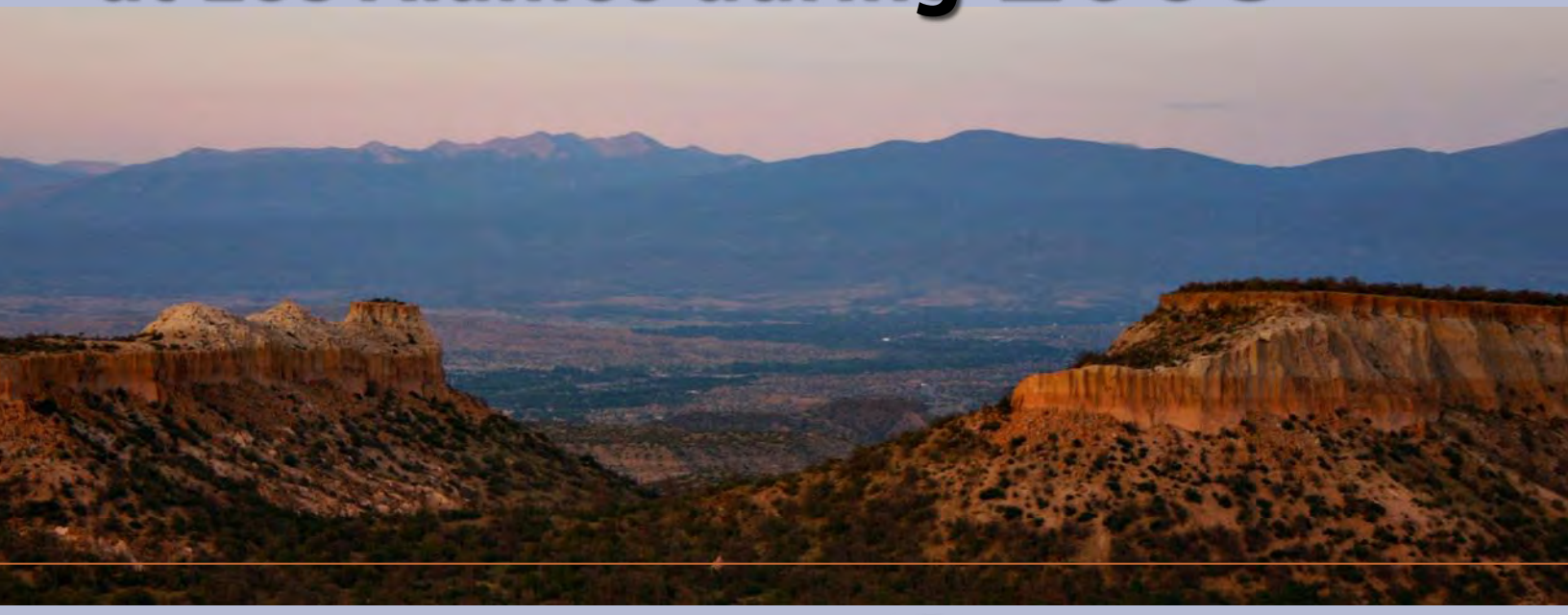
Environmental Surveillance at Los Alamos during 2008



Los Alamos
NATIONAL LABORATORY
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It is the policy of Los Alamos National Laboratory that we will be responsible stewards of our environment. It is our policy to:

- Manage and operate our site in compliance with environmental laws and standards and in harmony with the natural and human environment
- Meet our environmental permit requirements
- Use continuous improvement processes to recognize, monitor and minimize the consequences to the environment stemming from our past, present, and future operations
- Prevent pollution
- Foster sustainable use of natural resources
- Work to increase the body of knowledge regarding our environment

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Issued September 2009

Environmental Surveillance at Los Alamos during 2008

Waste and Environmental Services Division
505-667-0808

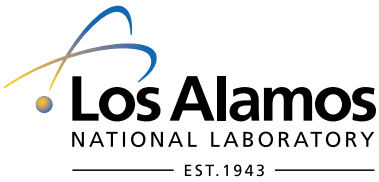
Water Stewardship Program
505-667-0132

Corrective Actions Program
505-667-2623

Environmental Protection Division
505-667-2211

Ecology and Air Quality Group
505-665-8855

Water Quality and RCRA Group
505-665-0453



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Abstract

Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) Environmental Programs Directorate, as required by US Department of Energy Order 450.1, *General Environmental Protection Program*, and US Department of Energy Order 231.1A, *Environment, Safety, and Health Reporting*.

These annual reports summarize environmental data that are used to determine compliance with applicable federal, state, and local environmental laws and regulations, executive orders, and departmental policies. Additional data, beyond the minimum required, are also gathered and reported as part of the Laboratory's efforts to ensure public safety and to monitor environmental quality at and near the Laboratory.

Chapter 1 provides an overview of the Laboratory's major environmental programs and explains the risks and the actions taken to reduce risks at the Laboratory from environmental legacies and waste management operations. Chapter 2 reports the Laboratory's compliance status for 2007. Chapter 3 provides a summary of the maximum radiological dose the public and biota populations could have potentially received from Laboratory operations and discusses chemical exposures. The environmental surveillance and monitoring data are organized by environmental media (Chapter 4, air; Chapters 5 and 6, water and sediments; Chapter 7, soils; and Chapter 8, foodstuffs and biota) in a format to meet the needs of a general and scientific audience. Chapter 9 provides a summary of the status of environmental restoration work around LANL. A glossary and a list of acronyms and abbreviations are in the back of the report. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurements used in this report, Appendix C describes the Laboratory's technical areas and their associated programs, and Appendix D provides web links to more information.

In printed copies of this report or Executive Summary, we have also enclosed a compact disc with a copy of the full report in Adobe Acrobat (PDF) form and detailed supplemental tables of data from 2008 in Microsoft Excel format. These files are also available for download from the web.

An online survey for providing comments, suggestions, and other input on the report is available at the web address given below. Inquiries or comments regarding these annual reports may be directed to

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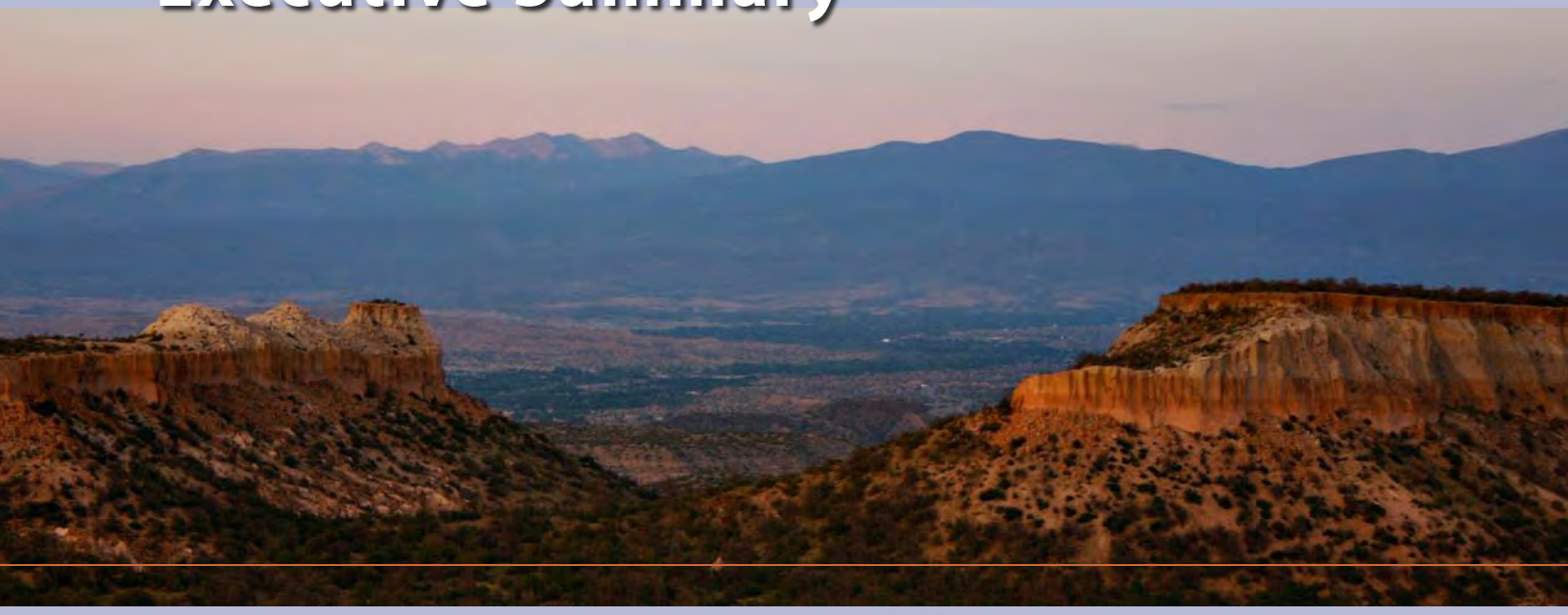
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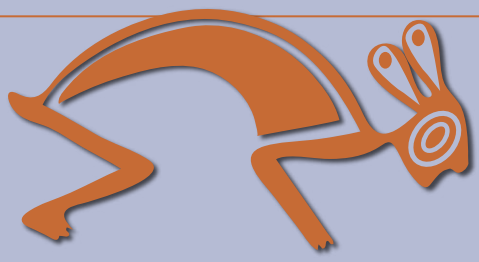
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This report is also available on the World Wide Web at
http://www.lanl.gov/environment/all/esr.shtml

Environmental Surveillance at Los Alamos during 2008

Executive Summary





Los Alamos
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Executive Summary

Los Alamos National Laboratory (LANL or the Laboratory) is located in Los Alamos County in north-central New Mexico (NM), approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure ES-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, a series of mesas separated by deep east-to-west-oriented canyons cut by stream channels. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft above the Rio Grande at White Rock Canyon. Most Laboratory and Los Alamos County community developments are confined to the mesa tops. With the exception of the towns of Los Alamos and White Rock, 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 US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and Los Alamos County. In addition, Pueblo de San Ildefonso borders the Laboratory to the east.

The mission of LANL is to develop and apply science and technology to (1) ensure the safety and reliability of the US nuclear deterrent, (2) reduce global threats, and (3) solve other emerging national security challenges. Meeting this diverse mission requires excellence in science and technology to solve multiple national and international challenges. Inseparable from the Laboratory's focus on excellence in science and technology is its commitment to environmental stewardship and full compliance with environmental protection laws. Part of LANL's commitment is to report on its environmental performance. This report

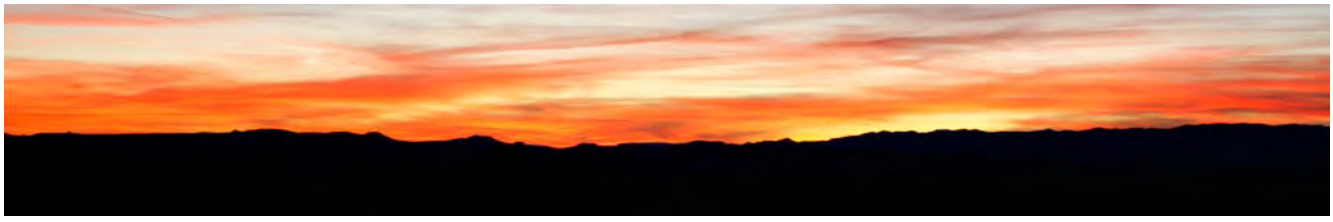
- characterizes LANL's environmental management, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment,
- summarizes environmental occurrences and responses,
- confirms compliance with environmental standards and requirements, and
- highlights significant programs and efforts.

Environmental Management System

As part of its commitment to protect the environment and improve its environmental performance, LANL implemented an Environmental Management System (EMS) pursuant to US Department of Energy (DOE) Order 450.1A and the international standard (ISO) 14000:2004. DOE defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." The EMS provides a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing and implementing improvements, and measuring results. In April 2006, LANL became the first National Nuclear Security Administration (NNSA) national laboratory and the first University of California-operated facility to receive full third-party certification of its EMS.

- ***Two additional surveillance audits in 2008 by an independent registrar concluded that the Laboratory's environmental management system continues to meet all requirements for full certification to the international standard.***
- ***NNSA again recognized the success of the EMS management by giving the Laboratory the 2009 NNSA "Best in Class Award" and the "DOE E-Star" Award for institutional improvements made in 2008.***

During 2008, the EMS was audited two additional times by an independent third-party ISO 14001 auditor who conducted three audits in 2006 and two audits in 2007. The auditors concluded that the LANL EMS continues to meet all the requirements of the ISO 14001:2004 standard with no major non-conformities and recommended that LANL maintain full certification.



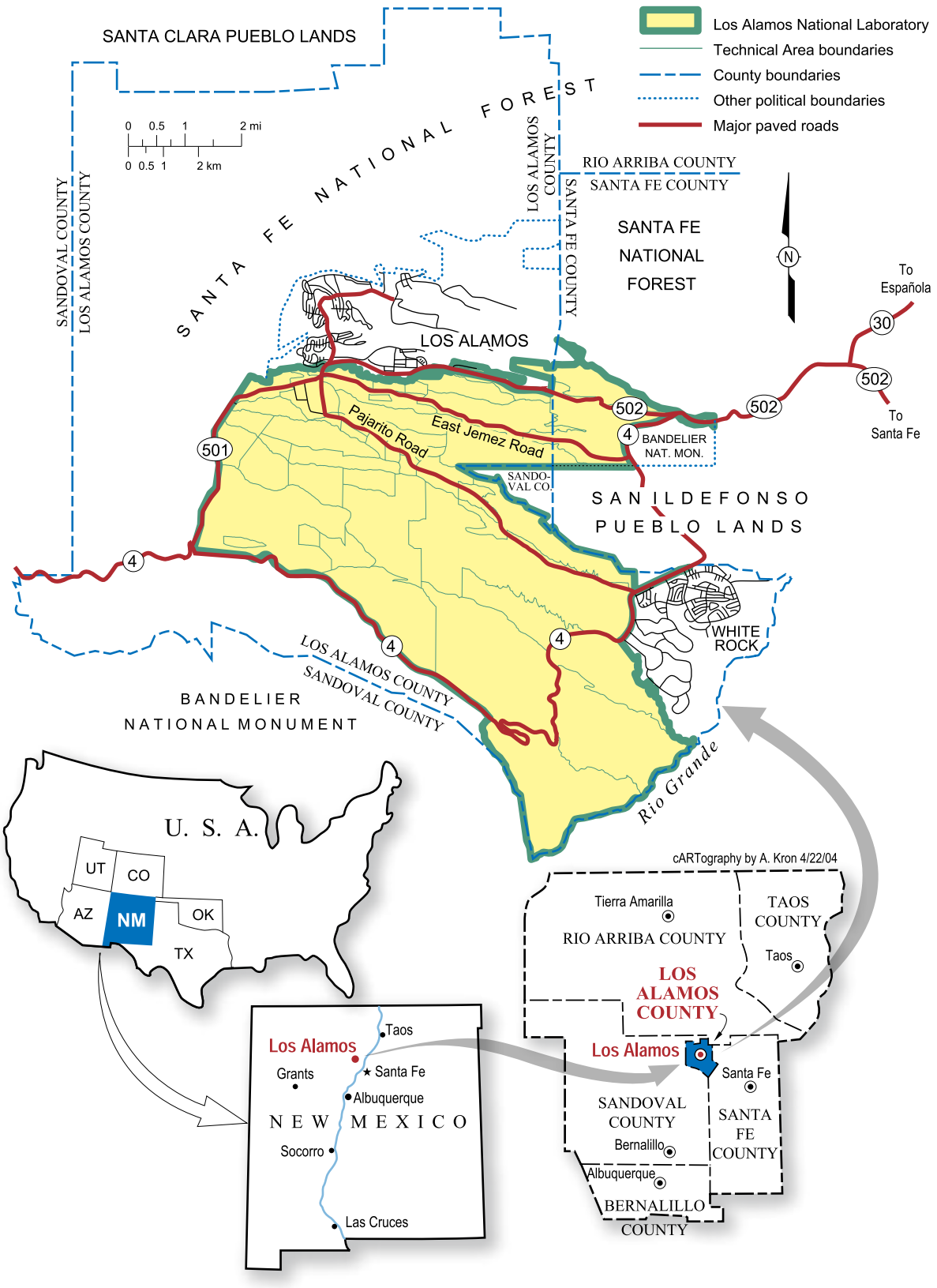


Figure ES-1. Regional location of Los Alamos National Laboratory.

NNSA and DOE recognized the success of the EMS and the unique approach by giving the Laboratory the 2009 NNSA "Best in Class" Award and the "DOE E-Star" for the institutional improvements identified and implemented through the EMS from 2006 through 2008.

The Pollution Prevention (P2) Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risk to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions. LANL was awarded eight NNSA awards in 2008:

NNSA Best in Class Awards:

- Wastewater Recycling at the Radioactive Liquid Waste Treatment Facility (RLWTF)
- Ultrapure Carbon and Carbon Nitride Nanomaterials

NNSA Environmental Stewardship Awards:

- Steam Generator Optimization
- Perchloric Acid Exhaust System
- Recycling of Asphalt, Soil and Mulch
- Mixed Office Paper Recycling
- Integrating Safety and Security in the Environmental Management System
- Uninterruptible Power Supply Project

- ***The Consent Order is the principal regulatory driver for the Laboratory's environmental restoration activities and the Water Stewardship Program. It specifies actions that the Laboratory must complete to characterize contaminated sites and monitor the movement of contaminants.***
- ***The Laboratory met all major deliverables of the Consent Order.***
- ***The NMED issued a Notice of Violation to LANL and DOE related to a late (by 5 days) delivery of a scheduled status report and an NOV related to a waste storage inspection in 2007.***

Federal Facility Compliance Agreement

During 2008, the DOE and the Laboratory continued to monitor and sample storm water under the requirements of a Federal Facility Compliance Agreement (FFCA) with the US Environmental Protection Agency (EPA) and the NM Environment Department (NMED). The agreement establishes a compliance plan for the regulation of storm water point source discharges from solid waste management units (SWMUs) and areas of concern (AOCs) at the Laboratory. Under the FFCA, LANL added 20 new rain gages to the existing five meteorology stations, installed 202 new site-specific surface water samplers, maintained 60 runoff gage stations, collected 310 storm water samples, conducted over 2300 inspections at 290 sites, and continued negotiations with EPA and NMED on the development of an individual storm water permit for storm water discharges (the FFCA was replaced by an individual storm water permit issued by EPA in April 2009.)

Compliance Order on Consent

The March 2005 Compliance Order on Consent (the Consent Order) between LANL, DOE, and the NMED is the principal regulatory driver for LANL's environmental restoration programs including the Water Stewardship Program. The Consent Order contains requirements for investigation and cleanup of SWMUs and AOCs at the Laboratory. The major activities conducted by the Laboratory included investigations and cleanup actions. All major deliverables of the Consent Order were met by the Laboratory during 2008. The projects wrote and/or revised 24 work plans and 22 reports and submitted them to the NMED. Thirteen SWMUs and AOCs were granted Certificates of Completion under the Consent Order by the NMED in 2008. In January 2008, the NMED Hazardous Waste Bureau issued a Notice of Violation (NOV) to DOE and LANL for a late delivery (by five days) of a scheduled status report in 2007. An NOV was also issued for eight alleged violations of hazardous waste storage requirements during an inspection in 2007. In 2008, NMED found no violations during a hazardous wastes storage inspection.

Improvement Targets

Improvement goals for the Laboratory include continuing to improve Resource Conservation and Recovery Act (RCRA) compliance. The Laboratory completed 2,552 self-assessments with a nonconformance rate of 2.82% in 2008 (compared with 3.71% in 2007). The Laboratory continues to improve its processes, systems, and training to reduce the number of violations in the future. Under its EMS, the Laboratory must identify and minimize environmental impacts and waste sources. Chromium discharged from a cooling tower in the 1960s through 1972 was discovered in the regional aquifer in early 2006, and LANL installed five additional monitoring wells to evaluate the extent of this contamination. A total of 10 alluvial, three intermediate perched, and six regional aquifer wells were installed in 2008. Though perchlorate and high explosives residues from former processing and manufacturing facilities are no longer discharged, the Laboratory is monitoring their movement from past effluent discharges to determine if they could pose a threat to drinking water sources.

Design of Surveillance System and Sample Locations

The Laboratory uses data from monitoring (surveillance) of known release points and multiple receptors (people, air, water, soil, sediment, foodstuffs, plants, and animals) over a long time period as a basis for policy and to determine actions to protect the environment. We collect data from the surrounding region to establish baseline environmental conditions in areas not influenced by LANL operations. We conduct regional monitoring to determine whether LANL operations are impacting areas beyond LANL's boundaries. Examples of regional monitoring include the radiological ambient air sampling network (AIRNET); soil, foodstuffs, and biota (plants and animals) sampling as far away as Dixon, NM (40 direct miles away); and sediment monitoring along the Rio Grande as far upriver as Abiquiu Reservoir and downriver at Cochiti Reservoir. We also collect data on-site and at the Laboratory perimeter to determine if operations are impacting LANL or neighboring properties (e.g., Pueblo and County lands). Perimeter monitoring also measures the highest potential impact to the public. To better quantify releases, we monitor at specific discharge or release points or other locations on LANL property that are known to or have the potential to release contaminants. Examples of locations with this type of monitoring include facility stacks, the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility, the Los Alamos Neutron Science Center (LANSCE), remediation sites where legacy waste is being managed, decontamination and decommissioning projects, Area G at Technical Area (TA) -54 (where waste is being handled, stored, and disposed), and water discharge locations (outfalls). We use these data to demonstrate compliance with applicable environmental laws and regulations. During 2008, the Laboratory collected more than 7,780 environmental monitoring samples from more than 770 locations and received almost 297,000 analyses or measurements on these samples.



Risk Reduction

Risk is evaluated either as current (present-day) or prospective (future) risk. The Laboratory assesses hazards and the corresponding risks by evaluating environmental data, measurements, inventories of buried or stored materials, and potential exposure pathways and scenarios. We use models, data, and computer programs to assist with these estimates.

Over the years, the Laboratory has decreased its release of materials into the environment and has reduced the amount of legacy contamination. Examples include the reduction in both the number of outfalls (plant and process discharges) and the volume of water released, the reduction in air emissions, changes to effluent treatment processes at the TA-50 RLWTF, and the removal of contaminated material and waste at sites such as Material Disposal Area (MDA) P. These efforts have significantly reduced or eliminated potential exposure and risk to workers, the public, and the environment.

Examples of ongoing risk reduction activities include the transport of stored legacy transuranic waste from Area G to the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM; the planned cleanup and remediation of the former plutonium processing facility at TA-21; ongoing studies of groundwater contamination to evaluate future hazards and risks; and numerous investigations and corrective actions at potentially contaminated sites.

- *Past risk reduction successes include the reduction in the number of outfalls (plant and process discharges) and the volume of water released from them, the reduction in air emissions over the past several years, changes to effluent treatment processes at the TA-50 Radioactive Liquid Waste Treatment Facility, and the removal of contaminated material and waste at former waste disposal sites.*
- *Ongoing risk reduction efforts include the transport of waste from Area G to permanent disposal at WIPP, studies of the movement of contaminants in groundwater, and planned or active cleanup operations at former waste and radionuclide processing sites.*
- *The environmental surveillance programs can detect very low levels of potential contaminants and thus help determine whether a new hazard is present and evaluate the associated level of risk.*

The sensitivity of measurements obtained by LANL's environmental surveillance program allows detection of hazardous and radioactive materials and other contaminants released during cleanup or normal operations. We monitor all major pathways to people and the environment. The data from monitoring can be used to assist with possible mitigation of impacts. Air monitoring by the AIRNET system has regularly detected airborne contaminants where both known and unexpected contamination is present on the soil surface; in many cases, remediation was initiated to remove the source, though levels detected have never approached regulatory limits. The AIRNET system can detect low levels of radionuclides that are dispersed during cleanup operations, and we have added many additional samplers in anticipation of upcoming cleanup operations. The Direct Penetrating Radiation network detects neutrons and gamma rays from the stored waste at Area G and is used to monitor off-site radiation levels. We conduct biota and foodstuffs monitoring to ensure there is no spread of contamination into plants, animals, and food. The monitoring of constituents in groundwater keeps track of the movement of previously-released contaminants and their potential migration in the aquifers.

Compliance

The Laboratory uses the status of compliance with environmental requirements as a key indicator of its environmental performance. Federal and state regulations provide specific requirements and standards to implement these statutes and maintain environmental quality. The EPA and the NMED are the principal administrative authorities for these laws. The Laboratory is also subject to DOE requirements for control of radionuclides. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations for 2008.

Table ES-1
Environmental Statutes under which LANL Operates and Compliance Status in 2008

Federal Statute	What it Covers	Status
Resource Conservation and Recovery Act (RCRA)	Generation, management, and disposal of hazardous waste and cleanup of inactive, historical waste sites	The Laboratory completed 2,552 self-assessments that resulted in a non-conformance finding rate of 2.8%. All major deliverables required by the Consent Order were submitted to NMED on time. NMED issued a Notice of Violation (NOV) to DOE and LANL for a required status report that was submitted five days late in 2007. Also in 2008, NMED issued another NOV to DOE and LANL for alleged violations during a RCRA inspection conducted in early 2007. The NMED conducted a RCRA hazardous waste compliance inspection and did not issue any findings. LANL discovered four instances of improper storage or labeling of hazardous wastes. All instances were corrected and did not result in actual or potential hazards to the environment or personnel. The Laboratory is in compliance with groundwater monitoring requirements. LANL installed 10 alluvial, three intermediate perched, and six regional aquifer wells.
Clean Air Act (CAA)	Air quality and emissions into the air from facility operations	The Laboratory was well below all permit limits for emissions to the air. Non-radiological air emissions were lower than the previous year for all but nitrogen oxides and carbon monoxide, both of which increased by less than 5%. The annual dose to the maximally exposed individual (MEI) from radioactive air emissions was 0.55 mrem, which is similar to the very low dose for the previous year.
Comprehensive Environmental Response and Liability Act (CERCLA)	Pollution and contaminants on property	LANL transferred three parcels of land to Los Alamos county after completing all CERCLA-required Environmental Baseline Survey Reports. A National Resources Damage Assessment was re-initiated and a pre-assessment report completed in December 2008.
Clean Water Act (CWA)	Water quality and effluent discharges from facility operations	Six of 1,300 samples collected from industrial outfalls and none of the 77 samples collected from the Sanitary Wastewater Systems Plant's outfall exceeded effluent limits. All exceedences were for either pH or residual chlorine levels. The Laboratory conducted 542 storm water inspections and 99% of the Laboratory's 51 permitted construction sites were compliant with National Pollutant Discharge Elimination System (NPDES) requirements. The Laboratory added 20 rain gages to a network of gages used to trigger sampling or inspections of sites, installed 202 new site-specific samplers, maintained 60 stream gage stations, collected 310 storm water samples, conducted 2,287 inspections at 290 sites, and installed and maintained Best Management Practices to manage pollutants and runoff at these locations.
Groundwater Discharge Plans	Discharges of water to groundwater	The Laboratory operated under one approved and two pending Discharge Plans submitted to or approved by the NMED. The approved plan regulates discharges from the sanitary wastewater treatment facility at TA-46 and the pending plans cover the TA-50 RLWTF and 21 domestic septic systems.
Aboveground Storage Tank Compliance Program	Liquid storage tank monitoring and compliance	One tank system at LANSCE (TA-53) was closed out with NMED in 2008 leaving a total of 19 regulated tanks. LANL performed additional characterization of the 2002 diesel release from a tank at TA-21.
Toxic Substances Control Act (TSCA)	Chemicals such as polychlorinated biphenyls (PCBs)	The Laboratory shipped 22 containers of PCB waste, 30 lbs of capacitors, and 1,617 lbs of fluorescent light ballasts for disposal or recycling to EPA-permitted disposal and treatment facilities.

Table ES-1 (continued)

Federal Statute	What it Covers	Status
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Storage and use of pesticides and herbicides	The Laboratory remained in compliance with regulatory requirements regarding use of pesticides and herbicides. The Laboratory used 313.75 oz of insecticides and 682.5 gal. of herbicides, 600 lbs of fertilizers, 5,340 lbs plus 5.5 gal. of water treatment chemicals, and 5 gal. of color marker.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public's right to know about chemicals released into the community	The Laboratory reported releases, waste disposal, and waste transfers totaling 14,520 lbs of lead, mostly at the firing range. No updates to Emergency Planning Notifications were necessary in 2008. Chemical Inventory Reports were updated to the Los Alamos County fire and police departments for 30 chemicals or explosives. There were no releases that triggered state or federal reporting requirements.
Endangered Species Act (ESA) and Migratory Bird Treaty Act (MBTA)	Rare species of plants and animals	The Laboratory maintained compliance with the ESA and MBTA and reviewed 629 excavation permits and 122 project profiles for potential impacts to threatened or endangered species. The Laboratory conducted annual surveys for Mexican spotted owl, southwestern willow flycatcher, Jemez Mountain salamander, and grey vireo. LANL prepared biological assessments for one project regarding potential impacts on federally listed threatened or endangered species.
National Historic Preservation Act (NHPA) and others	Cultural resources	The Laboratory maintained compliance with the NHPA. The Laboratory conducted 38 projects that required some field verification of previous survey information and identified 11 new archaeological sites and 27 new historic buildings. Eight historic buildings were determined eligible for the National Register of Historic Places.
National Environmental Policy Act (NEPA)	Projects evaluated for environmental impacts	The Laboratory and NNSA released the final Site-Wide Environmental Impact Statement for continued operation of LANL. A limited Record of Decision was issued in September 2008 that accepts some elements of the Expanded Operations Alternative.

Unplanned Releases

There were no unplanned airborne releases and no unplanned releases of radioactive liquids from LANL in 2008. There were 12 spills or releases of potable water, steam condensate, or domestic wastewater and one spill of about 2 quarts of motor oil with about 2 gallons of antifreeze into a canyon. LANL reported all liquid releases to NMED; the releases will be administratively closed upon final inspection.

Radiological Dose Assessment

Humans, plants, and animals potentially receive radiation doses from various Laboratory operations (Table ES-2). The DOE dose limits for the public and biota are the mandated criteria that are used to determine whether a measurement represents a potential exposure concern. Figure ES-2 shows doses to the hypothetical maximally exposed individual (MEI) via the air pathway over the last 15 years at an off-site location; this location was at East Gate in 2008, as it was through 2005. (In 2006, it was at the Los Alamos County Airport terminal and in 2007 at a location along DP Road.) The annual dose to the MEI for the airborne pathway was approximately 0.55 mrem, compared with the dose of 0.52 mrem in 2007 and a regulatory limit of 10 mrem (Figure ES-2). During 2008, the population within 80 km of LANL received a collective dose of about 0.79 person-rem, up from 0.36 person-rem in 2007. The doses received in 2008 from LANL operations

- *The location of the hypothetical maximally exposed individual (MEI) for airborne radionuclides was determined to be at East Gate near the eastern edge of Los Alamos. This location received a combination of low levels of radiation from LANSCE and other stack emissions.*
- *Radiation dose to the MEI was only slightly higher than the very low levels calculated in 2006 and 2007.*

by an average Los Alamos residence and an average White Rock residence totaled about 0.047 mrem and 0.038 mrem, respectively. The maximum all-pathways dose, composed almost entirely of direct radiation from waste stored at TA-54, Area G, could result in an exposure of 0.9 mrem per year to a hypothetical individual in the adjacent sacred area of Pueblo de San Ildefonso.

Table ES-2
What are the Sources of Radiological Doses?

Source	Recipient	Dose	Location	Trends
Background (includes man-made sources)	Humans	~700 mrem/yr	Not applicable	Increased from previous years due to new information about average medical doses.
Air	Humans	0.55 mrem/yr	East Gate in eastern Los Alamos	Similar to very low level in previous two years
Direct radiation	Humans	0.9 mrem/yr	San Ildefonso – offsite	Same as previous year
Food	Humans	<0.1 mrem/yr	All sites	Steady
Drinking water	Humans	<0.1 mrem/yr	All sites	Steady
All	Terrestrial animals	<20 mrad/day*	TA-15 "EF site", TA-21 MDA B	Steady
All	Terrestrial plants	<50 mrad/day*	TA-21 MDA B	Steady

* Highest reported dose from all sample years

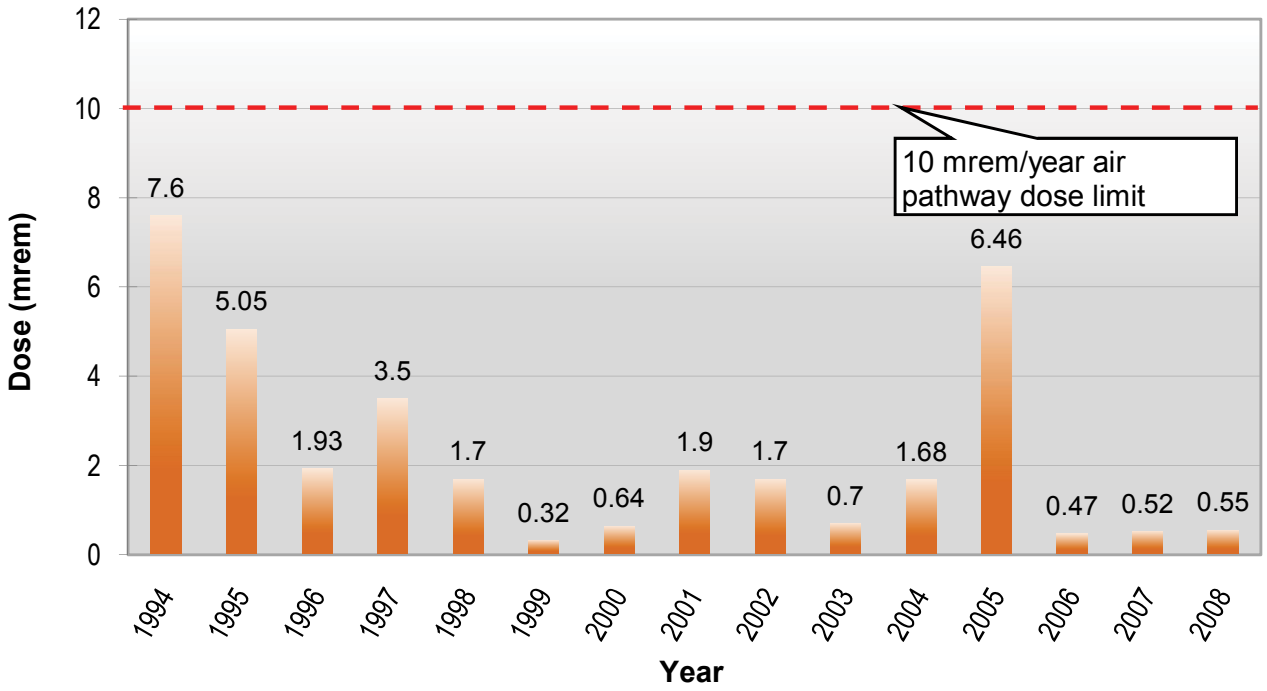


Figure ES-2. Annual airborne pathway dose (mrem) to the off-site MEI over the past 15 years. The 2008 location of the calculated MEI is at East Gate near the eastern side of Los Alamos County.

Biota Dose

The DOE biota dose limits are intended to protect populations of plants and animals, especially with respect to preventing the impairment of reproductive capability within the biota population. All radionuclide concentrations in vegetation sampled in 2008 were far below the plant 0.1 rad/day biota dose screening level (10% of 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled in 2008 were far below the terrestrial animal 0.01 rad/day biota dose screening level (10% of 0.1 rad/day dose limit).

Table ES-2 reports the highest biota doses calculated for all sample years. There were three cases in 2008 in which surface water concentrations exceeded the general biota screening levels for aquatic systems. However, the locations of these surface water samples did not coincide with aquatic habitats. So, terrestrial biota dose assessments were performed for these locations. All dose rates determined from the assessments were far below the applicable dose limits.

Nonradiological Risk Assessment

The environmental data collected in 2008 and previous years show that there is no potential public-health risk from nonradiological materials released from LANL.

Air Emissions and Air Quality

The Laboratory measures the emissions of radionuclides at the emission sources (building stacks) and categorizes these radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) air activation products (radioactive elements created by the LANSCE particle accelerator beam). In addition, the Laboratory collects air samples at general locations within LANL boundaries, at the LANL perimeter, and regionally to estimate the extent and concentration of radionuclides that may be released from Laboratory operations. These radionuclides include isotopes of plutonium, americium, uranium, and tritium.

- *Emissions of short-lived air activation products from LANSCE and emissions of tritium from other stacks increased from the relatively low levels last year. Emissions of tritium reflect a return to past levels after an extended maintenance period in 2007.*
- *Combined airborne emissions of radionuclides other than tritium and short-lived air activation products were similar to last year.*

Total stack emissions during 2008 were approximately 1,300 curies (Ci), an increase from 477 Ci in 2007. Diffuse emissions from the LANSCE facility and other smaller sources contributed another 74.6 Ci. Tritium emissions composed about 480 Ci of the total (260 in 2006) and reflect a slight increase over 2007 but were lower than the levels of the past several years. Short-lived air activation products from LANSCE stacks and diffuse emissions contributed 890 Ci (301 Ci in 2007) of the total. Most of the curies from LANSCE are from very short-lived radionuclides that decay significantly before reaching the location of the MEI. Combined airborne emissions of other radionuclides, such as plutonium, uranium, americium, and thorium, were less than 0.000012 Ci (same as 2007) and emissions of particulate/vapor activation products were similar to last year at 0.021 Ci.

- *Increased concentrations of radionuclides in ambient air were not detected at regional sampling locations nor at most perimeter locations.*
- *As in previous years, there were no detections of radionuclides above background at Pueblo and regional locations.*
- *The highest mean air concentrations at perimeter locations were below 1% of the applicable EPA limits.*

Radionuclide concentrations in ambient air samples in 2008 were generally comparable with concentrations in prior years. As in past years, the AIRNET system detected slightly elevated radionuclides from known areas of contamination. No new or increased airborne radioactivity was detected. At regional locations away from Los Alamos, all air sample measurements were consistent with background levels. Annual mean radionuclide concentrations at all LANL perimeter stations were less than 1% of the EPA dose limit for the public. Measurable amounts of tritium were reported at most on-site locations and at perimeter locations, but no elevated levels were detected in 2008. The highest off-site tritium concentration (measured at station #26 along State Road 4 near Bandelier National Monument) was 4.3 pCi/m^3 (0.3% of the EPA public dose limit of 1,500 pCi/m^3). The highest on-site tritium measurement (less than 1% of the DOE limit for worker exposure) was made at Area G near areas containing tritium-contaminated waste. No plutonium-238 was detected above normal levels. Plutonium-239/240 from historical activities at LANL's old main technical area was detected near the Ashley Hotel and Suites (formerly Los Alamos Inn) at about 23 aCi/m^3 or about 1% of the EPA public dose limit, and at very low levels near MDA B where soil disturbance from road construction occurred in preparation for remediation of the MDA. On-site detections of plutonium

occurred at Area G (an area with known low levels of contamination) at levels substantially below 0.5% of the DOE limit for workplace exposure. Americium-241 was detected near Area G at levels less than 0.05% of worker exposure limits and at seven off-site locations at levels less than 0.3% of public exposure limits. The maximum annual uranium concentrations were from natural uranium at locations with high dust levels from local soil disturbances. The regional and Pueblo samples had higher average concentrations of natural uranium isotopes than the perimeter group. There was one tentative detection of depleted uranium (which has lower radioactivity than natural uranium) in one sample near the LANL perimeter.

LANL demonstrated full compliance with all Clean Air Act requirements and met all permit reporting requirements and deadlines. One permit deviation regarded a calculation method that greatly overestimated emissions and NMED agreed the calculation needed to be changed. Emissions of criteria pollutants (nitrogen oxides, sulfur oxides, carbon monoxide, particulate matter, volatile organic compounds, and hazardous air pollutants) from 2004 through 2008 are very similar and remained relatively constant. In 2008, the TA-3 power plant and boilers located across the Laboratory were the major contributors of nitrogen oxides, carbon monoxide, and particulate matter. Science research and development activities were responsible for most of the volatile organic compound and hazardous air pollutant emissions.

Air monitoring for particles with diameters of 10 micrometers (μm) or less (PM-10) and for particles with diameters of 2.5 μm or less (PM-2.5) continued at one White Rock and one Los Alamos location. The annual averages at both locations for PM-10 was about 14 micrograms (μg)/m^3 and about 8 μg/m^3 for PM-2.5 and were mostly caused by natural dust and wildfire smoke. These averages are the same as measured in 2007 and are 28% and 53% of the EPA standards, respectively. In addition, the 24-hour maxima for both PM-10 and PM-2.5 at all three locations did not exceed 35% and 26% of the respective EPA standards.

- ***As in previous years, PM-10 and PM-2.5 particulate measurements in ambient air were well below EPA standards.***
- ***Most of the dust measured by the PM-10 and PM-2.5 samplers is from natural sources such as dust and wildfire smoke.***

The Laboratory analyzed air filter samples from 36 sites for beryllium. These sites are located near potential beryllium sources at LANL and in nearby communities. Beryllium air concentrations for 2008 were similar to those measured in recent years and are equal to or less than 2% of the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard. Past studies closely correlated beryllium concentrations with aluminum concentrations, which indicates that all measurements of beryllium are from naturally occurring beryllium in re-suspended dust.

Groundwater Monitoring

Groundwater at the Laboratory occurs as a regional aquifer (water-bearing rock capable of yielding significant quantities of water to wells and springs) at depths ranging from 600 to 1,200 feet and as perched groundwater of limited thickness and horizontal extent, either in canyon alluvium or at intermediate depths of a few hundred feet (Figure ES-3). All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate groundwater.

- ***In general, alluvial and intermediate groundwater quality at LANL continues to improve as a result of past efforts that have eliminated outfalls, reduced the quantity of discharges, and improved the quality of discharges.***
- ***Contamination may be discovered in additional locations, however, as groundwater characterization continues.***

In 2008, LANL installed 10 alluvial monitoring wells, three intermediate monitoring wells, and six regional monitoring wells. The alluvial wells were installed in Pajarito Canyon as part of the Pajarito Canyon investigation. Wells SCI-2, R-35a, R-36, and R-43 were installed in Sandia Canyon as part of the ongoing chromium contamination investigation.

Regional well R-42 was installed in Mortandad Canyon as part of the same investigation. Intermediate aquifer wells R-25b and R-25c were installed adjacent to existing well R-25, a 9-screen completion, in the western side of LANL to replace screens 1 and 3, respectively. Regional wells R-38 (Cañada del Buey) and R-39 (Pajarito Canyon) were installed to augment the existing groundwater-monitoring network around MDAs G, H, and L.

- *LANL detected chromium contamination in the regional aquifer under one canyon at concentrations 16 times the NM Groundwater Standard and under an adjacent canyon at 46% of the standard.*
- *The contamination is likely the result of cooling tower discharges containing chromate from the late 1950s to early 1970s.*
- *No drinking water wells have been affected by the chromium contamination.*

Monitoring network well assessments conducted in all of the Pajarito Plateau watersheds in 2007 and 2008 determined the adequacy of wells in each watershed for producing representative groundwater quality and the need for additional wells. As part of these assessments, we identified the existing wells that could be adequate if rehabilitated. We rehabilitated two wells in 2007, three in 2008, and two will be rehabilitated in 2009. Rehabilitation involves both active cleaning of the well, redevelopment of conditions near the screens, and conversion to a well with fewer screens and a different sampling system.

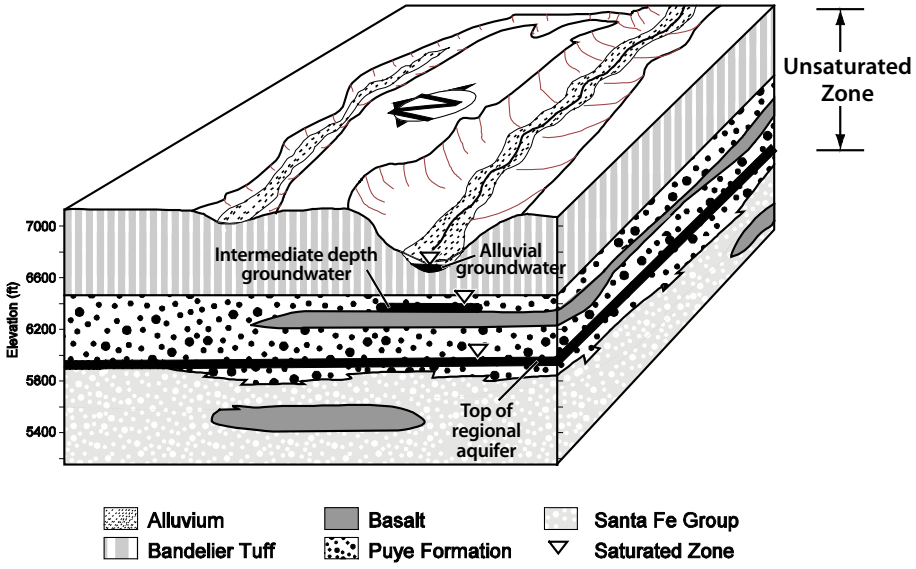


Figure ES-3. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

Laboratory contaminants have affected deep groundwater, including intermediate perched zones and the regional aquifer, primarily through liquid effluent disposal. Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 15 active) and the volume of water released (by more than 86%). From 1993 to 1997, total estimated average release was 1,300 million gal./yr; in 2006 through 2008, the annual releases were 222 million gal., 178 million gal., and 158 million gal., respectively. All discharges in 2008 met applicable federal and state standards except for minor exceedances of pH or residual chlorine on six occasions. Where Laboratory contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location where large amounts of liquid effluent have been discharged (e.g., Mortandad Canyon and upper Sandia Canyon). During 2008, LANL received and evaluated almost 198,000 analytical results for groundwater wells alone. Table ES-3 summarizes contaminants detected in portions of the groundwater system.

Table ES-3
Where Can We See LANL Impacts on Groundwater that Result in Values Near or Above Regulatory Standards, Screening Levels, or Risk Levels?

Chemical	On-Site	Off-Site	Significance	Trends
Tritium	Intermediate groundwater in Mortandad Canyon	No	Not used as a drinking water supply	Slight decline over four years of sampling
Strontium-90	Alluvial groundwater in DP/Los Alamos and Mortandad Canyons	No	Not used as a drinking water supply; has not penetrated to deeper groundwater	Mainly fixed in location; some decrease due to effluent quality improvement
Perchlorate	Alluvial, intermediate, and regional groundwater in Mortandad Canyon; intermediate in Los Alamos Canyon; regional aquifer in Pueblo Canyon	Yes, in Pueblo Canyon	Reflects past outfall discharges that have ceased	Decreasing in Mortandad Canyon alluvial groundwater as effluent quality improves; insufficient data for other groundwater
Chloride, total dissolved solids	Alluvial groundwater in Pueblo, DP, Sandia, Mortandad, Pajarito Canyons, intermediate groundwater near TA-3 main warehouse and in Sandia Canyon	Yes, in Pueblo Canyon	May be caused by road salt in snowmelt runoff, except intermediate groundwater in Sandia Canyon	Values generally highest in winter or spring samples
Nitrate	Alluvial and intermediate groundwater in Pueblo and lower Los Alamos Canyons, regional groundwater in Sandia Canyon, and Mortandad Canyon	Yes, in Pueblo and Los Alamos Canyons	In Pueblo and lower Los Alamos Canyons, result may be due to Los Alamos County's Bayo Sewage Treatment Plant; otherwise due to effluent discharges	Generally steady
Fluoride	Intermediate groundwater in Pueblo Canyon, alluvial groundwater in DP and Mortandad Canyons	Yes, in Pueblo Canyon	Result of past effluent releases; not affecting drinking water supply wells	Slow decrease in concentration due to effluent quality improvement
Fluoride, uranium, nitrate, TDS	No	Yes, Pine Rock Spring, Pueblo de San Ildefonso	Water quality apparently affected by irrigation with sanitary effluent at Overlook Park	Steady over several years
Boron	Intermediate groundwater in Cañon de Valle	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Barium	Alluvial groundwater in Cañon de Valle and Water Canyon, Pajarito, and Mortandad Canyons	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations

Table ES-3 (continued)

Chemical	On-Site	Off-Site	Significance	Trends
Chromium	Regional aquifer in Sandia and Mortandad Canyons, intermediate groundwater in Mortandad Canyon	No	Found in regional aquifer above groundwater standards; not affecting drinking water supply wells; source eliminated in 1972.	Fairly steady over four years
Dioxane[1,4-]	Intermediate groundwater in Mortandad and Pajarito Canyons	No	Not used as drinking water supply; limited in extent	Fairly steady over three years in Mortandad; seasonal variation in Pajarito
Bis(2-ethylhexyl) phthalate	Several wells, including regional aquifer monitoring well R-42	No	Used in plastics and sometimes appears in samples from wells with new sampling equipment or recent drilling	None
Tetrachloroethene [1,1,1-], Trichloroethene	Alluvial and intermediate groundwater in Cañon de Valle	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations
Trichlorothane [1,1,1-]; dichloroethene[1,1-]	Intermediate groundwater near main warehouse	No	Not used as drinking water supply; limited in extent	Seasonally variable
RDX	Alluvial and intermediate groundwater in Cañon de Valle, intermediate groundwater in Pajarito Canyon	No	Not used as drinking water supply; limited in extent	Generally stable, seasonal fluctuations

Drainages that received liquid radioactive effluents in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon. Mortandad continues to receive discharges of treated effluent from the RLWTF. For the past eight years, this facility has met DOE radiological discharge standards in all but two months, met all NPDES requirements, and voluntarily met NM groundwater standards for fluoride, nitrate, and total dissolved solids in all but two weeks. Voluntary perchlorate limits were exceeded for a short time as explained below.

- ***All water produced by the Los Alamos County water supply system comes from the regional aquifer and meets federal and state drinking water standards. No drinking water is supplied from the alluvial and intermediate groundwater.***
- ***One drinking water supply well, Otowi-1, has been affected by levels of perchlorate at 16% of the EPA interim health advisory for drinking water. No water from this well is used by Los Alamos County.***

The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so infiltration from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than the shallow perched groundwater bodies, and impacts on the regional aquifer are small.

- *Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system, which discharges into Mortandad Canyon.*
- *The facility has met all DOE radiological discharge standards and all NPDES (outfall) requirements for the past eight years.*
- *The facility has met NM groundwater standards for fluoride, nitrate, and total dissolved solids for seven years except for fluoride in two weekly composite samples in 2003.*

Water Canyon and its tributary Cañon de Valle formerly received effluents produced by high explosives processing and experimentation. In past years, Los Alamos County has operated three sanitary treatment plants in Pueblo Canyon; currently only one plant is operating. The Laboratory also operated many sanitary treatment plants but currently operates only one plant that discharges into Sandia Canyon.

The high explosive compound research department explosive (RDX) continued to be detected in the regional aquifer at Pajarito Canyon regional well R-18. The concentration was at 8% of the EPA tap water screening level.

The Laboratory detected hexavalent chromium and nitrate in several regional aquifer monitoring wells. The hexavalent chromium was found at eight and 16 times above the NM groundwater standard in two regional aquifer wells in Mortandad canyon and at 46% of the standard in a regional well in nearby Sandia Canyon (down from 70% in 2007). A new intermediate zone well in Sandia Canyon contains chromium at 11.2 times the standard and supports LANL's model for the path of the chromium contamination from Sandia Canyon downward and slightly south into the regional aquifer below Mortandad Canyon. Nitrate was 60% of the NM groundwater standard in three regional aquifer monitoring wells. Perchlorate was also above the NM screening level in two regional aquifer wells.

Naturally occurring uranium was the main radioactive element detected in the regional aquifer and is found in wells throughout the Rio Grande Valley. High concentrations of naturally occurring arsenic are also found in groundwater samples from some regional aquifer wells and springs. Many of the other metals found at high concentrations in groundwater samples at LANL result from well sampling and well construction issues rather than from LANL contamination.

One drinking water well in the Los Alamos area has been impacted by past Laboratory discharges of perchlorate. Well O-1 in Pueblo Canyon contains perchlorate at up to 16% of the EPA interim health advisory for perchlorate in drinking water of 15 µg/L. This well is not used by Los Alamos County for drinking water supply. Perchlorate is detected in most groundwater samples analyzed across northern NM. Naturally occurring perchlorate concentrations range from about 0.1 µg/L to 1.8 µg/L. Water samples from most LANL locations show low perchlorate concentrations in this range, but samples from Mortandad Canyon alluvial and intermediate groundwater show values near or above the NM Consent Order screening level of 4 µg/L and the EPA interim health advisory level of 15 µg/L. Due to treatment upgrades, the concentration of perchlorate in discharge from the RLWTF dropped to an undetectable level in 2002. However, for a three-month period in early 2008, the ion exchange resin became spent and levels averaged between 2.6 and 8.0 µg/L. After replacing the resin, levels returned to below detection level. No effects on downstream surface or ground water concentrations were seen. Perchlorate levels below the facility outfall have been steadily decreasing in the alluvial groundwater since 2000.

- *Polychlorinated biphenyls (PCBs) are often measured in storm water in Sandia and Los Alamos Canyons above screening levels.*
- *Radioactive elements from past Laboratory operations are being transported by runoff events. All radionuclide levels are well below applicable guidelines or screening levels.*
- *PCBs, radionuclides, and other contaminants adsorb onto sediment particles and thus overall water concentrations can be reduced by slowing the stream flows, reducing erosion, and allowing suspended sediment to settle out.*

The intermediate groundwater in various locations shows localized levels of tritium, organic chemicals (RDX, chlorinated solvents, dioxane[1,4-]), and inorganic chemicals (hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate) from Laboratory operations.

- *The overall quality of most surface water within the Los Alamos area is very good.*
- *Of the more than 100 analytes measured, most are within normal ranges or at concentrations below regulatory standards or risk-based advisory levels.*
- *Nearly every major watershed, however, shows some effect from Laboratory operations.*

The Laboratory uses federal and state drinking water and human health standards as "screening levels" to evaluate radionuclide concentrations in all groundwater, even though many of these standards only apply to drinking water. Only in the alluvial groundwater in portions of Mortandad and DP/Los Alamos Canyons does the total radionuclide activity from LANL discharges exceed the guidance that is applicable to drinking water (4 mrem/yr). This is mainly due to the presence of strontium-90. The maximum strontium-90 concentrations in Mortandad Canyon and DP/Los Alamos Canyon alluvial groundwater were also above the EPA's drinking water standard though this water is not used for drinking water supply.

Watershed Monitoring

Watersheds that drain LANL property are dry for most of the year. Of the more than 80 miles of watercourse, approximately two miles are naturally perennial and approximately three miles are perennial water created by effluent discharges (most notably in upper Sandia Canyon). Storm water runoff occasionally extends across the Laboratory but is short-lived. The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. It is not a source of livestock watering west of NM route 4 because there are no livestock in this area.

Occasional floods can redistribute sediment downstream. None of the streams within the Laboratory boundary average more than one cubic foot per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs, although two storms in 2008 resulted in an estimated combined mean daily runoff from LANL of about 18 cfs on January 28 and 29 (a rain-on-snow event) and 15 cfs on August 4. By comparison, the average daily flow in the Rio Grande at Otowi Bridge during those events was 774 and 970 cfs, respectively, or approximately 50 to 65 times higher.

Total runoff leaving the Laboratory in 2008 measured at downstream gages in the canyons was estimated at about 197 acre-feet (ac-ft) of which about 35 ac-ft was from the rain-on-snow event in January, 118 ac-ft from other snowmelt runoff, and 44 ac-ft from storm water runoff in the summer and early fall. In addition, approximately 130 ac-ft of effluent released from the Los Alamos County wastewater treatment plant (WWTP) is estimated to have passed the eastern LANL boundary in Pueblo Canyon. The volume of storm water runoff in 2008 was the least since 1995, the first year for which runoff estimates are available for all the canyons.

On July 4 and 5, 2008, a break in a fire-suppression water line at TA-21 released approximately 3.9 million gallons of potable water (1.3 ac-ft) that flowed over SWMU 21-027(a), eroding sediment on the canyon wall and transporting sediment into the canyon bottom. Runoff events in August 2008 transported some of this sediment downstream to the Los Alamos Canyon weir.

The overall quality of most surface water in the Los Alamos area is good, with low levels of dissolved solutes. Of the more than 100 analytes measured in sediment and surface water within the Laboratory, most are at concentrations far below standards and screening levels. However, nearly every major watershed indicates some effect from Laboratory operations, often for just a few analytes. Table ES-4 lists the locations of Laboratory-impacted surface water. All radionuclide levels are well below applicable guidelines or standards (Table ES-5).

Laboratory activities have caused contamination of sediment in several canyons, mainly because of past industrial effluent discharges. These discharges and contaminated sediment also affect the quality of storm water runoff, which carries much of this sediment during short periods of intense flow. In some cases, sediment contamination is present from Laboratory operations conducted more than 50 years ago. However, all measured sediment contaminant levels are below screening levels for recreational uses.

Table ES-4
Where Can We See LANL Impacts on Surface Water that Result in Values Near or Above Screening Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Specific radionuclides	No	No	Exposure potential is limited. Los Alamos Canyon surface water at 40% of DOE biota concentration guide for year; dose mainly from radium-226 that is of natural origin	Steady
Gross alpha radioactivity	Mortandad, Pueblo, and Los Alamos Canyons	No	57% of surface water results greater than screening level. Major source is naturally occurring radioactivity in sediments, except in Mortandad, Pueblo, and Los Alamos Canyons where there are LANL contributions	Steady
Copper	Multiple watersheds	No	From site monitoring locations or tributary drainages. All samples from major canyons were below screening level. Origins uncertain; probably several sources	Steady
Lead	Threemile Canyon	No	Elevated in one sample collected at a site monitoring area in Threemile Canyon	Steady
Selenium	Water Canyon	No	Elevated in one sample from TA-11 during major storm, not detected in next sample from this location.	Steady
Zinc	Acid, Los Alamos, Mortandad, Sandia, Ten Site, Twomile Canyons	No	Elevated zinc only from site monitoring areas or tributary drainages. All samples from major canyons were below screening level.	Steady
Chromium	Cañada del Buey, Los Alamos Canyon, Sandia	No	Above screening level in three nonfiltered samples and associated with suspended sediment. Filtered samples well below screening level.	Steady
Cyanide	Acid, Los Alamos, Mortandad, Pueblo, Sandia Canyons	No	Above screening level in 12 samples. Non-LANL source in Pueblo Canyon, possibly associated with burned areas.	Steady
Silver	Cañon de Valle, other canyons	No	In Cañon de Valle, from known former photography processing laboratory.	Steady
Polychlorinated biphenyls (PCBs)	Many canyons	No	Above screening levels. Wildlife exposure potential in Sandia Canyon.	Steady
Semi-volatile organic compounds (SVOCs)	Water, Pajarito, Sandia Canyons	No	Infrequently detected; commonly derived from runoff from developed areas.	Steady
RDX	Cañon de Valle	No	Confined to LANL; subject of focused investigations	Steady

Table ES-5
Estimated Annual Average Non-Filtered Surface Water Concentrations of Radionuclides in Selected Canyons Compared with the Biota Concentration Guides (pCi/L)

Radionuclide	BCG[a] (pCi/L)	Acid Canyon above Pueblo Canyon (pCi/L)	Lower Pueblo Canyon (pCi/L)	DP Canyon below TA-21 (pCi/L)	Los Alamos Canyon above DP Canyon (pCi/L)	Los Alamos Canyon above Weir (pCi/L)	Los Alamos Canyon near Rio Grande (pCi/L)	Mortandad Canyon below Effluent Canyon (pCi/L)	Maximum percent of BCG
Am-241	400	0.02	0.08	0.02	0.4	1.0	0.1	4	1%
Cs-137[b]	20,000	ND[c]	ND	ND	ND	1.2	ND	18	0.09%
H-3 (tritium)	300,000,000	2.7	1.2	38	ND	ND	1.1	580	<0.01%
Pu-238	200	<0.01%	0.01	ND	0.5	0.1	0.02	2.0	1%
Pu-239/240	200	0.5	2.0	0.03	11	1.3	3.0	3.2	6%
Ra-226	4	0.03	0.5	0.01	0.3	0.4	0.6	0.9	22%
Sr-90[b]	30,000	0.1	0.3	94	0.2	1.5	ND	1.1	0.3%
U-234	200	0.05	0.6	1.1	0.7	0.8	1.1	1.2	0.6%
U-235/236	200	ND	ND	ND	0.03	0.06	0.07	0.1	0.07%
U-238	200	0.02	0.5	0.4	0.6	0.5	1.0	1.1	0.5%

[a] BCG = DOE Biota Concentration Guides

[b] The BCG for cesium-137 and strontium-90 are site-specific modified BCGs

[c] ND = not detected in 2008

Consistent with previous years, most surface water samples in 2008 had gross alpha radiation greater than the surface water standard of 15 pCi/L for livestock watering. Of the 195 non-filtered samples analyzed from the Pajarito Plateau, 73% exceeded 15 pCi/L including samples from sites with no upstream releases of radionuclides from Laboratory activities (such as Guaje Canyon). Laboratory impacts are relatively small and the majority of the alpha radiation in surface water on the plateau is due to the decay of naturally occurring isotopes in sediment and soil carried in storm water runoff from uncontaminated areas. This is supported by the generally positive correlation between gross alpha radiation and suspended sediment in non-filtered surface water samples.

- ***The highest concentrations of several radionuclides in surface water samples were measured in Mortandad Canyon downstream from the TA-50 RLWTF outfall. All measurements are consistent with previous years and are below standards and screening levels.***
- ***The highest concentrations of most radionuclides in sediment, at levels slightly higher than the previous year, were obtained from one flood-associated fine-grained sample from the sediment retention basin behind the Los Alamos Canyon weir, but all are below recreational screening levels.***

We measured the highest concentrations of several radionuclides in surface water samples in Mortandad Canyon downstream from the TA-50 RLWTF outfall, including americium-241, cesium-137, plutonium-238, and tritium. The highest concentration of plutonium-239/240 was measured in Los Alamos Canyon upstream from DP Canyon and downstream from the site at TA-21 that experienced erosion during a potable water line break on July 4 and 5, 2008. We measured the highest concentration of strontium-90 in DP Canyon downstream from a former radioactive treatment plant effluent outfall at TA-21. We measured the highest concentrations of uranium-234, uranium-235, and uranium-238 at a site-monitoring area location in the Potrillo Canyon watershed below a firing site in TA-15. With the exception of the plutonium-239/240 in Los Alamos Canyon, all the other measurements discussed above are consistent with previous years.

The highest concentrations of most radionuclides in sediment were obtained in one fine-grained sample from the sediment retention basin behind the Los Alamos Canyon weir, including the highest values for americium-241, cesium-137, plutonium-239/240, and strontium-90. The sampled sediment was a thin layer (maximum of 7 cm thick) that was probably deposited by a flood in August 2008 which remobilized sediment associated with the potable water line break at TA-21. The highest concentration of thorium-228 was also measured in a fine-grained sample from the retention basin, the only result for this isotope above the LANL sediment background value (although less than concentrations in Bandelier Tuff). Except for cesium-137, these values are higher than previous results from the retention basin (LANL 2008g) but are below recreational screening levels.

The types of organic chemicals that we analyzed for varied depending on the sampling location and included the following suites: dioxins and furans, explosive compounds, herbicides, pesticides, PCBs, semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons-diesel range organics (TPH-DRO), and volatile organic compounds (VOCs). Under the Federal Clean Water Act §303(d) list, the state of NM has listed parts of three canyons within LANL as impaired for PCBs in the water column: Los Alamos, Pueblo, and Sandia Canyons. The most commonly detected PCBs were Aroclor-1254 and Aroclor-1260, which were detected in 7% and 8% of the samples, respectively. Two measurements were also reported for Aroclor-1242. All samples with detected PCBs had concentrations above the water screening level of 0.00064 µg/L, including site monitoring areas and canyon bottom locations in the watersheds of DP, Los Alamos, Mortandad, Sandia, and Ten Site Canyons. We measured the highest PCB concentrations in storm water at an site monitoring area (SMA) in the Los Alamos Canyon watershed. In 2001, the Laboratory excavated PCB-contaminated soil at a former transformer storage area in the Sandia Canyon watershed, and in 2008, we began an interim measure to address the transport of PCBs in storm water in Los Alamos and Pueblo Canyons. Monitoring results show no measurable levels of PCBs from LANL in the Rio Grande.

We detected no herbicides in any surface water samples.

Concentrations of many metals are elevated in Rio Grande and Cochiti Reservoir bottom sediment relative to background levels in Pajarito Plateau sediment, which is likely due to different background source rock types along the Rio Grande. For example, the highest concentrations in 2008 were obtained from sediment samples from Abiquiu Reservoir for 11 inorganic chemicals (arsenic, barium, cadmium, calcium, cobalt, copper, iron, magnesium, nickel, vanadium, and zinc), demonstrating regional differences in sediment background and non-LANL sources. Five inorganic chemicals have their highest concentrations in Cochiti Reservoir bottom sediment (aluminum, beryllium, manganese, potassium, and selenium), but these are also elevated in Abiquiu Reservoir relative to Pajarito Plateau samples.

- ***Concentrations of many metals are elevated in Rio Grande and Cochiti Reservoir bottom sediment relative to background levels in Pajarito Plateau sediment, but these may largely or entirely reflect different background conditions along the Rio Grande than on the plateau or upriver sources.***
- ***Monitoring results show no measurable effects of PCBs from LANL in the Rio Grande.***

We obtained PCB congener data from 10 sediment samples along the Rio Grande in December 2008, five samples were taken upriver from Los Alamos Canyon and downriver from Mortandad Canyon, below White Rock, collected when the river was at low-water conditions. The congener data allow evaluation of similarities or differences in the PCBs present above and below the primary LANL sources and also allows further comparison with PCBs present in LANL canyons. PCB congeners were detected in all of the upriver samples and four of the downriver samples. The mixtures of PCB congeners upriver and downriver from LANL sources are essentially identical, but different than the homolog signature from a potential LANL source (Sandia Canyon). These congener data therefore show no measureable evidence of LANL contributions to PCBs along the Rio Grande.

Soil Monitoring

Table ES-6 summarizes soil sampling results. We conduct large-scale soil sampling within and around the perimeter of LANL every three years. The last soil sampling event was in 2006. In general, results of that investigation showed that soil samples from on-site and perimeter areas contained radionuclides at very low (activity) concentrations and most were either not detected or below regional statistical reference levels (RSRLs) (equal to the average plus three standard deviations). The few samples with radionuclide concentrations above the RSRLs were collected near known or expected areas of contamination. These samples are below residential screening levels and thus do not pose a potential unacceptable dose to the public.

Table ES-6
Where Can We See LANL Impacts on Mesa-Top Surface Soil that Result in Values Near or Above Background or Screening Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Tritium	Yes, above background at some sites, particularly at TA-54, Area G	No	Far below residential screening levels	Consistently detected in the south sections of Area G, but not increasing
Plutonium-239/240	Yes, above background along State Road 502 at TA-73 (downwind of TA-21) and at TA-54, Area G	Yes, above background along State Road 502 on the west side of the airport (downwind of TA-21) and at LANL/Pueblo de San Ildefonso boundary	Far below residential screening levels	Plutonium-239/240 downwind of TA-21 is highly variable from sample to sample but is generally not increasing. Also, it is consistently detected on the north, northeast, and eastern sections of Area G, mostly not increasing
Other Radionuclides	Mostly depleted uranium at DARHT	Mostly no	Far below residential screening levels	Uranium-238 at DARHT increased through 2006 but decreased in 2007 likely because of the use of steel containment vessels
Inorganic Chemicals	Few detections	Few detections	Far below residential screening levels	Steady
PCBs	Most samples below detection limits. Aroclors 1254 and 1260 detected at Los Alamos Weir	No	Far below residential screening levels	Steady at Los Alamos Canyon weir
High Explosives	Not detected	No	Minimal potential for exposure	None
SVOCs	One sample along State Road 502 at TA-73 in 2006 detected SVOCs	No	Far below residential screening levels; from asphalt (not a LANL source)	None



Although large-scale soil sampling was not conducted in 2008, we annually collect soil samples from two locations on the Pueblo de San Ildefonso land downwind of TA-54, Area G. Radionuclides and metals in these soil samples were below background or near background and were consistent with levels measured in previous years.

- *Soil samples from most off-site locations show radionuclides and metals have not increased over the past years and are mostly at background levels.*
- *Soil samples from most on-site locations show no increases and some decreases of radionuclides and metals from previous years.*

We sampled other soil monitoring sites routinely in 2008 from around the perimeter of Area G and DARHT. Soil samples from around the perimeter of Area G contain above-background concentrations of tritium, americium-241, plutonium-238, and plutonium-239/240. The highest levels of tritium around Area G were detected at the southern end and the highest levels of the americium and plutonium were detected around the northern, northeastern, and eastern sections. Americium-241, plutonium-238, and plutonium-239/240 in soil along the northern, northeastern, and eastern sections of Area G are slightly elevated but consistent with data from previous years, though all levels are well below residential screening levels used to trigger investigations and decrease rapidly with distance from Area G. At DARHT, tritium and uranium-238 were elevated in only one sample from near a firing site but well below residential screening levels. Other constituents such as PCBs, high explosives, and SVOCs were not analyzed in 2008 but were not detected in 2007.

Foodstuffs Monitoring

In 2008, the foodstuffs monitoring focused on the sampling of fish in the Rio Grande and Chama River. We collected fish from three locations upstream (background) of LANL (Abiquiu Reservoir on the Rio Chama and from reaches near Lyden and Pueblo de San Ildefonso on the Rio Grande) and from three locations on the Rio Grande downstream of LANL (at the confluence of Los Alamos Canyon, at the confluence of Sandia/Mortandad Canyons, and from Cochiti Reservoir). We collected two types of fish for study based on their principal feeding strategy: top feeders (or predator fish) and bottom feeders. Fish were analyzed for radionuclides, metals, and PCB congeners. Radionuclide concentrations, for the most part, are similar to past fish surveys and show either no detections or were below background levels. Metals were also not elevated except for mercury, which is generally higher in upstream (above LANL canyons) than downstream fish, indicating no measureable LANL impact. Mercury levels exceed EPA screening levels and are near or above Food and Drug Administration consumption restrictions. Likewise, PCB concentrations are also generally higher directly upstream than downstream, indicating that LANL is not a significant source of PCBs to the Rio Grande. Also, based on the congener and homolog data, the PCBs in fish upstream and downstream of LANL are from the same general source. Fish collected from all upstream and downstream locations exceeded EPA consumption restrictions for PCBs to varying degrees.

- *Both mercury and PCB levels in fish from upstream locations are generally slightly higher than downstream, indicating no measureable LANL contributions.*
- *The types of PCBs are the same in upstream and downstream fish, indicating the same general source.*
- *Both mercury and PCBs in Rio Grande fish are near or above EPA and/or Food and Drug Administration consumption advisory levels.*

Biota Monitoring

Table ES-7 summarizes biota sampling results. In plants collected around Area G, only tritium and plutonium were detected in a few samples closest to the boundary fence and adjacent to known sources of these radionuclides.

Table ES-7
Where Can We See LANL Impacts on Foodstuffs and Biota that Result in Values Near or Above Background or Screening Levels?

Media	LANL Impact	On-Site	Off-Site	Significance	Trends
Wild edible plants	Radionuclides	Tritium in plants from Cañada del Buey	Above background concentrations for strontium-90 in plants from Mortandad Canyon on Pueblo de San Ildefonso land in 2006	Far below screening level; higher strontium-90 in wild plants is a function of low calcium in the soil and not a result of increased contamination levels	Steady
	Inorganic chemicals	No	No	No data	Steady
Native vegetation	Radionuclides	Mostly tritium and plutonium-239/240 at Area G; and depleted uranium at DARHT	No	Far below screening levels	Tritium and plutonium-239/240 are steady at Area G; uranium-238 in trees at DARHT increased through 2006, decreased in 2007
	Inorganic chemicals	Few detections: arsenic in one plant sample at DARHT	No	No	Steady for most metals
Small mammals, bees, and birds	Radionuclides	Depleted uranium at DARHT; some radionuclides in biota upstream of the Los Alamos Canyon Weir and the Pajarito Canyon Flood Retention Structure	No	Far below screening levels	Steady for most radionuclides
	Inorganic chemicals	Some detections in a bird at DARHT	No	One sample out of two	Steady
	PCBs	Detected in mice at the Los Alamos Canyon weir	No	Far below screening levels	Steady
	Species diversity	Abundance and species diversity of birds at DARHT during operations are similar to baseline	None collected	No stress to birds at DARHT	Steady



- *Vegetation at Area G contained elevated levels of radionuclides near known sources.*
- *Biota samples at DARHT contained depleted uranium but the levels were lower than previous years probably because of new contained testing measures.*
- *Biota and sediment samples collected above the Los Alamos Canyon Weir contained slightly elevated levels of some radionuclides and PCBs but far below screening levels.*

In vegetation around the DARHT facility, no significantly elevated levels of radionuclides were detected; the levels are lower than in previous years which may be because testing is now conducted in metal vessels instead of in the open. Mice at DARHT were not elevated in any radionuclides. Bees contained slightly higher levels of barium and copper than previous years. Bird monitoring near the DARHT facility showed a return to baseline (pre-operational) levels of number of birds, number of bird species, and bird diversity and evenness.

Upgradient of the Los Alamos Canyon weir, we measured slightly elevated levels of plutonium, uranium, strontium, and americium in plants. Aroclor 1260 (a type of PCB) was detected in both sediment and mice. The concentrations of all radionuclides, metals, and PCBs in all biotic and abiotic media collected upgradient of the weir were below residential screening levels and do not pose a potential unacceptable dose from radionuclides or risk from non-radionuclides to humans (sediment) or to the biota sampled. Above the Pajarito Canyon Flood Retention Structure, no contaminants are significantly elevated.

Environmental Restoration Program

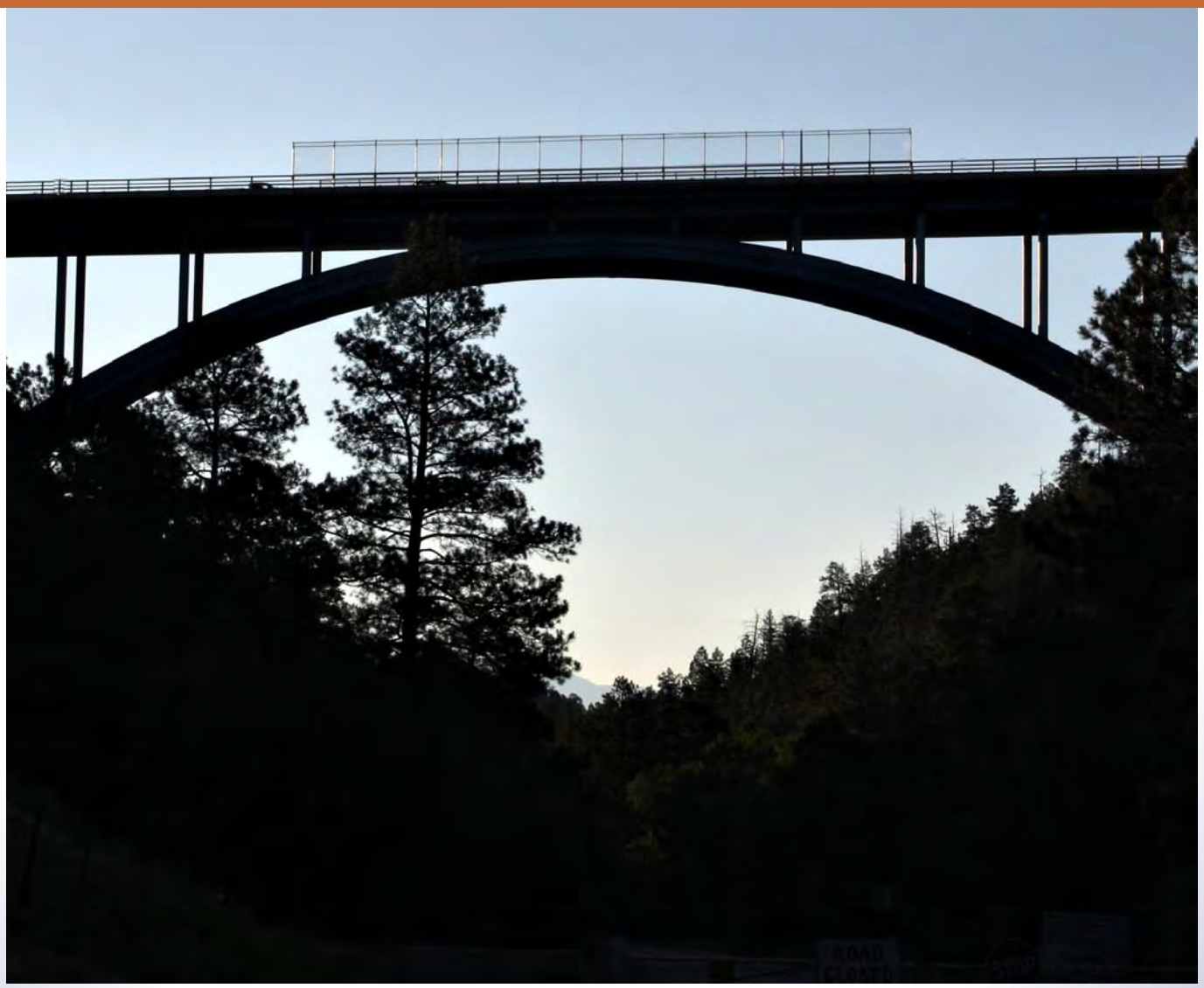
Corrective actions proposed and/or conducted at LANL in 2008 follow the requirements of the NMED Consent Order. The goal of the investigation efforts is to ensure that waste and contaminants from past operations do not threaten human or environmental health and safety. The investigation activities are designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, and watersheds. The characterization activities conducted include surface and subsurface sampling, drilling boreholes, geophysical studies, and installation of monitoring wells. Corrective action activities performed included the removal of structures (e.g., buildings, septic systems, sumps, and drainlines), excavation of contaminated media, and confirmatory sampling. These activities defined the nature and extent of contamination and determined the potential risks and doses to human health and the environment.

- *Characterization and cleanup of sites contaminated or potentially contaminated by past LANL activities follow the Consent Order.*
- *LANL submitted 24 investigation work plans and 22 investigation reports to NMED in 2008.*
- *Thirteen sites were granted certificates of completion.*

Accomplishments include the completion of investigation activities, approvals of proposed investigation activities, and approvals of the work completed at some sites. Numerous sampling activities were conducted in 2008 and included sampling of many locations in the area of the original Laboratory technical areas in Los Alamos townsite; borehole sampling and excavation of soil at former firing sites and explosives development buildings; sampling and digging of test pits in Bayo Canyon where radioactive materials were used; sampling of former septic systems that served abandoned or decommissioned buildings; installing and testing vapor extraction systems near the TA-54 Area G waste storage site; sampling of sediment deposits in the Pajarito Canyon watershed; studying biota including sampling and nest box monitoring in Sandia Canyon; sampling of sediment in Cañada del Buey; and removal of soil and tuff at TA-21. After results are received and interpreted, LANL will document these investigation activities in reports to the NMED. During 2008, environmental restoration activities collected more than 3,400 samples from more than 920 locations and requested more than 423,000 analyses or measurements on these samples.

Under the Consent Order, LANL submitted 24 new or revised investigation work plans and 22 investigation reports to NMED. Three historical investigation reports were also submitted as companion documents to some work plans. In 2008, NMED approved a total of 15 investigation work plans and 9 investigation reports, most with modifications or directions. A total of 13 SWMUs and AOCs were granted certificates of completion, which signifies that the investigations and any necessary cleanups have been completed. In addition, LANL submitted to NMED 24 periodic monitoring reports on sampling activities, 22 reports on groundwater monitoring well activities, and four miscellaneous reports or plans.

1. Introduction



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A. BACKGROUND AND REPORT PURPOSE

1. Introduction to Los Alamos National Laboratory

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. Although planners originally expected that the task would require only 100 scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. Through May 2006, the Laboratory was managed by the Regents of the University of California through the Los Alamos Site Office of the US Department of Energy (DOE). In June 2006, a new management organization, Los Alamos National Security (LANS), LLC, took over management of the 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 develop and apply science and technology to

- Ensure the safety and reliability of the United States' nuclear deterrent;
- Reduce global threats; and
- Solve other emerging national security challenges (LANL 2005a).

LANL defines its vision as: "Los Alamos, the premier national security science laboratory." The Laboratory has identified 12 strategic goals to implement its vision and mission:

- Make safety and security integral to every activity we do.
- Implement an information security system that reduces risk while providing exemplary service and productivity.
- Establish excellence in environmental stewardship.
- Assess the safety, reliability, and performance of LANL weapons systems.
- Transform the Laboratory and the nation's nuclear weapons stockpile to achieve the 2030 vision, in partnership with the [DOE] Complex.
- Leverage our science and technology advantage to anticipate, counter, and defeat global threats and meet national priorities.

- Be the premier national security science laboratory and realize our vision of an organization based upon capabilities.
- Provide efficient, responsive, and secure infrastructure and disciplined operations that effectively support the Laboratory mission and its workforce.
- Implement a management system based upon performance that drives mission and operational excellence.
- Deliver improved business processes, systems, and tools that meet the needs of our employees, reduce the cost of doing business, and improve the Laboratory's mission performance.
- Communicate effectively with our employees, customers, community, stakeholders, and the public at large.
- Develop employees and create a work environment to achieve employee and Laboratory success.

Inseparable from the Laboratory's commitment to excellence in science and technology is its commitment to complete all work in a safe, secure, and environmentally responsible manner. The Laboratory uses Integrated Safety Management (ISM) to set, implement, and sustain safety performance and meet environmental expectations. In addition, the Laboratory uses an International Standards Organization (ISO) 14001:2004 registered Environmental Management System (EMS) as part of ISM to focus on environmental performance, protection, and stewardship (see Section D of this chapter for additional information). The foundation of the EMS and the demonstration of the Laboratory's commitment comprises the LANL environmental policy:

- We approach our work as responsible stewards of our environment to achieve our mission.
- We prevent pollution by identifying and minimizing environmental risk.
- We set quantifiable objectives, monitor progress and compliance, and minimize consequences to the environment, stemming from our past, present, and future operations.
- We do not compromise the environment for personal, programmatic, or operational reasons.

2. Purpose of this Report

As part of the Laboratory's commitment to our environmental policy, we monitor and report on how Laboratory activities are affecting the environment. The objectives of this environmental surveillance report, as directed by DOE Order 231.1 (DOE 2004), are to

- Characterize site environmental management performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment.
- 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.

Over and above the DOE requirements, the Laboratory establishes annual environmental objectives, targets, and key performance indicators through the EMS. The current objectives are to

- Ensure environmental compliance.
- Reduce waste generation.
- Improve Laboratory-wide energy and fuel conservation.
- Dispose of excess items equipment, materials, chemicals, and documents.
- Achieve zero liquid discharge by 2012.

B. ENVIRONMENTAL SETTING

1. Location

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west-oriented canyons cut by streams. Mesa tops range in elevation from approximately 7,800 ft on the flanks of the Jemez Mountains to about 6,200 ft near the Rio Grande 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 US Bureau of Land Management, Bandelier National Monument, the US General Services Administration, and Los Alamos County. The Pueblo de San Ildefonso borders the Laboratory to the east.

2. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. Three major potentially active local faults constitute the modern rift boundary. Studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al., 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-2) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains volcanic center 1.2–1.6 million years ago, the tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft 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 volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. The Cerros del Rio Basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

Surface water in the Los Alamos region occurs primarily as short-lived or intermittent reaches of streams. 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 flows across the Laboratory property before the water is depleted by evaporation, transpiration, and infiltration.



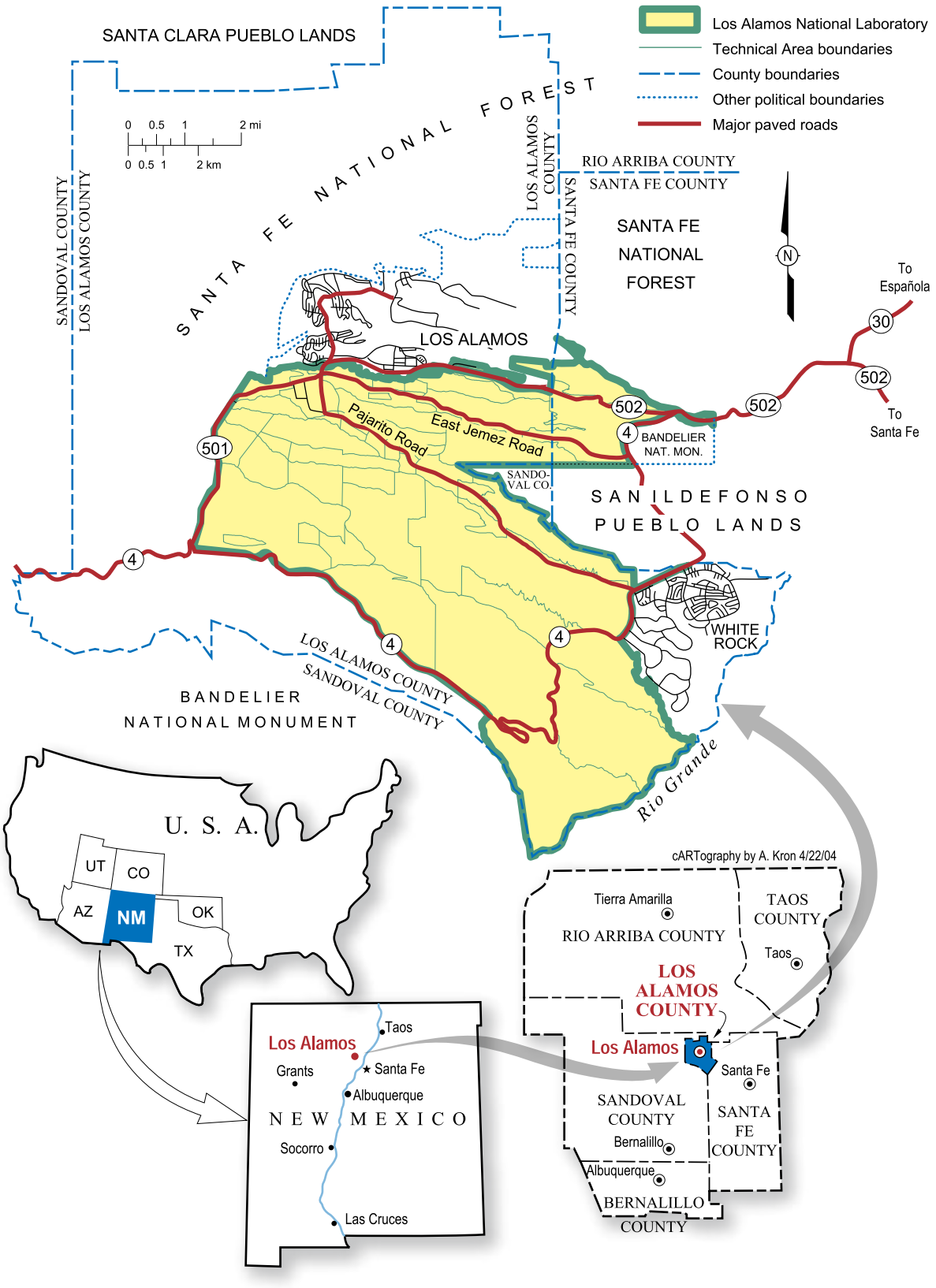


Figure 1-1. Regional location of Los Alamos National Laboratory.

