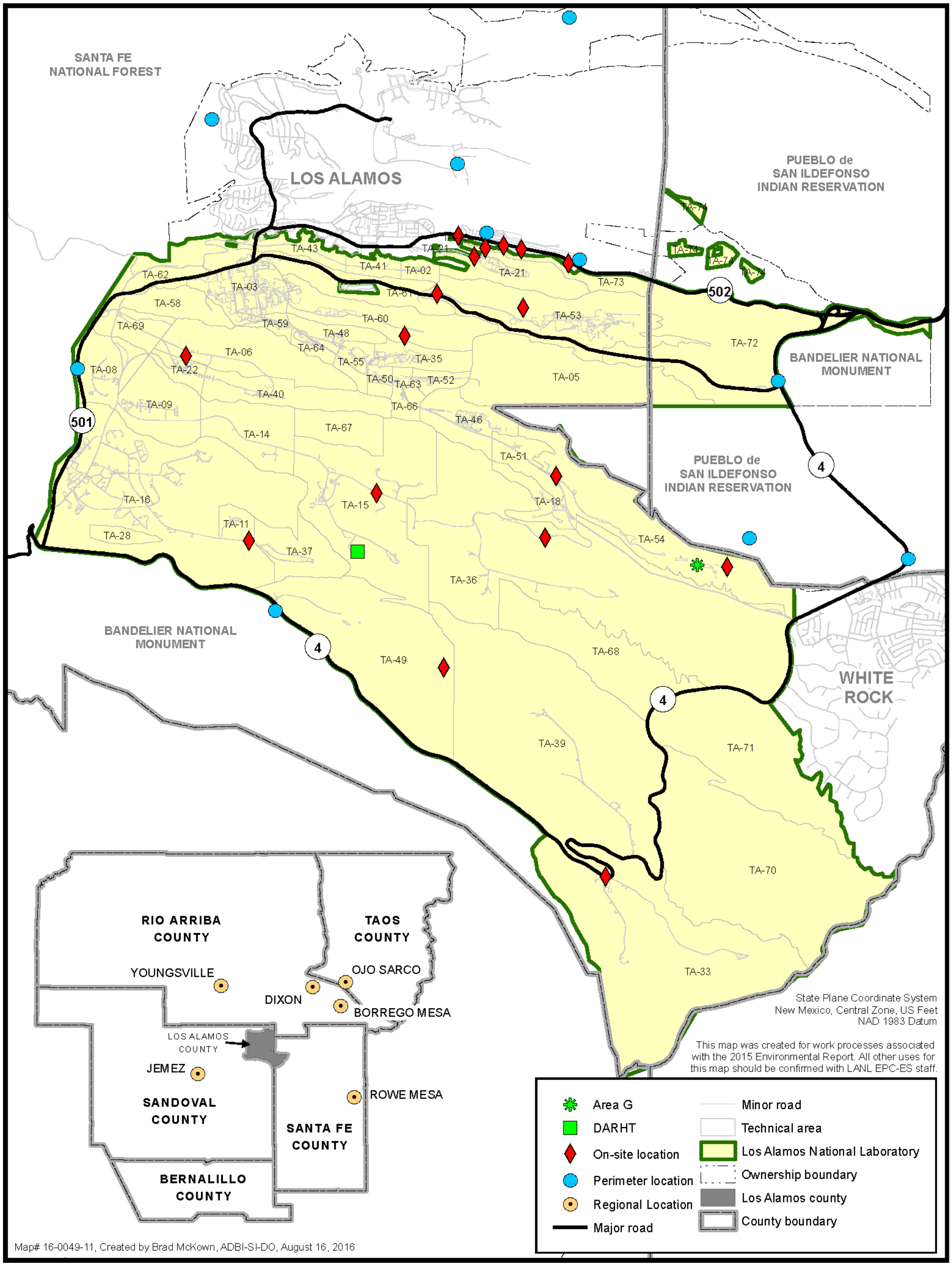
Soil and Biota Comparison Levels Related to Ecosystem Health

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

We compare levels of radionuclides and chemicals in soil, plant, and animal samples collected at and near the Laboratory with levels in samples collected from regional background locations near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast of the Laboratory; Rowe Mesa (near Pecos) to the southeast of the Laboratory; Youngsville to the northwest of the Laboratory; and Jemez Springs to the southwest (Figure 7-1). As required by the U.S. Department of Energy (DOE), all 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).

Radionuclides and chemicals in soil collected from these regional background locations come from naturally occurring elements in the soil, worldwide fallout of radioactive particles from testing of atomic weapons and nuclear facility accidents, and chemical releases from non-Laboratory sources such as power plants and automobile emissions. Levels found at the Laboratory and near the Laboratory are compared with levels in background locations using a Mann-Whitney nonparametric statistical test at the 0.05 significance level. Trends over time are tested with a Mann-Kendal nonparametric test at the 0.05 significance level. Individual values are compared with regional statistical reference levels. Regional statistical reference levels are the levels below which 99% of all background samples occur and are statistically calculated.

For soil samples, if individual or average results in soil exceed background levels, the level is then compared with ecological screening levels. Ecological screening levels include the highest level of a radionuclide or chemical in the soil that is known not to 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 2015a). We have soil ecological screening levels for the deer mouse (mammalian omnivore), the desert cottontail (mammalian herbivore), the earthworm (soil-dwelling invertebrate), the montane shrew (mammalian terrestrial insectivore), the red fox (mammalian carnivore), American kestrel (avian carnivore), American robin (avian omnivore, herbivore, and insectivore), and a generic plant (terrestrial autotroph-producer).



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 5 miles east of the Laboratory near the confluence of Los Alamos Canyon and the Rio Grande.

Any soil sample result exceeding background is first compared with the no-effect ecological screening level of the most sensitive receptor in the database (usually the earthworm or plant). If the constituent in the soil exceeds the no-effect ecological screening level, then the concentrations are compared with the low-effect ecological screening level for that receptor.

For animal or plant tissue samples, the levels of radionuclides and chemicals in the sample are compared with biota screening levels for radionuclides and with lowest observable adverse effect levels for chemicals. Radionuclide biota screening levels are set at 10% of the DOE limit for radiation doses to biota (McNaughton 2006). 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).

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 (version 1.8) (http://web.ead.anl.gov/resrad/home2/biota.cfm). This calculated dose is compared with DOE limits: 1 rad/day for terrestrial plants/aquatic animals and 0.1 rad/day for terrestrial animals (DOE 2002).

Institutional Soil and Vegetation Monitoring

Monitoring Network

Soil data reveal the transport of chemicals or radionuclides by wind and surface water, while vegetation data reveal the uptake of buried substances and deposition of substances on leaves by wind and rain. Institutional surface soil samples are collected from 17 on-site, 11 perimeter, and 6 regional background locations every third year (Figure 7-1). Most locations have been sampled for radionuclides since the early 1970s (Purtymun et al. 1980, 1987). The previous institutional soil sampling occurred in 2012 (Fresquez 2013).

The majority of on-site soil-sampling stations are located on undisturbed mesa tops close to and, if possible, downwind from major facilities or operations at the Laboratory. On-site samples were collected from Technical Area 16 (high-explosives processing and storage areas and firing sites); Technical Area 21 (former plutonium and tritium processing facilities); near Technical Area 33 (former firing sites and current experimental sites); north of Technical Areas 50 and 35 (Plutonium Facility and Radioactive Liquid Waste Treatment Facility); Technical Area 51 (environmental research site of radioactive materials); west and east of Technical Area 53 (Los Alamos Neutron Science Center); east of Technical Area 54 (low-level radioactive and transuranic waste storage and disposal facilities); Potrillo Drive at Technical Area 36 (firing sites that support explosive testing); near Test Well DT-9 at Technical Area 49 (former experimental site and current hazardous materials training facility); R-Site Road east at Technical Area 15 (explosives firing sites); and Two-Mile Mesa at Technical Area 06 (former radioactive materials processing facilities). We also collected four additional samples from along the south side of NM 502. These points are downwind of Technical Area 21 and its associated solid waste management units, including historical waste disposal sites.

All but 1 of the 11 perimeter stations are located within 2.5 miles of the Laboratory boundary. These stations are located in inhabited areas to the north and east of the Laboratory. Locations include the residential area on North Mesa, the Sportsman's Club in

Rendija Canyon, along Quemazon Trail near North Community, west and east of the Los Alamos airport, White Rock, the Pueblo de San Ildefonso property directly north of Technical Area 54, at Otowi bridge over the Rio Grande, and at the Bandelier National Monument unit of Tsankawi at the intersection of NM 4 and East Jemez Road. Additional samples were collected on U.S. Forest Service property west of Technical Area 08 and on Bandelier National Monument property south of Technical Area 49 to expand coverage.

Methods and Analysis

At each general location, surface soil samples are collected at the center and in the corners of a 33-foot by 33-foot square area using a stainless-steel soil ring 4 inches in diameter pushed 2 inches deep. The five samples per location are combined and mixed thoroughly in a large plastic bag to form a composite sample. Composite samples are placed in prelabeled 500-milliliter polyethylene bottles, sealed with chain-of-custody tape, placed into a sealed plastic bag, and submitted to the Laboratory's Sample Management Office. All samples are shipped under full chain of custody to ALS Laboratory Group for analysis. These samples are analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, radium-226, and radium-228 and 23 inorganic elements (aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury).

A separate grab sample is collected at each location from the 0 to 6–inch soil depth range using disposable polystyrene scoops. The grab sample is analyzed for 7 commercial polychlorinated biphenyl (PCB) Aroclor mixtures and 20 high-explosives compounds. Each grab sample is placed into a prelabeled 500-milliliter amber-colored glass jar, sealed with chain-of-custody tape, placed into a sealed plastic bag, and immediately cooled to 4°C. Grab samples are submitted to the Laboratory's Sample Management Office and shipped under full chain of custody to GEL Analytics, Inc., for analysis.

Native vegetation, either from understory plants (grasses and forbs) or trees is collected at the same general location. The last vegetation sampling conducted in 2012 focused on understory plants (Fresquez et al. 2013). In 2015, we collected samples from trees. In general, samples of branches and needles at chest height are collected and submitted to ALS Laboratory Group for the analysis of the same radionuclides and inorganic elements as the soil samples.

Radionuclide Results in Soil

Radionuclide activities are measured in each sample. For 2015, radionuclide activities in soil collected from perimeter and on-site areas in 2015 were either not detected (most results), similar to regional statistical reference levels, or far below ecological screening levels (see supplemental Table S7-1; supplemental tables are provided separately in electronic format). For radionuclides, a not detected value is one in which the result is less than the minimum activity detectable by the measuring equipment.

Results for 2015 are similar to past years. Activities of radionuclides at locations with histories of radionuclide detections are generally not increasing over time. The only area where a radionuclide activity has increased over time is east of the waste disposal site

Area G at Technical Area 54. Activities of plutonium-239/240 in soil collected east of Technical Area 54 are above the regional statistical reference level at the Area G boundary and are statistically increasing over time (Figure 7-2; Fresquez et al. 2015). However, activities of plutonium-239/240 in soil collected on the eastern side of Area G are still far below ecological screening levels and are not expected to impact plants or animals.

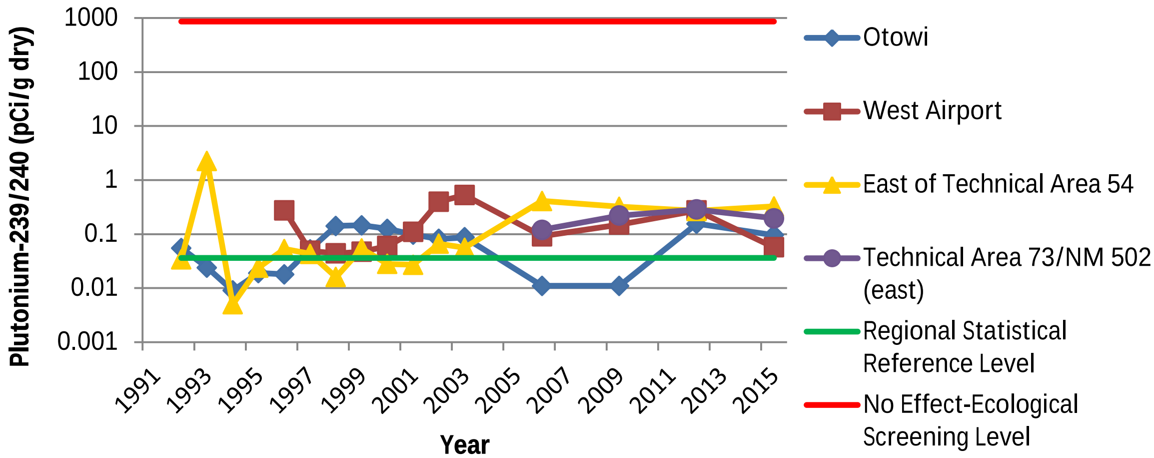


Figure 7-2 Plutonium-239/240 (detected and nondetected) in soil samples collected from perimeter (Otowi and West Airport) and on-site (East of Technical Area 54 and Technical Area 73/NM 502) lands that have a history of detections. Values are compared with the regional statistical reference level and the no-effect ecological screening level for earthworms. Note the logarithmic scale on the vertical axis.

Radionuclide Results in Vegetation

All radionuclide activities in native trees (branch plus needles) collected from perimeter and on-site areas were either not detected (most results), similar to regional statistical reference levels, or far below biota screening levels (Table S7-2). These data agree with past results (Gonzales et al. 2000, Fresquez and Gonzales 2004, Fresquez et al. 2010).

Inorganic Element Results in Soil

Table S7-3 shows the results of the inorganic element analyses in surface soil collected from regional, perimeter, and on-site areas in 2015. All metal concentrations, with the exception of lead, in perimeter and on-site locations were either similar to regional statistical reference levels or below ecological screening levels. Lead concentrations in one perimeter location (west airport) and in one on-site location (Technical Area 21 [DP Site]) were above the low-effect ecological screening level for the robin and the shrew.

In general, the two major sources of lead in soil are auto emissions and lead-based paint. Studies conducted in urban areas have shown that lead levels in soil are highest around building foundations and within a few feet of busy streets (Rolfe et al. 1977, Singer and Hanson 1969). Although lead is not presently used in household paint or gasoline, it can persist in the soil for a long time.

The increase in lead concentrations in soil on the northwest side of Technical Area 21 resulted from the demolition of a water tower in August of 2014 (Parsons 2014). Apparently, the collapse of the tower onto the ground spread out fragments of lead-based paint from the tower. The lead result at Technical Area 21 represents a large increase from past years (Figure 7-3). We do not know the reason for the increase in lead concentrations at the west end of the Los Alamos airport. These data were reported to Laboratory managers responsible for site cleanup (Fresquez 2016), and DOE's Office of Environmental Management has subsequently committed to a cleanup of lead-contaminated soil around the water tower site in fiscal year 2017.

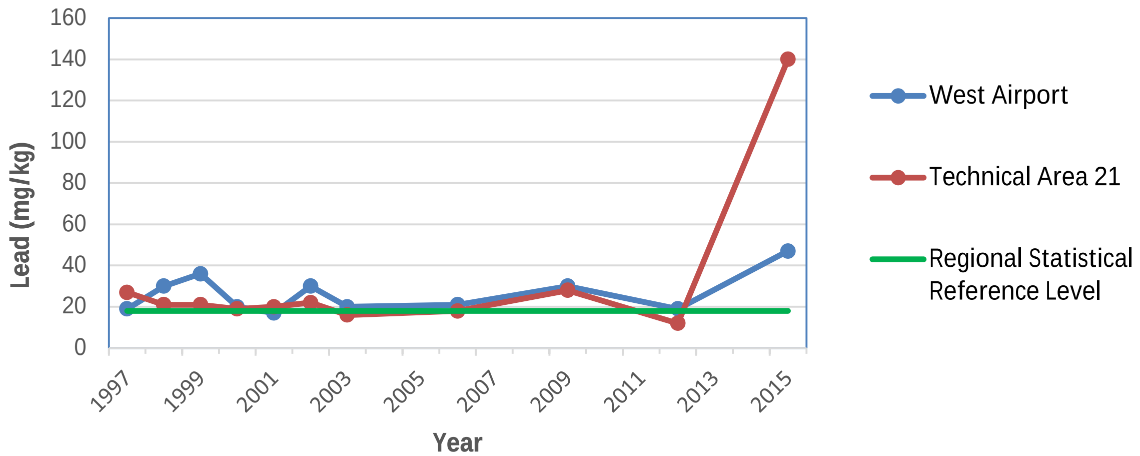


Figure 7-3 Lead concentrations in soil samples collected from the West Airport and Technical Area 21 from 1997 through 2015 compared with the regional statistical reference level

Inorganic Element Results in Vegetation

As with radionuclides, the majority of inorganic element concentrations in trees from both perimeter and on-site locations were below the regional statistical reference levels (Table S7-4). The few elements, including lead, that were above the regional statistical reference levels at some perimeter and on-site locations were far below levels considered toxic to plants (Gough et al. 1979). The site with the highest lead concentration in the soil—Technical Area 21—contained higher than background lead concentrations in the closest trees (0.71 milligrams per kilogram [mg/kg] dry weight); however, the levels were still considerably lower than concentrations considered to be toxic to plants (>18 mg/kg dry weight).