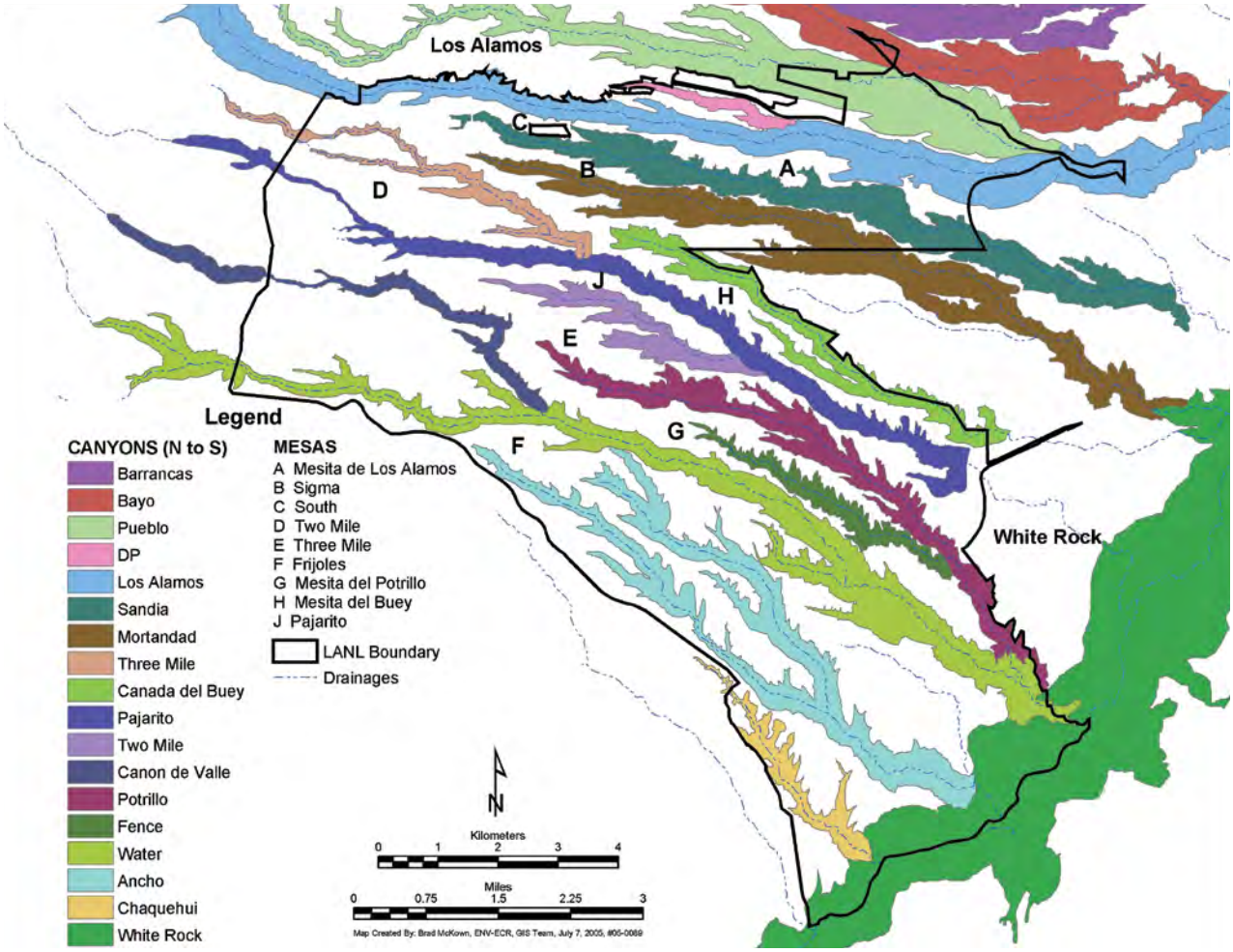


Figure 1-2. Major canyons and mesas on Laboratory land.

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 in artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (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. The regional aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 11.5-mi reach of the river in White Rock Canyon, between Otowi Bridge and the mouth of Rio de los Frijoles, receives an estimated 4,300–5,500 acre-feet (ac-ft) of water from the regional aquifer.

3. Biological Resources

The Pajarito Plateau, including the Los Alamos area, is biologically diverse. This diversity of ecosystems is due partly to the dramatic 5,000-ft elevation gradient from the Rio Grande on the east of the plateau up to the Jemez Mountains 12 mi (20 km) to the west and partly to the many steep canyons that dissect the area. Five major vegetative cover types are found in Los Alamos County. The juniper (Juniperus monosperma Englem. Sarg.)-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 5,600 and 6,200 ft. The piñon (Pinus edulis Engelm.)-juniper cover type, generally between 6,200 to 6,900 ft in elevation, covers large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine (Pinus ponderosa P. & C. Lawson) communities are found in the western portion of the plateau between 6,900 and 7,500 ft in elevation. These three vegetation types predominate the plateau, each occupying roughly one-third of the

Laboratory site. The mixed conifer cover type, at an elevation of 7,500 to 9,500 ft, 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 9,500 to 10,500 ft. Several wetlands and riparian areas enrich the diversity of plants and animals found on the plateau.

In May 2000, the Cerro Grande fire burned more than 43,000 ac of forest in and around LANL. Most of the habitat damage occurred on Forest Service property to the west and north of LANL. Approximately 7,684 ac, or 28% of the vegetation at LANL, was burned to varying degrees by the fire. However, few areas on LANL property were burned severely.

The extreme drought conditions prevalent in the Los Alamos area and all of New Mexico from 1998 through 2003 resulted directly and indirectly in the mortality of many trees. Between 2002 and 2005, more than 90% of the piñon trees greater than 10 ft tall died in the Los Alamos area. Lower levels of mortality also occurred in ponderosa and mixed conifer stands. Mixed conifers on north-facing canyon slopes at lower elevations experienced widespread mortality. These changes likely will have long-lasting impacts to vegetation community composition and distribution.

4. Cultural Resources

The Pajarito Plateau is an archaeologically rich area. Approximately 86% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1,800 sites have been recorded. During fiscal year 2006, sites that have been excavated since the 1950s were removed from the overall site count numbers. Thus, there are fewer recorded sites than the number reported in previous years. More than 85% of the resources are Ancestral Pueblo and date from the 13th, 14th, and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% located between 5,800 and 7,100 ft. Almost three-quarters of all cultural resources are found on mesa tops. 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 more than 400 buildings have been evaluated to date. In addition, "key facilities" (facilities considered of national historic significance) dating from 1963 to the end of the Cold War in 1990 are being evaluated.

5. Climate

Los Alamos County has a temperate, semiarid mountain climate. Large differences in locally observed temperature and precipitation exist because of the 1,000-ft elevation change across the Laboratory site and the complex topography. Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with occasional afternoon thunderstorms. Fall is typically dry, cool, and calm.

Daily temperatures are highly variable (a 23°F range on average). 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 1971 to 2000, the average annual precipitation (which includes both rain and the water equivalent of frozen precipitation) was 18.95 in., and the average annual snowfall amount was 58.7 in. (Note: By convention, full decades are used to calculate climate averages [WMO 1984].) The months of July and August account for 36% 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 convected 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 upslope 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 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, mainly because of the prevailing westerly winds.

C. LABORATORY ACTIVITIES AND FACILITIES

The Laboratory is divided into technical areas (TAs) used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (Appendix C and Figure 1-3). However, these uses account for only a small part of the total land area; much of the LANL land provides buffer areas for security and safety or is held in reserve for future use. The Laboratory has about 2,000 structures, with approximately 8.6 million square feet under roof, spread over an area of approximately 40 square miles.

DOE National Nuclear Security Agency (NNSA) issued a new Site-Wide Environmental Impact Statement (SWEIS) in May 2008 (DOE 2008a) and a limited Record of Decision (ROD) in September 2008 (DOE 2008b). In the SWEIS, LANL identified 15 Laboratory facilities as "Key Facilities" for the purposes of facilitating a logical and comprehensive evaluation of the potential environmental impacts of LANL operations (Table 1-1). Operations in the Key Facilities represent the majority of exposures associated with LANL operations. The facilities identified as "key" are those that house activities critical to meeting work assignments given to LANL and 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
- would be most subject to change as a result of programmatic decisions.

In the SWEIS, the remaining LANL facilities were identified as "Non-Key Facilities" because these facilities do not meet the above criteria. The Non-Key Facilities comprise all or the majority of 30 of LANL's 48 TAs and approximately 14,224 ac of LANL's 26,480 ac (Table 1-1). The Non-Key Facilities also currently employ about 42% of the total LANL workforce. The Non-Key Facilities include such important buildings and operations as the Nonproliferation and International Security Center (NISC), the new National Security Sciences Building (NSSB), which is now the main administration building, and the TA-46 sewage treatment facility.

The operation of the 15 Key Facilities, together with functions conducted in other Non-Key Facilities, formed the basis of the description of LANL facilities and operations analyzed in the 2008 SWEIS for potential environmental impacts (DOE 2008a). The Nicholas C. Metropolis Center for Modeling and Simulation (Metropolis Center) was added as a Key Facility because of the amounts of electricity and water it may use. Security Category I and II materials and operations have been moved from the TA-18 Pajarito Site and it is no longer a Key Facility. Tritium operations at TA-21 have ceased, and both the Tritium Science Test Assembly Facility and Tritium Science and Fabrication Facility are planned for decontamination, decommissioning, and eventual demolition.



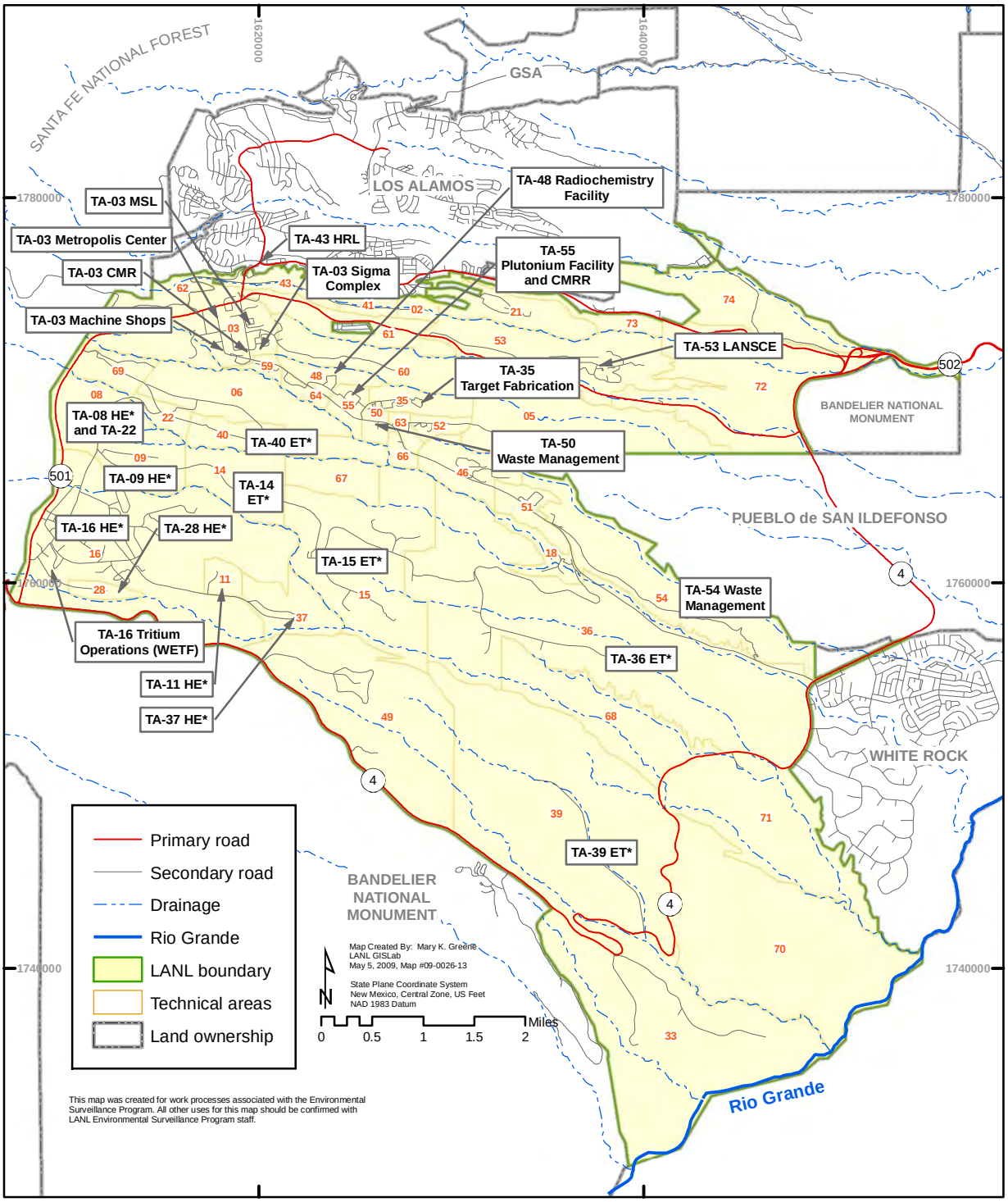


Figure 1-3. Technical Areas and Key Facilities of Los Alamos National Laboratory in relation to surrounding landholdings (*ET = Explosive testing; HE = High explosive processing).



Table 1-1
Key Facilities*

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

* Data from 2008 SWEIS.

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Safety, environmental protection, and compliance with environmental, safety, and health (ES&H) laws and regulations are underlying values of all Laboratory work. The Laboratory uses Integrated Safety Management (ISM) to create a worker-based safety and environmental compliance culture in which all workers are committed to safety and environmental protection in their daily work. A seamless integration of ES&H with the work being done is fundamental. ISM provides the Laboratory with a comprehensive, systematic, standards-based, performance-driven management system for setting, implementing, and sustaining safety performance and meeting environmental expectations. The term "integrated" is used to indicate that safety, protection of the environment, and compliance with ES&H laws and regulations are an integral part of how the Laboratory conducts its work. ISM is the way LANL meets the ethical commitment to avoid injury to people and the environment and the business imperative to meet the safety and environmental requirements of the contract for managing and operating the Laboratory.

Each Laboratory organization is responsible for its own environmental management and performance. Line management provides leadership and ensures ES&H performance is within the context of the Laboratory's values and mission. Laboratory managers establish and manage ES&H initiatives, determine and communicate expectations, allocate resources, assess performance, and are held accountable for safety performance.

Environmental characterization, remediation, surveillance, and waste management programs are part of the Environmental Programs (EP) Directorate. Environmental permitting, the environmental management system, pollution prevention, integrated environmental review, land transfer, the SWEIS, and other environmental risk reduction activities are managed within the Environmental Protection Division in the Environment, Safety, Health, and Quality (ESH&Q) Directorate. An organizational chart and description is available at http://www.lanl.gov/organization/. The major environmental programs and management system are described below.

1. Environmental Management System

The Laboratory is committed to protecting the environment while conducting its important national security and energy-related missions. DOE Order 450.1A, Environmental Protection Program, requires all DOE sites to "implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by Department of Energy (DOE) operations and by which DOE cost effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements." The order further states this objective must be accomplished by implementing an EMS at each DOE site.

LANL has implemented a pollution-prevention-based EMS pursuant to DOE Order 450.1A. The Laboratory met the DOE Order 450.1A requirement to have an EMS implemented by December 31, 2005.

An EMS is a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. DOE Order 450.1A defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." This DOE order mandates that the EMS be integrated with an existing management system already established pursuant to DOE Policy 450.4. Although it significantly exceeds DOE Order 450.1A requirements, LANL pursued and achieved registration to the ISO 14001:2004 standard in April 2006.

A key feature of the Laboratory EMS is the focus on ensuring that it is integrated with existing procedures and systems wherever possible. The intent is for the EMS to consolidate these existing programs into a systematic process for environmental performance improvement.

The ISM provides an important foundation for the five core elements of the EMS:

1. Policy and Commitment
2. Planning
3. Implementation and Operation
4. Checking and Corrective Action
5. Management Review

More information about the EMS may be found at http://ems.lanl.gov/.

The EMS met several milestones in 2008. Multi-disciplinary teams from each directorate executed the EMS process. These organizations identified their activities, products, and services and their potential environmental aspects. They prioritized these aspects to determine which were significant and developed an Environmental Action Plan designed to prevent or eliminate the environmental risk associated with those aspects. The directorate teams were aided by a trained support person from the EMS Management Team, whose members were trained in ISO 14001:2004 systems.

All 15 directorates completed the Directorate Environmental Action Plans. Together, these plans commit to nearly 424 environmental improvement and pollution prevention actions that began in fiscal year 2006. In addition, they developed new action plans to be implemented in 2009.

Registration to the ISO 14001:2004 standard requires extensive management review. External audits of the system have been conducted as follows:

- Kansas City Plant Pre-Audit, September 2004 (three auditors, three days)
- National Sanitation Foundation-International Strategic Registration, Ltd. (NSF-ISR, an independent third-party ISO 14001 registrar) Pre-Assessment, September 2005 (two auditors, three days)

- NSF-ISR Desk Audit, November 2005 (one auditor, two days)
- NSF-ISR Readiness Review, Phase 1 Audit, January 2006 (two auditors, three days)
- NSF-ISR Certification Audit, Phase 2 Audit, March 2006 (five auditors, five days)
- NSF-ISR Surveillance Audit 1, September 2006 (two auditors, three days)
- NSF-ISR Surveillance Audit 2, April 2007 (two auditors, three days)
- NSF-ISR Surveillance Audit 3, October 2007 (two auditors, three days)
- NSF-ISR Surveillance Audit 4, May 2008 (two auditors, three days)
- NSF-ISR Surveillance Audit 5, May 2008 (two auditors, three days)

These audits covered most of the directorates and divisions and all major support contractors and included interviews conducted from the Principal Associate Director level to individual staff and students chosen at random by the auditors. The auditors concluded that the Laboratory's EMS meets all the requirements of the ISO 14001:2004 standard with no major nonconformities and recommended that LANL maintain full certification. On April 13, 2006, LANL received full certification of its EMS to the ISO 14001:2004 standard. LANL was the first NNSA national laboratory and was the first University of California-operated facility to receive this distinction.

NNSA and DOE recognized the success of the EMS management and the unique approach by giving the Laboratory the 2009 NNSA "Best in Class" Award and the "DOE E-Star" for the institutional improvements identified and implemented through the EMS from 2006 to 2008.

A second important component of the EMS is the institutional environmental stewardship and management support programs. These programs, described in the following sections, assist with the integration of job and work-specific evaluations and ensure natural and cultural resources are managed from a Laboratory-wide perspective.

2. Waste Management Program

Research programs that support the Laboratory's mission generate contaminated waste that must be properly managed to avoid risks to human health, the environment, or national security. Remediation of sites contaminated by past Laboratory operations also generates substantial volumes of waste. The Laboratory generates Resource Conservation and Recovery Act (RCRA) regulated waste, Toxic Substances Control Act regulated waste, low-level radioactive waste (both solid and liquid), mixed low-level waste, transuranic waste, administratively controlled waste, medical waste, New Mexico Special Waste, and sanitary solid and liquid waste. Certain wastes are treated and/or disposed of at the Laboratory, but most wastes are shipped off-site for treatment and final disposal.

The Laboratory's goal is to minimize hazardous and nonhazardous waste generation as much as is technically and economically feasible, as discussed in Section 3 below. The Laboratory also strives to conduct waste management operations in a manner that maintains excellence in safety, compliance, environment, health, and waste management operations. This goal is accomplished through the following program tenets:

- Ensuring a safe and healthy workplace;
- Minimizing adverse impact to the general public;
- Minimizing adverse impact to the environment; and
- Ensuring compliance with all applicable laws, standards, and regulations governing environment, safety, and health.



LANL manages all waste management and disposal operations, except sanitary solid and liquid wastes, under its Environmental Programs Directorate. TA-54, Area G, managed by the Waste Disposition Project, is the Laboratory's primary solid radioactive and hazardous waste handling site. Thousands of drums of packaged transuranic waste are securely stored at this site awaiting transport to the DOE's Waste Isolation Pilot Plant (WIPP) near Carlsbad, NM. The site also receives, processes, and disposes of approximately 4,000 m^3 of low-level radioactive waste per year. In the past, wastes were often buried in or released to pits or trenches around the Laboratory; several of these areas, known as Material Disposal Areas (MDAs), have been remediated, and the remainder are either being investigated or undergoing remediation as discussed in Section 4 below.

The Radioactive Liquid Waste Program manages the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. The RLWTF treats approximately 1.6 million gal./year of radioactive liquid waste.

The Water Quality and RCRA Group in the Environmental Protection Division provides guidance and support to Laboratory waste generators on compliance with all waste handling requirements. Within the EP Directorate, both the Waste Disposition Project and the Waste and Environmental Services Division provide direct support to waste generators on specific aspects of waste packaging, waste acceptance criteria, and transportation of hazardous and radioactive wastes for proper treatment and disposal.

The Waste Disposition Project also operates the "Green is Clean Program" to reduce low-level radioactive waste generation through a waste segregation and verification program. Generators segregate clean waste from radioactive-contaminated waste and ship it to TA-54, Area G, for verification through a very sensitive radioactive measurement system.

3. Pollution Prevention Program

The Pollution Prevention (P2) Program implements waste minimization, pollution prevention, sustainable design, and conservation projects to enhance operational efficiency, reduce life-cycle costs of programs or projects, and reduce risk to the environment. Reducing waste directly contributes to the efficient performance of the Laboratory's national security, energy, and science missions. Specific P2 activities include the following:

- Collecting data and reporting on DOE P2 goals;
- Forecasting waste volume to identify P2 opportunities;
- Conducting P2 opportunity assessments for customer divisions;
- Providing technical support for pollution prevention;
- Funding specific waste reduction projects through the LANL Generator Set-Aside Fund Program;
- Supporting affirmative procurement efforts;
- Conducting an annual LANL P2 awards program to recognize achievements;
- Supporting sustainable design for the construction of new buildings; and
- Communicating P2 issues to the Laboratory community.

The Laboratory's P2 Program continues to be recognized for its accomplishments. The Laboratory received eight national NNSA Pollution Prevention awards for Laboratory projects in fiscal year 2008. Projects in fiscal year 2008 yielded more than $7 million in savings to the Laboratory. The P2 Program was instrumental in incorporating preventive measures into the EMS, and the Laboratory received ISO 14001 certification. The P2 Program received an overall performance rating of "Good" for fiscal year 2008. The P2 projects collectively avoided the treatment of 241,745 liters of radioactive liquid waste, 482 tons of solid waste; 48 metric tons of hazardous waste, 3.4 metric tons of mixed low-level waste, and 2,124 cubic meters of low-level waste.

LANL won eight NNSA awards in 2008. Award categories and titles are as follows:

NNSA Best in Class Awards:

- Wastewater Recycling at the Radioactive Liquid Waste Treatment Facility
- Ultrapure Carbon and Carbon Nitride Nanomaterials

NNSA Environmental Stewardship Awards:

- Steam Generator Optimization
- Perchloric Acid Exhaust System
- Recycling of Asphalt, Soil, and Mulch
- Mixed Office Paper Recycling
- Integrating Safety and Security in the Environmental Management System
- Uninterruptible Power Supply Project

"Green purchasing" is mandated by an executive order and calls for considering environmental factors in purchasing decisions in addition to traditional factors such as performance, price, health, and safety. Green purchasing, also known as affirmative procurement, is procurement of products or services considered to be environmentally preferable, meaning those products that have a comparatively smaller negative effect on human health and the environment. The aim is to eliminate waste, prevent pollution, and improve the quality of the environment. The Laboratory established new contracts in 2008 for office supplies and other goods and services with a strong emphasis on green product offerings.

4. Environmental Restoration Programs

The environmental restoration and cleanup work at LANL is organized into several projects that have responsibility for different aspects of environmental restoration:

- Water Stewardship Program (includes investigations and remediations in canyons)
- TA-21 Closure Project
- Corrective Actions Project

The goal of these programs is to ensure that residual contaminants from past Laboratory operations do not threaten human or environmental health and safety. To achieve this goal, the Laboratory is investigating and, as necessary, remediating sites contaminated by past Laboratory operations. In calendar year 2008, fieldwork at several sites was either implemented, ongoing, or completed. Much of the work under these projects is subject to the requirements in the Compliance Order on Consent (Chapter 2, Section B.1). Most environmental sample analyses (64%) were for characterization or assessment of sites being investigated or cleaned up at LANL (Table 1-2). Chapter 9 summarizes the cleanup work conducted or completed in calendar year 2008.

After sites have been remediated, long-term monitoring may be required as part of the chosen remedy solution. Such monitoring will eventually become part of the existing environmental surveillance programs and will fulfill DOE requirements for a long-term environmental stewardship program.



Table 1-2
Approximate Numbers of Environmental Samples, Locations, and Analytes Collected in 2008

Sample Type or Media	Locations	Samples	Analytes or Measurements
Ambient Air*	60	2,878	9,184
Stack Monitoring	28	3,012	22,921
Biota	7	40	2,338
Soil	27	51	892
Sediment	42	60	7,277
Foodstuffs	6	144	13,123
Groundwater	222	552	197,976
Surface Water Snowmelt	28	28	2,024
NPDES Outfalls	12	107	1,659
Surface Water Base Flow	34	79	24,762
Surface Water Storm Runoff	170	286	14,185
Neutron Radiation	47	188	188
Gamma Radiation	89	356	356
Environmental Restoration	928	3,404	423,362
Totals:	**1,700**	**11,185**	**720,247**

Note: Not all the data counted in the table above are reported in this document.

* Does not include particulate (in air) measurements made by six Tapered Element Oscillating Microbalance instruments that calculated particulate concentrations every half hour.

5. Compliance and Surveillance Programs

LANL's environmental compliance and surveillance programs identify possible environmental hazards and impacts by regularly collecting samples and comparing results with previous results and applicable regulatory standards. The Laboratory routinely collects samples of air particles and gases, water, soil, sediment, foodstuffs, and associated biota from over 1,660 locations (Table 1-2).

All monitoring data collected at LANL is available through the RACER Data Analysis Tool (http://www.racernm.com/). This tool was developed to provide public access to the same data that NMED and LANL use in making remediation and other environmental management decisions.

In 2008, LANL re-initiated the effort to pursue a natural resources damages assessment (NRDA) for LANL. The goal of the NRDA is to assess and recover monetary damages for injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances to the environment from the area of LANL. A draft pre-assessment, the initial step in the NRDA process, was completed in late 2008. See Chapter 2 for more information.

Monitoring can detect and identify environmental impacts from hazardous and radioactive materials and data from monitoring can be used to help with mitigation of any impacts. To this end, each pathway by which an individual could be exposed is monitored. The sensitivity of environmental surveillance measurements allows for the detection of contaminants during cleanup or normal operations. Additional monitoring may be conducted in places where there is an increased potential for environmental releases. In some cases, immediate actions are warranted because of monitoring results. The various environmental monitoring programs are discussed below.

a. Air Quality Monitoring

The Laboratory maintains a rigorous ambient air surveillance and 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 (AIRNET).

The Laboratory also works with and assists neighboring communities and pueblos in performing ambient air, direct penetrating radiation, and meteorological monitoring.

i. Compliance and Permitting

The Laboratory operates under a number of air emissions permits issued by the New Mexico Environment Department (NMED) and approvals for construction of new facilities or operations by the US Environmental Protection Agency (EPA). These permits and approvals require pollution control devices, stack emissions monitoring, and routine reporting.

LANS is authorized to operate applicable air emission sources at LANL per the terms and conditions as defined in Operating Permit No. P100-M2. As part of the Title V Operating Permit program, the Laboratory reports emissions from sources included in the Operating Permit twice a year. In 2008, the Laboratory submitted its new Title V permit application for a five-year renewal. The new permit is expected to be issued in 2009.



In addition, the Laboratory maintains compliance with Title VI of the Clean Air Act, which regulates the use of ozone-depleting substances, such as halons and refrigerants. The Laboratory maintains records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants.

To ensure compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAP) for asbestos, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly. During 2008, the Laboratory had 18 major renovation or demolition projects that involved removal of asbestos. LANL also reports emissions from chemical use associated with research and permitted beryllium activities.

In 2008, the Laboratory received a New Source Review air quality permit modification for a generator located at TA-33. The modification involved a record-keeping condition for tracking operating hours.

Chapter 2 of this report describes in greater detail these permits and the status of compliance; this information is also available online at http://www.lanl.gov/environment/air/.

ii. Stack Monitoring

As described in greater detail in Chapters 2 and 4, LANL rigorously controls and monitors stack emissions of radioactivity, as required by the Clean Air Act. Members of the Rad-NESHAP team at LANL evaluate these operations to determine potential impacts of the stack emissions on the public and the environment. This team continuously sampled 26 stacks at LANL for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP).

For particulate matter, a continuous sample of stack air is pulled through a glass-fiber filter that captures small particles of radioactive material. Charcoal filters are used to capture radioactive vapors and highly volatile compounds. Tritium emissions are measured with a device called a bubbler, which pulls air through a series of vials that contain ethylene glycol and absorbs tritium from the sample air stream. GMAP emissions are measured in real time by pulling air through an ionization chamber that measures the total amount of radioactivity in the sample and records the results on a strip chart.

During 2008, the off-site dose impact from LANL stack emissions was about 5.5% of the Clean Air Act standard for radionuclide emissions.

iii. Ambient Air Monitoring

The Laboratory operates an extensive network of ambient air quality monitoring stations (AIRNET) to detect other possible radioactive emissions (see Chapter 4). The network includes stations located on-site, in adjacent communities, and in regional locations. These stations are operated to ensure that air quality meets EPA and DOE standards. These data are published in this report (see Chapter 4) and online at http://www.lanl.gov/environment/air/. During 2008, the AIRNET system did not detect any radionuclide concentrations of concern.

b. Water Resources Monitoring

The water resources monitoring and compliance efforts consist of three main parts: compliance and permitting, groundwater monitoring, and surface water monitoring.

i. Compliance and Permitting

The Laboratory's Water Quality and RCRA Group is responsible for all compliance and permitting functions related to the state Water Quality Act and federal Clean Water Act requirements. The group provides institutional expertise and implementation assistance for obtaining regulatory permits and maintaining compliance with all permit requirements. These functions include sampling, processing, and analyzing water and wastewater from treatment facilities; institutional coordination, integration, and communication of all wastewater resource-related monitoring and reporting activities; submitting permit applications, notices of intent to discharge, analytical data, and compliance documentation; interpretation of major state and federal water quality laws and regulations; development of institutional standards and policy regarding water and wastewater with line organizations; and interaction with regulatory agencies, stakeholders, the public, and Native American pueblos on water quality or water resource management issues.

ii. Groundwater Monitoring

The LANL Water Stewardship Program manages and protects groundwater and surface water resources (see Chapters 5 and 6). The Laboratory conducts several activities to comply with the requirements of DOE orders, state and federal regulations, and the Consent Order.

Groundwater resource management and protection efforts at the Laboratory focus on (1) the regional aquifer underlying the plateau, (2) the shallow perched groundwater found within canyon alluvium, and (3) the perched groundwater at intermediate depths above the regional aquifer. The objectives of the Laboratory's groundwater programs are to determine compliance with liquid waste discharge requirements and to evaluate any impact from Laboratory activities on groundwater resources. This program includes environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations.

The Los Alamos County water supply system contains no detected LANL-derived contaminants. At present, the major thrust of the water-monitoring program, being developed in cooperation with NMED, is directed toward estimating the prospective risk from contamination that may enter the drinking water in the future. One such activity is modeling to estimate the possibility of contaminants migrating from the surface through the vadose zone to the aquifer. Data show that plutonium, uranium, cesium, and strontium are tightly bound to the soil matrix and so will not migrate in measurable amounts. Tritium is more mobile, but its migration is slower compared with its approximately 12-year radioactive half-life, so the concentrations of tritium in drinking water will remain far below drinking water standards. Thus, migration of radionuclides is not likely to be a problem, so attention is focused on migration of chemicals such as perchlorate, chromium, and high explosive residues.

LANL has drilled numerous additional monitoring wells over the past several years, and many more were drilled in 2008. These new wells will provide a better picture of the location and movement of contamination in the groundwater. Details of the new wells are provided in Chapter 2.

iii. Surface Water Monitoring

LANL's surface water protection efforts focused on monitoring surface water and stream sediment in northern New Mexico. The objectives of the surface water program are to address water pollution control compliance,

environmental surveillance, watershed management, surface and ground water protection, drinking water quality protection, pesticide protection obligations, and public assurance needs. Samplers at more than 290 sites are set to collect samples when sufficient water is present during storm runoff events. The Laboratory analyzes samples for radionuclides, high explosives, metals, a wide range of organic compounds, and general chemistry.

c. Biological Monitoring

The LANL biological resources program focuses on assisting Laboratory projects and programs to comply with federal and state laws and regulations, DOE Orders, and LANL directives related to biological resources. LANL adopted a Biological Resources Management Plan in 2007. This document, along with LANL's 2005 revision of its Threatened and Endangered Species Habitat Management Plan, provides guidance for biological resources protection at LANL. The presence of federally listed species is monitored annually. In addition, the biological resources program is currently conducting an inventory of riparian habitats at LANL and is continuing a project to monitor state-listed species such as the Gray Vireo and Jemez Mountains Salamander.

LANL's Emergency Management and Response Division manages wildland fire, including fuels monitoring and treatment on LANL property. One of the lasting results of past wildfires in and around LANL has been a significant increase in a regional, multi-agency approach to managing wildland fire. In September 2007, the Laboratory adopted the Wildland Fire Management Plan, which provides a strategic program to manage risk associated with wildland fires (LANL 2007).

d. Soil, Foodstuffs, and Non-foodstuff Biota Monitoring

The Laboratory collects surface soil, foodstuffs, and non-foodstuffs biota from the Laboratory, perimeter communities (Los Alamos, White Rock, and surrounding pueblos), and regional (background) areas to determine whether Laboratory operations impact human health via the food chain and the environment. The Laboratory conducts these programs to comply with the requirements of DOE Orders and state and federal regulations. Samples of the various media are collected on a three-year rotating schedule and analyzed for radionuclides, heavy metals, and organic chemicals to determine concentrations and distribution in soil and potential uptake by plants, animals, and humans. Radiation doses to humans and biota (see Chapter 3) and changes in concentrations over time are also measured and analyzed. These data are published in Chapters 7 and 8 of this report and other Laboratory publications.

Monitoring of soil, foodstuffs, and non-foodstuffs biota is an important indication of the health of the environment. Soil and sediment monitoring has established a baseline of known contamination concentrations in selected areas on Laboratory property, in surrounding areas, and regionally. Comparison of known concentrations with future results may indicate movement of contaminants.

Collection and analysis of foodstuff (crops, game animals, fish, honey, milk, etc.) from the region provides confidence that no unexpected contamination has reached off-site locations. Since the 1990s, the program has identified polychlorinated biphenyls (PCB) and mercury levels above EPA and NMED fish advisory levels in some types of fish both upstream and downstream of LANL in the Rio Grande.



Biota monitoring is a non-invasive method of detecting underground materials. The roots of some plants and trees penetrate into subsurface contamination and may bring contaminated material to the surface. For example, vegetation samples collected annually at Area G in TA-54 demonstrate low concentrations of isotopic plutonium (approximately 1 pCi/g or less) in the soil toward the north and east of Area G (Chapter 8). Tree samples indicate an area of underground tritium along the south fence of MDA G. At MDA B, tree samples from 2006 along the northern fence showed above-background plutonium-239 concentrations and cesium-137 concentrations, which indicate radioactive materials are within reach of the roots. Also, previous samples of chamisa within the fenced area of Bayo Canyon indicate underground concentrations of cesium on the order of 1,000 pCi/g near the southwest corner of former TA-10 (Fresquez et al 1995).

e. Radiation Monitoring

Gamma and neutron radiation is monitored by the direct penetrating radiation monitoring network (DPRNET) described in Chapter 4.

The largest source of direct radiation is TA-54, Area G, which is monitored at 33 DPRNET stations, all of which measure above-background intensities of neutron radiation. As discussed in Chapter 3, the all-pathway maximally exposed individual (MEI) is at the northern boundary of TA-54 and results primarily from neutrons. The neutron radiation is being reduced by removing the sources from Area G.

Though high radiation levels are not expected from TA-21 during the upcoming cleanup at that site, several new DPRNET stations were installed in 2006 along DP Road and State Road 502, between the potential sources at TA-21 and the public areas to the north and west.

Though not required for compliance purposes, the Laboratory operates several Neighborhood Environmental Monitoring Network (NEWNET) stations that measure gamma radiation levels at 15-minute intervals and post these data to the NEWNET website in near real time (http://newnet.lanl.gov/). Stations are located near the Laboratory boundary and in the nearby communities of Los Alamos, Pueblo de San Ildefonso, and Santa Clara Pueblo. The stations at East Gate and Mortandad Canyon are used to check the dose from LANSCE emissions. During 2008, the dose measured by NEWNET was 0.0 ±0.3 mrem. The data from these stations are available on the NEWNET website and are not discussed further in this report.

f. Cultural Resources Protection

The Laboratory manages the diverse cultural resources according to the requirements of the National Historic Preservation Act and other federal laws and regulations concerned with cultural resources protection. Cultural resources include archaeological sites and associated artifacts, historic buildings and associated artifacts, and traditional cultural places of importance to Native American and other ethnic groups. Section 106 of the Act requires federal agencies to take into account the effects of projects on historic properties and to allow review and comment by the State Historic Preservation Office and the Advisory Council on Historic Preservation. The Section 106 regulations outline a project review process that is conducted on a project-by-project basis.

The Laboratory has adopted a Cultural Resources Management Plan (LANL 2005b) as an institutional comprehensive plan that defines the responsibilities, requirements, and methods for managing its cultural properties. The plan provides an overview of the cultural resources program, establishes a set of procedures for effective compliance with applicable historic preservation laws, addresses land-use conflicts and opportunities, ensures public awareness of DOE's cultural heritage stewardship actions at LANL, and provides a 10-year road map that summarizes and prioritizes the steps necessary to manage these resources.



E. RISK AND HAZARD REDUCTION

The Laboratory is committed to reducing hazards and the associated risk to people and the environment. Current risk depends on the amount of hazardous material that actually reaches a receptor, whereas prospective risk depends on the amount of hazardous material and the probability of exposure in the future. Risk is often given as a range of concentrations and risks (expressed as a dose) rather than a single number or set of numbers due to the uncertainties associated with predicting future concentrations and exposures. For example, buried hazardous material may have little or no exposure under current conditions but may have an increased probability of exposure over time. In addition, if the material is brought to the surface either now or in the future, the potential for exposure and risk increases substantially.

1. Estimation of Risk

Risk is evaluated either as current (present-day) risk or prospective risk (defined by the EPA as "the future risks of a stressor not yet released into the environment or of future conditions resulting from an existing stressor"). The stressor (also known as a hazard) could be a radionuclide, a chemical, or a combination for which the potential risk is evaluated based on protective assumptions under a reasonable exposure scenario(s), safety analysis, or model.

The terminology used in describing the current risk is whether a potential unacceptable risk is present or not. The "acceptable" nature is determined by target levels dictated by the regulatory authorities (NMED or DOE) and are equal to or less than a 10^{-5} (1 in 100,000) probability of cancer, a hazard index equal to 1.0 or less for noncancer-causing chemicals (indicates that no adverse [noncancer] human health effects are expected to occur), and a dose of 15 mrem/yr or less for radionuclides. In keeping with the policy of maintaining all dose and risk as low as reasonably achievable, the Laboratory strives to reduce risk/dose to below these target levels whenever possible. For the MEI reported in Chapter 3 of this report, the calculated cancer risk from the estimated dose in 2008 was approximately 3×10^{-7} (a 3 in 10,000,000 chance of cancer).

To analyze current and prospective risk, LANL uses environmental data, computer evaluation tools, and computer models. The Laboratory uses models such as the residual radioactivity (RESRAD) model (http://web.ead.anl.gov/resrad/), Hotspot (http://www.llnl.gov/nhi/hotspot/), and CAP88 (http://www.epa.gov/radiation/assessment/CAP88/index.html) to evaluate potential risk based on material inventory buried or stored at a site or in transport (e.g., from the surface to the regional aquifer).

Prospective risk is also used to aid in the evaluation of remediation and corrective measure options. Probabilistic models account for physical system uncertainties within the context of the decisions under consideration. Prospective risk methods can also identify the additional data needed to determine the optimal decision, thus guiding data collection operations.

2. Examples of Risk Reduction

The following are examples of where current or past Laboratory operations have resulted in the storage of large quantities of wastes or the release of contaminants to the environment and where the Laboratory is working to reduce both current and prospective risks.

a. TA-54, Area G, and MDA G

The transuranic waste disposition program expedites the disposal of legacy transuranic waste to WIPP in Carlsbad, NM, and ensures appropriate facilities and equipment are available to facilitate disposal of current and future transuranic wastes. Area G stores substantial amounts of radioactively contaminated waste and other contaminated materials in aboveground storage. MDA G is a subsurface disposal site containing potentially hazardous and radioactive wastes from operational activities and wastes from environmental restoration and demolition activities at the Laboratory. MDA G was also used for the retrievable storage of transuranic waste. Most of the waste will eventually be transported to permanent storage at the Waste Isolation Pilot Plant (WIPP) in southern New Mexico.

As discussed in Chapter 3, the dose to the all-pathway MEI results from neutrons emitted from the transuranic waste at Area G (about 1 mrem/yr in 2008). The primary method used to reduce both the current and prospective risk at Area G is to steadily reduce the inventory of transuranic waste by transporting drums of radioactive material to WIPP. Of the approximately 120,000 plutonium equivalent curies (PE-Ci) of radioactive materials in secure aboveground storage at Area G, the Laboratory shipped approximately 25,000 PE-Ci in 2,000 drums to the WIPP in 2008. Additionally, the Laboratory disposed of 36 drums of radioactive sealed sources, recovered by the Off-Site Source Recovery Program, at WIPP.

In November 2008, the Laboratory completed a commitment to the Defense Nuclear Facility Safety Board to disposition some of the highest-risk transuranic waste stored at Area G. This campaign, which started in early 2007, comprised 282 drums of high-activity waste and over 23,000 PE Ci of activity. The shipping strategy for 2009 will focus on reducing the overall volume of transuranic waste stored at Area G with priority given to dispositioning the higher-activity materials when available. Starting in 2011, waste buried in retrievable forms in MDA G will be excavated, characterized, and shipped to WIPP. All retrievably stored transuranic wastes are scheduled to be removed by late 2013.

b. TA-21

TA-21 is the site of the Laboratory's original plutonium processing facility, a tritium processing and handling facility, and several MDAs. The inventories of hazardous and radioactive material at the MDAs are not well characterized because there are few records of waste disposal during the 1940s and the Manhattan Project. MDAs V and U have been remediated; MDAs A and T have or will undergo corrective measures evaluations to determine the appropriate corrective actions; and MDA B is scheduled to be remediated. In addition, the other sites at TA-21 are being characterized or remediated as part of the DP Site Aggregate Area investigation.

c. Groundwater

As discussed in detail in Chapter 5, Groundwater Monitoring, Laboratory-derived impacts to groundwater have been detected in some monitoring wells. At present, there is no measurable LANL-derived contamination in the Los Alamos County drinking water system, but there may be a prospective risk because of the potential for contamination to migrate to the drinking water supply wells. For the past several years, efforts have been underway to evaluate groundwater quality and augment the current monitoring network to ensure monitoring activities will detect contamination in groundwater before it can affect the drinking water. Most of the numerous additional monitoring wells installed in the past several years have been installed as part of the investigation of the known chromium contamination under Sandia and Mortandad Canyons.

d. Environmental Characterization and Restoration

The objective of the environmental investigation and cleanup activities at the Laboratory is to identify and characterize releases (the nature of the contamination), the location and extent of the contamination, whether it requires remediation (poses a potential unacceptable risk to humans or the environment), and what type of remediation is appropriate. Over the past few years, the Laboratory has been conducting corrective action activities under the Consent Order, which specifies requirements and goals to be met. LANL wrote or revised 24 work plans and 22 reports and submitted them to the NMED.

In the past several years, the Laboratory has determined where contamination is present and in many cases has reduced the legacy contamination. Where contamination is present, the risk is quantified to determine whether it is unacceptable to human health and the environment. Table 9-3 in Chapter 9 lists the sites for which corrective actions were completed and approved by NMED in 2008.

Numerous sampling and remediation activities were conducted in 2008 and included sampling and removal of contaminated soil around the former high explosives processing facility, sampling from 55 boreholes and several test pits in Bayo Canyon where explosives research was conducted from 1943 through 1961, drilling of vapor sampling holes and installation of vapor sampling test systems around three former waste disposal sites, and

drilling of several additional regional monitoring wells in Mortandad and Sandia Canyons to characterize the migration of legacy chromium contamination.

Previous risk reduction successes include the cleanup of the Los Alamos County Airport area at TA-73, which contained landfills, septic systems, an incinerator and surface disposal area (Airport Ashpile), and other miscellaneous sites; and MDA V at TA-21 where three absorption beds and other contaminated soil and tuff were excavated.



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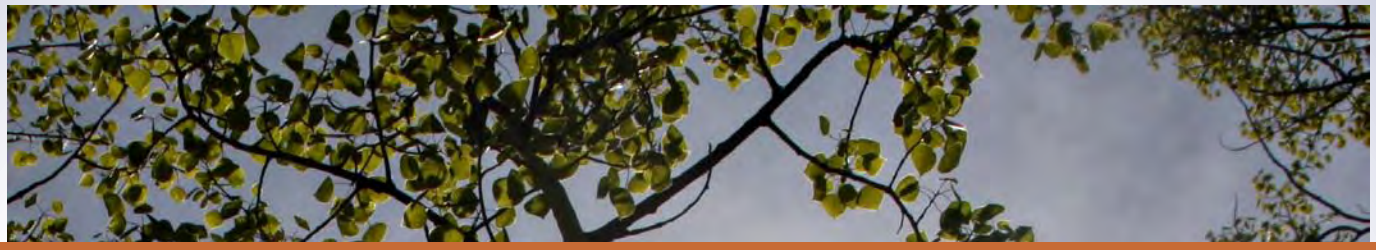
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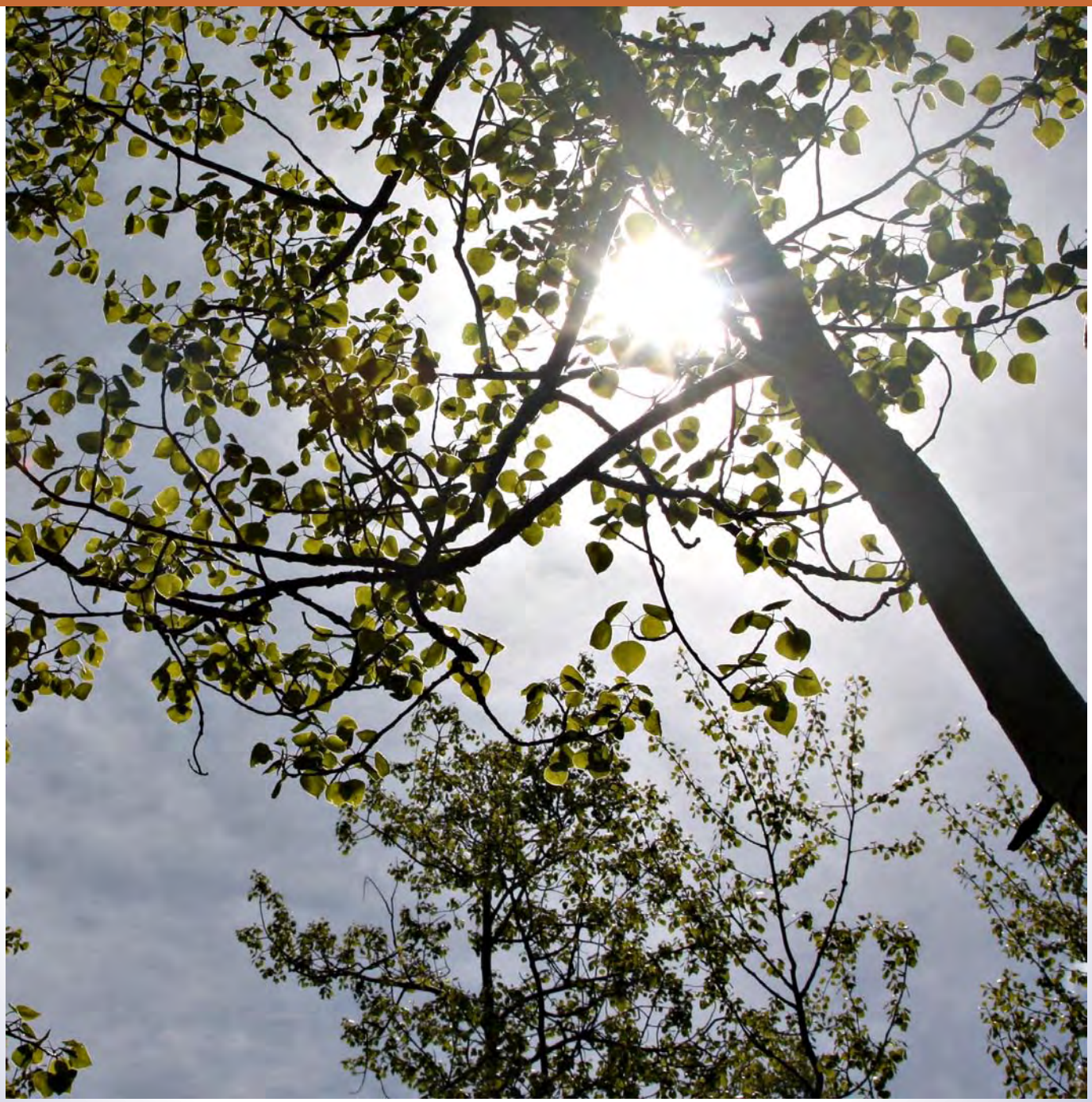
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2. Compliance Summary



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A. INTRODUCTION

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) use or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. Laboratory policy implements US Department of Energy (DOE) requirements by directing employees to protect the environment and meet compliance requirements of applicable federal and state environmental regulations. Federal and state environmental laws address: (1) handling, transporting, releasing, and disposing of contaminants and wastes; (2) protecting ecological, archaeological, historic, atmospheric, soil, and water resources; and (3) conducting environmental impact analyses. Regulations provide specific requirements and standards to ensure maintenance of environmental quality. The US Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. DOE and its contractors are also subject to DOE-administered requirements for control of radionuclides. Table 2-1 presents the environmental permits or approvals the Laboratory operated under in 2008 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2008. The following sections summarize the Laboratory's regulatory compliance performance during 2008.

B. COMPLIANCE STATUS

The Laboratory continues to meet requirements under the Clean Water Act (CWA). The year 2008 was the first complete year the Laboratory operated under the current National Pollutant Discharge Elimination System (NPDES) permit for industrial and sanitary waste water discharges (effective August 1, 2007). During 2008, none of the 77 samples collected from the Sanitary Wastewater Systems (SWWS) Plant's outfall exceeded Clean Water Act effluent limits. Only six of the 1300 samples collected from industrial outfalls exceeded effluent limits: four chlorine exceedances and two pH exceedances. The inspection compliance rate for NPDES-permitted construction sites in 2008 was maintained at the 2007 rate of 99%.

The Laboratory continues to be well below all Clean Air Act (CAA) permit limits for emissions to the air.



Table 2-1
Environmental Permits or Approvals under which the Laboratory Operated during 2008

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Permit	Hazardous Waste Facility Permit – Permitted hazardous waste storage units: Technical Areas 50 & 54	November 1989	November 1999*	NMED[b]
	40 CFR 265 Standards – Interim Status hazardous waste storage and treatment facilities: Technical Areas 3, 14, 16, 36, 39, 50, 54, & 55. Permit applications submitted to NMED.	Post 1980 – hazardous waste units; Post 1991 – mixed waste units	Inclusion in Hazardous Waste Facility Permit or closure	NMED
HSWA[c]	RCRA corrective activities	March 1990	December 1999*	NMED
Consent Order	Legacy and contaminated waste site investigations, corrective actions, and monitoring; revised to establish new notification and reporting requirements for groundwater monitoring data	March 1, 2005; revised June 18, 2008	September 20, 2015	NMED
CWA[d]/NPDES[e]	Outfall permit for the discharge of industrial and sanitary liquid effluents	August 1, 2007	July 31, 2012	EPA[f]
	MSGP[g] for the discharge of storm water from industrial activities	October 30, 2000; new permit September 29,2008	September 29, 2013	EPA
	Federal Facility Compliance Agreement for storm water discharges from Solid Waste Management Units (SWMUs)	February 5, 2005	Upon issuance of the Individual Permit (issued April 1, 2009)	EPA
	Construction General Permits (17) for the discharge of storm water from construction activities	July 1, 2003	June 30, 2008*	EPA
CWA Sections 404/401	COE[h] Nationwide Permits (1)	NA	NA	COE/NMED
Groundwater Discharge Plan, TA-46 SWWS Plant[i]	Discharge to groundwater	July 20, 1992 Renewed January 7, 1998	January 7, 2003*	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid-Waste Treatment Facility	Discharge to groundwater	Submitted August 20, 1996	Approval pending	NMED
Groundwater Discharge Plan, Domestic Septic Systems	Discharge to groundwater	Submitted April 27, 2006	Approval pending	NMED

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC[j])	LANL air emissions	April 30, 2004	April 29, 2009	NMED
	Operating Permit Modification 1	June 15, 2006		
	Operating Permit Modification 2	July 16, 2007		
Air Quality Construction Permits (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	Retired and removed from operating permit	June 15, 2006		
	Permit number will remain active to track exempt sources at LANL			
	TA-3 Power Plant	September 27, 2000	None	NMED
	Permit revision	November 26, 2003		
	Permit modification	July 30, 2004		
	1600-kW Generator at TA-33	October 10, 2002	None	NMED
	Permit revision	May 28, 2008	None	NMED
	Two (2) 20-kW Generators and One (1) 225-kW generator at TA-33	August 8, 2007	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Permit revision	September 12, 2006	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement (CMRR), Radiological Laboratory, Utility, Office Building	September 16, 2005	None	NMED
Air Quality (NESHAP[k])	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	February 11, 2000	None	NMED

[a] Resource Conservation and Recovery Act
[b] New Mexico Environment Department
[c] Hazardous and Solid Waste Amendments
[d] Clean Water Act
[e] National Pollutant Discharge Elimination System
[f] Environmental Protection Agency
[h] US Army Corps of Engineers
[l] Sanitary Wastewater Systems Plant
[j] New Mexico Administrative Code
[k] National Emission Standards for Hazardous Air Pollutants

* Permit was administratively continued for all of 2008

Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2008

Date	Purpose	Performing Agency
8/5/08–8/7/08	NPDES Industrial Point Source Permit Compliance evaluation Inspection	EPA
5/27/08–6/3/08	Hazardous waste compliance inspection (no findings)	NMED[a]
9/22/08–9/26/08	Title V Operating Permit compliance inspection	NMED

Note: No PCB[b]; Federal Insecticide, Fungicide, and Rodenticide Act; Section 401/404; Construction General Permit; or Groundwater Discharge Plan compliance inspections were conducted in 2008.

[a] New Mexico Environment Department.

[b] Polychlorinated biphenyls.

The Laboratory continued to conduct corrective actions in accordance with the March 2005 Compliance Order on Consent (Consent Order), though the NMED issued a Notice of Violation (NOV) for failing to meet the scheduled submittal date for the Status Report for Supplemental Sampling at Material Disposal Area (MDA) A. The report was submitted five days after the required submittal date. NMED determined that the violation cited in the NOV was adequately addressed and that no further action was required. Self-inspections of Resource Conservation and Recovery Act (RCRA) hazardous and mixed waste compliance found a nonconformance rate of 2.82% (compared with 3.71% in 2007).

1. Resource Conservation and Recovery Act

a. Introduction

The Laboratory produces a wide variety of hazardous wastes as a research facility. These wastes are mostly in small quantities compared with industrial facilities of comparable size. RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, establishes a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The EPA has authorized the State of New Mexico to implement the requirements of the program, which it does through the New Mexico Hazardous Waste Act and state regulations found in the New Mexico Administrative Code (NMAC) Title 20, Chapter 4, Part 1, as revised October 1, 2003 (20.4.1 NMAC).

The federal and state laws regulate management of hazardous wastes based on a combination of the facility's status, the quantities of waste generated, and the types of waste management conducted by the facility. Certain operations require a hazardous waste facility permit, sometimes called a RCRA permit. The LANL hazardous waste facility permit was initially granted in 1989 for storage and treatment operations. It expired in 1999 but was administratively continued beyond the expiration date as allowed by 20.4.1.900 NMAC.

The Laboratory has submitted various permit applications for NMED review since 1996 to renew the hazardous waste facility permit. Permit modification packages have also been submitted to revise and upgrade the waste management conditions and facilities contained in the original permit.

b. RCRA Permitting Activities

In 2007, NMED issued the draft renewed hazardous waste facility permit for public comment. The public comment period was extended until February 1, 2008. NMED received extensive comments from the Northern New Mexico Citizens' Advisory Board, the Embudo Valley Environment Monitoring Group, the Southwest Research and Information Center, the Natural Resources Defense Council, the Concerned Citizens for Nuclear Safety, Nuclear Watch New Mexico, the Pueblos de San Ildefonso and Santa Clara, the EPA, several private citizens, and the Laboratory. All commenters who requested a hearing were invited to participate in NMED-mediated permit negotiations to resolve comments, which were started in August 2008. The comment resolution process continued through the end of 2008 and included presentations and requests for additional information regarding the Laboratory's waste management units and related procedures. The discussions and draft revisions supported the development of a second draft permit and a public comment period anticipated for the summer of 2009.

On March 4, 2008, the Laboratory withdrew the Class 3 permit modification request for the Technical Area (TA)-52 Transuranic Waste Management Facility. The permit modification request had been submitted on August 20, 2007. The facility was to be used for the management of LANL transuranic waste after the closure of TA-54 Area G required by the Consent Order. A similar permit modification may be re-submitted in the future after further technical and schedule development for the project.

On October 1, 2008, the Laboratory submitted a Class 1 permit modification transmittal for the Contingency Plan in the permit. The modification reflected changes to the list of emergency coordinators and revised Table D-2 of the Contingency Plan. NMED acknowledged the modification and revised the appropriate permit pages on October 14, 2008.

On October 1, 2008, the Laboratory also submitted a Class 1 permit modification with prior approval that revised the lists of authorized EPA Hazardous Waste numbers in Attachment G of the permit. The changes were not made to increase the capacities or waste management practices for the permitted units but resolved inconsistencies in waste types between units. NMED approved the permit modification on October 14, 2008.

On October 14, 2008, the Laboratory responded to a Notice of Deficiency (NOD) NMED issued for the TA-16 Burn Ground air pathway assessment on July 22, 2008. The response included a revised report that provided additional explanation of technical issues related to the air pathway analysis, further discussions about operational procedures, and text corrections as required by the NOD.

c. Other RCRA Activities

The compliance assurance program performed Laboratory self-assessments to determine whether hazardous waste and mixed waste are managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. The program communicated findings from these self-assessments to waste generators, waste-management coordinators, and waste managers who help line managers implement appropriate actions to ensure continual improvement in LANL's hazardous waste program. In 2008, the Laboratory completed 2,552 self-assessments with a nonconformance rate of 2.82%.

d. RCRA Compliance Inspection

From May 27, 2008, to June 3, 2008, NMED conducted a hazardous waste compliance inspection at the Laboratory (see Table 2-2). The Laboratory received no potential findings for this inspection.

e. Site Treatment Plan

In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the DOE and the University of California, requiring compliance with the Site Treatment Plan. On June 1, 2006, Los Alamos National Security, LLC (LANS) replaced UC as the operating contractor at LANL, and LANS assumed responsibility for compliance with the order. The plan documents the use of off-site facilities for treating and disposing of mixed waste generated at LANL and stored for more than one year. In 2008, the Laboratory shipped more than 31 m^3 of Site Treatment Plan covered low-level mixed waste.

f. Solid Waste Disposal

LANL sends sanitary solid waste (trash) and construction and demolition debris for disposal to the Los Alamos County landfill on East Jemez Road. The DOE owns the property and leases it to Los Alamos County under a special-use permit. Los Alamos County operates this landfill and is responsible for obtaining all related permits for this activity from the state. The landfill is registered with the NMED Solid Waste Bureau. Laboratory trash placed in the landfill in 2008 included 1,833 metric tons of trash and 491 metric tons of construction and demolition debris. Through LANL recycling efforts, 1,920 metric tons of material did not go to the landfill in 2008.

g. Compliance Order on Consent (Consent Order)

The Consent Order is an enforcement document that prescribes the requirements for corrective action at Los Alamos National Laboratory. The purposes of the Consent Order are (1) to define the nature and extent of releases of contaminants at, or from, the facility; (2) to identify and evaluate, where needed, alternatives for corrective measures to remediate contaminants in the environment and prevent or mitigate the migration of contaminants at, or from, the facility; and (3) to implement such corrective measures. The Consent Order supersedes the corrective action requirements previously specified in Module VIII of the Laboratory's Hazardous Waste Facility Permit and applies to Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) subject to RCRA and HSWA requirements, but not to sites that are regulated by DOE under the Atomic Energy Act, such as those containing or releasing radionuclides. The Consent Order does not apply to those SWMUs and AOCs that received "no further action" decisions from EPA when it had primary regulatory authority. A description of the Consent Order work done in 2008 is presented in Chapter 9 of this report.

In 2008, the Laboratory submitted all of its deliverables (plans and reports) required by the Consent Order on time to NMED (see Tables 9-1 and 9-2 in Chapter 9 of this report).

h. Notices of Violation

In January 2008, the NMED Hazardous Waste Bureau issued an Notice of Violation (NOV) to DOE and LANS for failing to meet the scheduled submittal date for the Status Report for Supplemental Sampling at Material Disposal Area (MDA) A. The report was submitted five days after the required submittal date in 2007. NMED determined that the violation cited in the NOV was adequately addressed and that no further action was required

In August 2007, the NMED Hazardous Waste Bureau issued LANS and DOE a NOV identifying two alleged violations noted during the 2006 RCRA compliance inspection. The penalty assessed was $26,613 and was paid on February 25, 2008. The 2007 Hazardous Waste Bureau RCRA compliance inspection was conducted from January 22, 2007, through January 31, 2007, and resulted in an NOV dated January 28, 2008, containing eight alleged violations. The penalty assessed was $46,622.00 and was paid on September 17, 2008.

i. Other RCRA noncompliances

The following waste storage or transportation violations were found during waste processing operations at LANL:

- Four transuranic waste containers that contained hazardous wastes were discovered to be improperly labeled as "non-hazardous."
- A standard waste box was returned to Los Alamos National Laboratory on June 12, 2008, from the Waste Isolation Pilot Plant (WIPP) disposal facility because it was determined to contain an uncertified drum that contained liquids.
- Four containers of low-level waste accepted for storage before disposal off-site were later determined to contain lead concentrations higher than the regulatory limit. The containers were re-labeled as hazardous mixed low-level waste.
- Ten gallons of mixed waste paint thinner were stored at TA-55 for more than the one-year limit before being sent for off-site disposal.

There were no actual or potential hazards to the environment and human health outside the facility, and no material was lost or had to be recovered as a result of any of these incidents. None of these incidents required other reporting to the NMED by the LANL Hazardous Waste Facility Permit.

2. Comprehensive Environmental Response, Compensation, and Liability Act

a. Land Transfer

The DOE/National Nuclear Security Administration (NNSA) conveyed three parcels to the Incorporated County of Los Alamos in 2008. Tract A-11, which was conveyed on April 21, 2008, is a 3.2-acre parcel located at the west end of DP Road. Tract A-4, the Los Alamos County Airport, was conveyed on October 24, 2008, and is 89.1 acres in size. Finally, Tract A-18b of 48.1 acres was conveyed on October 24, 2008, and is located on the mesa above Pueblo Canyon east of the Los Alamos Airport along State Route 502. Also in 2008, the combined Environmental Baseline Survey for Tracts A-18a and b was finalized, and the local DOE office accepted it. The Tract A-4 Los Alamos Airport Environmental Baseline Survey was also completed and approved, and draft surveys for Tract A-10 (DP Canyon) and Tract B-3 (Little Otowi) were completed.

These reports contain the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 120(h) information required to convey these properties to private or municipal or federal entities and disclose any environmental liabilities that may exist on these tracts. The Environmental Baseline Survey Reports document remedial actions taken to protect human health and the environment for the proposed use of the properties and identify any restrictions on the use of the property where warranted. Additionally, the archeological report, Land Conveyance and Transfer: 7000 Years of Land Use on the Pajarito Plateau, was distributed in June 2008. This report represents a major milestone in the completion of the Land Conveyance and Transfer Programmatic Agreement. Finally, the State Cultural Properties Review Committee voted unanimously to list the Traditional Cultural Property sites in the State Register of Cultural Properties, and DOE/NNSA received the approval on April 17, 2008.

b. Natural Resource Damage Assessment

In early 2008, the DOE and several other federal, state, and tribal entities in the region re-initiated the effort to pursue a natural resources damages assessment (NRDA) for LANL. The effort was initiated under a memorandum of agreement signed by the DOE, the Department of Interior, the Department of Agriculture, the State of New Mexico, and the Pueblo de San Ildefonso (collectively known as Trustees). The governing regulations include the CWA, the Oil Pollution Act of 1990, the Department of Energy Organization Act, CERCLA, and the New Mexico Natural Resources Trustee Act.

The Trustees may assess and recover monetary damages for injuries to natural resources (including air, surface water, groundwater, soils, and biota) that have resulted from the release of hazardous substances to the environment from the area of LANL. Damages may include the cost of restoring the injured resources to their baseline condition (i.e., the condition that would have existed but for the release) as well as the value of interim losses pending restoration. Damages are used to restore, rehabilitate, replace, or acquire the equivalent of injured natural resources.

Using Department of Interior guidance for cooperative implementation of NRDA, the LANL Natural Resource Trustee Council completed a draft pre-assessment screen in December 2008. The draft pre-assessment is the initial step in the NRDA process and provides a rapid review of readily available information on hazardous substance releases and the potential impacts of those releases on natural resources and will be used to determine whether there is a reasonable probability of making a successful claim before efforts are expended in carrying out a full-scale assessment.

3. Emergency Planning and Community Right-to-Know Act

a. Introduction

The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management.

b. Compliance Activities

For 2008, the Laboratory submitted reports to fulfill its requirements under EPCRA, as shown in Table 2-3 and described below.

Table 2-3
Compliance with Emergency Planning and Community Right-to-Know Act during 2008

Statute	Brief Description	Compliance
EPCRA Sections 302–303 Planning Notification	Requires emergency planning notification to state and local emergency planning committees.	No changes to the notification have been made since the July 30, 1999, notification and an update in 2000.
EPCRA Section 304 Release Notification	Requires reporting of releases of certain hazardous substances over specified thresholds to state and local emergency planning committees and to the National Response Center.	No leaks, spills, or other releases of chemicals into the environment required EPCRA Section 304 reporting during 2008.
EPCRA Sections 311–312 Material Safety Data Sheets and Chemical Inventories	Requires facilities to provide appropriate emergency response personnel with an annual inventory and other specific information for any hazardous materials present at the facility over specified thresholds.	The presence of 30 hazardous materials stored at LANL over specified quantities in 2008 required submittal of a hazardous chemical inventory to the State Emergency Response Commission and the Los Alamos County Fire and Police Department.
EPCRA Section 313 Annual Toxic Release Inventory	Requires all federal facilities to report total annual releases of listed toxic chemicals used in quantities above reportable thresholds.	Laboratory use of lead exceeded the reporting thresholds in 2008, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the State Emergency Response Commission.

i. Emergency Planning Notification

Title III, Sections 302–303, of EPCRA require the preparation of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is 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 2008.

ii. Emergency Release Notification

Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals into the environment if these chemicals exceed specified reporting 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 EPCRA Section 304 reporting during 2008.

iii. Material Safety Data Sheet/Chemical Inventory Reporting

Title III, Sections 311–312, of EPCRA require facilities to provide an annual inventory of the quantity and location of hazardous chemicals above specified thresholds present at the facility. The inventory includes hazard information and the storage location for each chemical. The Laboratory submitted a report to the State Emergency Response Commission and the Los Alamos County Fire and Police Departments listing 30 chemicals and explosives at the Laboratory stored on-site in quantities that exceeded reporting threshold limits during 2008.

iv. Toxic Release Inventory Reporting

Executive Order 13423 requires all federal facilities to comply with Title III, Section 313, of EPCRA. This section requires reporting of total annual releases to the environment of listed toxic chemicals that exceed activity thresholds. Beginning with reporting year 2000, new and lower chemical-activity thresholds were put in place for certain persistent, bioaccumulative, and toxic chemicals and chemical categories. The thresholds for these chemicals range from 0.1 g to 100 lb. Until this change went into effect, the lowest threshold was 10,000 lb. LANL exceeded the threshold for use of lead in 2008 and therefore was required to report the uses and releases of this chemical. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. Table 2-4 summarizes the reported releases in 2008.

Table 2-4
Summary of 2008 Reported Releases under EPCRA Section 313

	Lead (lb)
Air Emissions	7.72
Water Discharges	0.03
On-Site Land Disposal	7,755
Off-Site Waste Transfers	6,757

4. Toxic Substances Control Act

Because the Laboratory's activities are research and development (R&D) rather than the manufacture of commercial chemicals, the Laboratory's main concerns under the Toxic Substances Control Act (TSCA) are the regulations covering polychlorinated biphenyls (PCBs) and the import/export of R&D chemical substances. The PCB regulations govern substances including, but not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat-transfer fluids, hydraulic fluids, slurries, soil, and materials contaminated by spills.

During 2008, the Laboratory shipped 22 containers of PCB waste off-site for disposal or recycling. The quantities of waste disposed of included 30 lb (13.6 kg) of capacitors and 1,617 lb (733.5 kg) of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 Code of Federal Regulations (CFR) 761 manifesting, record keeping, and disposal requirements. PCB wastes go to EPA-permitted disposal and treatment facilities. Light ballasts go off-site for recycling. The primary compliance document related to 40 CFR 761.180 is the annual PCB report that the Laboratory submits to EPA Region 6. The renewal request for the Area G PCB disposal authorization was withdrawn in 2006. During 2008, EPA did not perform any PCB site inspections. Approximately 15 TSCA reviews were conducted on imports and exports of chemical substances for the Laboratory's Property Management Group Customs Office.

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides and 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 Laboratory's licensing and certification of pesticide workers, record keeping, and equipment inspection, as well as application, storage, and disposal of pesticides. In previous years, a Laboratory contractor maintained appropriate FIFRA licensing. Beginning in 2008, the permitting program transitioned to the Laboratory. Laboratory staff consulted with the New Mexico Department of Agriculture to identify the appropriate licenses under FIFRA, and, as a result, the Laboratory's pesticide applicators maintain noncommercial applicator licenses.

The New Mexico Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2008. The Laboratory conducted four quarterly inspections of the pesticide storage area in 2008 and found that the storage area was maintained in accordance with RCRA regulations.

Table 2-5 shows the amounts of pesticides and herbicides the Laboratory used in 2008.

Table 2-5
Herbicides and Pesticides Used at LANL in 2008

Herbicides	Amount
Velpar L (Liquid)	682.5 gal
Insecticides	**Amount**
Advion ANT Bait granular	16.75 oz
Demand CS	5.75 oz
Prescription Treatment (PT) P.I. Contact	140 oz
Prescription Treatment (PT) Wasp Freeze	87.5 oz
Suspend SC	7.75 oz
Tempo 20 WP	56 oz
Fertilizers	**Amount**
16-8-8 all season	100 lbs
18-5-9 w/herbicide	500 lbs
Color Marker	**Amount**
Blazon (Liquid)	5 gal
Water Treatment Chemicals	**Amount**
Bromicide Tablets	2580 lbs
Garrat-Callahan 314T	2650 lbs
Garrat-Callahan 315	5.5 gal
Garrat-Callahan 316	31 packs
Sump Buddy	110 lbs

6. Clean Air Act

Through the Federal Clean Air Act Amendments and NMAC 20.2.70 Operating Permits, LANS is authorized to operate applicable air emission sources at LANL. The Laboratory was issued Operating Permit No. P100 in April 2004. An application to renew the permit was submitted to the NMED in April 2008. This permit provides the terms and conditions that must be followed in order to operate the applicable air emission sources. The operating permit conditions are a collection of existing source-specific permit conditions that address operation, record keeping, monitoring, and reporting. By complying with the conditions of the Title V Operating Permit, the Laboratory is deemed to be in compliance with all applicable air requirements existing at the date of permit issuance.

As part of the Title V Operating Permit program, LANL reports the emissions from sources included in the Operating Permit to NMED twice a year. These sources include multiple boilers and electric generators, a power plant, a combustion turbine generator, a data disintegrator, two carpenter shops, a degreaser, and an asphalt plant. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities.

The Title V Operating Permit requires the Laboratory to submit an Annual Compliance Certification to NMED. In the 2008 Compliance Certification, one permit deviation was reported. The deviation regarded a calculation of estimated nitrogen oxides (NO_X) and carbon monoxide (CO) emissions for the TA-3 Combustion Turbine. On October 22 and October 23, 2008, calculations resulted in values exceeding the permit limits for the pollutants. LANL had previously been working with the NMED Air Quality Bureau to modify the permit to remove these conditions and replace them with conditions that represent actual emissions. NMED agreed that the current calculations required by the permit do not provide a reasonable estimate of emissions. Using an emission factor derived from actual emissions data in the initial compliance test, conducted on October 5, 2007, emissions for the two days were determined to be much lower than the permit limits.

LANL demonstrated full compliance with all other applicable air permit terms and conditions and met all reporting requirement deadlines.

In 2008, LANL requested and received a revision to New Source Review (NSR) permit 2195F. The revision consisted of a change to a record keeping requirement. The permitted 1600-kW generator located at TA-33 had an existing condition to record the generator kilowatt hours on an hourly basis. In this revision, the record keeping condition was changed to a daily basis. This permit revision was issued on May 28, 2008.

In 2008, LANL performed the first NMED greenhouse gas reporting as required by NMAC 20.2.87. LANL will participate in tiered reporting of greenhouse gases to NMED starting with the 2008 reporting year. LANL collected data during 2008 and will submit the report in 2009.

Under the Title V Operating Permit program, LANL is a major source, based on the potential to emit NO_X, CO, and volatile organic compounds (VOCs). In 2008, the TA-3 power plant and boilers located across the Laboratory were the major contributors of NO_X, CO, and particulate matter (PM). R&D activities were responsible for most of the VOC and hazardous air pollutant emissions. Table 2-6 summarizes these data.

Table 2-6
Calculated Emissions of Regulated Air Pollutants Reported to NMED in 2008

	Pollutants[a], tons					
Emission Units	**NO_x**	**SO_x**	**PM**	**CO**	**VOC**	**HAPs**
Asphalt Plant	0.03	0.005	0.01	0.43	0.01	0.01
TA-3 Power Plant (Boilers and Turbine)	14.5	0.18	1.9	9.8	1.36	0.47
Regulated Boilers	5.4	0.03	0.5	3.8	0.32	0.11
R&D Chemical Use	NA[b]	NA	NA	NA	9.0	4.5
Degreaser	NA	NA	NA	NA	0.02	0.02
Data Disintegrator	NA	NA	0.31	NA	NA	NA
Carpenter Shops	NA	NA	0.05	NA	NA	NA
Storage Tanks	NA	NA	NA	NA	0.01	NA
Stationary Standby Generators[c]	5.0	0.17	0.21	1.1	0.22	0.001
Miscellaneous Small Boilers[c]	20.1	0.13	1.5	16.9	1.1	0.38
TA-33 Generators (4 units)	0.80	0.1	0.04	0.5	0.03	< 0.001
TOTAL	45.8	0.62	4.5	32.5	12.1	5.5

[a] NOx = nitrogen oxides. SOx = Sulfur oxides. PM = particulate matter. CO = carbon monoxide. VOC = volatile organic compounds. HAPs = hazardous air pollutants.

[b] NA = Not applicable.

[c] Emissions from these source categories were reported for the first time in 2004, as required by the Title V Operating Permit. Emissions units in these categories are exempt from construction permitting and annual emission inventory reporting requirements and are not included in Figure 2-1.

LANL staff calculates air emissions using emission factors from source tests, manufacturer's data, and EPA documents. Calculated emissions are based on actual production rates, fuel usage, and/or material throughput. To satisfy requirements found in NMAC 20.2.73, Notice of Intent and Emissions Inventory Requirements, and the Title V Operating Permit, LANL submits an annual Emissions Inventory Report and semi-annual Emissions Reports, respectively, to NMED. Figure 2-1 depicts a five-year history of criteria pollutant emissions. Emissions from 2004 through 2008 are very similar and remain relatively constant.

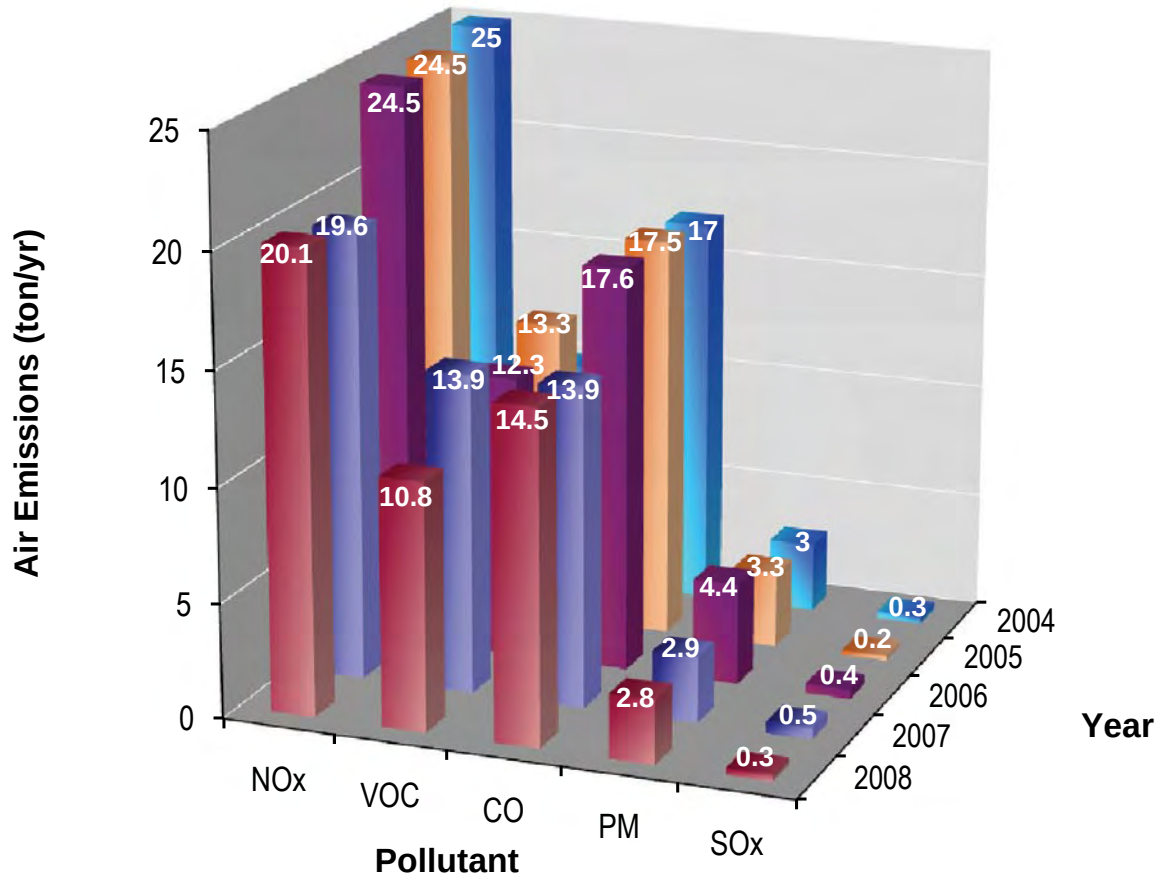


Figure 2-1. LANL criteria pollutant emissions from 2004 through 2008 for annual emissions inventory reporting. Totals from the emissions inventory report do not include small boilers or standby generators.

a. New Mexico Air Quality Control Act.

i. Permits

LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to apply for construction permits or to submit notifications to NMED. During 2008, the Laboratory performed approximately 166 air quality reviews. Also during 2008, LANL received an NSR air quality permit revision for the 1600-kW generator located at TA-33. No NSR permit applications were submitted in 2008. The Title V Operating Permit renewal application was submitted to NMED in April 2008. The Laboratory continued to operate under the existing Title V permit P100-M2 throughout 2008. LANL submitted two exemption notifications to NMED during 2008. The exemptions were for small boilers and small generators. During 2008, LANL operated under the air permits listed in Table 2-1.

ii. Open Burning

LANL may perform open burning under 20.2.60 NMAC (Open Burning) or 20.2.65 NMAC (Smoke Management) to thin vegetation and reduce the threat of fire. LANL did not perform any open burning during 2008.

iii. Asbestos

The National Emission Standard for Hazardous Air Pollutants (NESHAP) for Asbestos requires that LANL provide advance notice to NMED for large renovation jobs that involve asbestos and for all demolition projects. The asbestos NESHAP further requires that all activities involving asbestos be conducted in a manner that mitigates visible airborne emissions and that all asbestos-containing wastes be packaged and disposed of properly.

LANL continued to perform renovation and demolition projects in accordance with the requirements of the asbestos NESHAP. Major activities in 2008 included 18 renovation and demolition projects. NMED was provided advance notice on each of these projects. These projects, combined with other smaller activities, generated 546 m^3 of asbestos waste. All asbestos wastes were properly packaged and disposed of at approved landfills.

To ensure compliance, the Laboratory conducted internal inspections of job sites and asbestos packaging approximately monthly.

b. Federal Clean Air Act.

i. Ozone-Depleting Substances

Title VI of the CAA contains specific sections that establish regulations and requirements for ozone-depleting substances (ODS), such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting or otherwise releasing into the environment 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 EPA-certified and must use certified recovery equipment. The Laboratory is required to maintain records on all work that involves refrigerants and the purchase, usage, and disposal of refrigerants. The Laboratory's standards for refrigeration work are covered under Criterion 408, "EPA Compliance for Refrigeration Equipment," of the LANL Operations and Maintenance Manual.

The Laboratory continued eliminating the use of Class I and Class II ODS. Class I and Class II ODS are the refrigerants that have high ozone-depleting potentials. In 2008, the Laboratory removed approximately 817 pounds of Class II ODS from the active inventory.

ii. Radionuclides

Under the NESHAP regulations, which regulate the air emissions of radionuclides other than radon from facilities owned or operated by the DOE, the EPA limits to 10 mrem/yr the effective dose equivalent of airborne releases of radioactive material from a DOE facility, such as LANL, to any member of the public. The 2008 annual dose to the maximally exposed individual (MEI) (as calculated using EPA-approved methods) was 0.55 mrem. The location of the highest dose was the East Gate area near the eastern edge of Los Alamos County. Emissions of radioactive gases from the Los Alamos Neutron Science Center (LANSCE) accelerator facility contributed over half of this dose; the remainder came from other Laboratory stack emissions and environmental cleanup work. See Chapter 4 for more information about these emissions.

7. Clean Water Act

a. NPDES Industrial Point Source Outfall Self-Monitoring Program

The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The Act established the requirements for NPDES permits for point-source effluent discharges to the nation's waters. The NPDES outfall permit establishes specific chemical, physical, and biological criteria that the Laboratory's effluent must meet before it is discharged.

During 2008, LANS and DOE/NNSA were co-permittees of the NPDES permit covering Laboratory operations. EPA Region 6 in Dallas, Texas, issues and enforces the permit. NMED certifies the EPA-issued permit and performs some compliance-evaluation inspections and monitoring for the EPA. During 2008, the Laboratory's industrial point-source NPDES permit contained 15 permitted outfalls that include one sanitary outfall and 14 industrial outfalls (Table 2-7). In order to meet the requirements in the current permit, the Laboratory initiated a feasibility study to eliminate outfalls and to add additional treatment technologies. The Laboratory's NPDES permit is available online at http://www.lanl.gov/environment/h2o/permits.shtml.

Table 2-7
Volume of Effluent Discharge from NPDES Permitted Outfalls in 2008

Outfall Number	TA-Bldg	Description	Watershed (Canyon)	2008 Discharge (gal.)
02A129	21-357	TA-21 Steam Plant	Los Alamos	0
03A048	53-963/978	LANSCE Cooling Tower	Los Alamos	18,236,300
051	50-1	TA-50 Radioactive Liquid Waste Treatment Facility	Mortandad	1,397,265
03A021	3-29	CMR Building Air Washers	Mortandad	172,800
03A022	3-2238	Sigma Cooling Tower	Mortandad	296,640
03A160	35-124	National High Magnetic Field Laboratory Cooling Tower	Mortandad	101,560
03A181	55-6	Plutonium Facility Cooling Tower	Mortandad	235,123
13S	46-347	Sanitary Wastewater Treatment Plant	Sandia	101,276,290
001	3-22	Power Plant	Sandia	14,790,915
03A027	3-2327	Strategic Computing Complex Cooling Tower	Sandia	11,465,780
03A113	53-293/952	LANSCE Cooling Tower	Sandia	387,305
03A199	3-1837	Laboratory Data Communications Center	Sandia	9,225,860
03A130	11-30	TA-11 Cooling Tower	Water	2,628
03A185	15-312	DARHT Cooling Tower	Water	823,136
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2008 Total:	**158,411,602**

The Laboratory's current NPDES outfall permit requires weekly, monthly, quarterly, and yearly sampling to demonstrate compliance with effluent quality limits. The Laboratory reports analytical results to EPA and NMED at the end of the monitoring period for each respective outfall category. During 2008, none of the 77 samples collected from the SWWS Plant's outfall exceeded effluent limits; however, six of the 1,300 samples collected from industrial outfalls exceeded effluent limits (see discussion below). Monitoring data obtained from sampling at NPDES permitted outfalls are in Supplemental Data Table S2-1 (on included compact disc) and available online at http://www.racernm.com/.

The following is a summary of the corrective actions the Laboratory has taken during 2008 to address the NPDES outfall permit noncompliance cited above.

- TA-55 Plutonium Facility Outfall 03A181. On January 15, 2008, during a discharge, a pH measurement of 9.1 standard units (su) was outside of the acceptable range of 6.0 – 9.0 su. The conductivity meter electrodes had not been properly maintained resulting in erroneous conductivity meter readings. This resulted in the cooling tower not blowing down as anticipated. As water was continually recycled in the cooling tower, the pH increased. The conductivity meter electrodes were cleaned on January 16, 2008, and normal cooling tower operations resumed.

- TA-3 Power Plant Outfall 001. On January 31, 2008, a total residual chlorine (TRC) concentration of 110 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. Power Plant personnel did not consistently follow the manufacturer's procedures for the portable instrument used in operational monitoring of TRC. Also, the portable TRC instrument did not have the sensitivity necessary to detect very low levels of TRC. Administrative controls were implemented to adjust neutralization pumps for higher rates of discharge volume. After purchase of a more sensitive TRC instrument, Power Plant personnel were re-trained in the proper use of the instrument.
- TA-55 Plutonium Facility Outfall 03A181. On May 28, 2008, during a discharge, a pH measurement of 5.0 was outside of the acceptable range of 6.0 – 9.0. The cause was not determined. Operational samples taken by facility personnel in the afternoon of May 28, 2008, indicated the discharge was within the acceptable range.
- TA-3 Sigma Outfall 03A022. On June 16, 2008, a TRC concentration of 280 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. The TA-3 Sigma Emergency Cooling System was activated sometime before 7:30 a.m. on June 16, 2008, because the main cooling tower make-up valve was in the closed position. The Emergency Cooling System was isolated, and the discharge stopped at approximately 11:00 a.m. The Emergency Cooling System functions as a once-through system using potable water and is normally used for brief periods during power outages. No dechlorination of this water takes place before discharge. An alarm is normally activated when the Emergency Cooling System is engaged, but the alarm failed in this case.
- TA-53 LANSCE Outfall 03A048. On September 30, 2008, a TRC of 220 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. Facility personnel checked all systems, and all systems were found to be operating correctly. An operational sample collected at approximately 11:00 a.m. resulted in no chlorine being detected. The cause was never determined, and facility personnel are monitoring chorine levels in the cooling towers more frequently.
- TA-3 Power Plant Outfall 001. On December 10, 2008, a TRC concentration of 130 µg/L exceeded the NPDES daily maximum limit of 11 µg/L. Administrative controls were not followed to adjust neutralization pumps for higher rates of discharge volume. Procedures were reviewed to determine if neutralizer pump rates are adequate during higher discharge volumes that occur during cold ambient temperatures.

b. NPDES Sanitary Sewage Sludge Management Program

The Laboratory's TA-46 SWWS Plant is an extended-aeration, activated-sludge sanitary wastewater treatment plant. The activated-sludge treatment process requires periodic disposing of excess sludge (waste-activated sludge) from the plant's clarifiers to synthetically lined drying beds. After air-drying for a minimum of 90 days to reduce pathogens, the dry sludge is characterized and disposed of as a New Mexico Special Waste. Monitoring data obtained from routine characterization of SWWS Plant sludge are available online at http://www.racernm.com/. During 2008, the SWWS Plant generated approximately 30 dry tons (59,941 dry lb) of sewage sludge. All of this sludge was disposed of as a New Mexico Special Waste at a landfill authorized to accept this material.

c. NPDES Industrial Point Source Permit Compliance Evaluation Inspection

A Compliance Evaluation Inspection was performed from August 5–7, 2008. The inspection consisted of separate evaluations for the sanitary and industrial outfalls. The Laboratory received a rating of 4 for the industrial outfalls evaluation and a rating of 3 for the sanitary outfall evaluation. A rating of 5 indicates very reliable self-monitoring programs, 3 is for satisfactory, and 1 is for very unreliable programs.

d. NPDES Storm Water Construction General Permit Program

The NPDES Construction General Permit (CGP) Program regulates storm water discharges from construction activities disturbing one or more acres, including those construction activities that are part of a larger common plan of development collectively disturbing one or more acres.

LANL and the general contractor apply individually for NPDES CGP coverage and are co-permittees at most construction sites. Compliance with the NPDES CGP includes developing and implementing a Storm Water Pollution Prevention Plan (SWPPP) before soil disturbance can begin and conducting site inspections once soil disturbance has commenced. A SWPPP describes the project activities, site conditions, best management practices (BMPs), and permanent control measures required for reducing pollution in storm water discharges and protecting endangered or threatened species and critical habitat. Compliance with the NPDES CGP is demonstrated through periodic inspections that document the condition of the site and also identify corrective actions required to keep pollutants from moving off the construction site. Data collected from these inspections are tabulated weekly, monthly, and annually in the form of Site Inspection Compliance Reports.

During 2008, the Laboratory implemented and maintained 51 construction site SWPPPs and addendums to SWPPPs and performed 542 storm water inspections. The Laboratory uses a geographic information system to manage project information and generate status reports that facilitate reporting under the Director's Portfolio Reviews. The overall CGP inspection compliance record in 2008 was 99%. During the summer months, when most high-intensity precipitation events occur, all 275 of the inspections were compliant.

The LANL storm water team continued to utilize relatively new methods to assist with storm water compliance. Improvements in accounting for non-uniform distribution of precipitation were made by using a network of rain gages in association with the Thiessen polygon method. This method associated 13 precipitation gauges across the Laboratory with LANL construction projects to ensure refined data were used for triggering storm water inspections. The gauges were equipped with 5-minute tipping buckets connected to existing stations with data loggers. The team incorporated solutions for preventing noncompliances in its Quality Improvement Performance Report. To further reduce future CGP noncompliances and to increase awareness of CGP requirements, the storm water team briefed subcontractors on CGP requirements at pre-bid and pre-construction meetings. Storm water requirements were put into subcontract requirements, so each bidder who responds to or bids on a subcontract for a Laboratory project is given project-specific environmental requirements. Presentations were also given to multiple LANL organizations to increase awareness of CGP requirements. A standing weekly meeting with LANL Project Management personnel to review the storm water compliance status of projects was also continued.

e. NPDES Industrial Storm Water Program

The NPDES Industrial Storm Water Permit Program regulates storm water discharges from identified regulated industrial activities (including SWMUs) and their associated facilities. These activities include metal fabrication; hazardous waste treatment, storage, and disposal; landfill operations; vehicle and equipment maintenance; recycling activities; electricity generation; warehousing activities; and asphalt manufacturing.

UC and the DOE were co-permittees under the EPA 2000 NPDES Storm Water Multi-Sector General Permit for Industrial Activities (MSGP-2000). MSGP-2000 expired October 30, 2005, and was administratively continued until the new permit was issued on September 29, 2008. LANS and the DOE are co-permittees under the new MSGP-2008 permit.

MSGP-2000 and MSGP-2008 require the development and implementation of site-specific SWPPPs, which must include identifying potential pollutants and activities and implementing BMPs. Permit requirements also include the monitoring of storm water discharges from permitted sites. In 2008, LANL implemented and maintained 15 SWPPPs under the MSGP-2000 requirements, covering 19 facilities and 14 SWMUs. Compliance with the requirements for these sites is achieved primarily by implementing the following:

- Identifying potential contaminants and activities that may impact surface water quality and identifying and providing structural and nonstructural controls (BMPs) to limit the impact of those contaminants.
- Developing and implementing facility-specific SWPPPs.

- Monitoring storm water runoff at facility gauging stations for industrial sector-specific benchmark parameters and visually inspecting storm water runoff to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

Several additional facilities met the requirements for an MSGP-2000 "No Exposure Certification," which identified the facility as having a regulated industrial activity but did not require permit authorization for its storm water discharges because of a condition of no exposure. Such facilities were not covered under or subject to the requirements of a SWPPP.

f. Federal Facility Compliance Agreement/Administrative Order

On February 3, 2005, DOE entered into a compliance agreement with EPA to protect surface water quality at the Laboratory through a Federal Facilities Compliance Agreement. The FFCA established a compliance program for the regulation of storm water discharges from SWMUs and AOCs until such time as those sources are regulated by an individual storm water permit pursuant to the NPDES Permit Program. Certain SWMUs and AOCs (collectively, Sites) are covered by this agreement. On March 30, 2005, EPA issued an Administrative Order (AO) to the Laboratory that coincides with the FFCA.

The FFCA/AO established a schedule for monitoring and reporting requirements and required the Laboratory to minimize erosion and the transport of pollutants or contaminants from Sites in storm water runoff. The FFCA also required DOE and the Laboratory to comply with all requirements of the Laboratory's MSGP.

The FFCA/AO required two types of monitoring at specified sites, pursuant to two monitoring management plans, including (1) watershed sampling at approximately 60 automated gauging stations at various locations within the canyons pursuant to a Storm Water Monitoring Plan (SWMP) and (2) site-specific sampling at approximately 294 sites, on a rotating basis pursuant to a SWMU SWPPP over a four-year period. The purpose of storm water monitoring is to determine if there is a release or transport of contaminants into surface water that could cause or contribute to an exceedance of applicable water Screening Action Levels (wSALs). If a release or transport occurs, it may be necessary to implement BMPs to reduce erosion or to re-examine, repair, or modify existing BMPs to reduce erosion. The SWMU/SWPPP must also describe an erosion control program to control and limit contamination migration and transport from sites and to monitor the effectiveness of controls at the sites.

In 2008, the Laboratory completed the following tasks:

1. Submitted the annual modification of the SWPPP for SWMU/AOCs that describes watershed-scale monitoring, site-specific monitoring, and the erosion control program at SWMU/AOCs;
2. Continued negotiations with EPA and NMED on the development of an individual permit for storm water discharges from SWMUs/AOCs;
3. Submitted all monthly water screening action level exceedance reports and quarterly status reports required by the FFCA on schedule;
4. Completed the following fieldwork:
    - Increased rain gauge network by adding 20 rain gauges to the existing 5 meteorologic stations;
    - Installed 202 new site-specific samplers and maintained 60 gauge stations for storm event sampling;
    - Collected 310 storm water samples;
    - Conducted 2287 inspections at 290 sites;
    - Completed maintenance of BMPs at all FFCA sites;
    - Conducted 290 Annual Comprehensive Site Compliance Evaluation inspections.

Qualified personnel, as required under the MSGP, conducted the Annual Comprehensive Site Compliance Evaluation inspections to assess the presence of existing industrial materials, leaks and spills, off-site tracking of sediment, tracking/blowing of industrial materials, and evidence of pollutants entering into receiving waters. The annual inspections also included an evaluation of the existing structural BMPs at each site.

The Laboratory completed supplemental information submittals in support of the Individual Permit application for storm water discharges from certain SWMUs/AOCs. EPA issued a draft permit in early 2008 for public comment. The final Individual Permit was issued in April 2009.

g. Aboveground Storage Tank Compliance Program

The Laboratory's Aboveground Storage Tank (AST) Compliance Program is responsible for ensuring compliance with the requirements established by EPA (Clean Water Act 40 CFR, Part 112) and NMED's Petroleum Storage Tank Bureau (PSTB) Regulations (20.5 NMAC). During 2008, the Laboratory was in full compliance with both EPA and NMED requirements.

Spill Prevention Control and Countermeasures (SPCC) Plans fulfill the federal requirements for the AST Compliance Program, as required by the CWA (40 CFR, Part 112, Oil Pollution Prevention Regulations). Comprehensive SPCC Plans are developed to meet EPA requirements that regulate water pollution from oil spills.

EPA proposed additional extensions to compliance deadlines for meeting new regulatory requirements under the federal Clean Water Act (40 CFR, Part 112). Proposed new regulations will require the Laboratory to modify and implement its SPCC Plans by July 1, 2009. The primary modifications address AST storage capacity, inspection frequency, integrity testing requirements, and equipment. The Laboratory continued the process of completing all modifications to existing and new SPCC Plans and implementing those modifications.

The Laboratory continues to maintain and operate ASTs in compliance with 20.5 NMAC of the NMED-PSTB Regulations. The Laboratory paid annual AST registration fees of $100 per AST.

During 2008, the Laboratory continued to work on removing and decommissioning ASTs that are no longer in service. One AST system was closed out with NMED-PSTB pursuant to 20.5 NMAC. This AST system was located at TA-53-645 (near LANSCE).

On February 21, 2002, the Laboratory notified EPA, NMED, and the National Response Center of a discharge of approximately 48,000 gallons of diesel fuel released into the environment from a tank at TA-21-57. Soil removal and sampling were performed in accordance with Laboratory, state, and federal regulatory requirements to determine the extent of the leak. The Laboratory completed characterization of the release in December 2003 and is continuing to work with NMED on a path forward for mitigation efforts. In 2008, the Laboratory continued implementation of a Sampling and Analysis Plan to further evaluate subsurface diesel contamination. The Laboratory intends to develop applicable processes for site mitigation or monitoring, and proposed additional characterization has been scheduled for 2009.

On April 3, 2003, the Laboratory notified NMED of the discovery of diesel-contaminated soil near the TA-3 Power Plant AST (TA-3-26). The Laboratory completed characterization of the diesel-contaminated soil in April 2004 and August 2007. The Laboratory implemented the Tier 1 Evaluation in 2008 pursuant to 20.5 NMAC of NMED-PSTB Regulations to evaluate the need for mitigation at the site. The Tier 1 Evaluation determined no further action was required. NMED recommended administrative closure of the release pursuant to 20.6.2.1203 NMAC of the New Mexico Water Quality Control Commission Regulations.

h. Dredge and Fill Permit Program

Section 404 of the Clean Water Act requires the Laboratory to obtain permits from the US 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 the Corps or Engineers will not prevent attainment of state-mandated stream standards. NMED reviews Section 404/401 joint permit applications and issues separate Section 401 certification letters, which may include additional permit requirements to meet state stream standards for individual Laboratory projects. In addition, the Laboratory must comply with 10 CFR 1022, which specifies how DOE sites comply with Executive Order 11988, Floodplain Management, and Executive Order 11990, Protection of Wetlands.

During 2008, one Section 404/401 permit was issued to the Laboratory:

- TA-39 Emergency Security Fence Repair Project in an unnamed tributary to Ancho Canyon (Nationwide Permit No. 18, Minor Discharges).

In addition, LANL reviewed 598 excavation permits and 98 project profiles for potential impacts to watercourses, floodplains, or wetlands. No Floodplain/Wetland Assessments were prepared in 2008. No violations of the DOE Floodplains/Wetlands Environmental Review Requirements were recorded. NMED and the Corps of Engineers did not inspect any sites permitted under the Section 404/401 regulations during 2008.

8. Safe Drinking Water Act

Los Alamos County, as owner and operator of the Los Alamos water supply system, is responsible for compliance with the requirements of the federal Safe Drinking Water Act (SDWA) and the New Mexico Drinking Water Regulations (NMEIB 2007). The SDWA requires Los Alamos County to collect samples from various points in the water distribution systems at the Laboratory, Los Alamos County, and Bandelier National Monument to demonstrate compliance with SDWA maximum contaminant levels (MCLs). EPA has established MCLs for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The State of New Mexico has adopted these standards in the New Mexico Drinking Water Regulations. EPA has authorized NMED to administer and enforce federal drinking water regulations and standards in New Mexico. Information on the quality of the drinking water from the Los Alamos County water supply system is in the County's annual Consumer Confidence Report, available online at: http://www.losalamosnm.us/.

In 2008, the Laboratory conducted additional confirmation monitoring of the Los Alamos County water supply system for quality assurance purposes. The data are available in Chapter 5 of this report and online at: http://www.racernm.com/.

9. Groundwater

a. Groundwater Protection Regulations

Under requirements of DOE Order 450.1A, the Laboratory prepared for the local DOE site office a groundwater protection management plan that explains how LANL organizes and manages its programs that are responsible for protecting groundwater resources in and around the Los Alamos area and ensuring that all groundwater-related activities comply with applicable federal and state regulations. The Consent Order requires the Laboratory to establish a groundwater monitoring system, conduct investigations to determine the nature and extent of contamination in the groundwater, and remediate the groundwater if necessary. Figure 2-2 shows characterization wells in the intermediate and regional aquifers. More information about the monitoring efforts and results are presented in Chapter 5.

New Mexico Water Quality Control Commission (NMWQCC) regulations control liquid discharges onto or below the ground surface to protect all groundwater in New Mexico. Under the regulations, when required by NMED, a facility must submit a groundwater discharge plan and obtain NMED approval (or approval from the New Mexico Oil Conservation Division for energy/mineral-extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge plan. In 2008, the Laboratory had one approved groundwater discharge plan and two groundwater discharge plans pending NMED approval (see Table 2-1).

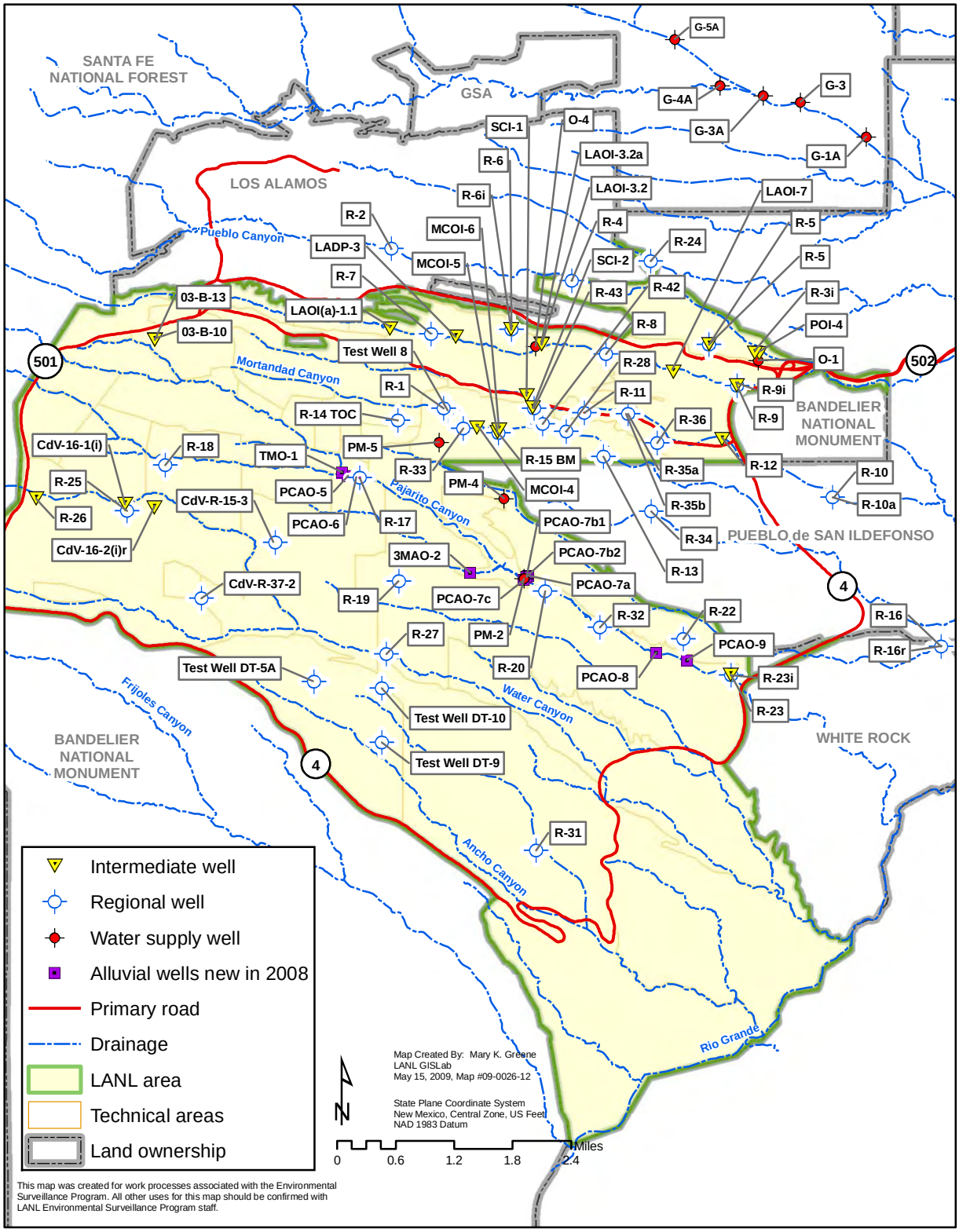


Figure 2-2. Characterization wells in the intermediate and regional aquifers.

i. TA-46 SWWS Plant Discharge Plan

On July 20, 1992, the Laboratory was issued a discharge permit (DP-857) for the TA-46 SWWS Plant. The permit was renewed on January 7, 1998. The permit requires quarterly sampling of the SWWS Plant's effluent, NPDES Outfalls 001 and 03A027, and Cañada del Buey alluvial groundwater well CDBO-6 to demonstrate

compliance with NMWQCC groundwater standards. The Laboratory reports the analytical results to the NMED quarterly. During 2008, none of samples collected exceeded NMWQCC groundwater standards. Monitoring data are available online at the RACER Data Analysis Tool (http://www.racernm.com/). On August 27, 2002, the Laboratory submitted a renewal application for the TA-46 SWWS Plant's discharge permit, and NMED approval was pending at the end of 2008.

ii. TA-50 RLWTF Discharge Plan

On August 20, 1996, at the NMED's request, the Laboratory submitted a discharge plan application for the RLWTF at TA-50; NMED approval was pending at the end of 2008. Since 1999, the Laboratory has conducted voluntary quarterly sampling of the RLWTF's effluent and alluvial groundwater monitoring wells MCO-3, MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon for nitrate (as N), fluoride, and total dissolved solids (TDS). The Laboratory reports the analytical results to the NMED quarterly. During 2008, none of the quarterly discharge plan samples exceeded NMWQCC groundwater standards. Monitoring data are available online at http://www.racernm.com/.

iii. Septic Tanks Discharge Plan

On April 27, 2006, at the NMED's request, 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 SWWS Plant's collection system is not practicable. The Laboratory regularly pumps and maintains these tanks. The NMED has declared the Laboratory's application to be administratively complete, but approval was still pending at the end of 2008.

b. Groundwater Monitoring Activities

The Laboratory performed most groundwater compliance work in 2008 pursuant to the Consent Order. These activities included groundwater monitoring, groundwater investigations, and groundwater well construction.

Sample analytical and other groundwater data can be reviewed online at http://www.racernm.com/. Periodic monitoring reports and water-level and well construction data can be found on the Laboratory's Environment Website at http://www.lanl.gov/environment/h2o/reports.shtml.

In 2008, LANL installed 10 alluvial monitoring wells, three perched-intermediate monitoring wells, and five regional monitoring wells (Table 2-8). The alluvial wells were installed in Pajarito Canyon as part of the Pajarito Canyon investigation (LANL 1998, 059577). Wells SCI-2, R-35a, R-36, and R-43 were installed in Sandia Canyon as part of the ongoing chromium contamination investigation. Regional well R-42 was installed in Mortandad Canyon as part of the same investigation. Intermediate wells R-25b and R-25c were installed adjacent to existing well R-25, a 9-screen completion, to replace screens 1 and 3, respectively. Regional wells R-38 (Cañada del Buey) and R-39 (Pajarito Canyon) were installed to augment the existing groundwater-monitoring network around MDAs G, H, and L.



Table 2-8
Wells and Boreholes Installed in 2008

Type*	Identifier	Watershed (Canyon)	Total depth (ft bgs)	Screened interval (ft bgs)	Water level (ft bgs)	Comments
R	R-35a	Sandia	1086.2	1013.1–1062.2	792.1	Lower Sandia Canyon, immediately southwest of municipal supply well PM-3.
A	PCAO-5	Pueblo	30	14.7–24.7	6.42	Approximately 100 ft upstream from the flood retention structure
A	PCAO-6	Pueblo	20	8–15	11.0	Approximately 300 ft downstream from the flood retention structure
A	PCAO-7A	Pajarito	25	9.7–19.7	11.0	North side of Pajarito Rd. approximately 100 ft from the TA-18 entrance
A	PCAO-7B1	Pajarito	60	44–54	56.92	North side of Pajarito Rd. directly across from the TA-18 entrance
A	PCAO-7B2	Pajarito	25	10–20	12.02	North side of Pajarito Rd. directly across from the TA-18 entrance
A	PAO-7C	Pajarito	25	9.7–19.7	10.55	South side of Pajarito Rd., approximately 50 ft from the TA-18 entrance
A	PCAO-8	Pajarito	25	9.7–19.7	22.5	In TA-36 on the south side of Pajarito Rd.
A	PCAO-9	Pajarito	21	6–16	7.75	In TA-36 on the south side of Pajarito Rd., (a quarter mile west of the security check point)
A	3MAO-2	Pajarito	30	14.7–24.7	26.6	In TA-18 in lower Threemile Canyon just above the confluence with Pajarito Canyon
A	TMO-1	Pajarito	6.5	3.5–6.5	1.00	Lower Two Mile Canyon above the confluence with Pajarito Canyon
I	SCI-2	Sandia	570	548–568	514.3	Lower Sandia Canyon due south of TA-53, adjacent to R-43
I	R-25b	Cañon de Valle	782	750–770.8	748.6	Adjacent to existing well R-25, above Cañon de Valle
I	R-25c	Cañon de Valle	1080.8	1039.6–1060.0	dry	Adjacent to existing well R-25, above Cañon de Valle
R	R-36	Sandia	803.7	766.9–789.9	749.1	Lower Sandia Canyon southeast of PM-3 and R-35a&b
R	R-38	Cañada del Buey	853.4	821.2–831.2	810.2	Cañada del Buey, northeast of MDA L
R	R-39	Pajarito	875.6	859–869	824	Pajarito Canyon, southeast of MDA G
R	R-42	Mortandad	973.5	931.8–952.9	918.8	Mortandad Canyon due south of TA-53 and southeast from R-43/SCI-2
R	R-43	Sandia	990.4	903.9–924.6 969.1–979.1	893.0 (composite)	Lower Sandia Canyon due south of TA-53, adjacent to SCI-2

* A = alluvial aquifer well; I = perched intermediate aquifer well; R = regional aquifer well.

10. National Environmental Policy Act

The intent of the National Environmental Policy Act (NEPA) (42 U.S.C. 4331 et seq.) is to promote productive harmony between humans and the environment. Federal agencies such as DOE/NNSA must consider the environmental impacts of proposed projects and ensure public participation as part of the decision-making process.

The Laboratory's Risk Reduction Office devotes considerable resources to assist NNSA in compliance with NEPA, pursuant to DOE Order 451.1B. Proposed projects and actions at LANL are reviewed to determine potential resource impacts and the appropriate coverage under NEPA, and these recommendations are provided to NNSA. The NEPA analysis in the new LANL Site-Wide Environmental Impact Statement (SWEIS) was prepared in 2007.

DOE NEPA implementing regulations (10 CFR Part 1021.330[d]) require a SWEIS to be reviewed at least every five years and a Supplemental Analysis be performed to examine whether the SWEIS still adequately covers site operations. In 2005, the DOE Los Alamos Site Office decided to develop a new SWEIS and after a scoping period, public comment period, and public hearings, the final SWEIS was issued in May 2008. A limited Record of Decision (ROD) was issued in September 2008 (DOE 2008b) in which DOE decided to implement the No Action Alternative with the addition of some elements of the Expanded Operations Alternative, as described below:

- Supporting the Global Threat Reduction Initiative and Off-Site Sources Recovery Project by broadening the types and quantities of radioactive sealed sources (Co-60, Ir-192, Cf-252, Ra-226) that LANL can manage and store before their disposal;
- Expanding the capabilities and operational level of the Nicholas C. Metropolis Center for Modeling and Simulation to support the Roadrunner Super Computer platform;
- Performing research to improve beryllium detection and to develop mitigation methods for beryllium dispersion to support industrial health and safety initiatives for beryllium workers;
- Retrieval and disposition of legacy transuranic waste (approximately 3,100 cubic yards of contact-handled and 130 cubic yards of remote-handled) from belowground storage.
- Planning, design, construction, and operation of the Waste Management Facilities Transition projects to facilitate actions required by the Consent Order;
- Repair and replacement of mission critical cooling system components for buildings in TA-55 to enable the continued operation of these buildings and to comply with current environmental standards; and
- Final design of a new Radioactive Liquid Waste Treatment Facility and design and construction of the Zero Liquid Discharge Facility component of this new treatment facility to enable LANL to continue to treat radioactive liquid wastes.

11. Endangered Species Act

The Endangered Species Act requires federal agencies to protect populations and habitats of federally listed threatened or endangered species. The Laboratory contains potential habitat for two federally endangered species (Southwestern willow flycatcher, Empidonax traillii extimus, and black-footed ferret, Mustela nigripes), one federally threatened species (Mexican spotted owl, Strix occidentalis lucida), and two candidate species (yellow-billed cuckoo, Coccyzus americanus, and New Mexico meadow jumping mouse, Zapus hudsonius luteus). The Southwestern willow flycatcher, black-footed ferret, 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 LANL (Table 2-9).

The Laboratory meets its requirements for threatened and endangered species protection through implementation of its Threatened and Endangered Species Habitat Management Plan and review of excavation permit requests and project profiles. During 2008, LANL reviewed 629 excavation permits, 122 project profiles, and 9 storm water pollution prevention plans for potential impacts to threatened or endangered species. The Laboratory conducted annual surveys for the Mexican spotted owl, Southwestern willow flycatcher, Jemez Mountains salamander, and grey vireo. During 2008, LANL prepared biological assessments for one project, Water Monitoring Stations and Wells, which required an amended consultation with the US Fish and Wildlife Service regarding potential impacts on federally listed threatened or endangered species.

Table 2-9
Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at LANL

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	C, NMS	Moderate
Zapus hudsonius luteus	New Mexico meadow jumping mouse	C, NMS	Moderate
Haliaeetus leucocepahlus	Bald Eagle	NMT, S1	High
Gila pandora	Rio Grande Chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains Salamander	NME, FSOC	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
Plegadis chihi	White-faced Ibis	S1	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
Plecotus townsendii pallescens	Townsend's Pale Big-eared Bat	NMS, FSOC	High
Nyctinomops macrotis	Big Free-tailed Bat	NMS	High
Myotis thysanodes thysanodes	Fringed Bat	NMS	High
Myotis yumanensis yumanensis	Yuma Bat	NMS	High
Myotis evotis evotis	Long-eared 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

[a] E = Federal Endangered; T = Federal Threatened; C = Federal Candidate Species; 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 on LANL; Moderate = Habitat exists, though the species has not been recorded recently; High = Habitat exists, and the species occurs at LANL.

12. Migratory Bird Treaty Act

Under the provisions of 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 US Fish and Wildlife Service. Through the project review process, LANL biologists provided specific comments for projects with the potential to impact migratory birds, their eggs, or nestlings through operation of an electrical power line or through disturbance of vegetation during the bird nesting season.

13. Cultural Resources

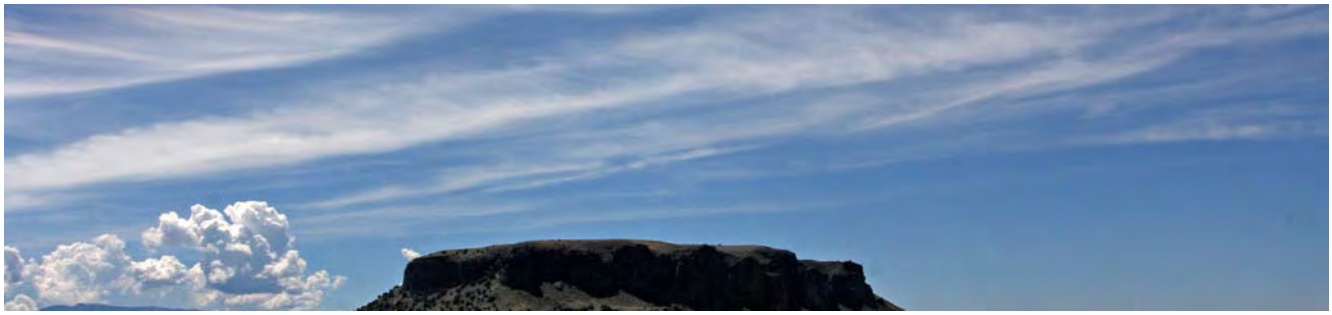
The goal of the National Historic Preservation Act (NHPA) of 1990 is to have federal agencies act as responsible stewards of the nation's resources when their actions affect historic properties. NHPA Section 106 requires federal agencies to take into account the effects projects may have on historic properties and to allow for comment by the Advisory Council on Historic Preservation. Section 106 regulations outline a project review process conducted on a project-by-project basis.

In 2008, the Laboratory conducted 38 projects that required some field verification of previous cultural surveys. Eleven new archaeological sites and 27 new historical buildings were identified in 2008. One archaeological site and eight historic buildings were determined eligible for the National Register of Historic Places.

The Laboratory began the seventh year of a multiyear program that included archaeological excavation in support of the Land Conveyance and Transfer Project. The DOE/NNSA is in the process of conveying to Los Alamos County approximately 2,000 acres of Laboratory lands. Thirty-nine archaeological sites were excavated during the 2002 to 2005 field seasons, with more than 200,000 artifacts and 2,000 samples collected. The artifacts are currently stored at LANL and are in the process of being transferred for curation to the Museum of New Mexico. Together, these sites provide new insights into past activities on the Pajarito Plateau from 5000 B.C. to A.D. 1943. From a compliance perspective, these excavations resolve the anticipated adverse effects to archaeological sites from the future development of lands to be acquired by Los Alamos County. These sites are also ancestral places to the local Pueblo populations, and, as such, representatives from the Pueblos de San Ildefonso and Santa Clara acted as tribal consultants and monitors on the project. During fiscal year 2008, the final report was completed and submitted to the New Mexico State Historic Preservation Office (NMSHPO) in fulfillment of the Data Recovery Plan and the Programmatic Agreement between the DOE Los Alamos Site Office, the Advisory Council on Historic Preservation, and the NMSHPO.

In support of LANL's 2008 decontamination and decommissioning program, square footage reduction, and Laboratory consolidation, the Laboratory conducted historic building assessments and other documentation work related to three proposed projects as required under the provisions of the NHPA. Buildings included in these projects are located at TAs-8, -11, and -37. This work included field visits to historic properties (including interior and exterior inspections), digital and archival photography, and architectural documentation (using standard LANL building recording forms). Additional documentation included the production of location maps for each of the evaluated projects. Historical research was also conducted using source materials from the LANL archives and records center, historical photography, the Laboratory's public reading room, and previously conducted oral interviews.

Native American consultation is ongoing with respect to identifying and protecting traditional cultural properties, human remains, and sacred objects in compliance with the NHPA and Native American Graves Protection and Repatriation Act (NAGPRA). Work included consultation with the Pueblos de San Ildefonso and Santa Clara concerning the procedures for the inadvertent discovery of Native American human remains and associated funerary objects, sacred objects, or objects of cultural patrimony, protection of traditional cultural properties, and student internships.



C. UNPLANNED RELEASES

1. Air Releases

No unplanned air releases occurred during 2008.

2. Liquid Releases

No unplanned releases of radioactive liquids occurred in 2008. There were 12 unplanned releases of non-radioactive liquids in 2008:

- Approximately 6,500 gal. of potable water into DP Canyon.
- Approximately 500 gal. of domestic wastewater onto the ground at TA-53.
- Approximately 1,350 gal. of potable water into Mortandad Canyon.
- Approximately 7,500 gal. of potable water into Mortandad Canyon.
- Approximately 4,000 gal. of steam condensate into Mortandad Canyon.
- Approximately 2,000 gal. of sanitary wastewater into Cañada del Buey.
- Approximately 4,000,000 gal. of potable water into Los Alamos Canyon.
- Approximately 0.5 gal. motor oil and 2 gallons of antifreeze mixed with storm water into Pajarito Canyon.
- Approximately 200 gal. of domestic wastewater into a storm drain at TA-53.
- Approximately 7,000 gal. of potable water into Cañada del Buey.
- Approximately 3,500 gal. of steam condensate into Los Alamos Canyon.
- Approximately 1,000 gal. of potable water into Los Alamos Canyon.

The Laboratory investigated all unplanned releases of liquids as required by the NMWQCC Regulations 20.6.2.1203 NMAC. Upon cleanup, the NMED and the DOE Oversight Bureau inspected the unplanned release sites to ensure adequate cleanup. In 2008, the Laboratory was in the process of administratively closing out all releases for 2008 with the NMED and the DOE Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

D. REFERENCES

DOE 1996: "Dual-Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," United States Department of Energy report USDOE/EIS-0228 (January 1996).

DOE 2008a: US Department of Energy, "Final Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico," DOE/EIS-0380 (May 16, 2008).

DOE 2008b: US Department of Energy, NNSA, "Record of Decision: Site-Wide Environmental Impact Statement for Continued Operation of Los Alamos National Laboratory, Los Alamos, New Mexico" (September 19, 2008).

LANL 2006: "Interim Measures Work Plan for Chromium Contamination in Groundwater," Los Alamos National Laboratory document LA-UR-06-1961, Los Alamos, New Mexico. (LANL 2006, 091987) (March 2006).

NMEIB 2007: New Mexico Environmental Improvement Board, State of New Mexico, "Drinking Water Regulations" (as amended through April 2007), found at 20.7.10 NMAC.

3. Radiological and Nonradiological Dose Assessment



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A. INTRODUCTION

This chapter presents the results of the calculation of radiological dose and nonradiological risk to the public and biota from Laboratory operations in 2008 and reports whether the doses are below specified limits. This chapter also provides a measure of the significance of environmental radioactivity in the context of its potential risk to humans and biota. In this respect, the human dose assessment provides a different perspective from the biota dose assessment. The calculated human dose is received near the publicly accessible Laboratory boundaries, whereas the calculated biota dose is potentially received throughout the interior of the Los Alamos National Laboratory (LANL or the Laboratory) property, usually at locations rarely visited by humans. In addition, the potential risks from nonradiological materials detected during 2008 and previous years' sampling activities are summarized.

As defined by US Department of Energy (DOE) Standard 1153-2002 (DOE 2002), biota are divided into plants and animals. Plants receive the highest radiation dose because they live in one location. Most animals range over a wider area, which usually minimizes their dose. Humans receive the lowest radiation dose because they limit their time in areas with residual contamination and do not typically eat the vegetation or drink the water in these areas. Therefore, locations with no significant human radiation dose may have a higher biota radiation dose.

B. RADIOLOGICAL DOSE ASSESSMENT FOR HUMANS

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented are calculated using standard methods specified in guidance documents (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997, 1999; ICRP 1996; NRC 1977). The "effective dose equivalent," referred to here as "dose," is calculated using radiation weighting factors and tissue weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in millirem (mrem), is a measure of the overall dose to an individual, whether from external radiation or contact with radioactive material. For example, 1 mrem of direct gamma radiation is effectively equivalent to 1 mrem from inhalation of plutonium.

Federal government standards limit the dose that the public may receive from Laboratory operations. The DOE dose limit to a member of the public is 100 mrem/yr (DOE 1993) received from all pathways (i.e., all ways in which a person can be exposed to radiation, such as inhalation, ingestion, and direct radiation). Furthermore, doses to members of the public must be reduced to low levels consistent with a documented as low as reasonably achievable (ALARA) process (LANL 2008a) and generally not exceeding a dose constraint of one-quarter of the primary dose limit, or 25 mrem/yr (DOE 1999). The dose received from airborne emissions of radionuclides

is further restricted by the US Environmental Protection Agency (EPA) dose standard of 10 mrem/yr (EPA 1986), also known as the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities (Rad-NESHAP) dose limit. These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from community drinking water supplies are limited in accordance with the Clean Water Act, either by established maximum contaminant levels (MCLs) for some radionuclides or by dose rate (4 mrem/yr for man-made radionuclides) (EPA 2000).

2. Public Dose Calculations

a. Scope

The objective of our public dose calculations is to report incremental (above-background) doses caused by LANL operations. Therefore, we don't include dose contributions from radionuclides present in our natural environment or from radioactive fallout.

Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and direct (or external) radiation. We calculate doses for the following cases:

1. The entire population within 80 km of the Laboratory
2. The maximally exposed individual (MEI) who is not on LANL property for the airborne pathway dose only and compared with the EPA RAD-NESHAP dose limit of 10 mrem/yr
3. The MEI not on LANL property for the all-pathways dose and compared with the DOE Order 5400.5 dose limit of 100 mrem/yr
4. Residents in Los Alamos and White Rock

b. General Considerations

We began with environmental measurements of air, water, soil, foodstuffs, sediment, and nonfoodstuffs biota and convert these measurements to dose using the standard methods specified above.

As discussed in Section B.4, the dose rate from naturally occurring radioactivity is approximately 450 mrem/yr (additional man-made sources of radiation, such as medical/dental uses of radiation and building products such as stone walls, raise the total background dose to about 700 mrem/yr on average) (NCRP 1975, 1987, 2009). It is extremely difficult to measure doses from LANL less than 0.1% (one one-thousandth) of natural doses. As the dose rates become smaller, the estimates become less certain and less significant. Generally, we conclude that a dose rate less than 0.1 mrem/yr is essentially zero and cannot be distinguished from natural background radiation.

i. Direct Radiation Exposure

The Laboratory monitors direct radiation from gamma photons or neutrons at about 100 locations in and around LANL (see Chapter 4, Section C). Direct radiation doses above natural background are measured near Technical Area (TA) -54, but elsewhere there are no other sources of external radiation to off-site areas.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source of external radiation. At distances more than one kilometer, the decrease in radiation dose rate with increasing distance from the radiation source (inverse-square law), combined with scattering and attenuation or shielding in the air, reduces the dose to much less than 0.1 mrem/yr, which cannot be distinguished from natural background radiation. This means the only significant above-background doses from direct radiation are measured near TA-54 (see Section B.3.b of this chapter).

To estimate the dose to the public near TA-54, we combined the measurements of gamma and neutron dose with an occupancy factor of 1/16 (NCRP 1976). The direct radiation measurements reported in Chapter 4 apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/yr). We followed standard guidance and assumed continuous occupancy for residences and places of business. For all other locations, we multiplied the measured dose by the 1/16 occupancy factor.

ii. Airborne Radioactivity (Inhalation Pathway)

At distances more than a few hundred meters from LANL sources, the dose to the public is almost entirely from airborne radioactive material. Whenever possible, we use the direct measurements of airborne radioactivity concentrations measured by the Ambient Air Sampling Network (AIRNET) and reported in Chapter 4, Section A. Where local concentrations are too small to measure, we calculate the doses using the CAP88 model (PC Version 3.0) (EPA 2007a), an atmospheric dispersion and dose calculation computer code that combines stack radionuclide emissions information with meteorological data to estimate where the released radioactive material went and the dose from that radioactive material.

In particular, some of the radionuclide emissions from the Los Alamos Neutron Science Center (LANSCE) are not measured by AIRNET. These emissions are measured at the stacks (see Chapter 4, Section B), and the resulting doses are calculated with CAP88. These doses decrease substantially with distance from the stack because the radioactive half-lives are short (mostly 20 minutes or less).

iii. Water (Ingestion Pathway)

The majority of radionuclides detected in groundwater samples collected from known or potential drinking water sources (i.e., Los Alamos County drinking water supply wells and natural springs) in 2008 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226. However, several radionuclides attributable to Laboratory operations were measured in samples from an on-site alluvial spring in middle Los Alamos Canyon (DP Spring), which is not a recognized drinking water source. Strontium-90, americium-241, plutonium-239/240, and tritium were measured in DP Spring samples at maximum concentrations of 44 pCi/L, 0.075 pCi/L, 0.059 pCi/L, and 56 pCi/L, respectively. The maximum dose from ingesting one liter of water from this spring is approximately 0.007 mrem. The highest concentration of tritium detected in a Los Alamos County drinking water supply well was 32 pCi/L in a sample collected from the Otowi-1 well located in Pueblo Canyon and is within the range of tritium concentrations found in rain water (16 to 35 pCi/L) (Holloway 1993). This concentration is far below the EPA MCL of 20,000 pCi/L and results in a dose of approximately 0.002 mrem/yr if this water were to be ingested for an entire year (assumes 730 L ingested for the year). However, this well has not been used by Los Alamos County as a drinking water source for several years.

Surface water samples were obtained in 2008 from three locations along the Rio Grande. Radionuclide analysis of these samples indicated the presence of radium-226, tritium, uranium-234, uranium-235/236, and uranium-238. The highest concentrations of tritium, uranium-234, and uranium-238 were measured in samples taken from a location above LANL at Otowi Bridge, indicating a non-LANL source for these radionuclides. Radium-226 is a decay product of natural radioactivity, and the highest concentration was measured in a sample obtained from the Rio Grande in the Buckman area. The highest uranium-235/236 level was measured in a sample taken from the Rio Grande at Frijoles Canyon. In no case did any concentration exceed the screening levels specified in LANL 2003 necessitating a dose assessment.

These water ingestion doses are very small relative to the 4-mrem/yr EPA community drinking water dose limit.

iv. Soil (Direct Exposure Pathway)

We report measurements of radionuclide concentrations in surface soil in Chapter 7. As described in Chapter 7, Section C.1, soil samples are collected on the perimeter of the Laboratory and at regional and on-site locations on a triennial basis (every three years). Routine soil samples were last collected in 2006 and are due for collection again in 2009. No regional samples have had radionuclide concentrations detected above the Regional Statistical Reference Levels (RSRLs). RSRLs represent background radionuclide concentrations plus three standard deviations in media, such as soil, sediment, and crops, collected or harvested in regional areas far from the influence of the Laboratory averaged over a period of five years.

However, soil concentrations measured in samples from previous years were above the RSRL at some perimeter locations. For example, plutonium-239/240 was above the RSRL at locations near TA-1 in the Los Alamos town site, near TA-21 along DP Road, and at TA-73 along State Route 502. In Chapter 7, Section D.2, new data for 2008 are reported at two off-site locations north of Area G. One sample identified as "San Ildefonso," was collected across Cañada del Buey about one-half mile north of Area G. Another sample, identified as "Tsankawi/PM-1," was collected just a little over two miles away and is also located north of Area G. Stronium-90, cesium-137, plutonium-239/240, uranium-234, and uranium-238 were detected in these samples, and all results were below their respective RSRLs. At both locations, calculated doses corrected for regional background levels were much less than 0.1 mrem/yr.

In summary, we conclude that the LANL contribution to the dose from soil around the perimeter of the Laboratory is less than 0.1 mrem/yr, and the majority of the anthropogenic radionuclides detected are primarily due to worldwide fallout and historical operations at the Laboratory.

v. Food (Ingestion Pathway)

We report measurements of the radioactive content of food, mostly crops, fish, and native vegetation, in Chapter 8. The food is collected on a triennial basis, rotating with the collection of soils. This year focused on the analysis of predator and bottom-feeding fish caught in the Rio Grande River upriver and downriver of LANL, as well as in Abiquiu Reservoir and Cochiti Reservoir. The dose from consuming 25 g/day (EPA 1997) of predator or bottom-feeding fish from any location where these fish were caught is less than 0.1 mrem/yr. Calculated doses from consuming predator fish upriver and downriver of LANL are approximately 0.008 mrem/yr and 0.01 mrem/yr, respectively. Calculated doses from consuming bottom-feeding fish upstream and downstream of LANL are approximately 0.02 mrem/yr and 0.03 mrem/yr, respectively. In general, ingestion doses from bottom-feeding fish are higher than from predator fish because bottom-feeding fish ingest radionuclides bound to sediments.

The food ingestion doses are very small relative to the all-pathways dose limit of 100 mrem/yr and the 25-mrem/yr dose constraint.

vi. Release of Items and Real Property

The Laboratory releases miscellaneous surplus items of salvageable office and scientific equipment to the general public. The requirements for release of such items are found in LANL 2008. All items destined for release from known or potentially contaminated areas are screened for radioactive contamination in accordance with the procedures of LANL's Health Physics Operations Group. Any items with surface contamination or dose levels above the authorized release limits for uncontrolled use are not released to the public. Items from a known or potentially contaminated area that cannot be completely surveyed are also not released. The authorized release limits for items (LANL 2008) are the limits in Figure IV-1 of DOE requirements (DOE 1993, DOE 1995). In 2008, no items were released to the public with contamination or dose levels approaching the authorized release limits. Therefore, the dose to the public from this pathway is negligible.

The transfer of real property (land) from DOE to the public is allowed if the modeled dose is no greater than the authorized release limit of 15 mrem/yr and the modeled dose is ALARA. One ALARA analysis for the release of real property was performed in 2008, specifically for the conveyance and transfer of land tracts A-04 and A-18b within TA-73. All calculated doses were found to be below the authorized release limit of 15 mrem/yr. However, not all calculated doses were below the 3 mrem/year quantitative ALARA analysis threshold. Therefore, a quantitative analysis was performed for these land tracts. The analysis indicated that the cost of further remediation of these land tracts far exceeded the benefit, and no further remedial action was recommended. Therefore, the doses are ALARA.

3. Dose Calculations and Results

a. Collective dose to the population within 80 Kilometers

We used the local population distribution to calculate the dose from 2008 Laboratory operations to the population within 80 km (50 miles) of LANL. Approximately 280,000 persons live within an 80-km radius of the Laboratory. We used New Mexico county population estimates provided by the University of New Mexico Bureau of Business and Economic Research (available at http://www.unm.edu/~bber/).

The collective dose from Laboratory operations is the sum of the estimated doses for each member of the public within an 80-km radius of LANL. For example, if two persons each receive three mrem, the collective dose is six person-mrem. This collective dose results from airborne radioactive emissions. Other potential sources, such as direct radiation, are essentially zero. We calculated the collective dose by modeling the transport of radioactive air emissions using CAP88.

The 2008 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory is 0.79 person-rem, which is about twice the collective dose of 0.36 person-rem reported for 2007. This increase is primarily due to the increased gaseous tritium and tritium oxide released from the TA-16-450 stack and activated air products released from the Los Alamos Neutron Science Center (LANSCE) stacks compared with 2007. Tritium contributed 33% of the dose, and short-lived air activation products such as carbon-11 from LANSCE contributed 64% of the dose. The decrease in the 2006–2008 collective population dose compared with 2005 (2.46 person-rem) is primarily attributable to the repair of a leak at LANSCE in December 2005 and to an additional delay line installed at LANSCE in 2005. LANSCE has historically been the major contributor to the collective population dose. Collective population doses for the past 15 years have generally declined from a high of four person-rem in 1994 to less than one person-rem in 2008 (Figure 3-1). It is expected that future collective population doses will be less than one person-rem. No observable health effects in the local population are expected from this dose.

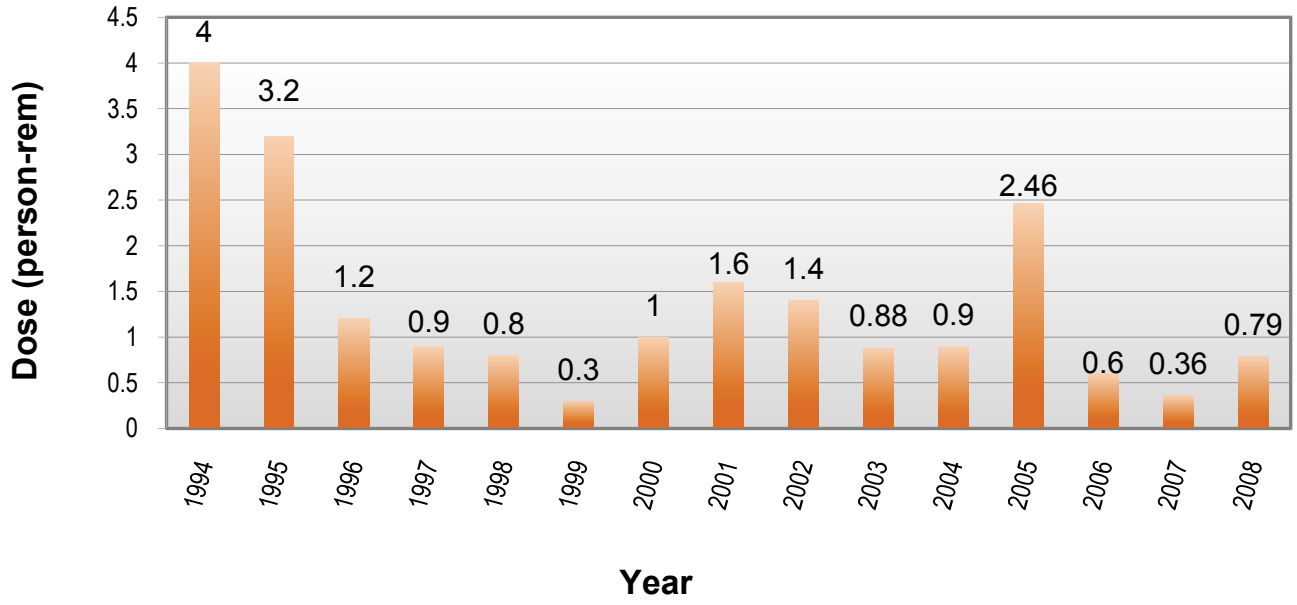


Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL.

b. Dose to the Maximally Exposed Individual

The MEI is a hypothetical member of the public who, while not on DOE/LANL property, receives the greatest dose from LANL operations. For most of the past 15 years, the airborne pathway (RAD-NESHAP) MEI location has been at 2470 East Road, usually referred to as "East Gate." East Gate has normally been the location of greatest exposure because of its proximity to LANSCE and the prevailing wind direction. During LANSCE operations, short-lived positron emitters, such as carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose.

i. Airborne Pathway (RAD-NESHAP) MEI Dose

Because the LANSCE emissions after 2005 have been reduced to such low levels, the location of the MEI for 2008 was not as readily apparent as in the past and required more detailed evaluation, as follows.

We modeled the dose at East Gate from LANSCE and from the LANL stacks using CAP88. The CAP88-modeled individual doses (Stavert 2009) were 0.28 mrem/yr from LANSCE and 0.24 mrem/yr from other LANL stacks. We added 0.03 mrem/yr calculated from the airborne radionuclide concentrations measured at the East Gate AIRNET station, though this dose includes tritium, which was also in the CAP88 modeled doses (thus, tritium dose is conservatively included twice). Therefore, the total dose at East Gate was approximately 0.55 mrem/yr (Figure 3-2).

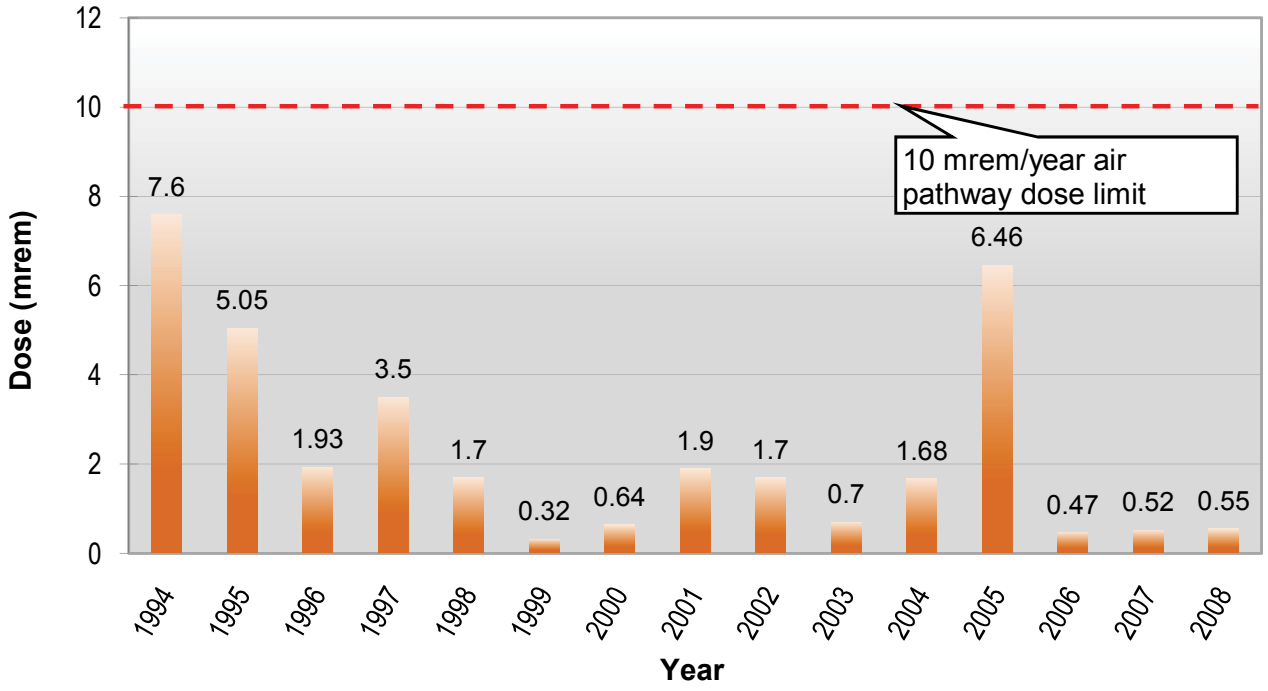


Figure 3-2. Annual airborne pathway (RAD-NESHAP) dose (mrem) to the MEI over the past 15 years.

To ensure the East Gate location is the location with the highest potential dose (the actual MEI), we estimated the potential dose at two other locations that had relatively high AIRNET doses: station 42 near a DP Road business and station 66 near the Ashley Suites (formerly Los Alamos Inn) on Trinity Drive. Though the dose from LANSCE emissions is a significant contributor at the East Gate location, it is much less so at other possible MEI locations. For each location, we determined the LANSCE facility (stack 53000702) annual gaseous mixed activation products (GMAP) emissions dose contribution and added the dose contribution from the AIRNET-measured radionuclides. The sums of these contributions at stations 42 and 66 were lower than the corresponding sum at East Gate. Therefore, the East Gate site was determined to be the MEI. See Section III of Stavert (2009) for the details of how the MEI calculations were performed.

ii. All-Pathways MEI Dose

The location evaluated in 2008 as the potential all-pathways MEI is the Laboratory boundary near the Pueblo de San Ildefonso sacred area north of TA-54, Area G. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant (WIPP) emits neutrons. The measured neutron dose at the boundary was 16 mrem/yr. After subtracting a 2-mrem/yr neutron background dose and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose is 14 mrem/16 = 0.9 mrem/yr. The gamma dose is calculated to be less than 0.01 mrem and is not included because it cannot be distinguished from the

much larger gamma background measured at this and other nearby monitoring locations. To estimate the contributions from airborne radionuclides at this location, we used CAP88 to model the dose contribution from the LANL stacks as 0.05 mrem/16 = 0.003 mrem/yr. We added the dose derived from measurements at the highest-dose AIRNET station along the northern boundary of Area G (0.23 mrem/yr) close to where the neutron dose was measured and applied the occupancy factor of 1/16 to obtain a dose of 0.01 mrem/yr. This resulted in a dose at this location of approximately 0.9 mrem/yr, which is greater than the airborne pathway MEI dose at East Gate.

iii. Dose Summary

The airborne pathway MEI dose of 0.55 mrem/yr at East Gate is below the 10 mrem/yr EPA airborne emissions dose limit for the public (40 CFR 61, EPA 1986), and, based on previous studies, we conclude it causes no observable health effects (BEIR 2006). The all-pathways MEI dose of 0.9 mrem/yr at the Laboratory boundary of the Pueblo de San Ildefonso sacred area north of Area G is below the 100 mrem/yr DOE limit for all pathways and the 25 mrem/yr dose constraint (DOE Order 5400.5, DOE 1993, DOE 1999), and, again, we conclude it causes no observable health effects.

In most past years, LANSCE has been the major contributor to the MEI airborne pathway dose. Future operations of the facility and associated emissions are expected to stay consistent with 2008 levels. Although total stack emissions during 2008 increased several times over those of 2007, the airborne pathway MEI dose in 2008, 0.55 mrem/yr, was similar to the 2007 airborne pathway MEI dose of 0.52 mrem/yr. The 2008 MEI was located at East Gate and was primarily due to short-lived air activation emissions from LANSCE and from tritium emissions from TA-16. The 2007 airborne pathway MEI was located on DP Road and was primarily due to the resuspension of plutonium-239 in soil from Material Disposal Area (MDA) B.

c. Doses in Los Alamos and White Rock

We used background-corrected AIRNET data (reported in Chapter 4, Section A) and the factors in EPA guidance (EPA 1986) to calculate an annual dose at each of the perimeter AIRNET stations that represent the Los Alamos resident and the White Rock resident. To these doses, we added the contributions from LANSCE and other stack emissions, calculated using CAP88 for two representative locations: 5 km northwest of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

i. Los Alamos

During 2008, the Laboratory contributions to the dose at an average Los Alamos residence were 0.008 mrem/yr from tritium, 0.018 mrem/yr from transuranics, 0.012 mrem/yr from uranium, and 0.009 mrem/yr from LANSCE. Other radionuclides contributed less than 0.001 mrem/yr. This results in a total dose to an average Los Alamos resident of approximately 0.047 mrem/yr.

ii. White Rock

During 2008, the Laboratory contributions to the dose at an average White Rock residence were 0.014 mrem/yr from tritium, 0.007 mrem/yr from transuranics, 0.008 mrem/yr from uranium, and 0.008 mrem/yr from LANSCE. Other radionuclides contributed 0.001 mrem/yr. This results in a total dose to an average White Rock resident of approximately 0.038 mrem/yr.

iii. Dose Summary

The contributions from direct radiation, food, water, and soil are discussed in Section B.2 of this chapter; each contribution is considered to be essentially a zero dose (i.e., <0.1 mrem/yr). In summary, the total annual dose in 2008 to an average Los Alamos/White Rock resident from all pathways was about 0.04 to 0.05 mrem and is well below the all-pathways dose limit of 100 mrem/yr and the 25 mrem/yr dose constraint. No observable health effects are expected from this dose.

4. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

In this section, we discuss the potential LANL dose contribution relative to natural radiation and radioactive materials in the environment (NCRP 1975, 1987a, 1987b).

External radiation comes from two sources that are approximately equal; cosmic radiation from space and terrestrial gamma radiation from naturally occurring radionuclides. Doses due to cosmic radiation range from 50 mrem/yr at lower elevations near the Rio Grande to about 90 mrem/yr in the higher elevations west of Los Alamos (Bouville and Lowder 1988). In addition, background doses from terrestrial radiation range from about 50 to 150 mrem/yr.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products. Nationwide, the average dose from radon is about 200 to 300 mrem/yr (NCRP 1987b.) In northern New Mexico, the radon concentrations and doses are higher than the national average. For more information, refer to the radon section of the EPA Website (http://www.epa.gov/radon/) and the map of radon zones (http://www.epa.gov/radon/zonemap.html). An additional 40 mrem/yr results from naturally occurring radioactive materials in the body, primarily potassium-40, which is present in all food and living cells.

In addition, members of the US population receive an average dose of 300 mrem/yr from medical and dental uses of radiation. Compared to estimates used in previous years, this is a significant increase and is attributable to new information about the average medical dose received by members of the US population (NCRP 2009). About 10 mrem/yr comes from man-made products, such as stone or adobe walls, and less than 1 mrem/yr comes from global fallout from nuclear weapons tests. Therefore, the average total annual dose from sources other than LANL is approximately 700 mrem. Figure 3-3 compares the natural radiation background (and other sources) in Los Alamos to the United States average background. The estimated LANL-attributable 2008 all-pathways MEI dose, 0.9 mrem/yr, is about 0.1% of this dose.

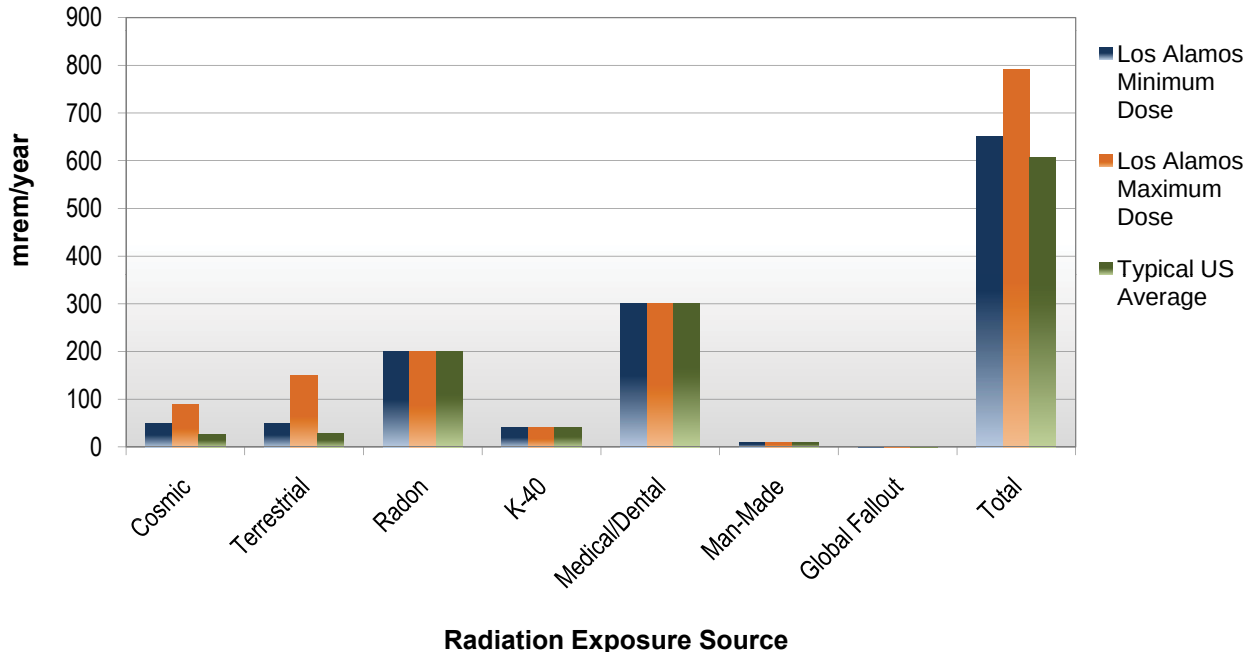


Figure 3-3. Los Alamos County radiation background compared with average US background. Los Alamos County-specific background doses have not been determined for radon, potassium-40, medical/dental exposures, man-made radiation, and global fallout and are assumed to be the same as the US average in this figure.

5. Effect to an Individual from Laboratory Operations

Health effects from radiation exposure have been observed in humans at doses in excess of 10 rem (10,000 mrem), and as low as 1 rem (1,000 mrem) for the in utero fetus (BEIR 2006). However, doses to the public from LANL operations are much smaller (Table 3-1). Therefore, the doses presented in this chapter are not expected to cause observable health effects. At doses less than 10 rem (10,000 mrem), statistical limitations make it difficult to evaluate the human risks (BEIR 2006). Therefore, the doses presented in this chapter are not expected to cause observable health risk.

Table 3-1
LANL Radiological Dose for Calendar Year 2008

Pathway	Dose to Maximally Exposed Individual mrem/yr	% of DOE 100 mrem/yr Limit	Estimated Population Dose person-rem	Population within 80 km	Estimated Background Radiation Population Dose person-rem
Air	0.55[a]	0.55%	0.79	NA[b]	NA
Water	<0.1	<0.1%	0	NA	NA
Other Pathways (foodstuffs, soils, etc.)	<0.1	<0.1%	0	NA	NA
All Pathways	0.9[c]	1%	0.79	~280,000	~200,000[d]

[a] RAD-NESHAP MEI dose measured at 2470 East Road (East Gate).

[b] NA = Not applicable. Pathway-specific populations are not specified, and pathway-specific background doses have not been determined, as allowed by DOE guidance.

[c] All-pathways MEI dose at the boundary of the Pueblo de San Ildefonso sacred area north of Area G.

[d] Based on 200 mrem/yr from inhalation of radon and its decay products, 70 mrem/yr from cosmic radiation, 100 mrem/yr from terrestrial radiation, 40 mrem/yr from potassium-40, 300 mrem/yr from medical and dental uses of radiation, and 10 mrem/yr from man-made products (see Section B.4).

C. BIOTA DOSE ASSESSMENT

1. Biota Dose Assessment Approach

a. Overview

The biota dose assessment methods are described in detail in the DOE Standard 1153-2002 (DOE 2002) and in the computer program RESRAD-BIOTA (http://web.ead.anl.gov/resrad/home2/biota.cfm). The DOE methods are general in nature and allow specific parameters to be adjusted according to local conditions because the calculations apply to all types of biota and all types of ecosystems. The site-specific methods used at LANL are specified in the quality assurance project plan for Biota Dose Assessment (available at http://www.lanl.gov/environment/air/qa.shtml?2), and McNaughton 2005 describes in detail the application of these methods to specific locations at LANL.



We calculate the dose to selected plants and animals following the guidance of DOE Standard 1153-2002 (DOE 2002) and LANL (LANL 2004). Trees of the pine family (Pinaceae) are representative of terrestrial plants because they are radiosensitive (UNSCEAR 1996) and because their deep roots might tap into buried contamination (Foxx et al. 1984a, b; Tierney and Foxx 1987). Deer mice are representative of terrestrial animals because of their relatively small home range, which means the maximally exposed mouse might spend a large fraction of its time in the most contaminated location. These representative plants and animals are common and widespread within LANL and the surrounding area. Other plants and animals (including aquatic plants and animals) may be collected and analyzed to estimate biota dose depending on availability and locations of interest.

b. Biota Dose Limits

The biota dose limits (DOE 2002) are applied to representative biota populations rather than to the MEIs because it is the goal of DOE to protect populations, especially with respect to preventing the impairment of reproductive capability within the population. For animals, we used the population area for deer mice of 3 ha (30,000 m^2) (Ryti et al. 2004; LANL 2004). We also averaged the dose to plants over this same area (McNaughton 2005).

The DOE dose limits to biota populations are

- Terrestrial animals: 0.1 rad/day (100 mrad/day)
- Terrestrial plants: 1 rad/day (1,000 mrad/day)
- Aquatic animals: 1 rad/day (1,000 mrad/day)

c. Methods

To ensure that the assessment is comprehensive, we began with a level 1 initial screening (DOE 2002) comparing the maximum radionuclide concentrations in soil, sediment, and surface water with the DOE Biota Concentration Guides (BCGs). The DOE Standard (DOE 2002) states, "An important point is that exceeding the BCGs should not force a mandatory decision regarding remediation of the evaluation area, but rather is an indication that further investigation is likely necessary." If the BCGs are exceeded, a level 2 site-specific assessment (DOE 2002) is conducted that uses average concentrations and incorporates site-specific bioaccumulation factors. Following the guidance of the DOE Standard (DOE 2002), we did not include external-radiation dose from experimental facilities such as the Dual Axis Radiographic HydroTest (DARHT) facility and LANSCE.

2. Biota Dose Results



As reported in Chapters 5 through 8, we collected water, soil, sediment, vegetation (overstory and/or understory), bees, and small mammals in 2008 from several locations. All radionuclide concentrations in vegetation sampled were far below the plant 0.1 rad/day biota dose screening level (10% of the 1 rad/day dose limit), and all radionuclide concentrations in terrestrial animals sampled were far below the terrestrial animal 0.01 rad/day biota dose screening level (10% of the 0.1 rad/day dose limit). As previously mentioned in the soil pathway section of this chapter (see Section B.2.iv.), certain perimeter and on-site sample locations had soil radionuclide concentrations above RSRLs attributable to historical Laboratory operations. However, none of these concentrations exceeded the limiting terrestrial animal BCG screening levels.

As reported in Chapter 6, there were three cases in which surface water concentrations exceeded the general screening levels. These are discussed below.

In Los Alamos Canyon above DP Canyon, one storm water sample at gage E030 exceeded the DOE BCG for plutonium-239/240 by <2 times the DOE BCG for aquatic systems (sample result of 341 pCi/L compared with the BCG of 200 pCi/L). This location is not an aquatic habitat, so we used the concentrations listed in Table 6-2 (adjusted for intermittent flow) for a terrestrial biota dose assessment. The resulting dose rates are 1.0×10^{-5} rad/day for terrestrial animals and 4.3×10^{-8} rad/day for terrestrial plants. These dose rates are far below the dose limits, so this location passes the assessment.

Storm monitoring station PT-SMA-1 in the Potrillo Canyon watershed south of the TA-15 firing site collected surface water samples for a single storm event with concentrations for uranium-234 and uranium-238 of 395 pCi/L and 758 pCi/L, respectively. These concentrations exceed the uranium isotope BCGs of 200 pCi/L for aquatic systems. However, this location is not an aquatic habitat, so we used the maximum values of 395 and 758 pCi/L along with the maximum concentrations of associated radionuclides for a terrestrial biota dose assessment. The resulting dose rates were 4.1×10^{-4} rad/day to animals and 2.1×10^{-5} rad/day to plants and so are far below the dose limits.

In addition, 28% of surface water samples collected from the Pajarito Plateau in 2008 contained radium-226 at concentrations exceeding the DOE BCG for aquatic systems. However, this is a naturally occurring radionuclide and was found in all major watersheds and from releases upstream of LANL. The concentrations that exceed the BCG are for storm water containing sediment, and not from aquatic habitats, so we used the maximum concentrations detected for this location in terrestrial biota dose assessments. The worst-case dose rates were 3.7×10^{-4} rad/day for terrestrial animals and 6.7×10^{-6} rad/day for plants. Therefore, this worst case passes the assessment.

D. NONRADIOLOGICAL RISK ASSESSMENT

1. Overview

We have concluded that dose to members of the public and the environment from LANL radiological hazards is well understood and extensively documented. We place equal emphasis on the risk to members of the public and the environment from nonradiological hazards present at LANL, such as heavy metals and organic compounds.

This section assesses the potential human health risk from nonradiological materials released from LANL. Nonradiological air pollutants are regulated by the Clean Air Act, as discussed in Chapter 2, Section 6. The applicable standards for other media are summarized in Table 5-1, Table 6-1, Table 8-1, and Appendix A. Air emissions data are reported in Chapter 2, ambient air data are reported in Chapter 4, and the data for other environmental media are reported in Chapters 5 through 8. The resulting potential public health risks are summarized below.

2. Results

a. General Considerations

Environmental releases from LANL and the associated off-site concentrations of nonradiological contaminants in air, water, soil, and food from these releases are below the applicable standards or risk-based concentrations (EPA 2007, NMED 2006). Nevertheless, members of the public could potentially be exposed to hazardous materials from each of the environmental media discussed in the following sections.

i. Air (Inhalation Pathway)

The assessment of the ambient air impacts of high explosives testing, reported in Chapter 4, Section D.4, indicates no adverse impacts to the public. The beryllium concentrations reported in Chapter 4, Section D.5, appear to be of natural origin.

ii. Groundwater (Ingestion)

Groundwater results are reported in Chapter 5. The only Laboratory impact on a potential drinking water supply is at well Otowi-1 in Pueblo Canyon. For 2008, groundwater samples from this well had perchlorate concentrations ranging from 1.7 to 2.4 µg/L. However, this well is not used by Los Alamos County for its drinking water supply, and these values are below the EPA interim health advisory of 15 µg/L for drinking water. These perchlorate levels do not present a potential risk to human health.

Basalt Spring, on Pueblo de San Ildefonso land in lower Los Alamos Canyon, had nitrate concentrations ranging from 6.5 mg/L to 10.6 mg/L, which is slightly above the NMED groundwater standard of 10 mg/L. The elevated level of nitrate in the spring water is most likely due to past and present releases of treated effluent from the Los Alamos County sanitary treatment plants. This spring is not a recognized drinking water source and because of minimal water ingestion expected from this source, i.e., much less than 730 liters per year, and levels of nitrate just above the standard, no health effects are expected from this level of nitrate. Pine Rock Spring, also on Pueblo de San Ildefonso land, also had nitrate concentrations just above the NMED standard at 10 mg/L, but these levels should not present any health effects.

LANL has detected hexavalent chromium in the Mortandad Canyon regional aquifer monitoring well samples at up to 16 times the New Mexico groundwater standard (see Chapter 5, Table 5-15) and at about 46% (23 µg/L) of the standard (50 µg/L of any dissolved form of chromium) in a Sandia Canyon regional aquifer monitoring well. However, hexavalent chromium has not been found in Los Alamos County and Santa Fe Buckman drinking water supply wells above natural levels, so there is no health risk from ingestion of water from the drinking water supply wells.

iii. Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. No potentially hazardous chemicals of LANL origin were detected off-site, and we conclude there is no current hazard to the public from surface water and sediment exposure from past and present LANL environmental releases.

Polychlorinated biphenyls (PCBs) are present in the on-site surface water and sediment. However, there are no aquatic organisms within the LANL boundaries that are part of a food ingestion pathway to humans. Measurements of PCBs in sediment using the Aroclor method indicated that none of the results were greater than recreational or residential screening levels. Refer to Chapter 6, Section E.3.b. for further information.

PCBs are carried in sediment by storm water runoff events to the Rio Grande. In 2008, sediment samples from the Rio Grande, Abiquiu Reservoir, and Cochiti Reservoir were analyzed for PCBs using the Aroclor method. While the highest concentration of total Aroclors in sediment samples in 2008 was measured in an upper Cochiti Reservoir bottom sediment, over half of the total Aroclors was Aroclor-1248, which is usually not attributable to LANL operations. In addition, PCB congener homolog data from samples collected along the Rio Grande indicate the mixtures upriver and downriver from LANL sources are essentially identical, but are different than the Sandia Canyon homolog signature. This would be indicative of no measurable contribution of PCBs from LANL to the Rio Grande.

Of particular interest are the results of surface water samples collected from three locations along the Rio Grande in 2008. The locations of these samples are representative of locations where water will be diverted from the Rio Grande in the future to supply the drinking water needs of the City of Santa Fe. The three locations are Otowi Bridge, Buckman, and the mouth of Frijoles Canyon. None of the samples exceeded the screening level for metals, but nonfiltered samples collected on one day during 2008 at Otowi Bridge and Buckman exceeded the total PCB screening level. However, the sample with the highest result was collected at Otowi Bridge, which would indicate a source of PCBs above LANL.

iv. Soil

Concentrations in soil are reported in Chapter 7. The concentrations are far below their residential (NMED 2006) soil screening levels and, therefore, do not pose a potential human health risk.

v. Foodstuffs (Ingestion)

The concentrations of nonradioactive materials in foodstuffs are reported in Chapter 8. Of particular concern are mercury and PCB levels in bottom-feeding and predator fish caught in the Rio Grande and in Abiquiu Reservoir and Cochiti Reservoir in 2008. Several fish caught upriver and downriver of LANL had total mercury levels exceeding the EPA screening level of 0.30 mg/kg wet weight. Two predator fish caught in Cochiti Reservoir had levels exceeding the Federal Drug Administration (FDA) standard of 1 mg/kg wet weight. Although these levels are a concern because mercury is a neurotoxin, the data indicate LANL is not the major source of the mercury. Refer to Chapter 8, Section A.4.b., for further information.

Predator and bottom-feeding fish were collected from Abiquiu Reservoir and Cochiti Reservoir and at six locations along the Rio Chama and Rio Grande for the analysis of PCB congeners. Both predator and bottom-feeding fish from all collection points, including upriver locations, exceeded the screening levels, which are based on the EPA risk-based consumption limits for PCBs. However, the standard itself was not exceeded. Refer to Chapter 8, Section A.4.c., for further information.

Concentrations of mercury and PCBs in fish caught upriver of LANL were generally higher than in fish caught downriver, indicating no measurable contribution of these contaminants from LANL sources.

vi. Potential Future Risks

The possibility of hexavalent chromium and perchlorate from LANL sources entering the drinking-water supply in the future is being evaluated. Our goal is to assess both present and future risk. Models to calculate future risks are being developed.

3. Conclusion

The environmental data collected in 2008 and previous years show that there is no potential public-health risk from nonradiological materials released from LANL.

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4. Air Surveillance



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A. AMBIENT AIR SAMPLING

1. Introduction

The radiological air sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides, such as plutonium, americium, uranium, tritium, and some activation products, that may be released from Los Alamos National Laboratory (LANL or the Laboratory) operations. Natural atmospheric and fallout radioactivity levels fluctuate, affecting measurements. Most of the regional airborne radioactivity is from fallout (from past nuclear weapons tests worldwide), natural radioactive constituents in particulate matter, terrestrial radon and its decay products, and cosmic radiation products. Table 4-1 summarizes regional levels of airborne radioactivity for the past five years, which can be useful in interpreting similar data.

Table 4-1
Average Background Concentrations of Radioactivity in the Regional[a] Atmosphere

Analyte	Units	EPA Concentration Limit[b]	Annual Averages[c]				
			2004	2005	2006	2007	2008
Alpha	fCi/m^3	No limit exists	1.1	0.9	1.0	1.0	0.9
Beta	fCi/m^3	No limit exists	18.3	16.3	17.0	19.1	17.3
Tritium[d]	pCi/m^3	1,500	0.1	0.1	-0.2	0.2	0.8
Pu-238	aCi/m^3	2,100	-0.5	0.1	-0.3	-0.3	0.1
Pu-239	aCi/m^3	2,000	0.1	0.0	0.1	0.6	-0.1
Am-241	aCi/m^3	1,900	-0.1	0.1	0.2	-0.1	-0.3
U-234	aCi/m^3	7,700	17.7	12.4	16.6	15.3	18.0
U-235	aCi/m^3	7,100	1.2	1.2	0.8	0.8	1.3
U-238	aCi/m^3	8,300	17.4	13.2	16.1	14.7	16.5

[a] Data from regional air sampling stations operated by LANL (locations can vary by year).
[b] Each EPA Concentration Limit is from 10 CFR 40 and corresponds to 10 mrem/year.
[c] Alpha and beta values are gross air concentrations. All others are net air concentrations.
[d] Tritium values have been corrected for the tritium lost to bound water in the silica gel.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days increase soil entrainment; precipitation washes particulate matter out of the air. Meteorological conditions cause large daily and seasonal fluctuations in airborne radioactivity concentrations. Forest fires can dramatically increase short-term ambient concentrations of particulate matter.

LANL's air quality staff compares ambient air concentrations for publicly accessible locations to the 10-mrem annual dose equivalent concentration established by the US Environmental Protection Agency (EPA) (EPA 1989). Concentrations for on-site locations in controlled access areas are compared to Department of Energy (DOE) Derived Concentration Guides (DCGs) for workplace exposure.

2. Air Monitoring Network

During 2008, LANL operated approximately 60 environmental air stations to sample radionuclides by collecting water vapor and particulate matter. LANL categorizes the AIRNET sampling locations (Figures 4-1 through 4-4) as regional, pueblo, perimeter, waste site (Technical Area [TA] –54), decontamination and decommissioning (D&D) at Material Disposal Area (MDA) B, or other on-site locations.

3. Sampling Procedures, Data Management, and Quality Assurance

The AIRNET quality assurance project plan and the implementing procedures provide details about sample collection, sample management, chemical analysis, and data management.

a. Sampling Procedures

Generally, each AIRNET station continuously collects a sample during a two-week sample period. The stations collect particulate matter on 47-mm polypropylene filters at airflow rates of about 110 liters per minute. Cartridges that contain about 135 g of desiccant (silica gel) collect water vapor samples at an airflow rate around 0.2 liters per minute. The silica gel is dried in an oven to remove most residual water before use. After use in the field, the silica gel is removed from the cartridge and shipped to the analytical laboratory where the moisture is distilled and then analyzed for tritium.

b. Data Management

In the field, personnel record the sampling data on a palm-held microcomputer, including timer readings, volumetric airflow rates at the beginning and end of the sampling period, and comments pertaining to these data. These data are later transferred to a database.

c. Analytical Chemistry

A commercial laboratory analyzes each filter for gross alpha and gross beta activities. These filters are also grouped by region into 'clumps' of four to nine filters and analyzed for gamma-emitting radionuclides. A quarterly composite for each station is made up of half-filters from six or seven sampling periods. Analysts at the laboratory dissolve these composites, separate them chemically, and analyze them for isotopes of americium, plutonium, and uranium using alpha spectroscopy. The analytical laboratory uses liquid scintillation spectrometry to analyze the distillate from the gel for tritium. All analytical procedures meet the requirements of Title 40 Code of Federal Regulations (CFR) Part 61, Appendix B. The AIRNET quality assurance project plan specifies the target minimum detectable activities for all samples.

d. Laboratory Quality Control Samples

The sampling team and the analytical laboratory maintain a program of blank, spike, duplicate, and replicate analyses. This program provides information on the quality of the data received from the analytical laboratory. These data are reviewed to ensure they meet all quality assurance requirements.

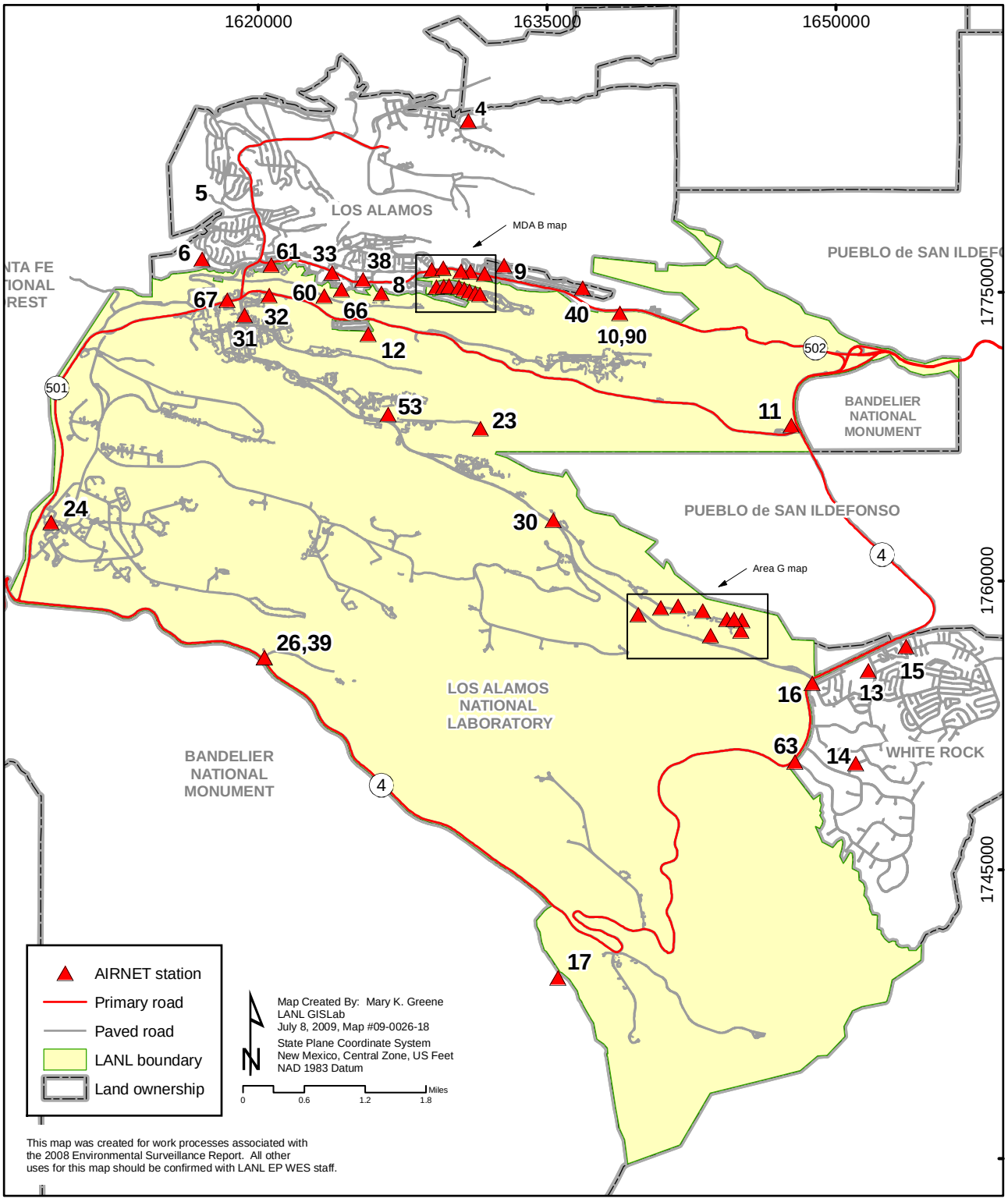


Figure 4-1. AIRNET locations at and near Los Alamos National Laboratory.



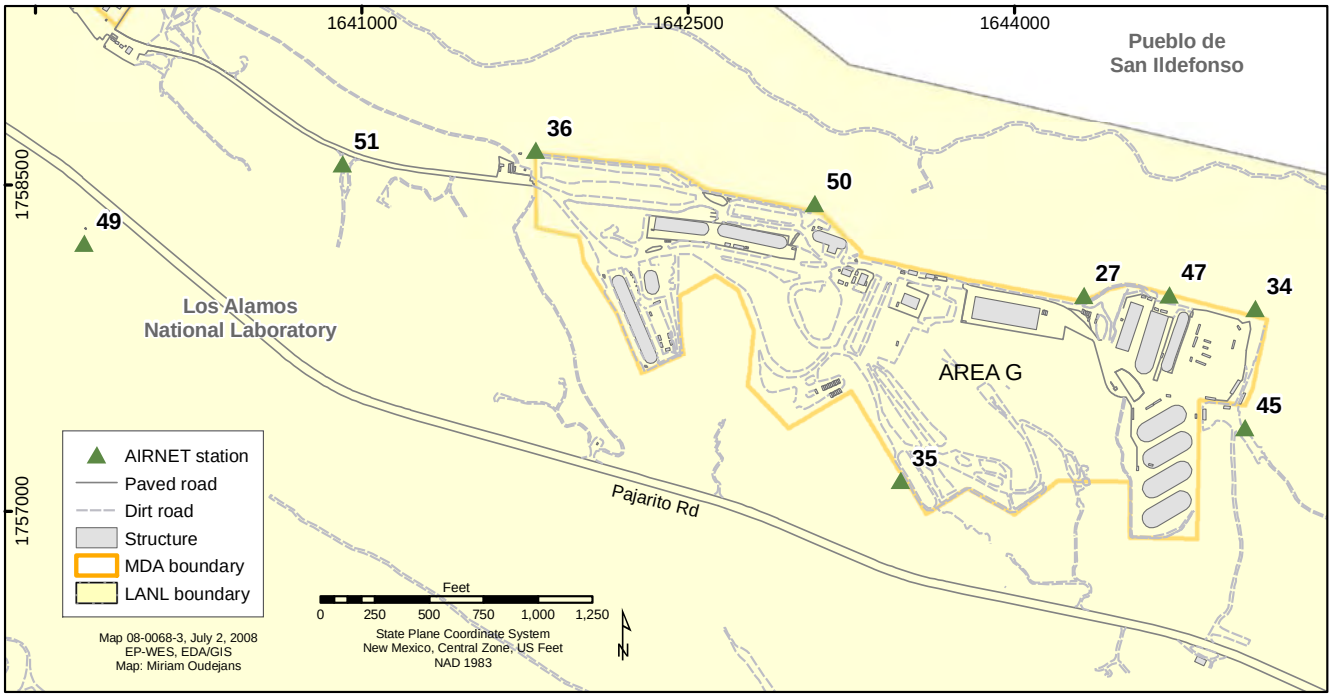


Figure 4-2. AIRNET station locations at Area G, TA-54, Los Alamos National Laboratory.