High Explosives and PCBs in Soil

All high explosives (Table S7-5) and most PCBs (Table S7-6) in soils collected from regional, perimeter, and on-site locations were not detected.

The PCB Aroclor-1260 (0.018 mg/kg) was detected in soil at Technical Area 21. The level was below the no-effect ecological screening level for the most sensitive biota (robin = 0.88 mg/kg) (LANL 2015a).

Facility Soil, Plant, and Animal Monitoring

The areas sampled in 2015 as part of the Laboratory's facility-specific annual monitoring include the Area G waste disposal site at Technical Area 54, the Dual-Axis Radiographic Hydrodynamic Test Facility firing site, and three sediment- or flood-control structures located in Los Alamos, Pueblo, and Pajarito Canyons.

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 7-4). Tritium, plutonium, americium, and uranium are the main radioactive waste materials at Area G. The Laboratory has conducted soil, vegetation, and small mammal monitoring at Area G since 1980 to determine whether and how far radionuclides migrate beyond the waste burial area (LANL 1981, Mayfield and Hansen 1983).

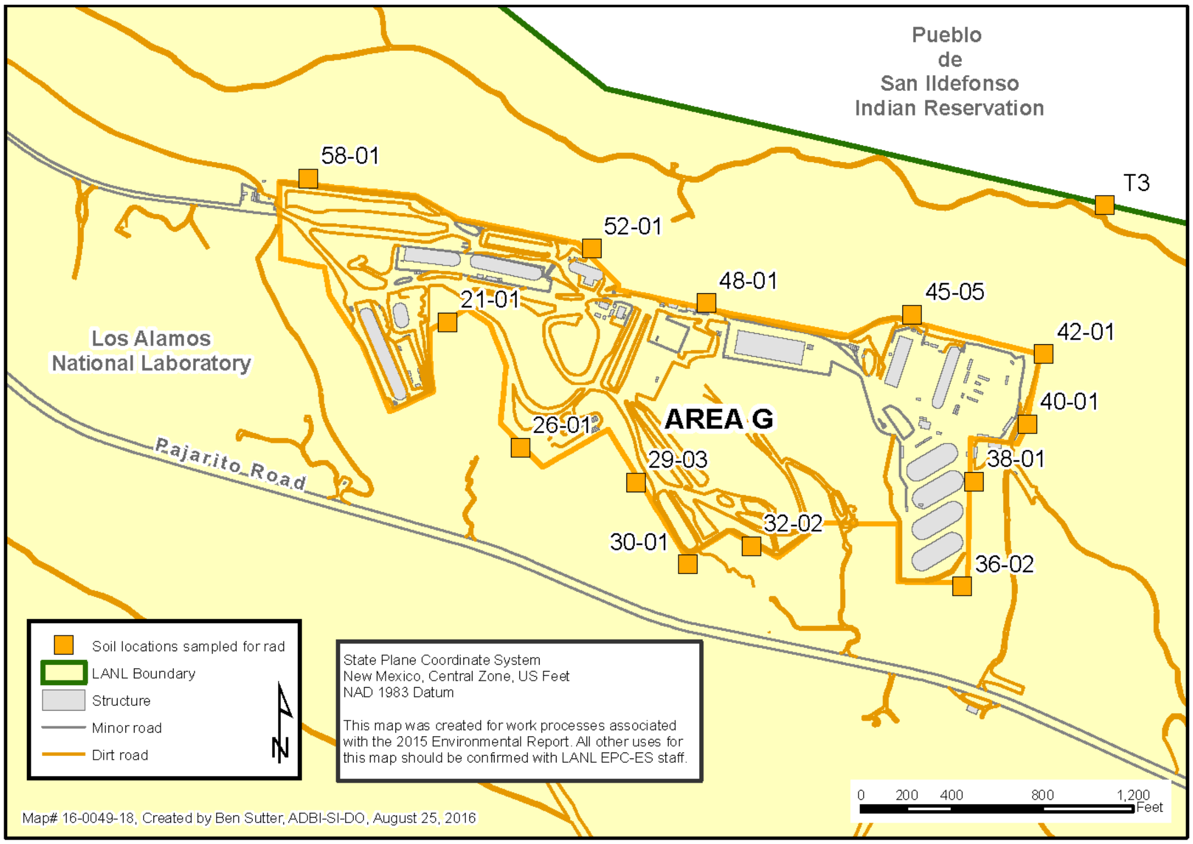


Figure 7-4 Locations of soil and vegetation samples collected around Area G in 2015

Surface soil grab samples and composite tree samples were collected in April 2015 at 13 designated locations around the perimeter of Area G, and one soil sample and one tree sample were collected at the boundary between the Laboratory and the Pueblo de San Ildefonso (site T3), approximately 800 feet northeast of Area G (Figure 7-4). Small mammal samples, mostly deer mice, were collected from sites 29-03 and 38-01. All samples were analyzed for tritium, americium-241, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238.

Radionuclides in Soil and Vegetation at Area G

All radionuclide activities in soil samples from the perimeter of Area G were either similar to regional statistical reference levels or below the no-effect ecological screening levels (Table S7-7). The activities of several radionuclides were lower than in previous years.

Tritium was detected in surface soil above the regional statistical reference level (0.84 picocuries per milliliter [pCi/mL]) at the same two locations (near the underground tritium waste disposal shafts) as past years. However, the activities were much lower than in previous years. The two locations are site 29-03, which contained 1.4 pCi/mL in 2015 and 1187 pCi/mL in 2014, and site 30-01, which contained 8.0 pCi/mL in 2015 and 51 pCi/mL in 2014. Tritium activities at site 29-03 were at their lowest level since measurements began (Figure 7-5). The degree of variability in tritium activities in surface soil from year to year may be influenced by engineering and environmental factors, including soil moisture, time of sampling, distance from the perimeter fence, temperature, and/or barometric pressure (Purtymun 1973, Abeele and Nyhan 1987, Childs and Conrad 1999).

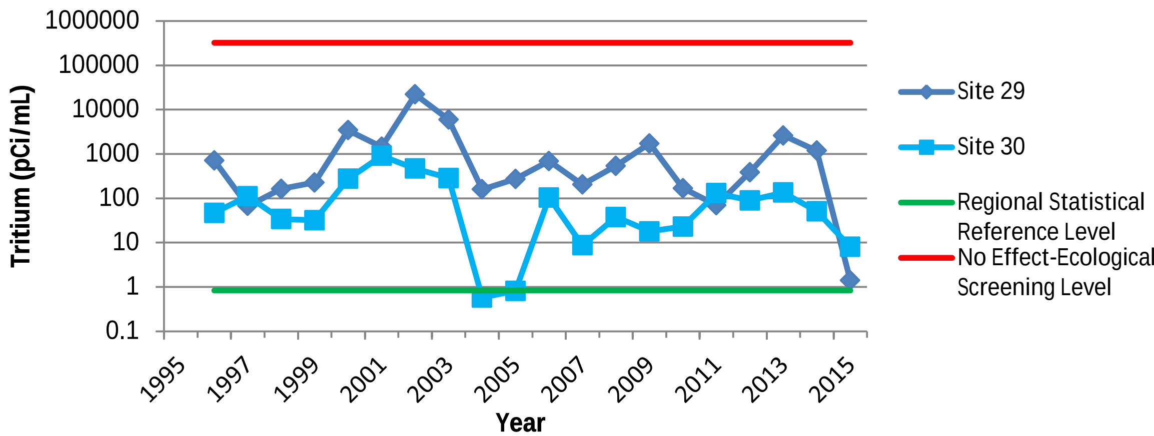
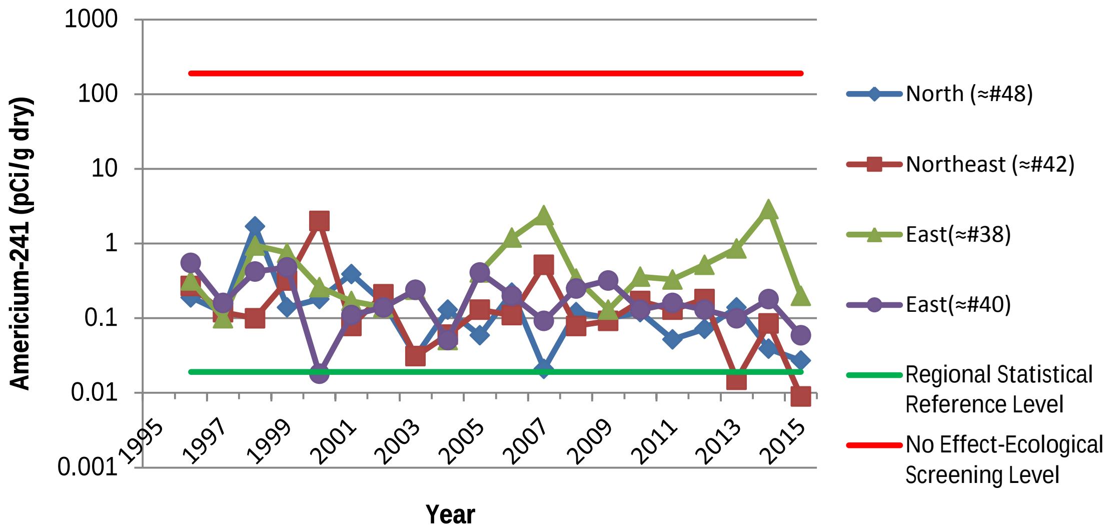


Figure 7-5 Tritium activities in surface soil samples collected from the southern portions of Area G at Technical Area 54 from 1996 to 2015 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for the plant). Note the logarithmic scale on the vertical axis.

Americium-241, plutonium-238, and plutonium-239/240 activities in soil directly around the perimeter of Area G were also lower than previous years (Figures 7-6, 7-7, and 7-8).

Results from native trees (branches and needles of mostly juniper trees) are an indicator of both deep root uptake (as in the case of tritium) and deposition of radionuclides on the surfaces of leaves and branches. Tree samples were collected at the same general locations as the soil samples (Figure 7-4). However, because of a firebreak between the fenceline and the trees (>10 meters from the fenceline), tree samples are collected at various distances 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.

All radionuclides in tree samples were either similar to regional statistical reference levels or below the biota screening levels (Table S7-8a).



pci/g = Picocuries per gram.

Figure 7-6 **Americium-241 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 1996 to 2015 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.**

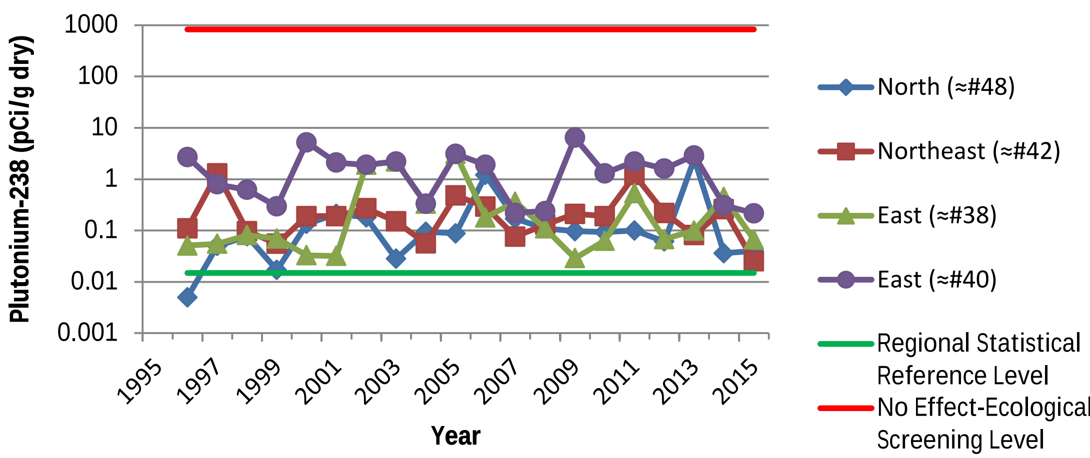


Figure 7-7 **Plutonium-238 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 1996 to 2015 compared with the regional statistical reference level and and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.**

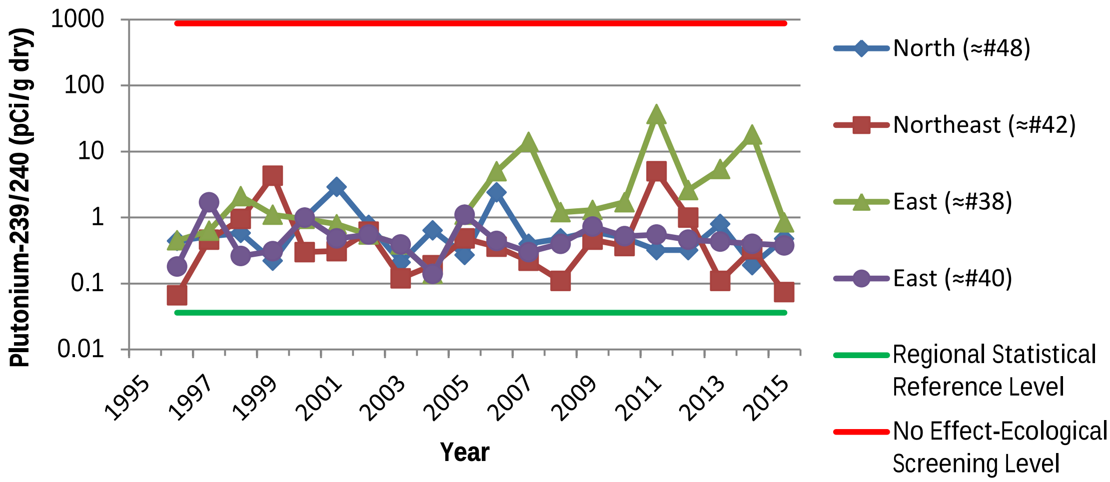


Figure 7-8 Plutonium-239/240 activities in surface soil collected from the northern, northeastern, and eastern portions of Area G at Technical Area 54 from 1996 to 2015 compared with the regional statistical reference level and the lowest no-effect ecological screening level (for earthworm). Note the logarithmic scale on the vertical axis.

Tritium was detected above the regional statistical reference level in over 50% of the tree samples collected around the perimeter of Area G, with the highest amounts (up to 165 pCi/mL) occurring in trees growing in the southern sections near the tritium disposal shafts. Levels of tritium in trees in 2015 were generally lower than in past years. The overall trend is highly variable from year to year, and activities are not significantly increasing over time (Figure 7-9). Variability in tritium levels may be a result of soil moisture, depth of roots, time of sampling, distance from the perimeter fence, temperature, and/or barometric pressure.

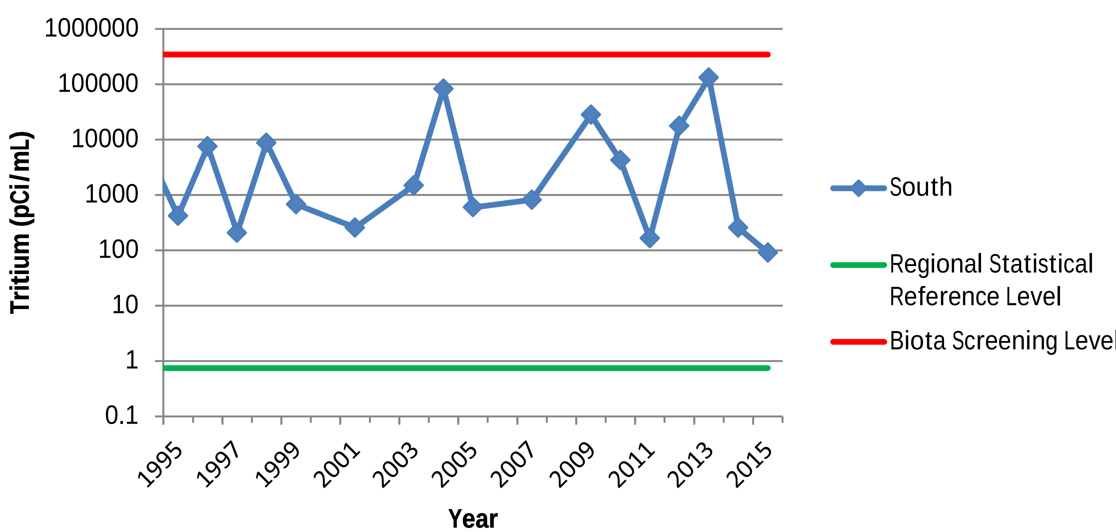


Figure 7-9 Mean activities of tritium in tree samples collected from the south side of Area G at Technical Area 54 (sites 29-03 and 30-01) from 1994 to 2015 compared with the regional statistical reference level and the biota screening level (for earthworm). Note the logarithmic scale on the vertical axis.