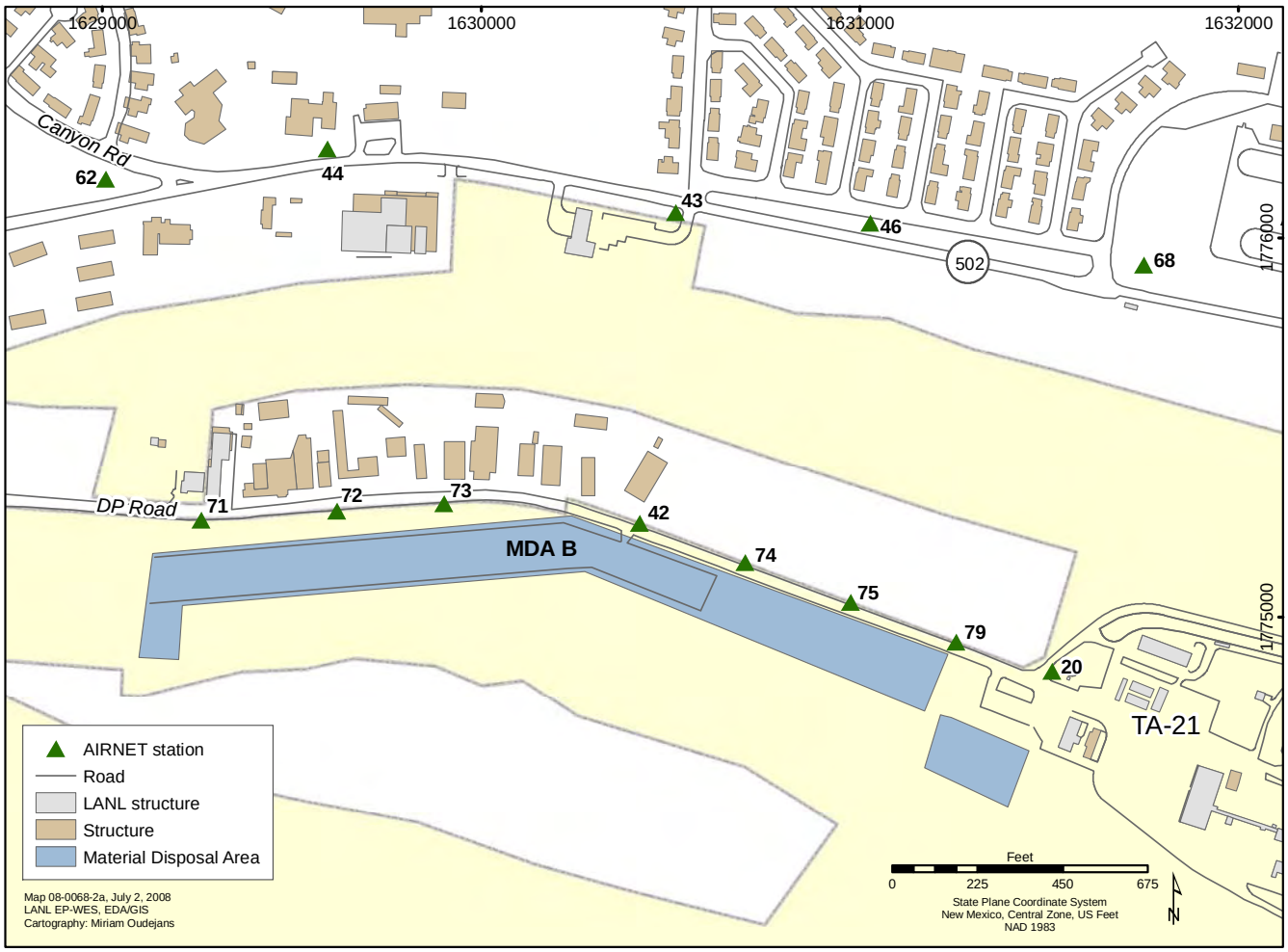


Figure 4-3. AIRNET station locations near TA-21, MDA B.

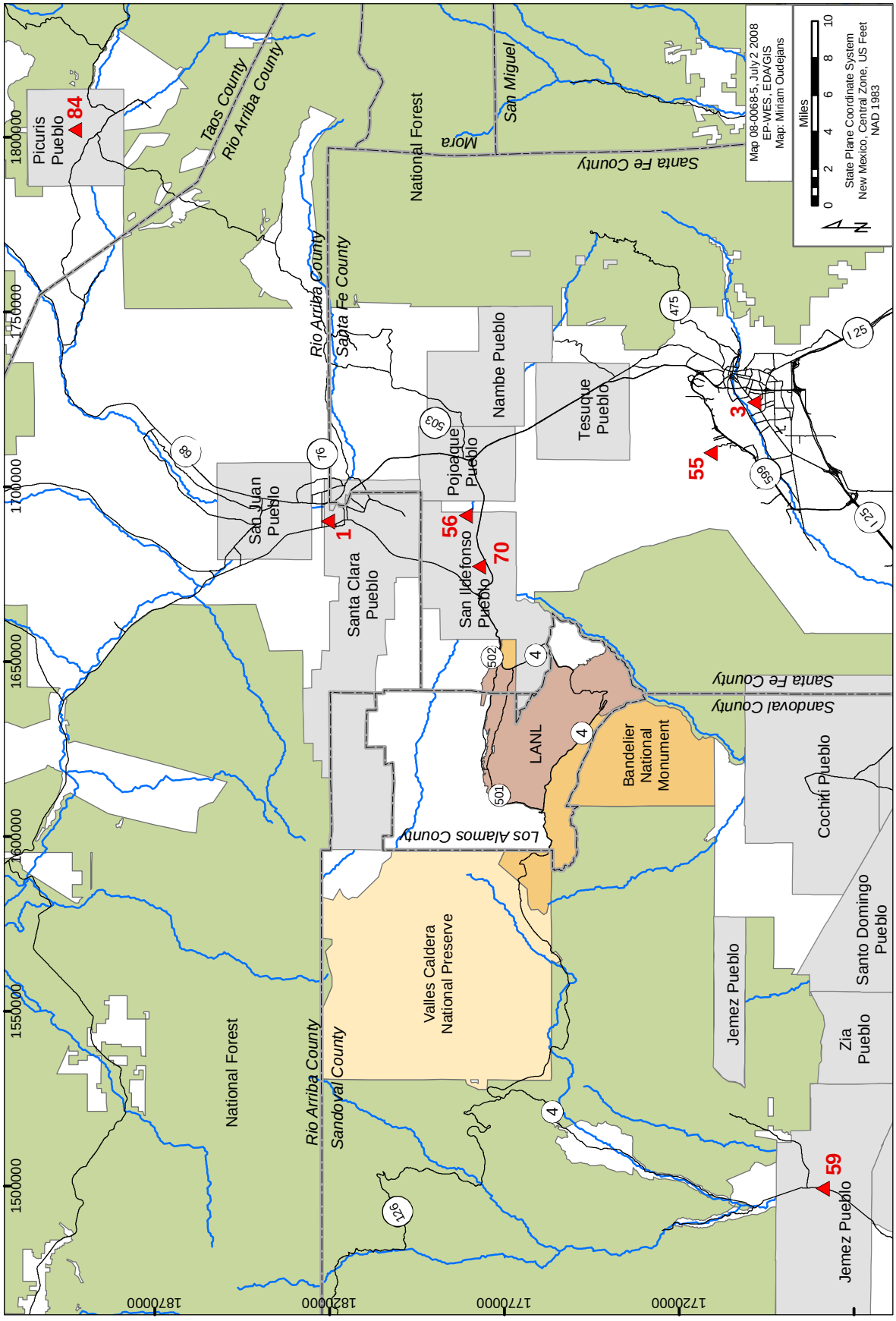


Figure 4-4. Regional and Pueblo AIRNET locations.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-10 summarize the calculated 2008 ambient air concentrations. In the Data Supplement, Tables S4-1 through S4-9 provide data from individual sites. The number of measurements is normally equal to the number of samples analyzed. Measurements containing measurable amounts of the material of interest are those in which the value is greater than three times the standard deviation(s) of the measurement's uncertainty. The minimum detectable activities are those that the instrumentation detects under ideal conditions. AIRNET concentrations don't have any background subtraction, but they do include corrections for radioactivity in the filter material, the acids used to dissolve the filter, and the tracers added to determine recovery efficiencies. The net uncertainties include the variation added by correcting for the blank measurements.

Table 4-2
Airborne Long-Lived Gross Alpha Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (fCi/m^3)	95% Confidence Interval* (fCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (fCi/m^3)
Regional	103	103	0.9	±0.05	01	1.0
Pueblo	77	77	0.9	±0.07	59	1.0
Perimeter	701	701	0.8	±0.02	33	1.0
Waste Site	208	208	0.8	±0.04	35	0.9
On-Site	130	130	0.8	±0.05	30	0.8
D&D	208	208	0.8	±0.04	72	0.9

* 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-3
Airborne Long-Lived Gross Beta Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (fCi/m^3)	95% Confidence Interval* (fCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (fCi/m^3)
Regional	103	103	17.3	±0.8	01	18.1
Pueblo	77	77	16.7	±1.0	70	17.4
Perimeter	701	701	15.7	±0.2	13	16.9
Waste Site	208	208	16.0	±0.4	34	16.5
On-Site	130	130	15.8	±0.6	23	16.3
D&D	208	208	14.9	±0.4	79	16.5

* 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-4
Airborne Tritium as Tritiated Water Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (pCi/m^3)	95% Confidence Interval[a] (pCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (pCi/m^3)
Regional[b]	103	28	0.8	±0.3	3	1.2
Pueblo[b]	76	14	0.8	±0.8	70	1.3
Perimeter[b]	701	178	1.0	±0.2	26	4.3
Waste Site[c]	208	177	77	±41	35	546
On-Site[c]	130	64	6.4	±2.9	53	25
D&D[b]	208	54	1.4	±0.7	42	3.2

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 1,500 pCi/m^3.

[c] DOE Derived Concentration Guide for workplace exposure is 100,000 pCi/m^3.

Table 4-5
Airborne Plutonium-238 Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration	
					Station	(aCi/m^3)
Regional[b]	16	0	0.1	±0.5	1	0.9
Pueblo[b]	12	0	0.0	±0.3	84	0.1
Perimeter[b]	109	0	0.2	±0.1	33	0.7
Waste Site[c]	32	0	0.4	±0.2	51	0.8
On-Site[c]	20	0	0.0	±0.3	24	0.3
D&D[b]	32	0	0.1	±0.2	20	0.5

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 2,100 aCi/m^3.
[c] DOE Derived Concentration Guide for workplace exposure is 30,000 aCi/m^3.

Table 4-6
Airborne Plutonium-239/240 Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration	
					Station	(aCi/m^3)
Regional[b]	16	1	-0.1	±0.5	56	0.1
Pueblo[b]	12	0	0.0	±0.4	59	0.4
Perimeter[b]	109	7	1.0	±1.0	66	23
Waste Site[c]	32	11	5.5	±4.5	51	21
On-Site[c]	20	1	0.5	±0.7	53	2.5
D&D[b]	32	12	5.9	±5.7	79	25

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 2,000 aCi/m^3.
[c] DOE Derived Concentration Guide for workplace exposure is 20,000 aCi/m^3.

Table 4-7
Airborne Americium-241 Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration	
					Station	(aCi/m^3)
Regional[b]	16	0	-0.3	±0.6	56	0.4
Pueblo[b]	12	0	0.1	±0.7	59	0.3
Perimeter[b]	109	4	-0.5	±0.6	40	1.2
Waste Site[c]	32	7	1.0	±0.7	27	4.0
On-Site[c]	20	2	0.0	±0.7	53	1.2
D&D[b]	32	3	0.3	±0.4	20	1.5

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 1,900 aCi/m^3.
[c] DOE Derived Concentration Guide for workplace exposure is 20,000 aCi/m^3.

Table 4-8
Airborne Uranium-234 Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (aCi/m^3)
Regional[b]	16	15	18.0	±6.2	03	28.9
Pueblo[b]	12	11	17.2	±7.4	59	26.7
Perimeter[b]	109	84	8.2	±1.4	32	31.6
Waste Site[c]	32	31	14.6	±6.0	51	29.7
On-Site[c]	20	16	8.5	±3.0	53	11.7
D&D[b]	32	28	16.8	±5.0	20	22.0

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 7,700 aCi/m^3.
[c] DOE Derived Concentration Guide for workplace exposure is 90,000,000 aCi/m^3.

Table 4-9
Airborne Uranium-235 Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (aCi/m^3)
Regional[b]	16	1	1.3	±1.1	03	2.9
Pueblo[b]	12	0	0.7	±0.6	70	1.0
Perimeter[b]	109	3	0.6	±0.2	32	2.5
Waste Site[c]	32	2	0.7	±0.4	51	1.8
On-Site[c]	20	0	0.4	±0.3	30	0.6
D&D[b]	32	0	0.9	±0.5	79	1.5

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 7,100 aCi/m^3.
[c] DOE Derived Concentration Guide for workplace exposure is 100,000 aCi/m^3.

Table 4-10
Airborne Uranium-238 Concentrations for 2008 — Group Summaries

Station Grouping	Number of Samples	Number of Samples > 3s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station	Maximum Annual Concentration (aCi/m^3)
Regional[b]	16	16	16.5	±5.4	03	26.9
Pueblo[b]	12	12	16.5	±6.9	59	25.9
Perimeter[b]	109	89	8.5	±1.3	32	28.2
Waste Site[c]	32	28	14.1	±5.7	50	25.1
On-Site[c]	20	18	8.5	±2.9	53	10.4
D&D[b]	32	29	15.8	±4.2	20	19.3

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40, CFR Part 61, Appendix E, concentration limit is 8,300 aCi/m^3.
[c] DOE Derived Concentration Guide for workplace exposure is 100,000 aCi/m^3.

Uncertainties for all data in this ambient air sampling section represent a 95% confidence (2s) interval. Since confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurements and analytical errors but also seasonal and spatial variations. As such, the calculated 95% confidence intervals are overestimated for the average concentrations and probably represent confidence intervals approaching 99%. All ambient concentrations are activities per cubic meter of sampled air. Negative values are included in long-term averages because the omission of negative values would bias the averages upwards (see Appendix B for more information about negative numbers).

Concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. A control limit of 3s is widely used for statistical quality control charts (Duncan 1986, Gilbert 1987). It reduces the rate of false positives or detections from about 5% of the time at 2s to about 0.3%.

b. Gross Alpha and Gross Beta Radioactivity

We use gross alpha and gross beta analyses to evaluate general radiological air quality, identify potential trends, and detect sampling problems. Elevated gross analytical results may induce analyses for specific radionuclides to investigate a potential problem.

The National Council on Radiation Protection and Measurements (NCRP) estimated the national average concentration of long-lived gross alpha activity in air to be 2 femtocuries (fCi)/m^3. Polonium-210 and other naturally occurring radionuclides are the primary sources of alpha activity (NCRP 1975, NCRP 1987a). The NCRP estimated the national average concentration of long-lived gross beta activity in air to be 20 fCi/m^3. Lead-210 and bismuth-210, also decay products of radon, and other naturally occurring radionuclides are the primary sources of this activity.

In 2008, we collected and analyzed more than 1,400 air samples for gross alpha and gross beta activity. The annual mean for all of the stations is about half of the NCRP average for gross alpha concentration (Table 4-2). At least two factors contribute to these lower concentrations: (1) the use of actual sampled air volumes instead of standard temperature and pressure volumes and (2) the burial of alpha emitters in the filter that are not measured by front-face counting. Gross alpha activity depends on natural conditions, such as atmospheric pressure, atmospheric mixing, temperature, and soil moisture.

Table 4-3 shows gross beta concentrations within and around LANL. These data show variability similar to the gross alpha concentrations. The annual average is below the NCRP national average, but the gross beta measurements include little if any lead-210 because of its low-energy beta emission. We calculate the gross beta measurements on the actual sampled air volumes instead of standard temperature and pressure volumes. The primary source of measured gross beta activity in particulate matter is bismuth-210 in the radon-222 decay chain.

Figures 4-5 and 4-6 show the temporal variability of gross alpha and gross beta activities in air, respectively. Geographical variability is usually much less than temporal variability and is often larger in winter than summer. In winter, at lower elevations around LANL, radon may be trapped below an inversion layer, resulting in higher gross alpha and gross beta count rates at these locations.



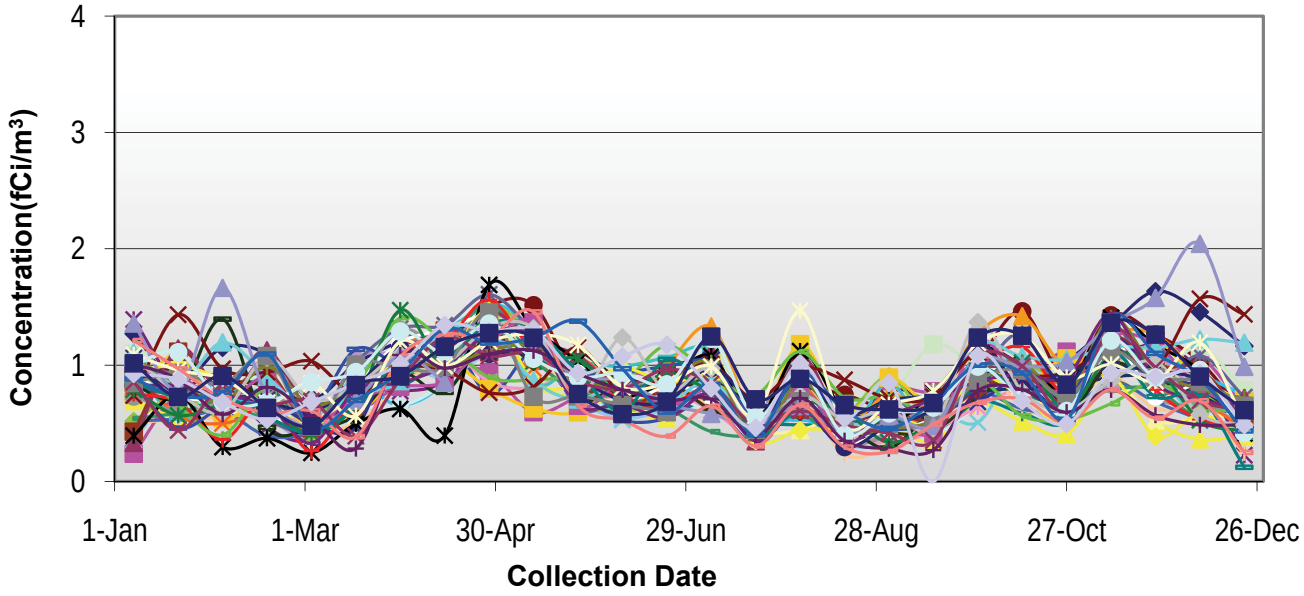


Figure 4-5. Gross alpha measurements (fCi/m³) for all sampling sites by date collected in 2008.

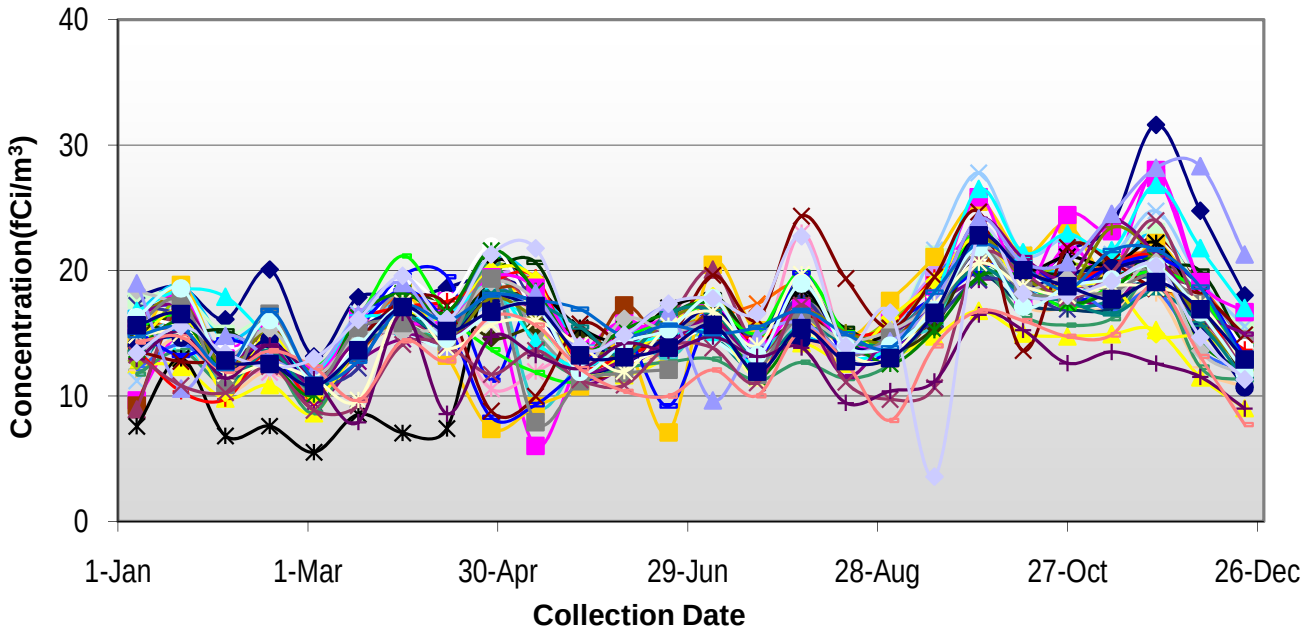


Figure 4-6. Gross beta measurements (fCi/m³) for all sampling sites by date collected in 2008.

c. Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). We measure the tritium in water (HTO or tritiated water) because the dose impact is about 25,000 times higher than if it were hydrogen gas (HT or T_2) (ICRP 1978).

We used water-vapor concentrations in the air and tritium concentrations in the water vapor to calculate ambient levels of tritium. We included corrections for blanks, bound water in the silica gel, and isotopic distillation effects in this calculation.

During 2008, all annual mean concentrations were well below EPA and DOE guidelines (Table 4-4). The highest off-site annual tritium concentration is equivalent to about 0.3% of the EPA public dose limit. We measured elevated tritium concentrations at a number of on-site stations, with the highest annual mean station concentration (546 pCi/m^3) near a known source at TA-54, Area G. This concentration is less than 1% of the DCG for worker exposure.

d. Plutonium

While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), this element is not naturally present in measurable quantities in the ambient air. All measurable sources in air are from plutonium research and development activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, worldwide fallout from atmospheric testing of nuclear explosives is the primary source of plutonium in ambient air.

Table 4-5 summarizes the plutonium-238 data for 2008. No measurement above 3s was made. All stations had an annual average for plutonium-238 less than 0.05% of the EPA public limit.

Table 4-6 summarizes the plutonium-239/240 data for 2008. All quarterly concentrations at Station 66 (on the canyon edge south of Ashley Pond) were above their 3s uncertainties. The annual mean concentration at Station 66 was 23 aCi/m^3, or about 1% of the EPA public dose limit. These higher ambient concentrations are from historical activities that deposited plutonium on the hillside to the south. Twelve quarterly concentrations above 3s were measured off-site near the MDA-B site. This fact should be viewed in light of our cautious choice of baseline levels for new stations, which have yet to accumulate historical data. Four other off-site measurements were recorded above 3s, but they all had average annual concentrations below 1% of the EPA public limit.

Finally, 12 quarterly concentrations of plutonium-239/240 on LANL property exceeded 3s; 11 were at or near Area G. All were below 0.5% of the DCG for workplace exposure.

e. Americium-241

As with plutonium isotopes, americium is present in very low concentrations in the environment. Table 4-7 summarizes the americium-241 data. Seven off-site quarterly samples with a concentration greater than 3s were measured. Nine on-site quarterly samples (seven near Area G) were measured with concentrations greater than 3s. The highest quarterly off-site and on-site concentrations were less than 0.3% and 0.05% of the public and worker limits, respectively.

f. Uranium

Three isotopes of uranium are normally found in nature: uranium-234, -235, and -238. In natural uranium, relative isotopic abundances are constant and known; the ratio of the activity of uranium-238 to that of uranium-234 is 0.993 (Walker et al., 1989). LANL uses comparisons of isotopic concentrations to estimate Laboratory contributions because known LANL emissions in the past 50 years are not of natural uranium, but are of enriched uranium (EU) (enriched in uranium-234 and -235) or depleted uranium (DU) (depleted of uranium-234 and -235). EU and DU were identified by comparing uranium-234 and -238 concentrations. If the concentrations were more than 3s apart, the sample was considered to have significant concentrations of EU or DU.

No EU was detected during 2008 while one detection of DU was reported close to the LANL perimeter (see Figure 4-7). The concentration for the DU detection was comparable to historical natural uranium concentrations. Legacy DU dust at the Laboratory may be re-suspended by strong winds or clean-up operations.

Annual mean concentrations of the three uranium isotopes were below 0.3% of the EPA guidelines (Tables 4-8 to 4-10). The highest annual uranium concentrations are typically at dusty locations.

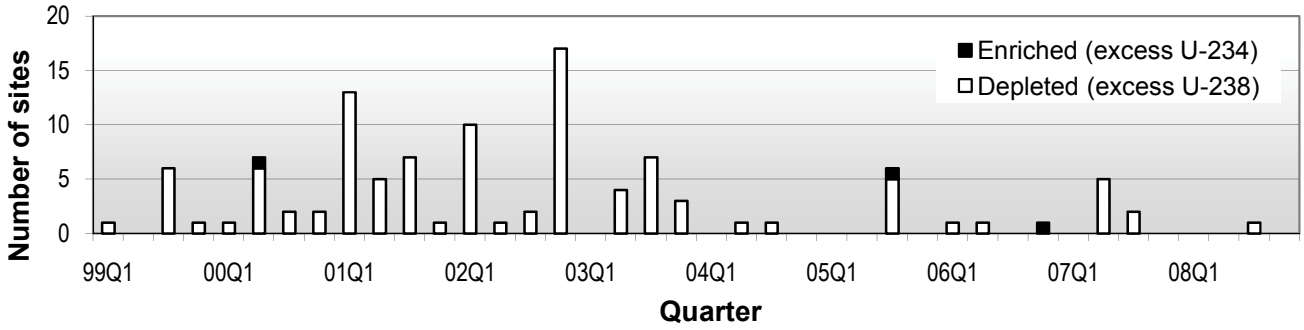


Figure 4-7. Number of sites where enriched or depleted uranium has been detected since 1999.

g. Gamma Spectroscopy Measurements

For gamma screening, we group filters across sites in "clumps" for each sampling period. The clumps were analyzed for the following analytes: arsenic-73, arsenic-74, cadmium-109, cobalt-57, cobalt-60, cesium-134, cesium-137, manganese-54, sodium-22, rubidium-83, rubidium-103, selenium-75, and zinc-65. None have been detected in the last five years. We investigate the measurement of any of these analytes above its minimum detectable activity.

We also analyze the natural radionuclides beryllium-7, potassium-40, and lead-210. However, we only initiate investigations elevated levels are found. No elevated levels of these were found during 2008.

5. Investigation of Elevated Air Concentrations

We have established two action levels to determine the potential impact of an unplanned release. "Investigation" action levels indicate that an air concentration is elevated above historic measurements at that location. These levels are set at values equal to a five-year average plus 3s. "Alert" action levels are based on allowable EPA and DOE annual doses and require a more thorough and immediate follow-up.

When a measured air concentration exceeds an action level, we verify that the calculations were done correctly and that the sampled air concentrations are representative. If so, we work with operations personnel to assess potential sources and implement possible mitigation plans.

In 2008, measurements for plutonium, americium, and uranium did not exceed alert action levels. Tritium alert levels were not exceeded off-site. Elevated tritium levels were observed at Area G near a known tritium source.

6. Special Monitoring

On June 11, 2008, an experimental equipment failure caused a vegetation fire at TA-39 in Ancho Canyon. Two high-volume samplers were deployed and one AIRNET sample was collected and analyzed early. No elevated levels were detected for any of the most likely elements or isotopes expected.

7. Long-Term Trends

a. Uranium

Concentrations for uranium isotopes typically peak during windier quarters (Figure 4-8). Over the last five years the trends are flat.

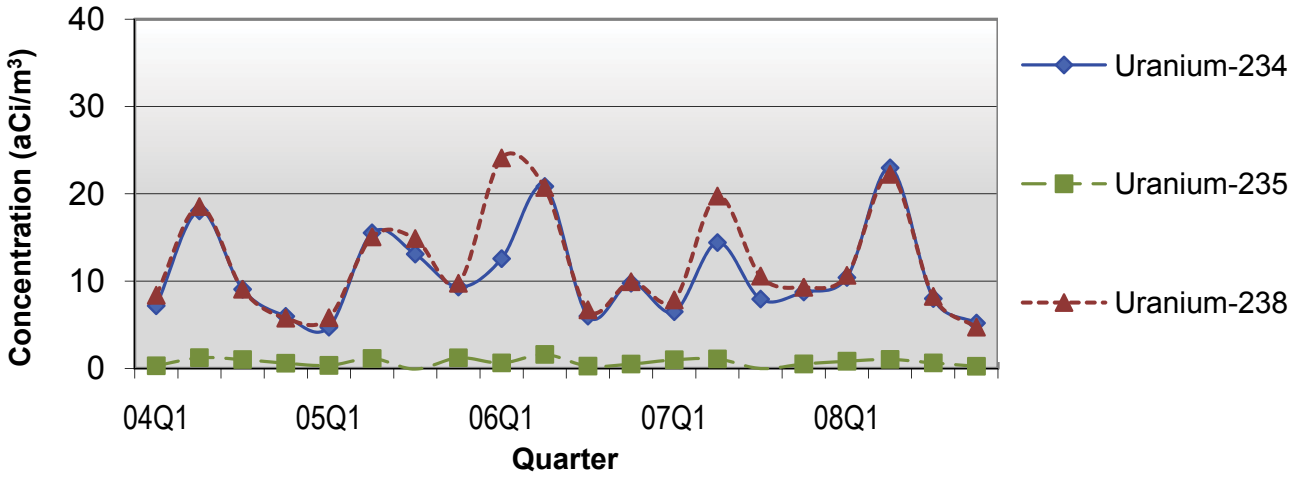


Figure 4-8. Quarterly concentrations of uranium isotopes.

b. Plutonium and Americium

Concentrations of plutonium and americium show no distinctive trends over the past five years. In 2007 and 2008, remediation activities at TA-21 increased plutonium and americium averages near that location. Figures 4-9 to 4-11 show the annual grouping average concentrations, except Area G which is shown separately in Figure 4-12. The increased concentration of plutonium-239 in 2006 was due to operations involving cleanup of waste.

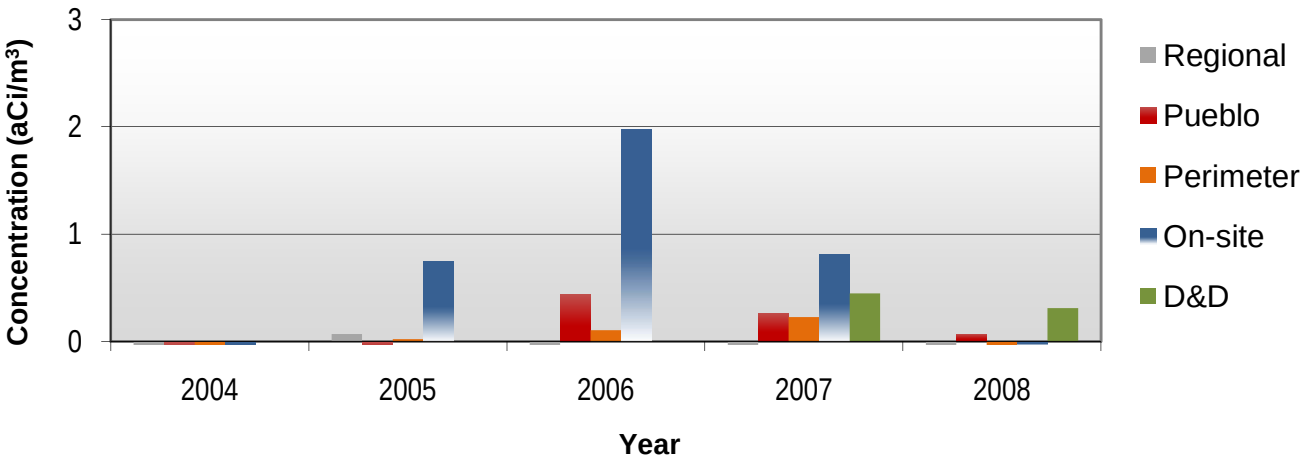


Figure 4-9. Americium-241 concentrations.

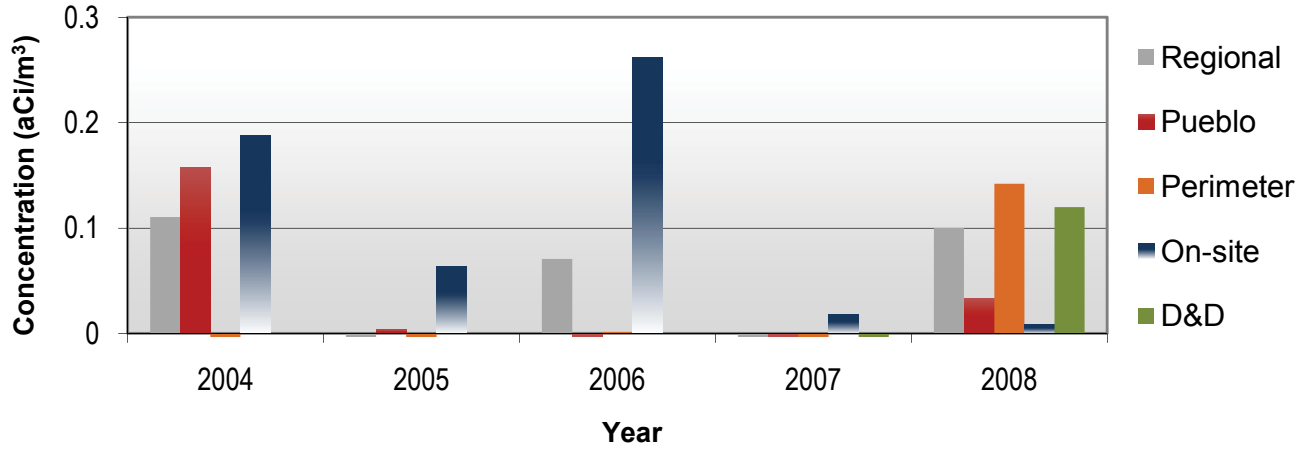


Figure 4-10. Plutonium-238 concentrations.

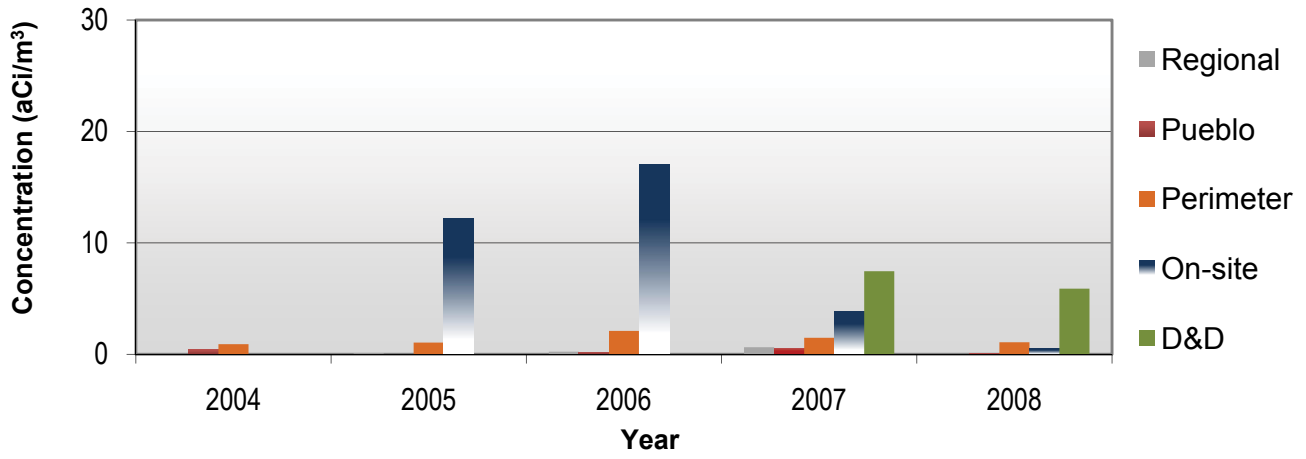


Figure 4-11. Plutonium-239/240 concentrations.

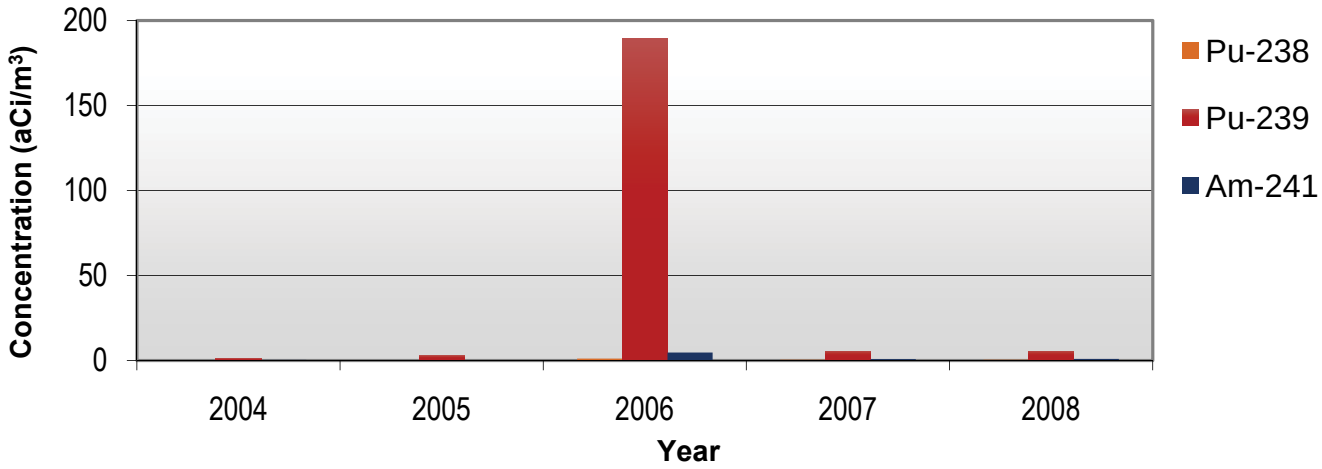


Figure 4-12. Americium and plutonium concentrations at TA-54, Area G.

c. Tritium

Tritium concentrations reflect current operations and show no distinctive trends (Figure 4-13). In 2006, tritiated waste at Area G raised the annual average. This waste was moved to tritium shafts at Area G.

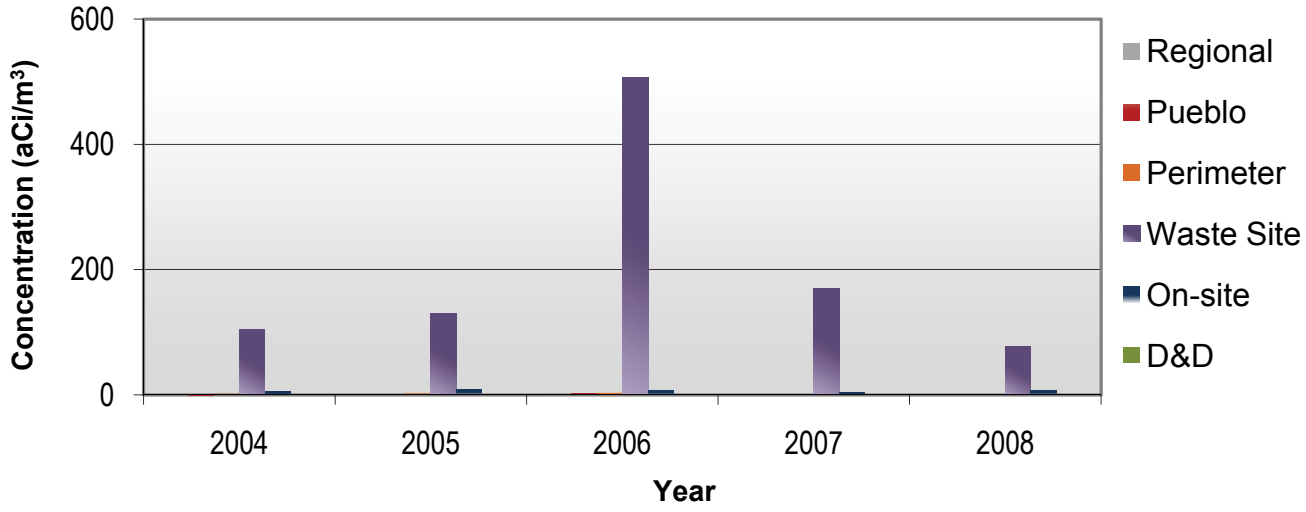


Figure 4-13. Tritium concentration trends.

B. STACK SAMPLING FOR RADIONUCLIDES

1. Introduction

Radioactive materials are an integral part of many activities at LANL. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. Members of the stack monitoring team at LANL evaluate these operations to determine potential impacts to the public and the environment. Emissions are estimated using engineering calculations and radionuclide materials usage information with the assumption there are no emission controls in place, such as the high-efficiency particulate air filters which are present on all stacks. If this evaluation shows that emissions from a stack may potentially result in a member of the public receiving as much as 0.1 mrem in a year, LANL must sample the stack in accordance with 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (Rad-NESHAP) (EPA 1989). During 2008, we identified 26 stacks meeting this criterion.

2. Sampling Methodology

In 2008, we continuously sampled 26 stacks for the emission of radioactive material to the ambient air. LANL categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products, (3) tritium, and (4) gaseous mixed activation products (GMAP). For each of these emission types, LANL employs an appropriate sampling method, as described below.

We sample emissions of radioactive particulate matter generated by operations at facilities, such as the Chemistry and Metallurgy Research Building and the TA-55 Plutonium Facility, using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. We collect these samples weekly and ship them to an off-site analytical laboratory. The analytical laboratory uses gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, the analytical laboratory composites these samples and analyzes them to determine the cumulative activity on all the filters of radionuclides such as uranium-234, -235, and-238, plutonium-238 and -239/240, and americium-241. The laboratory uses the isotopic data to calculate emissions from the stack for the six-month period.

A charcoal cartridge samples emissions of vapors, such as bromine-82, and highly volatile compounds, such as selenium-75, generated by operations at the Los Alamos Neutron Science Center (LANSCE) and hot cell activities at the Chemistry and Metallurgy Research Building and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. This charcoal filter is mounted downstream of a glass-fiber filter (discussed above) that removes any particulates from this sample media prior to the vapor sampling. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the charcoal filter, which is collected weekly at the same time as the filter.

We measure tritium emissions from LANL's tritium facilities with a collection device known as a bubbler. This device enables us to determine not only the total amount of tritium released but also whether it is in the elemental (HT) or oxide (HTO) form. The bubbler pulls a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). "Bubbling" through these three vials removes essentially all HTO from the air, leaving only HT. The air is then passed through a palladium catalyst that converts the HT to HTO. The sample is pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. We collected the vials of ethylene glycol weekly and sent them to an analytical laboratory for liquid scintillation counting to determine the amount of HTO and HT.

In previous years, we monitored stacks at LANSCE for tritium. After an historical evaluation of HTO emissions from LANSCE in 2001, we discontinued sampling tritium following the July 2001 report period based on the low historical emissions of HTO from TA-53 and the low relative contribution of tritium to the off-site dose from TA-53 emissions. Emissions of tritium reported in 2008 from LANSCE are based on 2001 tritium generation rates.

We measure GMAP emissions from LANSCE 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. Gamma spectroscopy and decay curves are used to continuously identify specific radioisotopes and the quantity of each. From these data, the total emissions of each radionuclide are calculated.

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis

Analytical methods used comply with EPA requirements in 40 CFR 61, Appendix B, Method 114 (EPA 1989). Section F of this chapter presents the results of analytical quality assurance measurements. This section discusses the sampling and analysis methods for each type of LANL's emissions.

b. Particulate Matter Emissions

We remove and replace the glass-fiber filters that each week sample facilities with significant potential for radioactive particulate emissions, and we then ship them to an off-site analytical laboratory. Prior to shipping, we screen each sample filter with a hand-held instrument to determine if there are any unusually high levels of gross alpha or beta radioactivity. The laboratory performs analyses for the presence of alpha and beta radioactivity after the sample has been allowed to decay for approximately one week (to allow short-lived radon progeny to decay). In addition to alpha and beta analyses, the laboratory performs gamma spectroscopy analysis to identify specific isotopes in the sample. While alpha and beta counting are performed on individual glass-fiber filters, gamma spectroscopy is performed on "clumps" of filters, a group of seven or eight filters stacked together to allow quick analysis for gamma-emitting radionuclides. Subsequent analyses, if needed, are performed on individual filters.

The glass-fiber filters are composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We use the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compares the results of the isotopic analysis with gross activity measurements to ensure that the requested analyses (e.g., uranium-234, -235, and -238; and plutonium-238 and -239/240, etc.) identify all significant activity in the composites.

For particulate filters from the LANSCE accelerator facility, the analytical laboratory only performs gamma spectroscopy analyses based on the anticipated suite of emissions from this facility. Again, we perform hand-screening of each filter prior to shipping them to the off-site analytical laboratory.

c. Vaporous Activation Products Emissions

We remove and replace the charcoal canisters weekly at facilities with the potential for significant vaporous activation products emissions and ship the samples to the off-site analytical laboratory where gamma spectroscopy identifies and quantifies the presence of vaporous radioactive isotopes. For charcoal filters, gamma spectroscopy analyses are performed on individual filters instead of clumped filters.

d. Tritium Emissions

Each week, we collected tritium bubbler samples, used to sample facilities with the potential for significant elemental and oxide tritium emissions, and transport them to LANL's Health Physics Analytical Laboratory. The Health Physics Analytical Laboratory adds an aliquot of each sample to a liquid scintillation cocktail and determines the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions

To record and report GMAP emissions, we used continuous monitoring, rather than off-line analysis, for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off-line. The GMAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total GMAP emissions are measured with the ionization chamber. The real-time current this ionization chamber measures is recorded on a strip chart and the total amount of charge collected in the chamber over the entire beam operating cycle is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determine the relative composition of the emissions. Decay curves are typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes are made at LANSCE, new decay curves and energy spectra are recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2008 totaled approximately 1,300 Ci (compared to 477 Ci in 2007). Of this total, tritium emissions contributed approximately 480 Ci (compared to 260 Ci in 2007), and air activation products from LANSCE stacks contributed nearly 815 Ci (compared to nearly 218 Ci in 2007). Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 0.000012 Ci. Emissions of particulate matter plus vaporous activation products (P/VAP) were about 0.021 Ci, which is consistent with recent years.

Table 4-11 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-11
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2008 (Ci)

TA-Bldg	H-3[a]	Am-241	Pu[b]	U[c]	Th[d]	P/VAP[e]	GMAP[f]	Sr-90[g]
TA-03-029		5.49×10^{-7}	4.63×10^{-6}	6.23×10^{-6}	5.01×10^{-7}			
TA-03-102				2.94×10^{-9}	2.28×10^{-10}			
TA-16-205/450	4.36×10^{2}							
TA-48-001			9.63×10^{-10}			1.43×10^{-2}		
TA-50-001		8.39×10^{-9}	2.00×10^{-8}		1.92×10^{-8}			
TA-50-037					1.05×10^{-9}			
TA-50-069			1.60×10^{-10}	3.03×10^{-10}	2.52×10^{-10}			
TA-53-003	2.55×10^{1}					2.13×10^{-4}	7.44×10^{1}	
TA-53-007	4.80					6.10×10^{-3}	7.41×10^{2}	
TA-55-004	9.40		9.53×10^{-10}	1.30×10^{-8}	1.43×10^{-8}			
Total[h]	4.76×10^{2}	5.57×10^{-7}	4.65×10^{-6}	6.24×10^{-6}	5.36×10^{-7}	2.06×10^{-2}	8.90×10^{2} [i]	0.00

NOTE: Some buildings have more than one sampled stack.

[a] Includes both gaseous and oxide forms of tritium.

[b] Includes Pu-238, Pu-239, and Pu-240.

[c] Includes U-234, U-235, and U-238. Does not include radioactive progeny of U-238.

[d] Includes Th-228, Th-230, and Th-232.

[e] P/VAP–Particulate/vapor activation products (with measured radionuclides and short-lived radioactive progeny).

[f] GMAP–Gaseous mixed activation products.

[g] Strontium-90 values include short-lived radioactive progeny of yttrium-90.

[h] Some differences may occur because of rounding.

[i] Total for GMAP includes 74.6 curies released from diffuse sources at TA-53.

Table 4-12 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-13 presents the half-lives of the radionuclides typically emitted by LANL. During 2008, the LANSCE facility non-point source emissions of activated air comprised approximately 72 Ci of carbon-11 and 3 Ci of argon-41.

5. Long-Term Trends

Figures 4-14 to 4-17 present radioactive emissions from sampled LANL stacks and illustrate trends in measured emissions for plutonium, uranium, tritium, and GMAP emissions, respectively. As the figures demonstrate, emissions from plutonium and uranium isotopes stayed relatively steady over recent years, varying slightly each year but staying in the low-microcurie range. Tritium emissions showed an increase over 2007 emissions, reflecting a return to normal operations at the main tritium facility after an extended maintenance period in 2007. In 2008, emissions of GMAP increased from 2007 levels but are still very low relative to the one-year elevation in 2005, as described below.

LANSCE operated in the same configuration as recent years, with continuous beam operations to the 1L Target and the Lujan Neutron Scattering Center, causing the majority of radioactive air emissions. Operations to the 1L Target took place from late spring of 2008 through the end of the calendar year.

The emissions control system at the LANSCE 1L Target is a "delay line," which retains the short-lived activation products for a short time before release out the stack. This time interval allows decay of the short-lived radionuclides to non-radioactive components. A cracked valve in the inlet of this delay system caused substantially elevated emissions in 2005, compared with previous years. Additional delay line sections were installed in May and November 2005 and the defective valve was fixed in late 2005. The additional delay line contributed to the relatively low emissions in 2006 through 2008. In all years, emissions were below all regulatory limits.

Figure 4-18 shows the individual contribution of each emission type to total LANL emissions. It clearly shows that GMAP emissions and tritium emissions make up the vast majority of radioactive stack emissions. This plot does not directly relate to off-site dose because some radionuclides have a higher dose impact per curie released than others. GMAP and tritium remain the highest contributors to the total curies released. These gas-phase nuclides are not easily removed from an exhaust stack air stream by standard control techniques, such as filtration. GMAP and tritium emissions continue to fluctuate as the major emissions type; tritium facility operations and LANSCE operations vary from year to year. GMAP emissions are normally the greatest source of off-site dose from the airborne pathway because of the close proximity of the LANSCE facility to the LANL boundary.



Table 4-12
Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2008 (curies)

TA-Building	Nuclide	Emission (Ci)
TA-48-0001	Br-77	0.0000151
TA-48-0001	Ga-68	0.00708
TA-48-0001	Ge-68	0.00708
TA-48-0001	Se-75	0.0000123
TA-48-0001	As-73	0.00000195
TA-48-0001	Br-77	0.00000504
TA-48-0001	Ga-68	0.0000479
TA-48-0001	Ge-68	0.0000479
TA-48-0001	Se-75	0.00000289
TA-53-0003	Ar-41	2.98
TA-53-0003	Be-7	0.0000770
TA-53-0003	Br-82	0.000119
TA-53-0003	C-11	71.4
TA-53-0003	Na-24	0.0000175
TA-53-0007	Ar-41	11.9
TA-53-0007	As-73	0.0000247
TA-53-0007	Be-7	0.000000814
TA-53-0007	Br-76	0.00106
TA-53-0007	Br-77	0.000294
TA-53-0007	Br-82	0.00250
TA-53-0007	C-10	0.941
TA-53-0007	C-11	448.5
TA-53-0007	Co-58	0.0000000845
TA-53-0007	Hg-197	0.00103
TA-53-0007	Hg-197m	0.00103
TA-53-0007	N-13	47.2
TA-53-0007	N-16	0.0815
TA-53-0007	Na-24	0.000129
TA-53-0007	O-14	3.52
TA-53-0007	O-15	228.7
TA-53-0007	Os-191	0.0000119
TA-53-0007	Se-75	0.00000371

Table 4-13
Radionuclide Half-Lives

Nuclide	Half-Life
H-3	12.3 yr
Be-7	53.4 d
C-10	19.3 s
C-11	20.5 min
N-13	10.0 min
N-16	7.13 s
O-14	70.6 s
O-15	122.2 s
Na-22	2.6 yr
Na-24	14.96 h
P-32	14.3 d
K-40	1,277,000,000 yr
Ar-41	1.83 h
Mn-54	312.7 d
Co-56	78.8 d
Co-57	270.9 d
Co-58	70.8 d
Co-60	5.3 yr
As-72	26 h
As-73	80.3 d
As-74	17.78 d
Br-76	16 h
Br-77	2.4 d
Br-82	1.47 d
Se-75	119.8 d
Sr-85	64.8 d
Sr-89	50.6 d
Sr-90	28.6 yr
I-131	8 d
Cs-134	2.06 yr
Cs-137	30.2 yr
Os-183	13 h
Os-185	93.6 d
Os-191	15.4 d
Hg-193	3.8 h
Hg-195	9.5 h
Hg-195m	1.67 d
Hg-197	2.67 d
Hg-197m	23.8 h
U-234	244,500 yr
U-235	703,800,000 yr
U-238	4,468,000,000 yr
Pu-238	87.7 yr
Pu-239	24,131 yr
Pu-240	6,569 yr
Pu-241	14.4 yr
Am-241	432 yr

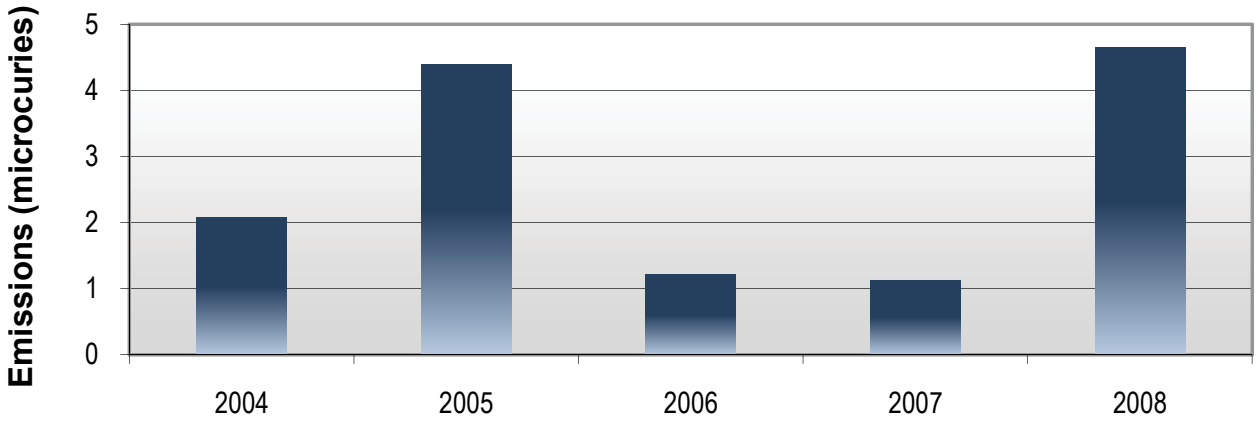


Figure 4-14. Plutonium emissions from sampled LANL stacks.

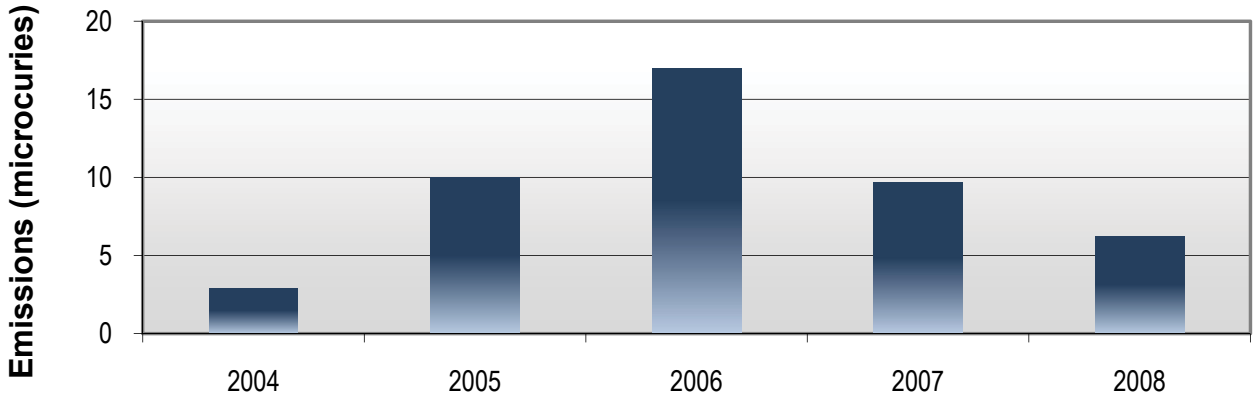


Figure 4-15. Uranium emissions from sampled LANL stacks.

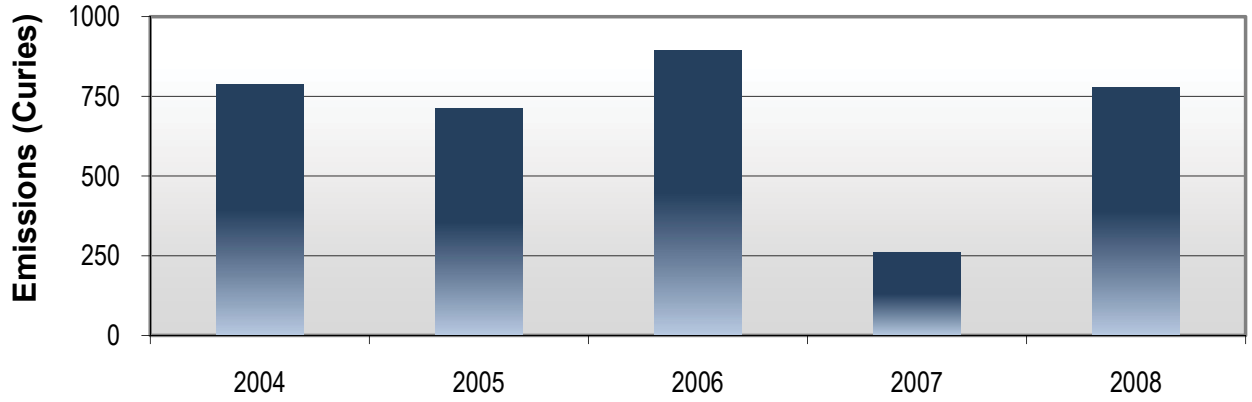


Figure 4-16. Tritium emissions from sampled LANL stacks.

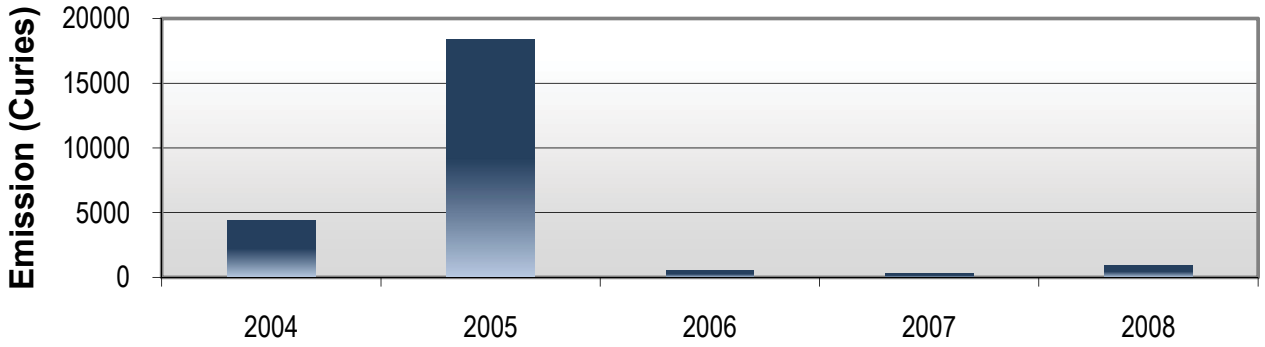


Figure 4-17. GMAP emissions from sampled LANL stacks.

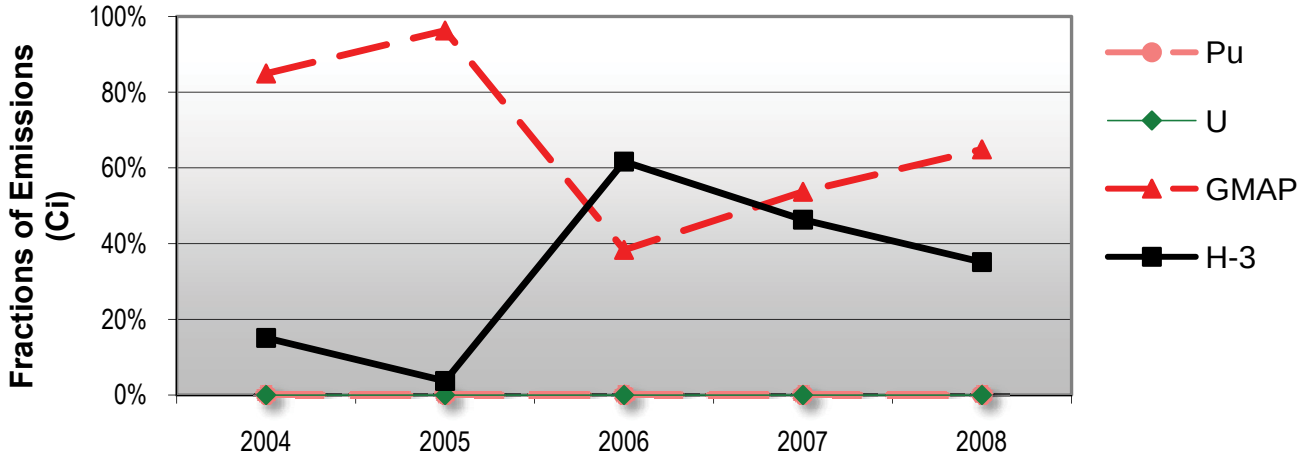


Figure 4-18. Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP.

C. GAMMA AND NEUTRON RADIATION MONITORING PROGRAM

1. Introduction

We monitor gamma and neutron radiation in the environment—that is, outside of the workplace—according to the criteria specified in McNaughton et al. (2000) as part of our Direct Penetrating Radiation Monitoring Network (DPRNET). Naturally occurring radiation originates from terrestrial and cosmic sources. It is extremely difficult to distinguish man-made sources from the natural background because the natural radiation doses are generally much larger than those from man-made sources. The external dose rate from natural terrestrial and cosmic sources measured by the dosimeters varies from approximately 100 to 200 mrem/yr.

2. Monitoring Network

a. Dosimeter Locations

In an attempt to distinguish any impact from LANL operations on the public, we located 90 thermoluminescent dosimeter (TLD) stations around LANL and in the surrounding communities. There is a TLD at every AIRNET station (shown in Figures 4-1 and 4-3). The corresponding TLD station numbers are listed in Supplementary Data Table S4-10. Additional stations are around TA-54, Area G (shown in Figure 4-19); at TA-53, LANSCE (eight stations); at Santa Clara Pueblo (two stations); and inside the Pueblo de San Ildefonso sacred area (two stations).

b. Neutron Dosimeters

We monitor potential neutron doses with 47 albedo TLD stations near known or suspected sources of neutrons: TA-53 (LANSCE) and TA-54 (Area G). Albedo dosimeters are sensitive to neutrons and use a hydrogenous material that causes neutron backscatter to simulate the human body.

c. Neutron Background

Natural cosmic rays result in a neutron background dose of approximately 10 mrem/yr (NCRP 1987b). However the neutron dosimeters record a dose of approximately 2 mrem/yr because the environmental dosimeters are calibrated with a deuterium oxide (D_2O)-moderated neutron source with a different energy spectrum from cosmic-ray neutrons. Therefore, a neutron reading of 2 mrem/yr indicates a normal background reading.

3. Quality Assurance

The calibration laboratory at LANL's Health Physics Measurements Group (RP-2) calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited the dosimeters that RP-2 provides, and RP-2 provides quality assurance (QA) for the dosimeters. The uncertainty in the TLD data is estimated from the standard deviation of data from dosimeters exposed to the same dose. The overall 1s uncertainty is similar to previous data and is 8%.

4. Results

The annual dose equivalents at all stations except those within or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Supplemental Data Table S4-10. The only locations with a measurable contribution from LANL operations are within the boundaries of TA-53 (LANSCE) and near TA-54 (Area G). Figure 4-19 shows the locations of the stations at TA-54, Area G.

South of the line of TLDs from #601 to #608, Area G is a controlled-access area, so these data are not representative of a potential public dose. However, TLDs #642 and #643 are close to the boundary of the Pueblo de San Ildefonso sacred area, which is accessible to members of the Pueblo. Furthermore, TLDs #133 and #134 are deployed by Pueblo staff within the boundaries of the sacred area.

After subtracting background, the annual doses measured by TLDs #134, #642, and #643 were 14 mrem, 8 mrem, and 8 mrem, respectively. The dose measured by TLD #134 is higher than the others because TLDs #642 and #643 are in Cañada del Buey and are partially shielded by the rim of the canyon. These are the doses that would be received by a person who is at the location of the TLDs 24 hours per day, 365 days per year. As discussed in Chapter 3, we apply an occupancy factor of 1/16 (NCRP 1976) so the public dose near TLD #134 is calculated to be 0.9 mrem/yr.

TLD #133 is located several hundred meters farther from Area G and measures nothing above the terrestrial and cosmic-ray natural background. This is expected because of the distance and the shielding provided by the air. Annual doses of 10 mrem were measured by TLDs #651 and #652, which are located along Pajarito Road, south of Area G. This section of Pajarito Road has limited public access.

D. NONRADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

The non-radioactive ambient air monitoring network measures concentrations of total suspended particulates and some selected nonradiological species in communities near LANL. The program consists of four ambient particulate matter monitoring units at two locations plus selected AIRNET samples, which are analyzed for the nonradiological constituents aluminum, calcium, and beryllium.

2. Air Monitoring Network and Equipment

During 2008, ambient particulate matter monitoring continued at the old White Rock Fire Station on Rover Boulevard and at the Los Alamos Medical Center. Two monitors run at each location: one for particles smaller than 10 micrometers (PM-10) and another for those smaller than 2.5 micrometers (PM-2.5).

A tapered-element oscillating microbalance ambient particulate monitor is fitted with either a PM-10 or a PM-2.5 sample inlet. The microbalance has an oscillating ceramic "finger" with a filter that collects particles. The mass of accumulated particulate matter is derived and saved for later download. These data measure the dust and pollutant loadings in the atmosphere.

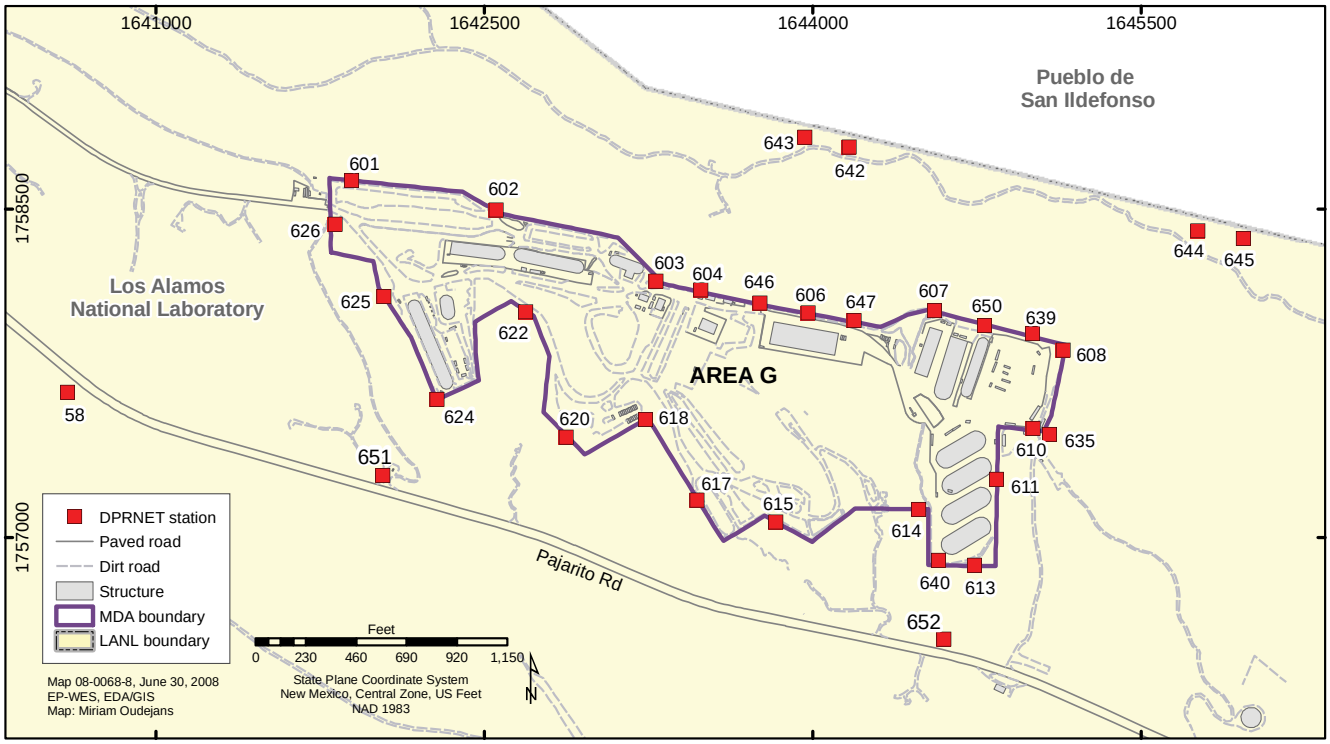


Figure 4-19. Thermoluminescent dosimeter locations at TA-54, Area G, as part of the Direct Penetrating Radiation Monitoring Network (DPRNET).

3. Ambient Air Concentrations

In 2008, the particulate matter data collection efficiency was about 97%. Annual averages and 24-hour maxima are shown in Table 4-14. The annual averages and the 24-hour maxima for both PM-2.5 and PM-10 are well below EPA standards.

Table 4-14
PM-2.5 and PM-10 Concentration Data Summary for 2008 (µg/m³)

Station Location	Constituent	Maximum 24-Hour (µg/m³)	Annual Average (µg/m³)
Los Alamos Medical Center	PM-10	53	14
	PM-2.5	17	8
White Rock Fire Station	PM-10	46	14
	PM-2.5	17	7
EPA Standard*	PM-10	150	50
	PM-2.5	65	15

* EPA 40 CFR Part 50

4. Detonation and Burning of Explosives

LANL uses explosives at firing sites and maintains records that include the type of explosives used and other materials expended. Supplemental Table S4-11 summarizes the amounts of expended materials for the last three years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2008, LANL burned roughly 6,000 kilograms of high explosives. An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicated no adverse air-quality impacts.

5. Beryllium Sampling

During 2008, we analyzed quarterly composite samples from 36 sites for beryllium, aluminum, and calcium (Supplemental Data Table S4-12). These sites are located near potential beryllium sources at LANL or in nearby communities. The State of New Mexico has no ambient air quality standard for beryllium. For comparison purposes, we use the beryllium NESHAP standard of 10 ng/m^3 from 40 CFR Part 61 Subpart C (EPA 1989). All concentrations measured in 2008 were less than 2% of this standard and similar to those of recent years. Aluminum and calcium are used to evaluate elevated uranium measurements. No unusual concentrations were measured in 2008.

E. METEOROLOGICAL MONITORING

1. Introduction

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. To accommodate the broad demands for weather data at the Laboratory, the meteorology team measures a wide variety of meteorological variables across the network, including wind, temperature, pressure, relative humidity and dew point, precipitation, and solar and terrestrial radiation. The Meteorological Monitoring Plan (Johnson and Young 2008) provides details of the meteorological monitoring program. An electronic copy of the "Meteorological Monitoring Plan" is available online at http://www.weather.lanl.gov/.

2. Monitoring Network

A network of seven towers gathers meteorological data at the Laboratory (Figure 4-20). Four of the towers are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), two are in canyons (TA-41 in Los Alamos Canyon and MDCN in Mortandad Canyon), and one is on top of Pajarito Mountain (PJMT). A precipitation gauge is also located in North Community (NCOM) of the Los Alamos town site. The TA-6 tower is the official meteorological measurement site for the Laboratory. A sonic detection and ranging (SODAR) instrument is located adjacent to the TA-6 meteorological tower.

3. 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 wake effects on wind and precipitation measurements. Temperature and wind are measured at multiple levels on open lattice towers. The multiple levels provide a vertical profile of conditions 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.

Data loggers at the tower sites sample most of the meteorological variables at 0.33 Hz, store the data, average the samples over a 15-min period, and transmit the data to a Hewlett-Packard workstation located at the Meteorology Laboratory (TA-59) by telephone or cell phone. The workstation automatically edits measurements that fall outside of realistic ranges. 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, observers log cloud type and percentage cloud cover three times daily.

We refurbish all meteorological instruments biennially and calibrate them during an internal audit/inspection. Field instruments are replaced with backup instruments, and the replaced instruments are checked to verify that they remained in calibration while in service. An external audit of the instrumentation and methods is typically performed once every three years. The most recent audit was an "assist visit" by the DOE Meteorological Coordinating Council (DMCC) in August 2006. The DMCC report can be requested at http://www.weather.lanl.gov/. An external contractor inspects and performs maintenance on the tower network structure and hoists on an annual basis.

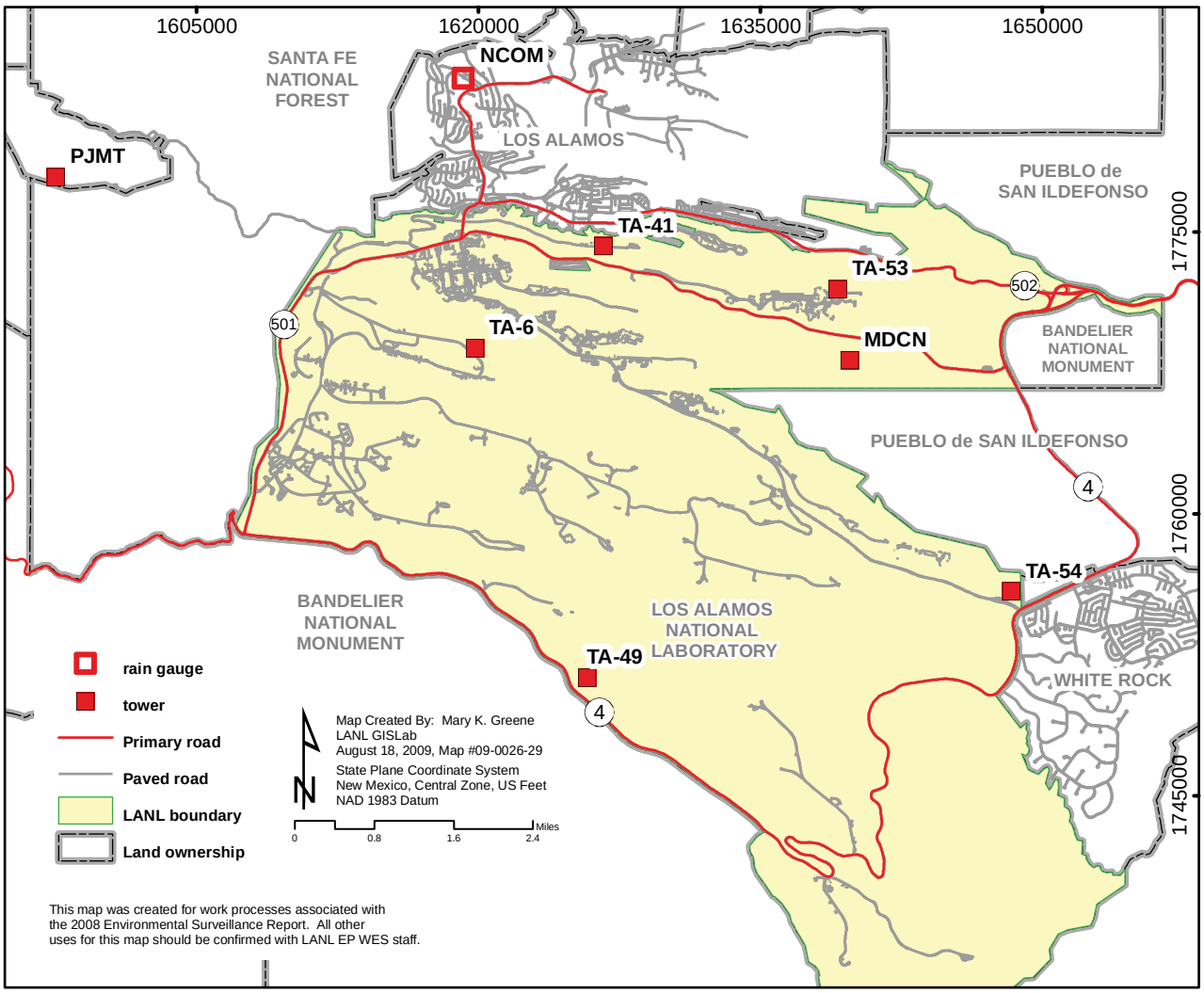


Figure 4-20. Location of meteorological monitoring towers and rain gauges.

4. Climatology

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 long-wave 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 team and following Bowen (1990 and 1992).

The years from 1971 to 2000 represents the time period over which the climatological standard normal is defined. The standard should be 1961–1990, according to the World Meteorological Organization, until 2021 when 1991–2020 will become the standard, and so on every 30 years (WMO 1984). In practice, however, normals are computed every decade, and so 1971–2000 is generally used. Our averages are calculated according to this widely followed practice.

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 mid-afternoon, range from 25°F to 55°F. The record low temperature of -18°F was recorded on January 13, 1963. Wintertime arctic air masses that descend into the central United States tend to have sufficient time to heat before they reach our southern latitude so the occurrence of local subzero temperatures is rare. Winds during the winter are relatively light, so extreme wind chills are uncommon.

Temperatures are highest from June through August. Ninety percent of minimum temperatures during these months range from 45°F to 61°F. Ninety percent of maximum temperatures range from 67°F to 89°F. The record high temperature of 95°F was recorded on June 29, 1998.

The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.95 in. The average annual snowfall is 58.7 in. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are also occasionally enhanced as a result of orographic lifting of the storms by the high terrain. The record single-day snowfall is about 39 in., which occurred between 11 a.m. on January 15, 1987, and 11 a.m. the next day. The record single-season snowfall is 153 in. set in 1986–87.

Precipitation in July and August account for 36% of the annual precipitation and encompass 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 convected 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, notable in the absence of large-scale disturbances. Often a distinct diurnal 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.

5. 2008 in Perspective

Figure 4-21 presents a graphical summary of Los Alamos weather for 2008. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared to monthly normals (averages during the 1971–2000 time period).

The year 2008 was slightly warmer and drier than normal. The average annual temperature in 2008 of 48.3°F exceeded the normal annual average of 47.9°F by 0.4°F. The total precipitation of 17.38 in. was 92% of normal (18.95 in.). November and June were particularly warm, while January was quite a bit colder than normal. The year began with better than normal precipitation amounts but this tend reversed in March. Rainfall amounts were less than normal from March through July, with the exception of May. An unusually wet August brought the annual precipitation total from 2.5 inches below normal to slightly above normal. The dry months returned, however, to finish the year at less than normal precipitation. 2008 was the fourth year in a row that the monsoon brought well above normal precipitation, making up for the unseasonably dry remainder of the year. The year's end came with a dramatic finale, however, as snow on 13 days during December blanketed the area in a total of 29 inches for the month, almost three times the normal 11 inches. The total snowfall during 2008 was 61 inches, almost 3 inches above normal.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-22 shows the historical record of temperatures in Los Alamos from 1924 through 2008. The annual average temperature is not the average temperature per se, but rather the mid-point between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-22. Every year since 1998 has been warmer than the 1971–2000 normal, just under 48°F. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it appears that the warm spell during the past decade is not as extreme as the warm spell during the early-to-mid 1950s. On the other hand, the current warm trend is longer-lived.

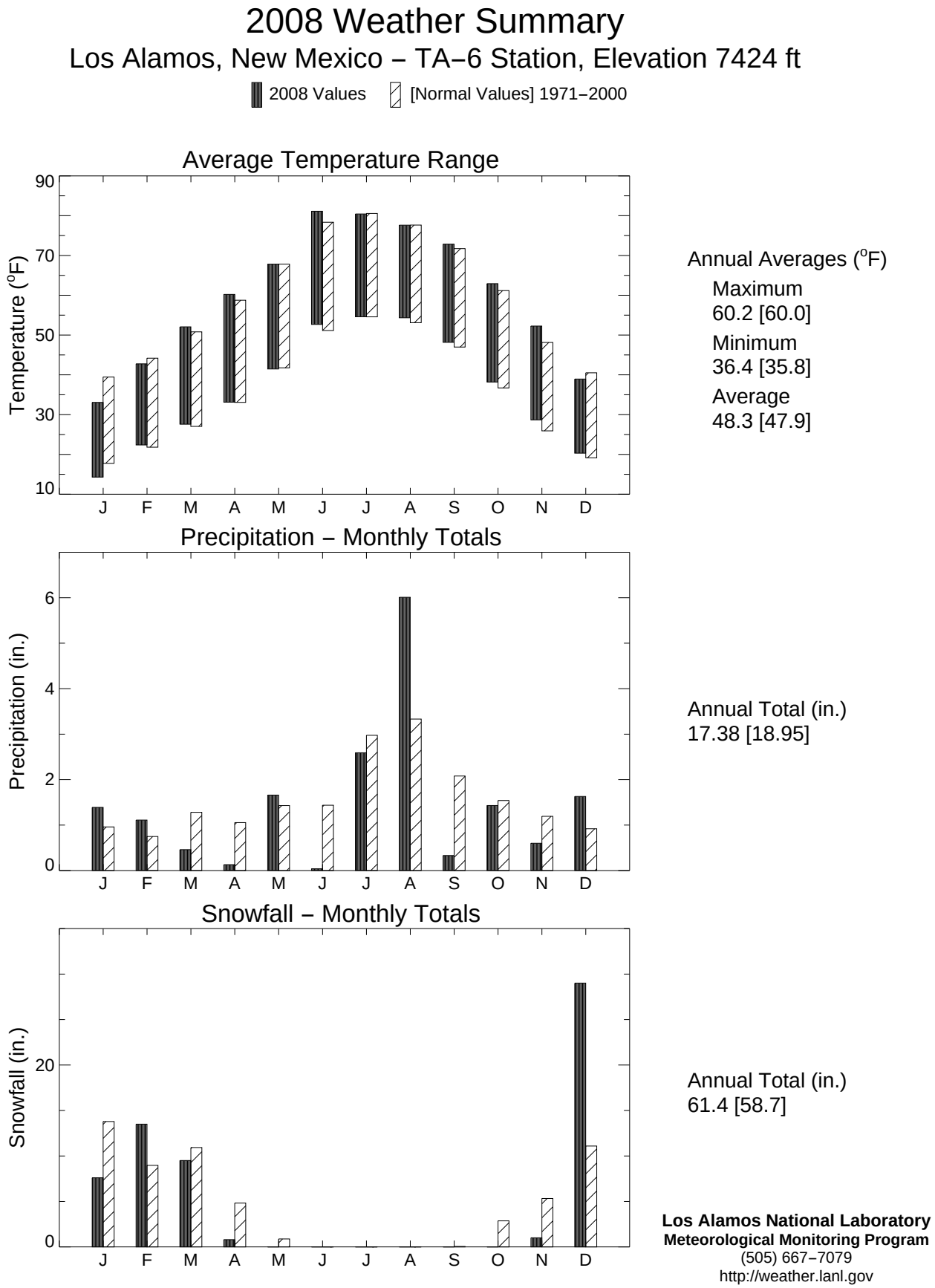


Figure 4-21. Weather summary for Los Alamos for 2008 at the TA-6 meteorology station.

Figure 4-23 shows the historical record of the annually summed total precipitation. The drought appears to have ended in 2003, and 2004 and 2005 brought surplus precipitation to help restore normal conditions. The moist trend did not continue in 2006, but returned again in 2007 with just over 20 in., where the norm is 19 in. The 2008 total of 17.4 in. was about 1.5 in. below normal. As with the historical temperature profile, the five-year running mean is also shown. The five-year average suggests not only that the recent drought is behind us, but that it was the most severe drought in the 80-year record in Los Alamos.

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-24. Wind roses depict the percentage of time that wind blows from each of 16 direction bins. For example, winds are directly from the south at TA-6 over 12% of the time during days in 2008. Winds are directly from the north about 3% of the time during the day. Wind roses also show the distribution of wind speed. About 8% of the time, for example, winds at TA-6 are from the south and range from 2.5 to 5 meters per second. Winds from the south at TA-6 exceed 7.5 meters per second only a fraction of 1% of the time.

The wind roses are based on 15-minute-averaged wind observations for 2008 at the four Pajarito Plateau towers. Accurate wind speed and direction data from the Pajarito Mountain Tower are not available for much of 2008 due to a malfunctioning anemometer. Interestingly, wind roses from different years are almost identical, indicating that wind patterns are constant when averaged over a year.

Daytime winds measured by the four Pajarito Plateau towers are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and typically have a westerly component, resulting from a combination of prevailing westerly winds and downslope katabatic flow of cooled mountain air.

Winds on the Pajarito Plateau are faster during the day than at night. This is due to 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 little boosting from aloft.

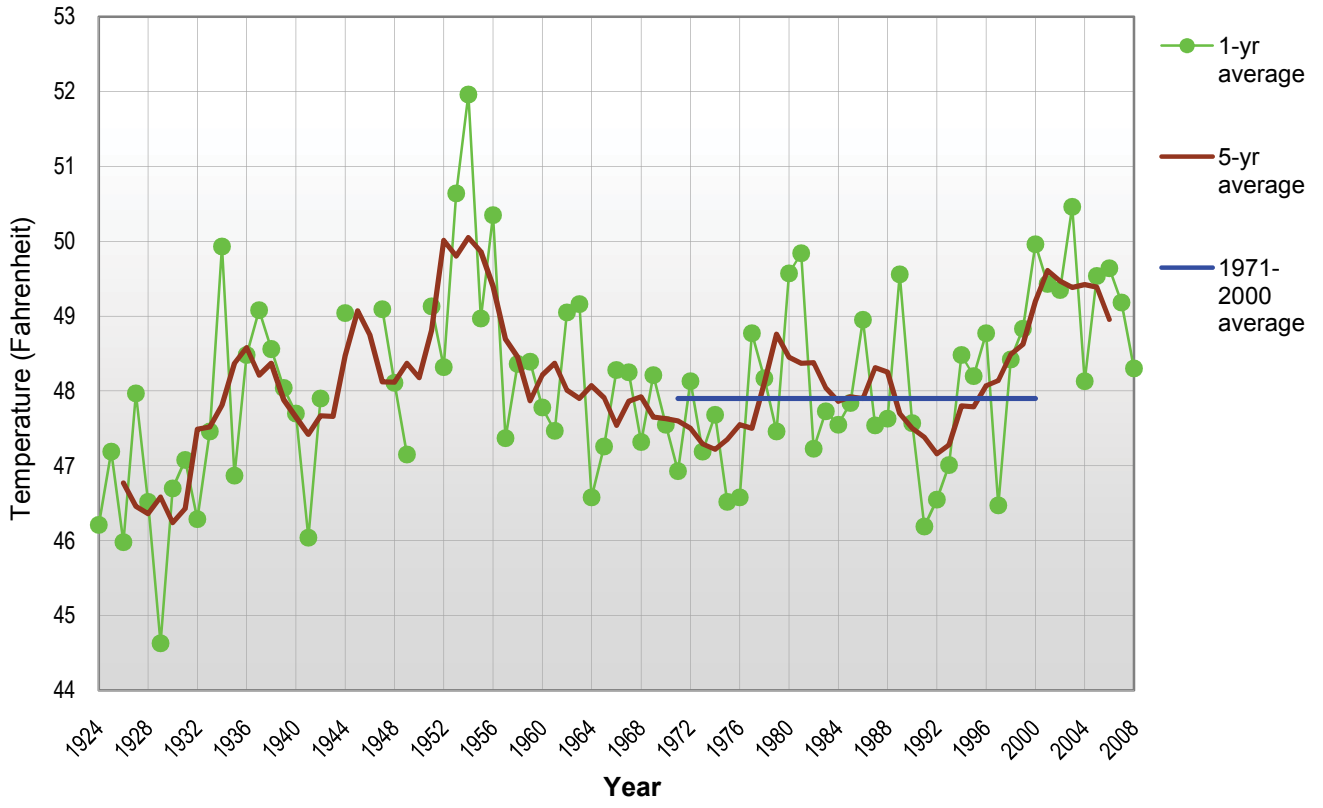


Figure 4-22. Temperature history for Los Alamos.