Radionuclides in Soil and Vegetation at the Laboratory/Pueblo de San Ildefonso boundary in Cañada del Buey

All radionuclides in a soil sample collected at the Laboratory/Pueblo de San Ildefonso boundary northeast of Area G in Cañada del Buey (Figure 7-4, Site T3) were either not detected, similar to regional statistical reference levels, or below the no-effect ecological screening level (Table S7-7).

Long-term trends in activities of americium-241, plutonium-238, and plutonium-239/240 at the Laboratory/Pueblo de San Ildefonso boundary are not increasing over time (Figures 7-10, 7-11, and 7-12).

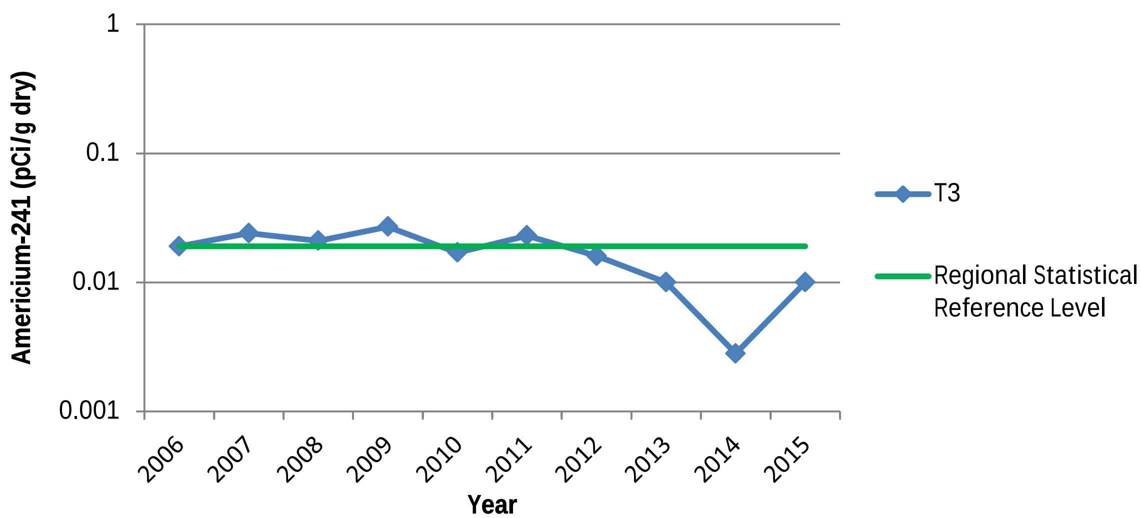


Figure 7-10 Americium-241 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at Technical Area 54 from 2006 to 2015 compared with the regional statistical reference level. Note the logarithmic scale on the vertical axis.

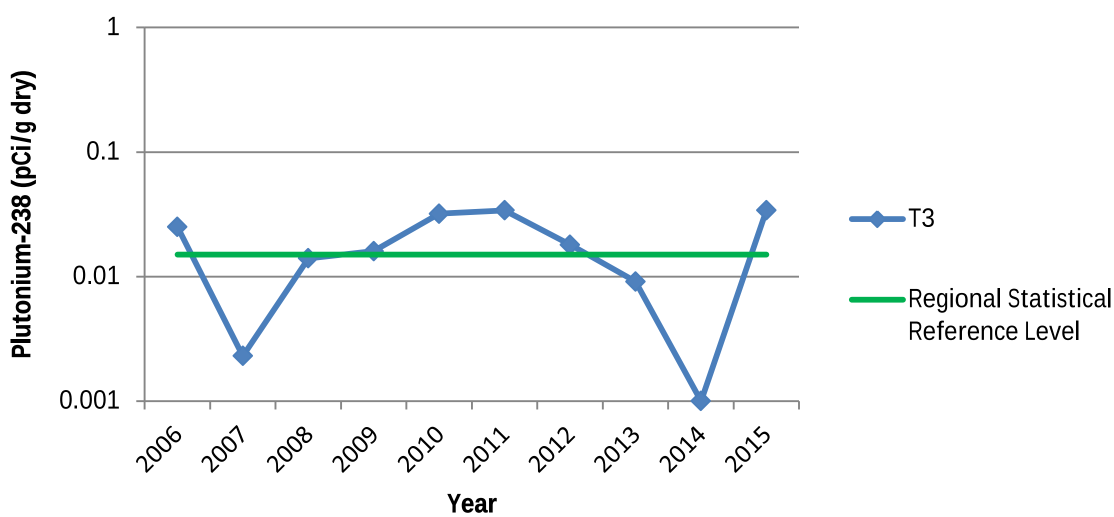


Figure 7-11 Plutonium-238 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at Technical Area 54 from 2006 to 2015 compared with the regional statistical reference level. Note the logarithmic scale on the vertical axis.

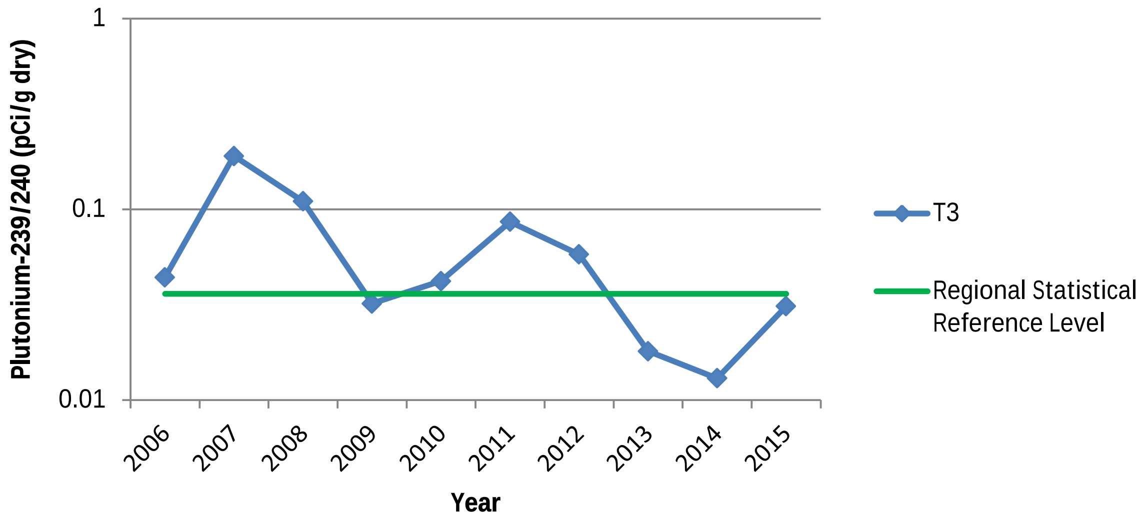


Figure 7-12 Plutonium-239/240 (detected and nondetected) activities in surface soil collected from the Laboratory/Pueblo de San Ildefonso boundary (T3) northeast of Area G at Technical Area 54 from 2006 to 2015 compared with the regional statistical reference level. Note the logarithmic scale on the vertical axis.

All radionuclides measured in samples from trees located northeast of Area G at the Laboratory/Pueblo de San Ildefonso boundary were either similar to regional statistical reference levels or below biota screening levels (Table S7-2).

Radionuclides, Metals, and PCBs in Small Mammals at Area G

Small mammals at Area G, including deer mice, gophers and rock squirrels, have been collected periodically from 1994 to 2003 (Bennett et al. 2002, Budd et al. 2004, Fresquez et al. 2005). This year, we collected deer mice from the perimeter of the south side (near site 29-03) and east side (near site 38-01) of Area G (Figure 7-4) and analyzed whole-body samples for radionuclides, metals, and PCB congeners. At least five small mammals are composited for radionuclide analysis, three individual small mammals are tested for inorganic elements, and three different individual small mammals are tested for PCBs.

Radionuclides in deer mice from the south and east sides of the Area G perimeter were below biota screening levels (Table S7-8b). Tritium activities in whole-body mice collected on the south side near the tritium storage shafts (361 pCi/mL) decreased from the last sampling date in 2003 (1650 pCi/mL). In contrast, the plutonium-239/240 activity in the mouse sample from the east side (site 30-01) was slightly higher (0.06 pCi/g ash) than in 2003 (0.04 pCi/g ash) (Fresquez et al. 2005).

There were no significant differences in any of the 23 inorganic elements in whole-body mice collected from the two Area G samples on the south and east sides compared with mice collected from regional background locations (Table S7-8c).

PCB levels in field mice collected from both sites at Area G were greater than PCB levels in mice from regional background locations (Table S7-8d). However, the highest individual total PCB concentration in a field mouse collected on the east side of Area G (12,200 picograms per gram [pg/g] wet weight) was orders of magnitude below the average whole-body amount (2,500,000 pg/g wet weight) reported at PCB-contaminated sites where field-mouse populations were negatively affected (Batty et al. 1990). The current PCB levels are not expected to significantly impact the field-mouse population.

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. We monitor soil, sediment from drainages, plants, and animals at the facility to determine whether releases of constituents are consistent with expectations and are not affecting plants or animals. 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 were conducted starting in 2007.

Monitored constituents in soil and sediment include radionuclides, beryllium (and other metals), and organic chemicals such as high explosives, dioxins, and furans. The plant and animal samples collected at the Dual-Axis Radiographic Hydrodynamic Test Facility have included trees, small mammals, bees, and birds. Starting in 2014, soil plus one type of biota were collected per year, with the biota type being rotated each year.

Composite soil samples (five subsamples per location) were collected in late April 2015 on the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter along the fenceline (Figure 7-13). An additional sample was collected about 75 feet north of the firing point. Sediment grab samples were collected on the north, east, south, and southwest sides. All soil and sediment samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, the inorganic elements listed previously, and high explosives. The sample nearest the firing point was also analyzed for dioxins and furans.

In 2015, field mice were collected on the northeast side of the facility and analyzed for radionuclides, inorganic elements, dioxins, and furans. In animals, results for tritium are reported on a picocuries per milliliter basis, results for the other radionuclides are reported on a picocuries per gram ash weight basis, and results for the inorganic elements and dioxins/furans are reported on a milligrams per kilogram wet weight basis.

Results of most chemical analyses were compared with the baseline statistical reference levels. The baseline statistical reference levels for the Dual-Axis Radiographic Hydrodynamic Test Facility are the levels below which 99% of samples collected at the facility occurred during 1996 to 1999, before the beginning of firing site operations (Nyhan et al. 2001). In cases where there are no baseline statistical reference levels, the biota chemical results were compared with regional statistical reference levels for tissue activities and concentrations in mice (Fresquez 2015).

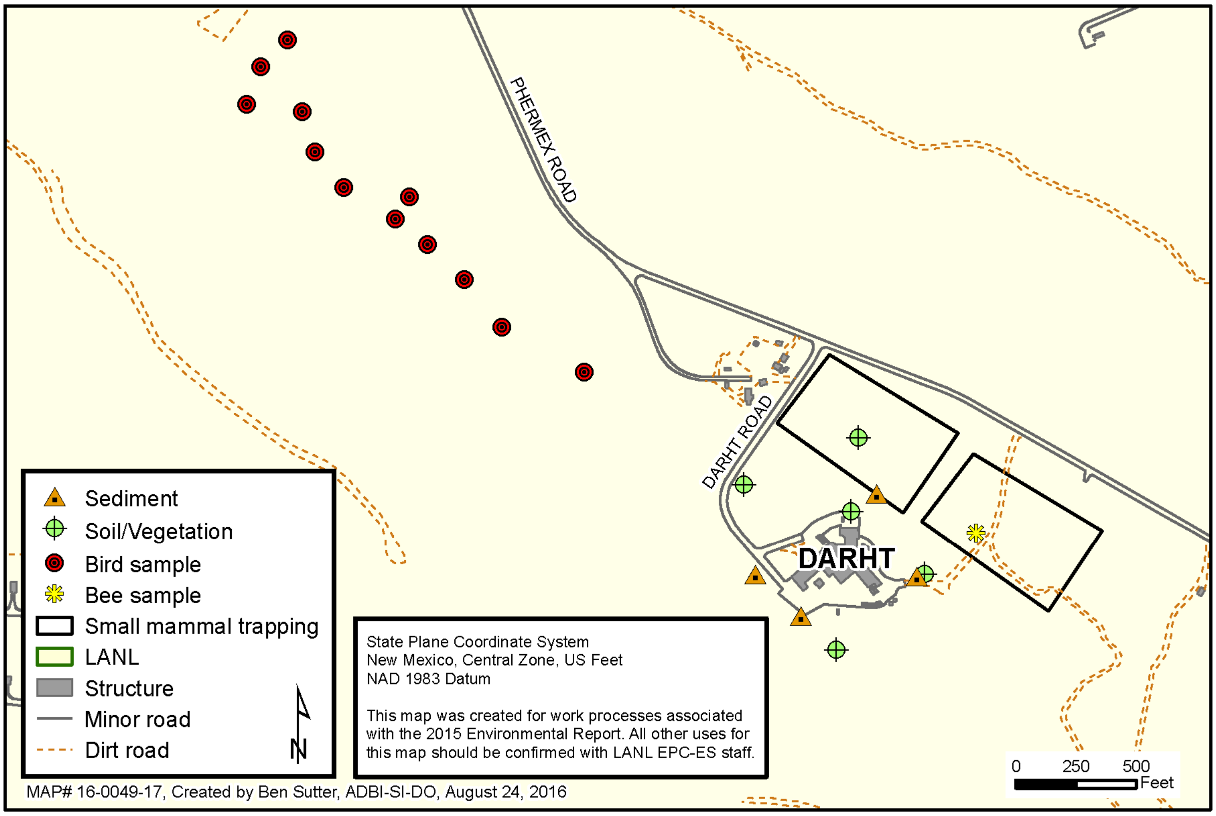


Figure 7-13 Soil, sediment, and biota sample locations at the Dual-Axis Radiographic Hydrodynamic Test Facility

Soil and Sediment Results 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 no-effect ecological screening levels (Table S7-9).

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. Operations at the Dual-Axis Radiographic Hydrodynamic Test Facility have changed since 2007 to include the use of closed containment vessels; since 2008, the uranium-238 activity near the firing point has decreased to the baseline statistical reference level (Figure 7-14).

With the exception of lead, the inorganic element concentrations in the soil and sediment samples collected within and around the facility were below the baseline or regional statistical reference levels (Table S7-10). The highest lead concentration (20 mg/kg) was collected on the south side of the Dual-Axis Radiographic Hydrodynamic Test Facility from both soil and sediment samples. The amounts are slightly above the regional statistical reference level of 18 mg/kg and above the lowest no-effect ecological screening level of 14 mg/kg for the robin. The concentration, however, is below the low-effect ecological screening level of 28 mg/kg for the robin, and because these data represent only one area, it is not expected to significantly impact the health of birds at the site overall. Bird abundance and diversity are not negatively impacted at Dual-Axis Radiographic Hydrodynamic Test Facility (Keller et al. 2015).

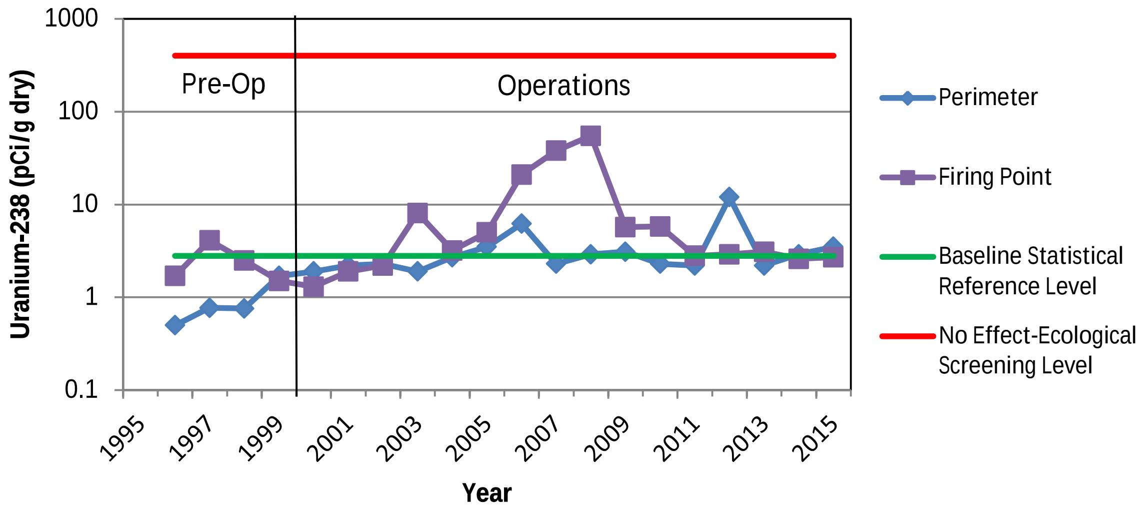


Figure 7-14 Uranium-238 activities in surface soil collected within (near the firing point) and around the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter (north-, west-, south-, and east-side average) at Technical Area 15 from 1996 to 1999 (preoperations) and from 2000 to 2015 (operations) compared with the baseline statistical reference level and the lowest no-effect ecological screening level (plant). Note the logarithmic scale on the vertical axis.