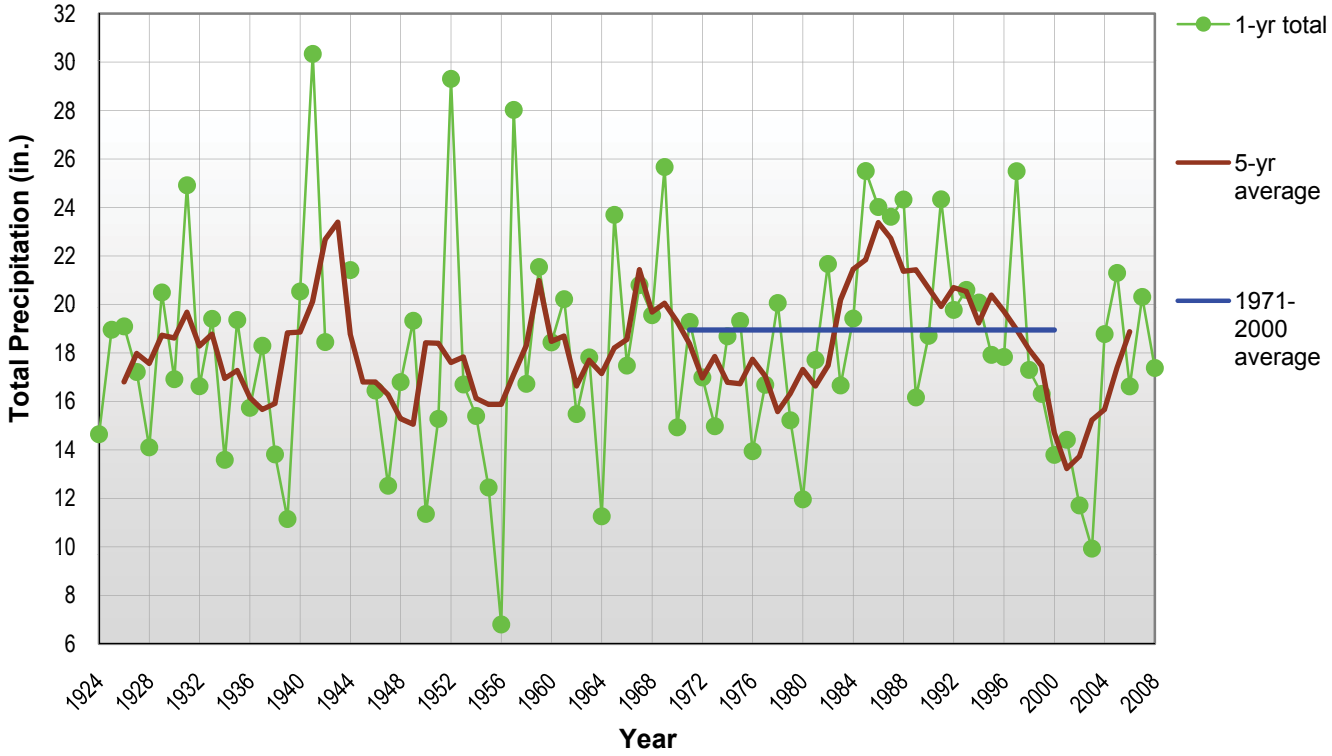


Figure 4-23. Total precipitation history for Los Alamos.

F. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

During 2008, the air quality monitoring and compliance organizations revised approximately 18 procedures and three QA project plans to reflect constant improvements in the processes. Together, these plans and procedures describe or prescribe all the planned and systematic activities necessary to provide confidence that processes perform satisfactorily. All current quality-related documents are available online at http://www.lanl.gov/environment/air/qa.shtml.

2. Field Sampling Quality Assurance

a. Methods

Overall quality of this portion of the program is maintained through the rigorous use of documented procedures that govern all aspects of the sample collection program.

Particulate and water-vapor samples are (1) collected from commercially available media of known performance, (2) collected under common chain-of-custody procedures using field-portable electronic data systems to minimize the chances of data transcription errors, and (3) prepared in a secure and radiologically clean laboratory for shipment. We deliver the samples to all internal and external analytical laboratories under full chain-of-custody, including secure FedEx shipment, and track them at all stages of their collection and analysis through the AIRNET and RADAIR relational databases.

Field sampling completeness is assessed every time the analytical laboratory returns the AIRNET biweekly gross alpha/beta data. RADAIR field sampling completeness is evaluated each week upon receipt of the gross alpha/beta and tritium bubbler data. All these calculations are performed for each ambient air and stack sampling site and are included in the QA memo prepared by stack monitoring staff to evaluate every data group received from a supplier.

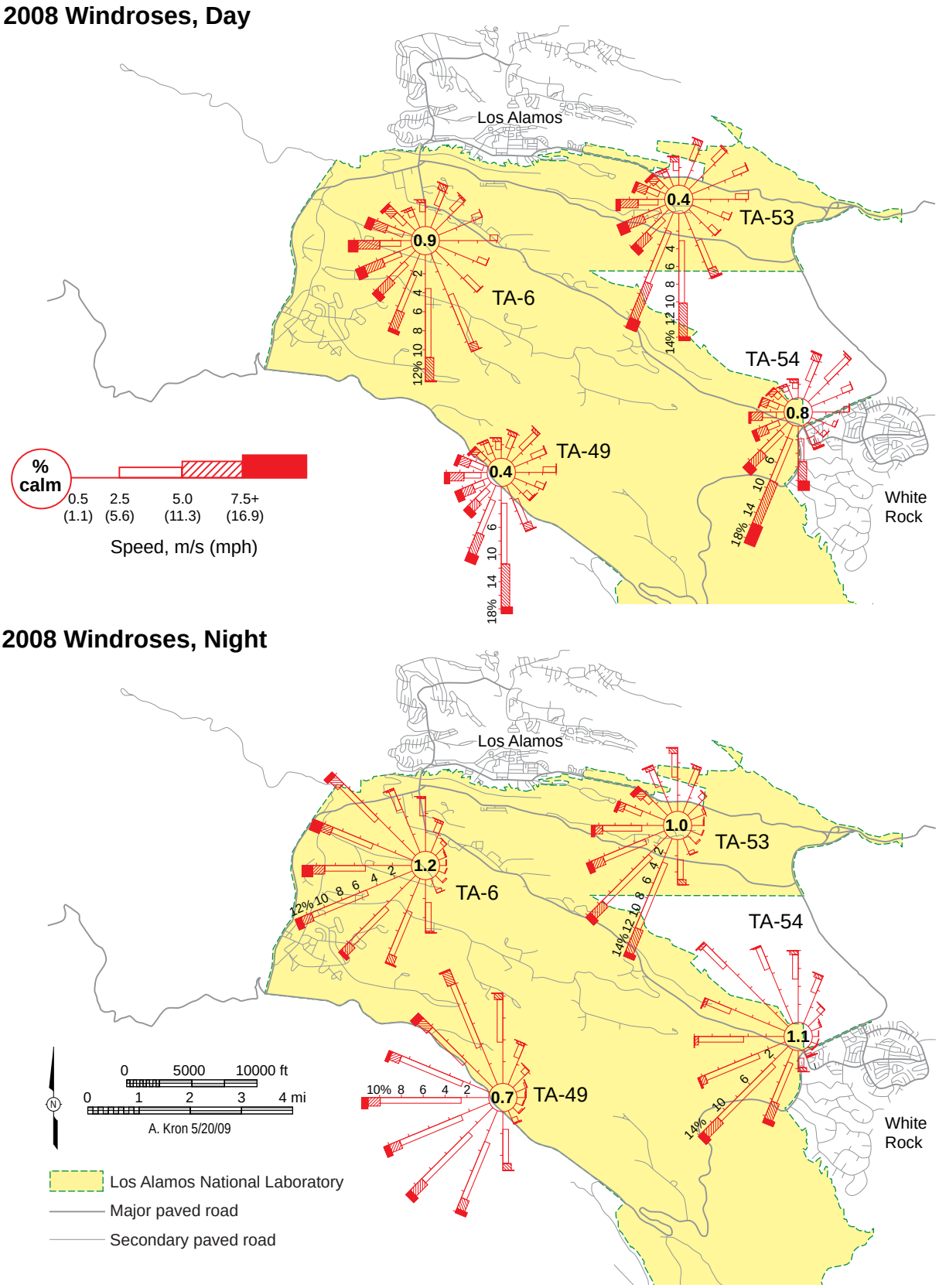


Figure 4-24. Daytime and nighttime wind roses for 2008.

b. Results

Field sample completeness for AIRNET was 99.9% for filters and 99.8% for silica gel (tritium samples). Field sample completeness for stack samples was 100%. Sample run time was greater than 98.5% for AIRNET and 99.69% for stacks.

3. Analytical Laboratory Quality Assessment

a. Method

LANL writes specific statements of work to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified our program objectives. We send these statements of work to potentially qualified suppliers who undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry-laboratory assessors. Statement of work specifications, professional judgment, and quality system performance at each laboratory, including recent past performance on nationally conducted performance evaluation programs, are primarily used to award contracts for specific types of radiochemical and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. We submit independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned by email in an electronic data deliverable of specified format and content. The analytical laboratory also submits a full paper set of records that serves as the legally binding copy of the data. Each set of samples contains all the internal QA/quality control data the analytical laboratory generates during each phase of analysis, including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable. The electronic data are uploaded into either the AIRNET or RADAIR databases and immediately subjected to a variety of quality and consistency checks. Analytical completeness is calculated, tracking and trending of all blank and control-sample data is performed, and all tracking information documented in the quality assessment memo mentioned in the field sampling section. All parts of the data management process are tracked electronically in each database, and periodic reports to management are prepared.

b. Results

Analytical data completeness was 99.9% for AIRNET filters, 99.8% for AIRNET silica gel, and 99.095% for stacks. The overall results of the quality monitoring in 2008 indicate that all analytical laboratories maintained the same high level of control observed in the past several years.

4. Analytical Laboratory Assessments

During 2008, one internal and one external laboratory performed all analyses reported for AIRNET and stack samples. Paragon Analytics, Inc., Fort Collins, Colorado, provided the following analyses:

- Biweekly gross alpha, gross beta, and gamma analyses of filters for AIRNET.
- Biweekly analyses for tritium in AIRNET silica gel.
- Weekly gross alpha, gross beta, gamma, and stable beryllium analyses on stack samples.
- Quarterly analyses for alpha-emitting isotopes (americium, plutonium, and uranium) and stable beryllium, calcium, and aluminum on AIRNET quarterly composite samples.
- Semester analyses of composites of stack filters for gross alpha, gross beta, americium-241, gamma-emitting isotopes, lead-210, polonium-210, plutonium isotopes, strontium-90, thorium isotopes, and uranium isotopes.

The Laboratory's on-site Health Physics Analytical Laboratory (HSR-4) performed instrumental analyses of tritium in stack emissions.

LANL assessed Paragon Analytics during 2006, and we found that the laboratory provides very high quality work in compliance with all LANL requirements. This laboratory has consistently performed well. The laboratory annually participates in two national performance evaluation studies and the study sponsors have consistently judged the analytical laboratory to have acceptable performance for all analytes attempted in all air sample matrices.

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5. Groundwater Monitoring



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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples to monitor water quality beneath the Pajarito Plateau and the surrounding area. The Laboratory conducts groundwater monitoring and characterization programs to comply with the requirements of the Department of Energy (DOE) Orders and New Mexico (NM) and federal regulations. The objectives of the Laboratory's Water Stewardship Program are to determine compliance with waste discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources. This program addresses regulatory compliance, environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations (LANL 1996, 1998).

Because of the Laboratory's semiarid, mountainside setting, significant groundwater is found only at depths of more than several hundred feet. The Los Alamos County public water supply comes from supply wells that draw water from deep zones of the regional aquifer, the top of which is found at a depth that ranges between 600 to 1,200 ft. Groundwater protection efforts at the Laboratory focus on the regional aquifer underlying the area and also include the shallow perched groundwater found within canyon alluvium and the perched groundwater at intermediate depths above the regional aquifer.

Most of the groundwater monitoring conducted during 2008 was carried out according to the Interim Facility-Wide Groundwater Monitoring Plans (LANL 2007a, 2008a) approved by the New Mexico Environment Department (NMED) under the Compliance Order on Consent (Consent Order). The Water Stewardship Program collected groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

B. HYDROGEOLOGIC SETTING

The following sections describe the hydrogeologic setting of the Laboratory and include a summary of groundwater contaminant sources and distribution. Additional detail can be found in a report summarizing results of investigations conducted under the Hydrogeologic Workplan from 1998 through 2004 (LANL 2005a). This and many other reports are available at http://lanl.gov/environment/compliance/consent_order.shtml.

1. Geologic Setting

The Laboratory is located in northern New Mexico on the Pajarito Plateau, which extends eastward from the Sierra de los Valles, the eastern range of the Jemez Mountains (Figure 5-1). The Rio Grande borders the Laboratory on the east. Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff was formed from volcanic ashfall deposits and pyroclastic flows that erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1,000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

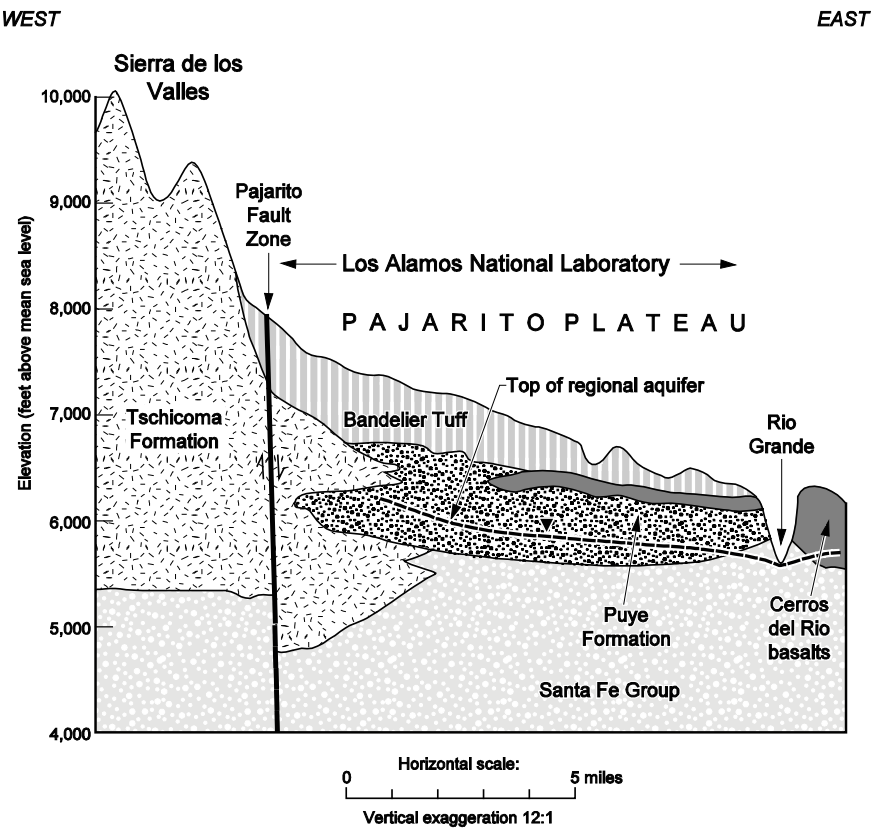


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains (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 interfinger with the Puye Formation conglomerate beneath the Laboratory. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

2. Groundwater Occurrence

Due to its location on a semiarid mountainside, the Laboratory sits atop a thick zone of mainly unsaturated rock, with the principal aquifer found 600 to 1,200 ft below the ground surface. Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater is a zone of saturation with limited extent that is retained above less permeable layers and is separated from underlying groundwater by unsaturated rock.

The three modes of groundwater occurrence are (1) perched alluvial groundwater in canyon bottoms, (2) discontinuous zones of intermediate-depth perched groundwater whose location is controlled by availability of recharge and by subsurface changes in rock type and permeability, and (3) the regional aquifer beneath the Pajarito Plateau. The regional aquifer extends throughout the neighboring Española Basin.

Stream runoff may be supplemented or maintained by Laboratory discharges. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. Streams have filled some parts of canyon bottoms with alluvium up to a thickness of 100 ft. In wet 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 saturated zones have limited extent, as evapotranspiration and percolation into underlying rocks deplete the alluvial groundwater as it moves down the canyon.

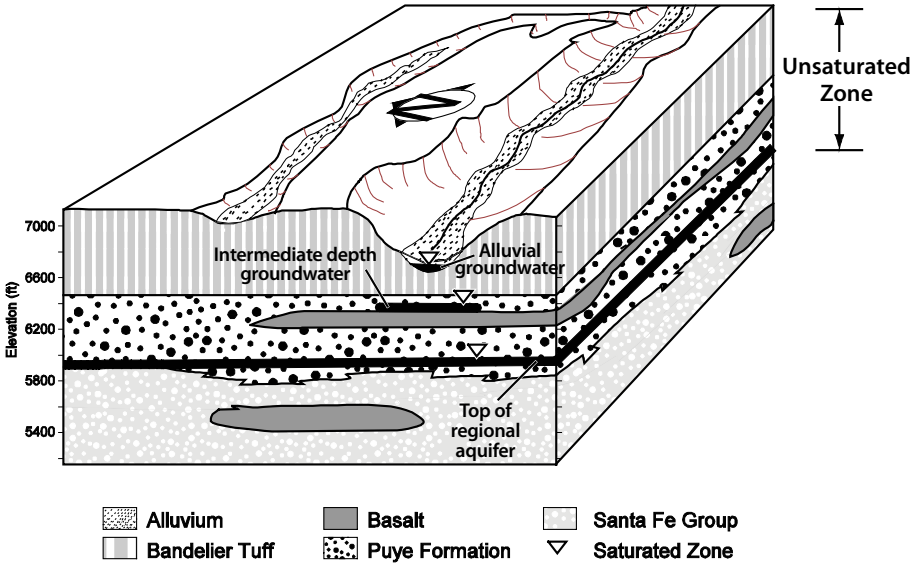


Figure 5-2. Illustration of geologic and hydrologic relationships in the Pajarito Plateau, showing the three modes of groundwater occurrence.

Underneath portions of Pueblo, Los Alamos, Mortandad, Sandia, and other canyons, intermediate perched groundwater occurs within the lower part of the Bandelier Tuff and within the underlying Puye Formation and Cerros del Rio basalt (Figure 5-2). These intermediate-depth groundwater bodies are formed in part by recharge from the overlying perched alluvial groundwater. The intermediate groundwater may be discontinuous or may connect with other zones across canyons; occurrence is controlled by availability of recharge and variations in permeability of the rocks underlying the plateau. Depths of the intermediate perched groundwater vary: for example, approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched groundwater occurs in volcanic rocks on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs and yields a significant flow from a gallery in Water Canyon. Intermediate groundwater also occurs in the southwest portion of the Laboratory just east of the Sierra de los Valles. A number of intermediate springs, fed by local recharge, discharge from mesa edges along canyons. Other intermediate groundwater is found in the Bandelier Tuff at a depth of approximately 700 ft. The source of this deeper perched groundwater may be percolation from streams that discharge from canyons along the mountain front or may be underflow of recharge from the Sierra de los Valles.

The regional aquifer occurs at a depth of 1,200 ft along the western edge of the plateau and 600 ft along the eastern edge (Figures 5-1 and 5-3). The regional aquifer lies about 1,000 ft beneath the mesa tops in the central part of the plateau. This is the only aquifer in the area capable of serving as a municipal water supply. Water in the regional aquifer generally flows east or southeast toward the Rio Grande. Groundwater model studies indicate that underflow of groundwater from the Sierra de los Valles is the main source of regional aquifer recharge (LANL 2005a). Groundwater velocities vary spatially but are typically 30 ft/yr.

The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation, part of the Santa Fe Group (Figure 5-1). Underneath the central and western part of the plateau the aquifer rises farther into the Cerros del Rio basalt and the lower part of the Puye Formation.

The regional aquifer is separated from alluvial and intermediate perched groundwater by approximately 350 to 620 ft of unsaturated tuff, basalt, and sediments with generally low moisture content (<10%). Water lost by downward seepage from alluvial and intermediate groundwater zones travels through the underlying rock by unsaturated flow. This percolation is a source of certain contaminants, mobile in water, which may reach the regional aquifer within a few decades. The limited extent of the alluvial and intermediate groundwater bodies, along with the dry rock that underlies them, restricts their volumetric contribution to recharge reaching the regional aquifer.

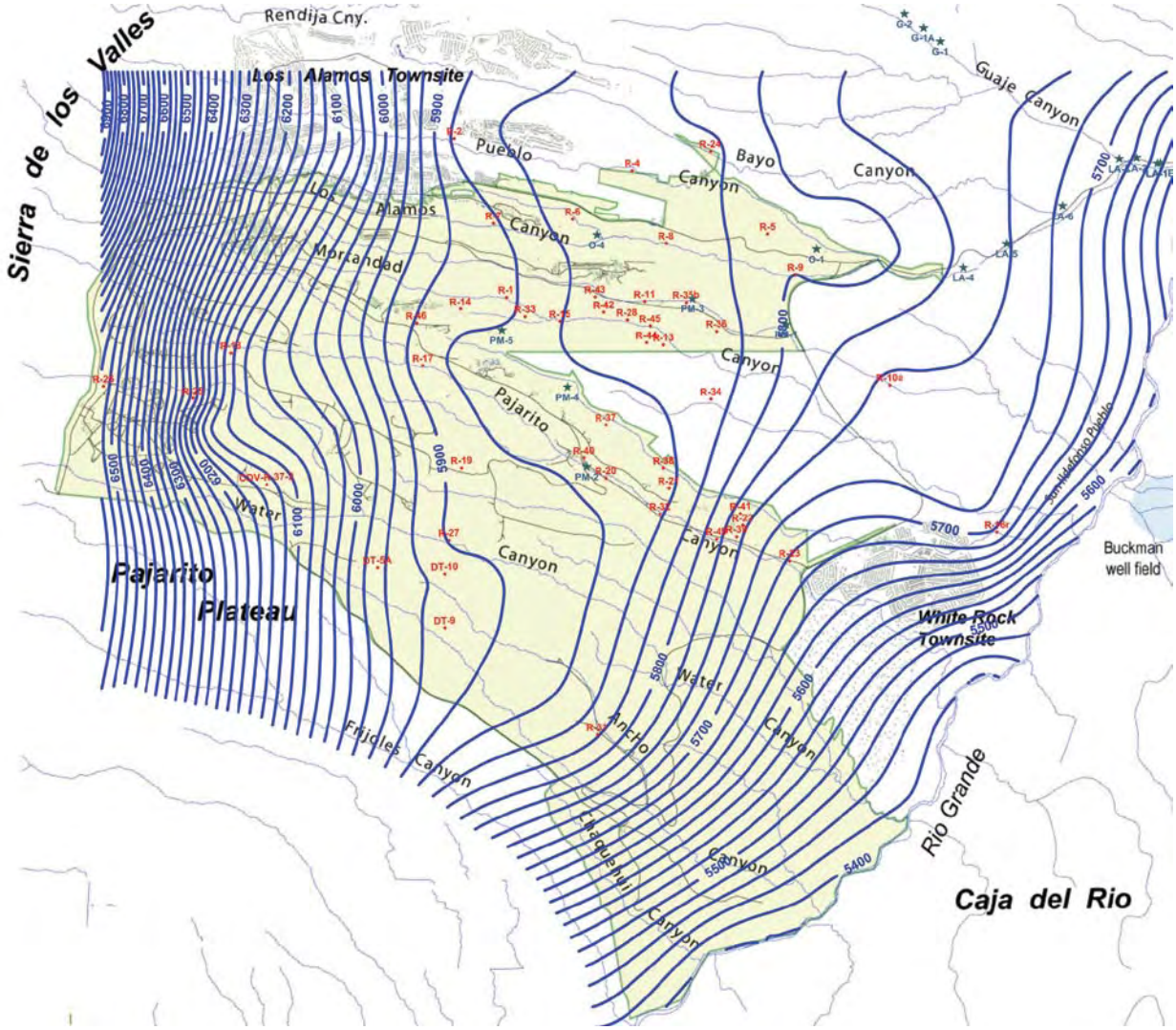


Figure 5-3. Contour map of average water table elevations for the regional aquifer (based on a map in LANL 2009). This map represents a generalization of the data; other interpretations are possible.

3. Overview of Groundwater Quality

Since the 1940s, liquid effluent discharge by the Laboratory has affected water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. Liquid effluent discharge is also the primary means by which Laboratory contaminants have affected the quality of intermediate perched zones and the regional aquifer. Where contaminants are found at depth, the setting is either a canyon where alluvial groundwater is usually present (perhaps because of natural runoff or Laboratory effluents) or a location beneath a mesa-top site where large amounts of liquid effluent have been discharged.

The contaminated alluvial and intermediate perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so recharge from the shallow groundwater occurs slowly. As a result, less contamination reaches the regional aquifer than is found in the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced or not present.

Drainages that received liquid radioactive effluents 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 radioactive effluent discharge history at the Laboratory.

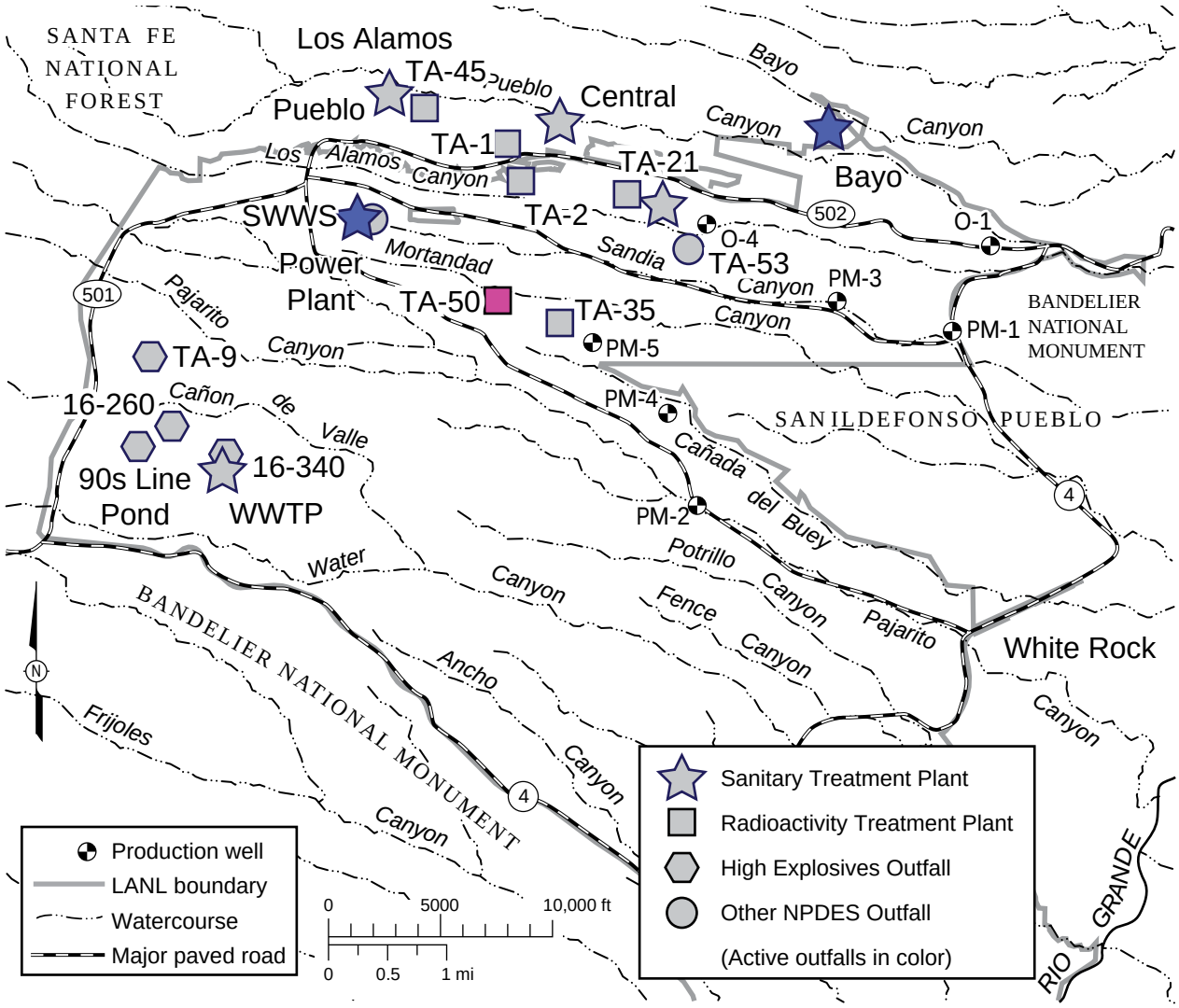


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. Most outfalls shown are inactive.

Because of releases of power plant cooling water and water from the Laboratory's Sanitary Wastewater Systems (SWWS) Plant, Sandia Canyon has received the largest liquid discharge volumes of any canyon in recent decades. Water Canyon and its tributary Cañon de Valle have received effluents produced by high explosives (HE) processing and experimentation (Glatzmaier 1993; Martin 1993).

Over the years, Los Alamos County has operated several sanitary wastewater treatment plants in Pueblo Canyon (ESP 1981). Only the new Los Alamos County Wastewater Treatment Plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls (from 141 to 17) and the volume of water released (by more than 80%). For 1993 to 1997, total estimated average flow was 1,300 M gal./yr; flow decreased to 230 M gal./yr for 1998 to 2005 (Rogers 2006) and to 158 M gal./yr in 2008. The quality of the remaining discharges has been improved through treatment process improvements so that the discharges meet applicable standards.

Certain chemicals are good indicators of the possible presence of Laboratory effluents in groundwater. These chemicals are described as being chemically conservative, that is, their concentrations are usually not affected by chemical reactions. Examples of these conservative chemicals include perchlorate, tritium, hexavalent chromium, and, to a lesser extent, nitrate. Nitrate is often conservative but its concentration may be affected by bacterial

activity. Because these chemicals travel readily in groundwater and are indicators of effluents, groundwater that has background concentrations of perchlorate, tritium, hexavalent chromium, and nitrate is not necessarily affected by LANL discharges. However, these indicators may not be useful in identifying organic contamination.

Liquid effluent discharges have affected intermediate perched groundwater and the regional aquifer to a lesser degree. The intermediate groundwater in various locations shows localized contamination from Laboratory operations, including presence of tritium, high explosives compounds, chlorinated organic chemical compounds, dioxane(1,4-), hexavalent chromium, barium, boron, perchlorate, fluoride, and nitrate.

In 2008, the HE compound Research Department Explosive (RDX) continued to be detected in the regional aquifer at Pajarito Canyon regional aquifer well R-18. The RDX concentration was near the detection limit and at 8% of the Environmental Protection Agency's (EPA's) Human Health tap water screening level of 6.1 µg/L. Earlier detection of RDX in the regional aquifer at regional aquifer well R-25 (to the south of R-18) was probably due to cross-contamination from shallower well screens caused by well construction delays.

Hexavalent chromium and nitrate have been found in several aquifer regional monitoring wells. In regional aquifer monitoring wells R-42 and R-28 in Mortandad Canyon, hexavalent chromium is found at concentrations of about 17 times and nine times the NM groundwater standard. Nitrate (as nitrogen) concentrations in regional aquifer monitoring wells R-43 and R-11 in Sandia Canyon and R-42 in Mortandad Canyon at concentrations between 50% and 60% of the NM groundwater standard. Traces of tritium and perchlorate are also found in the regional aquifer.

With one exception, drinking water wells in the Los Alamos area have not been impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate was found during 2008 at concentrations up to 16% of the Environmental Protection Agency's (EPA's) interim health advisory for perchlorate in drinking water of 15 µg/L. Consequently, this well is not used by Los Alamos County for water supply. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards.

C. GROUNDWATER STANDARDS AND SCREENING LEVELS

In evaluating groundwater samples, we applied regulatory standards and risk levels as described in Table 5-1. For drinking water supply wells, which draw water from the regional aquifer, we compared concentrations of radionuclides in samples to (1) the derived concentration guides (DCGs) for ingested water calculated from DOE's 4-mrem/yr drinking water dose limit and (2) the EPA maximum concentration levels (MCLs). EPA MCLs are the maximum permissible level of a contaminant in water delivered to any user of a public water system. Thus, compliance with the MCL is measured after treatment; measurements in a water supply well may be higher.

For radioactivity in groundwater other than drinking water, there are NM groundwater standards for uranium and radium. For risk-based screening of other radioactivity, groundwater samples from sources other than water supply wells may be compared with DOE's 4-mrem/yr drinking water DCGs and with EPA MCLs. The DCGs for the 100-mrem/yr public dose limit apply as effluent release guidelines. Where used in this chapter for such comparison purposes, in assessing water samples from sources other than water supply wells, these DCGs and EPA MCLs are referred to as screening levels.

The NM drinking water regulations and EPA MCLs apply as regulatory standards to nonradioactive constituents in water supply samples after treatment. They may be used as risk-based screening levels for other groundwater samples. The New Mexico Water Quality Control Commission (NMWQCC) groundwater standards (NMWQCC 2002) apply to concentrations of nonradioactive chemical quality parameters in all groundwater samples. Except for mercury and organic compounds, these standards apply only to dissolved (that is, filtered) concentrations. Because many metals are either chemically bound to or components of aquifer material that makes up suspended sediment in water samples, the unfiltered concentrations of these substances are often higher than the filtered concentrations. The EPA MCLs are intended for application to water supply samples that generally have low turbidity. As the EPA does not specify that the MCLs apply to dissolved concentrations, we use them to screen both filtered and unfiltered concentrations.

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

Constituent	Sample Type	Standard	Risk-Based Screening Level	Reference	Location	Notes
Radionuclides	Water supply wells	DOE 4-mrem/yr DCGs, EPA MCLs	None	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/yr dose limit and EPA MCLs apply to water provided to users of drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem/ yr DCGs	None	DOE Order 5400.5	On-site	DOE public dose limit of 100 mrem/yr applies to effluent discharges
Radionuclides	Non water supply groundwater samples	None	4-mrem/yr DCGs EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/yr dose limit and EPA MCLs are for comparison purposes because they apply only to drinking water systems
Non-radionuclides	Water supply wells	EPA MCLs, NM groundwater standards, EPA Human Health 10^{-5}, and HQ = 1 tap water risk levels for NM toxic pollutants with no standard	None	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	On-site and off-site	EPA MCLs apply to water provided to users of drinking water systems. Use EPA Human Health tap water table for 10^{-5} and HQ = 1 risk levels
Non-radionuclides	Non water supply groundwater samples	NM groundwater standards, EPA Human Health 10^{-5} and HQ = 1 tap water risk levels for NM toxic pollutants with no standard	EPA MCLs	40 CFR 141-143, 20.6.2 NM Administrative Code, http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm	On-site and off-site	NMED regulations apply to all groundwater. EPA MCLs are for comparison purposes because they apply only to drinking water systems. Use EPA Human Health tap water table for 10^{-5} and HQ = 1 risk levels

NMWQCC (2002) specifies how to determine standards for the toxic pollutants listed in the NMWQCC groundwater standards, if they have no other state or federal standard. Accordingly, we screened results for these compounds at a risk level of 10^{-5} for cancer-causing substances or a hazard quotient of one (HQ = 1) for non-cancer-causing substances. A HQ of one or less indicates that no (noncancer) adverse human health effects are expected to occur from that chemical. We used the EPA Human Health tap water screening levels to screen these toxic pollutant compounds (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm). For cancer-causing substances, the EPA Human Health tap water screening levels are at a risk level of 10^{-6}, so we use 10 times the values to screen at a risk level of 10^{-5}. These screening levels are updated several times each year; an earlier edition of the current values was used to prepare this report.

Groundwater is a source of flow to springs and other surface water that neighboring tribal members and wildlife use. NMWQCC's surface water standards (NMWQCC 2000), including the wildlife habitat standards, also apply to this surface water (for a discussion of surface water, see Chapter 6).

D. MONITORING NETWORK

In 2005, DOE and its Operations and Management Contractor and NMED signed the Consent Order, which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory annually submit an Interim Facility Groundwater Monitoring Plan (Interim Plan) to NMED for its approval. The first Interim Plan was approved in June 2006 (LANL 2006). Groundwater monitoring conducted during calendar year 2008 was carried out according to two Interim Facility-Wide Monitoring Plans approved by NMED under the Consent Order (LANL 2007a, 2008a).

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: perched alluvial groundwater beneath the floor of some canyons, localized intermediate-depth perched groundwater systems, and the regional aquifer (Figures 5-5 through 5-9).

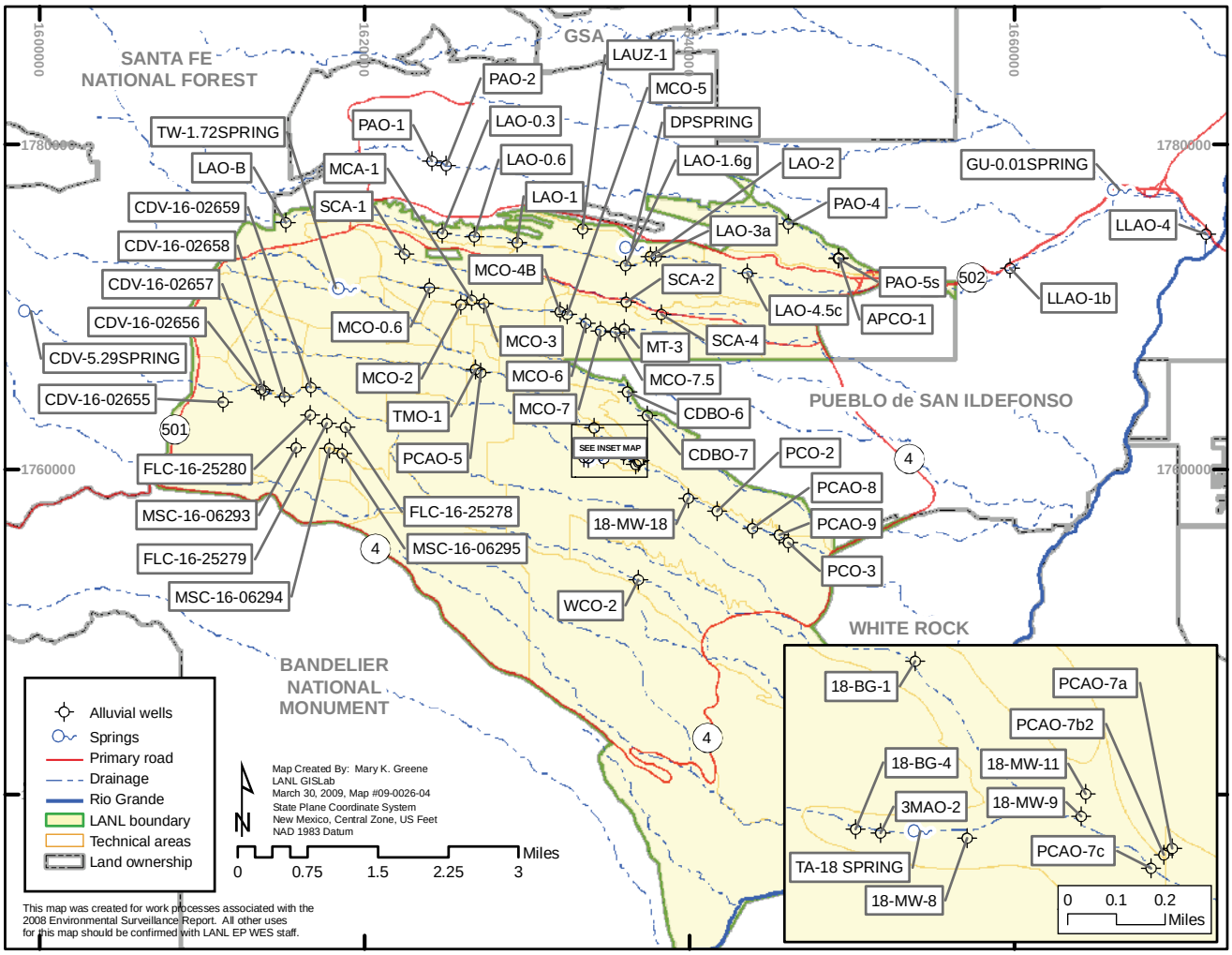


Figure 5-5. Springs and wells used for alluvial groundwater monitoring.

To document the potential impact of Laboratory operations on Pueblo de San Ildefonso land, the DOE signed a memorandum of understanding in 1987 with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on Pueblo land. Groundwater monitoring stations at Pueblo de San Ildefonso are shown in Figure 5-9 and mainly sample the regional aquifer. Basalt Spring, Los Alamos Spring, GU-0.01 Spring, and Pine Rock Spring are intermediate groundwater sampling points, and wells LLAO-1B and LLAO-4 sample alluvial groundwater. The Laboratory also monitors water supply wells for Los Alamos County (Figure 5-7) and three City of Santa Fe supply wells (Figure 5-9).

LANL conducts a regular program of water level measurements for monitoring wells. A summary of groundwater level measurements for 2008 is given in Koch et al. (2009).

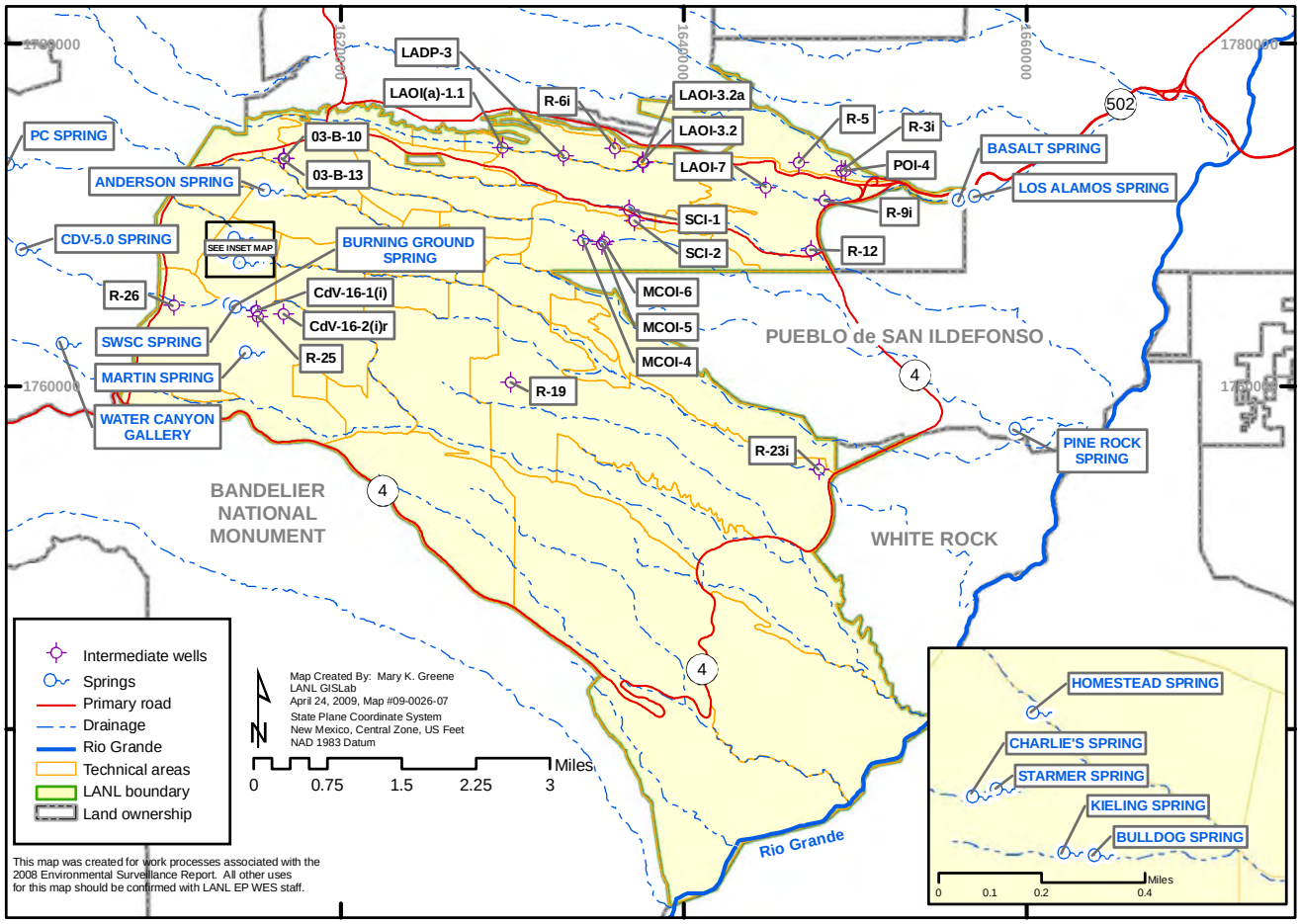


Figure 5-6. Springs and wells used for intermediate-depth perched zone monitoring.

1. Regional Aquifer and Intermediate Perched Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. Wells constructed since the Hydrogeologic Workplan (LANL 1998) are intended for additional groundwater characterization efforts and to extend the Laboratory's groundwater monitoring system. The Laboratory added several of these wells to the monitoring well network beginning in 2002. New wells completed in 2008 are described in Chapter 2, Section B.9.b. A column on the supplemental data tables for Chapter 5 (located on the included compact disc) identifies the groundwater zones sampled by different ports of these wells and gives the depth of the sampled well port for multiscreen wells or top of the sampled well screen for single screen wells.

The Laboratory collected samples from 12 Los Alamos County water supply wells in three well fields that produce drinking water for the Laboratory and the community. The water supply wells are screened up to lengths of 1,600 ft within the regional aquifer, and they draw samples that integrate water over a large depth range. Los Alamos County owns and operates these wells and is responsible for demonstrating that the supply system meets Safe Drinking Water Act requirements. This chapter reports on supplemental sampling of those wells by the Laboratory.

Additional regional aquifer samples came from wells located on Pueblo de San Ildefonso lands and from the Buckman well field operated by the City of Santa Fe.

We also sample numerous springs near the Rio Grande because they represent natural discharge from the regional aquifer (Purtymun et al., 1980). Sampling the springs allows us to detect possible discharge of contaminated groundwater from underneath the Laboratory into the Rio Grande.

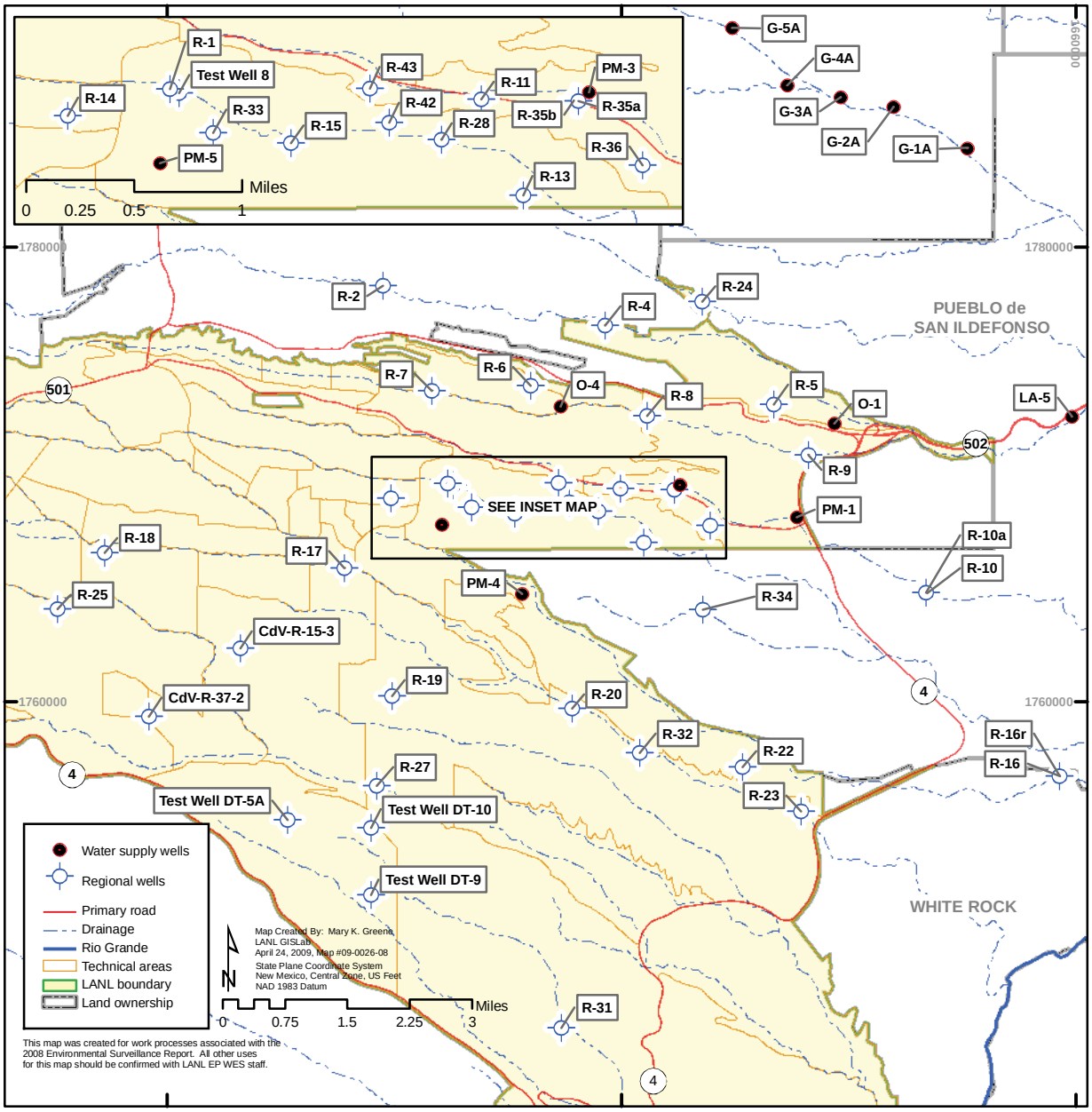


Figure 5-7. Wells used for regional aquifer monitoring.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, we used shallow wells and some springs to sample perched alluvial groundwater in several canyons. In any given year, some of these alluvial observation wells may be dry, and water samples cannot be obtained. Some observation wells in Water, Fence, and Sandia Canyons have been dry most often since their installation in 1989. All but one of the wells in Cañada del Buey are generally dry.

3. Well Redevelopment and Conversion

Monitoring network well assessments conducted in all of the Pajarito Plateau watersheds in 2007 and 2008 determined the adequacy of wells in each watershed for producing representative groundwater quality and the need for additional wells. As part of these assessments, we identified the existing wells that could be adequate if rehabilitated. As a result, two wells were rehabilitated in 2007, three were rehabilitated in 2008, and two will be rehabilitated in 2009. Rehabilitation involves both active cleaning of the well, redevelopment of conditions near the screens, and conversion to a well with fewer screens and a different sampling system.

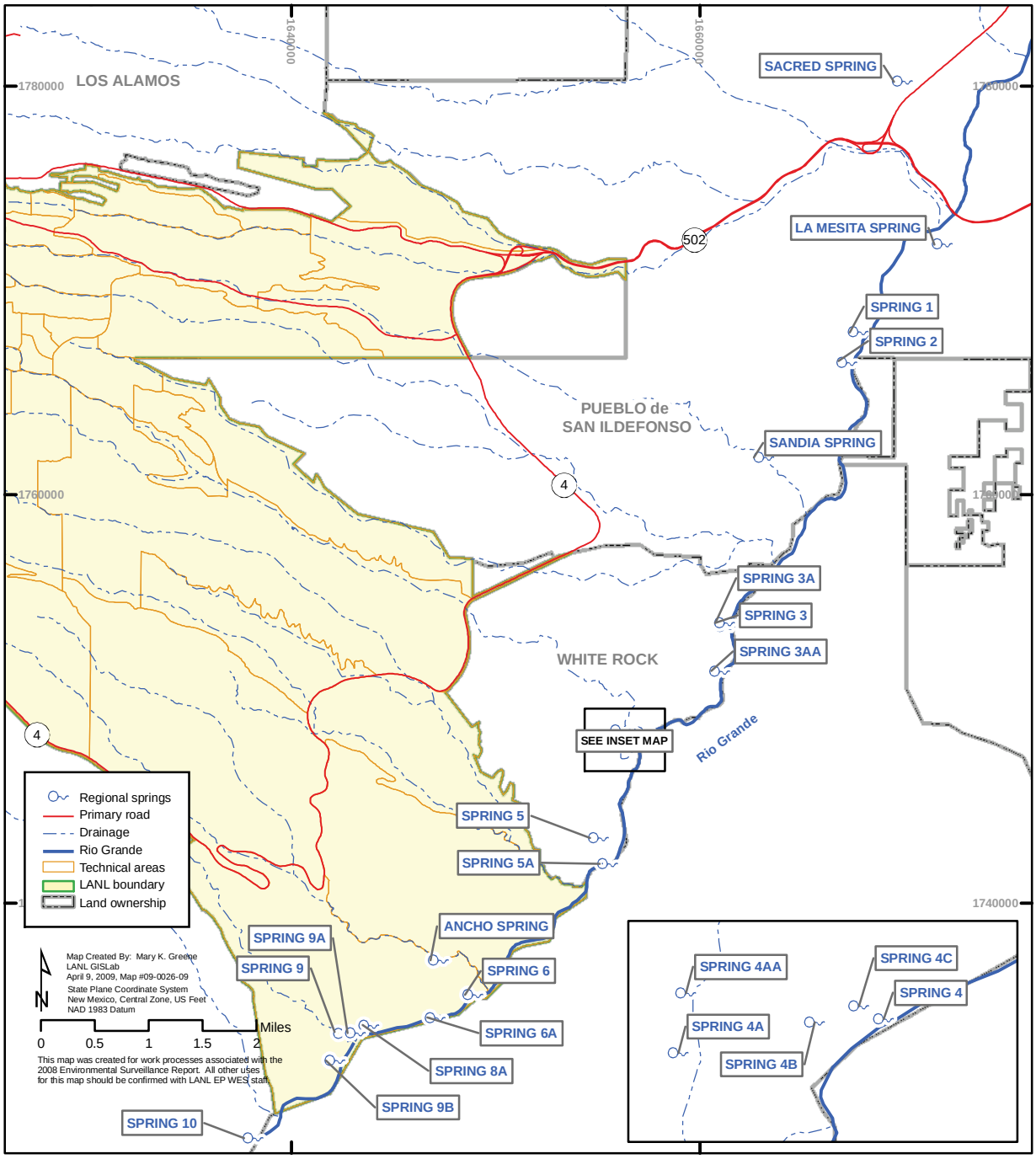


Figure 5-8. Springs used for regional aquifer monitoring.

As background, it is worth noting that in some LANL characterization wells, the use of fluids to assist well drilling has affected the chemistry of groundwater samples. From 1998 through 2006, more than 40 new wells were drilled for hydrogeologic characterization beneath the Pajarito Plateau as part of the Laboratory's Hydrogeologic Workplan (LANL 1998) or as part of corrective measures. Of these wells, some have screens in perched intermediate zones, most have screens in the regional aquifer, and a few have screens in both perched intermediate zones and the regional aquifer. Concerns about the reliability or representativeness of the groundwater quality data obtained from some wells stem from the potential for residual drilling fluids and additives to mask the present and future detection of certain contaminants.

Wells drilled since 2007 have been drilled without the use of drilling fluids other than water (with minor exceptions of using foam above the water table) in the saturated zone and also undergo extensive well development at the outset to reduce the turbidity of water samples.

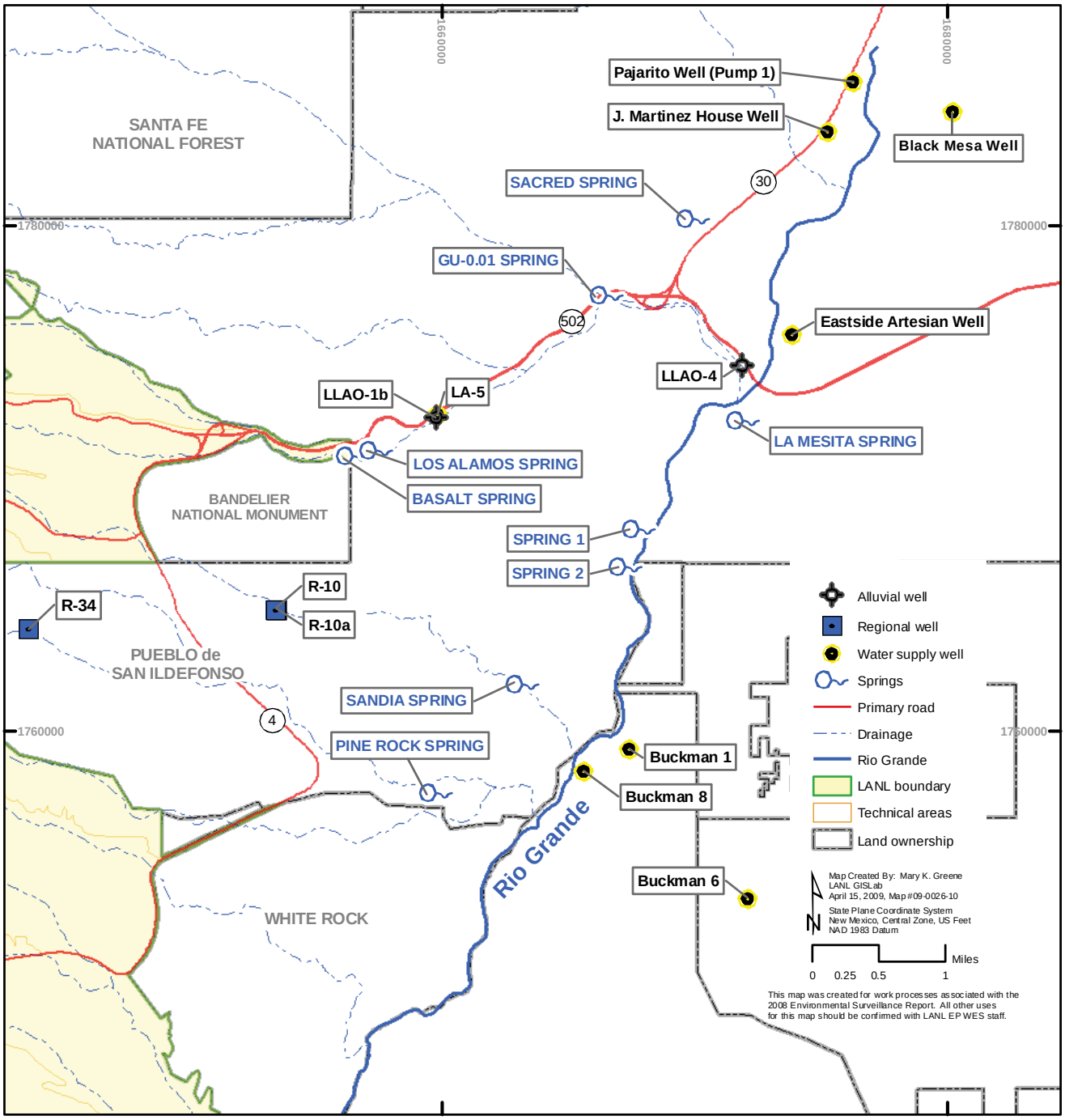


Figure 5-9. Springs and wells used for groundwater monitoring at the City of Santa Fe Buckman well field and on Pueblo de San Ildefonso lands.

In 2008, three wells drilled under the Hydrogeologic Workplan underwent redevelopment: R-33, R-14, and R-20 (for additional redevelopment beyond that performed in 2007). These wells were selected for redevelopment because of their importance as locations for groundwater monitoring. Physical redevelopment methods included surging, jetting with simultaneous pumping, swabbing, and extensive pumping. Following physical redevelopment, samples were collected and analyzed for key geochemical indicator parameters, as described in the "Well Screen Analysis Report, Rev. 2" (LANL 2007c), to determine the extent of the improvement in water quality. All of the wells were then converted to dual- or single-screen wells. The Baski sampling system, which allows active purging before sampling, was installed in dual-screen wells.

Submersible pumps in single-screen wells also allow for active purging. A summary of redevelopment results for each of the wells follows:

- R-33 was retained as a dual-screen well, but its Barcad sampling system was replaced with a Baski system following the redevelopment activities mentioned above. Its water quality, post-redevelopment, is now very good (that is, unaffected by drilling impacts), as determined by analysis of geochemical parameters (LANL 2008b).
- R-14 was converted from a dual-screen to a single-screen well with a dedicated submersible pump. The top screen that was retained improved in water quality and in hydraulic properties. Its water quality is now very good (LANL 2008c).
- R-20 was converted from a three-screen to a dual-screen well with a Baski sampling system. The top two screens that were retained improved in water quality and in hydraulic properties. Following a second minor redevelopment and sampling using a different pipe, water quality improved even more (LANL 2008d). A persistent but low concentration of toluene in the bottom screen along with a December 2008 detection of trichloroethene is puzzling, however, and the cause of these detections is being investigated.

The project for rehabilitation of older characterization wells is planned for completion in 2009 with the redevelopment and conversion of wells R-22 and R-16.

E. SUMMARY OF 2008 SAMPLING RESULTS

In 2008 LANL sampled 222 groundwater wells, well ports, and springs in 552 separate sampling events. The samples collected were analyzed for about 198,000 separate results. If results from in-house analytical laboratories, field parameters, and field quality control blanks are excluded, the samples were analyzed for 122,742 results. The total numbers of results are given in Table 5-2 for each analytical suite and groundwater zone. The bottom row of the table gives the number of sample results, not including field quality control blanks, field parameters (for example, temperature or pH), or measurements made at an in-house analytical laboratory.

Table 5-3 gives the total number of sample results that were above the screening levels described in Section C. About 0.3% of the results had values greater than a screening level. These totals are based on omitting field quality control blanks, field parameters (for example, temperature or pH), and measurements made at an in-house analytical laboratory. The analytes, number of times above the screening level, and the screening level value are given in Table 5-4.

The total number of sample results that were above the screening levels may give a high estimate for several reasons. For a particular sample event, multiple measurements made for an analyte may be included in the total. The multiple measurements could include both filtered and unfiltered sample results, multiple analytical laboratory analyses (for example, made on diluted samples to improve analytical accuracy), and results from field duplicate samples. As well, in many cases the given screening level may not apply to a particular groundwater sample. For example, some of the screening levels (the EPA MCLs and EPA Human Health tap water screening levels) apply specifically to drinking water, and not to a sample result from a non-drinking water source. The monitoring results are described in detail in the following sections.

F. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables for this chapter present groundwater quality monitoring data for 2008 (included on compact disc). Columns on the data tables identify the groundwater zones sampled—whether alluvial, intermediate, or regional; the latter includes water supply wells—or indicate if the location is a spring. For wells with several sampling ports, the depth and groundwater zone sampled for each port appear in the table. For single-screen wells, the depth of screen top is given. Springs have a depth of 0 ft, and wells with unknown depth list a value of –1. Supplemental Data Table S5-1 provides definitions for sample description codes used in the data tables.

Table 5-2
Total Number of Groundwater Sample Results Collected by LANL in 2008

Groundwater Zone	Total Results	Dioxins & Furans	Diesel Range Organics	General Inorganic Chemistry	Herbicides	High Explosives	Isotopes	Metals	Pesticides & PCBs	Radio-activity	Semivolatile Organic Compounds	Volatile Organic Compounds
Alluvial	50,956	475		4,993	240	2,082	113	7,502	1,306	2,422	11,120	20,703
Alluvial Spring	2,224			216		69		342	53	87	480	977
Intermediate	33,533	25		3,056	80	1,721	47	5,148	681	1,522	5,360	15,893
Intermediate Spring	16,836	25		1,618	10	1,203	28	2,640	562	965	3,280	6,505
Regional	73,925	150		9,104	220	3,311	133	16,990	1,482	2,926	8,800	30,809
Regional Spring	13,531			1,286		796	26	2,164	58	735	3,120	5,346
Water Supply	6,971		2	656		520	5	646	208	416	1,440	3,078
Total	**197,976**	**675**	**2**	**20,929**	**550**	**9,702**	**352**	**35,432**	**4,350**	**9,073**	**33,600**	**83,311**
Number of groundwater sample results omitting field parameters, field quality control blanks, and data analyzed in-house												
Total	**122,742**	**500**	**2**	**11,527**	**550**	**7,197**	**138**	**24,458**	**4,030**	**9,060**	**26,800**	**38,480**

Table 5-3
Total Number of Groundwater Sample Results above Screening Levels in 2008
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed In-House)

Groundwater Zone	Total Results	Dioxins & Furans	Diesel Range Organics	General Inorganic Chemistry	Herbicides	High Explosives	Isotopes	Metals	Pesticides & PCBs	Radio-activity	Semivolatile Organic Compounds	Volatile Organic Compounds
Number of results	122,746	500	2	11,531	550	7,197	138	24,458	4,030	9,060	26,800	38,480
Number above Standard	355	0	0	96	0	28	0	143	0	23	14	51
Percentage above Screening Level	0.29	0	0	0.83	0	0.39	0	0.58	0	0.25	0.05	0.13

Table 5-4
Groundwater Analytes with Results above Screening Levels in 2008
(Omitting Field Parameters, Field Quality Control Blanks, and Data Analyzed in-House)

Suite or Analyte	No. of Results	Screening Level	Units	Screening Level Type
General Inorganic Chemistry	**96**			
Chloride	11	250	mg/L	NM groundwater standard
Perchlorate	49	4	µg/L	NM Consent Order
Ammonia	21	0.21	mg/L	EPA Human Health tap water screening level
Nitrate+Nitrite	11	10	mg/L	NM groundwater standard
Total Dissolved Solids	4	1000	mg/L	NM groundwater standard
High Explosives	**28**			
RDX	28	6.11	µg/L	EPA Human Health tap water screening level
Metals	**143**			
Aluminum	9	5000	µg/L	NM groundwater standard
Arsenic	8	10	µg/L	EPA MCL
Boron	2	750	µg/L	NM groundwater standard
Barium	13	1000	µg/L	NM groundwater standard
Beryllium	1	4	µg/L	EPA MCL
Chromium (dissolved)	19	50	µg/L	NM groundwater standard
Chromium (total)	17	100	µg/L	EPA MCL
Iron	39	1000	µg/L	NM groundwater standard
Manganese	28	200	µg/L	NM groundwater standard
Nickel	1	200	µg/L	NM groundwater standard
Lead	4	15	µg/L	EPA MCL
Antimony	2	6	µg/L	EPA MCL
Radioactivity	**23**			
Plutonium-239/240	1	1.2	pCi/L	DOE 4 mrem/yr DCG
Radium-226	1	4	pCi/L	DOE 4 mrem/yr DCG
Radium-228	3	4	pCi/L	DOE 4 mrem/yr DCG
Strontium-90	18	8	pCi/L	EPA MCL
Semivolatile Organic Compounds	**14**			
Bis(2-ethylhexyl)phthalate	5	6	µg/L	EPA MCL
Dioxane[1,4-]	7	61.1	µg/L	EPA Human Health tap water screening level
Phenol	2	5	µg/L	NM groundwater standard
Volatile Organic Compounds	**51**			
Bromomethane	2	8.66	µg/L	EPA Human Health tap water screening level
Dichloroethene[1,1-]	15	5	µg/L	NM groundwater standard
Dioxane[1,4-]*	19	61.1	µg/L	EPA Human Health tap water screening level
Methylene Chloride	1	5	µg/L	EPA MCL
Tetrachloroethene	1	5	µg/L	EPA MCL
Trichloroethane[1,1,1-]	11	60	µg/L	NM groundwater standard
Trichloroethene	2	5	µg/L	EPA MCL

* VOC results for Dioxane[1,4-] are not usable
MDL = minimum detection level
DCG = DOE derived concentration guide

Table S5-2 lists the results of radiochemical analyses of groundwater samples for 2008. The table also gives the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. A "<" symbol indicates that based on the analytical laboratory or

secondary validation qualifiers the result was a nondetect. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results.

Table S5-4 lists radionuclides detected in groundwater samples, as reported by the analytical laboratory. For most radionuclide measurements, we reported a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (which indicates that the result is a nondetect). The analytical laboratory reports a result as detected that is greater than the measurement-specific MDA. Some low-detection-limit tritium data do not have laboratory qualifiers; in that case, a result is reported as detected when analytical results are greater than three times the reported (one-sigma) uncertainty.

Data with qualifier codes other than X or U are shown in Table S5-4 to provide additional information on analytical results; in some cases there were analytical quality issues. The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7). After we received the analytical laboratory data packages, an independent contractor, Analytical Quality Associates, Inc. (AQA), performed a secondary validation on the packages. The reviews by AQA include verifying that holding times were met, that all documentation is present, and that analytical laboratory quality control measures were applied, documented, and kept within contract requirements.

Because uranium, gross alpha, and gross beta are usually detected in water samples and to focus on the higher measurements, Table S5-4 only includes occurrences of these measurements above threshold values (all of the results are included in Table S5-2). We selected threshold levels of 5 µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta, which are lower than the respective EPA MCLs or screening levels (30 µg/L for uranium, 15 pCi/L for gross alpha, and 50 pCi/L for gross beta). The right-hand columns of Table S5-4 compare results with the regulatory standards or screening levels listed on the table.

Table S5-8 lists the results of general chemical analyses of groundwater samples for 2008. Table S5-9 lists perchlorate results. We analyzed samples for perchlorate by the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method (SW-846:6850). The results of trace metal analyses appear in Table S5-10.

1. Contaminant Distribution Maps

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross the Laboratory. The accompanying maps depict the location of groundwater contaminants that are found at levels near or above screening levels or standards. The maps provide a spatial context for distribution of groundwater contamination.

The contaminant distribution maps show contaminant locations extrapolated beyond the area covered by monitoring wells. This extrapolation takes into account the location of contaminant sources and direction of groundwater flow. Question marks on the maps indicate where contaminant extent is inferred but not confirmed by monitoring coverage. For alluvial groundwater in canyons, the extent of contamination lateral to the canyon is not to scale; contaminated groundwater is confined to the canyon bottom alluvium and is quite narrow at the map scale.

2. Organic Chemicals in Groundwater

In 2008, we analyzed samples from selected springs and monitoring wells for organic chemicals. Table S5-11 summarizes the stations sampled and organic chemical suites for which samples were analyzed. These samples were analyzed for some or all of the following organic chemical suites: volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, diesel-range organics (DRO), and HE. The Quality Assurance (QA) section of this chapter (Section H) covers analytes and analytical methods. Table S5-12 shows organic chemicals detected in 2008 and detections in field QC samples.

Certain organic compounds used in analytical laboratories or derived from sampling equipment are frequently detected in laboratory blanks, that is, contamination introduced by the analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993) and many others.

One of the compounds found as analytical contaminants, bis(2-ethylhexyl)phthalate, was present in relatively high concentrations at several wells during 2008. This compound is also derived from plastics including sample bottles and tubing. The EPA MCL for this compound is 6 µg/L. For example, R-32, which underwent redevelopment in late 2007, had bis(2-ethylhexyl)phthalate detections in the first four sample events after redevelopment. The concentrations in these samples ranged from 2.4 µg/L to 6 µg/L. However, bis(2-ethylhexyl)phthalate was not detected in the final sample event at R-32 in 2008; it has been found at 3.0 µg/L in an early 2009 sample. R-42, a new well, had two 2008 sample events with bis(2-ethylhexyl)phthalate concentrations of 2.6 µg/L to 11.9 µg/L; early 2009 sampling shows concentrations of 3.0 µg/L. R-36 was first sampled in May 2008 and has been sampled five times through early 2009. Samples were analyzed for bis(2-ethylhexyl)phthalate during only two of the sample events. It was found at concentrations of 59.1 µg/L in 2008 and 12.2 µg/L in early 2009.

One hypothesis for presence of bis(2-ethylhexyl)phthalate in these water samples is that some new wells may have sampling system or other components from which the compound is leached during the initial life of the well. For example, MCOI-6 showed bis(2-ethylhexyl)phthalate concentrations ranging from 2.3 µg/L to 12.4 µg/L between June 2005 and August 2007. Samples taken in 2008 did not contain the compound.

3. Radioactivity in Groundwater

The principal radioactive element detected in the regional aquifer is naturally occurring uranium, found at high concentrations in springs and wells throughout the Rio Grande Valley. The large gross alpha values found in samples from these springs and wells result from the decay of naturally occurring uranium in the water. Other radioactivity in groundwater samples comes from members of the decay chains for naturally occurring uranium-235, uranium-238 (including radium-226 and uranium-234), and thorium-232 (including radium-226). Potassium-40 is also a source of natural radioactivity.

In 2008, no activity or concentration value for a water supply radioactivity analyte exceeded any regulatory standard, including the 4-mrem/yr DOE DCGs applicable to drinking water. Two values for naturally occurring radioactivity results in regional aquifer samples were greater than screening levels (Table 5-5). In 2008 the method for analyzing radium-228 changed from EPA:901.1 to EPA:904, with a corresponding decrease in MDA from a range of 10 to 30 pCi/L to a range of 0.3 to 1 pCi/L. This change in method sensitivity corresponds to an increased number of detections.

Table 5-5
Radioactivity results above screening levels in regional aquifer groundwater for 2008

Chemical	Location	Result	Trends
Radium-228	R-22 at 907 ft in Pajarito Canyon	4.45 pCi/L, above 4-mrem/yr DCG screening level of 4 pCi/L	Naturally occurring isotope, lower detection limit than earlier samples
Radium-226	Test Well DT-9 in Ancho Canyon	4.03 pCi/L, above 4-mrem/yr DCG screening level of 4 pCi/L	Naturally occurring isotope, previous detections near 1 pCi/L

Pine Rock Spring, which flows from intermediate groundwater on Pueblo de San Ildefonso lands, had a uranium concentration near the NM groundwater standard. The high uranium value may be due to dissolution of uranium from the bedrock by sanitary effluent, which is used to water athletic fields at nearby Overlook Park (Teerlink 2007). Other radioactivity results near screening levels are shown in Table 5-6.

Table 5-6
Radioactivity results near screening levels in intermediate groundwater for 2008

Chemical	Location	Result	Trends
Tritium	MCOI-4, MCOI-5, MCOI-6 in Mortandad Canyon	3,310 to 12,600 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Values steady over four years of sampling; wells sample separate isolated perched zones
Uranium	Pine Rock Spring (Pueblo de San Ildefonso)	28.8 µg/L, below NM groundwater standard of 30 µg/L	Steady over three years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields

Results for strontium-90 from alluvial groundwater in Los Alamos and Mortandad Canyons were near or exceeded the 4-mrem/yr DOE DCG and EPA MCL screening levels (Table 5-7, Figures 5-10 and 5-11). Note that strontium-90 has a half-life of 28.8 years. Variable plutonium-239/240 results in some Pueblo Canyon wells occasionally exceed the 4-mrem/yr DOE DCG screening level, mainly in unfiltered samples. Radium-226 and radium-228 (apparently of natural origin) are detected in many well samples, occasionally above the 4-mrem/yr DOE DCG screening levels.

Table 5-7
Radioactivity results above screening levels in alluvial groundwater for 2008

Chemical	Location	Result	Trends
Plutonium-239/240	Two wells in Pueblo Canyon	0.33 pCi/L to 1.66 pCi/L, above 1.2 pCi/L 4-mrem/yr DOE DCG screening level	Results variable over time, higher in unfiltered samples and downstream wells
Strontium-90	One spring and four wells in DP and Los Alamos Canyons	8.9 pCi/L to 66 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Decreased since cessation of discharges in 1986, now stable due to retention on sediments
Strontium-90	Three wells in Mortandad Canyon	40 pCi/L to 66 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Fairly stable for 10 years due to retention on sediments
Radium-226 and -228	Wells in all canyons	0.44 pCi/L to 7.65 pCi/L, above 4-mrem/yr DCG screening level of 4 pCi/L	Naturally occurring isotope, results are variable through time; average is 1.1 pCi/L, naturally occurring

4. Perchlorate in Groundwater

Perchlorate is an important contaminant to monitor at LANL because it was discharged in some effluents and travels readily through groundwater. Based on a toxicity assessment by the National Academy of Sciences, the EPA set a drinking water equivalent level of 24.5 µg/L for perchlorate in 2006. In January 2009 EPA issued an interim health advisory for perchlorate in drinking water of 15 µg/L (http://www.epa.gov/safewater/contaminants/unregulated/perchlorate.html). The Consent Order mandates a 4 µg/L screening level for perchlorate.

Several studies indicate that perchlorate occurs naturally in groundwater of arid regions due to atmospheric deposition and other sources. Plummer et al. (2006) found perchlorate concentrations ranging from 0.12 µg/L to 1.8 µg/L in samples of north-central NM groundwater that have ages predating anthropogenic influence and that are not affected by industrial perchlorate sources. At LANL, perchlorate concentrations in groundwater samples from Pueblo, Los Alamos, and Mortandad canyons are above background as a result of past effluent discharges (Figure 5-12). Otherwise perchlorate concentrations are near the values found by Plummer et al. (2006).

G. GROUNDWATER SAMPLING RESULTS BY WATERSHED

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that cross the Laboratory. The tables and discussions are grouped according to groundwater mode, proceeding from the regional aquifer to the alluvial groundwater. Contamination found in the regional aquifer results from effluents released in past decades, because of the time required for percolation to that depth. On the other hand, except for adsorbed or reactive contaminants such as barium or strontium-90, contaminants in alluvial groundwater reflect contamination that occurred during the past few years.

The accompanying tables and text mainly address contaminants found at levels near or above standards or screening levels. In the case of the regional aquifer, information regarding contaminants (such as nitrate, perchlorate, and tritium) found at trace levels but possibly indicating contamination by LANL activities is included. The discussion usually addresses radioactivity, general inorganic compounds (major anions, cations, and nutrients), metals, and then organic compounds for each groundwater zone. The accompanying plots and maps give a temporal and spatial context for most of the contaminants found near or above screening levels.

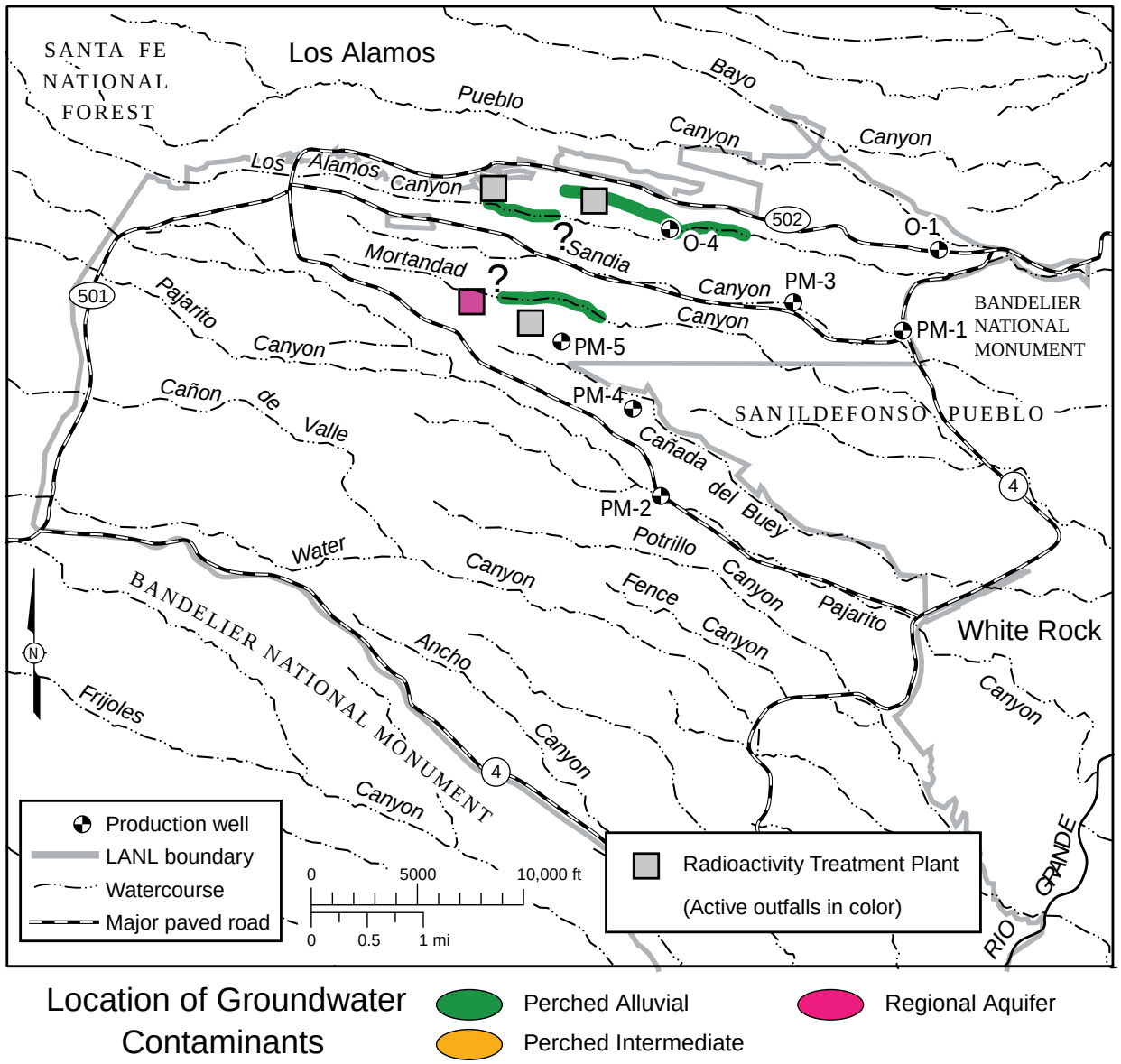


Figure 5-10. Location of groundwater contaminated by strontium-90 above the 8-pCi/L EPA MCL screening level (the MCL applies only to drinking water, not to alluvial groundwater). Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage. Along canyons, the extent of alluvial groundwater contamination lateral to the canyon is not to scale; contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.

1. Guaje Canyon (includes Rendija and Barrancas Canyons)

Guaje Canyon is a major tributary in the Los Alamos Canyon watershed that heads in the Sierra de los Valles and lies north of Laboratory land. The canyon has not received any effluents from LANL activities (Table 5-8). The Guaje well field, located northeast of the Laboratory, contains five drinking water supply wells. Naturally occurring arsenic has generally been found in this well field at levels above the EPA MCL of 10 µg/L since the field was developed in the early 1950s (Table 5-9). In 2008 all arsenic sample results were <5 µg/L. Rendija and Barrancas Canyons have seen, respectively, little and no past Laboratory activity, have only ephemeral surface water, and have no known alluvial or intermediate groundwater.

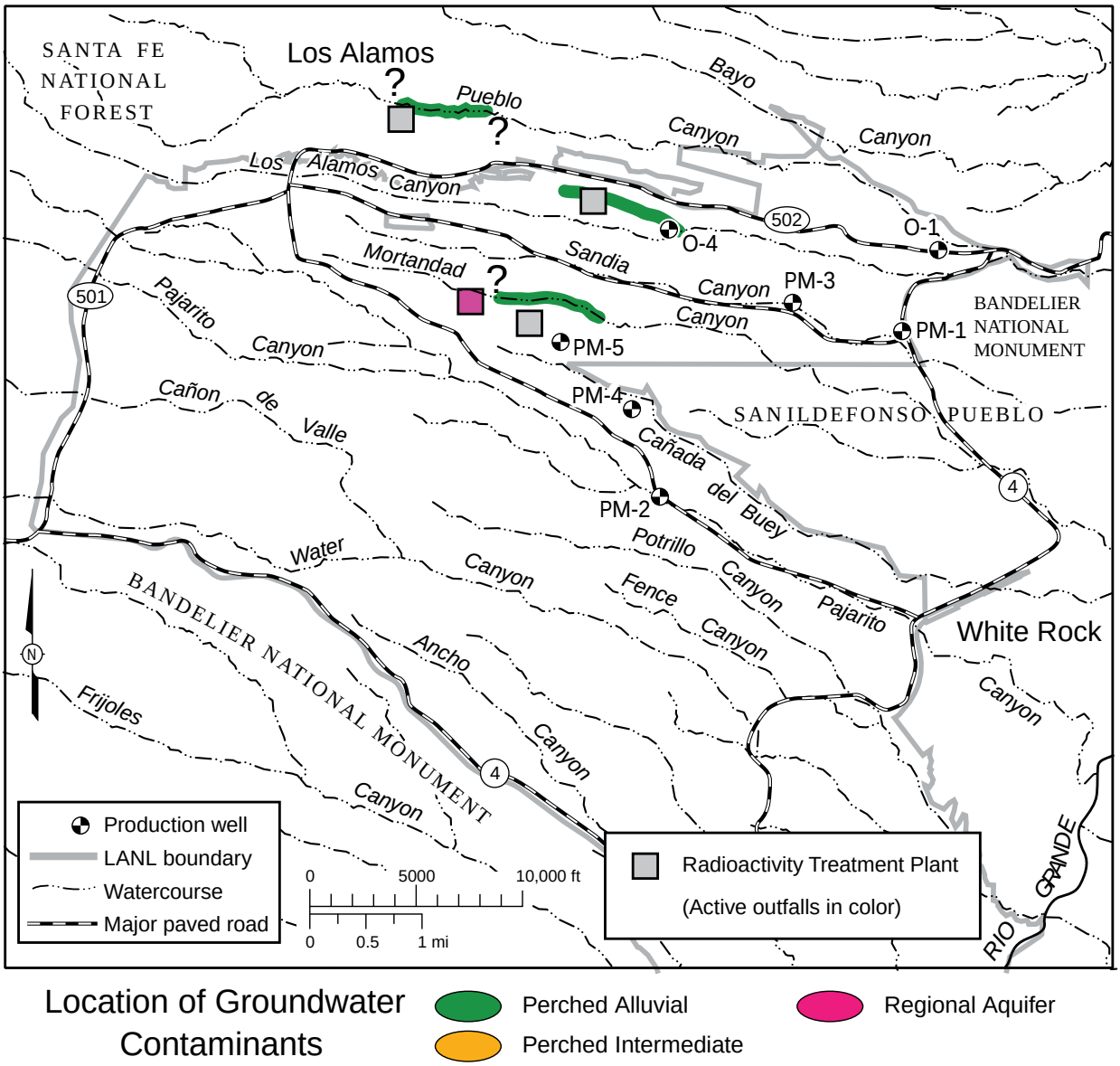


Figure 5-11. **Location of groundwater contaminated by radioactivity: areas indicated have the sum of radioactivity from a DOE source (that is, Sr-90, Pu-238, Pu-239/240, and Am-241) above the 4-mrem/yr DOE DCG screening level (the 4-mrem/yr DOE DCG applies only to drinking water, not to alluvial groundwater). Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

Table 5-8
Summary of Groundwater Contamination in Guaje Canyon
(includes Rendija and Barrancas Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Guaje, Rendija, and Barrancas Canyons	Minor dry sources	None, alluvial groundwater only in upper Guaje Canyon	No intermediate groundwater	Natural arsenic above EPA MCL

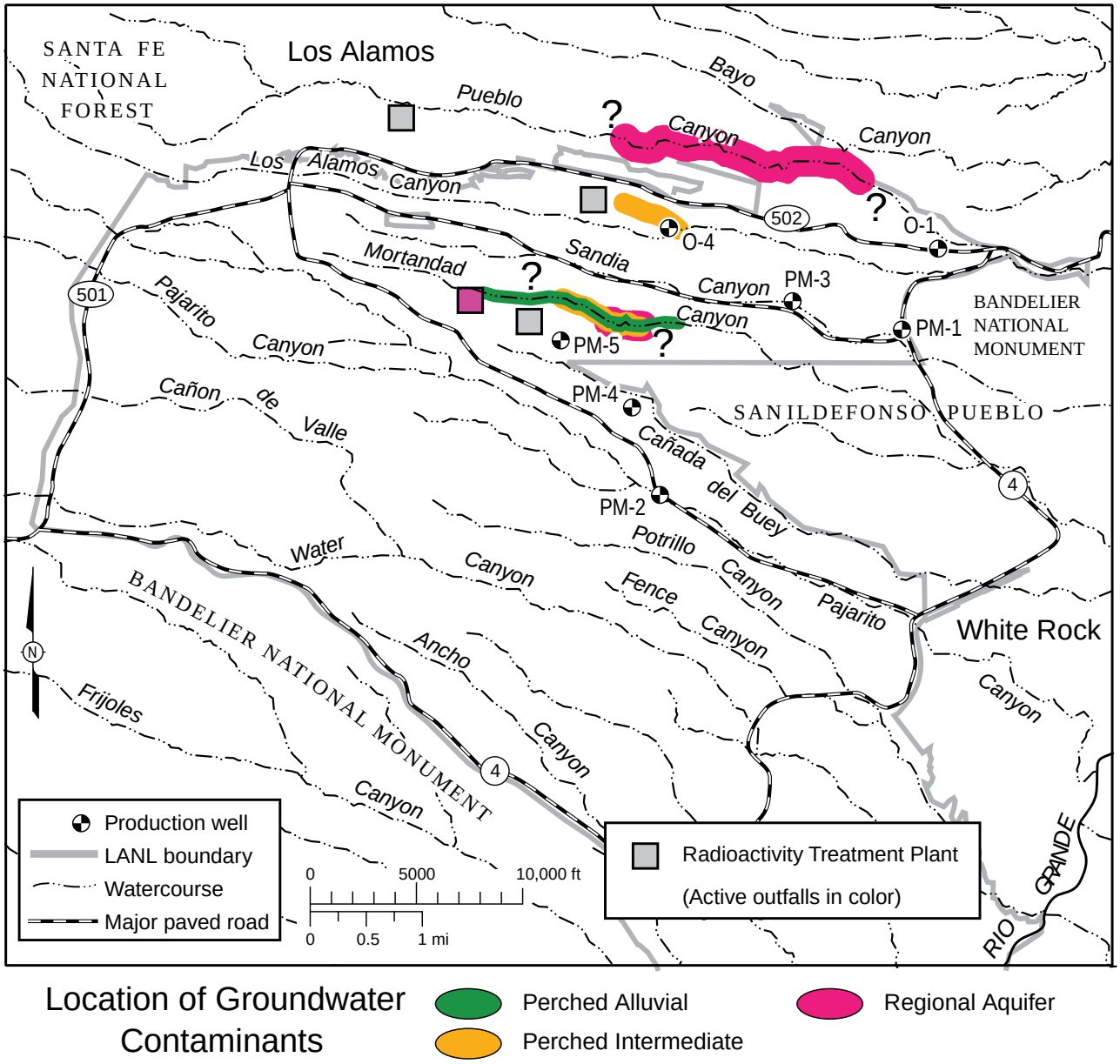


Figure 5-12. Location of groundwater contaminated by perchlorate; the concentrations in the areas indicated are above the 4 µg/L NM Consent Order screening level. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

2. Los Alamos Canyon (includes Bayo, Acid, Pueblo, and DP Canyons)

Bayo Canyon contains a now-decommissioned firing site. The canyon has only ephemeral surface water, and no known alluvial or intermediate groundwater (Table 5-10).

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at Technical Area (TA)-1 (1942–1945) and until 1993 from nuclear reactors at TA-2. From 1952 to 1986, a liquid-waste treatment plant discharged effluent containing radionuclides from the former plutonium-processing facility at TA-21 into DP Canyon, a tributary to Los Alamos Canyon. Los Alamos Canyon also received radionuclides and metals in discharges from the sanitary sewage lagoons and cooling towers at the Los Alamos Neutron Science Center (LANSCE) at TA-53. Except for strontium-90, contaminant concentrations in shallow groundwater have decreased dramatically in recent years.

Table 5-9
Groundwater Quality in Guaje Canyon
(includes Rendija and Barrancas Canyons)

Chemical	Location	Result	Trends
Arsenic	Regional aquifer water supply wells	<5 µg/L, below EPA MCL of 10 µg/L; NM groundwater standard is 100 µg/L	Sporadic values above EPA MCL for many years in this well field

Table 5-10
Summary of Groundwater Contamination in Los Alamos Canyon
(includes Bayo, Acid, Pueblo, and DP Canyons)

		Groundwater Contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Bayo Canyon	Minor past dry and liquid sources	No alluvial groundwater	No intermediate groundwater	None
Pueblo and Acid Canyons	Multiple past effluent discharges, current sanitary effluent	Plutonium-239/240 above 4 mrem/yr DCG screening level, nitrate at 80%, TDS at 55% and boron at 85% of NM groundwater standard, arsenic at 67% of EPA MCL screening level	Nitrate at 75% and fluoride at 70% of NM groundwater standard, perchlorate at 72% of Consent Order screening level	Perchlorate above Consent Order screening level, trace tritium, fluoride and nitrate
Los Alamos and DP Canyons	Multiple past effluent discharges	Strontium-90 above 4 mrem/yr DCG screening level, chloride at 78%, TDS at 62%, and fluoride at 50% of NM groundwater standards, trace molybdenum	Nitrate at 51% of NM groundwater standard perchlorate above Consent Order screening level, tritium at 20% of EPA MCL screening level	None
Lower Los Alamos Canyon	Multiple past effluent discharges	Nitrate above NM groundwater standard	Nitrate above NM groundwater standard, fluoride at 55% of NM groundwater standard	None

a. Pueblo Canyon

The levels of tritium, perchlorate, and nitrate for supply well O-1, though below standards or screening levels, indicate the presence of past effluent and surface water recharge in the regional aquifer (Table 5-11). Because of the perchlorate concentrations, Los Alamos County does not use the well for water supply, although the concentrations are below the EPA interim health advisory for perchlorate in drinking water of 15 µg/L.

Only one Pueblo Canyon regional aquifer monitoring well, R-4, located downstream from the former Acid Canyon outfall, shows perchlorate or low-detection-limit tritium values indicative of past discharges. Perchlorate concentrations in R-4 are above the NMED screening level of 4 µg/L (Figure 5-12). The tritium values range up to 60 pCi/L. Two regional aquifer wells (R-4 and R-5) show fluoride values higher than those in unaffected wells, but the results are below the NM groundwater standard (Figure 5-13).

Intermediate groundwater also shows the effects of past effluent releases, with concentrations near standards of perchlorate, fluoride, and nitrate (Figures 5-12, 5-14, and 5-15). The nitrate concentration in intermediate well POI-4 has nearly doubled over 11 years of sampling (Figure 5-16). An intermediate port in regional aquifer well R-5 shows fluoride values higher than that in unaffected wells, but the results are below the NM groundwater standard (Figure 5-13). The uranium concentrations in samples from Pueblo Canyon intermediate well R-3i ranged from 9.2 µg/L to 10.2 µg/L, above levels in unaffected wells but below the standard. The higher uranium may result from dissolution of uranium from surrounding bedrock by sanitary effluent (Teerlink 2007).

Table 5-11
Groundwater Quality in Pueblo Canyon (includes Acid Canyon)

Chemical	Location	Result	Trends
Tritium	Water supply well O-1	32 pCi/L, below EPA MCL of 20,000 pCi/L	Variable between 14 pCi/L and 58 pCi/L since 2000
Tritium	Regional aquifer monitoring well R-4	59 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Results higher than unaffected wells, fairly steady for four years of sampling
Perchlorate	Water supply well O-1	1.7 µg/L to 2.4 µg/L, below NMED screening level of 4 µg/L	Variable between 1.2 µg/L and 3 µg/L since 2001
Perchlorate	Regional aquifer monitoring well R-4	4.5 µg/L to 5.2 µg/L, above NMED screening level of 4 µg/L	Results higher than unaffected wells, vary by factor of two during four years of sampling
Fluoride	Regional aquifer monitoring wells R-4 and R-5	0.68 mg/L to 0.77 mg/L, below NM groundwater standard of 1.6 mg/L	Results higher than unaffected wells, fairly steady for four to five years of sampling
Nitrate (as Nitrogen [N])	Regional aquifer monitoring wells R-4 and R-5	2.0 mg/L to 2.8 mg/L, below NM groundwater standard of 10 mg/L	Results higher than unaffected wells, fairly steady for four to five years of sampling
Uranium	Intermediate monitoring well R-3i	9.2 µg/L to 10.2 µg/L, below NM groundwater standard of 30 µg/L	May be leached from bedrock by percolation of sanitary effluent; steady over two years of sampling
Fluoride	Intermediate monitoring well R-5 at 384 ft	1.1 mg/L, below NM groundwater standard of 1.6 mg/L	Results fairly steady for five years of sampling
Nitrate (as N)	Intermediate monitoring wells POI-4, R-3i	4.4 mg/L to 7.6 mg/L, below NM groundwater standard of 10 mg/L	POI-4 concentrations nearly doubled over 12 years of sampling
Nitrate (as N)	Alluvial monitoring wells APCO-1, PAO-5s	5.3 mg/L to 8.1 mg/L, below NM groundwater standard of 10 mg/L	Only result for PAO-5s; other alluvial well results for 2008 below 0.4 mg/L; APCO-1 samples above standard in 1995, 2004
Total Dissolved Solids (TDS)	Alluvial monitoring well PAO-5s	553 mg/L, below NM groundwater standard of 1,000 mg/L	Only result for well; other alluvial well results for 2008 between 215 mg/L and 420 mg/L
Turbidity	Alluvial monitoring wells PAO-1, PAO-2, PAO-4	14.8 Nephelometric Turbidity Units (NTU), 39.1 NTU, and 2.4 NTU, respectively	PAO-1, PAO-2 results higher than flood-affected 2006 results of 10.7 NTU and 32.2 NTU, respectively
Boron	Alluvial monitoring wells APCO-1, PAO-4, PAO-5s	274 µg/L to 638 µg/L, below NM groundwater standard of 750 µg/L	Only result for PAO-5s; prior results in other wells often above 400 µg/L
Arsenic	Alluvial monitoring well PAO-5s	6.7 µg/L, below EPA MCL screening level of 10 µg/L and NM groundwater standard of 100 µg/L	Only result for well; nearby alluvial well results for 2008 of 2.9 µg/L to 4.6 µg/L with similar or higher values for 10 years, may be naturally occurring
Plutonium-239/240	Alluvial monitoring wells PAO-2, PAO-4	Unfiltered results of 0.42 to 1.66 pCi/L, above 4 mrem/yr DCG screening level of 1.2 pCi/L	Above earlier values for 8 and 11 years of samples, in PAO-2 above flood-affected 2006 results of 1.2 pCi/L

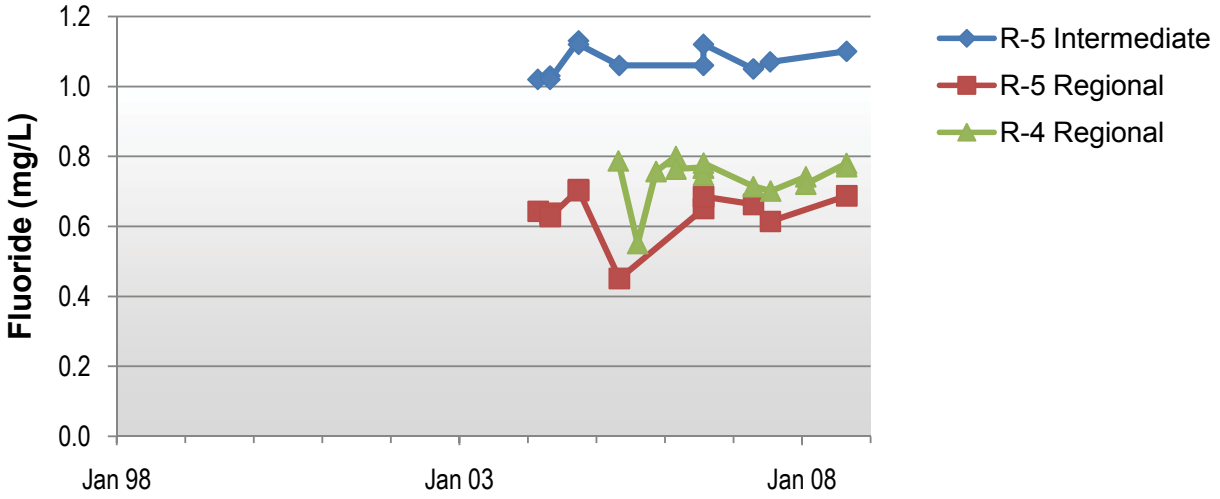


Figure 5-13. **Fluoride in Pueblo Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 1.6 mg/L.**

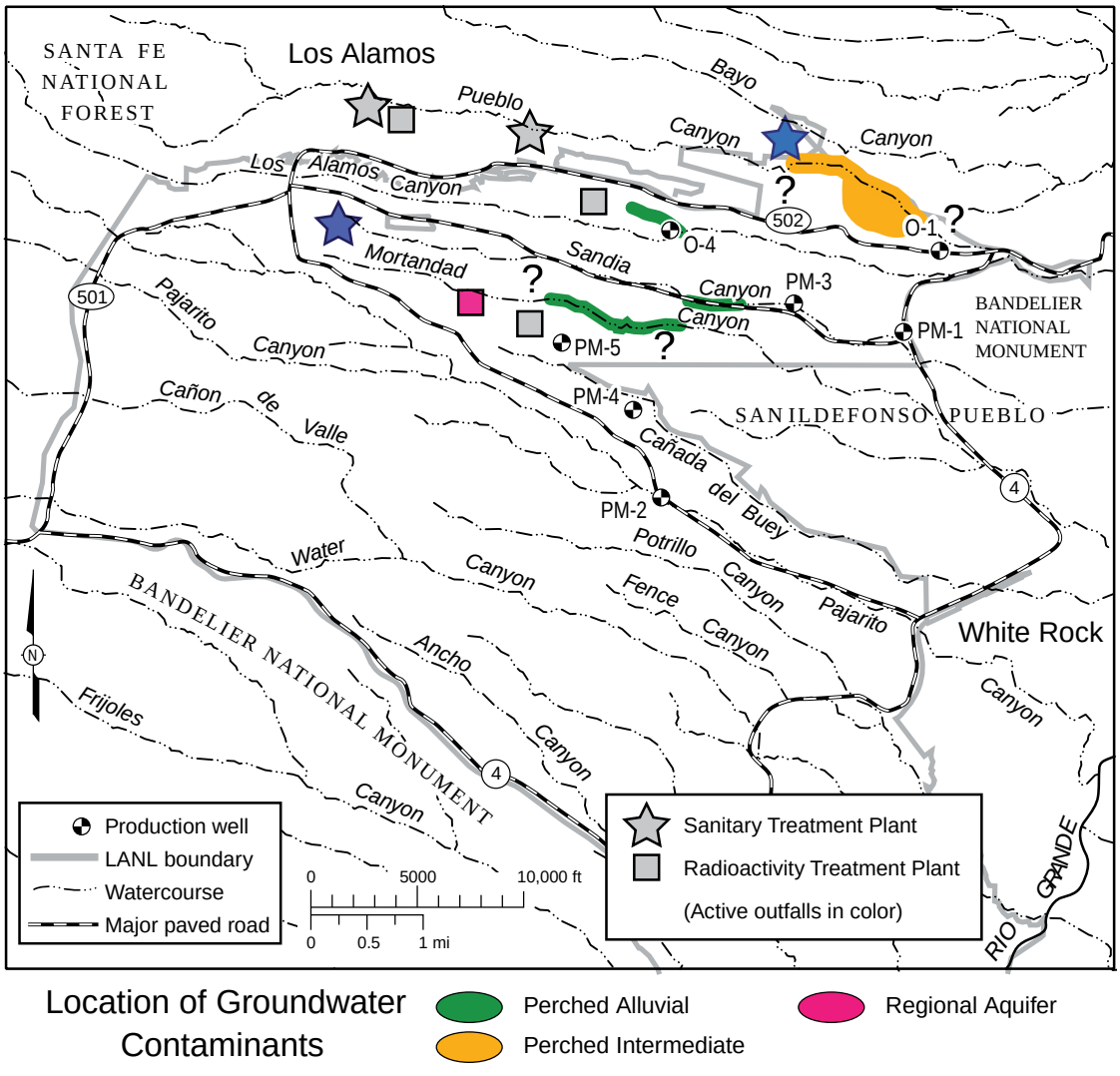


Figure 5-14. **Location of groundwater containing fluoride above one half of the 1.6-mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.**

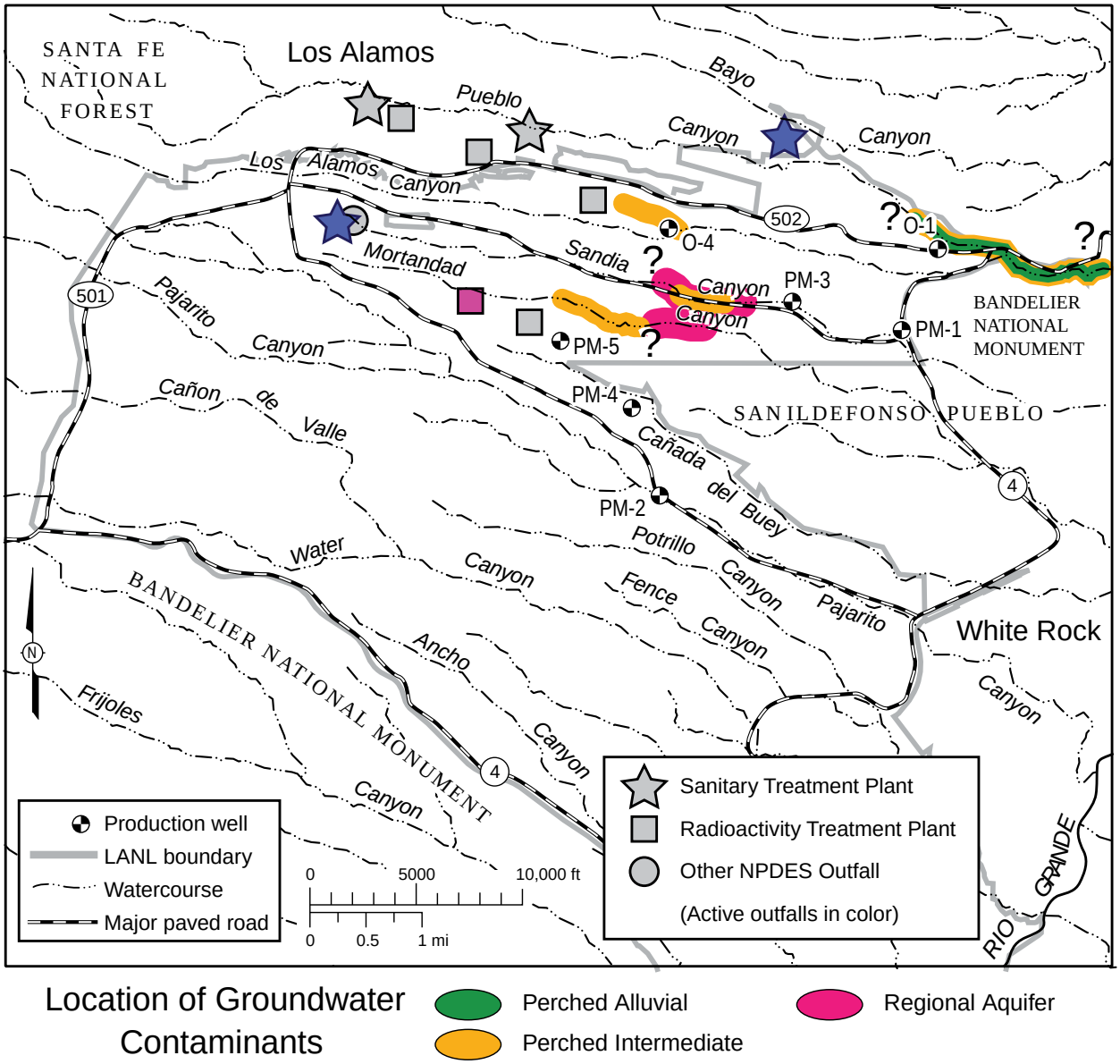


Figure 5-15. Location of groundwater containing nitrate (as nitrogen) above one half of the 10 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

The 2008 unfiltered plutonium-239/240 results in alluvial wells PAO-2 and PAO-4 were the highest yet measured (Figure 5-17). Prior to 2006, plutonium-239/240 results in these wells and at nearby well APCO-1 were lower. On several days in August 2006 large rainstorms caused significant runoff in Pueblo Canyon. All of the alluvial wells were flooded and one was washed away. Several wells were sampled immediately after flooding. The samples from PAO-2 and APCO-1 showed unusually high turbidity and unfiltered plutonium-239/240 results. The 2006 unfiltered plutonium-239/240 activities were near or above the 4-mrem/yr DOE DCG screening level of 1.2 pCi/L. Turbidity measured in 2007 had returned to usual ranges; 2007 plutonium-239/240 results were much lower, but were still above results measured before 2006 flooding. In 2008, turbidity and plutonium-239/240 results in PAO-2 were again high, similar to 2006 results.

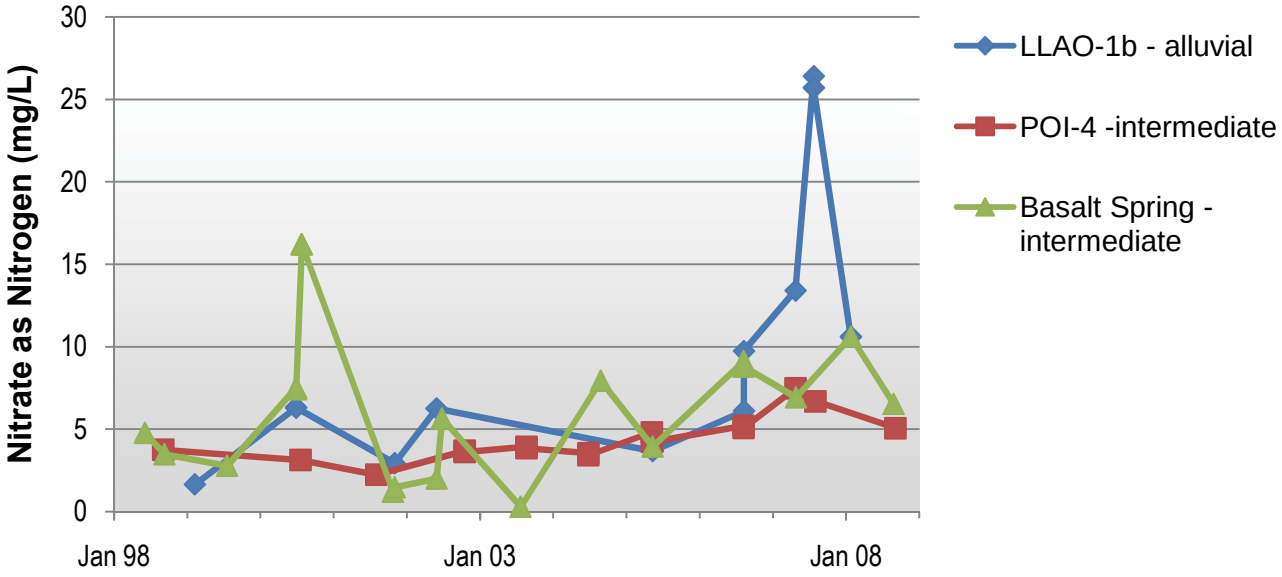


Figure 5-16. Nitrate (as nitrogen) in Pueblo and lower Los Alamos Canyon alluvial and intermediate groundwater. The NM groundwater standard is 10 mg/L.

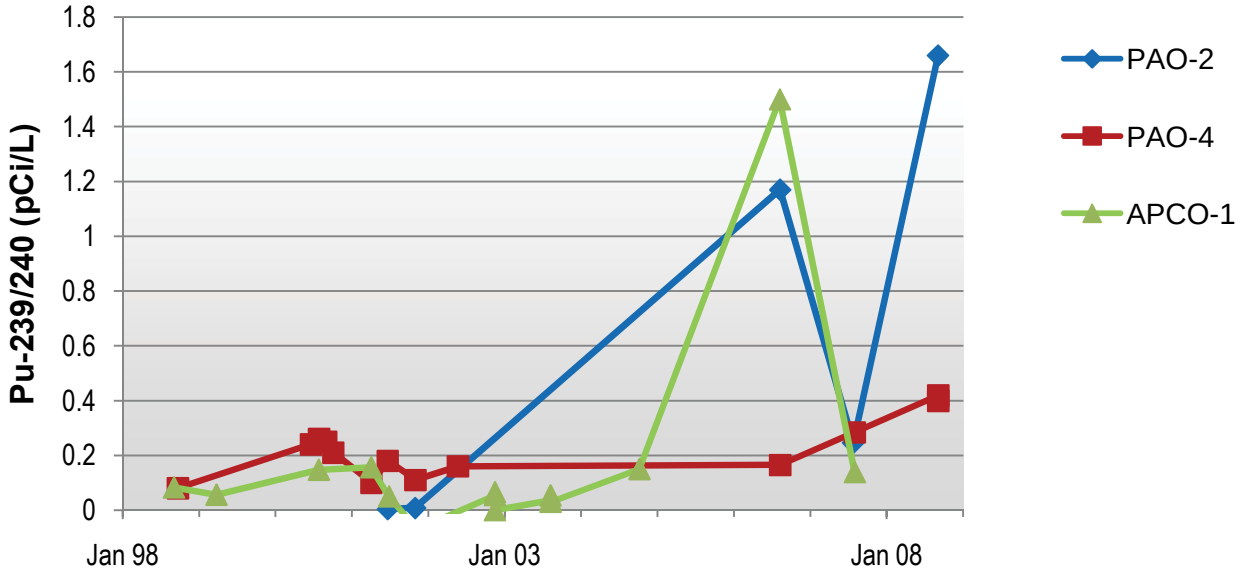


Figure 5-17. Total plutonium-239/240 activity in Pueblo Canyon alluvial groundwater. The 4 mrem/yr DOE DCG screening level is 1.2 pCi/L. Variation in turbidity (not shown) coincides with variation in total plutonium.

Prior to 2007, samples at many locations were often taken annually. More frequent samples taken over the past two years at Pueblo Canyon surface water and alluvial groundwater locations suggest that runoff from road salting increases chloride concentrations in mid-winter and early spring (Figures 5-18, 5-19, and 5-20). The locations of surface water monitoring stations are shown in Chapter 6. The sodium and TDS concentrations (not shown) show a similar trend, supporting the conclusion that salt is the chloride source. While the samples are infrequent, results suggest that a mid-winter or spring rise in chloride concentration (such as at surface water location Acid above Pueblo in April 2007) is mirrored by a rise in concentration in alluvial groundwater at downstream locations (such as at PAO-2 the same month). The chloride concentration at surface water (Pueblo 3) and groundwater (PAO-4) locations farther downstream show less variation, perhaps due to mixing with other runoff. The highest groundwater chloride concentration in 2008 was 111 mg/L in PAO-1, at 44% of the 250 mg/L NM groundwater standard.

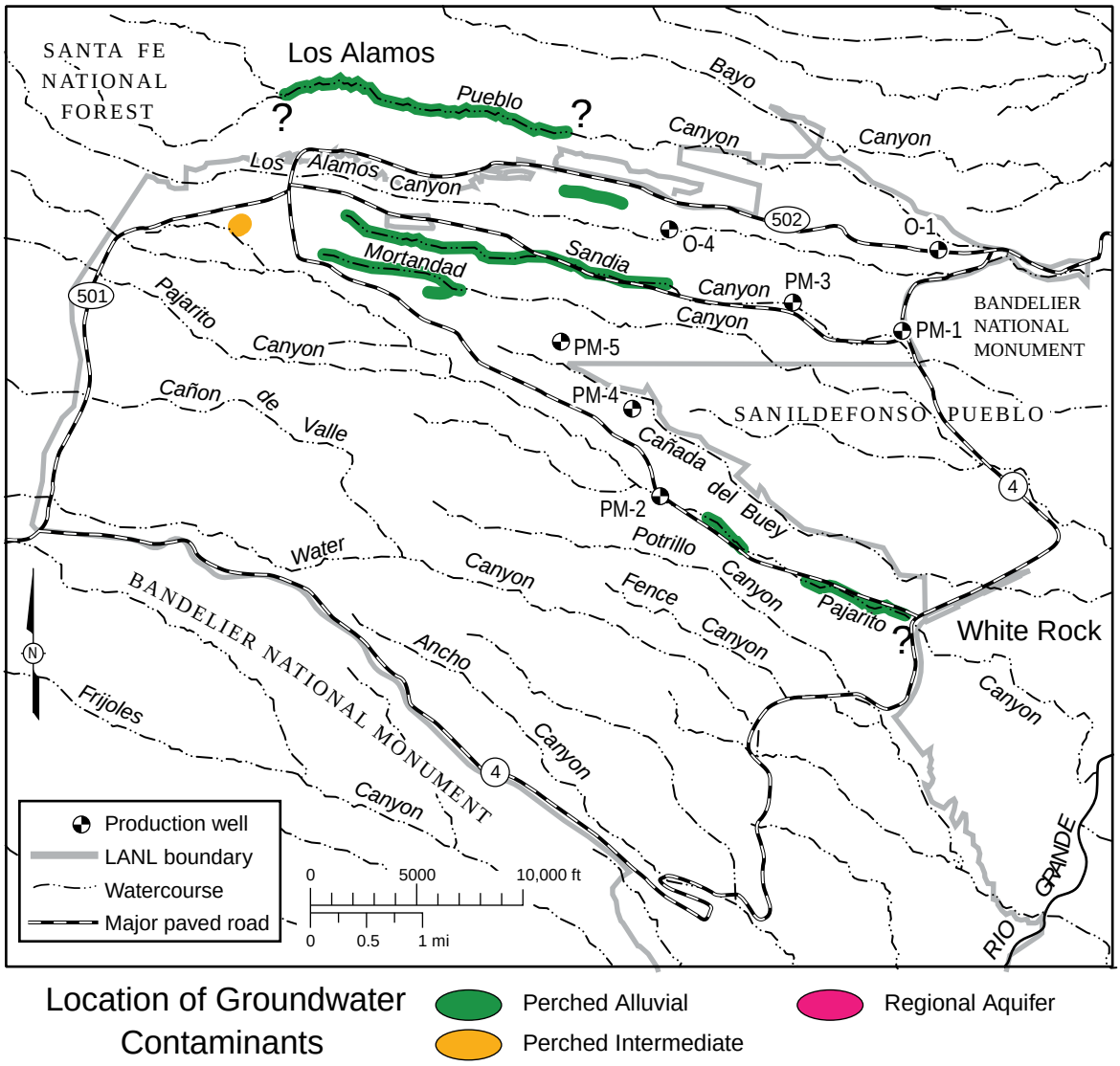


Figure 5-18. Location of groundwater containing chloride above one half of the 250 mg/L NM groundwater standard. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

b. Los Alamos Canyon

Alluvial and intermediate groundwater in Los Alamos Canyon show effects of past effluent releases (Table 5-12).

Samples from intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 contained up to 3,800 pCi/L of tritium (Figure 5-21). These moderate values indicate a residual impact of past effluent discharges; the wells lie downstream from the former radioactive liquid waste discharge from TA-21 in DP Canyon. Nitrate (as nitrogen) concentrations in these wells have increased over the period of sampling (Figure 5-22) but are below the 10 mg/L NM groundwater standard. The perchlorate concentrations in these wells ranged up to 7.5 µg/L, above the NMED screening level of 4 µg/L (Figure 5-12, Figure 5-23).

Alluvial groundwater in DP and Los Alamos Canyons continues to show high activities of strontium-90; the values range up to and above the 8 pCi/L EPA MCL screening level (Figures 5-10 and 5-24). Fluoride is also present in samples as a result of past effluent release but at concentrations below the NM groundwater standard of 1.6 mg/L (Figure 5-25).

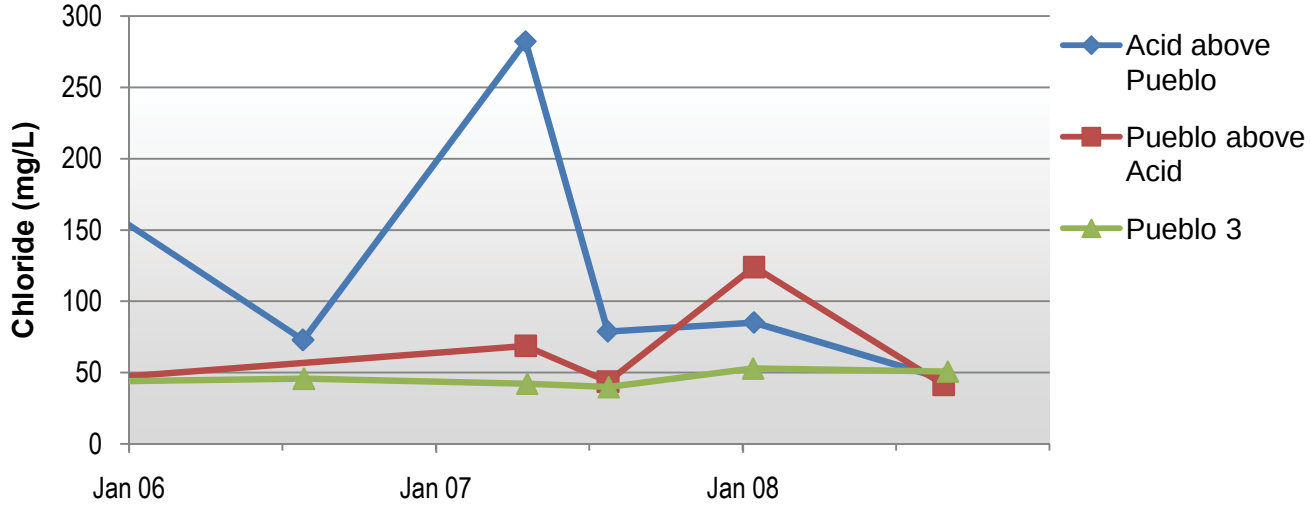


Figure 5-19. Chloride in Pueblo Canyon surface water. The NM groundwater standard is 250 mg/L.

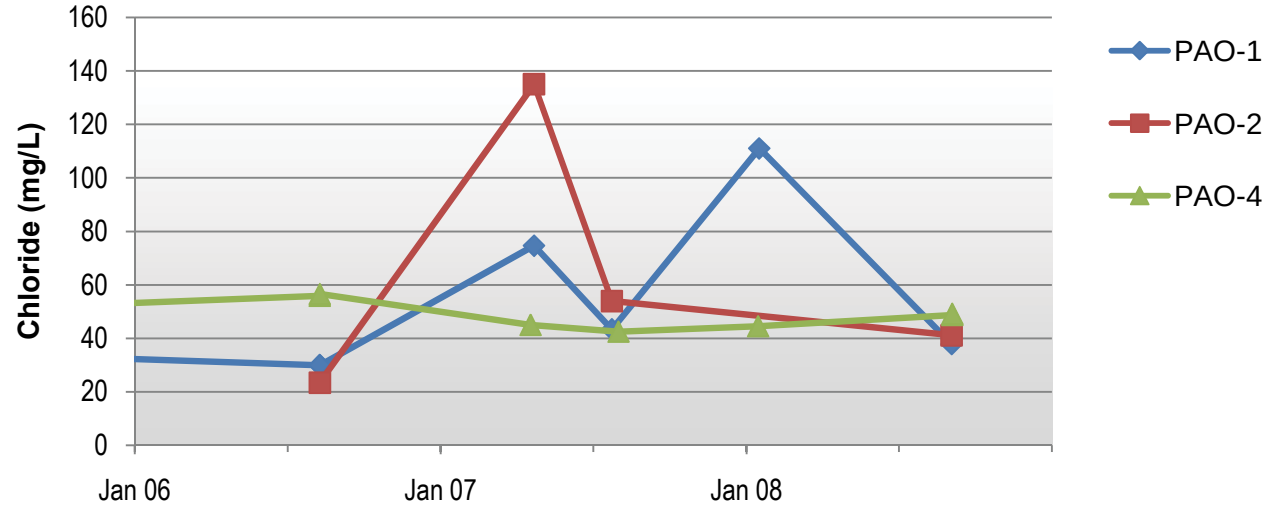


Figure 5-20. Chloride in Pueblo Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

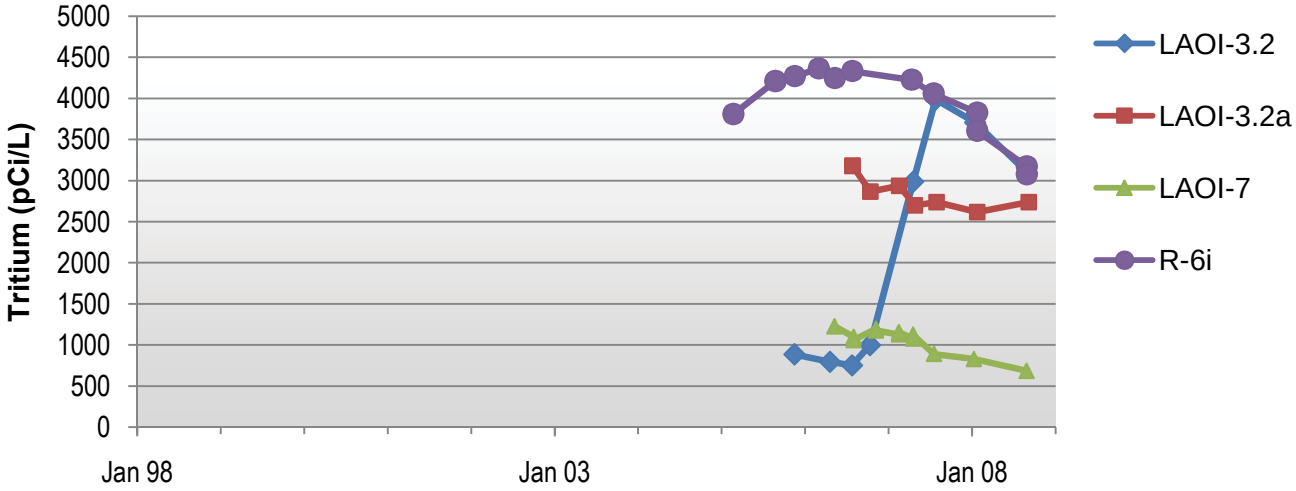


Figure 5-21. Tritium in Los Alamos Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level is 20,000 pCi/L.

Table 5-12
Groundwater Quality in Los Alamos Canyon (includes DP Canyon)

Chemical	Location	Result	Trends
Tritium	Four intermediate wells	690 pCi/L to 3800 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Highest activities in R-6i, LAOI-3.2, LAOI-3.2a; increased in LAOI-3.2, now similar to R-6i
Nitrate (as N)	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a	2.2 mg/L to 5.1 mg/L, below NM groundwater standard of 10 mg/L	Increased in LAOI-3.2, now similar to R-6i
Perchlorate	Intermediate wells R-6i, LAOI-3.2, LAOI-3.2a	3.3 µg/L to 7.5 µg/L, above Consent Order screening level of 4 µg/L	Increased in LAOI-3.2, now similar to R-6i
Strontium-90	One alluvial spring and four alluvial wells	8 pCi/L to 66 pCi/L, above 8 pCi/L EPA MCL screening level and 40 pCi/L 4-mrem/yr DOE DCG screening level	Decreased since cessation of discharges in 1986, remains high due to retention on sediments
Fluoride	One alluvial spring and three alluvial wells	0.52 to 0.84 mg/L, below NM groundwater standard of 1.6 mg/L	Some fluctuation but similar concentrations at each location for 10 years
Chloride	Alluvial well LAUZ-1	111 mg/L to 195 mg/L, below NM groundwater standard of 250 mg/L	Similar but variable results over 10 years of monitoring, above standard twice
Molybdenum	Alluvial wells LAO-2, LAO-3a	177 µg/L to 235 µg/L, below NM groundwater standard of 1,000 µg/L	Last above standard in 2004; concentrations decreasing due to outfall improvement
Nitrate (as N)	Intermediate Basalt Spring (Pueblo de San Ildefonso)	6.5 mg/L to 10.6 mg/L, above NM groundwater standard of 10 mg/L	Apparent result of discharge from Bayo Sanitary Treatment Plant (STP)
Nitrate (as N)	Alluvial well LLAO-1b (Pueblo de San Ildefonso)	10.6 mg/L, above NM groundwater standard of 10 mg/L	Large increase in last three years; apparent result of discharge from Bayo STP

Basalt Spring, which is fed by intermediate groundwater, is in lower Los Alamos Canyon on Pueblo de San Ildefonso land. Alluvial well LLAO-1b is located nearby. The nitrate (as nitrogen) results from samples at both locations were above the NM groundwater standard of 10 mg/L (Figures 5-15 and 5-16). The source of nitrate may be releases into Pueblo Canyon from the present and former Los Alamos County sanitary treatment plants.

In Los Alamos Canyon, molybdenum in LAO-2 and LAO-3a has dropped to 30% of the NM groundwater standard, which is for irrigation use. The molybdenum came from cooling towers at TA-53 (LANSCE). Use of sodium molybdate was discontinued in June 2002. Molybdenum concentrations in Los Alamos Canyon alluvial groundwater have been quite variable in recent years.

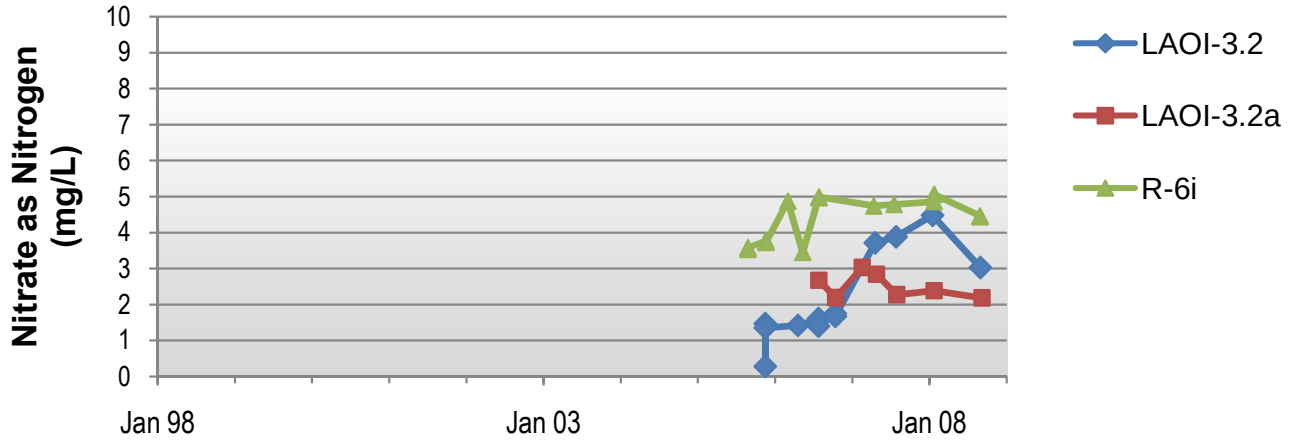


Figure 5-22. Nitrate (as nitrogen) in Los Alamos Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L.

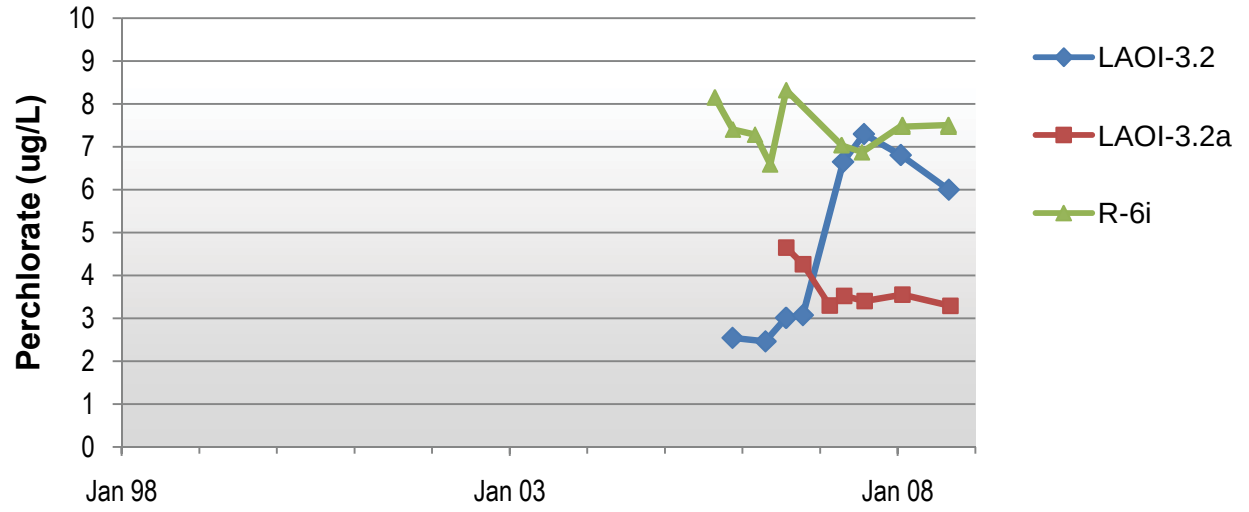


Figure 5-23. **Perchlorate in Los Alamos Canyon intermediate groundwater. The Consent Order screening level is 4 µg/L.**

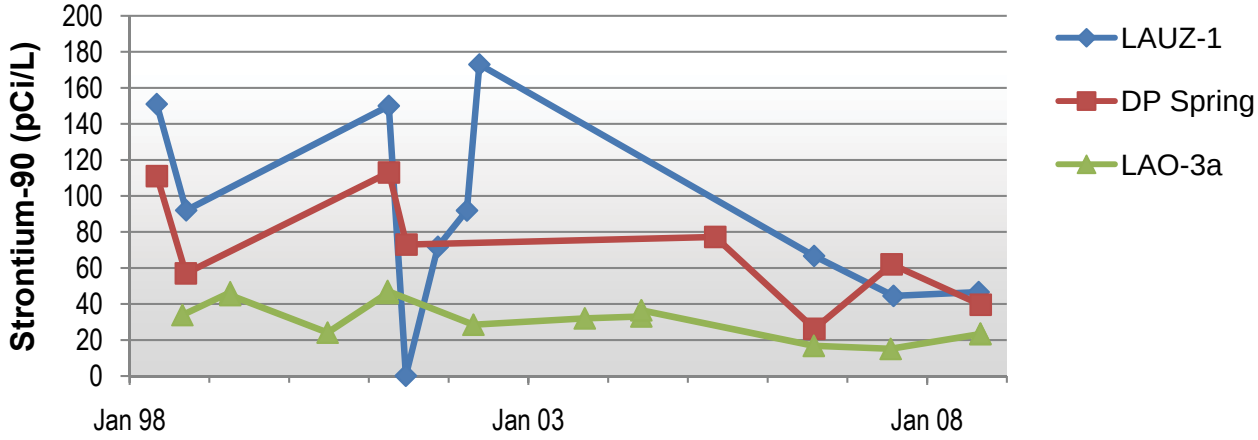


Figure 5-24. **Strontium-90 in Los Alamos Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level is 8 pCi/L.**

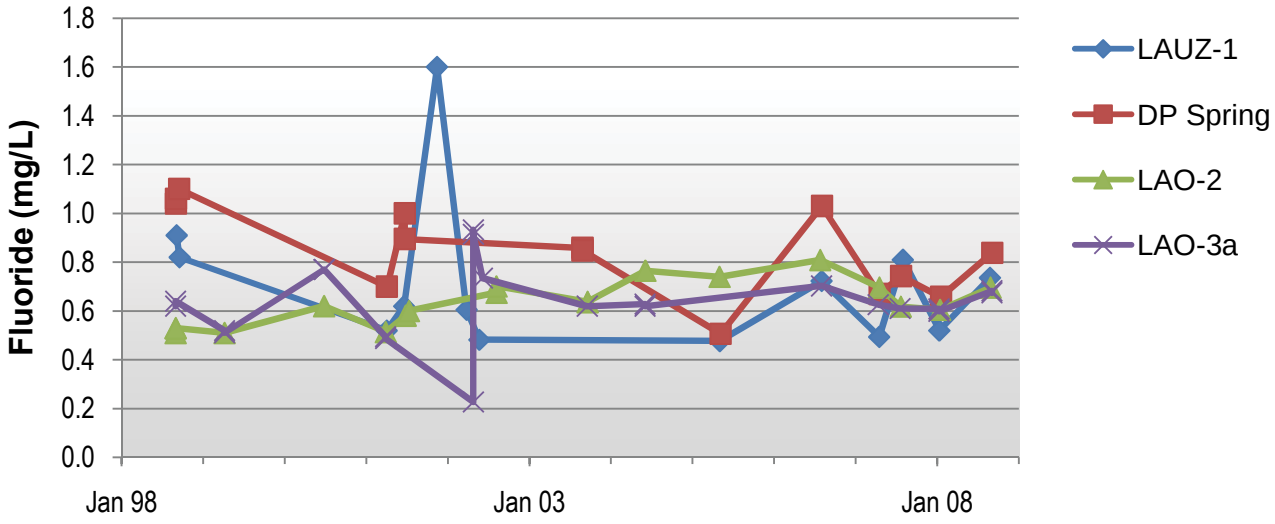


Figure 5-25. **Fluoride in Los Alamos Canyon alluvial groundwater. The NM groundwater standard is 1.6 mg/L.**

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives the largest liquid discharges of any canyon at the Laboratory from the cooling tower at the TA-3 power plant (Table 5-13). Treated effluents from the TA-46 SWWS Plant have been routed to Sandia Canyon since 1992. Chromate was used to treat cooling water at the power plant until 1972 (ESP 1973). These earlier discharges are identified as the source for hexavalent chromium concentrations discovered in intermediate groundwater and the regional aquifer beneath Sandia and Mortandad Canyons that are above the 50 µg/L NM groundwater standard (Figure 5-26). This standard applies to dissolved chromium (regardless of the chemical form). Sandia and Mortandad Canyons lie close together, and water percolating downward beneath Sandia Canyon may have been diverted to the south by southwesterly dipping basalts prior to reaching the regional aquifer (ERSP 2006, LANL 2008e).

Table 5-13
Summary of Groundwater Contamination in Sandia Canyon

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Sandia Canyon	Multiple liquid discharges	Chloride above, fluoride at 58%, and TDS at 75% of NM groundwater standard; chromium, lead and arsenic above EPA MCL screening level	Chromium above, TDS at 51%, and nitrate at 51% of NM groundwater standard	Chromium at 46% and nitrate at 60% of NM groundwater standard

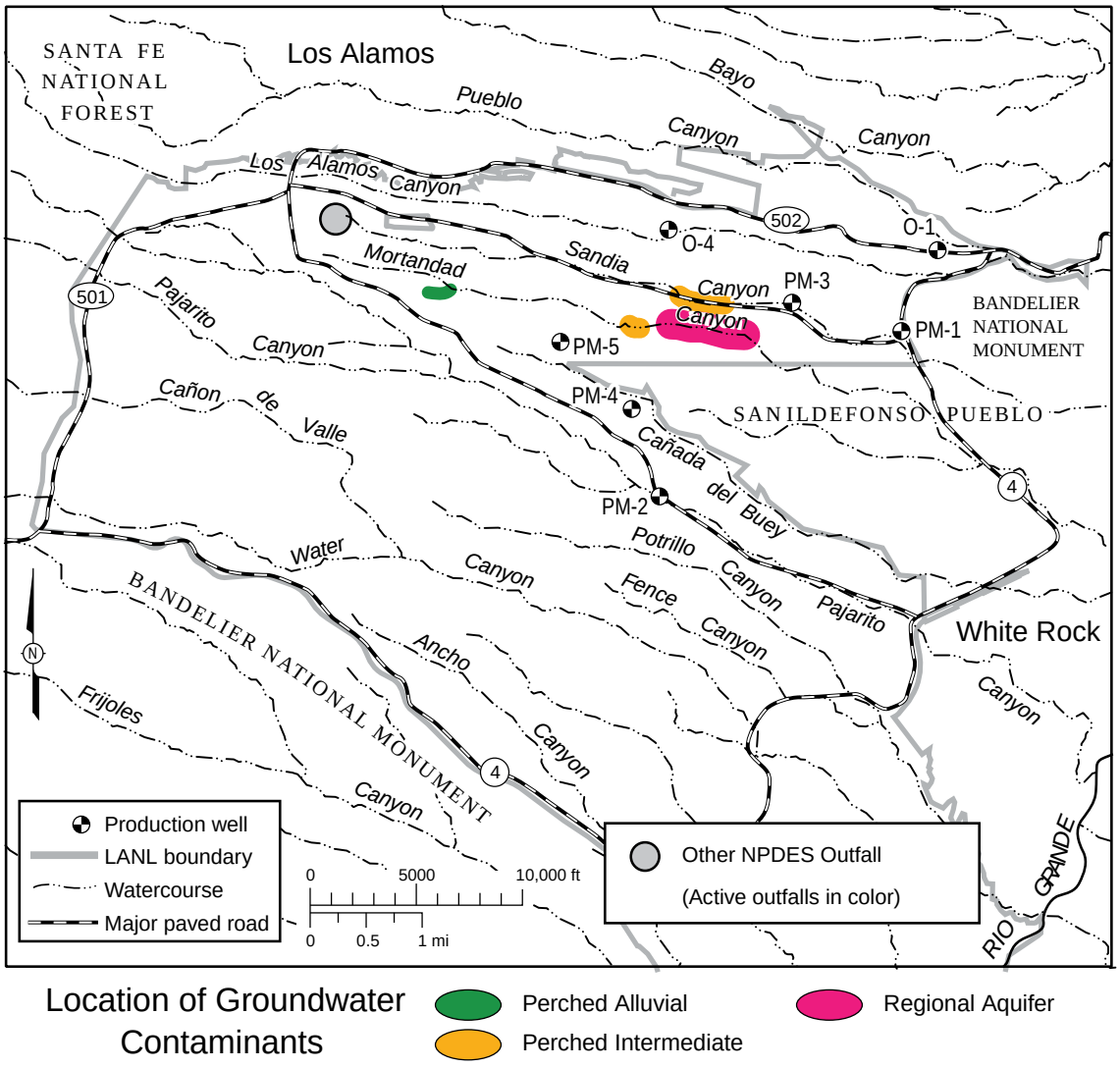


Figure 5-26. Location of groundwater containing dissolved or hexavalent chromium above one half of the 50 µg/L NM groundwater standard. Different colors indicate the affected groundwater zones.

In 2008, chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon were 23 µg/L or 46% of the groundwater standard (Table 5-14, Figure 5-27); other analyses show the chromium is in the hexavalent form. Nitrate (as nitrogen) in R-11 and regional aquifer well R-43 were up to 60% of the NM groundwater standard, apparently due to past Laboratory sanitary effluent releases (Figure 5-15, Figure 5-28).

Newly sampled intermediate well SCI-2 had chromium 11.2 times the NM groundwater standards (Table 5-14, Figure 5-27). The nitrate concentration in this well was 51% of the NM groundwater standard (Figure 5-15, Figure 5-28). SCI-1 had total dissolved solids (TDS) up to 51% of the NM groundwater standard.

Two new alluvial wells, SCA-1 and SCA-2, had results for chloride and TDS that approached or exceeded NM groundwater standards. Data from these new wells and more frequent data from adjacent surface water monitoring locations indicate seasonal variation in chloride concentrations, with highest values in winter (Figure 5-18, Figures 5-29 and 5-30). The locations of surface water monitoring stations are shown in Chapter 6. The surface water locations show peaks in chloride concentrations in early winter, evidently the result of road salting. Similar trends occur in sodium concentrations and TDS (not shown). Although alluvial groundwater data are less frequent, they support the pattern of high concentrations of chloride, sodium, and TDS in winter. The highest chloride concentration is seen at the farthest upstream surface water location, South Fork of Sandia Canyon at E122. At SCA-4, the well located farthest downstream, the chloride concentration peaks appear to be delayed and have lower amplitude.

Table 5-14
Groundwater Quality in Sandia Canyon

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring well R-11	15.6 µg/L to 23 µg/L, below NM groundwater standard of 50 µg/L	Rose to 35 µg/L over three years of sampling, now decreasing
Nitrate (as N)	Regional aquifer monitoring wells R-11, R-43	5.0 mg/L to 6.0 mg/L, below NM groundwater standard of 10 mg/L	Results in R-11 have nearly doubled over three years of sampling
Nitrate (as N)	Intermediate well SCI-2	4.7 mg/L to 5.1 mg/L, below NM groundwater standard of 10 mg/L	New well
TDS	Intermediate well SCI-1	483 mg/L to 512 mg/L, below NM groundwater standard of 1,000 mg/L	First sampled in 2007, values fairly steady
Chromium	Intermediate well SCI-2	560 µg/L, above NM groundwater standard of 50 µg/L	New well
Chloride	Alluvial well SCA-2	41 mg/L to 266 mg/L, above NM groundwater standard of 250 mg/L	Variable results over two years, high in winter/spring and low in summer/fall
TDS	Alluvial wells SCA-1 and SCA-2	295 mg/L to 750 mg/L, below NM groundwater standard of 1,000 mg/L	In SCA-1, steady for three years, in SCA-2 high in winter/spring and low in summer/fall
Fluoride	Alluvial well SCA-4	0.54 mg/L to 0.93 mg/L, below NM groundwater standard of 1.6 mg/L	High but variable for two years
Chromium	Alluvial wells SCA-2 and SCA-4	Unfiltered concentrations of 222 µg/L and 95 µg/L, above EPA MCL screening level of 100 µg/L	Variable results at each location; higher results related to higher turbidity
Arsenic	Alluvial well SCA-4	Filtered/unfiltered results of 3 µg/L to 12 µg/L, above EPA MCL screening level of 10 µg/L, below NM groundwater standard of 100 µg/L	Variable over two years, may be naturally occurring
Lead	Alluvial wells SCA-2 and SCA-4	Unfiltered concentrations of 17 µg/L and 14 µg/L, above EPA drinking water system screening level of 15 µg/L, below NM groundwater standard of 50 µg/L	Variable results at each location; higher results related to higher turbidity

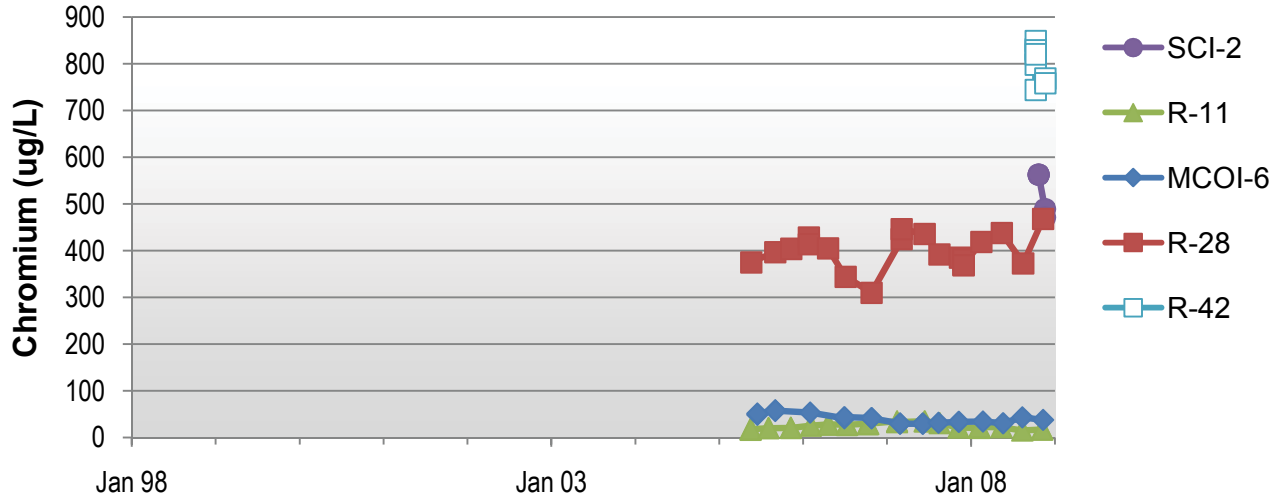


Figure 5-27. Filtered chromium in Sandia and Mortandad Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 50 µg/L.

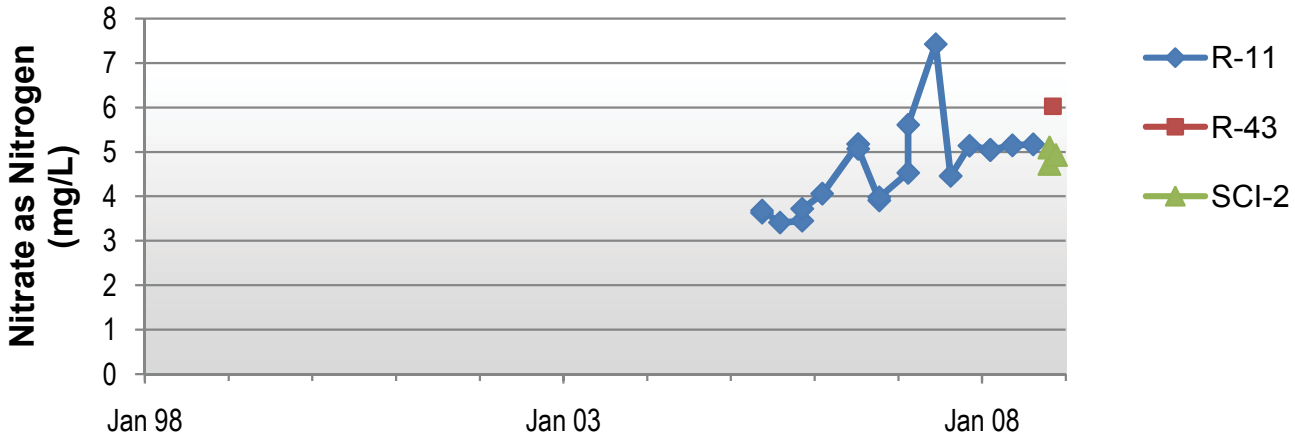


Figure 5-28. Nitrate (as nitrogen) in Sandia Canyon intermediate and regional aquifer groundwater. The NM groundwater standard is 10 mg/L.

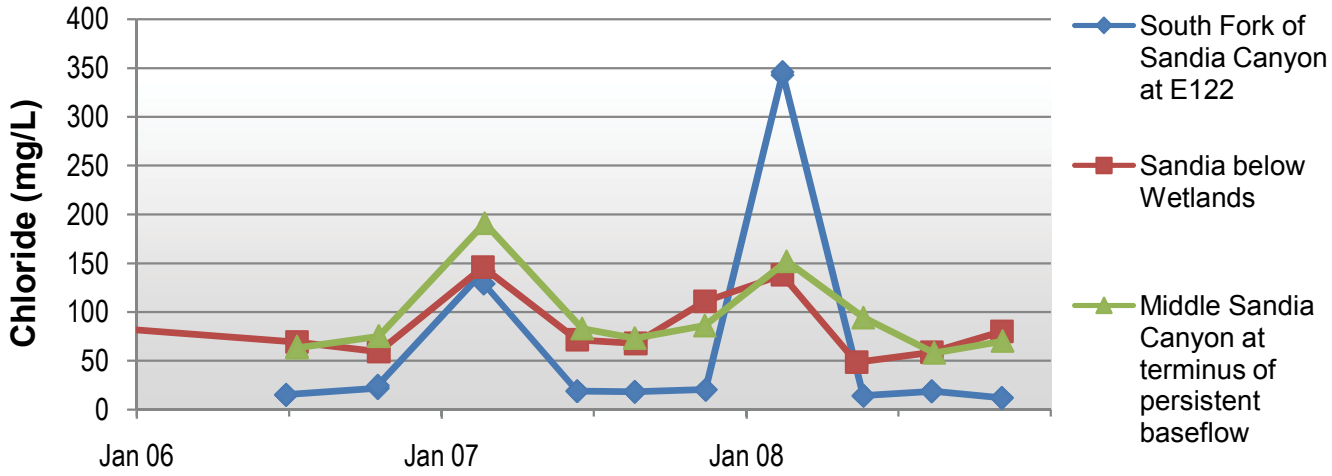


Figure 5-29. Chloride in Sandia Canyon surface water. The NM groundwater standard is 250 mg/L.

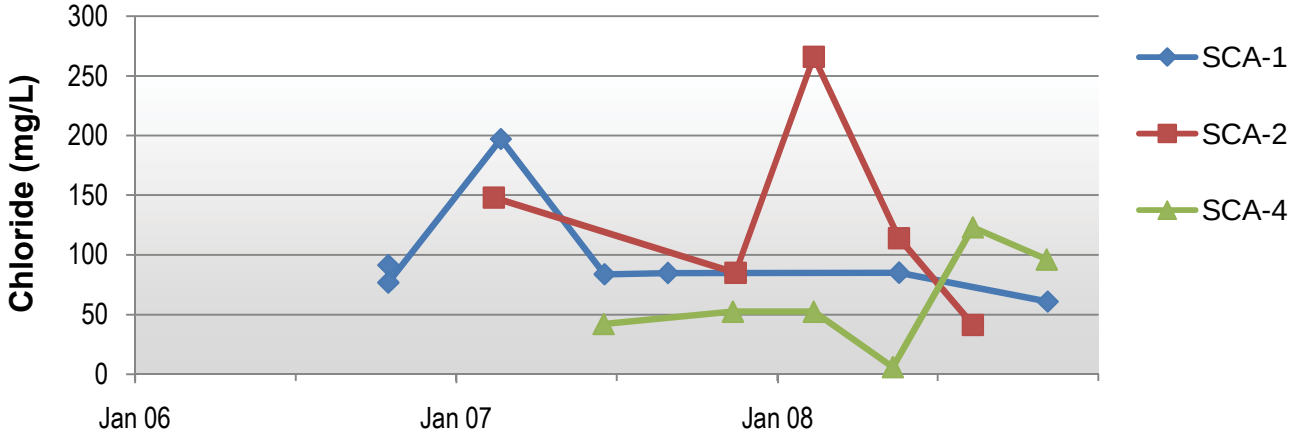


Figure 5-30. Chloride in Sandia Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

4. Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Mortandad Canyon has a small drainage area that heads at TA-3. This drainage area receives inflow from natural precipitation and a number of National Pollutant Discharge Elimination System (NPDES) outfalls, including one from the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50 (Table 5-15). Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35. These discharges have affected groundwater quality in the canyons (Table 5-16).

Table 5-15
Summary of Groundwater Contamination in Mortandad Canyon
(includes Ten Site Canyon and Cañada del Buey)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Mortandad and Ten Site Canyons	Multiple past and current effluent discharges	Chloride, TDS, barium, and chromium above and fluoride at 93% of NM groundwater standards; strontium-90, arsenic, beryllium, and lead above EPA MCL screening levels; perchlorate above Consent Order screening level	Nitrate above and hexavalent chromium at 87%, uranium at 96%, fluoride at 66%, and TDS at 54% of NM groundwater standards; tritium at 63% of EPA MCL screening level, dioxane[1,4-] above EPA Human Health tap water screening level, perchlorate above Consent Order screening level	Hexavalent chromium above (see Table 5-16) and nitrate at 60% of NM groundwater standards; perchlorate above Consent Order screening level, bis(2-ethylhexyl)phthalate above EPA MCL screening level
Cañada del Buey	Major dry, minor liquid sources	None, little alluvial groundwater	No intermediate groundwater	None

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two wells have ever contained water. Because treated effluent from the Laboratory's SWWS facility may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture-monitoring holes was installed during 1992 within the upper and middle reaches of the drainage. Past discharges included accidental releases from experimental reactors and laboratories at TA-46.

Table 5-16
Groundwater Quality in Mortandad Canyon (includes Ten Site Canyon and Cañada del Buey)

Chemical	Location	Result	Trends
Chromium	Regional aquifer monitoring wells R-28 and R-42	Average of 408 µg/L at R-28 and 800 µg/L at R-42, above NM groundwater standard of 50 µg/L	R-42 is new; results at R-28 in this range over four years of sampling
Nitrate (as N)	Regional aquifer monitoring wells R-42, R-28, and R-15	1.9 mg/L to 6.0 mg/L, below NM groundwater standard of 10 mg/L	Higher values in R-42 and lowest in R-15, results in this range in R-28 and R-15 for four years of sampling
Perchlorate	Regional aquifer monitoring well R-15	5.6 µg/L to 7.0 µg/L, above Consent Order screening level of 4 µg/L	Results in this range for five years of sampling
Bis(2-ethylhexyl) phthalate	Regional aquifer monitoring well R-42	11.9 µg/L, above EPA MCL screening level of 6 µg/L	Common component of plastics, may be related to construction of new well
Tritium	Intermediate wells MCOI-4, MCOI-5, MCOI-6	3,300 to 12,600 pCi/L, below EPA MCL screening level of 20,000 pCi/L	Slight decline over four years of sampling; wells sample separate isolated perched zones
Nitrate (as N)	Intermediate wells MCOI-4, MCOI-5, MCOI-6	4.2 mg/L to 20 mg/L, above NM groundwater standard of 10 mg/L	Results in this range for four years of sampling; slight decrease in MCOI-4; wells sample separate isolated perched zones
Perchlorate	Intermediate wells MCOI-4, MCOI-5, MCOI-6	78 µg/L to 187 µg/L, above Consent Order screening level of 4 µg/L	Results decreasing over four years of sampling; 50% decrease in MCOI-4
Chromium	Intermediate well MCOI-6	30.5 µg/L to 43.3 µg/L, below NM groundwater standard of 50 µg/L	Results in this range over four years
Dioxane[1,4-]	Intermediate wells MCOI-4 and MCOI-6	Volatile organic results are 24 µg/L to 73 µg/L, above EPA Human Health tap water screening level of 61 µg/L; more precise semivolatile results are 5 µg/L to 30 µg/L, below the screening level	Semivolatile results at each location fairly steady over three years
Uranium	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	28.8 µg/L, below NM groundwater standard of 30 µg/L	30% fluctuation over three years, may be leached from bedrock by percolation of sanitary effluent used to irrigate Overlook Park athletic fields
Nitrate (as N)	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	10 mg/L, at NM groundwater standard of 10 mg/L	Values range from 3.6 mg/L to 14.4 mg/L over three years
Fluoride	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	0.96 mg/L to 1.05 mg/L, below NM groundwater standard of 1.6 mg/L	Similar values over three years
TDS	Intermediate Pine Rock Spring (Pueblo de San Ildefonso)	528 mg/L to 543 mg/L, below NM groundwater standard of 1,000 mg/L	Similar values over three years
Strontium-90	Alluvial wells MCO-4B, MCO-5, MCO-6	40 pCi/L to 66 pCi/L, above EPA MCL screening level of 8 pCi/L and 40 pCi/L 4-mrem/yr DOE DCG screening level	Fairly stable between 30 pCi/L to 80 pCi/L for 10 years due to retention on sediments
Fluoride	Seven alluvial wells	0.27 mg/L to 1.5 mg/L, below NM groundwater standard of 1.6 mg/L	Results stable and generally below standard since 1999 effluent treatment upgrades
Chloride	Alluvial wells MCO-0.6, MCO-2	76 mg/L to 2,180 mg/L, above NM groundwater standard of 250 mg/L	Peaks in mid-summer at MCO-0.6, mid-winter at MCO-2 (at 2180 mg/L); generally above standard for four years at MCO-0.6

Table 5-16 (continued)

Chemical	Location	Result	Trends
TDS	Alluvial wells MCO-0.6, MCO-2	540 mg/L to 3,800 mg/L, above NM groundwater standard of 1,000 mg/L	Highest result yet in MCO-2; often above standard for four years at MCO-0.6
Perchlorate	Seven alluvial wells	2.2 µg/L to 31 µg/L, above Consent Order screening level of 4 µg/L	Results substantially decreasing since 2002 effluent treatment upgrades
Barium	Alluvial wells MCO-0.6, MCO-2	154 µg/L to 694 µg/L in MCO-0.6, 98 µg/L to 1960 µg/L in MCO-2 above NM groundwater standard of 1000 µg/L	Summer highs in MCO-0.6 in 2007-8, winter high in MCO-2 in 2008, possibly due to cation exchange caused by high sodium in road salt runoff
Total arsenic	Alluvial well MCO-2	Unfiltered concentrations 6 µg/L to 21.4 µg/L above EPA MCL screening level of 10 µg/L	Results variable, few prior sampling events, may be naturally occurring
Chromium	Alluvial well MCO-2	3.8 µg/L to 53 µg/L, above NM groundwater standard of 50 µg/L	Two prior measurements up to 41.8 µg/L in 2007
Total Lead	MCO-2, MCA-1	Unfiltered concentrations <2 µg/L to 38.6 µg/L, above EPA MCL screening level of 10 µg/L	Three or four years of variable results in each well

a. 2008 Radioactive Liquid Waste Treatment Facility Discharges

Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2006 through 2008 appear in Supplemental Data Table S5-13. Table S5-13 shows mean annual levels in effluent for each radionuclide and the ratio of this to the 100-mrem/yr DOE DCG for public dose. Figures 5-31 and 5-32 show RLWTF average annual radionuclide activities and selected general inorganic chemical concentrations (fluoride, nitrate) in discharges in relation to DOE DCGs or NM groundwater standards since 1996.

Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, activities of most radionuclides in the effluent have dropped one or more orders of magnitude and several can no longer be detected in samples. For the last eight years, including 2008, the RLWTF has met all DOE radiological discharge standards and all NPDES requirements, and for all but two weeks in 2003, the RLWTF has voluntarily met NM groundwater standards for fluoride, nitrate, TDS, and tritium. Two weekly composite samples exceeded the fluoride standard in 2003. However, for perchlorate, the effluent met the voluntary discharge standard for 38 of 43 samples. The Consent Order screening level for perchlorate, 4 µg/L, was exceeded for samples taken during the five weeks from March 30 through May 04, 2008, with concentrations ranging from 5.5 µg/L to 15.2 µg/L.

A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002. For 2008, perchlorate was detected for the first time in effluent samples since that date. Perchlorate analyses of the effluent samples at an external analytical laboratory gave an average annual concentration of 2.6 µg/L. The maximum monthly concentration was 8.0 µg/L, in April. The next-highest month was May, with an average monthly concentration of 4.1 µg/L. The appearance of higher perchlorate concentrations in the effluent samples was the result of spent ion exchange resins in the removal system. First indications of depleted resin, based on the external analytical laboratory results, were received in February; replacement resin was procured and installed in May. The effect of this brief increase in effluent perchlorate concentration was not seen in surface water or groundwater samples taken downstream.



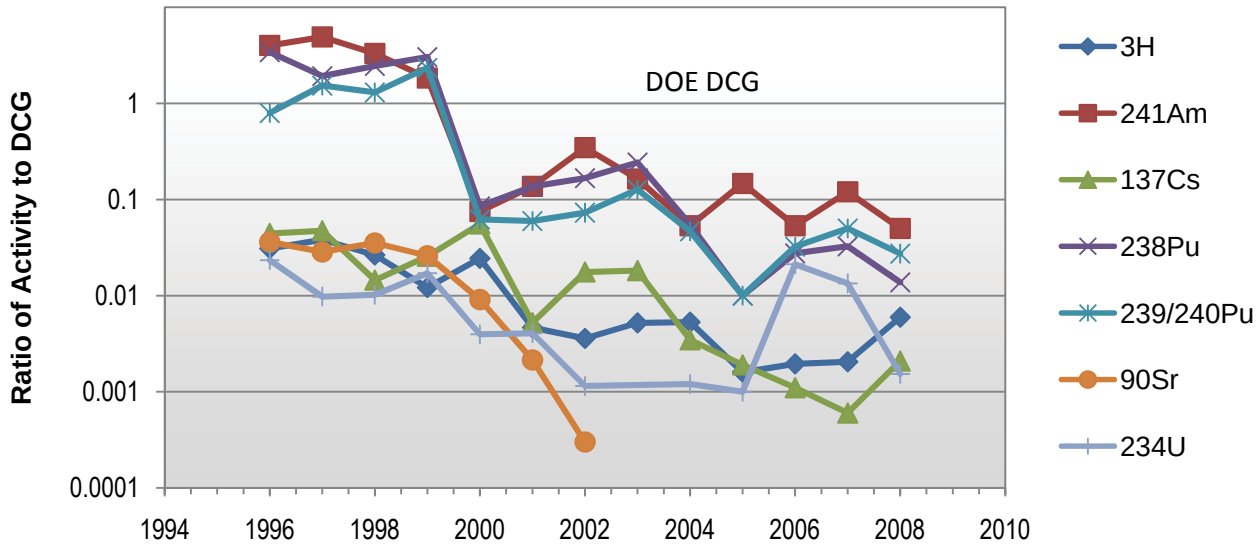


Figure 5-31. Ratio of 1996–2008 average annual radionuclide activity in RLWTF discharges to the 100-mrem/yr public dose DOE DCGs, which are applicable to effluent releases.

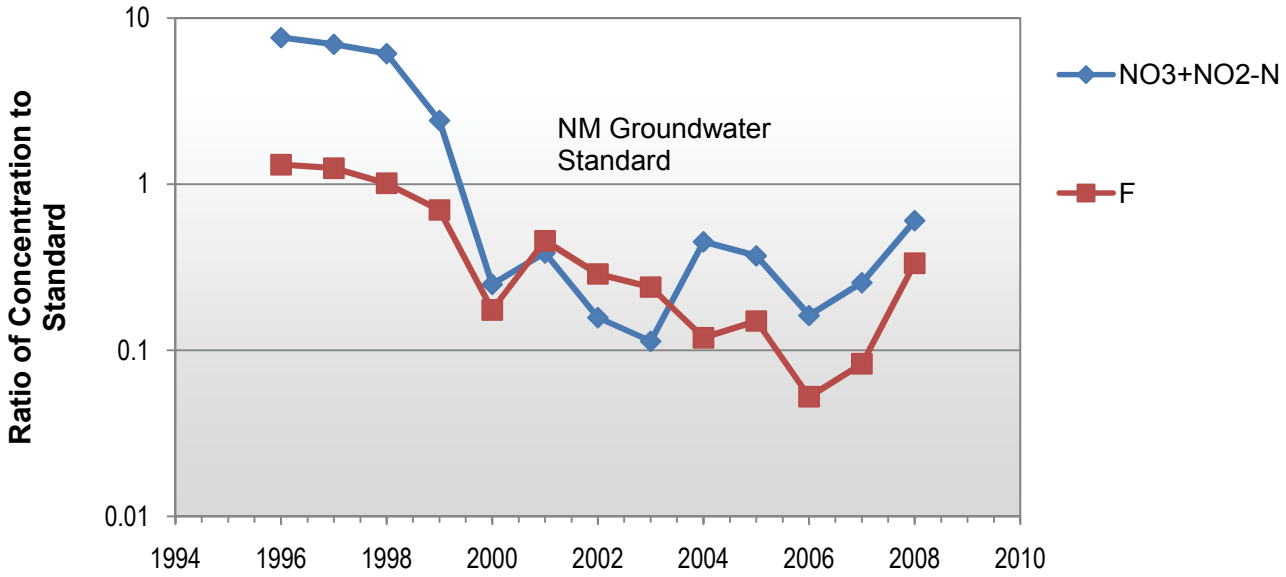


Figure 5-32. Ratio of 1996–2008 average annual nitrate plus nitrite (as nitrogen) and fluoride concentrations in RLWTF discharges to the NM groundwater standards.

During 2008, the nitrate (as nitrogen) concentrations of all monthly analyses of effluent discharges from the RLWTF were less than the NM groundwater standard for nitrate (as nitrogen) of 10 mg/L, as has been the case since 2000. However, in some cases the nitrate + nitrite (as nitrogen) concentration of the effluent discharges was near or slightly above10 mg/L (Figure 5-33). The average 2008 effluent total nitrate + nitrite (as nitrogen) concentration was 6.03 mg/L. In 2008, the highest nitrate concentration in a base flow grab sample collected below the outfall was 6.49 mg/L, at the surface water station Mortandad below Effluent Canyon.

The fluoride concentration in the effluent has also declined over the last few years (Figure 5-34). The 2008 effluent fluoride concentration (average value of 0.54 mg/L) was below the NM groundwater standard of 1.6 mg/L. In 2008, the highest fluoride concentration in a base flow grab sample collected below the outfall was 0.48 mg/L, at the surface water station M-2E in Mortandad Canyon.

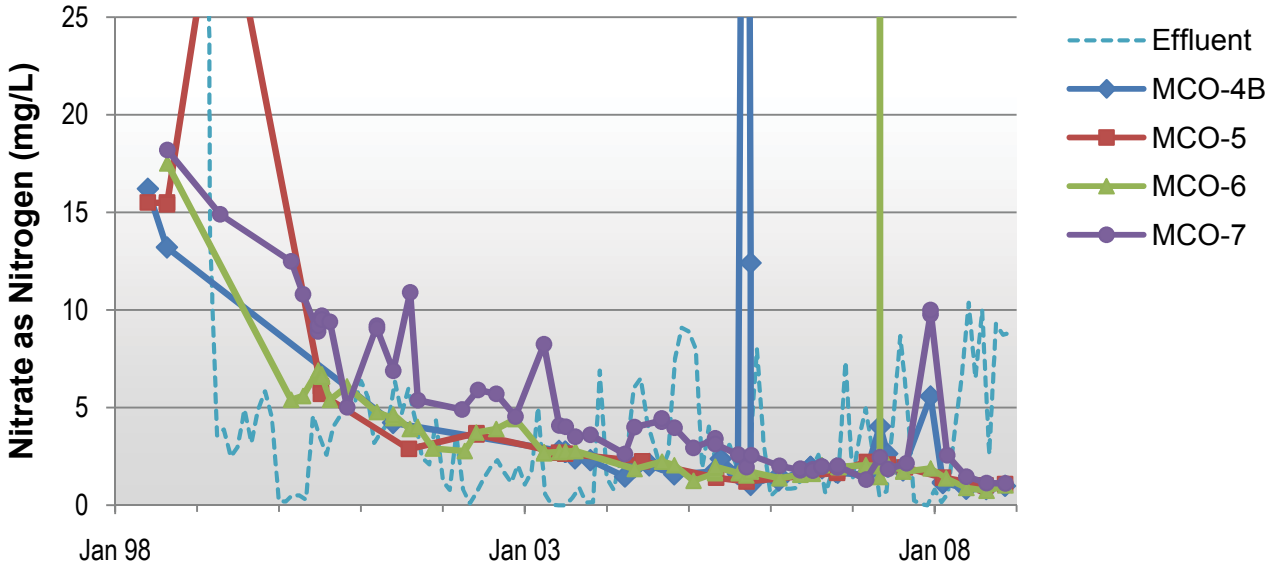


Figure 5-33. **Nitrate + nitrite (as nitrogen) in RLWTF effluent and Mortandad Canyon alluvial groundwater; the NM groundwater standard is 10 mg/L. Groundwater results above about 3 mg/L taken after 2005 reflect field preservation errors.**

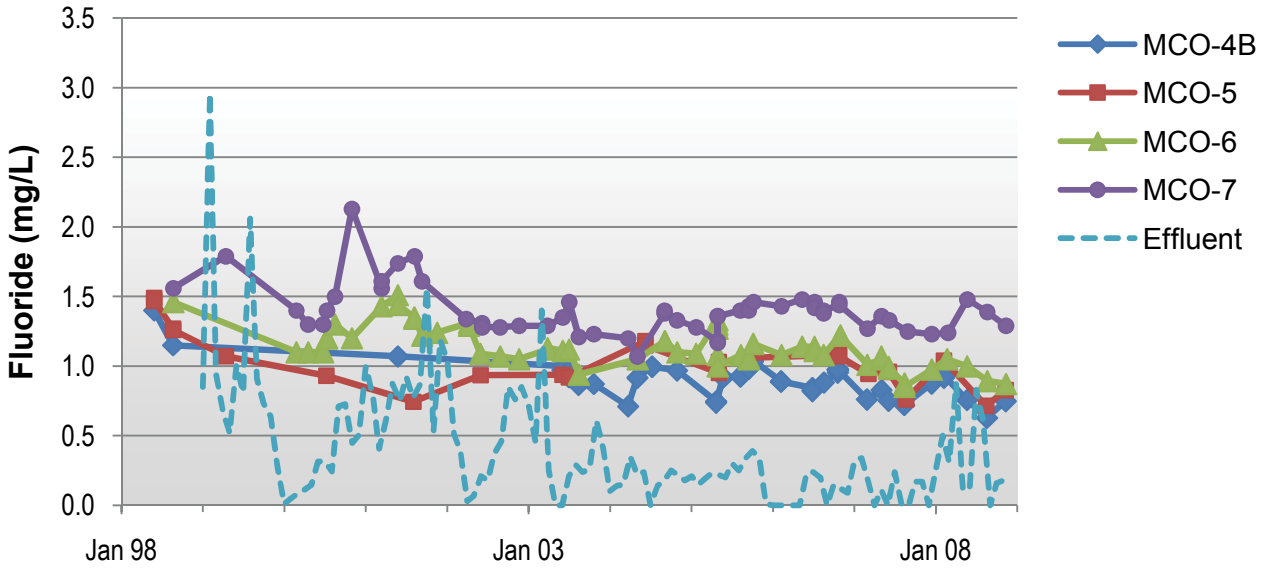


Figure 5-34. **Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater. The NM groundwater standard is 1.6 mg/L.**

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer

The regional aquifer beneath Mortandad Canyon shows impacts from past LANL discharges; intermediate groundwater shows a generally larger effect. In 2008, sampling at regional aquifer monitoring well R-28 in Mortandad Canyon continued to show contamination by hexavalent chromium above the NM groundwater standard of 50 µg/L (which applies to any dissolved form of chromium) (Table 5-16, Figure 5-26, Figure 5-27). The concentrations found at newly drilled regional aquifer monitoring well R-42 were in the range of 800 µg/L, and those in R-28 were approximately 400 µg/L. The Laboratory is investigating this issue in cooperation with NMED and identified past cooling tower discharges in Sandia Canyon as the likely source (ERSP 2006, LANL 2008e).

The 2008 nitrate concentration in R-28 was up to 46% of the NM groundwater standard (Figure 5-35). The nitrate concentration in newly drilled R-42 was 60% of the standard. In nearby regional aquifer monitoring well R-15, results for tritium, perchlorate, and nitrate are higher than in unaffected wells but are below standards or screening levels. Nitrate concentrations ranged up to 22% of the NM groundwater standard in 2008 (Figure 5-35). The perchlorate concentration was above the Consent Order screening level of 4 µg/L. Samples taken from R-15 since June 2004 have results between 5.3 µg/L and 7.4 µg/L (Figure 5-36). Sampling started in 2000; the first few samples had lower values.

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with some concentrations near or exceeding regulatory standards or screening levels. MCOI-6, an intermediate groundwater well in Mortandad Canyon, consistently shows chromium in filtered samples at concentrations just below the NM groundwater standard (Figure 5-27). Nitrate (Figures 5-15, 5-37, 5-38), dioxane[1,4-] (Figure 5-39), and perchlorate (Figures 5-12 and 5-40) are consistently near or above standards or screening levels in some of these intermediate groundwater monitoring wells.