Beryllium, listed as a chemical of potential concern before the start-up of operations at the facility (DOE 1995), was not detected above baseline or regional statistical reference levels in any of the soil or sediment samples during 2015. Beryllium concentrations in soil over the 16-year operations period have mostly remained below the baseline statistical reference level over time.

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 S7-11). Dioxins and furans also were not detected in any of the soil or sediment samples (Table S7-12).

Small Mammal Results at the Dual-Axis Radiographic Hydrodynamic Test Facility

In a composite sample of five field mice collected from the north and northeast sides of the Dual-Axis Radiographic Hydrodynamic Test Facility, radionuclides were either not detected (most results) or similar to baseline or regional statistical reference levels and were far below biota screening levels (Table S7-13).

The amount of uranium-238 in small mammals, as seen with soil, increased until the year 2007 and then decreased thereafter to the baseline statistical reference level; the decrease is concurrent with the change from open-air and/or foam-mitigated detonations during the 2000–2006 period to closed vessel containment, starting in 2007 (Figure 7-15).

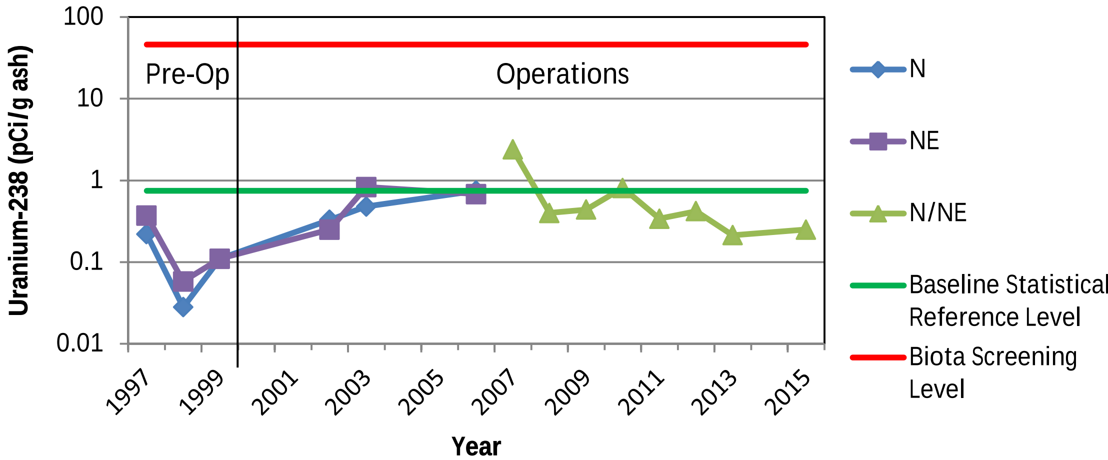


Figure 7-15 Uranium-238 activities in mice collected from the north and northeast sides of the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15 from 1997 to 1999 (preoperations) and 2002 to 2015 (operations) compared with the baseline statistical reference level and the biota screening level. Note the logarithmic scale on the vertical axis.

Average concentrations of inorganic elements in three field mice collected from the northeastern perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility were not statistically different from the regional background (Fresquez 2015; Table S7-14a). Dioxins and furans were not detected in three different field mice collected from the same location (Table S7-14b).

Avian Community Characteristics at the Dual-Axis Radiographic Hydrodynamic Test Facility: Final Report

The Laboratory conducted an 18-year study of breeding bird abundance, species richness, evenness, diversity, composition, productivity, and survivorship near the Dual-Axis Radiographic Hydrodynamic Test Facility during preoperations (1997–1999) and operations (2000–2014) periods to determine whether the firing site operations affected characteristics of local bird populations (Keller et al. 2015).

A total of 2952 bird captures, representing 80 species, were recorded during 18 years of mist net operations. Captured birds were identified by species, age, and sex and were banded during May through August of each year.

There were no significant differences in avian abundance and species evenness in any of the operations periods compared with the preoperations period. Species richness and diversity were significantly higher during the vessel containment period (2007–2014) than in the preoperations period.

The time period of this study coincided with a wildfire (2000), a bark beetle infestation (2002), and two periods of drought (November 1999–March 2004 and December 2005–December 2014). These ecological disturbances altered the study area vegetation from a ponderosa pine woodland to a more open woodland/shrub environment. Analysis of aerial photos determined that the average percentage of canopy cover of mature ponderosa pines within 100 feet of mist net sites declined from 12% to 3% between 1991 and 2014, and the percentage of shrub cover slightly increased. Two bird species associated with large trees became less common over the study period (capture rate dropped below 2 adults per 600 net-hours relative to the preoperations period), and four bird species associated with edge and scrub habitats became more common over the study period (capture rate increased to more than 2 adults per 600 net-hours relative to the preoperations period).

Bird productivity and survival were not affected by the initiation of firing site operations. The increase in diversity and the change in bird species composition over time were probably related to the change in vegetation.

Biota Monitoring at Sediment and Flood-Retention Structures

Los Alamos Canyon received wastes from early Laboratory operations at Technical Areas 01 and 21 and from the Los Alamos townsite. Pajarito Canyon received waste from Technical Area 03 and the other technical areas along the Pajarito corridor. Many chemicals and radionuclides in waste products adhere to soil and sediment particles. Storm water flows can transport these soil and sediment particles downstream in canyon bottoms.

The Laboratory has constructed flood- and sediment-retention structures, including the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure built following the Cerro Grande fire in 2000. These structures accumulate sediment and/or slow its movement.

As part of an environmental analysis of actions taken in response to the Cerro Grande fire, DOE identified various mitigation measures (DOE 2000). One of the mitigation measures is the monitoring of soil, surface water, groundwater, and biota at areas of sediment retention 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, the Laboratory collects native grasses and forbs and field mice in the retention basin of the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure. This year, we also included samples from the upstream side of the Pueblo Canyon weir.

We submitted a composite sample of five whole-body deer mice for radionuclide analyses, three individual field mice for inorganic elements analyses, and three additional field mice for PCBs (congeners, homologs, and totals) analysis from each sampled location. The following two sections report the 2015 results of this monitoring.

Los Alamos Canyon Weir

The Los Alamos Canyon weir was installed in late 2000. Accumulated sediment was excavated from the weir in 2009, 2011, 2013, and 2014 (Figure 7-16). Excavated sediment in 2009 was placed on the west side of the basin and stabilized, whereas sediment in 2011, 2013, and 2014 was removed from the immediate area.

In 2015, vegetation and small mammals were collected in June and July, respectively. Small mammals were collected at two locations—one on the upstream side of the retention basin and the second approximately 4.5 miles downstream in the active channel area.

Figure 7-16 Los Alamos Canyon weir after sediment excavation in 2014

A composite understory vegetation sample was collected within the Los Alamos Canyon weir retention basin and submitted for radionuclide and inorganic element analyses. All radionuclides in the understory vegetation sample either were not detected, were similar to regional statistical reference levels, or were far below biota screening levels (Table S7-15). These activities, particularly americium-241, plutonium isotopes, and strontium-90, vary widely from year to year but are not increasing (Figure 7-17). This high variability may be a result of sampling variability; plants are collected at different locations within the basin each year. In addition, because of high-runoff events and ponding of water, the stems and leaves of the plant may retain different amounts of sediments each year. Sediment on plant material can alter radionuclide results significantly.

All inorganic elements in understory vegetation were below or similar to the regional statistical reference levels (Table S7-16).

Radionuclides in the whole-body composite samples of field mice collected upstream and downstream of the Los Alamos Canyon weir were either not detected, similar to regional statistical reference levels (Fresquez 2015), or below biota screening levels (Table S7-17). All radionuclides are similar to past years and are not increasing over time. (Figure 7-18).

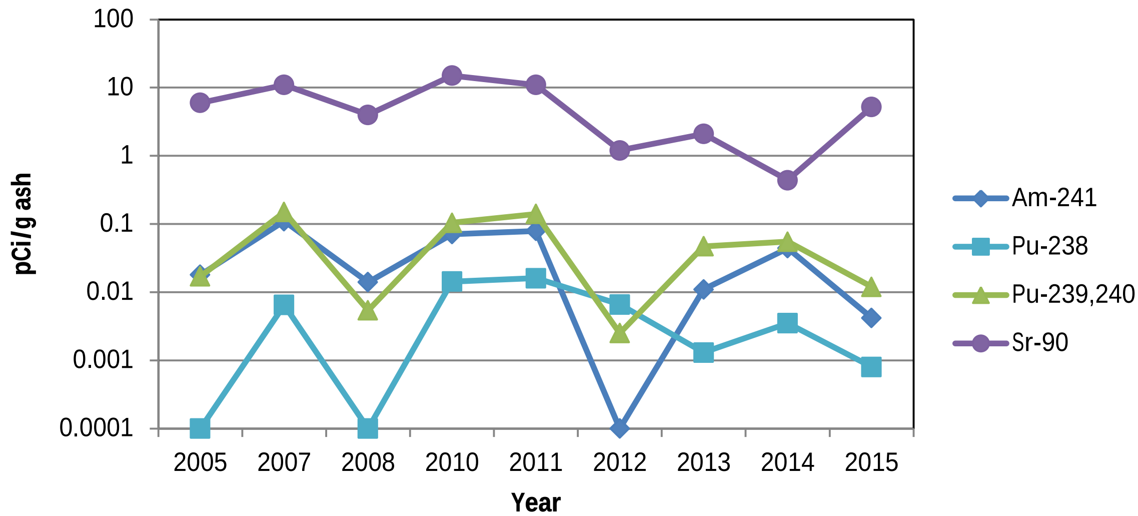


Figure 7-17 **Americium-241, plutonium-238, plutonium-239/240, and strontium-90 activities in understory vegetation collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2005 to 2015. Note the logarithmic scale on the vertical axis.**

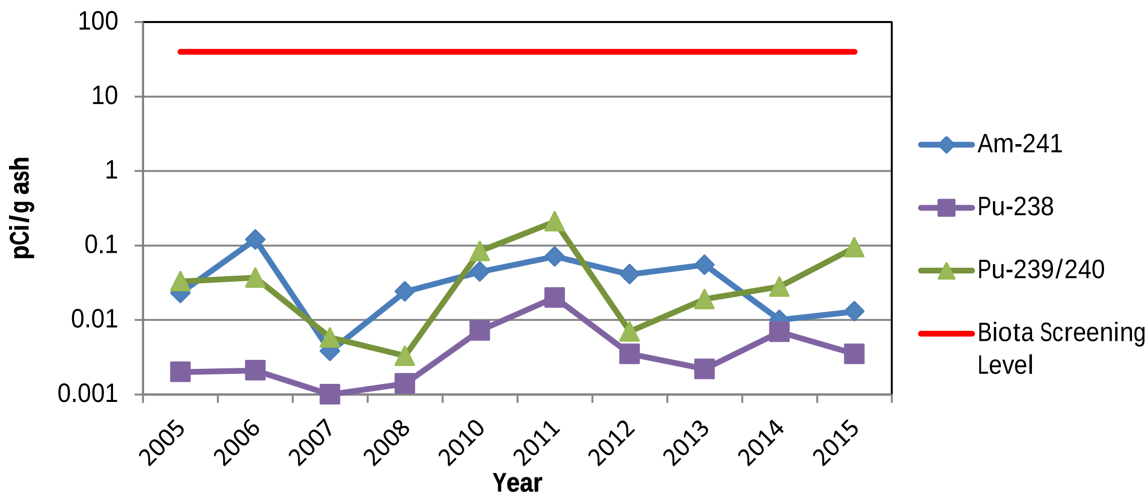


Figure 7-18 **Americium-241, plutonium-238, and plutonium-239/240 activities in composite whole-body field-mouse samples (n >5) collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2005 to 2015 compared with the biota screening level. Note the logarithmic scale on the vertical axis.**

Results of inorganic elements in whole-body field mice are in Table S7-18. All mean inorganic element concentrations in field mice collected on the upstream side of the Los Alamos Canyon weir were not statistically different from regional background concentrations (Fresquez 2015).

Concentrations of total PCBs in whole-body field-mouse samples collected upstream from the Los Alamos Canyon weir were statistically higher than regional background concentrations (Figure 7-19; Table S7-19). The highest individual total PCB concentration (38,300 pg/g wet weight) in field mice collected from the retention basin in 2015 was orders of magnitude below the average whole-body amount (2,500,000 pg/g wet weight) reported at PCB-contaminated sites where field-mouse populations were negatively affected

(Batty et al. 1990). Thus, the current PCB levels are not expected to significantly impact the field-mouse population living near the retention basin. The mean total PCB concentrations in field mice collected 4.5 miles downgradient of the retention basin were statistically equal to regional background (Fresquez 2015).

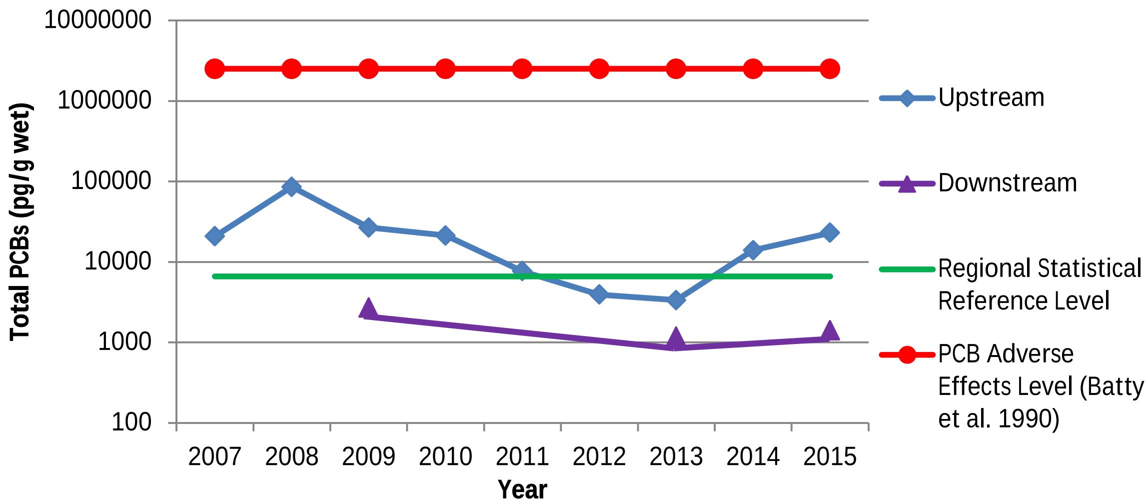


Figure 7-19 Mean total PCB concentrations in whole-body field mice collected upstream (retention basin) and 4.5 miles downstream of the Los Alamos Canyon weir from 2007 to 2015 compared with the regional statistical reference level and the mean level of an affected population from Batty et al. (1990). Note the logarithmic scale on the vertical axis.

The levels of total PCBs in whole-body field mice collected from the upstream side of the retention basin decreased from 2008 through early 2013 and then statistically increased from regional background during 2014 and 2015 (Figure 7-19). The decline from 2008 to 2013 may have resulted from many sediment-control mitigations (sediment traps, willow plantings, and sediment removal) put in place by the Laboratory in Los Alamos Canyon upstream of the weir (Fresquez 2014). There were higher-than-normal amounts of rainfall and some flash flooding in September of 2013 and July–August 2014 (Dewart et al. 2013, 2014). The detention basins below Solid Waste Management Unit 01-001(f) in Los Alamos Canyon released water during these years (Cuthbertson et al. 2013, 2014). The higher-than-normal rainfall events may have resulted in sediment with associated PCBs migrating down Los Alamos Canyon and being deposited behind the Los Alamos Canyon weir.

A plot of the distribution of the PCB compounds with differing numbers of chlorine atoms found in the field mice shows that the pattern is most similar to the commercial mixture Aroclor-1260 (Figure 7-20). Aroclor-1260 has been the most consistently detected PCB formulation in sediment collected upstream of the Los Alamos Canyon weir (Fresquez et al. 2007, Fresquez 2008, Reneau and Koch 2008).

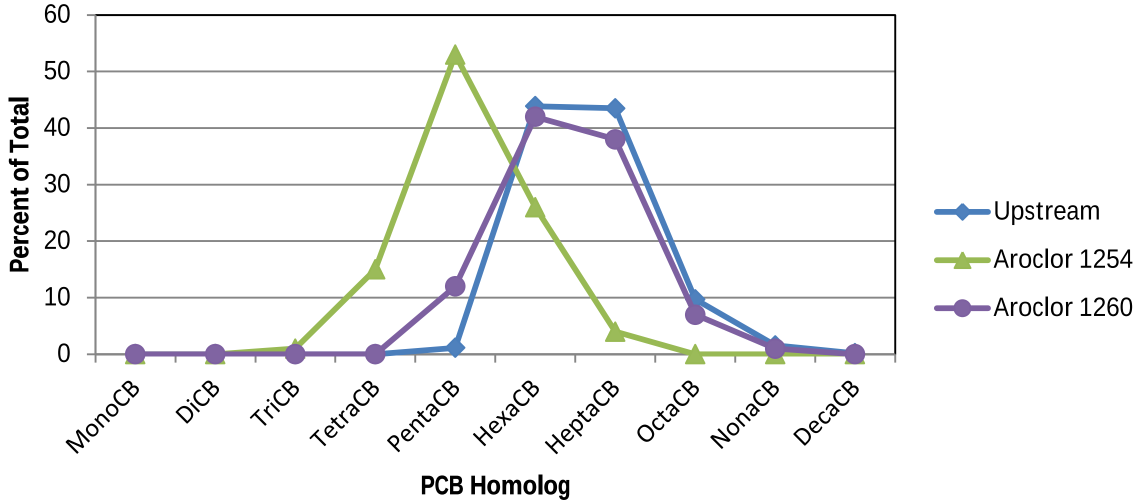


Figure 7-20 The distribution of PCB compounds with differing numbers of chlorine atoms in whole-body field-mouse samples collected upstream of the Los Alamos Canyon weir in 2015 compared with the commercial mixtures Aroclor-1240 and Aroclor-1260

Pajarito Canyon Flood Retention Structure

All of the radionuclides and inorganic elements in a composite understory vegetation sample collected from the upstream side of the Pajarito Canyon flood-retention structure were either not detected or were detected below the regional statistical reference levels (Tables S7-20 and S7-21). These data are similar to past years.

All radionuclides in whole-body field mice were either not detected, were similar to regional statistical reference levels, or were below biota screening levels (Table S7-22). The mean inorganic element concentrations in whole-body field mice (Table S7-23) were statistically similar to regional background mean concentrations (Fresquez 2015). These data are similar to past years.

The mean concentration of total PCBs in whole-body field mice collected upstream of the Pajarito Canyon flood-retention structure was statistically higher than the regional background (Fresquez 2015; Table S7-24). The highest amount (6150 pg/g wet weight) was orders of magnitude below the average whole-body amount (2,500,000 pg/g wet weight) reported at PCB-contaminated sites where field-mouse populations were negatively affected (Batty et al. 1990). PCB concentrations have been quite variable over the years, probably because of the varying amounts of sediment associated with storm events; however, the trend for at least the last 4 years is consistent and is not increasing over time (Figure 7-21).

The distribution of the PCB compounds with differing numbers of chlorine atoms in field mice collected from the Pajarito Canyon flood-retention structure mostly overlaps the distribution pattern of Aroclor-1260 (Figure 7-22). These data are similar to past years and have not changed. Aroclor-1254 and Aroclor-1260 have both been detected in sediment collected upstream and downstream of the Pajarito Canyon flood-retention structure in past years (Fresquez et al. 2007, Fresquez 2008, LANL 2008, Reneau and Koch 2008).

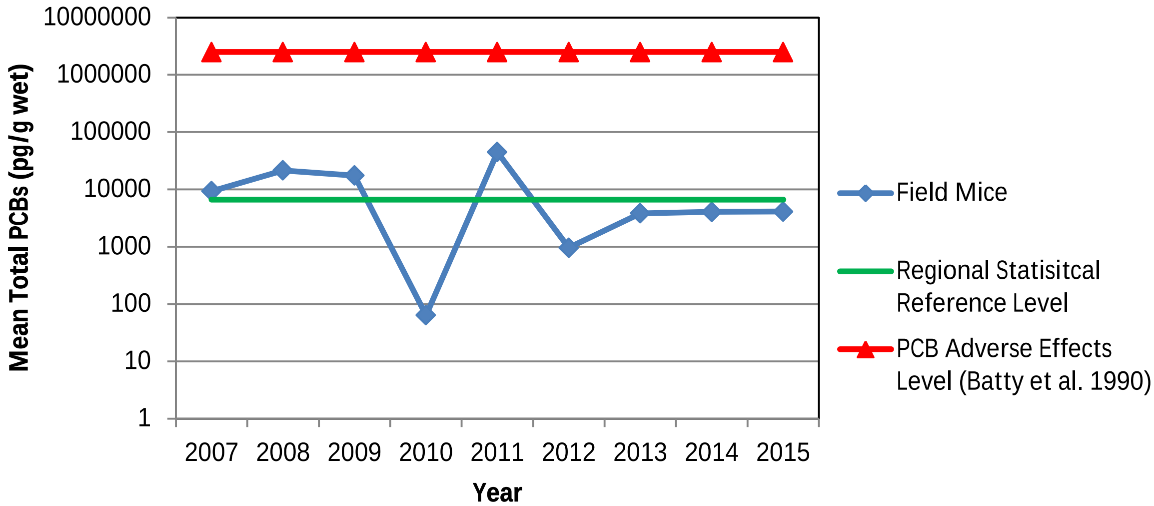


Figure 7-21 **Mean total PCB concentrations in whole-body field-mouse samples collected on the upstream side of the Pajarito Canyon flood-retention structure from 2007 to 2015 compared with the regional statistical reference level and the mean level of an affected population from Batty et al. (1990). Note the logarithmic scale on the vertical axis.**

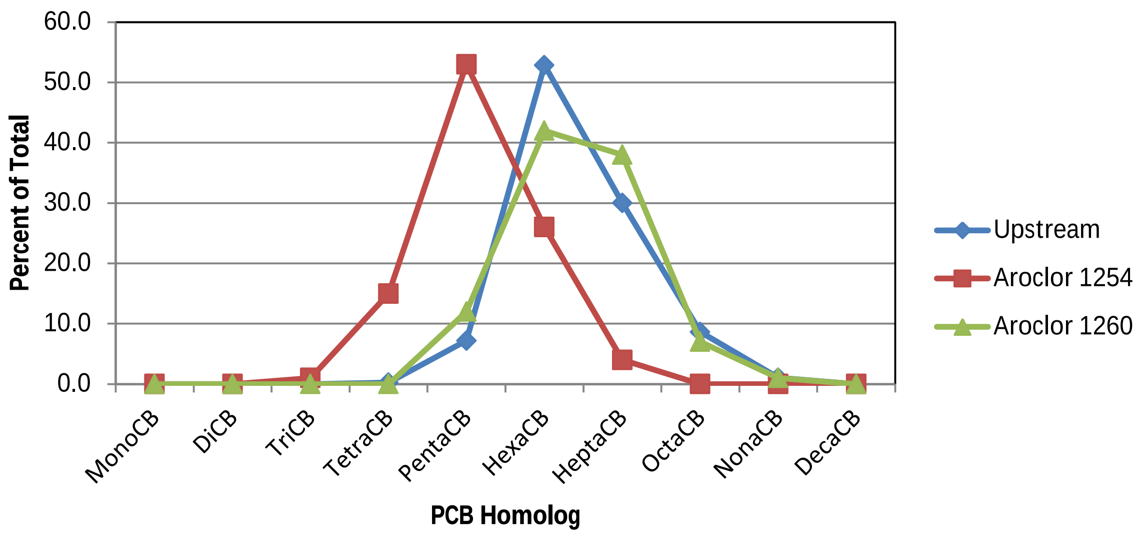


Figure 7-22 **The distribution of PCB compounds with differing numbers of chlorine atoms in whole-body field-mouse samples collected on the upstream side of the Pajarito Canyon flood-retention structure in 2015 compared with the commercial mixtures Aroclor-1254 and Aroclor-1260**

Pueblo Canyon Grade-Control Structure

This is the first year that biota were collected above the Pueblo Canyon grade-control structure. Grade-control structures prevent erosion of the streambed in a stream channel and stabilize the banks by reducing the speed of water flowing through the channel. Sediment drops out of slow water more rapidly than out of fast water. Pueblo Canyon empties into Los Alamos Canyon downstream of the Los Alamos Canyon weir.

Radionuclides in a composite understory vegetation sample from above the Pueblo Canyon grade-control structure were either not detected, similar to regional statistical reference levels, or below biota screening levels (Table S7-25). Similarly, most inorganic elements, with the exception of antimony (0.075 mg/kg dry weight) and zinc (55 mg/kg dry weight), were below regional statistical reference levels (Table S7-26). Up to 2.5 mg/kg dry weight of antimony in plants has shown no evidence of toxicity to plants. Zinc is an essential micronutrient for plants, and levels of zinc from 25 to 150 mg/kg dry weight in plant tissue are not excessive (Gough et al. 1979).

Radionuclides in whole-body field mice were either not detected, were similar to regional statistical reference levels, or were below biota screening levels (Table S7-27). The mean inorganic element concentrations in whole-body field mice (Table S7-28), with the exception of zinc, were statistically similar to regional background concentrations (Fresquez 2015). The mean level of zinc in whole-body field mice (130 mg/kg wet weight) was below the lowest observable adverse effect level of 2500 mg/kg for mice (Gough et al. 1979) and is not expected to affect the field-mouse population.

The mean concentration of total PCBs in whole-body field mice collected upstream of the Pueblo Canyon grade-control structure was statistically higher than the regional background (Fresquez 2015; Table S7-29). The highest PCB level recorded (26,400 pg/g wet weight) was orders of magnitude below the average whole-body amount (2,500,000 pg/g wet) reported at PCB-contaminated sites where field-mouse populations were negatively affected (Batty et al. 1990). The distribution of the PCB compounds with differing numbers of chlorine atoms in field mice collected from Pueblo Canyon mostly overlaps the distribution pattern of the commercial PCB mixture Aroclor-1260 (Figure 7-23).

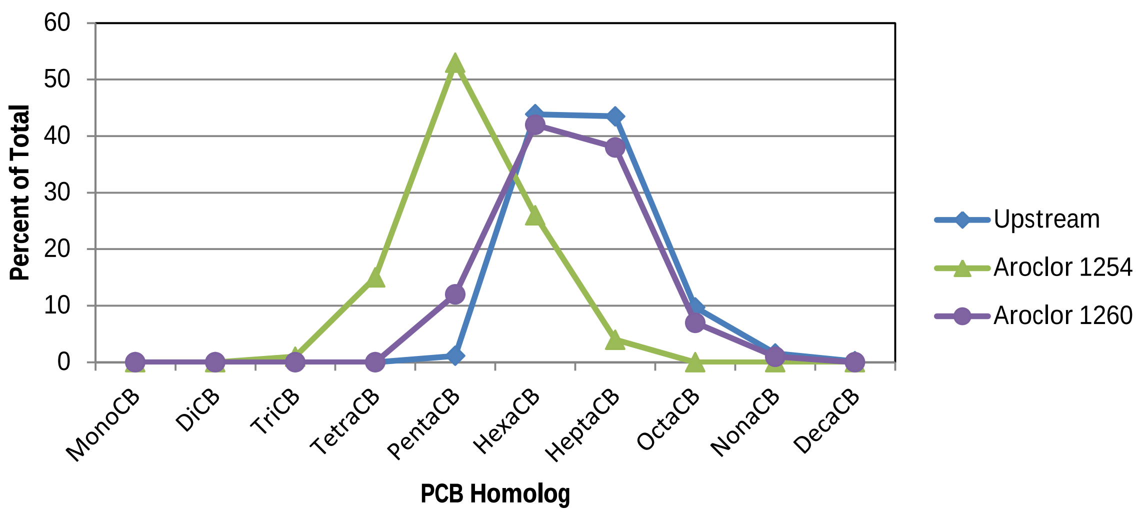


Figure 7-23 The distribution of PCB compounds with differing numbers of chlorine atoms in whole-body field-mouse samples collected on the upstream side of the Pueblo Canyon grade-control structure in 2015 compared with Aroclor-1254 and Aroclor-1260

Avian Monitoring within the Laboratory

The Laboratory monitors migratory birds to meet regulatory commitments and to watch for effects of Laboratory operations on these animals. The migratory bird program is based on four concepts: compliance with the Endangered Species Act, compliance with the Migratory Bird Treaty Act, migratory bird population monitoring, and targeted research projects and outreach. The program collects baseline data on what bird species are present at the Laboratory at different times of the year and how many birds there are and monitors for off-normal events. The Laboratory's migratory bird monitoring programs include the breeding season banding station using Monitoring Avian Productivity and Survivorship protocols (DeSante et al. 2002), the fall migration banding station, seasonal bird surveys, and an avian nest-box network.

Breeding Season and Fall Migration Capture and Banding

Breeding season banding allows the Laboratory to monitor birds that breed in any specific area of interest. A breeding season banding station is currently located in the Sandia Canyon wetland and has been operating since 2014. It is composed of 12 mist nets deployed in and around the wetland in upper Sandia Canyon, below the Los Alamos County landfill. This wetland contains primarily broadleaf cattail and some tree species, including Rio Grande cottonwood and Russian olive.

Fall migration banding allows the Laboratory to document birds that use areas of the Laboratory during their migration. A fall migration banding site is currently located in the Pajarito Canyon wetland and has been operating since 2010. It is composed of 14 mist nets deployed in the upper end of the Pajarito Canyon wetland on the north side of Pajarito Road in Technical Area 36. This wetland contains primarily narrowleaf willow with some broadleaf cattail and narrowleaf cottonwood.

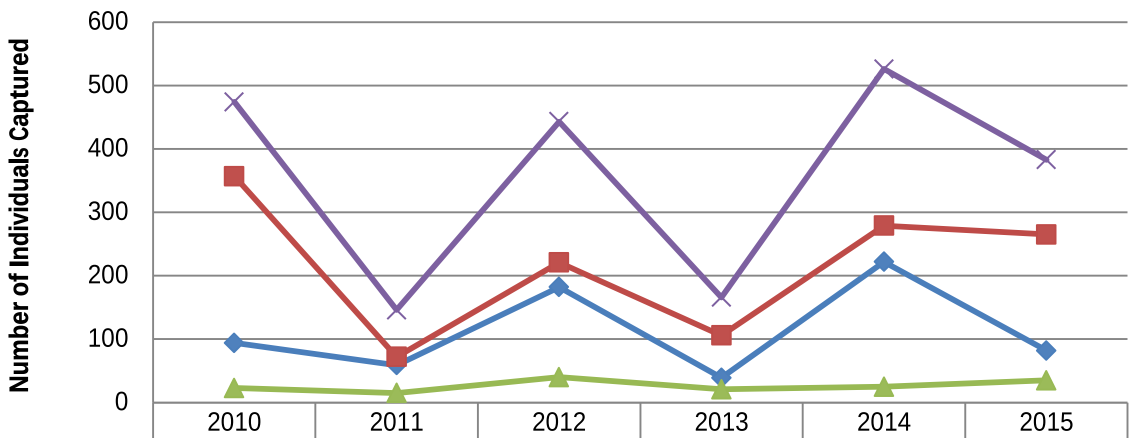
For each banding station, we calculate Shannon's diversity index (Shannon 1948) and species-specific abundance indices each year. The Shannon's diversity index is used to examine bird species diversity. It includes both the number of species and the relative abundance of each species. The Shannon's diversity index can range from 0.0 to 4.6, where larger values represent increasing diversity.

A total of 240 birds representing 39 species was banded during the breeding season of 2015 at the Sandia Canyon wetland. The birds with the most captures in 2015 were the song sparrow, pygmy nuthatch, American robin, house wren, and Virginia's warbler. The Shannon's diversity index of 3.2 at the Sandia Canyon wetland was the same in 2015 as in 2014.

A total of 383 birds representing 51 species was banded in the fall of 2015 at the Pajarito Canyon wetland (Thompson and Hathcock 2016). The birds with the most captures in 2015 were the Wilson's warbler, orange-crowned warbler, ruby-crowned kinglet, Oregon junco, and spotted towhee. Table S7-30 lists the top 10 species in total number of captures over the history of the project, along with their abundance, percentage of birds aged at less than 1 year, and their first arrival date and last departure date for 2015.

The overall percentage of birds less than 1 year old for the site was 70% in 2015. This was the second year in a row that migrating birds captured at this site contained young birds at this high percentage. Migration peaked on October 7. The Shannon's diversity index increased over the 6 years of netting at this site with values of 2.8, 3.0, 3.1, 3.3, 3.1, and 3.3 for 2010, 2011, 2012, 2013, 2014, and 2015, respectively.