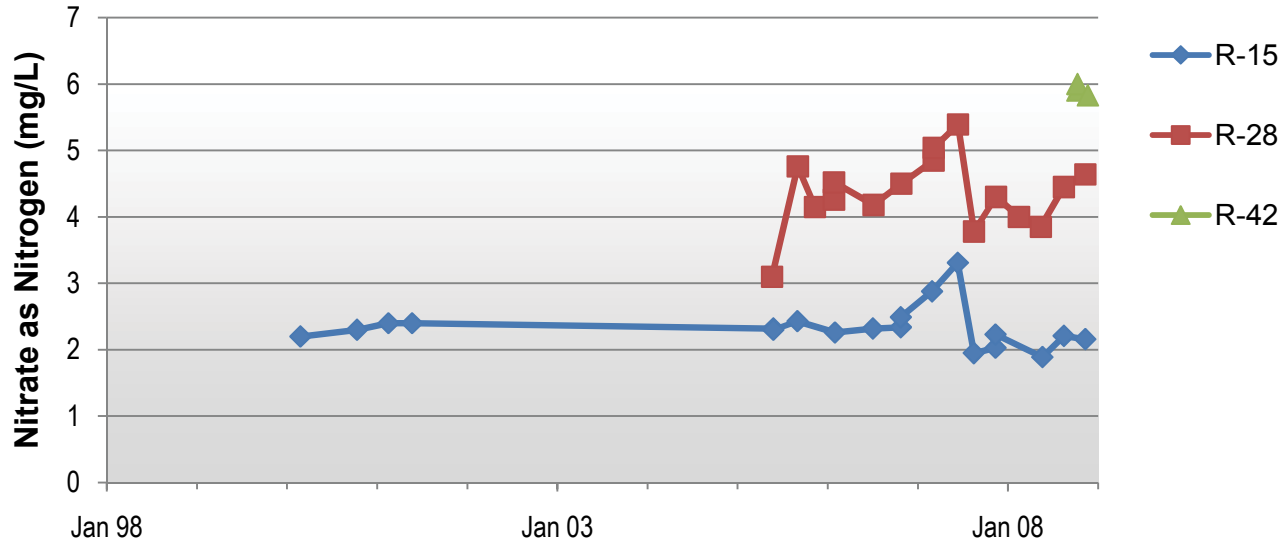


Figure 5-35. Nitrate (as nitrogen) in Mortandad Canyon regional aquifer groundwater. The NM groundwater standard is 10 mg/L.

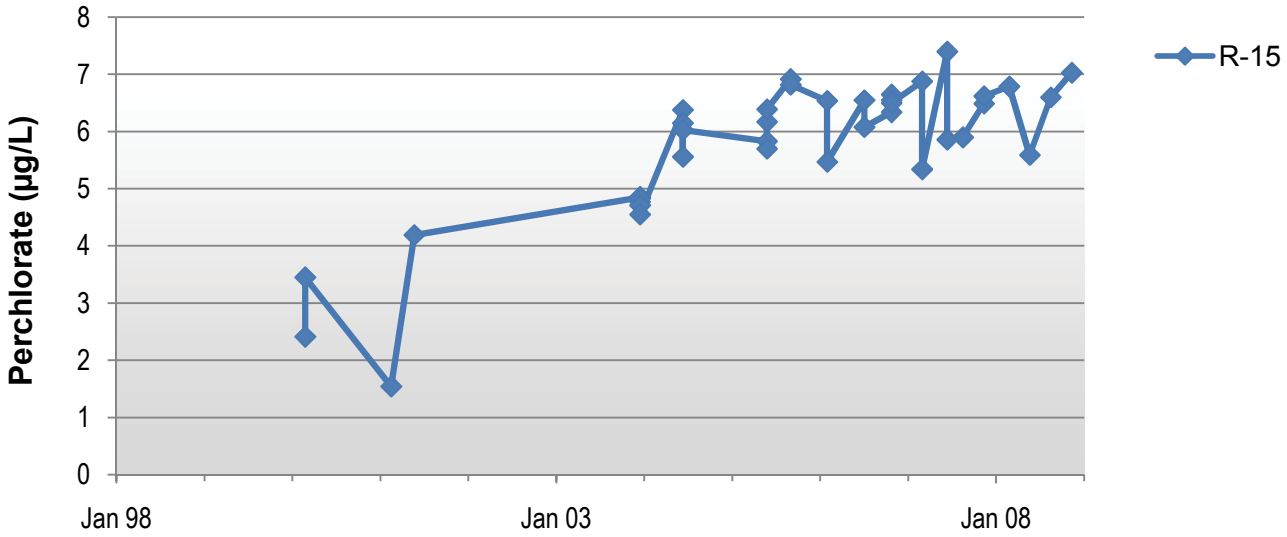


Figure 5-36. Perchlorate in Mortandad Canyon regional aquifer. The Consent Order screening level is 4 µg/L.

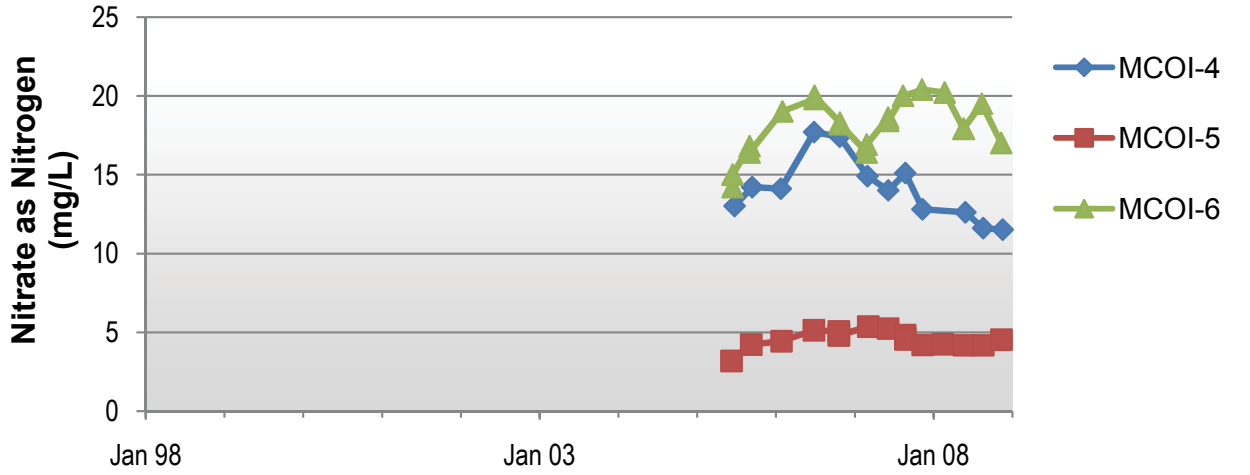


Figure 5-37. **Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater. The NM groundwater standard is 10 mg/L.**

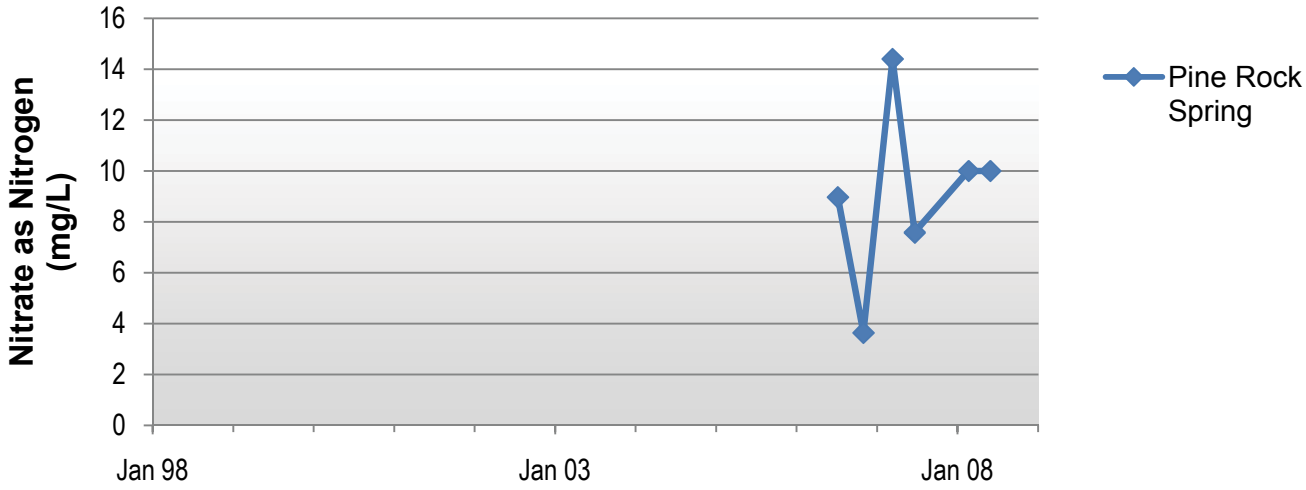


Figure 5-38. **Nitrate (as nitrogen) in Mortandad Canyon intermediate groundwater at Pine Rock Spring on Pueblo de San Ildefonso land. The NM groundwater standard is 10 mg/L.**

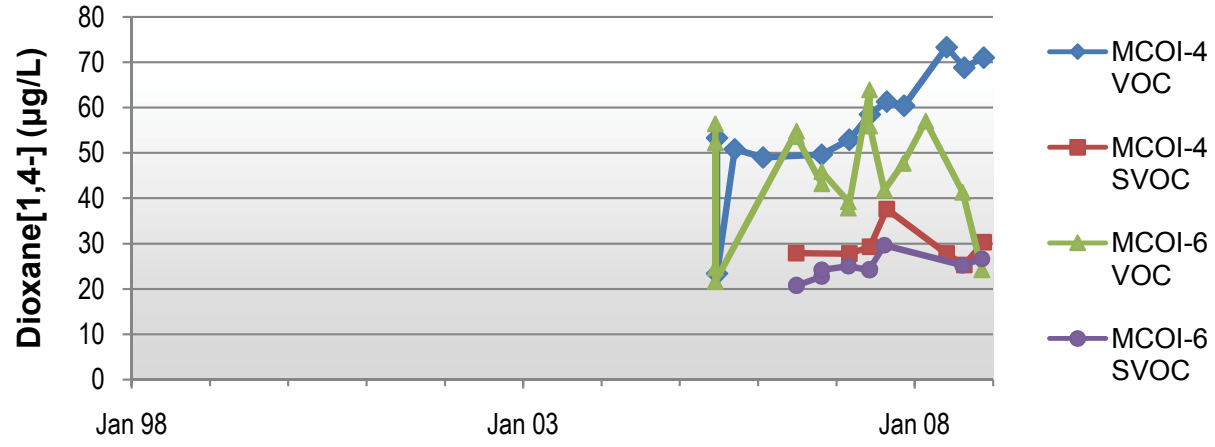


Figure 5-39. **Dioxane[1,4-] in Mortandad Canyon intermediate groundwater; the EPA Human Health tap water screening level is 61.1 µg/L. The results using the volatile organic compound (VOC) method are higher than from the semivolatile organic compound (SVOC) method but are not accurate.**

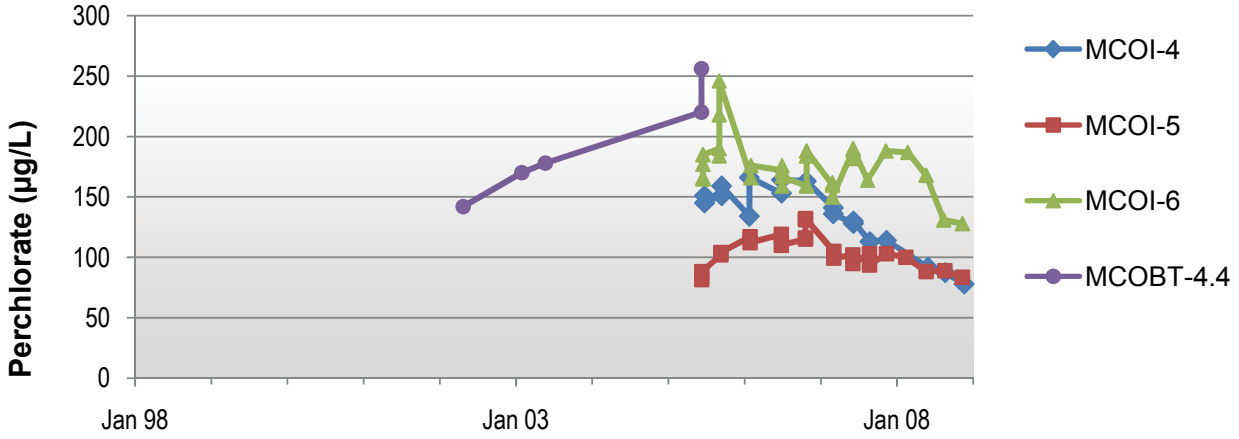


Figure 5-40. Perchlorate in Mortandad Canyon intermediate groundwater; the Consent Order screening level is 4 µg/L.

Three intermediate wells in Mortandad Canyon (MCOI-4, MCOI-5, and MCOI-6) had tritium activities that ranged from 17% to 63% of the EPA MCL screening level of 20,000 pCi/L (Figures 5-41 and 5-42). Another intermediate well, MCOBT-4.4, was installed in 2001 and had construction problems that caused groundwater to leak from the perched zone it sampled. As a result, we have not sampled the well for several years, and it will be plugged and abandoned. The Laboratory drilled MCOI-4 nearby as a replacement.

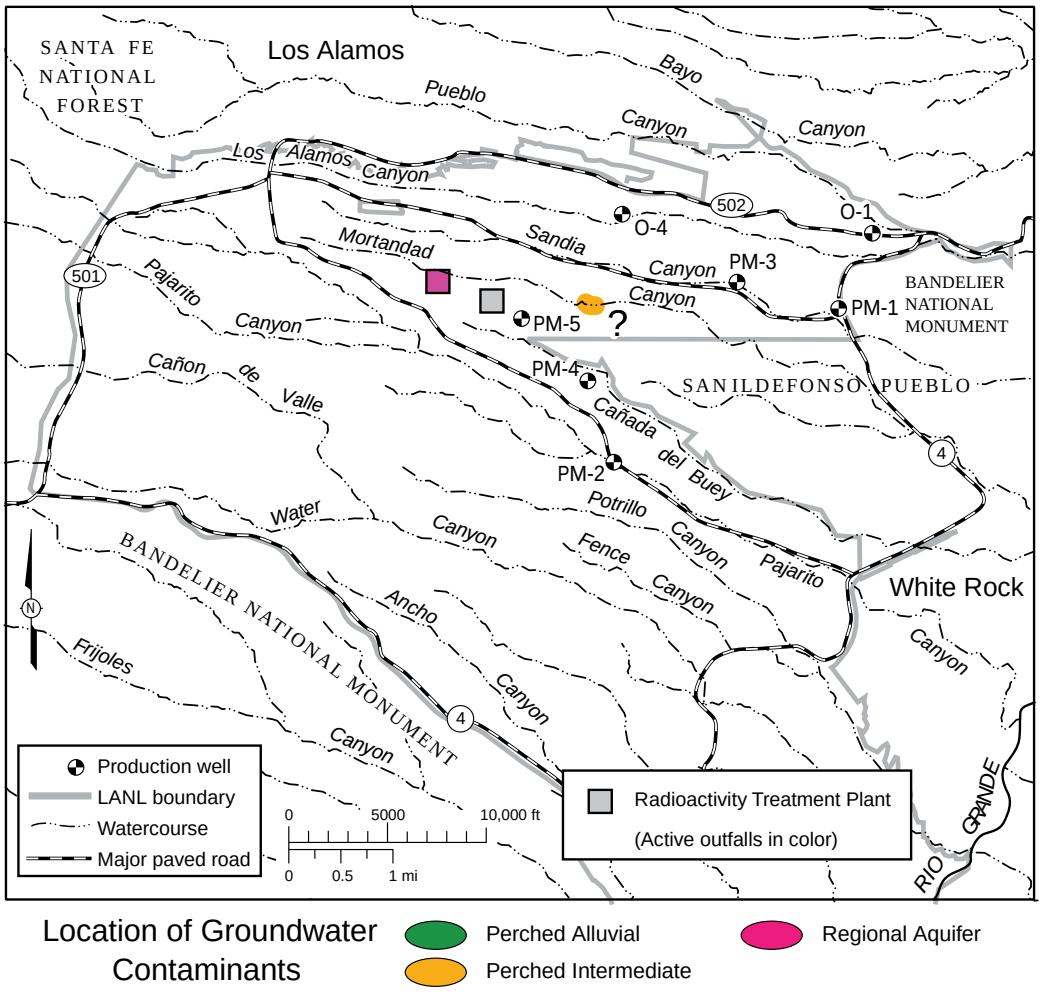


Figure 5-41. Location of groundwater contaminated by tritium; the area indicated has tritium activity above one-half of the 20,000-pCi/L EPA MCL screening level. Different colors indicate the affected groundwater zones. Question marks indicate where contaminant extent is inferred but not confirmed by monitoring coverage.

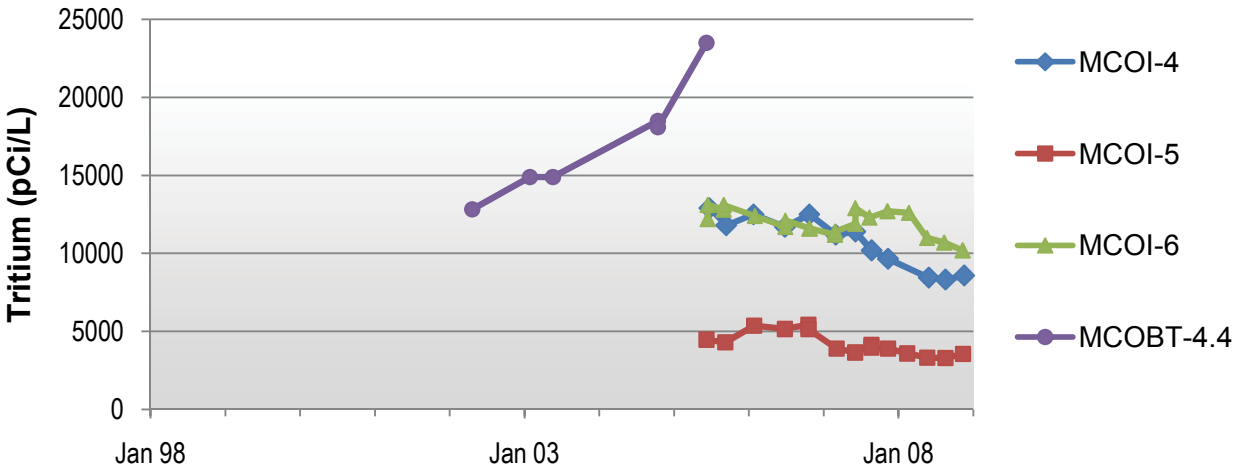


Figure 5-42. Tritium in Mortandad Canyon intermediate groundwater. For comparison purposes, the EPA MCL screening level is 20,000 pCi/L.

Pine Rock Spring on Pueblo de San Ildefonso land had uranium concentrations near and nitrate concentrations (Figure 5-38) above the NM groundwater standards. Fluoride and TDS were also near the NM groundwater standards. The uranium values may be caused by dissolution of uranium from the bedrock by sanitary effluent used to water athletic fields at nearby Overlook Park (Teerlink 2007). The fluoride and TDS concentrations also appear to be caused by the contribution of effluent to spring flow.

In 2005, we measured and detected dioxane[1,4-] for the first time in two intermediate wells in Mortandad Canyon (Figure 5-39). The dioxane[1,4-] EPA Human Health tap water screening level is 61 µg/L. This compound has been measured by two methods. The volatile organic compound method SW-846:8260B is not really suitable for this analysis; it has a practical quantitation limit (PQL) of 50 µg/L (the MDL is 20 µg/L). Many measured results by this method are above the EPA Human Health tap water screening level. A more sensitive semivolatile organic compound method SW-846:8270C has a PQL of 10 µg/L (the MDL is 1 µg/L). Results measured by this method are below the EPA Human Health tap water screening level.

In 2008, we did not detect bis(2-ethylhexyl)phthalate in samples from MCOI-6 for the first year since sampling began in 2005. The concentrations in prior years ranged from 2.3 µg/L to 12.4 µg/L and were above the 6 µg/L EPA MCL screening level. The source of this chemical at this well is not known; it was found in seven of 10 samples from MCOI-6.

c. Alluvial Groundwater

Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest just below the TA-50 RLWTF outfall at wells MCA-1 or MCO-4B and decrease down the canyon. Most radionuclides are adsorbed to sediment closer to the outfall and subsequently move with sediment rather than in groundwater. Since the early 1990s, radionuclide levels in alluvial groundwater samples have not exceeded the 100-mrem/yr public dose DOE DCG screening levels (applicable to effluent discharges).

In 2008, total LANL-derived radioactivity exceeded the 4-mrem/yr DOE DCG screening level in Mortandad Canyon alluvial groundwater samples from wells MCO-4B, MCO-5, and MCO-6 (Figure 5-11). Strontium-90 was the dominant contributor to dose in these samples. The 2008 results for strontium-90 exceeded the 4-mrem/yr DOE DCG screening level (40 pCi/L) and the EPA MCL screening level (8 pCi/L) in all three wells (Figure 5-10, Figure 5-43).

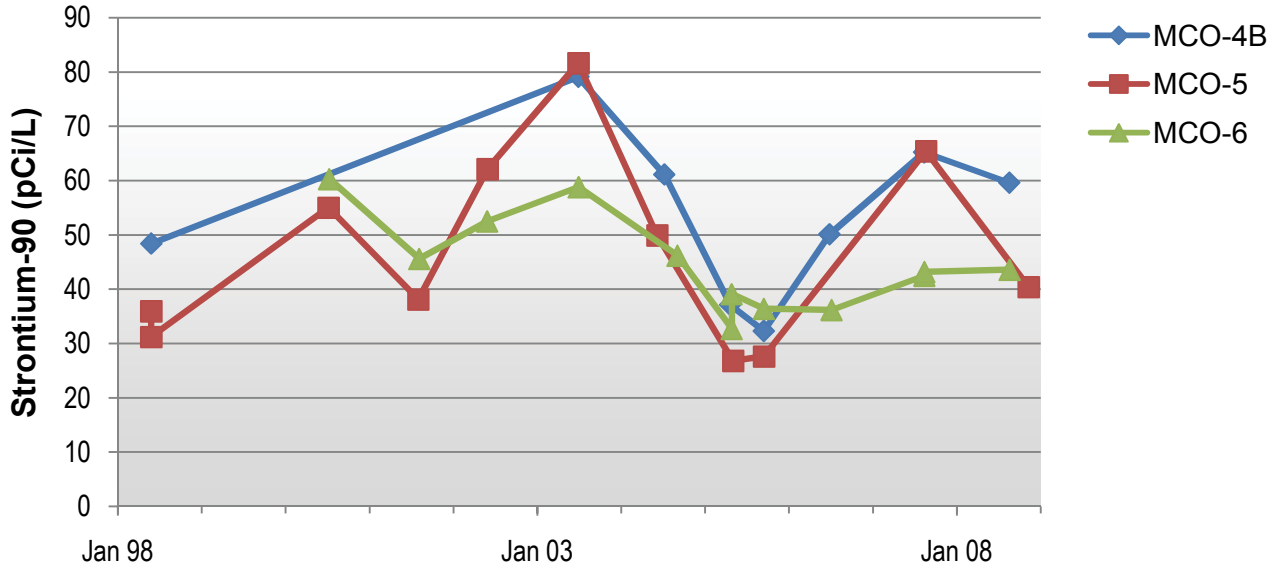


Figure 5-43. Strontium-90 in Mortandad Canyon alluvial groundwater. For comparison purposes, the EPA MCL screening level is 8 pCi/L.

The strontium-90 activity in the RLWTF effluent has been below detection since 2003. The inventory of strontium-90 in the alluvium is gradually declining, since discharge amounts have decreased and the half-life of strontium-90 is 28.8 years. Strontium-90 continues to be found in groundwater samples because it has been retained by cation exchange on sediment within the upstream portion of the alluvium. The level of strontium-90 has risen gradually at downstream wells MCO-5 and MCO-6 during the last 20 years, suggesting that the radionuclide is moving slowly down the canyon.

Two alluvial wells, MCO-0.6 and MCO-2, had results for chloride and TDS that approached or exceeded NM groundwater standards. MCO-0.6 is in Mortandad Canyon upstream of Effluent Canyon, a tributary of Mortandad Canyon, and MCO-2 is in Effluent Canyon. For the past two years, more frequent data from these wells and from adjacent surface water monitoring locations indicate seasonal variation in chloride concentrations, with highest values beginning in winter (Figure 5-18, Figures 5-44, 5-45, and 5-46). The locations of surface water monitoring stations are shown in Chapter 6. The surface water locations show peaks in chloride concentrations in early winter, evidently the result of road salting. Similar trends occur in sodium concentrations and TDS (not shown).

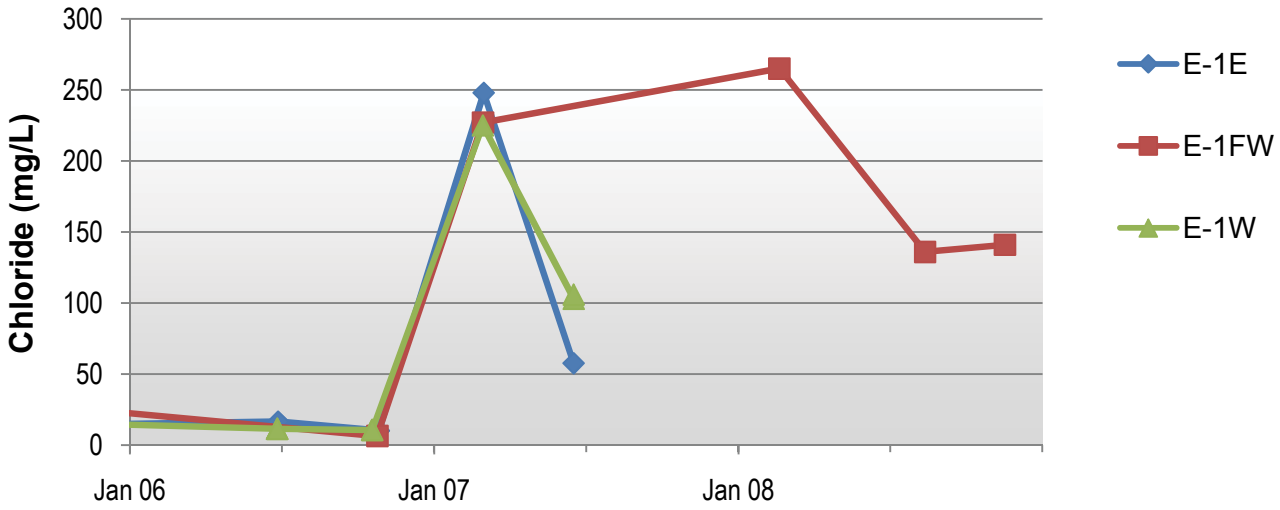


Figure 5-44. Chloride in Mortandad Canyon surface water. The NM groundwater standard is 250 mg/L.

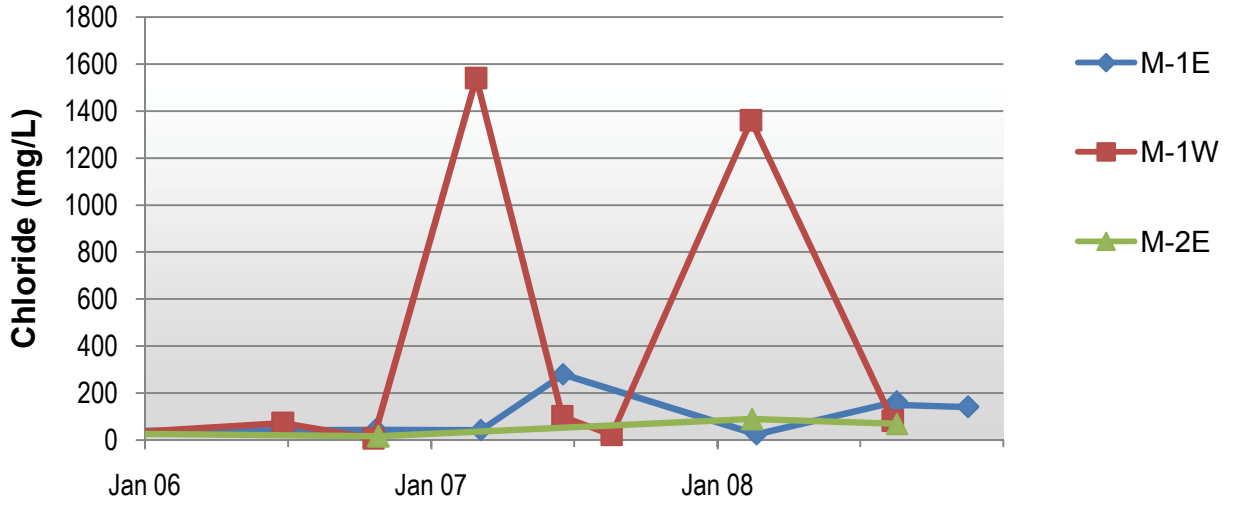


Figure 5-45. Chloride in Mortandad Canyon surface water. The NM groundwater standard is 250 mg/L.

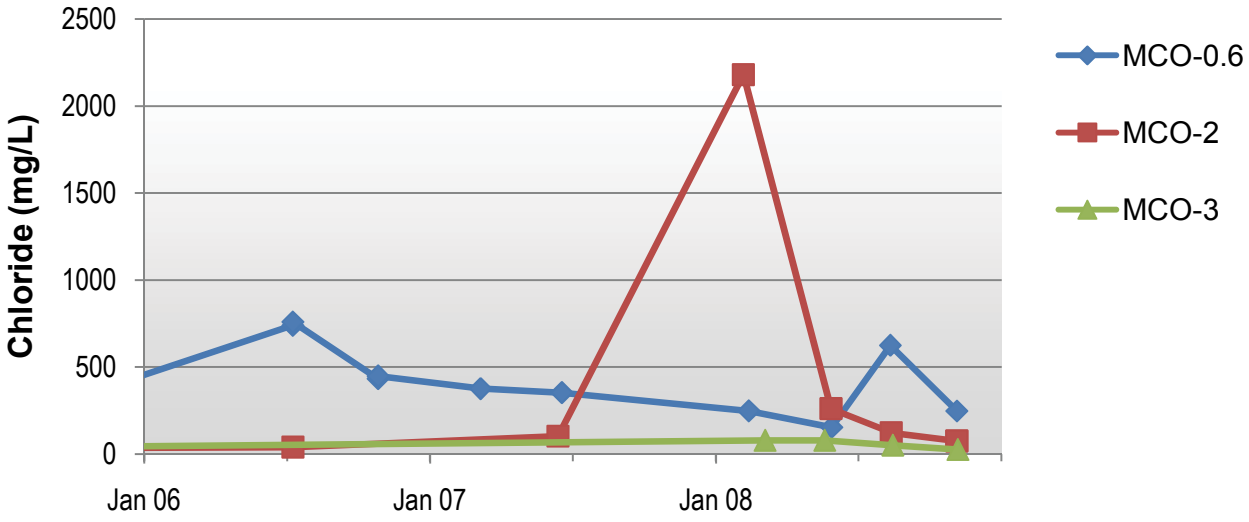


Figure 5-46. Chloride in Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

The highest surface water chloride concentrations were seen in February 2007 (1540 mg/L) and February 2008 at location M-1W. This station is in upper Mortandad Canyon in the Laboratory's main technical area, just east of Pajarito Road, below a large area of roads and parking lots. In June of 2007 the chloride concentration at downstream station M-1E reached 280 mg/L. Since September 2005, the concentration at alluvial well MCO-0.6, located farther down the canyon, ranged from 155 mg/L to 759 mg/L. The highest values at MCO-0.6 occurred in August of 2006 and 2008; the cause of this timing is unclear.

The three surface water locations in Effluent Canyon show similar chloride concentrations of around 225 mg/L in March 2007. Only the most upstream location, E-1FW, was sampled in 2008. The chloride concentration at that location in February 2008 was 265 mg/L. Although alluvial groundwater data at MCO-2 (near M-1W in the middle of Effluent Canyon) are less frequent, they support the pattern of high concentrations of chloride and sodium in winter.

At MCO-3, located downstream of these monitoring sites and the RLWTF outfall, the chloride concentration peaks appear to be delayed and have much lower amplitude. With the exception of a few chloride results in about 1971 and 1990, the recent chloride concentrations at MCO-3 are the highest measured at the well over its monitoring history (Figure 5-47).

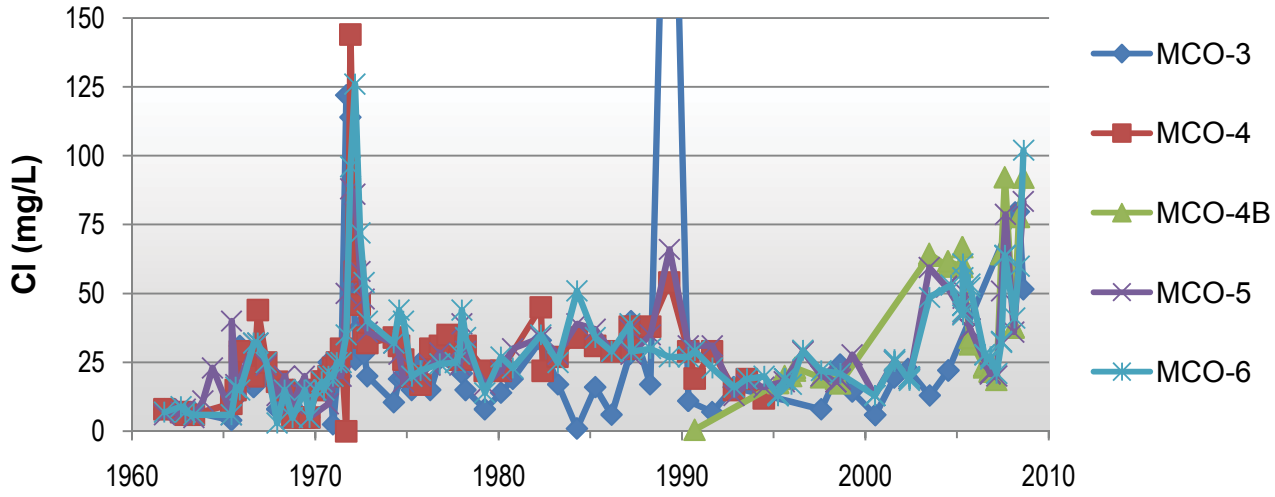


Figure 5-47. Chloride histories for Mortandad Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

MCO-3 has been sampled since 1963. The chloride concentrations at MCO-3 and downstream alluvial groundwater wells have risen since 2003 and are now higher than most previous values (Figure 5-47). The volume of RLWTF effluent discharge and the total chloride mass discharged have decreased since 1990 (Figure 5-48). The annual average effluent chloride concentration has also decreased, though it was higher in 2008 than in recent years (Figure 5-49). While this concentration increased in 2008, the mass of chloride discharged did not increase significantly compared to discharges of past years. As the RLWTF effluent is now contributing less volume to stream flow in Mortandad Canyon and less chloride mass, this is not likely to be the cause of the increasing chloride concentration in downstream alluvial groundwater samples. These results indicate that recent application of road salt now has a greater impact on groundwater chloride concentrations than the past RLWTF effluent discharges.

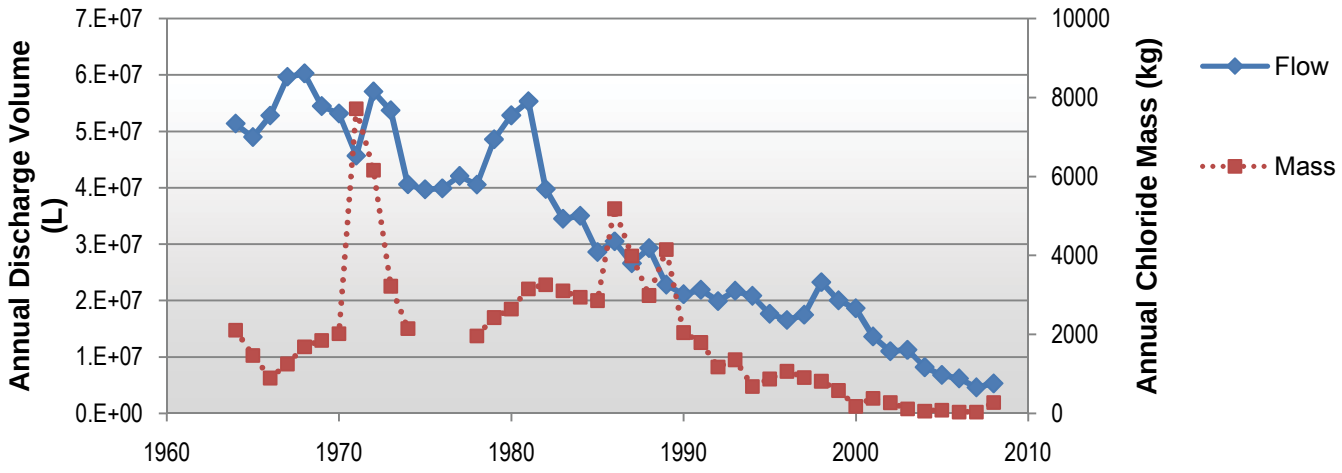


Figure 5-48. History of RLWTF annual effluent discharge volume and chloride mass.

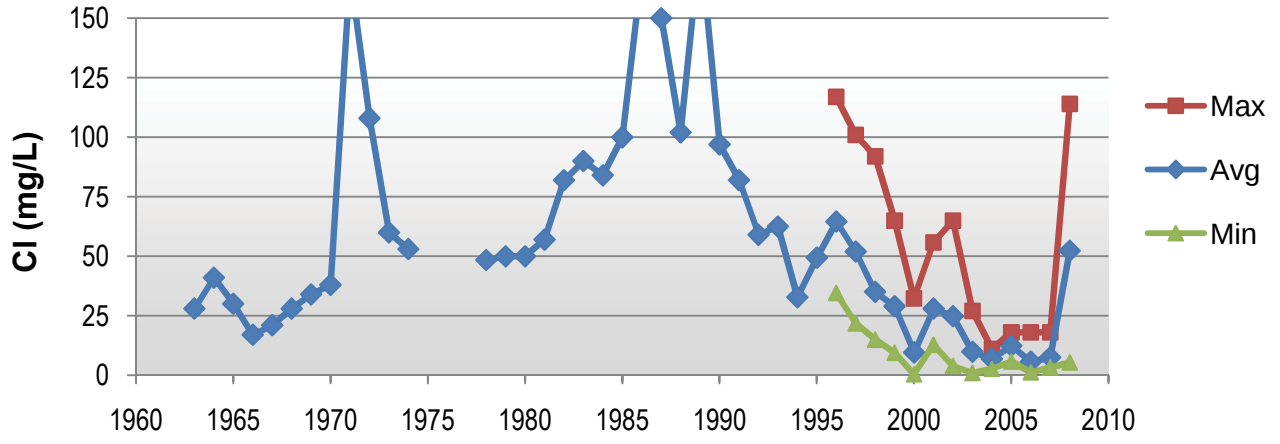


Figure 5-49. History of RLWTF annual effluent chloride concentration ranges. The NM groundwater standard is 250 mg/L.

As shown in Figures 5-33 and 5-34, the nitrate (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 are below the NM groundwater standards. As mentioned above, in some cases the combined nitrate + nitrite (as nitrogen) concentration of the effluent discharges was near or slightly above 10 mg/L. Under the groundwater discharge plan application for the RLWTF, the Laboratory collected additional quarterly samples for nitrate, fluoride, perchlorate, and TDS during 2008 from four alluvial monitoring wells below the outfall in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7.

The nitrate (as nitrogen) concentrations in these wells were below the NM groundwater standard of 10 mg/L (Figure 5-33), and fluoride concentrations were below the NM groundwater standard of 1.6 mg/L (Figure 5-34). Many alluvial groundwater samples collected below the RLWTF outfall had fluoride concentrations above 50% of the NM groundwater standard (Figures 5-14 and 5-34). In 2008, a downstream well (MCO-7.5, not shown) had a fluoride result exceeding the standard, a result of past effluent discharge.

Many Mortandad Canyon alluvial groundwater samples from wells downstream of the RLWTF outfall had high perchlorate concentrations (Figures 5-12 and 5-50). The 2008 concentrations at some wells were above the Consent Order screening level of 4 µg/L. Alluvial groundwater concentrations of perchlorate have dropped, especially near the outfall, following the removal of perchlorate from RLWTF effluent in March 2002.

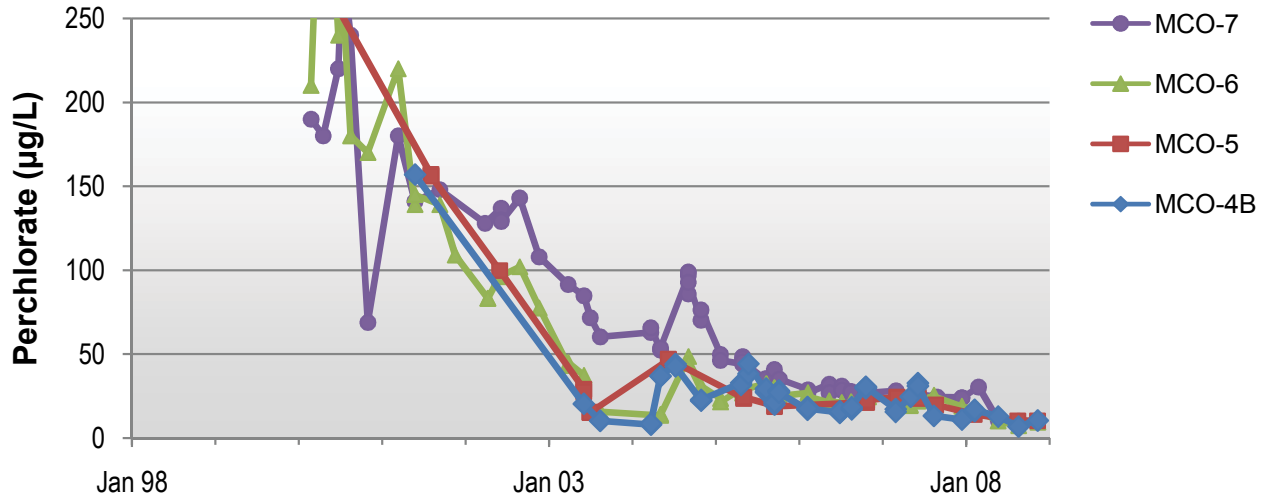


Figure 5-50. Perchlorate in Mortandad Canyon alluvial groundwater; the Consent Order screening level is 4 µg/L.

d. Cañada del Buey

Alluvial well CDBO-6 in Cañada del Buey was sampled four times and CDBO-7 once in 2008. Other than one unfiltered beryllium result just above the EPA MCL screening level in CDBO-6, there were no results measured near regulatory standards or screening levels. Beryllium was not detected in three other samples taken during 2008, but has been detected in four other samples taken since 1992.

5. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon has a drainage that extends into the Sierra de los Valles, west of the Laboratory. Saturated alluvium occurs in lower Pajarito Canyon near the eastern Laboratory boundary, but does not extend beyond the boundary. In the past, the Laboratory released small amounts of wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-9 (Table 5-17). Some firing sites border portions of tributaries Twomile and Threemile canyons. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at TA-18. Waste management areas at TA-54, used for disposal of organic chemicals and low-level radioactive waste, occupy the mesa north of the lower part of the canyon. A small contaminated body of shallow intermediate groundwater occurs behind a former Laboratory warehouse location at TA-3, where the Laboratory disposed of waste materials. The main water quality impacts are from organic chemicals released at the TA-3 warehouse and from HE (Table 5-18).

Table 5-17
Summary of Groundwater Contamination in Pajarito Canyon
(includes Twomile and Threemile Canyons)

		Groundwater Contaminants		
Canyon	Contaminant Sources	Alluvial	Intermediate	Regional
Pajarito, Twomile, and Threemile Canyons	Major dry sources; liquid sources major in past but minor currently	Antimony above; chloride and TDS at 74%, barium at 60% of NM groundwater standards; lead at 84% and arsenic at 69% of EPA MCL screening levels	Dichloroethene[1,1-], trichloroethane[1,1,1-] , chloride and TDS above NM groundwater standards; dioxane[1,4-] and RDX above EPA Human Health tap water screening levels; trichloroethene at trace levels	Trace RDX

RDX was detected at Pajarito Canyon regional well R-18 at a concentration that is near the detection limit and at 4% of the EPA Human Health tap water screening level. RDX is listed as a toxic pollutant in the New Mexico groundwater regulations (NMWQCC 2002).

Samples from several of the intermediate groundwater springs in upper Pajarito Canyon contained RDX, HMX, and other HE compounds as in prior years. One RDX result from Bulldog Spring was above the EPA Human Health tap water screening level (Figure 5-51).

SWMU 03-010(a) is the outfall area from a former vacuum repair shop and is currently under investigation (LANL 2005b). The outfall area is located on a steep slope on the rim of Twomile Canyon about 30 ft west of a general warehouse (Building 03-30). Technicians working at the vacuum repair shop discarded vacuum pump oil at this site in the 1950s. The oil contained radionuclides, rinse solvents, and mercury. A small zone of shallow intermediate perched groundwater is apparently recharged by runoff from the parking lot and building roofs; the groundwater becomes contaminated through contact with the soil.

The perched groundwater is tapped by three wells. The wells are problematic because they are installed in vaults below roadways, are occasionally flooded at the surface, and have been damaged by snowplows. Water quality results in two wells, 03-B-10 and 03-B-13, are similar. Another well, 03-B-9, rarely contains water.

Table 5-18
Groundwater Quality in Pajarito Canyon
(includes Twomile and Threemile Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-18	0.26 µg/L to 0.49 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Found in all sample events since August 2006; values increasing
Bis(2-ethylhexyl) phthalate	Regional aquifer monitoring well R-32	Up to 6 µg/L, at EPA MCL screening level of 6 µg/L	Common component of plastics; may be related to new sampling system installed in December 2007
Chloride	Intermediate wells 03-B-10, 03-B-13	95 mg/L to 552 mg/L, above NM groundwater standard of 250 mg/L	Highest results during March and December for two years of sampling; from road salt
TDS	Intermediate wells 03-B-10, 03-B-13	216 mg/L to 1050 mg/L, above NM groundwater standard of 1,000 mg/L	Highest results during March and December for two years of sampling; from road salt
Dichloroethene [1,1-]	Intermediate wells 03-B-10, 03-B-13	3 µg/L to 19.4 µg/L, above NM groundwater standard of 5 µg/L	Detected in every sample for three years; seasonally variable with highest concentrations in 2008
Trichloroethane [1,1,1-]	Intermediate wells 03-B-10, 03-B-13	52 µg/L to 254 µg/L, above NM groundwater standard of 60 µg/L	Detected in every sample for three years; seasonally variable with highest concentrations in 2006
Dioxane[1,4-]	Intermediate wells 03-B-10, 03-B-13	Volatile organic results are 44 µg/L to 4790 µg/L; more precise semivolatile results are 47 µg/L to 746 µg/L, above EPA Human Health tap water screening level of 61 µg/L	Detected for three years; seasonally variable with highest concentrations in December 2007 and March 2008
RDX	Intermediate Bulldog Spring	1.7 µg/L to 6.9 µg/L, above EPA Human Health tap water screening level of 6.1 µg/L	Found in every sample at Bulldog Spring; sampled since 2004; values fluctuate
Chloride	Alluvial wells 18-MW-18, PCO-3, PCAO-8	51 mg/L to 186 mg/L, below NM groundwater standard of 250 mg/L	Concentrations peak in winter due to road salt
TDS	Alluvial wells PCO-3, PCAO-5	331 mg/L to 732 mg/L, below NM groundwater standard of 1000 mg/L	Concentrations peak in winter due to road salt
Barium	Alluvial well PCAO-5	281 µg/L to 601 µg/L, below NM groundwater standard of 1000 µg/L	New well, three sample events in 2008, possibly due to cation exchange caused by high sodium in road salt runoff
Lead	Alluvial well PCAO-9 and TW-1.72 Spring	Total lead concentration of 9.7 µg/L in TW-1.72 Spring, 12.6 µg/L in PCAO-9, below EPA drinking water system screening level of 15 µg/L	Highest concentration of 3 samples since 2005 in spring, two samples in new well with nondetect in one sample
Arsenic	Alluvial well PCAO-5	4.8 µg/L to 6.9 µg/L, below EPA MCL screening level of 10 µg/L	New well, three sample events in 2008, may be naturally occurring

Samples from wells 03-B-10 and 03-B-13 had TDS and chloride results that were above groundwater standards (Figure 5-18, Figure 5-52). The seasonal pattern of sodium (not shown) and chloride concentrations, with high values in winter, suggest that road salting is the source of this variation. Samples from these wells also contained several organic chemicals including four chlorinated solvents (Table 5-18). Several organic chemicals were at concentrations exceeding NM groundwater standards. Compounds found in well samples included dichloroethane[1,1-], dichloroethene[1,1-], and trichloroethane[1,1,1-], and dioxane[1,4-].

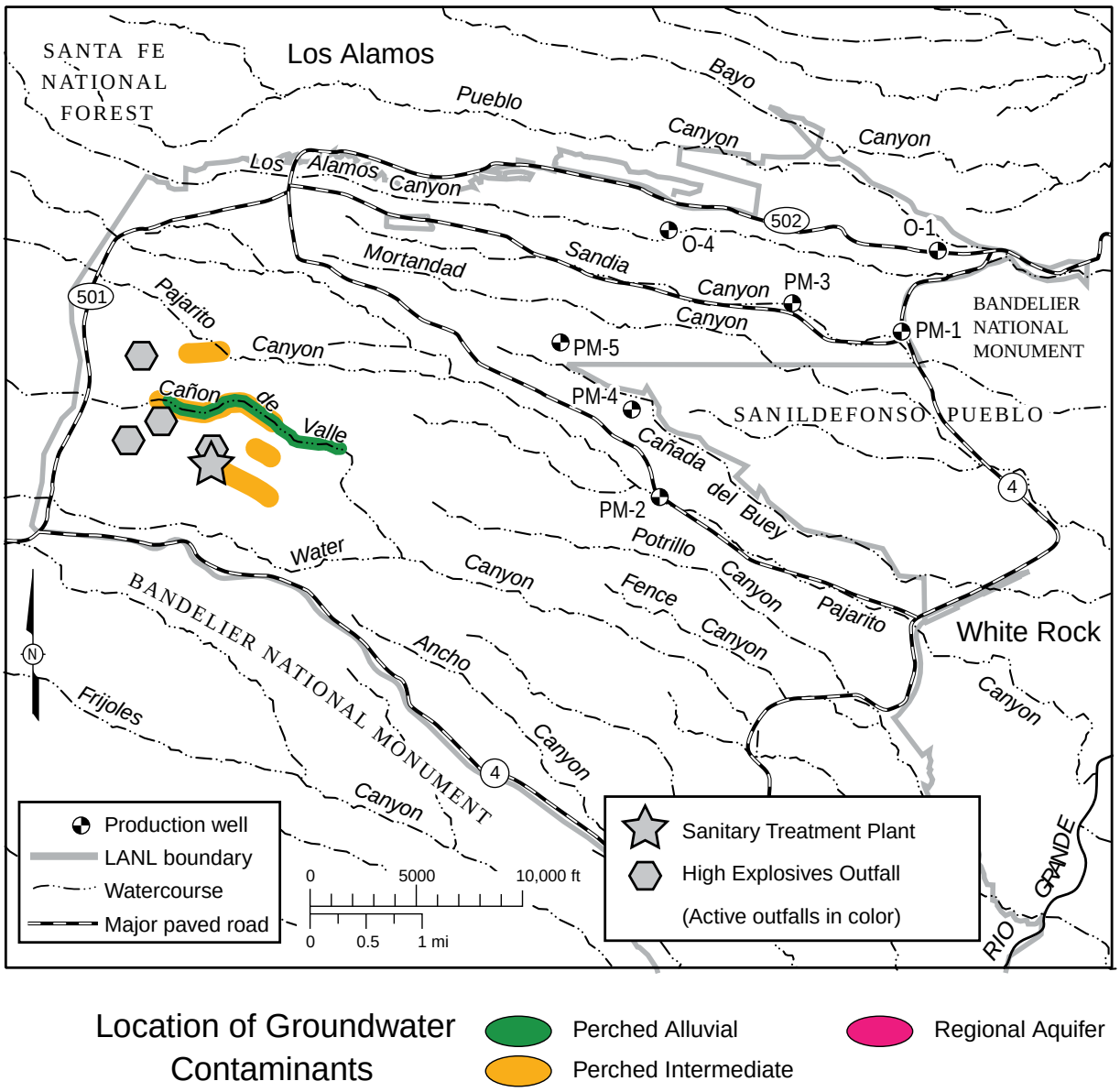


Figure 5-51. Location of groundwater containing RDX above one half of the EPA Human Health tap water screening level of 6.1 µg/L. Different colors indicate the affected groundwater zones.

Seasonal variation is shown by several other field parameters and chemical compounds measured in water samples from wells 03-B-10 and 03-B-13. Figure 5-53 shows histories for ORP (oxidation-reduction potential) and TOC (total organic carbon). Higher values of ORP indicate conditions that are more oxidizing, and lower ORP indicates more reducing conditions. TOC shows the opposite behavior- it is high when ORP is low. High TOC suggests higher organic matter in the groundwater, which provides the carbon and energy sources for extensive bacterial metabolism including aerobic oxidation, nitrate reduction, Fe(III) and Mn(IV) reduction, sulfate reduction, and methanogenis. The anaerobic conditions resulting from increased bacterial activity would cause lower ORP values.

Total (that is, unfiltered) iron concentrations are shown in Figure 5-54. Turbidity values and total manganese concentrations (not shown) have a seasonal behavior similar to total iron. The high total iron in late summer might be due to the reducing conditions in the groundwater; under more reducing conditions iron and manganese are more soluble.

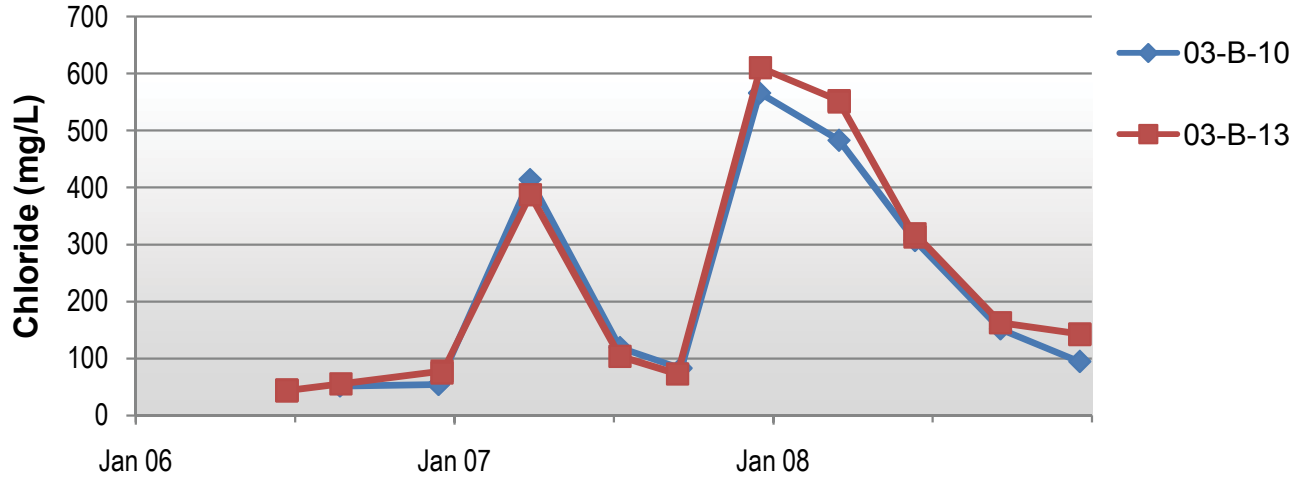


Figure 5-52. **Histories for chloride in Pajarito Canyon intermediate groundwater at TA-3 wells 03-B-10 and 03-B-13. The NM groundwater standard is 250 mg/L.**

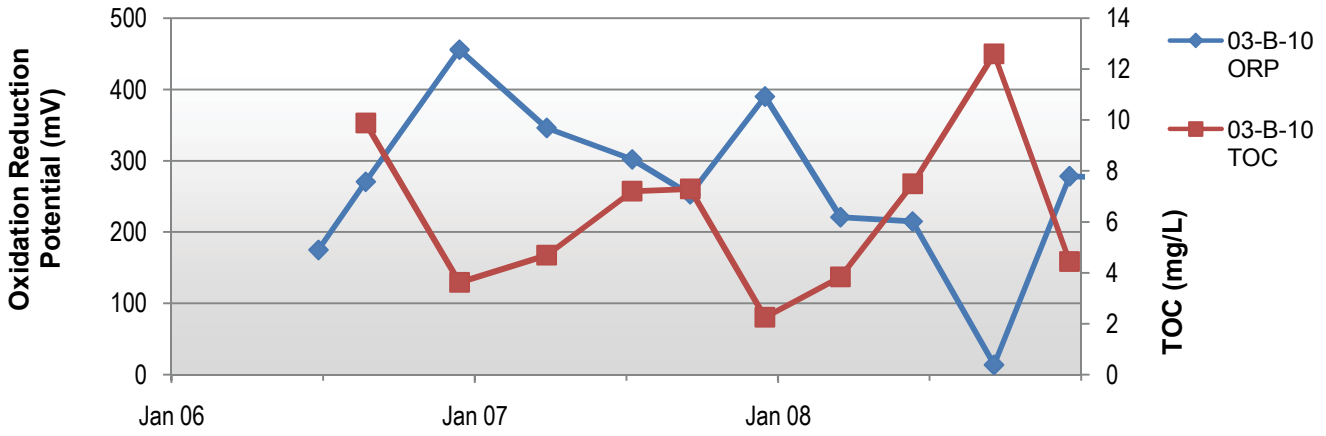


Figure 5-53. **Histories for oxidation-reduction potential (ORP) and total organic carbon (TOC) at well 03-B-10.**

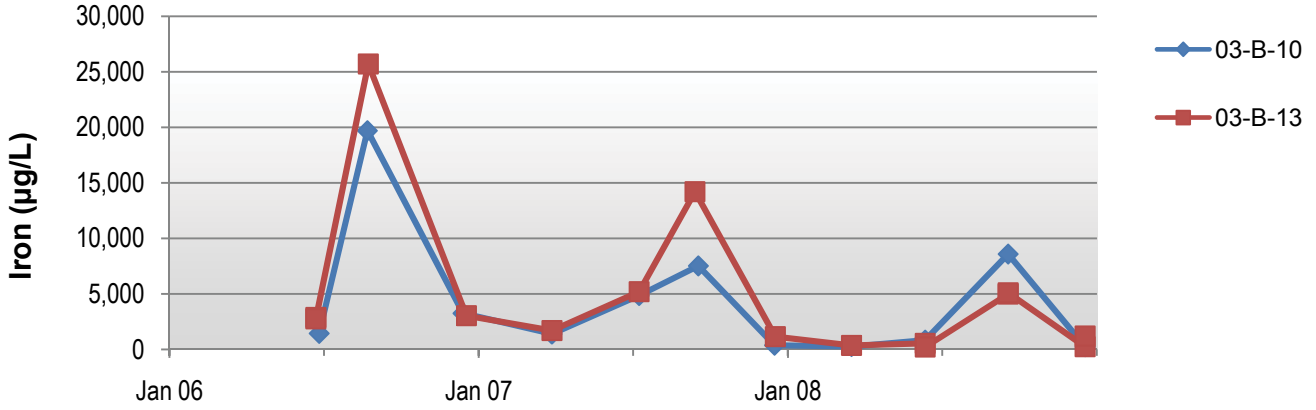


Figure 5-54. **Histories for unfiltered iron concentrations at wells 03-B-10 and 03-B-13.**

Figures 5-55 and 5-56 show dioxane[1,4-] and trichloroethane[1,1,1-] histories for 03-B-10 and 03-B-13. The seasonal pattern for concentrations of dichloroethene[1,1-] (not shown) is similar to that for trichloroethane[1,1,1-]. For some solvents, their retention on solid surfaces is lower in higher ionic strength solutions. Thus, a possible cause for increasing concentration of trichloroethane[1,1,1-] is that increasing concentration of sodium and chloride releases these compounds from the aquifer matrix. For example, the high chloride (Figure 5-52) and TDS observed in the groundwater in December 2007 might cause release of trichloroethane[1,1,1-] during the following months (Figure 5-56).

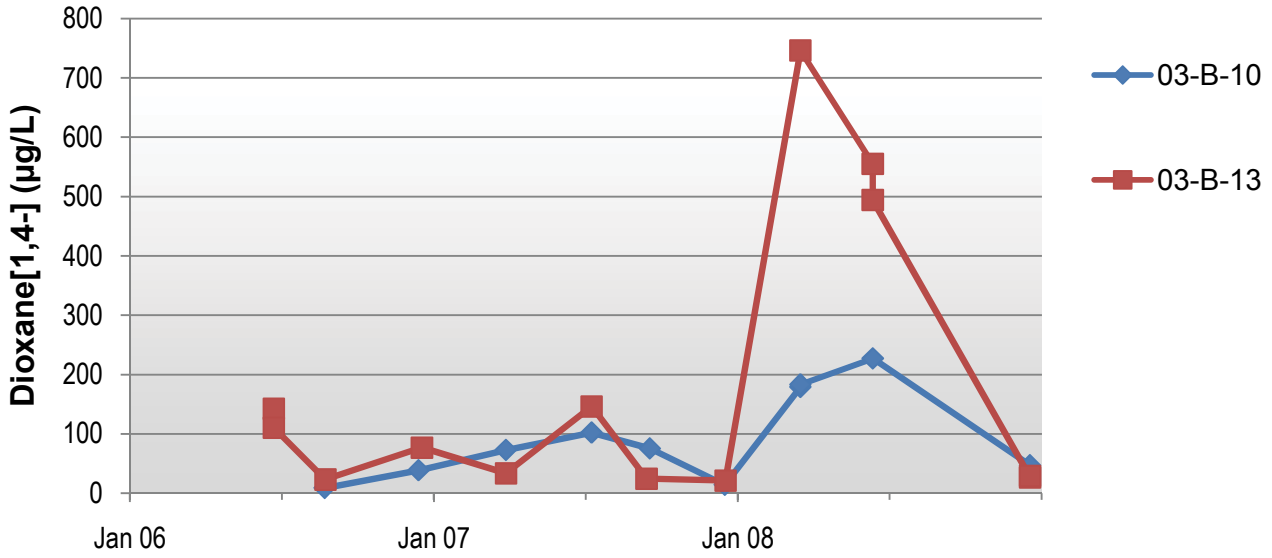


Figure 5-55. Histories at wells 03-B-10 and 03-B-13 for 1,4-dioxane measured by the SVOC method. The EPA Human Health tap water screening level is 61 µg/L.

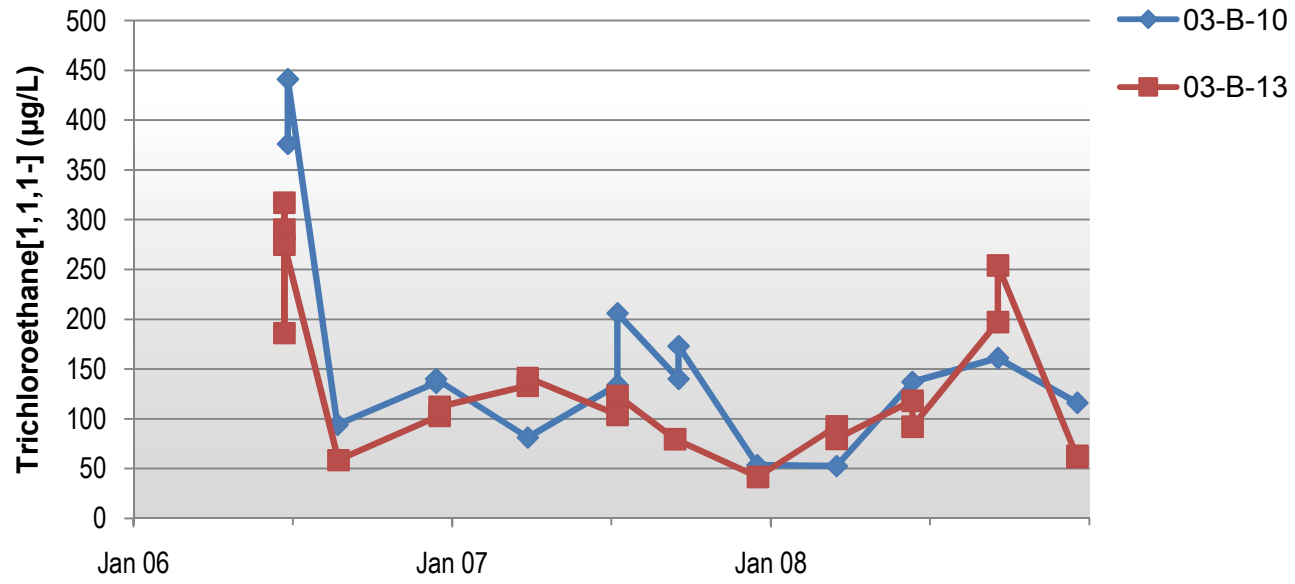


Figure 5-56. Histories at wells 03-B-10 and 03-B-13 for 1,1,1 –trichloroethane. The NM groundwater standard is 60 µg/L.

Several alluvial groundwater wells along Pajarito Road showed high chloride concentrations during 2008 (Figure 5-18, Figure 5-57). More frequent sampling in recent years shows a seasonal pattern of winter increase in concentrations of chloride, sodium, and TDS. Runoff related to road salting is the apparent cause. The highest chloride concentrations are above the NM groundwater standard of 250 mg/L, near the eastern Laboratory boundary at PCO-3.

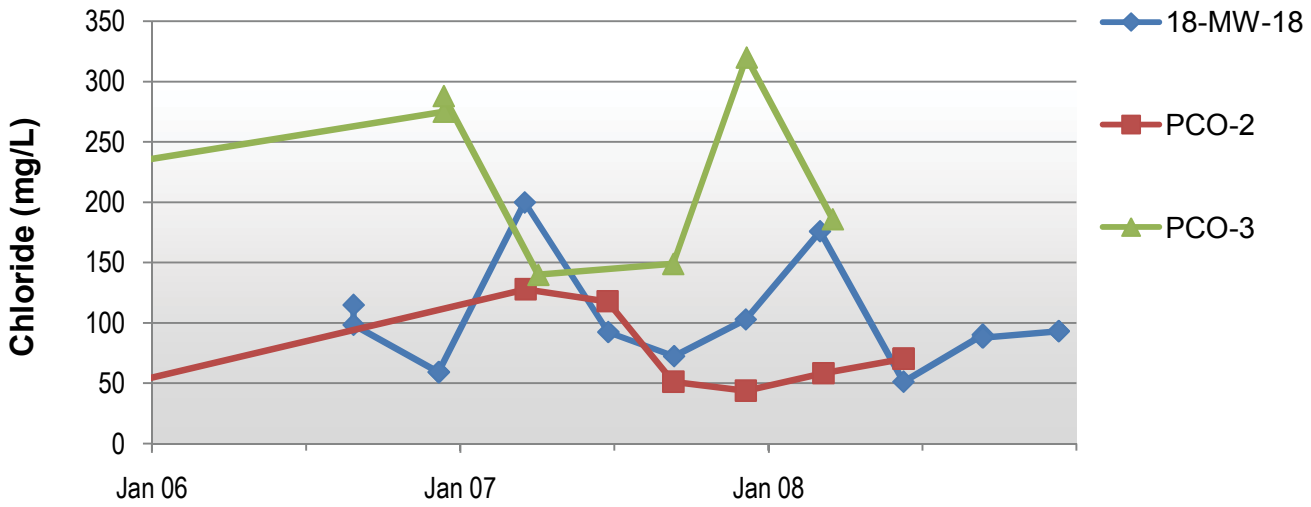


Figure 5-57. Histories for chloride in Pajarito Canyon alluvial groundwater. The NM groundwater standard is 250 mg/L.

6. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon and Cañon de Valle (a tributary) pass through the southern portion of LANL where the Laboratory conducts explosives development and testing. In the past, the Laboratory released wastewater into both canyons from several HE processing sites in TA-16 and TA-9 (Table 5-19). In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall from the High Explosives Wastewater Treatment Facility. This outfall discharges a much smaller amount of water that generally meets NPDES permit requirements. Alluvial groundwater in Cañon de Valle shows barium above 1,000 µg/L, the NM groundwater standard (Table 5-20, Figure 5-58), and RDX above the EPA Human Health tap water screening level of 6.1 µg/L (Figure 5-51). Intermediate perched groundwater in this area also shows RDX at concentrations above 6.1 µg/L. The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for testing of weapons system components. These three small canyons have surface water only in response to precipitation events and no known alluvial or intermediate groundwater.

Table 5-19
Summary of Groundwater Contamination in Water Canyon
(includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Cañon de Valle	Multiple dry and past effluent sources	Barium above, boron at 83%, and TDS at 51% of NM groundwater standards, RDX above EPA Human Health tap water screening level; tetrachloroethene and trichloroethene above and lead at 76% of EPA MCL screening level	Boron and nickel above NM groundwater standards, total chromium at 97% of EPA MCL screening level; RDX above EPA Human Health tap water screening level; tetrachloroethene at 32% and trichloroethene at 32% of EPA MCL screening level	Trace tetrachloroethene, RDX
Water Canyon	Multiple dry and past effluent sources	None, little alluvial groundwater	No intermediate groundwater	None
Potrillo, Fence, and Indio Canyons	Minor dry sources	No alluvial groundwater	No intermediate groundwater	None

Table 5-20
Groundwater Quality in Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Chemical	Location	Result	Trends
RDX	Regional aquifer well R-25	0.55 µg/L, below EPA Human Health tap water screening level of 6.1 µg/L	Likely present due to well construction delays in 2000; levels have decreased; present in only one regional port in 2008
Tetrachloroethene	Regional aquifer well R-25	0.34 µg/L, below EPA MCL screening level of 5 µg/L	Present for two years of sampling at shallowest regional port
Boron	Intermediate Martin Spring	892 µg/L to 1230 µg/L, above NM groundwater standard (for irrigation use) of 750 µg/L	Consistent with results collected over 18 year period; approximate 40% decrease since 2003
Nickel	Intermediate well R-25	338 µg/L, above NM groundwater standard of 200 µg/L	Similar results in shallowest port since 2001
Total chromium	Intermediate well R-25	97 µg/L, below EPA MCL screening level of 100 µg/L	High total results in shallowest port since 2004
RDX	Three intermediate springs, five wells or well ports	Up to 114 µg/L, above EPA Human Health tap water screening level of 6.1 µg/L	Present for 13 years of sampling at springs, during several years of sampling of wells
Tetrachloroethene	Two intermediate springs, four wells or well ports	0.4 µg/L to 1.6 µg/L, below EPA MCL screening level of 5 µg/L	Present for 13 years of sampling at springs, during several years of sampling of wells
Trichloroethene	Three intermediate springs, three wells or well ports	0.27 µg/L to 1.6 µg/L, below EPA MCL screening level of 5 µg/L	Present for 13 years of sampling at springs, during several years of sampling of wells
Bis(2-ethylhexyl)phthalate	Intermediate well CdV-16-2(i)r	4 µg/L, below EPA MCL screening level of 6 µg/L	First detect in five years, not found in field duplicate
Phenol	Intermediate well R-25	38 µg/L, above NM groundwater standard of 5 µg/L	Only sample ever taken at this port
Barium	Four alluvial wells in Cañon de Valle	3680 µg/L to 7,320 µg/L, above NM groundwater standard of 1,000 µg/L	Present at these levels for 11 years in Cañon de Valle wells
Boron	Alluvial well MSC-16-06293	623 µg/L, below NM groundwater standard (for irrigation use) of 750 µg/L	Lowest concentration of three samples since 2000
TDS	Alluvial well CDV-16-02655	509 mg/L, below NM groundwater standard of 1000 mg/L	Lowest concentration since 1998, previously up to 1000 mg/L
RDX	Four alluvial wells in Cañon de Valle	0.56 µg/L to 29 µg/L, above EPA Human Health tap water screening level of 6.1 µg/L	Present at these levels for 11 years
Tetrachloroethene	FLC-16-25280	193 µg/L, above EPA MCL screening level of 5 µg/L	Second sample in three years, results above prior values
Trichloroethene	FLC-16-25280	11.8 µg/L, above EPA MCL screening level of 5 µg/L	Second sample in three years, results much above prior values
Total Lead	FLC-16-25280	11.4 µg/L, below EPA drinking water system screening level of 15 µg/L	First measurement at well

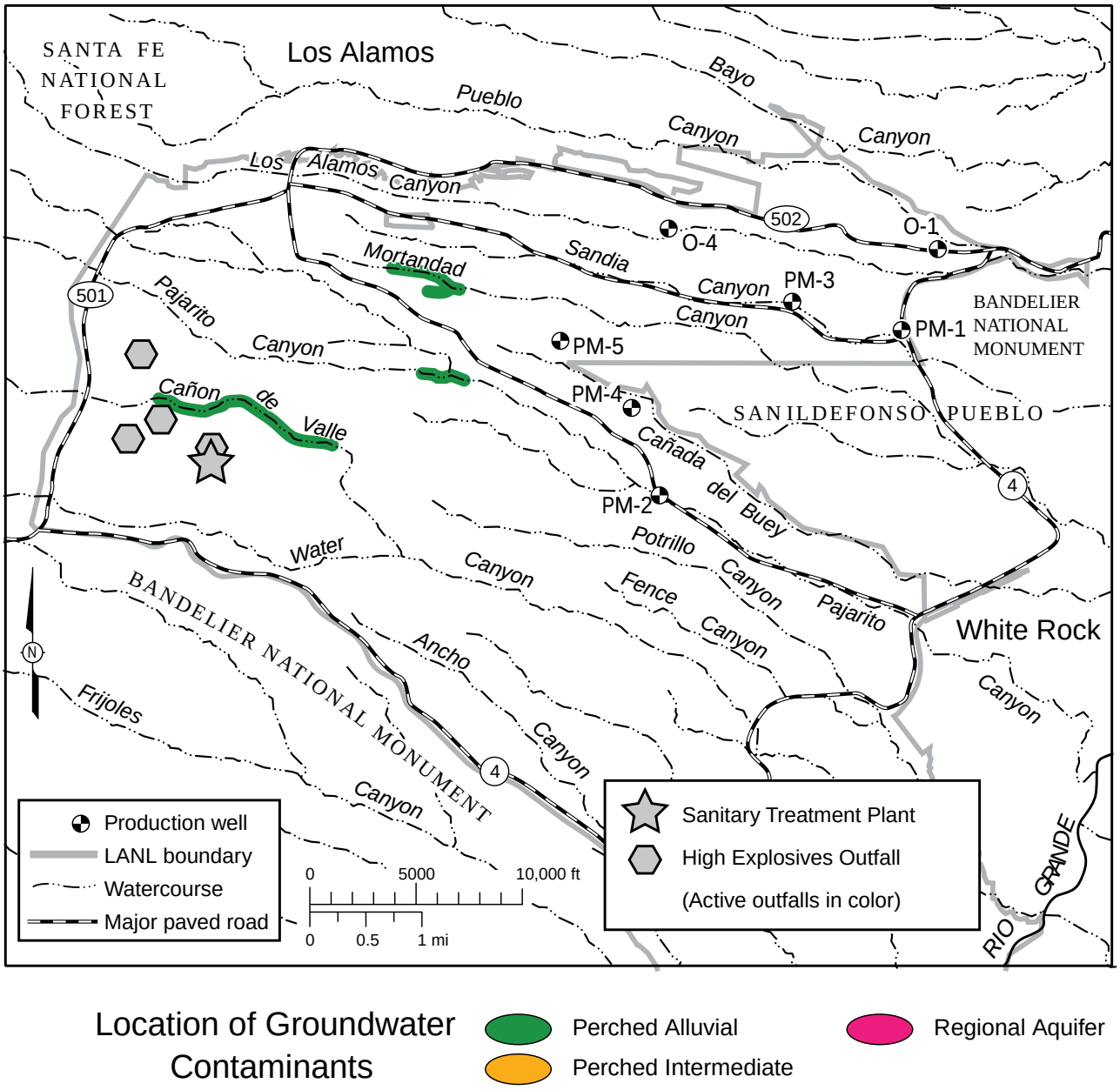


Figure 5-58. Location of groundwater containing barium above one half of the NM groundwater standard of 1,000 µg/L. Different colors indicate the affected groundwater zones.

Boron was found in samples from intermediate Martin Spring at concentrations above the NM groundwater standard for irrigation use, a reflection of past effluents (Figure 5-59). This spring is not used for irrigation.

The shallowest two screens at well R-25 (which sample intermediate groundwater) have shown high concentrations of metals such as nickel and chromium for several years. These screens were damaged during drilling of the well. In 2008 new wells were drilled to replace some of the upper R-25 screens.

Intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX was present at the highest concentrations compared to screening levels, above the 6.1 µg/L EPA Human Health tap water screening level (Figures 5-51, 5-60, 5-61, 5-62). The RDX levels have been fairly steady at most of these monitoring sites. The concentrations show some seasonal fluctuation, for example, at Martin Spring (Figure 5-62).

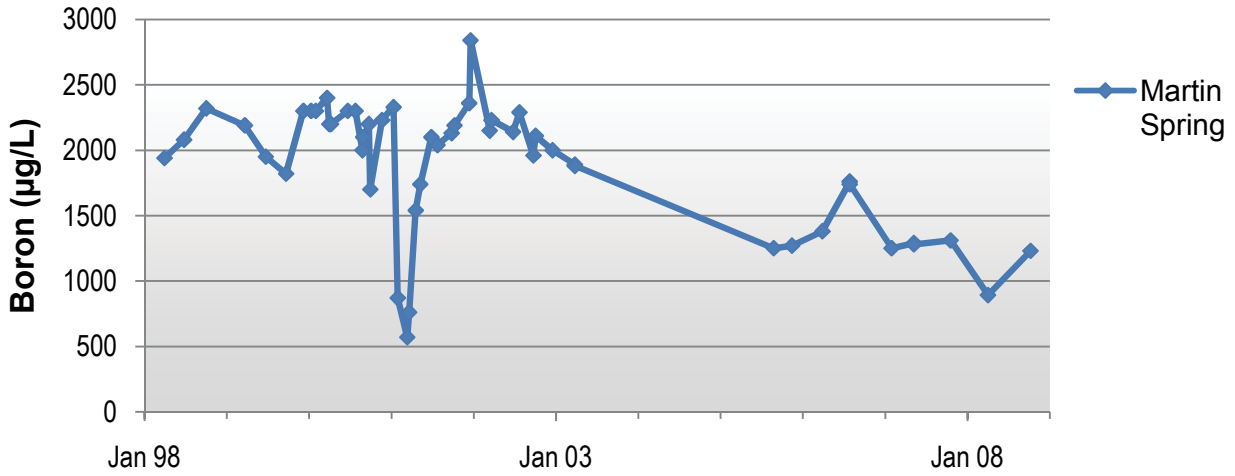


Figure 5-59. **Boron in Cañon de Valle intermediate groundwater. The NM groundwater standard (for irrigation use) is 750 µg/L.**

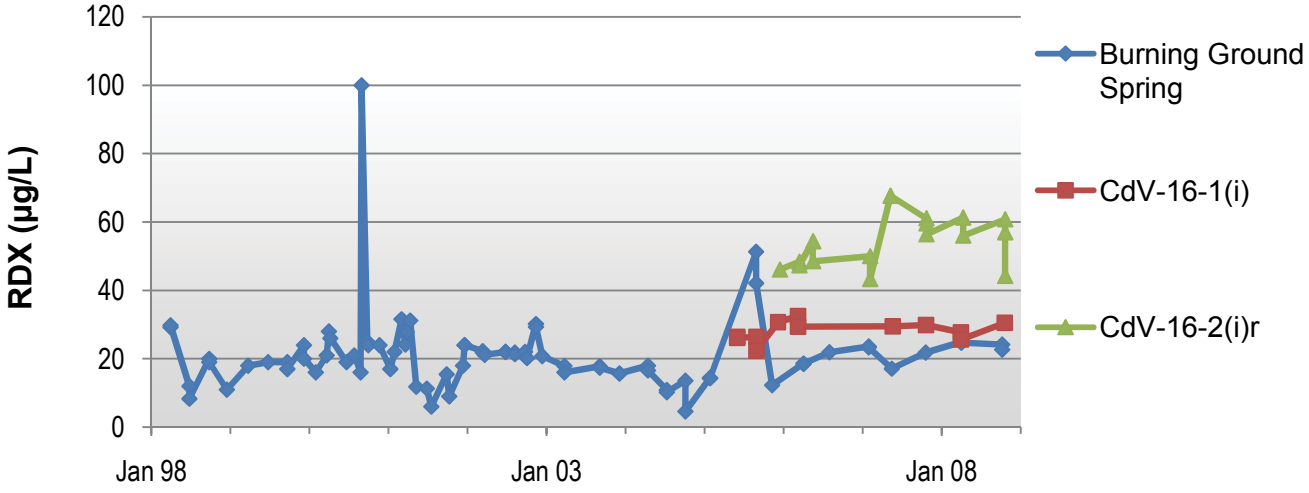


Figure 5-60. **RDX in Cañon de Valle intermediate groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.**

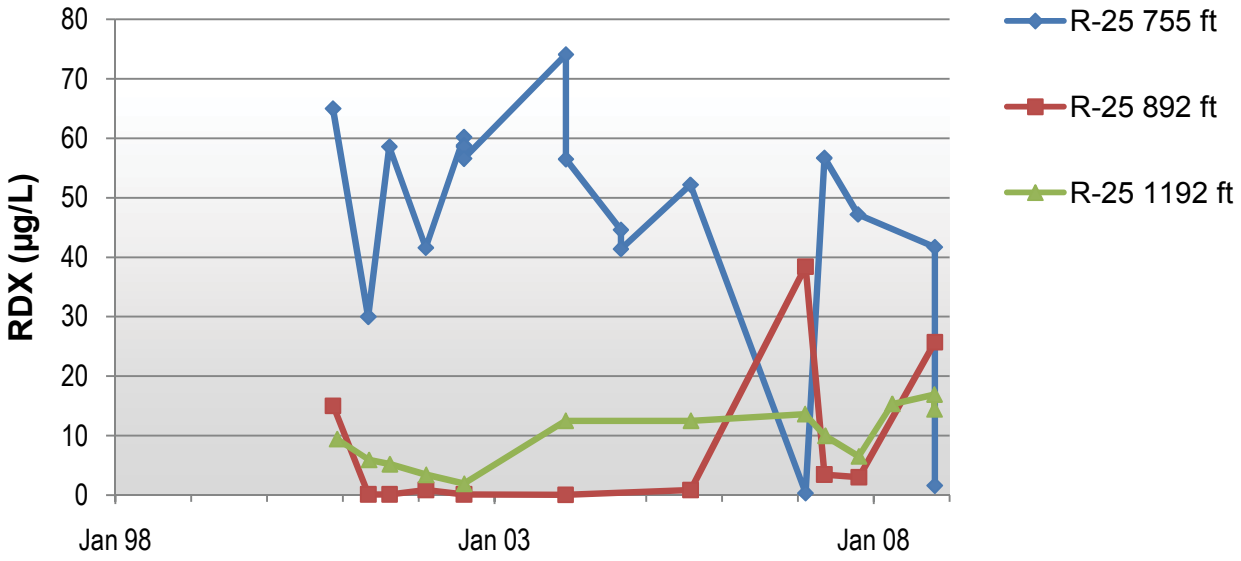


Figure 5-61. **RDX in Cañon de Valle intermediate groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.**

As seen in Figure 5-61, samples from the shallowest two screens at well R-25, which sample intermediate groundwater, may have been switched on February 7, 2007. The concentrations of RDX and other high explosive compounds at depths of 755 ft. and 892 ft. switched the trends for those screens in this sampling event, and continue at usual values in later events. On October 22, 2008 a low RDX result of 1.59 µg/L in the 755 ft. screen was caused by an analytical laboratory QA problem; the higher result of 41.7 µg/L from a diluted second analysis of the same sample is consistent with earlier results in that screen.

A different explanation may apply to the RDX result from the 892 ft. screen at R-25 for the October 22, 2008 sample. The concentration of 25.7 µg/L was higher than all earlier results except the February 7, 2007 value. This latest RDX result may reflect water from the 755 ft. perched zone that flowed down a nearby borehole and reached the 892 ft. screen. In 2008 two new wells were drilled about 40 ft. from R-25 to replace screens 1 and 3 (LANL 2008f, LANL 2008g). R-25c was drilled during July and August to 1140 ft. to replace the dry third screen of R-25; R-25c has a 20 ft. screen with top at 1039.6 ft. No groundwater was observed in the R-25c screen. R-25b was drilled during September to 786 ft. to replace the 755 ft. screen of R-25.

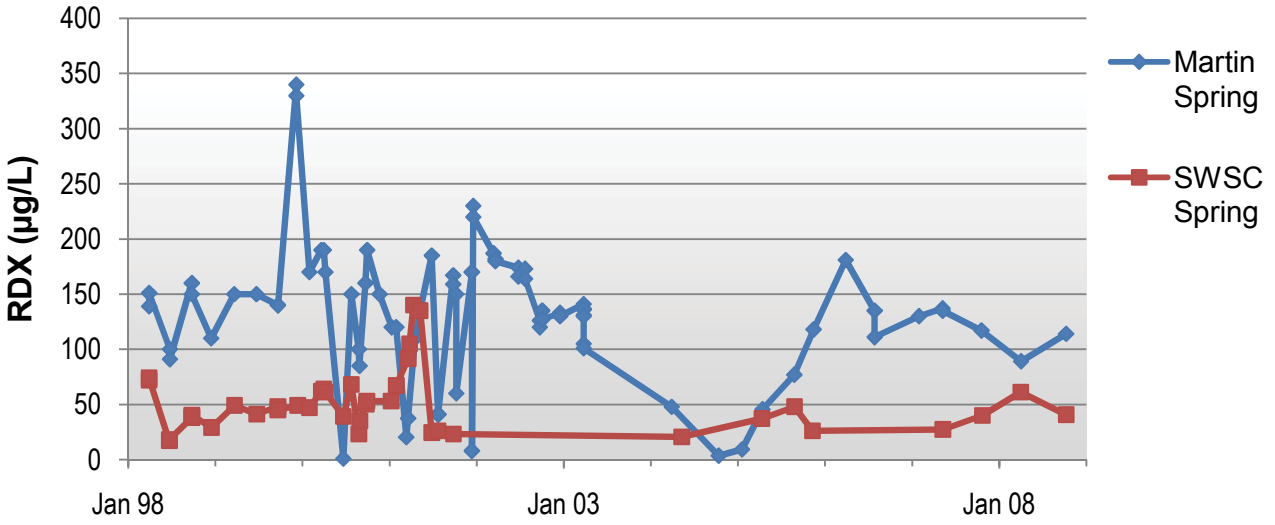


Figure 5-62. RDX in Cañon de Valle intermediate groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.

Compressed air was used to drill the new wells and large pressure responses were observed in the upper screens of R-25 during drilling of R-25c (Koch et. al 2009). During drilling of R-25c, the water level at the 755 ft. screen of R-25 declined, suggesting a loss of water from that perched zone through the R-25c borehole. The R-25 pressure fluctuations stopped when construction of R-25c was finished. During a subsequent slug test at R-25c, 966 gallons of water were lost, and water in the sump of R-25 screen 3, a dry screen, rose slightly. This movement of water suggests that the high October 2008 RDX results observed in R-25 at the 892 ft. screen reflect water moving in through the R-25c borehole from a shallower perched zone contaminated with RDX.

The chlorinated solvents tetrachloroethene and trichloroethene continue to be found in several intermediate wells and springs (Table 5-20).