Total bird captures in 2015 were in the mid-range of values seen during 2010–2014 (Thompson and Hathcock 2015). Birds were grouped into one of three diet classifications (feeding guilds) based on life history information (BNA 2012). The three groups were (1) granivores, whose diet consists primarily of seeds; (2) insectivores, whose diet consists primarily of insects; and (3) omnivores, whose diet is split evenly between seeds and insects. Granivores accounted for 21% of individuals captured, insectivores 69%, and omnivores 9% (Figure 7-24).



	2010	2011	2012	2013	2014	2015
Granivore	94	59	182	39	222	82
Insectivore	357	72	221	106	279	265
Omnivore	23	15	40	21	25	35
All Birds	474	146	443	166	526	383

Figure 7-24 Abundance trends by bird feeding guild from 2010 to 2015 at the fall migration banding station

Avian Nest-Box Network

Bird eggs have proven especially useful as a method for measuring levels of chemicals because birds occupy many trophic levels, collection of eggs is noninvasive and nondestructive to populations, and collection is relatively easy as many species live within close proximity to humans. Eggs also have a consistent composition and can be preserved for a long period of time (Becker 2003, Dauwe et al. 2005, Hashmi et al. 2015).

The avian nest-box network at the Laboratory was established during the winter of 1997 with 438 boxes and now contains more than 500 boxes. The majority of nest boxes were placed on ponderosa pine, piñon pine, or one-seed juniper trees; were hung approximately 2 meters off the ground; and placed approximately 50 to 75 meters apart. The reference sites are located in the Los Alamos townsite north of the Laboratory at the golf course and a cemetery.

The western bluebird and the ash-throated flycatcher are the primary species using the nest boxes. They occupy a limited home range during the breeding season. Both species are migratory; however, western bluebirds may reside year round in some locations and are present in New Mexico during the winter (Ornithology 2015a, 2015b). Nest box visits typically begin each May and continue throughout the breeding season. Unhatched eggs are collected from nest boxes when nestlings in the same nest are ≥10 days old or when an entire clutch has been abandoned.

In 2015, we completed analyses of radionuclides, metals, polycyclic aromatic hydrocarbons, PCBs, and organochlorine pesticides in western bluebird and ash-throated flycatcher eggs collected from 1998 through 2013. Fourteen samples were submitted for radionuclide analysis, 89 samples for inorganic element analysis, 32 samples for polycyclic aromatic hydrocarbon analysis, 15 samples for PCB analysis, and 32 samples for organochlorine pesticide analysis. Some samples consisted of a single egg, and some consisted of multiple eggs composited together.

Several constituents were not detected in most eggs. No eggs analyzed for radionuclides had detectable levels, and the majority (>80%) of egg samples did not have detectable levels of the 15 types of polycyclic aromatic hydrocarbons (acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenzo[a,h]anthracene, fluoranthene, fluorene, indeno[1,2,3-cd]perylene, phenanthrene, and pyrene); of antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, thallium, vanadium; or of the organochlorine pesticides (alpha-benzenehexachloride, alpha-chlordane, beta-benzenehexachloride, dichlorodiphenyldichloroethane [DDD], gamma-chlordane, heptachlor, lindane, and methoxychlor).

Iron, manganese, zinc, dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyltrichloroethane (DDT), dieldrin, and total PCBs concentrations did not differ between species (Table S7-31). Western bluebird eggs contained 3 times more barium ($p < 0.001$) than ash-throated flycatcher eggs. However, ash-throated flycatcher eggs contained 5% more copper ($p < 0.01$), 2 times more mercury ($p < 0.001$), and 1.7 times more selenium ($p < 0.01$) than western bluebird eggs (Table S7-32).

Differences in life histories between western bluebirds and ash-throated flycatchers may explain the observed differences in copper, mercury, selenium, and barium levels in eggs. Western bluebirds may be local residents and may be exposed to more barium throughout the year because of the geological soil composition on the Pajarito Plateau. Some metals are stored in the body and become mobilized when a female begins to lay eggs; therefore, ash-throated flycatchers could have ingested or picked up metals elsewhere, such as wintering grounds (Hashmi et al. 2015)

When western bluebird eggs collected within current and historical Laboratory boundaries were compared with eggs collected at the reference sites, no differences in levels of barium, iron, manganese, selenium, zinc, and DDT were observed (Table S7-32). Copper, however, was 3.2 times higher in western bluebird eggs collected within current and historical Laboratory boundaries compared with eggs from the reference sites ($p < 0.001$). Some parts of the area receive storm water runoff from the Los Alamos townsite, and the County of Los Alamos operated a waste water treatment plant within the historical Laboratory boundaries. Ash-throated flycatcher eggs were not collected at background sites and therefore no comparison between the study area and background can be made.

Eggs from the reference sites contained 2 times more dieldrin ($p = 0.02$), 4.5 times more oxychlordane ($p = 0.01$), and 6.6 times more trans-nonachlor ($p < 0.01$) than eggs collected from within current and historical Laboratory boundaries. PCB levels were not compared between the study area and the reference sites because of a small sample size. The reference sites include both a municipal cemetery and a municipal golf course where managers have likely applied pest control chemicals (McKenna 2016), which would explain why levels of some organochloride pesticides were higher at the reference sites.

Mercury- and selenium-induced adverse reproductive effects have been associated with egg concentrations of 0.5 parts per million (ppm) wet weight for mercury (Thompson 1996) and 3.0 ppm wet weight for selenium (Heinz 1996). While these elements were detected in the majority of eggs of both species, only one western bluebird egg slightly exceeded these limits for each element. Additionally, DDE-, dieldrin-, heptachlor-, and PCB-induced adverse biological effects have been associated with egg residues of 3.0 ppm for DDE (Blus 1996), 1 ppm for dieldrin (Peakall 1996), 1.5 ppm for heptachlor (Wiemeyer 1996), and 1.0–4.0 ppm for PCBs (Hoffman et al. 1996). While PCBs and organochlorine chemicals were detected in the majority of eggs in this study, all residues were well below and even one to two orders of magnitude less than the values associated with adverse effects. The data indicate that levels of radionuclides, metals, PCBs, and organochlorine chemicals in the eggs of western bluebirds and ash-throated flycatchers in the areas studied are not likely to cause adverse effects to the avian population.

Threatened and Endangered Species Surveys

We completed surveys in 2015 for three species protected under the Endangered Species Act (Hathcock et al. 2015). These species include the Mexican spotted owl, the Jemez Mountains salamander, and the southwestern willow flycatcher. Of these three species, only the Mexican spotted owl and the Jemez Mountains salamander were found.

Mexican Spotted Owl

The Mexican spotted owl generally inhabits mixed conifer and ponderosa pine-Gambel oak forests in mountains and canyons. Mexican spotted owls in the Jemez Mountains of northern New Mexico seem to prefer cliff faces in canyons for their nest sites (Johnson and Johnson 1985). The young leave the nest at 32 to 36 days to perch on surrounding branches and can fly short distances at 40 to 45 days. The recovery plan for the Mexican spotted owl recommends that mixed conifer and pine-oak woodland types on slopes greater than 40% be protected (USFWS 2012). Although seasonal movements vary among owls, adults commonly remain within their summer home ranges throughout the year.

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan (LANL 2015b), Mexican spotted owl habitat has been identified based on a combination of topographical features and forest characteristics. Areas defined as suitable Mexican spotted owl habitat are classified as 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 between April 1 and August 31 of each year. Surveys are conducted until four surveys have been completed or a Mexican spotted owl is found.

During 2015, all seven canyons were surveyed. Mexican spotted owls were found in two Areas of Environmental Interest, and a total of seven Mexican spotted owl chicks were fledged.

Jemez Mountains Salamander

The Jemez Mountains salamander is found only in the Jemez Mountains. They live mostly at elevations ranging from 7000 to 11,250 feet (2130 to 3430 meters) in mixed-conifer forests (Degenhardt et al. 1996). The Jemez Mountains salamander spends most of its life underground but can be found on the surface when conditions are warm and wet, typically from July through September (USFWS 2013). When on the surface, the salamanders are usually under decaying logs, rocks, or bark or moss mats or inside decaying logs or stumps. They are terrestrial salamanders and do not require free-flowing water to live.

In 2015, Jemez Mountain salamander surveys were conducted in Los Alamos Canyon, Twomile Canyon, and near the Fenton Hill facility; two salamanders were found in Los Alamos Canyon.

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, Russian olive (*Elaeagnus angustifolia*), and other riparian vegetation, often with a scattered overstory of cottonwood (USFWS 2002). The size of vegetation patches or habitat mosaics used by Southwestern willow flycatchers varies considerably and ranges from as small as 2 acres (0.8 hectare) to several hundred acres.

In 2015 the breeding season banding station in the Sandia Canyon wetland captured multiple willow flycatchers of unknown subspecies during the spring migration period. Southwestern willow flycatcher surveys were conducted during their breeding season within the Sandia Canyon wetland and the Pajarito Canyon wetland complex. No Southwestern willow flycatchers were located during those surveys.

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 Chg 3, Radiation Protection of the Public and the Environment. The 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.

Previous biota dose assessments found that the biota doses at the Laboratory are well below the DOE limits of 1 rad/day for terrestrial plants/aquatic animals and 0.1 rad/day for terrestrial animals (DOE 2002). During 2015, there were no events or releases with the potential to significantly increase biota doses, so the previous assessments apply to present conditions. Nevertheless, we repeat assessments for the on-site locations where continuing Laboratory operations have the greatest potential for significant increases.

The material potentially contributing to the biota doses at the Laboratory is legacy waste material. Ongoing remediation and radioactive decay generally result in decreasing trends, so a decreasing trend in biota doses is expected. However, movement of sediment as reported in Chapter 6 may cause an accumulation of radioactive material in areas where sediment is retained. The biota doses at the Los Alamos Canyon weir, the Pueblo Canyon grade-control structure, and the Pajarito Canyon flood-retention structure were assessed. Finally, we completed a site-wide assessment of the biota dose from radioactive materials for 2015.

Mesa-Top Facilities

Area G

The Laboratory reported new measurements of soil, vegetation, and small mammals around Area G. Activities are generally comparable with previous years.

Area G activities vary considerably, so it is difficult to select a representative set of data. As recommended by the DOE standard (DOE 2002), the first assessment is conservative and uses the highest values. These are entered into RESRAD-BIOTA, and the results are reported in Tables 7-1 and 7-2.

Table 7-1
Dose to Terrestrial Animals at Area G for 2015

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	6.53E-11	6.53E-07	2.19E-08	5.06E-06	5.74E-06
H-3	1.17E-06	2.35E-06	5.70E-05	5.70E-05	1.17E-04
Pu-238	4.27E-11	1.71E-07	8.91E-08	6.22E-06	6.48E-06
Pu-239	5.97E-11	2.39E-07	2.10E-07	1.35E-05	1.39E-05
U-234	8.51E-09	8.51E-07	6.36E-06	2.43E-05	3.15E-05
U-235	1.08E-08	1.08E-06	2.70E-07	1.00E-06	2.36E-06
U-238	6.25E-07	6.25E-05	5.97E-06	2.24E-05	9.14E-05
Medium Total	**5.81E-05**	**1.80E-04**	**1.27E-04**	**1.86E-04**	**Overall Dose 5.51E-04**

Table 7-2
Dose to Terrestrial Plants at Area G for 2015

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	6.53E-11	6.53E-07	9.67E-06	1.03E-05
H-3	1.17E-06	2.35E-06	4.79E-05	5.14E-05
Pu-238	4.27E-11	1.71E-07	1.91E-05	1.93E-05
Pu-239	5.97E-11	2.39E-07	6.60E-05	6.62E-05
U-234	8.51E-09	8.51E-07	2.41E-05	2.50E-05
U-235	1.08E-08	1.08E-06	1.02E-06	2.11E-06
U-238	6.25E-07	6.25E-05	2.26E-05	8.58E-05
Medium Total	5.81E-05	1.80E-04	2.64E-04	**Overall Dose 5.02E-04**

Comparison of soil, animal, and plant data provides different perspectives because animals and plants may be affected by underground soil that is inaccessible to humans. For most radionuclides, the doses calculated from soil data were slightly higher than from animal and plant tissue data, showing that the bioaccumulation factors in RESRAD-BIOTA are overestimates. The tritium activities in biota tissue were higher than in soil because plants and animals can be exposed to higher underground activities in burial shafts. In this case, biota tissue data were used for the assessment.

At Area G, there is no surface water or obvious source of drinking water, so small animals such as mice get most of their water from moisture in and on plants and from the water that is produced by metabolism. They may supplement this water occasionally by using small puddles after rainfall; dose from this additional source of water was calculated using distribution coefficients (K_d) listed in Table 6.5 of the DOE standard (DOE-STD-1153-2002).

As shown in Tables 7-1 and 7-2, the largest dose contribution is from the combination of naturally occurring uranium isotopes: uranium-234, uranium-235, and uranium-238. Any contribution of uranium from DOE operations is too small to be distinguished from naturally occurring background.

The results in Table 7-1 show that the biota doses at Area G are well below the DOE limits of 0.1 rad/day for animals, and Table 7-2 shows doses are also below the limit of 1 rad/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 conservative 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 7-3 and 7-4.

Table 7-3
Dose to Terrestrial Animals at Dual-Axis Radiographic Hydrodynamic Test Facility for 2015

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	3.53E-12	3.53E-08	1.18E-09	2.74E-07	3.10E-07
Cs-137	5.43E-08	5.43E-05	6.89E-09	3.49E-06	5.79E-05
H-3	1.09E-08	2.18E-08	2.15E-08	2.15E-08	7.56E-08
Pu-238	2.00E-12	8.01E-09	4.18E-09	2.92E-07	3.04E-07
Pu-239	3.55E-12	1.42E-08	1.25E-08	8.03E-07	8.29E-07
Sr-90	4.34E-07	2.60E-05	3.47E-06	1.04E-04	1.34E-04
U-234	3.30E-08	3.30E-06	2.47E-05	9.41E-05	1.22E-04
U-235	5.29E-08	5.29E-06	1.33E-06	4.93E-06	1.16E-05
U-238	2.75E-06	2.75E-04	2.63E-05	9.84E-05	4.03E-04
Medium Total	3.45E-06	3.64E-04	8.00E-05	3.07E-04	**Overall Dose 7.30-04**

Table 7-4
Dose to Terrestrial Plants at Dual-Axis Radiographic Hydrodynamic Test Facility for 2015

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	3.53E-12	3.53E-08	5.23E-07	5.58E-07
Cs-137	5.43E-08	5.43E-05	3.49E-06	5.79E-05
H-3	1.09E-08	2.18E-08	2.29E-08	5.56E-08
Pu-238	2.00E-12	8.01E-09	8.97E-07	9.05E-07
Pu-239	3.55E-12	1.42E-08	3.92E-06	3.94E-06
Sr-90	4.34E-07	2.60E-05	1.00E-04	1.27E-04
U-234	3.30E-08	3.30E-06	9.35E-05	9.69E-05
U-235	5.29E-08	5.29E-06	5.03E-06	1.04E-05
U-238	2.75E-06	2.75E-04	9.97E-05	3.78E-04
Medium Total	3.45E-06	3.64E-04	2.04E-04	**Overall Dose 6.75E-04**

The largest dose contribution is from uranium-238, some of which is a result of Dual-Axis Radiographic Hydrodynamic Test Facility operations. The activities of the other radionuclides are consistent with natural background and global fallout.

Tables 7-3 and 7-4 show that the biota doses from soil at the Dual-Axis Radiographic Hydrodynamic Test Facility are well below the DOE limits of 0.1 rad/day for animals and 1 rad/day for plants. Therefore, there are no measurable impacts to biota.

Sediment-Retention Sites in Canyons

Los Alamos Canyon Weir

The Los Alamos Canyon weir receives drainage from the hillsides south of the original technical area, Technical Area 01; from Technical Area 02, which was the site of the early Laboratory reactors; and from Technical Area 21, which was the plutonium-processing site from 1945 through the 1970s. The accumulated soil trapped by the weir includes slightly elevated activities of cesium-137, plutonium-239, and americium-241, each about 1 pCi/g, which is far below all ecological screening levels.

Animal and plant tissue data were generally consistent with the soil data. For most radionuclides, the doses calculated from the soil data were higher than the tissue doses, showing that the concentration ratios are overestimates. The plutonium-239 activity in small mammals indicated a slightly higher dose than the sediment data, so the higher value was used. Generally, maximum values were used to calculate a conservative upper limit for the dose.

The largest doses were from naturally occurring uranium. At this location, any contributions from anthropogenic uranium are indistinguishable from the background of naturally occurring uranium.

The total biota doses from soil shown in Table 7-5 (animals) and Table 7-6 (plants) are less than 1% of the DOE limits and are mostly from naturally occurring material. Therefore, there are no measurable impacts to biota.

Table 7-5
Dose to Terrestrial Animals in Los Alamos Canyon at the Weir for 2015

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	1.21E-10	1.21E-06	4.04E-08	9.35E-06	1.06E-05
Cs-137	4.83E-08	4.83E-05	6.20E-09	3.10E-06	5.14E-05
H-3	4.26E-08	8.53E-08	8.43E-08	8.43E-08	2.96E-07
Pu-238	6.59E-12	2.64E-08	1.37E-08	9.60E-07	1.00E-06
Pu-239	4.88E-11	1.95E-07	3.39E-07	2.18E-05	2.20E-05
Sr-90	2.51E-07	1.50E-05	2.01E-06	6.02E-05	7.75E-05
U-234	9.24E-09	9.24E-07	6.91E-06	2.63E-05	3.42E-05
U-235	1.93E-08	1.93E-06	4.85E-07	1.80E-06	4.24E-06
U-238	5.60E-07	5.60E-05	5.35E-06	2.00E-05	8.19E-05
Medium Total	9.11E-07	1.22E-04	2.84E-05	1.20E-04	**Overall Dose 2.83E-04**

Table 7-6
Dose to Terrestrial Plants in Los Alamos Canyon at the Weir for 2015

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Soil (rad/day)	
Am-241	1.21E-10	1.21E-06	1.79E-05	1.91E-05
Cs-137	4.83E-08	4.83E-05	3.10E-06	5.14E-05
H-3	4.26E-08	8.53E-08	8.99E-08	2.18E-07
Pu-238	6.59E-12	2.64E-08	2.95E-06	2.98E-06
Pu-239	4.88E-11	1.95E-07	5.40E-05	5.42E-05
Sr-90	2.51E-07	1.50E-05	5.78E-05	7.31E-05
U-234	9.24E-09	9.24E-07	2.62E-05	2.71E-05
U-235	1.93E-08	1.93E-06	1.84E-06	3.79E-06
U-238	5.60E-07	5.60E-05	2.03E-05	7.68E-05
Medium Total	9.11E-07	1.22E-04	1.74E-04	**Overall Dose 3.09E-04**

Pueblo Canyon Grade-Control Structure

The Pueblo Canyon grade-control structure receives drainage from Acid Canyon. The sediment includes slightly elevated activities of plutonium-239/240, less than 1 pCi/g, which is far below all ecological screening levels. The doses calculated from the small mammal data were slightly higher than the doses from the sediment data, so the higher values were used. The largest doses were from naturally occurring uranium-234 and uranium-238. Uranium activities from historical site operations are too small to measure and are indistinguishable from naturally occurring uranium.

The total biota doses from soil shown in Table 7-7 (animals) and Table 7-8 (plants) are less than 1% of the DOE limits and are mostly from naturally occurring material. There are no measurable impacts to biota.

Table 7-7
Dose to Terrestrial Animals in Pueblo Canyon for 2015

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Tissue (rad/day)	
Am-241	5.88E-12	5.88E-08	4.22E-06	4.28E-06
Cs-137	3.16E-09	3.16E-06	3.96E-07	3.56E-06
Pu-239	3.34E-11	1.34E-07	1.49E-05	1.50E-05
Sr-90	5.79E-09	3.47E-07	1.45E-06	1.80E-06
U-234	8.25E-09	8.25E-07	2.43E-05	2.52E-05
U-235	9.12E-09	9.12E-07	1.97E-06	2.90E-06
U-238	5.41E-07	5.41E-05	3.66E-05	9.12E-05
Medium Total	5.67E-07	5.95E-05	8.38E-05	**Overall Dose 1.44E-04**

Table 7-8
Dose to Terrestrial Plants in Pueblo Canyon for 2015

Nuclide	External		Internal	Nuclide Total (rad/d)
	Water (rad/d)	Soil (rad/d)	Soil (rad/d)	
Am-241	5.88E-12	5.88E-08	8.71E-07	9.30E-07
Cs-137	3.16E-09	3.16E-06	2.03E-07	3.37E-06
Pu-239	3.34E-11	1.34E-07	3.70E-05	3.71E-05
Sr-90	5.79E-09	3.47E-07	1.33E-06	1.69E-06
U-234	8.25E-09	8.25E-07	2.34E-05	2.42E-05
U-235	9.12E-09	9.12E-07	8.68E-07	1.79E-06
U-238	5.41E-07	5.41E-05	1.96E-05	7.42E-05
Medium Total	5.61E-07	5.92E-05	9.11E-05	**Overall Dose 1.43E-04**

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure does not receive significant quantities of anthropogenic radionuclides. The biota doses at this location are almost entirely from naturally occurring material or global fallout, so 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% of the DOE limits and has no measurable impact on biota populations.

Naturally Occurring Radionuclides

At many locations, the largest contributors to biota dose are the naturally occurring radionuclides of the uranium and thorium decay series. In particular, Table 6-5 of the Watershed Quality chapter lists radium-226 and radium-228 concentrations that are greater than the aquatic biota concentration guides. These concentrations do not cause doses that exceed the DOE limits for the following reasons.

- The locations (E050.1 and E060.1) do not have perennial water and are not aquatic or riparian habitats.

- The concentrations were in unfiltered storm water that exists for less than 0.10% of the time, so the time-average concentrations are less than 1% of the biota concentration guides (DOE 2002).

Furthermore, the data for radium in Rio Grande fish (Fresquez et al. 2015) show that the default bioaccumulation factors are not applicable to the Los Alamos area and should be replaced by more realistic values. This issue will be addressed in the new version of the DOE standard and in a future Los Alamos report.

Site-Wide Assessment

Site-wide measurements of soil and vegetation are reported starting on page 7-5. The activities of most radionuclides and at most locations are consistent with regional background. As expected, the resulting doses are lower than those calculated for the mesa-top facilities and sediment-retention locations described above. Above-background activities of plutonium-239/240 continue to be measured within 2 kilometers of Technical Area 01 and Technical Area 21 and especially at Technical Area 73, which is downwind of the original Technical Area 21 building 12 stacks (McNaughton et al. 2011).

The biota doses to animals and plants from soil at Technical Area 73 are shown in Tables 7-9 and 7-10. Natural uranium contributes the largest dose, and the total is less than 1% of the DOE limits.

Table 7-9
Dose to Terrestrial Animals at Technical Area 73 for 2015

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	2.18E-11	2.18E-07	7.30E-09	1.69E-06	1.91E-06
Cs-137	2.59E-08	2.59E-05	3.32E-09	1.66E-06	2.76E-05
H-3	5.59E-08	1.12E-07	1.10E-07	1.10E-07	3.88E-07
Pu-238	2.38E-12	9.53E-09	4.97E-09	3.47E-07	3.62E-07
Pu-239	4.46E-11	1.78E-07	1.56E-07	1.01E-05	1.04E-05
Sr-90	4.15E-08	2.49E-06	3.32E-07	9.95E-06	1.28E-05
U-234	8.31E-09	8.31E-07	6.22E-06	2.37E-05	3.08E-05
U-235	1.37E-08	1.37E-06	3.43E-07	1.27E-06	3.00E-06
U-238	6.39E-07	6.39E-05	6.10E-06	2.29E-05	9.35E-05
Medium Total	7.87E-07	9.50E-05	1.35E-05	7.17E-05	**Overall Dose 1.81E-04**

Conclusion

Previous biota dose assessments have shown that the doses are far below the DOE limits. The 2015 data indicate similar results and do not indicate the need for more detailed analysis. There are no measurable effects from radioactivity in soil to the Pajarito Plateau biota populations.

Table 7-10
Dose to Terrestrial Plants at Technical Area 73 for 2015

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Sum (rad/day)	
Am-241	2.18E-11	2.18E-07	5.70E-07	7.87E-07
Cs-137	2.59E-08	2.59E-05	8.67E-09	2.59E-05
H-3	5.59E-08	1.12E-07	6.10E-08	2.29E-07
Pu-238	2.38E-12	9.53E-09	5.67E-08	6.63E-08
Pu-239	4.46E-11	1.78E-07	7.49E-06	7.66E-06
Sr-90	4.15E-08	2.49E-06	1.16E-08	2.54E-06
U-234	8.31E-09	8.31E-07	6.43E-06	7.27E-06
U-235	1.37E-08	1.37E-06	4.59E-07	1.84E-06
U-238	6.39E-07	6.39E-05	5.36E-06	6.99E-05
Medium Total	7.87E-07	9.50E-05	2.05E-05	**Overall Dose 1.16E-04**

SPECIAL STUDIES AND FUTURE DIRECTIONS

LANL Forest Management Plan and Vegetation Cover Type Map

Between 1996 and 2014, the Los Alamos region experienced four major wildfires, losses of up to 90% of piñon trees because of drought and a bark beetle outbreak, and a higher-than-normal ongoing rate of tree mortality for all species of trees (Breshears et al. 2005, Goeking et al. 2014). The Laboratory's operations must take into account changing environmental influences. These types of weather-related events and their consequences, including wildfire, flash flooding, and soil erosion, present challenges for maintenance of Laboratory infrastructure, mission activities, environmental compliance, and management of wastes and legacy releases.

Current climate modeling indicates that northern New Mexico is on a trajectory of continually increasing temperatures, with no concurrent long-term increase in precipitation (Garfin et al. 2013, Llewellyn and Vaddey 2013). The Laboratory and other researchers predict that many native conifer trees in the Southwest will be dead by 2050 (Williams et al. 2010, Jiang et al. 2013, Williams et al. 2013). Projected climate changes and mortality of trees will lead to increased loss of forest cover, continued high risks of severe wildfire, and higher soil erosion rates in the Laboratory region.

In 2014, the Laboratory published a forest management plan (Hansen et al. 2014). The purpose of the forest management plan is to provide guidance to manage the landscape at the Laboratory to reduce impacts to Laboratory operations from these climate-driven events. The plan presents forest health prescriptions to meet the following objectives:

- Minimize soil erosion
- Maintain piñon-juniper, ponderosa pine, and mixed conifer woodland and forest types in a healthy condition for as long as possible
- Support wildfire fuel mitigation efforts

These forest health prescriptions support the Laboratory's overall goals of protecting Laboratory facilities and assets, minimizing off-site sediment transport and achieving water-quality compliance goals, protecting existing plant communities and soil, and minimizing negative impacts of future transitions to new plant communities.

As part of forest management plan implementation, during 2015 the Laboratory worked on updating its vegetation cover type map (last produced in 2003). This updated map is derived from August 2014 WorldView 2 satellite imagery and extensive ground-truthing data. The updated vegetation cover type map may be used for the following applications at the Laboratory:

- Accurate wildfire model simulations and risk assessment, including decision-making during a wildfire event
- Measuring and modeling climate change impacts on the Laboratory, including changes in wildfire risk
- Planning forest and fuels management actions
- Flood risk modeling
- Carbon storage estimation
- Benchmarking of dynamic vegetation models
- Benchmarking of surface and subsurface water-cycle models
- Defining changes in endangered species habitat boundaries
- Meteorological modeling of plume dispersion behavior
- Dose assessment modeling of wind dispersion of aerially transported chemicals or radionuclides
- Environmental impact evaluation of projects for planning and National Environmental Policy Act assessment

The vegetation cover map will be completed in 2016.

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:

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program (ENV-ES-TP-003)
- Sampling Soil and Vegetation at Facility Sites (ENV-ES-TP-006)
- Produce Sampling (ENV-ES-TP-004)

- Fish Sampling (ENV-ES-TP-005)
- Game Animal Sampling (ENV-ES-TP-007)
- Collection of Crawfish in the Rio Grande (ENV-ES-TP-008)
- Collection of Benthic Macroinvertebrates in the Rio Grande (ENV-ES-TP-013)

Also, procedures and protocols for biota dose 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/community-environment/environmental-stewardship/plans-procedures.php and available at 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. The project leader of the Sample Management Office tracks 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 2015 was 100%.

Analytical Laboratory Quality Assessment

There were no analytical laboratory data quality issues related to the soil and biota sampling program during 2015. Analytical data completeness for soil sampling was 100% in 2015.

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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 dose and risk to the public from Los Alamos National Laboratory’s operations?” The assessments show that during 2015, all doses to the public were far below all regulatory limits and guidance, and the public is well protected. Radiological doses to the public from Los Alamos National Laboratory operations are less than 1 millirem per year, and health risks are indistinguishable from zero.

INTRODUCTION

In this chapter, dose and risk 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 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.

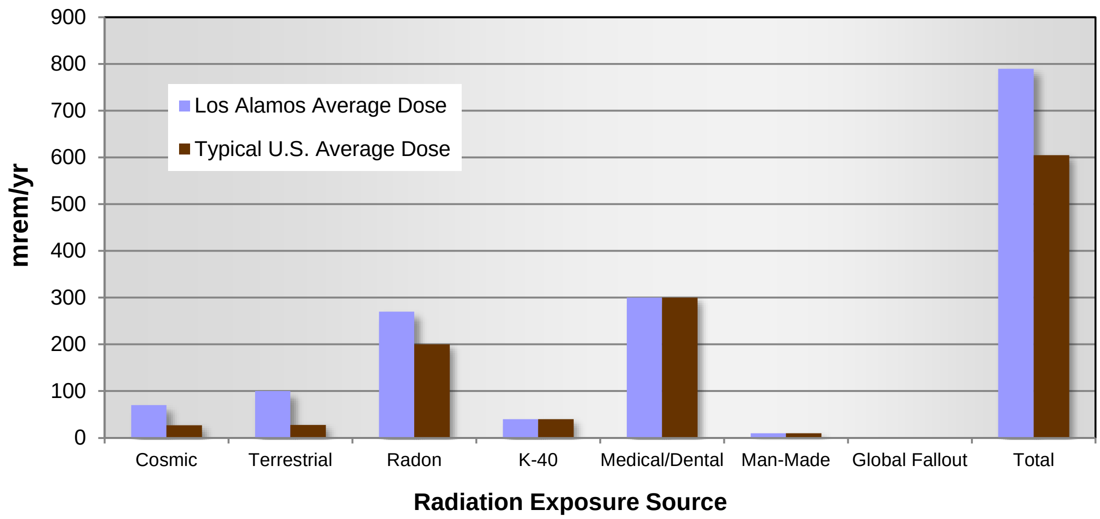
RADIOLOGICAL DOSE ASSESSMENT FOR THE PUBLIC

Overview of Radiological Dose

Radiological dose is the primary measure of harm from radiation and radioactive materials. 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 biota are assessed in Chapter 7.

DOE regulations limit the total annual dose to the public from Los Alamos National Laboratory (LANL or the Laboratory) operations to 100 millirem (mrem). Furthermore, doses must be as low as reasonably achievable and not exceed 25 mrem from any one exposure pathway (such as inhaling particles in the air or eating food) or from storage of waste (DOE 1999, LANL 2008, DOE 2011a). The annual dose received by the public from airborne emissions of radionuclides is limited to 10 mrem 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 mrem (EPA 2004).

To place these limits in context, the dose from natural background and medical/dental procedures is about 800 mrem per year (mrem/yr) (Figure 8-1). Doses from Laboratory operations are below the regulatory limits and are less than 1 mrem/yr.



K-40 = Potassium-40.

Figure 8-1 **Average Los Alamos County radiation background dose compared with average U.S. radiation background dose**

Exposure Pathways

Potential doses to the public are determined by evaluating all exposure pathways from present or past Laboratory operations. Doses are evaluated for three principal exposure pathways: (1) direct external (photon or neutron) radiation, (2) inhalation of radioactive particles in air, and (3) ingestion of water and food.

Direct Radiation

We monitor direct external radiation from gamma photons and neutrons at 80 locations in and around the Laboratory (see Chapter 4). To receive a measurable dose from direct external radiation, a member of the public must be within 1 kilometer of the source of radiation at the Laboratory. Dose decreases with increasing distance from the source. At distances more than 1 kilometer, dispersion, scattering, and absorption reduce the annual dose to much less than 0.1 mrem, which cannot be distinguished from natural background radiation. The only measurable above-background doses from direct radiation are within 400 meters of Technical Area 53 and Technical Area 54 as reported in Chapter 4.

Inhalation

At distances of more than 1 kilometer from Laboratory sources, any LANL-generated dose to the public is almost entirely from airborne radioactive emissions. Whenever possible, we use airborne radioactivity concentrations measured by the air-sampling network reported in Chapter 4 (the Ambient Air Sampling section) to measure public doses. Where local concentrations are too small to measure or cannot be measured by the environmental air-monitoring stations, 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 the 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 Stack Sampling for Radionuclides section), and the resulting doses are calculated with CAP88.

The air-pathway dose assessment is described in detail in an annual air-emissions report (Fuehne 2016) and in Chapter 4.

Ingestion

Ingestion includes drinking water and eating plants and animals. We report measurements of water in Chapters 5 and 6, and measurements from soil, plants, and animals are reported in Chapter 7.

Local drinking water contains no measurable material 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 "2015 Annual Drinking Water Quality Report" (Los Alamos County 2016).

Ingestion of water can occur through the drinking water systems or indirectly via irrigation, livestock watering, consumption of fish, or consumption of other animals or plants. Near Los Alamos, these pathways are limited because of the absence of fish, water fowl, and aquatic habitats. In Los Alamos County, potable water is sourced from the regional aquifer and is used, for example, to irrigate domestic gardens and to water domestic animals.

Locally produced foodstuffs are analyzed as available. Residual radionuclides have been detected on-site and at former Manhattan Project locations such as the original technical area, Technical Area 01. However, no measurable radionuclides from the Laboratory have been detected in produce intended for human or animal consumption.

Road-killed deer and elk are analyzed as available. In the 1990s, before the cleanup of Technical Area 21 and DP Canyon, small amounts of strontium-90 were detected in a sample of deer bone. The concentrations were unlikely to result in doses greater than 0.1 mrem, and no radionuclides from the Laboratory have been detected since the 1990s.

The soil data are similar to those in the past and show the presence of legacy radionuclides near the historical Manhattan Project locations, especially Technical Areas 01 and 21. The potential doses near these locations are assessed every year as part of the calculations to determine the maximally exposed individual, as reported later in this chapter.

The conclusion is that the ingestion dose is too small to measure and is essentially zero.

Dose from Naturally Occurring Radiation

Near Los Alamos, the annual dose from naturally occurring sources includes cosmic rays, terrestrial radiation, radon, and elements that occur naturally inside the human body such as potassium-40 (Figure 8-1). Additional man-made sources of radiation, including medical/dental equipment and building products such as stone walls, raise the total annual dose to about 800 mrem (NCRP 1975, 1987a, 1987b, 2009). Generally, any additional dose of less than 0.1 mrem/yr cannot be distinguished from natural background radiation.

Annual doses from cosmic radiation range from 50 mrem at lower elevations near the Rio Grande to about 90 mrem in the higher elevations west of Los Alamos (Bouville and Lowder 1988, Gillis et al. 2014). In addition, annual background doses from terrestrial radiation (other than radon) range from about 50 mrem to 150 mrem (DOE 2012).

The inhalation of naturally occurring radon and its decay products is generally a large proportion of the annual dose for a member of the public. Nationwide, the average annual dose from radon is about 200 mrem to 300 mrem (NCRP 1987b.) In Los Alamos County, the average residential radon concentration results in an annual dose of about 300 mrem (Whicker 2009a, 2009b).

An additional 30 mrem/yr 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 mrem from medical and dental uses of radiation (NCRP 2009). Another 10 mrem/yr comes from man-made products, such as stone or adobe walls.

In total, the average total annual dose from sources other than Laboratory operations is about 800 mrem 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.

Dose Calculations and Results

The objective of this section is to calculate doses to the public from Laboratory operations. Therefore, contributions from naturally occurring radioactive material, from global fallout, from consumer products, or from medical sources are not included.

As required by DOE Order 458.1 Chg 3, Radiation Protection of the Public and the Environment, doses from the Laboratory to the following members of the public are calculated:

- 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 on-site dose
- Other locations with measurable dose
- The off-site dose

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). The collective dose was calculated by modeling the transport of radioactive air emissions using CAP88. The doses from the other pathways are either negligible or nonexistent.

The 2015 collective population dose to persons living within 80 kilometers of the Laboratory is 0.06 person-rem (Fuehne 2016). Averaged over the 343,000 people who live within 80 kilometers (McNaughton 2012), the dose is less than 0.001 mrem per person, which is much less than the background doses shown in Figure 8-1.

Tritium contributed almost 60% of the dose from the Laboratory, and short-lived activation products, such as carbon-11 from the Los Alamos Neutron Science Center, contributed almost 33%. Collective population doses for recent years are shown in Figure 8-2. The downward trend is the result of improved engineering controls at Los Alamos Neutron Science Center and the tritium facilities.

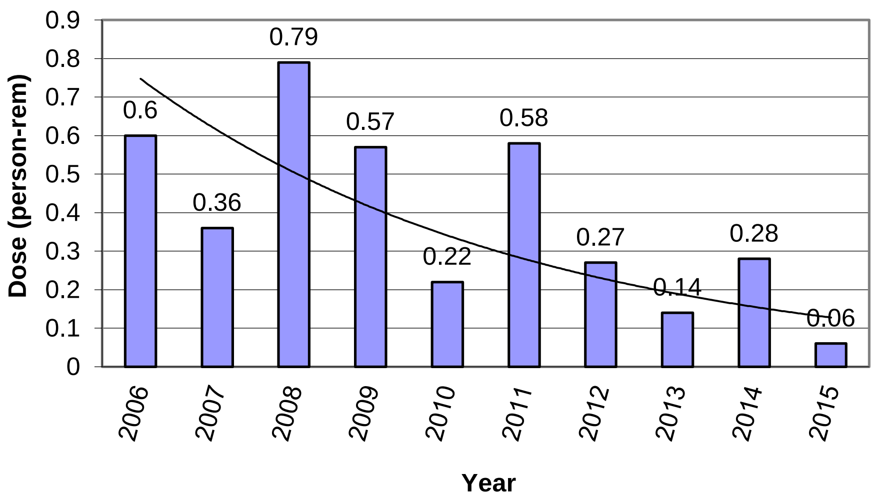


Figure 8-2 **Annual collective dose (person-rem) to the population within 80 kilometers of the Laboratory**

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, all exposure pathways that could cause a dose and all publicly accessible locations are considered, both within the Laboratory boundary (on-site) and outside the boundary (off-site.)

Maximally Exposed Individual Off-Site Dose for 2015

The air-pathway dose calculations are described in an annual air-emissions report (Fuehne 2016). For 2015, the off-site location of the hypothetical maximally exposed individual was at 2470 East Road in the general area known as East Gate, close to environmental air-monitoring stations #157 and #206 (Chapter 4, Figure 4-1). The total off-site dose for a maximally exposed individual during 2015 was 0.13 mrem (Fuehne 2016).

Contributions to this annual dose were from short-lived activation products from the Los Alamos Neutron Science Center stacks (0.03 mrem), diffuse emissions of short-lived activation products from the Los Alamos Neutron Science Center (0.04 mrem), other stack emissions (0.01 mrem), environmental measurements at air-monitoring stations (0.02 mrem), and the potential dose contribution from unmonitored stacks (0.03 mrem). Doses from ingestion and direct radiation were much less than 0.01 mrem.

The calculated off-site 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-mrem dose in 2005 resulted from a leak at Technical Area 53, and the 3.53-mrem dose in 2011 was from the remediation of Material Disposal Area B. The general downward trend is the result of improved engineering controls at the Los Alamos Neutron Science Center accelerator.

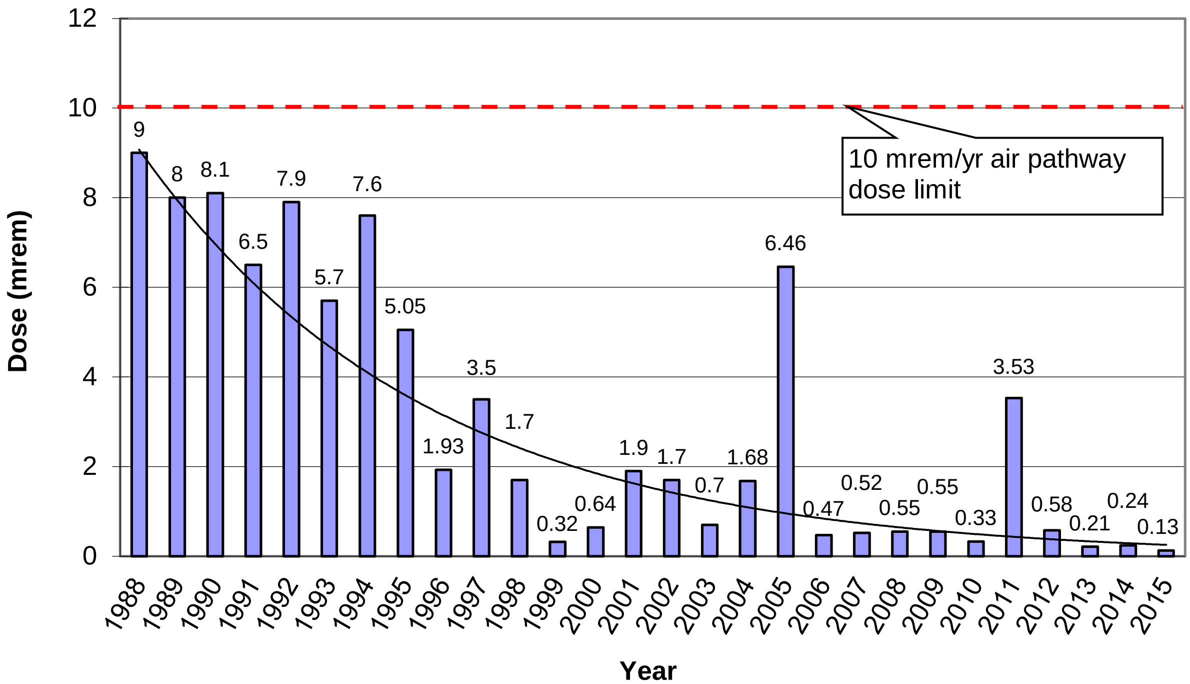


Figure 8-3 Annual maximally exposed individual off-site dose

Maximally Exposed Individual On-Site Dose for 2015

The on-site locations where a member of the public could receive a measurable dose are on or near the publicly accessible roads and hiking trails, which 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 Gamma and Neutron Radiation Monitoring section), at this location during 2015 the neutron dose was 0.4 mrem, and the gamma dose was 0.1 mrem, for a total of 0.5 mrem. The contribution from stack emissions was much less than 0.1 mrem. 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% of their time at this location, so the on-site dose for a maximally exposed individual is less than 1% of 0.5 mrem, which is much less than the off-site dose for a maximally exposed individual described in the previous section.

Other Locations with Measurable Dose

As reported in Chapter 4, the 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 2015 was 1.6 mrem. After applying the standard factor of 1/16 for occasional occupancy (NCRP 1976), the individual neutron dose during 2015 was 1.6/16 = 0.1 mrem.

The contribution from Laboratory stack emissions was less than 0.001 mrem. Within the boundaries of Area G, the average concentration of transuranic material was 2 attocuries per cubic meter (Chapter 4, Table 4-4), so using the dose conversion factors from DOE Standard 1196 (DOE 2011b), and assuming 1/16 occupancy, the annual dose both within and near Area G was much less than 0.001 mrem. Thus, during 2015, the total dose in Cañada del Buey was 0.1 mrem.

Maximally Exposed Individual Summary

At the off-site location for the maximally exposed individual (i.e., East Gate), the direct-radiation and ingestion doses are essentially zero, so the largest all-pathway dose for 2015 was the same as the air-pathway dose of 0.13 mrem.

The dose of 0.13 mrem in 2015 is far below the 10-mrem annual limit (EPA 1989) and the 100-mrem DOE limit (DOE 2011a). The dose for the maximally exposed individual is less than 0.1% 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 2015

Pathway	Dose to Maximally Exposed Individual (mrem/yr)	Percentage of DOE 100-mrem/yr Limit	Estimated Population Dose (person-rem)	Population within 80 kilometers	Estimated Background Radiation Population Dose (person-rem)
Air	0.13	0.13%	0.06	n/a[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	0.13	0.13%	0.06	~343,000	~268,000[b]

[a] n/a = Not applicable.

[b] Based on 780 mrem 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 2015. Air emissions are reported in Chapters 2 and 4. Groundwater and surface water are reported in Chapters 5 and 6, respectively. Soil is reported in Chapter 7. The results are summarized below.

Results Summary

Air

The data reported in Chapters 2 and 4 show that the 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 2015. No materials from the Laboratory were detected, and the drinking water meets New Mexico Environment Department and U.S. Environmental Protection Agency drinking water standards (Los Alamos County 2016).

Additional water sampling was conducted in the City of Santa Fe's Buckman well field. No Laboratory materials were found in this drinking water supply.

Within Laboratory boundaries, hexavalent chromium has been detected above the New Mexico groundwater standard (50 micrograms per liter) in Mortandad Canyon monitoring wells. As described in Chapter 5, we have received approval for interim measures to control migration of this water.

Surface Water and Sediment

The concentrations of chemicals in surface water and sediment for 2015 are reported in Chapter 6. The sediment data verify the conceptual model that sediment transport results in lower concentrations in newer deposits compared with previous deposits, and further data show that the 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 previous conclusions that there were no human health risks remain accurate because the concentrations decrease with time.

In Chapter 6, unfiltered storm water concentrations are compared with drinking water standards as screening levels, though storm water is not a drinking water source and there is no significant pathway to human exposure. The biota measurements reported in Chapter 7 confirm that suspended sediment does not result in significant uptake into the food chain.

Polychlorinated biphenyls (PCBs) are discussed in Chapter 6. Concentrations are compared with standards in Table 6-6 and in Figures 6-8a through j. Because of the limited number of aquatic organisms on the Pajarito Plateau, the number entering the food chain is small. The biota data reported in Chapter 7 confirm that the PCB concentrations in off-site animals and vegetation are similar to background.

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 and Biota

Soil and biota sampling results are reported in Chapter 7. The results are similar to previous years. During 2015 and at off-site locations, chemical concentrations above human-health-based screening criteria were not detected.

Conclusion

The environmental data collected in 2015 show that at present there is no measurable risk to the public from materials released from the Laboratory. In all cases, the public doses and risks from Los Alamos National Laboratory operations are much smaller than the regulatory limits and the naturally occurring background levels.

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GENERAL FORMATION OF A STANDARD OR SCREENING LEVEL

An environmental standard is a value, generally defined by a regulator such as the U.S. Environmental Protection Agency, which 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 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 people at the site, which influences 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

DOE limits the radiation dose that can be received by members of the public as a result of normal Laboratory operations.

In 2011, DOE issued Order 458.1, which describes the current radiation protection standards for the public, now referred to as public dose limits. They 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[b]	10 mrem/yr
Drinking water	4 mrem/yr

[a] Guidance (DOE 1999).

[b] 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)
^{3}H	2,000,000	80,000
^{7}Be	1,000,000	40,000
^{89}Sr	20,000	800
^{90}Sr	1000	40
^{137}Cs	3000	120
^{234}U	500	20
^{235}U	600	24
^{238}U	600	24
^{238}Pu	40	1.6
^{239}Pu	30	1.2
^{240}Pu	30	1.2
^{241}Am	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 http://164.64.110.239/nmac/parts/title20/20.007.0010.pdf.

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 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 concentrations 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 http://164.64.110.239/nmac/parts/title20/20.006.0004.htm. The New Mexico Water Quality Control Commission groundwater standards can also be applied in cases where discharges may affect groundwater.

SOILS

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 soils 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 non-cancer-causing but hazardous chemicals. 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 2009).

FOODSTUFFS

Federal standards exist for radionuclides and selected nonradionuclides (e.g., mercury and polychlorinated biphenyls [PCBs]) in foodstuffs. Federal screening levels exist for selected nonradionuclides; 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 concentrations 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 concentrations 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 levels 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).

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Throughout this 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 - 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 (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 environmental remediation project 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 for the purpose of ensuring 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. In the western part of Technical Area 21 was the former radioactive materials (including plutonium) processing facility. 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 at 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 and is the chosen location for the Chemistry and Metallurgy Research Building Replacement. 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. Construction of the Chemistry and Metallurgy Research Building Nuclear Facility (formerly the Chemistry and Metallurgy Research Building Replacement) was cancelled 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 primary purpose of the technical area is observation of astronomical events. Technical Area 57 houses the Milagro Gamma Ray Observatory and a suite of optical telescopes. Drilling technology research is also performed at this technical area.
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 that 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 area. 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 website	*http://nnsa.energy.gov/fieldoffices/losalamos*
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	*http://www.intellusnmdata.com/*

Cavates in Mortandad Canyon

Back cover: Photo by Phil Noll, ENV-ES.

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 Services Group (Leslie Hansen and Sonja Salzman, Coordinators)
  - Environmental Compliance Programs Group (Robert Beers, Coordinator)
- Waste Management Division (Luciana Vigil-Holterman, Coordinator)

Associate Directorate for Environmental Management
- Environmental Remediation Program

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Technical coordination by Leslie Hansen, Environmental Protection and Compliance, Environmental Stewardship Services

Edited by Pamela Maestas, Communications and Public Affairs, Communication Arts and Services

Composition by Teresa Hiteman, Environmental Protection and Compliance, Environmental Stewardship Services


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