Barium, present due to past HE wastewater discharges, exceeded the NM groundwater standard in several alluvial wells in Cañon de Valle (Figures 5-58, 5-63). These alluvial well samples also contained several HE compounds. As with intermediate perched groundwater, RDX was the HE compound present at the highest concentrations compared to risk levels, some above the 6.1 µg/L EPA Human Health tap water screening level (Figures 5-51 and 5-64).

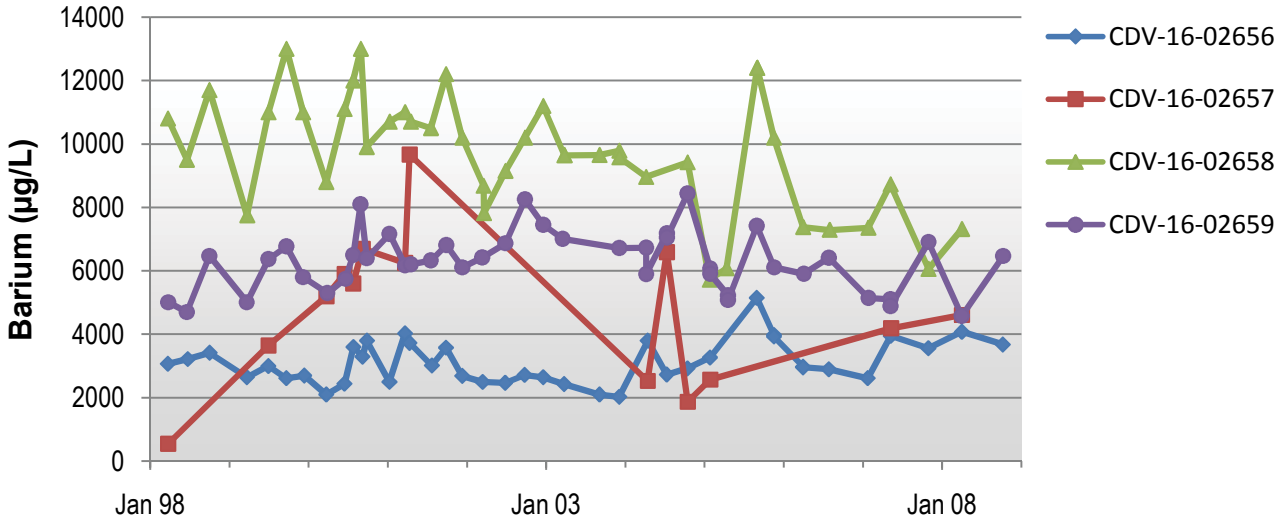


Figure 5-63. Barium in Cañon de Valle alluvial groundwater. The NM groundwater standard is 1,000 µg/L.

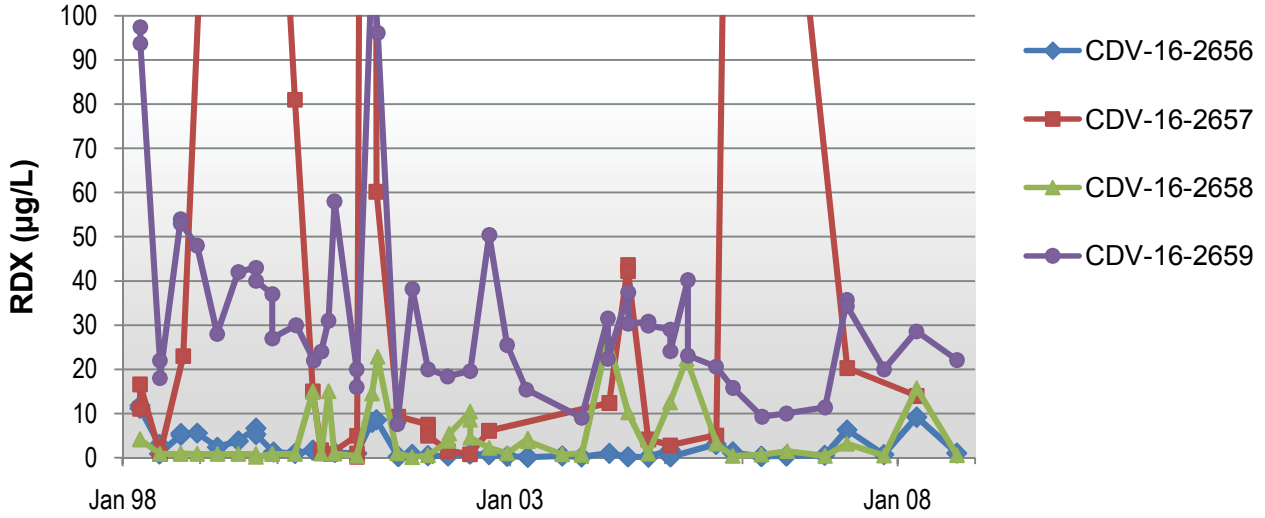


Figure 5-64. RDX in Cañon de Valle alluvial groundwater. The EPA Human Health tap water screening level is 6.1 µg/L.

The 2008 sample from alluvial well FLC-16-25280 in Fish Ladder Canyon contained high concentrations of tetrachloroethene (193 µg/L) and trichloroethene (11.8 µg/L). This is the second sample at this well; the previous sample was collected in 2006. Similarly high tetrachloroethene concentrations of about 40 µg/L have also been found in past samples from nearby Fish Ladder Spring. Otherwise, this is the highest tetrachloroethene concentration measured in groundwater samples at LANL, by nearly two orders of magnitude. The trichloroethene concentration measured at FLC-16-25280 is also among the highest measured. Both compounds are found in other groundwater samples in this part of LANL.

7. Ancho Canyon

Area AB at TA-49 was the site of underground nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved insufficient HEs and fissionable material to produce a nuclear reaction. The canyons in the watershed are mainly dry with little alluvial and no known intermediate groundwater. In 1960, the US Geological Survey drilled three deep wells (Test Wells DT-5A, DT-9, and DT-10) to monitor regional aquifer water quality. Another regional aquifer well, R-31, lies downstream from firing sites at TA-39. No contaminants were found in these wells at concentrations near or above standards (Table 5-21).

Table 5-21
Summary of Groundwater Contamination in Ancho Canyon

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
Ancho Canyon	Minor dry sources and past effluent sources	Little or no alluvial groundwater	No intermediate groundwater	None

8. White Rock Canyon Springs

The springs that issue along the Rio Grande in White Rock Canyon represent a principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al., 1980). The White Rock Canyon springs serve as boundary monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande (Table 5-22). A few springs such as Spring 2B appear to represent discharge of intermediate perched groundwater; that spring is supplied by municipal sanitary effluent discharge or irrigation with effluent from athletic fields near White Rock. Other springs may be a mixture of regional aquifer groundwater, intermediate perched groundwater, and recent percolation (Longmire et al., 2007).

Table 5-22
Summary of Groundwater Contamination in White Rock Canyon Springs

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: Springs	Sources in tributary canyons	No alluvial groundwater	Little intermediate groundwater	Natural fluoride, arsenic, uranium

Other than tritium, the only radionuclide detection of note in White Rock Canyon springs was natural uranium in La Mesita Spring (Table 5-23). Naturally occurring uranium is commonly detected in this spring and a few other nearby wells and springs. The tritium values in the White Rock Canyon springs are similar to results measured during the last decade. The highest results have been found at the Spring 4 group of springs. Activities there have decreased since 2002 and are now about 8 pCi/L at Spring 4 and Spring 4C and 27 pCi/L at Spring 4B. These springs discharge within a hundred yards of each other near the Rio Grande.

Table 5-23
Groundwater Quality in White Rock Canyon Springs

Chemical	Location	Result	Trends
Uranium	Regional aquifer La Mesita Spring, east of Rio Grande (Pueblo de San Ildefonso)	11.8 µg/L, below NM groundwater standard of 30 µg/L	Naturally occurring
Arsenic	Regional aquifer Spring 2 (Pueblo de San Ildefonso)	Up to 10.3 µg/L, above EPA MCL screening level of 10 µg/L; NM groundwater standard is 100 µg/L	Naturally occurring

Results for White Rock Canyon spring perchlorate samples collected in 2008 are consistent with prior data; concentrations are below background levels observed in sampling of NM groundwater by Plummer et al. (2006). The highest perchlorate value occurs east of the Rio Grande at La Mesita Spring on Pueblo de San Ildefonso land at a concentration of 0.85 µg/L. This spring also shows high nitrate and uranium values; it is not located near any apparent sources of contamination. Several of the springs in the Spring 4 series had perchlorate values of 0.5 to 0.7 µg/L, the highest concentrations for springs on the west side of the Rio Grande.

Spring 2 samples had fluoride concentrations at 0.95 mg/L, below the NM groundwater standard of 1.6 mg/L. The fluoride in this and nearby springs occurs naturally in groundwater near the Rio Grande and in the Española Basin.

9. Pueblo de San Ildefonso

This section covers results from Pueblo de San Ildefonso supply wells that lie near and east of the Rio Grande (Table 5-24). Other Pueblo de San Ildefonso wells and springs were covered in prior sections. The groundwater data for these wells and springs indicate the widespread presence of naturally occurring uranium at levels below the NM groundwater standard of 30 µg/L (Table 5-25). These measurements are consistent with previous samples. Naturally occurring uranium concentrations near or exceeding the NM groundwater standard are prevalent in well water throughout the Pojoaque area and Pueblo de San Ildefonso lands.

Table 5-24
Summary of Groundwater Contamination in White Rock Canyon Wells

Canyon	Contaminant Sources	Groundwater Contaminants		
		Alluvial	Intermediate	Regional
White Rock Canyon: San Ildefonso Pueblo and Buckman Well Field	None	No alluvial groundwater	No intermediate groundwater	Natural fluoride, arsenic, and uranium

Table 5-25
Groundwater Quality in White Rock Canyon Wells

Chemical	Location	Result	Trends
Uranium	Pueblo de San Ildefonso and Buckman regional aquifer supply wells	Up to 15 µg/L at Pueblo de San Ildefonso and 18 µg/L at Buckman Well field, below NM groundwater standard of 30 µg/L	Naturally occurring
Fluoride	Supply well Pajarito Well Pump 1 (Pueblo de San Ildefonso)	Up to 0.95 mg/L, below NM groundwater standard of 1.6 mg/L	Naturally occurring
Arsenic	Pueblo de San Ildefonso and Buckman regional aquifer supply wells	Up to 14.8 µg/L at Pueblo de San Ildefonso and 12 µg/L at Buckman Well field, above EPA MCL of 10 µg/L	Naturally occurring

10. Buckman Well Field

In 2008, we sampled three wells in the City of Santa Fe's Buckman Well Field (Table 5-24, 5-25). As in past samples, these wells contain natural uranium below the NM groundwater standard of 30 µg/L.

The water in some of these wells has high TDS, so concentrations of several chemicals including chloride are near or above NM groundwater standards or EPA health advisory levels. Naturally occurring metals such as arsenic and boron are also high in some wells.

H. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SEDIMENT ANALYSES

1. Introduction

Environmental sampling incorporated Quality Assurance (QA) in 2008 in accordance with DOE Order 414.1C, which prescribes a risk-based, graded approach to QA. To maximize effective resource use, this process promotes the selective application of QA and management controls based on the risk associated with each activity.

The LANL water quality database (http://www.racernm.com/) contains all the surface water and groundwater analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results were inconsistent with prior data, we investigated the laboratory records, and the sample may be reanalyzed or the location resampled. Both the initial sample and the follow-up sample analyses are kept in the database and are available to the public. In some cases, comments were appended to the records to indicate existence of recognized analytical issues. The primary documentation of analytical issues for data from a given year is provided in this report.

Negative values are sometimes reported in radiological measurements. Negative numbers occur because radiochemistry counting instrument backgrounds are subtracted from sample readings to obtain net counts. Because of slight background fluctuations, individual values for samples containing little or no activity can be positive or negative numbers. Although negative values do not represent a physical reality, removing negative values would introduce a positive bias to a data set, so we report them as they are received from the analytical laboratory as required by the "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991). Also see Appendix B.

The precision of radiological analytical results is reported as one standard deviation (one sigma) of the total propagated uncertainty. For most radionuclide measurements, we report a detection as an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (indicating nondetect). University of Miami tritium data do not have laboratory qualifiers; in which case, a detected result is reported when analytical results are greater than three times the reported (one-sigma) uncertainty.

For organic chemicals and some general inorganic chemistry parameters (that is, major anions, cations, and nutrients), the nondetections are reported at the practical quantitation limit (PQL). For the metals and the rest of the general inorganic chemicals, nondetections are reported at the MDL. Data between the MDL and PQL are qualified as estimated (J) by the analytical laboratory. The analytical laboratory reports nonradiological results below the MDL as nondetections.

The LANL analytic services Statement of Work (SOW) requires that analytical laboratories verify their calculated MDLs empirically. Federal regulations prescribe a process for determining analytical laboratory detection limits that uses standards based on deionized water. For analysis of environmental samples, these detection limits may not be achievable. The additional chemicals present in natural water samples may lead to matrix interference in the analytical process, which decreases the method sensitivity. Comparing results from these analyses with a detection limit based on deionized water will lead to additional false positive results for environmental samples. Empirical determination of detection limits using natural sample matrices produces a detection limit that is achievable for these samples.

In addition to data validation, LANL reviews results to assess the need for actions. In some cases, the data review identifies issues with data quality that require action to determine the overall quality of the reported results. Issues with data quality identified either through validation or data review are addressed in this section.

Because of the sensitive nature of organic chemical sampling and analysis, a carefully designed field and analytical laboratory quality control (QC) program is essential for evaluating the presence of organic chemicals in environmental samples. Organic chemicals may be detected in field QC samples such as field blanks or equipment blanks, indicating that they are not truly present in associated groundwater samples. These analytes may be present in the QC samples because of inadvertent contamination of sampling or analytical laboratory equipment by organic chemicals that come from other sources.

Most analytical methods require the analysis of laboratory-prepared method blanks or instrument blanks with each batch of samples. Target organic chemicals that are detected in these blanks indicate contamination from the sampling or analytical environments. Certain organic chemicals used in analytical laboratories are frequently detected in laboratory blanks; that is, contamination introduced by the analytical process is common for these compounds. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis(2-ethylhexyl)phthalate (Fetter 1993). Numerous field, trip, and equipment blanks collected during this reporting period contained toluene, acetone, methylene chloride, and 2-butanone, which indicated inadvertent sample contamination in either the field or analytical laboratory.

All analytical laboratory results are validated according to procedures based on the US EPA Contract Laboratory Program National Functional Guidelines for Data Review. An independent DOE contractor, Analytical Quality Associates, Inc. (AQA), of Albuquerque, NM, performs this secondary data validation. As necessary, AQA applies data qualifiers to the data.

In 2008, the majority of the data collected were not qualified by the analytical laboratory or in secondary data validation. The analytical laboratories qualified 6.4% of the data for potential data use issues; 55% of the data qualified by the analytical laboratory (3.5% of the total data) were qualified as J (estimated) because the results were between the quantitation and method detection limits. The remaining approximately 2.9% of the total data were qualified by the analytical laboratory for potential data quality reasons. After secondary data validation, by AQA, 97.4% of all results were of sufficient quality for use (i.e., 2.6% of the data was rejected in secondary data validation due to severe QC sample failures). Overall, 15% of the accepted results were qualified in secondary data validation as estimated (J flagged) for data quality reasons, including holding time violations, potential cross contamination, instrument calibration, and other reasons discussed in this section.

There are several interrelated components of the QA efforts in the groundwater and surface water programs:

- Ensuring the quality and consistency of work processes at LANL used to collect and ship samples and to assess and validate data.
- Use of field and laboratory QC samples to measure the quality of sample collection processes and analytical results.
- Qualification and performance assessment of analytical laboratories.
- Secondary validation of data packages.
- Audits and assessments of program and analytical laboratories.

2. Procedures for Work Processes

a. Methods

All sampling, data reviews, and data package validations were conducted using standard operating procedures that are part of a comprehensive QA program. The LANL quality program and procedures may be viewed at http://www.lanl.gov/environment/all/qa.shtml. Completed chain-of-custody forms serve as an analytical request form and include the requester or owner, sample number, program code, date and time of sample collection, total number of bottles, list of analytes to be measured, bottle sizes, and preservatives for each analysis required.

b. Results

Field quality assurance procedures and the quality plan documents were revised in 2006 and implemented for 2007 and 2008 sampling. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that processes perform satisfactorily.

See Supplemental Tables S5-14, S5-15, and S5-16 for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples, respectively, during 2008.

3. Quality Control for Samples and Analytical Results

a. Methods

All samples are analyzed at analytical laboratories authorized by the SOW for General Inorganic, Organic, Radiochemical, and Asbestos Analytical Laboratory Service. LANL requires all laboratories to produce legally defensible data packages which include the following types of QC samples and data: instrument raw data, initial and continuing calibration verifications, method blanks, internal standard recoveries, laboratory duplicates, laboratory control samples, and matrix spike samples. The results from these laboratory QC samples are used to check the accuracy and precision of the analytical data in secondary data validation by AQA.

The percentage of data qualified based on AQA's secondary data validation of laboratory QC samples is shown in Table 5-26.

Table 5-26
Secondary Data Validation Summary for 2008 Data

QC Sample Type	Number of Analytes Qualified as Estimated (J)	Percent 2008 Data
Blanks	738	0.5
Holding Times	2481	1.8
Initial Calibration Verifications or Continuing Calibration Verifications	7498	5.4
Interference Check Samples	49	0.03
Internal Standards or Surrogates	1275	0.9
Laboratory Control Samples	249	0.2
Laboratory Duplicates	64	0.05
Matrix Spike Samples	1502	1.1
Analyte Detected Between the Method Detection Limit And the Practical Quantitation Limit	4894	3.5
Serial Dilutions	36	0.03
Tracers (Radionuclides only)	27	0.02
Other		1.4
Percent Data Qualified as Estimated (J)		**15%**
QC Sample Type	Number of Analytes Qualified as Rejected (R)	Percent 2008 Data
Holding Times	57	0.04
Initial Calibration Verifications or Continuing Calibration Verifications	2619	1.9
Internal Standards or Surrogates	507	0.4
Laboratory Control Samples	115	0.1
Matrix Spike Samples	19	0.01
Other		0.21
Percent Rejected (R)		**2.6%**
QC Sample Type	Number of Analytes Qualified as Not Detected (U)	Percent 2008 Data
Blanks Percent Data Qualified as Not Detected (U)	1232	0.9%

In addition to the laboratory QC samples, field QC samples were submitted along with environmental samples so that field and analytical laboratory contamination could be tracked and analytical laboratory performance can be assessed. Field QC samples collected include equipment blanks, field blanks, field duplicates, field trip blanks, and performance evaluation blanks. Differences in analytical results between Field Duplicate samples, for example, may indicate that the samples were not uniform or that there was significant variation in analyses. Detection of target analytes in deionized water Field Blanks could indicate contamination of the deionized water source, sample bottles, or the analytical laboratory.

Equipment and Field Blanks: Equipment and field blanks were submitted for metals, organic chemicals, general inorganic, and radiochemistry analyses to monitor for contamination during sampling and decontamination of equipment. Contamination in the equipment and field blanks could be from either field contamination or contamination after sample collection. Any contamination in equipment or field blanks was reviewed to determine if a cause could be found.

Performance Evaluation Blanks: Performance evaluation blanks are deionized water blanks submitted as regular samples, without any indication that they are QC samples. These go through the same analytical process as the regular field samples. The deionized water blanks are measured with the same background contributions from reagents and biases as the regular samples, give an estimate of background and systematic analytical errors, and aid in the determination of false detections in associated environmental samples.

Field Trip Blanks: Trip blanks are a special case of performance evaluation blanks applicable to volatile organic compound measurements. They are kept with the samples from collection to analysis. Field trip blanks are used to help identify volatile organic compound cross-contamination that may occur during sample handling, shipping, and storage, or that may occur at the analytical laboratory.

Field Duplicates: Field duplicates are split samples that provide information about field variation of sample results as well as analytical laboratory variation. Field duplicates can indicate sampling techniques with poor reproducibility.

b. Results

In the secondary data validation, AQA rejected (R flagged) as unusable only 2.6% of the 2008 data. AQA qualified 15% of the 2008 results in secondary data validation as estimated (J flagged) for data quality reasons shown in Table 5-26. Less than 1% of the 2008 detected results was qualified as not detected (U) based on method blank contamination.

In 2008, American Radiation Services (ARS) analyzed 178 water samples for low-level tritium. AQA initially qualified 28% (49 results) as not detected (U, R4) because the sample result was over five times the concentration of tritium in the method blank. After determining that the ARS method blank results were approximately 10 times higher than usual because the laboratory method blank water was contaminated with tritium, these results have now been rejected (R flagged) because there is no usable method blank associated with these samples.

4. Qualification and Performance Assessment of Analytical Laboratories

a. Methods

The Laboratory is responsible for acquiring analytical services that support monitoring activities. The Statement of Work (SOW) for analytical services follows the National Nuclear Security Administration Service Center's Analytical Management Program's Model SOW. The SOW provides to the contract analytical laboratories the general QA guidelines and includes specific requirements and guidelines for analyzing surface water, groundwater, and sediment samples.

Analytical laboratories undergo a pre-award assessment to evaluate their ability to perform the needed analyses.

LANL requires most analytical laboratories to participate in independent national performance evaluation programs. These programs measure each laboratory's performance when analyzing analytes in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP) and other pertinent programs as available for the analytical methods conducted under contract with LANL. For 2008, GEL participated in both MAPEP and proficiency testing offered by Environmental Resource Associates.

b. Results

To provide access to additional laboratories and meet the requirements of the NMED Consent Order, LANL combined the analytical laboratory contracts with the contracts within the LANL Environmental Programs Directorate under control of the Sample Management Office (SMO). We included additional laboratories were added to address specific needs created by the Consent Order.

- To address the continuing requirement for analyses of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), LANL contracted with ALTA Analytical Laboratory. ALTA Analytical laboratory has since changed its name to Vista Analytical Laboratory of El Dorado Hills, California.

- Because the Consent Order requires the analyses of the biodegradation products of Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), LANL selected Severn-Trent Laboratories in Earth City, Missouri to do the analysis for mononitroso-RDX (MNX), dinitroso-RDX (DNX), and trinitroso-RDX (TNX) because of its previous experience with this method. Severn-Trent Analytical Laboratories has since changed its name to Test America, Inc. of Earth City, Missouri.

In 2008, other than the specialty laboratory analyses listed above, GEL Charleston, South Carolina, performed the majority of the analyses. GEL participated in many different performance evaluation studies that addressed a majority of the parameters for which they conduct analysis. There are no performance evaluation programs for the specialty analyses conducted at Vista Analytical Laboratory (dioxins and furans) and Test America, Inc. (RDX breakdown products). Therefore, performance on samples at Vista Analytical Laboratory and Test America was not assessed through performance evaluation programs.

Results for the applicable 2008 water performance evaluation programs at GEL are given in Table 5-27, and 2008 soil results are presented in Table 5-28. Only results that were found deficient are discussed.

Table 5-27
2008 Water Performance Evaluation Results at GEL

Evaluation	Analytes Affected	Results and Actions Taken
1st Quarter 2008 Performance Evaluations		
Water General Inorganics		
NY310	Chemical Oxygen Demand by EPA 410.4	This analyte was reported above the acceptance range. The Laboratory Control Sample was 98.7%. The laboratory duplicate would have also failed, even though the relative percent difference was 9.3%. A remedial sample from WP-158 was analyzed with acceptable results.
NY310	Chloride by EPA 300	This analyte was reported below the acceptance range. No reason to suspect any low recoveries. No anomalies were identified from this batch. All batch QC criteria were met.
Water Pesticides		
NY310	alpha-Chlordane by EPA 8081 Endrin Aldehyde by EPA 8081 Endosulfan II by EPA 8081	These analytes were reported as detected (false positives); the performance sample was not spiked with these analytes.
Water High Explosives (EPA 8330)		
WP-156	RDX by EPA 8330, RDX by EPA 8321, 3-Dinitrobenzene by EPA 8321, 3-Nitrotoluene by EPA 8321	These analytes were reported above the acceptance range. The comparison of 8330 and 8321 show similar results. Most analytes appear to be biased high. Interference can be seen on the RDX primary analysis. The 8330 confirmation value meets acceptance limits, as do all 8321 analytes at a dilution of 1:10. A more thorough inspection of the data will be conducted in the future. A remedial sample from WP-158 will be ordered.
2nd Quarter 2008 Performance Evaluations		
Water Metals		
NY312	Vanadium by EPA 200.8	Vanadium was reported at 1530 µg/L below the acceptance range of 2030–2480 µg/L. The sample was analyzed twice with similar results. All QC criteria were met for this analyte. No anomalies can be determined at this time. A remedial sample will be ordered for this parameter.
NY312	Chloride by EPA 300.0	Chloride was reported at 24.2 mg/L below the acceptance range of 25–31.7 mg/L. A duplicate sample was analyzed with similar results. All QC criteria were met for this analyte. No anomalies can be determined at this time. A remedial sample will be analyzed for this analyte.

Table 5-27 continued

Evaluation	Analytes Affected	Results and Actions Taken
2nd Quarter 2008 Performance Evaluations (continued)		
Water General Inorganics		
NY312	Bromoform by EPA 524.2	Bromoform was reported at 16.3 ug/L below the acceptance range of 18.1–27.1 ug/L. Anomalies were not noted with this data. A remedial sample will be ordered.
WP-158	Turbidity by EPA 180.1	Turbidity was reported at 3.39 mg/L below the acceptance range of 3.5–5.06 mg/L. A new turbidity meter was ordered in May 2008. ERA known lot P153–777 (207919) was analyzed and a value of 3.92 was reported. The true value was 3.88 with an acceptance range of 3.14–4.60.
Water Radionuclides		
RAD73	Cesium-137 by EPA 901.1, Cobalt-60 by EPA 901.1	These analytes were reported below the acceptance range. All of the gamma emitters failed at about the same percentage due to a dilution error. The dilution instructions for these performance evaluation samples were incorrect. Dilution instructions are now correct.
3rd Quarter 2008 Performance Evaluations		
Water General Inorganics		
NY315	Total Organic Carbon EPA 415.1	Total Organic Carbon was reported at 65.9 mg/L above the warning range of 52.2–64.6 mg/L. No corrective action reported.
NY315	Chloride by EPA 300.0, Total Kjeldahl Nitrogen by EPA 351.2, Total Phosphorus by EPA 365.4	These analytes were reported below the warning range. No corrective action reported.
Water Metals		
NY315	Titanium by EPA 6010/200.7	Titanium was reported at 207 µg/L below the warning range of 215–257 µg/L. No corrective action reported.
Water PCBs		
NY315	PCB-1248 by EPA 8082 or 608	PCB-1248 was reported at 2.17 µg/L below the warning range of 2.26-4.85 µg/L. No corrective action reported.
Metals Water		
NY317	Thallium by EPA 200.8	Thallium was reported at 2.3 µg/L below the acceptance range of 2.35-4.36 µg/L. The known value is only three times our Practical Quantitation Limit. The laboratory duplicate result was 3.1 ug/L and would have passed. The criterion for the laboratory duplicate was +/- 1.00 µg/L, which was met. There was no indication our result would be anything less than correct.
4th Quarter 2008 Performance Evaluations		
Pesticides Water		
MAPEP Study 19	Heptachlor	Heptachlor was reported at 1.04 µg/L below the acceptance range of 1.56–6.60 µg/L. No corrective action reported.

All other water analytes not shown in the table were acceptable.

Table 5-28
2008 Soil Performance Evaluation Results at GEL

Evaluation	Analytes Affected	Results and Actions Taken
1st Quarter 2008 Performance Evaluations		
Soil Metals		
MAPEP Study 18	Selenium	This analyte was reported above the acceptance range. The selenium failure was attributed to instrument sensitivity.
Soil Pesticides		
MAPEP Study 18	Heptachlor	This analyte was reported as not detected (false negative). The performance evaluation sample was spiked with this analyte. A review of the raw data showed a small peak eluting within the Heptachlor retention time window on the primary column and co-eluting with another peak on the confirmation column.
Soil Semivolatile Organic Analytes		
MAPEP Study 18	Benzo(a)anthracene and chrysene	This analyte was reported as not detected (false negative). The performance evaluation sample was spiked with this analyte. A false negative result was reported for Benzo(a)anthracene and a false positive result was reported for Chrysene. The relative retention time for Benzo(a)anthracene was 0.999 and for Chrysene 1.001. The unknown peak in the performance evaluation sample had a retention time of 0.999 and should have been identified as Benzo(a)anthracene.
MAPEP Study 18	Hexachlorobenzene	This analyte was reported below the acceptance range. A low result was reported for Hexachlorobenzene. A review of the raw data did not reveal any anomalies. The peak was correctly identified and integrated. The Calibration Verification Standard indicated the instrument was within control limits. The low recovery may be attributed to the extraction (although the surrogate recoveries were within control limits).
Soil Radionuclides		
MAPEP Study 18	Americium-241 and Cesium-134	These analytes were reported below the acceptance range. Two containers, 10 grams and 100 grams, for the performance evaluation sample were received and logged in for all parameters. The Americium-241 result was reported from the 100 gram container. The gamma spectroscopy analyses should have been performed from the 10-gram container because of possible matrix interferences and the potential for analyte volatilization from the 100-gram container.
Soil Metals		
NY 310	More than 80% of the metal target analytes for the soil sample analyzed by EPA Method 6010 failed acceptance criteria.	The sample spattered during the digestion process due to the makeup (nature) of the sample. Using a smaller sample size, the sample was re-digested prior to the performance evaluation study closing. The performance evaluation data system would not accept the revised results. An acceptable rating would have been received for all analytes in the re-digested sample. A remedial sample will be analyzed.
NY310	Mercury by EPA 245	This analyte was reported above the warning range. No reason to suspect a possible high result. The QC passed. No anomalies could be determined for this batch. All batch QC criteria were met.

Table 5-28 continued

Evaluation	Analytes Affected	Results and Actions Taken
Soil Semivolatile Organic Analytes (EPA Method 8270)		
NY310	More than 80% of the semivolatile organic target analytes for the soil sample analyzed by EPA Method 8270 failed acceptance criteria.	It was discovered that the extracts were switched during extractions. This sample was switched with the MAPEP 18 (205760). Soil 62 was analyzed as a remedial test. Acceptable results were reported.
Soil Herbicides (EPA Method 8151)		
NY310	2,4,5-T, 2,4-D, 2,4-DB, Dicamba, Dinoseb, 2,4,5-TP (Silvex)	These analytes were reported below the acceptance range. The failures were caused by a poor extraction. While the batch QC parameters were within the acceptance range, all recoveries were low. A remedial performance evaluation sample will be ordered for these parameters.
3rd Quarter 2008 Performance Evaluations		
Soil PAHs		
NY 315	Anthracene by EPA 8310	Anthracene was reported at 833 ug/kg above the acceptance range of 34.6–381 ug/kg. The lab reported 83.3 ug/kg. However when the result was entered via the Web, the decimal point was not entered. The error was not caught during the review.
Pesticides Soil		
NY 315	Endrin aldehyde by EPA 8081	Endrin aldehyde was reported as not detected (false negative) when the sample was spiked with a concentration of 51.5 ug/kg. The lab reported 22 ug/kg which was less than the RDL, so <50 was reported.
Soil Volatile Organic Analytes		
NY 315A	More than 80% of the 8260 compounds in soil were rated unacceptable.	The analyst did not correctly spike the performance evaluation sample. The analyst was retrained.
4th Quarter 2008 Performance Evaluations		
Metals Soil		
MAPEP Study 19	Mercury	Mercury was reported at 0.0239 mg/kg above the acceptance range of 0.0117--0.0217 mg/kg. The sample laboratory duplicate would have passed the audit with a 0.0178 mg/kg result. The matrix spike was 90% recovery. No anomalies noted.
Pesticides Soil		
MAPEP Study 19	Endosulfan I, Endosulfan II, Endrin Ketone	These analytes were reported as detected (false positives). The performance sample was not spiked with these analytes. These compounds were detected at low concentrations. The peak was very small. The lab consulted with a Quality Officer and together the decision was made to report the results. Sample clean-up may have removed some of the co-eluting matrix interference.

All other soil analytes not shown in the table were acceptable

For the first quarter of 2008, GEL failed two EPA Methods for the soil performance evaluation sample from the Environmental Laboratory Approval Program (ELAP) January 2008 Non-potable Water/Solid and Chemical Materials/Air and Emissions Chemistry Proficiency Test #310. The following failures were noted:

- More than 80% of the metal target analytes for the soil sample analyzed by EPA Method 6010 failed acceptance criteria. GEL noted that this performance evaluation sample spattered during the digestion process due to the nature/makeup of the sample. This sample was then re-digested using a smaller sample size prior to the closing of the performance evaluation study but the performance evaluation system would not accept the revised results. An acceptable rating would have been received for all elements in the re-digested sample. Another performance evaluation sample (LPTP08-S1 study) was also analyzed by GEL during this time frame and acceptable results were reported for all target analytes.
- More than 80% of the semivolatile organic target analytes for the soil sample analyzed by EPA Method 8270 failed acceptance criteria. After a reanalysis of the extract, GEL discovered that the soil extract was switched during extraction with another sample (MAPEP 18 205760). Another performance sample (Soil 62) was analyzed as a remedial performance evaluation sample. Acceptable results were reported for Soil 62.

In the third quarter of 2008, GEL had another method failure for the soil performance evaluation sample for the Environmental Laboratory Approval Program (ELAP) July/August 2008 Non-potable Water/Solid and Chemical Materials/Air & Emissions Chemistry Proficiency Test #315. The following failure was noted:

- More than 80% of the volatile organic target analytes for the soil sample analyzed by EPA Method 8260 compounds failed acceptance criteria. After reviewing the data for this performance evaluation sample, GEL determined that the analyst did not correctly spike the sample. The analyst was retrained.

5. Validation of Data Packages

a. Methods

LANL verifies all analytical data used to support monitoring activities are verified to ensure they are defensible and of known quality. Analytical data packages sent to us by the analytical laboratories undergo a rigorous review and validation process following the guidelines set in the DOE-AL Model standard operating procedure for data validation, which includes review of the data quality and the documentation's correctness and completeness. Tables S5-5, S5-6, and S5-7 include the list of qualifiers and validation reason codes used to qualify the 2008 sediment and water data. When documentation or contract-compliance problems are identified during data validation, we contact the analytical laboratory and attempt to resolve or clarify the problem.

b. Results

AQA validated all of the 2008 data packages. Individual validation memos were issued for each analytical fraction (method) for each data report. The average report had five data validation memos. AQA issued a number of nonconformance reports (NCRs) for data validation memos that had to be reissued. Most of the NCRs were written in response to problems concerning minor documentation and typographical errors on individual memos. These reports were corrected and reissued. Associated sample results were generally not affected.

In 2008, documentation or contract-compliance problems required the largest analytical services provider, GEL, to issue package-specific NCRs. Most of the NCRs written in response to these problems concerned requests for clarification on data results and missing pages in the data packages. GEL reissued corrected documents for all of the reports containing missing documentation or erroneous data.

6. Department of Energy Contract Analytical Program Audits

a. Methods

The Office of Environmental Management at DOE Headquarters (HQ-EM) mandated participation in the DOE Contract Analytical Program (DOECAP; https://doecap.oro.doe.gov/). DOECAP is a consolidated, uniform audit program for conducting annual audits of commercial laboratories to eliminate audit redundancy

by involving all DOE program line organizations and field elements, provide a pool of trained auditors sufficient to support consolidated audits, standardize terms and conditions of existing and proposed contracts to allow acceptance of consolidated audit results, and interface with state and federal regulatory agencies, as well as other industry standard-setting groups, such as the National Environmental Laboratory Accreditation Conference. LANL requires participation in DOECAP for all major analytical providers. Smaller or specialty providers are audited following the LANL Waste and Environmental Services Division QA Program.

Table 5-29 below shows the DOECAP audits conducted for 2008 for analytical laboratories used for analyses of all water and sediment samples.

Table 5-29
DOECAP Audits Conducted in 2008 for Analytical Laboratories used by LANL

Laboratory	Audit Type	Audit Dates
Vista Analytical Laboratory, El Dorado Hills, California	Annual Qualifications Audit	February 19–20, 2008
Paragon Analytics, Fort Collins, Colorado	Annual Qualifications Audit	March 18–20, 2008
Test America, Inc. Earth City, Missouri	Annual Qualifications Audit	April 22–24, 2008
GEL, LLC, Charleston, South Carolina	Annual Qualifications Audit	May 6–8, 2008
American Radiation Services, Inc., Port Allen, Louisiana	Annual Qualifications Audit	July 22–24, 2008

DOECAP audits result in findings and observations when there are items of concern that need to be addressed in the audit report. The DOECAP Policies and Practices document defines the following findings and observations:

- A Priority I finding is only issued for a significant item of concern or significant deficiency regarding key management/programmatic control(s), which in and of itself represents a concern of sufficient magnitude to potentially render the audited facility unacceptable to provide services to the DOE if not resolved via immediate and/or expedited corrective action(s).
- A Priority II finding is issued to document a deficiency which in and of itself does not represent a concern of sufficient magnitude to render the audited facility unacceptable to provide services to the DOE.
- An observation provides the DOECAP with a mechanism for identifying and tracking a deficiency of an isolated nature or lesser significance than that of warranting an issuance of a Priority II finding, as well as an opportunity for improvement identified during a DOECAP audit.

b. Results

The following DOECAP audits were conducted at facilities providing water and sediment data to the Water Stewardship Program:

- Paragon Analytics, Fort Collins, Colorado: This audit occurred on March 18–20, 2008. There were 14 previous Priority II findings that were closed, and two remain open. There were nine new Priority II findings issued. Eight new observations were identified. The corrective action plan has been approved and is available from the DOECAP website.
- Severn Trent (Test America, Inc.), Earth City Missouri: This audit occurred on April 22–24, 2008. There were no previous open Priority II findings. Two previous Priority II findings were closed, and none remain open. One new Priority I finding was issued. Two new Priority II findings were issued. Fourteen new observations were identified. The corrective action plan has been approved and is available from the DOECAP website.
- GEL, LLC, Charleston, South Carolina: This audit occurred May 6–8, 2008. There were thirteen previous Priority II findings that were closed, and one remains open. Four new Priority II findings were

issued. Thirteen new observations were identified. The corrective action plan has been approved and is available from the DOECAP website.

- American Radiation Services, Port Allen, Louisiana: This audit occurred July 22–24, 2008. This DOECAP audit found that ARS meets established requirements necessary to produce data of acceptable and documented quality through analytical operations that follow approved and technically sound methods. DOE samples and analysis-derived waste are handled in a manner that is protective of human health and the environment.
- Vista Analytical Laboratory, El Dorado Hills, California: This audit of EPA Method 1668 Revision A, Chlorinated Biphenyl Congeners in Water, Soil, Sediment and Tissue by HRGC/HRMS occurred February 19–20, 2008. There were four findings and nine observations. The corrective action plan has been approved and is available from the DOECAP website.

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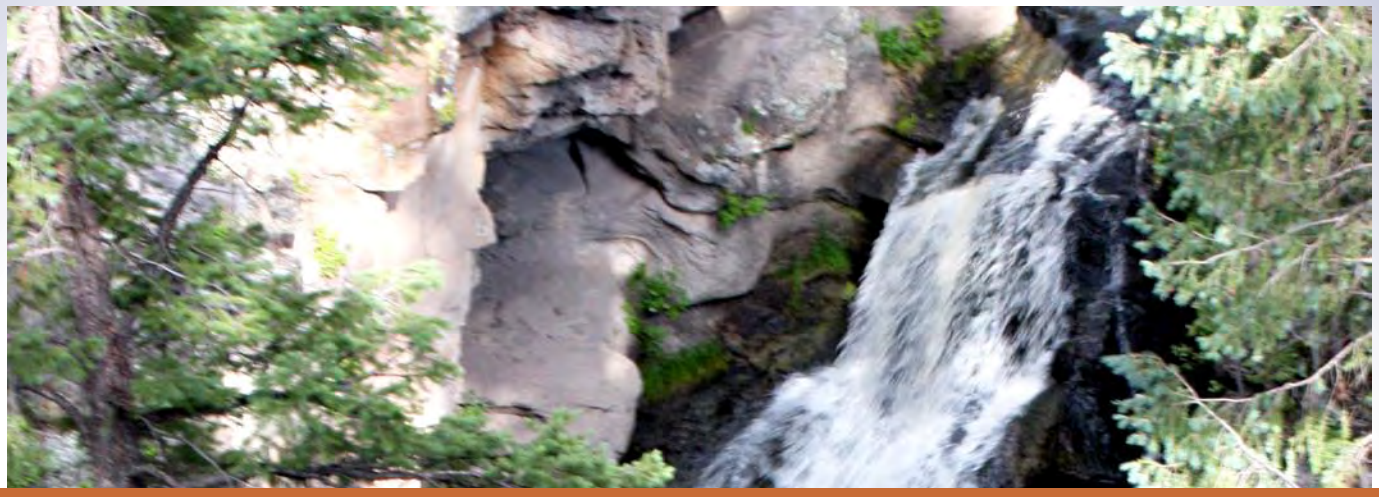
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6. Watershed Monitoring



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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) monitors the quality of surface water, including storm water, and stream sediment in northern New Mexico to evaluate the potential environmental effects of Laboratory operations on affected watersheds. The Laboratory collects and analyzes samples for a variety of parameters, including radionuclides, inorganic and organic chemicals, and general chemistry of surface water. In this chapter, the effects of Laboratory operations on surface water and stream sediment are evaluated geographically and over time. Additionally, the sampling results are compared with screening criteria established to protect human health and the aquatic environment.

Surface water monitoring and assessments at the Laboratory increased substantially after 2005 following agreements with federal and state regulatory agencies that require widespread monitoring of both perennial and ephemeral stream flows for an extensive list of constituents. As a result, increased sampling of base flow or persistent surface water has resulted from the March 1, 2005, Compliance Order on Consent (the Consent Order) with the New Mexico Environment Department (NMED). This sampling is described in the annual Interim Facility-Wide Groundwater Monitoring Plan (LANL 2008a). Additionally, increased sampling of storm water and snowmelt runoff resulted from the Federal Facility Compliance Agreement (FFCA) and Administrative Order with the US Environmental Protection Agency (EPA) (EPA 2005a, b). The FFCA sampling is described in the annual Storm Water Pollution Prevention Plan (SWPPP) (LANL 2008b). In 2008, surface water sampling was conducted at more than 160 different locations, yielding a substantial amount of water quality data.

B. HYDROLOGIC SETTING

The Laboratory includes parts or all of seven primary watersheds that drain directly into the Rio Grande, each defined by a master canyon (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 western Jemez Mountains (the Sierra de los Valles), mostly within the Santa Fe National Forest, while the remainder head on the Pajarito Plateau. Only the Ancho Canyon watershed is entirely located on Laboratory land. Canyons that drain Laboratory property are dry for most of the year, and no perennial surface water (i.e., water that is present all year) extends completely across Laboratory land in any canyon. Approximately two miles of canyons on Laboratory land have streams that are naturally perennial, fed by springs, and approximately three miles have perennial streams created by effluent discharges.

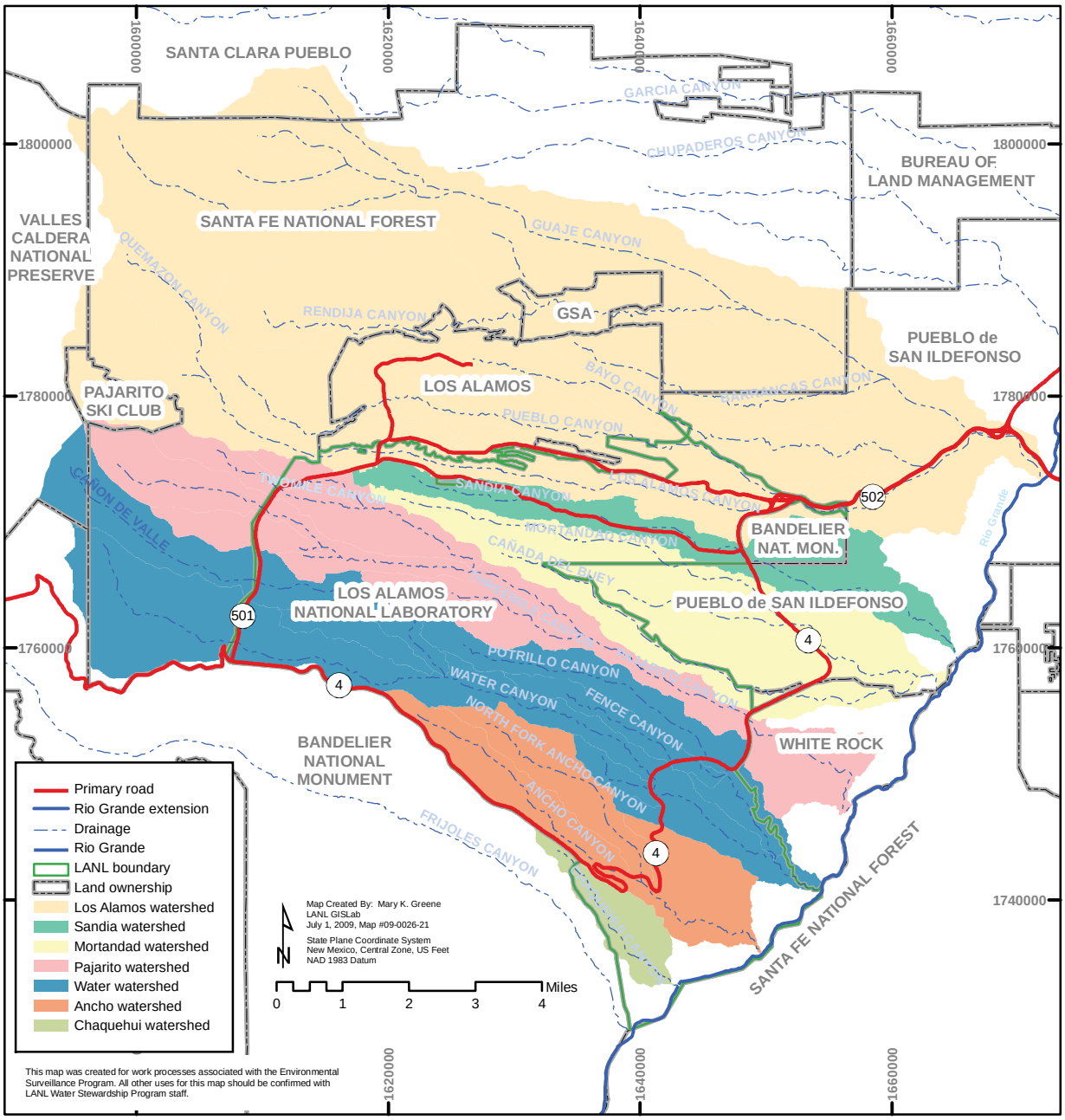


Figure 6-1. Primary watersheds at Los Alamos National Laboratory.

The remaining stream channels are dry for varying lengths of time. The driest segments flow only after local precipitation events or during snowmelt periods, and the stream beds are always above the water table. The flow in these streams is ephemeral. Other streams sometimes have the water table higher than the stream bed and/or experience extensive snowmelt runoff and are considered intermittent. Intermittent streams may flow for several weeks to a year or longer.

To aid in water quality interpretation, we consider three basic types of stream flow. At times, the flow might represent a combination of several of these flow types:

- Base flow—persistent stream flow but not necessarily perennial water. This type of flow is generally present for periods of weeks or longer. The water source may be springs, effluent discharge, or alluvial groundwater that emerges along stream beds.
- Snowmelt runoff—flowing water present because of melting snow. This type of water may be present for up to a month or more and in some years may not be present at all.
- Storm water runoff—flowing water present in response to rainfall. These flow events are generally very short lived, with flows lasting from less than an hour to—rarely—several days.

Because base flow and snowmelt runoff can be present for extended periods of time, they may be available for potentially longer-term exposures, such as when wildlife use them for watering. Storm water runoff may provide a short-term water source for wildlife, particularly when it collects in bedrock pools or other local depressions, although water quality will improve at these locations over time as the suspended sediment settles out. Storm water runoff in particular is capable of transporting Laboratory-derived constituents associated with sediment particles off-site and possibly into the Rio Grande.

None of the streams within the Laboratory boundary averages more than one cubic foot per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs, although two storm events in 2008 resulted in estimated combined mean daily runoff from LANL canyons of about 18 cfs on January 28–29 and about 15 cfs on August 4, as discussed below. By comparison, the average daily flows in the Rio Grande at Otowi Bridge on those days were about 774 and 970 cfs, respectively, or approximately 50 to 65 times higher than the flows from LANL. Although most of the streams at LANL are dry throughout the year, occasional floods can redistribute sediment downstream. Excluding effluent, stream flow in 2008 on the Pajarito Plateau was dominated by snowmelt runoff from January through June in some of the larger canyons that head in the Sierra de los Valles, with smaller amounts of storm water runoff events in the summer and early fall. Total runoff measured at downstream gages in the canyons leaving the Laboratory was estimated at about 197 ac-ft with about 35 ac-ft from the rain-on-snow event in January, 118 ac-ft from other snowmelt runoff, and 44 ac-ft from storm water runoff in the summer and early fall. In addition, approximately 130 ac-ft of effluent released from the Los Alamos County wastewater treatment plant (WWTP) is estimated to have passed the eastern LANL boundary in Pueblo Canyon. The estimated volume of storm water runoff in the summer and fall of 2008 was the least since 1995, the first year for which runoff estimates are available for all the canyons. Figure 6-2 shows the estimated storm water runoff at LANL from June through October and the seasonal precipitation since 1995.

A rain-on-snow event on January 28–29, 2008, resulted in flow across the eastern LANL boundary or New Mexico State Highway 4 (NM 4) in several canyons, including Ancho, Los Alamos, Pajarito, Potrillo, Pueblo, Sandia, and Water Canyons and Cañada del Buey. Total runoff past these stations is estimated at about 35 ac-ft, or roughly 18% of the total runoff in 2008. Because this was a short-duration runoff event involving rainfall, it is different from normal snowmelt runoff. In subsequent sections, the samples from this event are therefore evaluated as storm water in the screening level comparisons.

The snowmelt in 2008 resulted in stream flow in Pajarito Canyon extending from the Jemez Mountains (the Sierra de los Valles), across LANL, and into White Rock intermittently between mid-February and mid-April. The estimated total volume of runoff measured in Pajarito Canyon above the Laboratory's eastern boundary during this period was about 88 ac-ft, or about 40% of the total estimated runoff from the Laboratory in 2008. Snowmelt runoff was also measured at the eastern Laboratory boundary in Los Alamos and Pueblo Canyons.

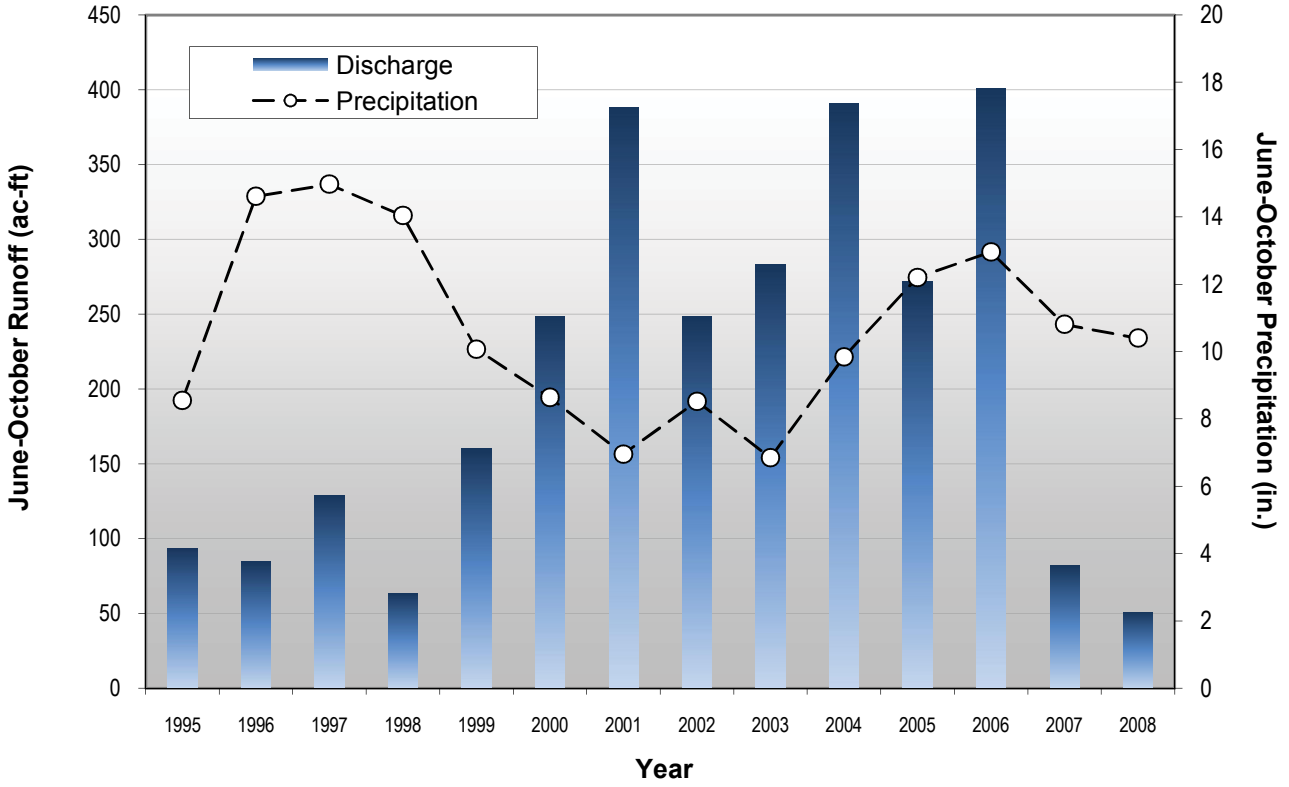


Figure 6-2. Estimated storm water runoff in LANL canyons (Pueblo Canyon to Ancho Canyon) and precipitation at TA-6 during the months of June through October from 1995 through 2008.

The most notable precipitation event at LANL in 2008 occurred on August 4, when the meteorological station at Technical Area (TA)-49, at the head of the Ancho Canyon watershed, recorded the highest precipitation totals ever measured at LANL for a range of durations from 15 minutes to 24 hours. Over one inch of rain fell in a 15-minute interval, and three inches fell over a four-hour period. The one-hour to three-hour rainfall amounts (2.42 to 2.88 inches) have estimated return periods of 200 years or longer using either a locally derived precipitation-frequency relation (Reneau et al. 2003) or a regional precipitation-frequency atlas (Bonnin et al. 2006), which means that this much rain or more is expected to fall at that location only once in a 200 year period. The peak discharge estimate at stream gage E275 in Ancho Canyon following this storm was the largest on record at that station, 537 cfs, with total estimated discharge of 30 ac-ft. We collected sediment samples from new deposits resulting from this event to evaluate the effects of this flood. These samples are discussed in later sections.

A break in a fire suppression water line at TA-21 occurred on July 4–5, 2008 and released approximately 3.9 million gallons of potable water (1.3 ac-ft) that flowed over solid waste management unit (SWMU) 21-027(a), eroding sediment on the canyon wall and transporting it into the bottom of Los Alamos Canyon. Runoff events in August 2008 transported some of this sediment downstream to the Los Alamos Canyon weir. The Laboratory first partially stabilized the sediment deposits below SWMU 21-027(a) in July 2008 and then again after the August 2008 runoff events.

C. SURFACE WATER AND SEDIMENT STANDARDS AND SCREENING LEVELS

Table 6-1 summarizes the standards, screening levels, and comparisons used to evaluate the monitoring data. For brevity, they are all commonly referred to as "screening levels" in this chapter. The surface water screening levels include biota concentration guides (BCGs), water quality standards, risk-based screening levels, and water screening action levels (wSALs). The wSALs were established under the FFCA and are presented in the

Laboratory's annual SWPPP (LANL 2008b). The suite of screening levels for surface water varies, depending on the stream flow conditions and established or potential uses, as discussed below in Section C.1. Results for sediment are compared with background concentrations, human health risk-based screening levels, and BCGs. Because some of the criteria are not for current uses, actual impacts can be less than indicated by these comparisons. For example, use of livestock watering standards is required by New Mexico regulations, although there are no livestock at the Laboratory except for some feral, trespassing cows grazing at low elevations near the west bank of the Rio Grande. In addition, risk-based screening levels for drinking water are included for consistency with other evaluations at the Laboratory, although use of surface water at LANL for human drinking water is highly unlikely.

1. New Mexico Surface Water Standards

The New Mexico Water Quality Control Commission (NMWQCC) establishes surface water standards for New Mexico in Standards for Interstate and Intrastate Surface Waters (NMWQCC 2005). Certain watercourses may be 'classified' and have segment-specific designated uses. A designated use may be an attainable or an existing use (e.g., wildlife watering, aquatic life) for the surface water. Nonclassified surface water may be described as ephemeral, intermittent, or perennial, each of which also has corresponding designated uses. The designated uses for surface water are associated with use-specific water quality criteria, including numeric criteria. Some of the standards are for total concentrations, which are compared to data from non-filtered surface water samples. Other standards are for dissolved concentrations, which are compared to data from filtered samples.

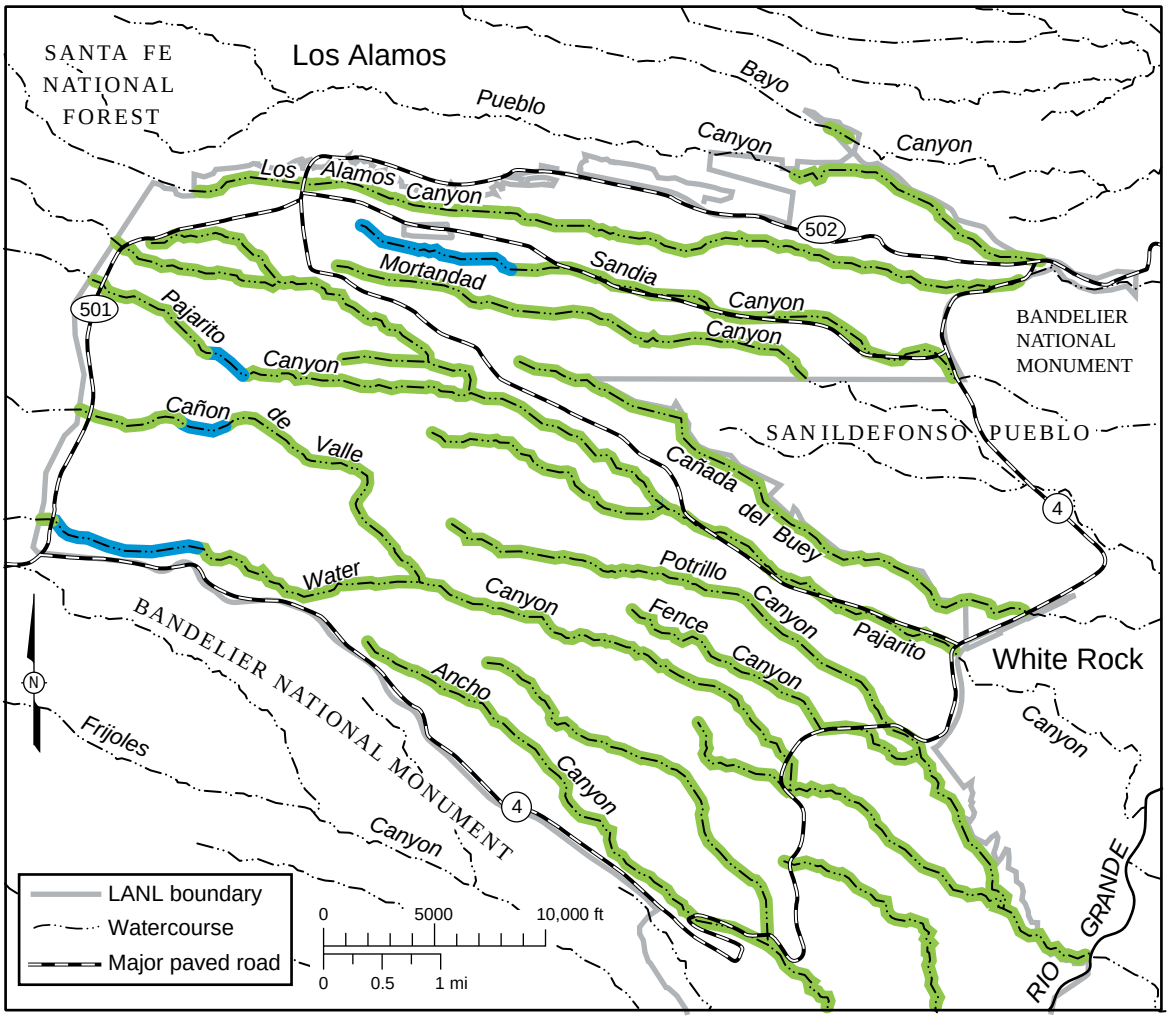
The NMWQCC classified all surface water within the Laboratory boundary with segment-specific designated uses (NMWQCC 2005) (Figure 6-3). Four stream segments are classified as perennial, with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact. Three of these segments are spring-fed (Cañon de Valle, Pajarito Canyon, and Water Canyon), and the fourth is supplied by treated sanitary effluent (Sandia Canyon). The remaining stream segments are classified as ephemeral or intermittent, with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact.

Surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. While direct use of the surface water is minimal within the Laboratory, stream flow may extend beyond the LANL boundary where the potential is greater for more direct use of the water. Stream flows sometimes extend onto Pueblo de San Ildefonso land, particularly flows in Pueblo Canyon derived from treated sanitary effluent discharged from the Los Alamos County WWTP. Spring water may be used traditionally and ceremonially by Pueblo de San Ildefonso members and may result in exposure through ingestion or direct contact.



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

Media and Analyte Type	Standard	Screening Level	Reference	Notes
Surface Water, Radionuclides and Radioactivity	New Mexico gross alpha water quality standard for surface water	Biota Concentration Guides (BCGs) and Derived Concentration Guidelines (DCGs)	DOE (1990, 2002, 2004)	Surface water is generally present sporadically or is not available for long-term access and does not provide persistent drinking water. The actual exposure pathway is to plants and animals and not to humans. BCGs are based on 1 rad/day exposure limit for aquatic animals and terrestrial plants, and 0.1 rad/day for terrestrial animals. Comparison with radionuclide criteria is based on time-weighted average over the year per DOE guidance (DOE 2003). DCGs based on 100 mrem/yr are included for completeness, although use of surface water at LANL for drinking water is highly unlikely.
			20.6.4 NMAC NMWQCC (2005)	Based on the protection of livestock watering for radium-226 + radium-228, tritium, and gross alpha radiation. NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, single sample results are compared with numeric criteria. The gross alpha standard excludes alpha radiation from source, special nuclear, and byproduct material regulated by the Atomic Energy Act.
Surface Water, Nonradionuclides	New Mexico water quality standards for surface water	wSALs	20.6.4 NMAC NMWQCC (2005) EPA (2005a) LANL (2008e)	Single sample results are compared with screening levels based on water quality standards and wSALs.
		Tap water screening levels	EPA (2009)	Single sample results in base flow and snowmelt runoff are compared with risk-based tap water screening levels (converted to 10^{-5} risk level for carcinogens per NMWQCC guidance), although use of surface water at LANL for drinking water is highly unlikely.
Sediment, Radionuclides	None	Human health screening levels	LANL (2005a)	Screening action levels (SALs) are derived to determine if more detailed assessment is needed to evaluate potential impacts to the public; comparisons in this report are made for recreational exposure parameters. SALs are based on a dose rate limit of 15 mrem/year. Recreational SALs are appropriate for Laboratory lands because of public access. There are no residential uses of LANL lands, and residential use is impractical at many locations (e.g., active floodplains in canyon bottoms).
		BCGs	DOE (2002, 2004)	Dose limit to biota same as for surface water. Individual results compared with BCGs.
		Background	Ryti et al. (1998) or McLin and Lyons (2002)	Results from Pajarito Plateau stations are compared with plateau-specific background levels. Results from regional stations are compared with background levels specific to major rivers and reservoirs within the Rio Grande drainage system.
Sediment, Nonradionuclides	None	Human health screening levels	LANL (2007a)	Recreational or industrial screening levels derived to determine if more detailed assessment is needed to evaluate potential impacts to the public.
		Background	Ryti et al. (1998)	Results for metals from Pajarito Plateau stations are compared with plateau-specific background levels. There are no established background levels for metals in major rivers and reservoirs within the Rio Grande drainage system and no established background levels for organic chemicals on or off the Pajarito Plateau.



Stream Type Designated Uses

Perennial (NM 20.6.4.126): Coldwater Aquatic Life, Livestock Watering, Wildlife Habitat, Secondary Contact

Ephemeral and Intermittent (20.6.4.128): Limited Aquatic Life, Livestock Watering, Wildlife Habitat, Secondary Contact

Perennial

Ephemeral and Intermittent

Figure 6-3. Major drainages within Los Alamos National Laboratory land, showing designated stream segments and uses.

2. Radionuclides in Surface Water

US Department of Energy (DOE) Order 5400.5 prescribes total dose limits associated with exposure to radionuclides in environmental media. Because of the limited extent of stream flow, 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 to aquatic organisms, rather than to humans, although human health screening levels are included for completeness. For protection of biota, concentrations of radionuclides in surface water are compared with the DOE BCGs (DOE 2002, 2004), with site-specific modifications by McNaughton et al. (2008). DOE Derived Concentration Guidelines (DCGs), calculated based on a target dose limit of 100 mrem/yr, are used as a human health screening level for base flow and snowmelt runoff. For screening purposes, single sample results are first compared with BCGs and DCGs to identify if radionuclides at a location

pose a potential risk to biota or humans. Following DOE guidance (DOE 2003), final evaluations of potential risk at these locations use annual time-weighted radionuclide content of the water rather than individual sample results. Surface water analytical results for gross alpha radiation, radium isotopes, and tritium are also compared with the NMWQCC standard for protection of livestock watering use, which is a designated use for surface water within the Laboratory boundary (NMWQCC 2005). NMWQCC standards are not specific about exposure frequency or duration. Therefore, for screening purposes, single sample results are compared with numeric criteria for these analytes, as discussed in Section C.3. It should be noted that the gross alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act, and the gross alpha radiation data discussed in this chapter were not adjusted to remove these sources of radioactivity.

3. Nonradioactive Constituents in Surface Water

Surface water concentrations of nonradioactive constituents are compared with screening levels that correspond to the designated uses for the stream, as discussed in Section C.1. Hardness-dependent aquatic life numeric criteria from NMWQCC (2005) are calculated using a water hardness value of 100 mg $CaCO_3$/L (EPA 2006). For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life in perennial stream segments, the Laboratory uses the protocol employed by NMED for assessing standards attainment in New Mexico (NMED 2006). For designated perennial stream segments, single sample results are compared with the chronic screening level, which is 1.5 times the chronic aquatic life criterion (NMWQCC 2005). Tap water screening levels (EPA 2009) are used as human health screening levels for base flow and snowmelt runoff, consistent with other evaluations at the Laboratory (e.g., LANL 2008c, 2009). EPA values are converted using a target risk level of 10^{-5} for carcinogens per NMWQCC (2005).

4. Sediment

Sediment analytical results are compared with screening levels to identify concentrations that may require further assessment. The Laboratory uses human health screening action levels (SALs) to identify radionuclides of interest (LANL 2005a). Comparisons with SALs are used to determine if more detailed evaluations are required. Recreation is the dominant use in canyon bottoms along streams at the Laboratory, and recreational SALs provide the most appropriate comparison to sediment data. Concentrations of nonradioactive compounds in sediment are compared with recreational soil screening levels (SSLs) developed by LANL (2007a). All of these screening levels are protective because they are calculated based on the assumption that humans are exposed to the chemicals or radionuclides for extended periods of time, which is not the case on LANL property because of the restricted access. Sediment data from the Pajarito Plateau are also compared with established plateau-specific background concentrations of metals or radionuclides that are naturally occurring or result from atmospheric fallout (Ryti et al. 1998; McDonald et al. 2003) and sources other than LANL. Radionuclide data from regional sediment stations are compared with background levels established for major drainages of the area: the Rio Grande, the Rio Chama, and the Jemez River (McLin and Lyons 2002; McLin 2004). There are no established background levels for metals along these regional rivers, and results upriver and downriver from LANL are compared to evaluate possible impacts. Also, there are no established background levels for organic chemicals and all detected results are compared with screening levels.

D. SAMPLING LOCATIONS AND DATA ANALYSIS METHODS

1. Regional Monitoring Locations

Regional base flow and sediment sampling stations (Figure 6-4) are located in northern New Mexico outside of the Laboratory boundary. Samples from upriver regional stations reflect baseline concentrations and provide a basis for evaluating potential Laboratory impacts to the Rio Grande drainage system. In 2008, LANL collected regional sediment samples from stations on the Rio Grande, from Abiquiu Reservoir on the Rio Chama, and from Cochiti Reservoir on the Rio Grande. Sampling stations in the Rio Grande drainage system are located up to approximately 37 mi (60 km) upriver of the Laboratory.

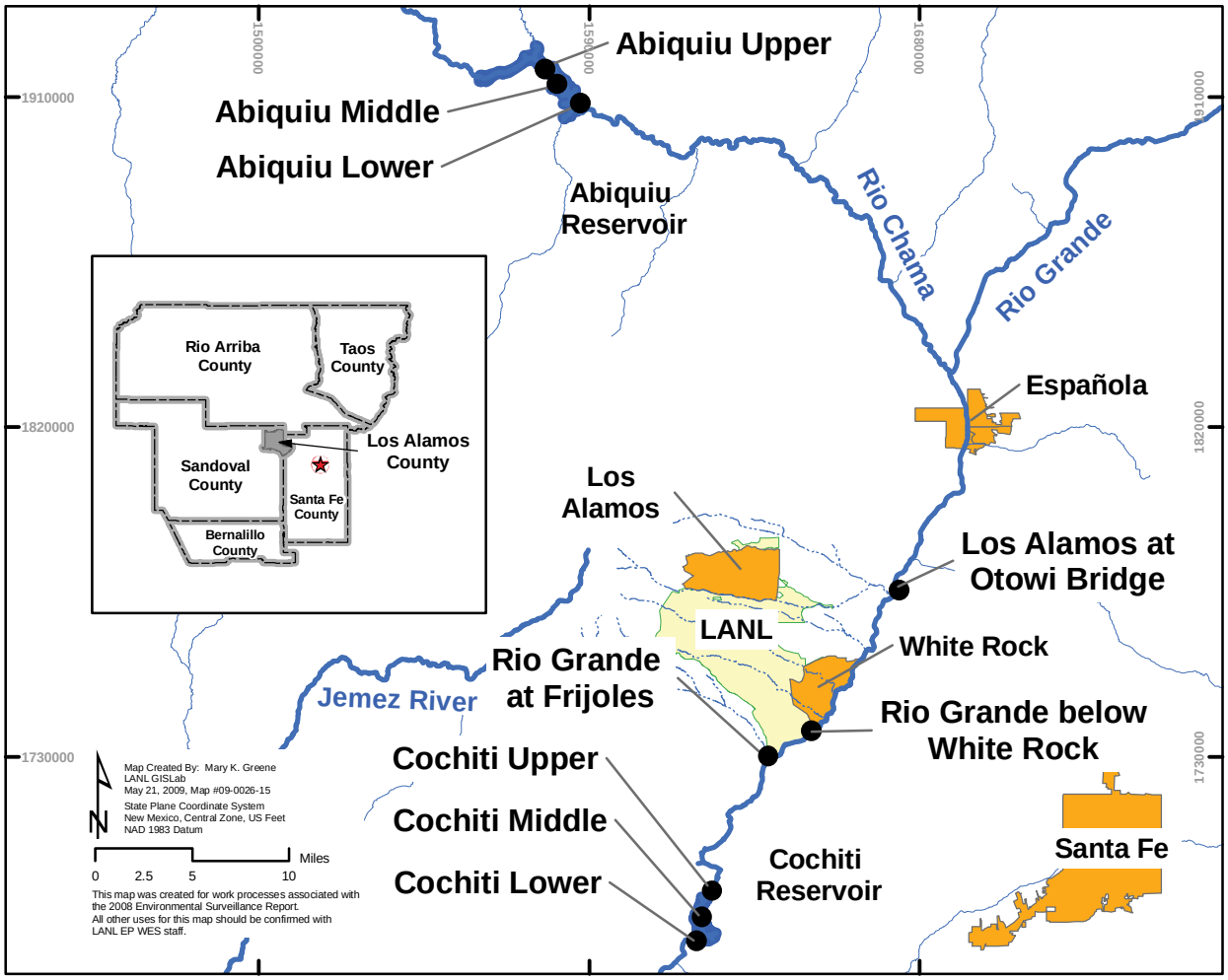


Figure 6-4. Regional base flow and sediment sampling locations.

2. On-Site and Perimeter Monitoring Locations

Surface water and sediment are sampled in all major canyons that cross current or former Laboratory lands. Stream channel sediment is sampled to evaluate the accumulation of potential contaminants in the aquatic environment (DOE 1991). LANL collects surface water samples across the Pajarito Plateau within and near the Laboratory, with particular emphasis placed on monitoring close to and downstream of potential Laboratory contaminant sources, such as at the downstream Laboratory boundary or NM 4. These samples include base flow grab samples from locations where effluent discharges or natural springs maintain stream flow.

LANL collects storm water runoff samples in streams at stream gages using automated samplers (Figure 6-5). Many gages are located near where drainages cross the Laboratory's eastern boundary or NM 4. Base flow, snowmelt runoff, or persistent surface water are also sampled at some gages and at other locations along stream channels (Figure 6-6). Storm water runoff is also sampled at many mesa-top and hillside sites (site monitoring areas [SMAs]), which allows the Laboratory to evaluate runoff from specific Laboratory sites (Figure 6-7). The SMAs usually have negligible runoff from other sources, although some receive runoff from paved areas in the Los Alamos town site and may include non-LANL contaminants. Four of the surface water sampling locations at the Laboratory in 2008 were from designated perennial stream segments, as discussed in Chapter C.1 and shown on Figure 6-3. These locations are in Cañon de Valle below Material Disposal Area (MDA) P (now removed) (gage E256), Sandia Canyon below the wetland (gage E123), middle Sandia Canyon at the terminus of persistent base flow, and lower "Starmer Gulch" (the south fork of Pajarito Canyon; gage E242).

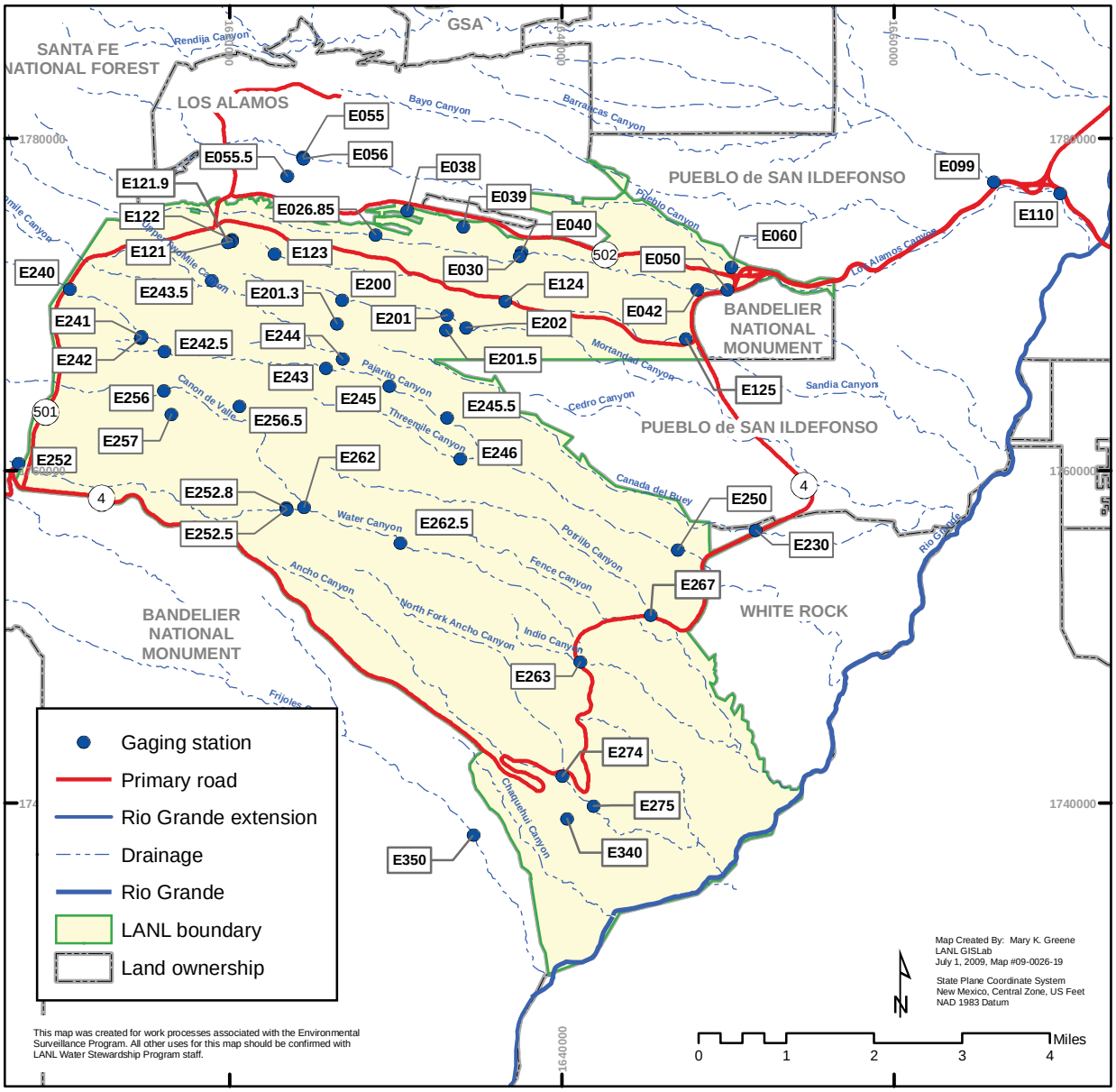


Figure 6-5. Stream gages sampled in 2008 within and in the vicinity of Los Alamos National Laboratory.

Sediment stations on the Pajarito Plateau and vicinity (Figure 6-8) are located within approximately 8 km of the Laboratory's boundary, with the majority located within the Laboratory's boundary. Many of the annual sediment sampling stations on the Pajarito Plateau are located within canyons to monitor sediment in the active channel related to past and/or present effluent discharges. LANL has completed or is in progress on more extensive evaluations of sediment, including both active channel and floodplain sediment deposits, in several canyons (LANL 2004a, 2006a, 2007b, 2008f, 2009a; Reneau et al. 2004). These evaluations complement the active channel sampling at these annual sediment stations.

LANL also collected sediment in 2008 from short tributary drainages to Cañada del Buey and Pajarito Canyon below and within MDA G at TA-54 (Figure 6-9), which is an active waste storage and disposal area. Sampling stations were established outside its perimeter fence in 1982 to monitor possible transport of radionuclides from MDA G. Metals and organic chemicals are also sampled at these locations.

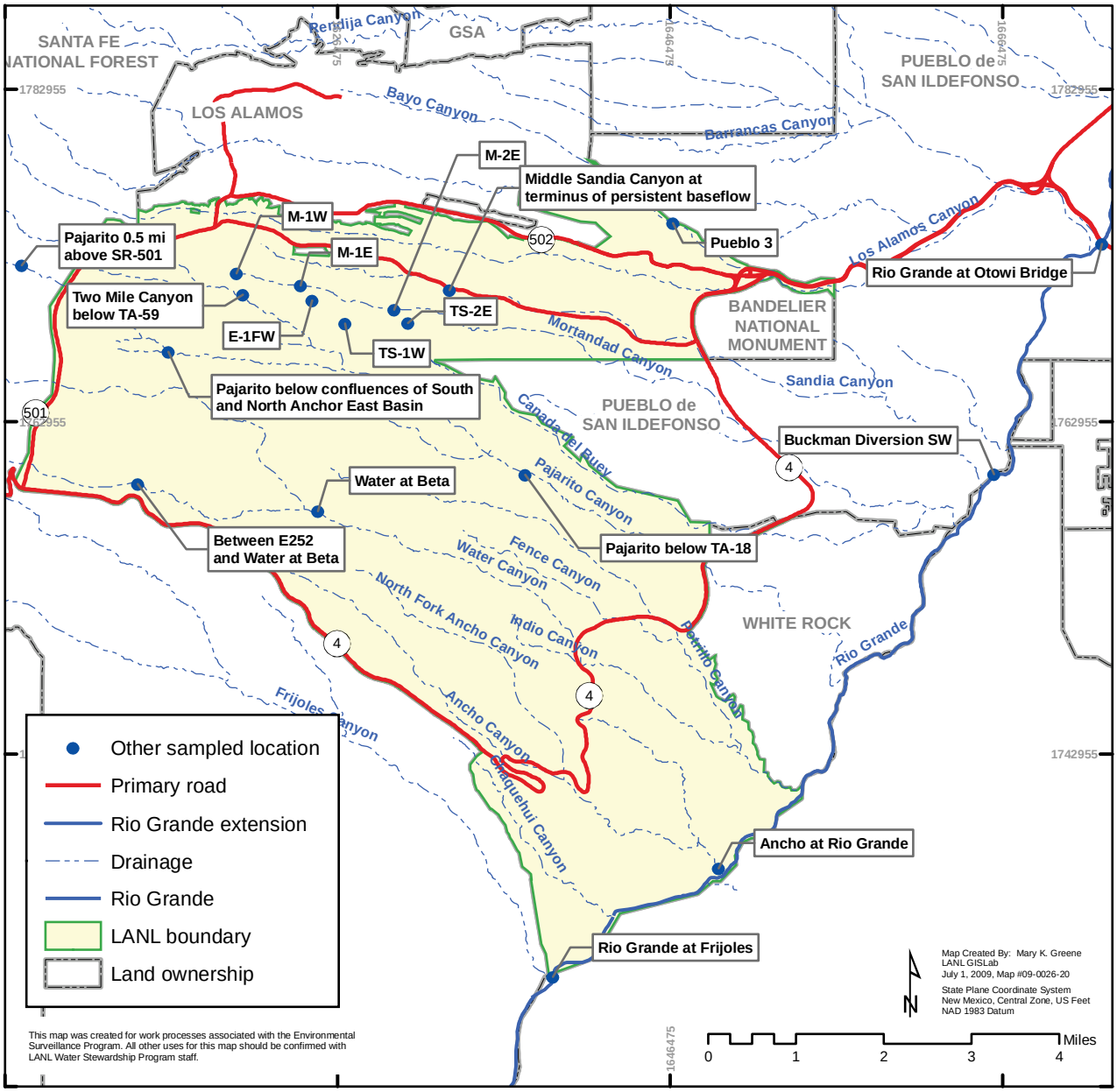


Figure 6-6. Other surface water locations sampled in 2008 within and in the vicinity of Los Alamos National Laboratory.

Additionally, surface water and sediment were sampled at several locations on Pueblo de San Ildefonso lands. DOE entered into a Memorandum of Understanding with the Pueblo de San Ildefonso and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on Pueblo land. The drainages that pass from LANL onto Pueblo de San Ildefonso land are Bayo, Los Alamos, Mortandad, and Sandia Canyons and Cañada del Buey.

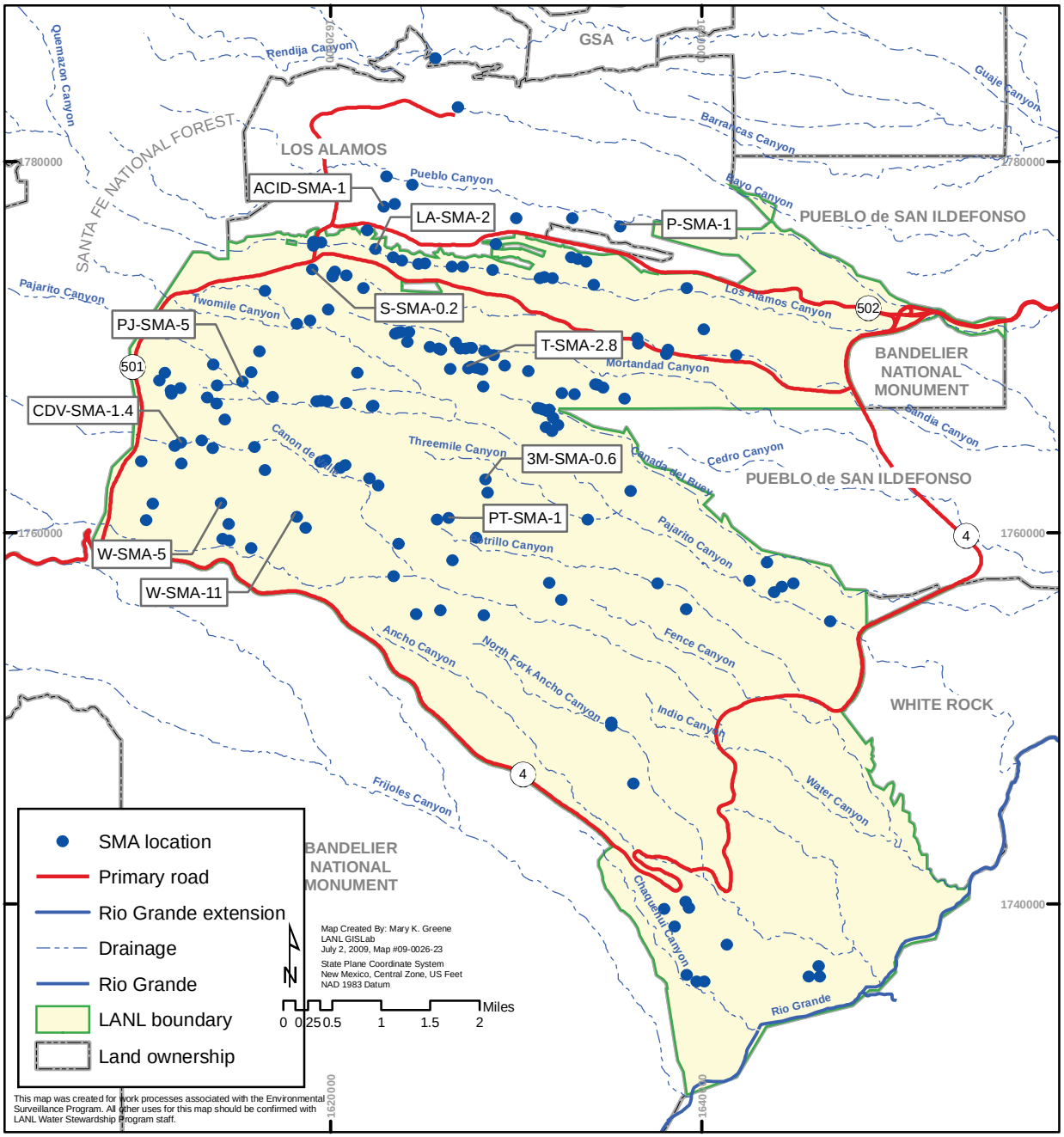


Figure 6-7. Site-specific storm water monitoring stations sampled in 2008 within and in the vicinity of Los Alamos National Laboratory. Labeled stations are referred to in text.

3. Sampling Procedures

The procedures for sampling depend on the type of stream flow and location. Grab samples of base flow and snowmelt runoff are collected from free-flowing streams near the bank. The grab samples are either filtered or left unfiltered and preserved in the field. The gages, located mostly in canyon bottoms, are equipped with automated ISCO samplers that are activated at the start of significant storm water runoff events. Typically, the automated samplers collect water from the first 30 minutes of the runoff event to sample water near the leading edge of flood bores, also called the "first flush." This is the fifth year that the first flush of storm water has been sampled, and it is a significant change from previous years (2003 and before) when samples were collected over a two-hour period. Higher concentrations occur in the first flush compared with the average concentration during a flow event because suspended sediment concentration is highest near the flood bore (Malmon et al. 2004, 2007). As a result, the post-2003 data are not directly comparable to data from previous years.

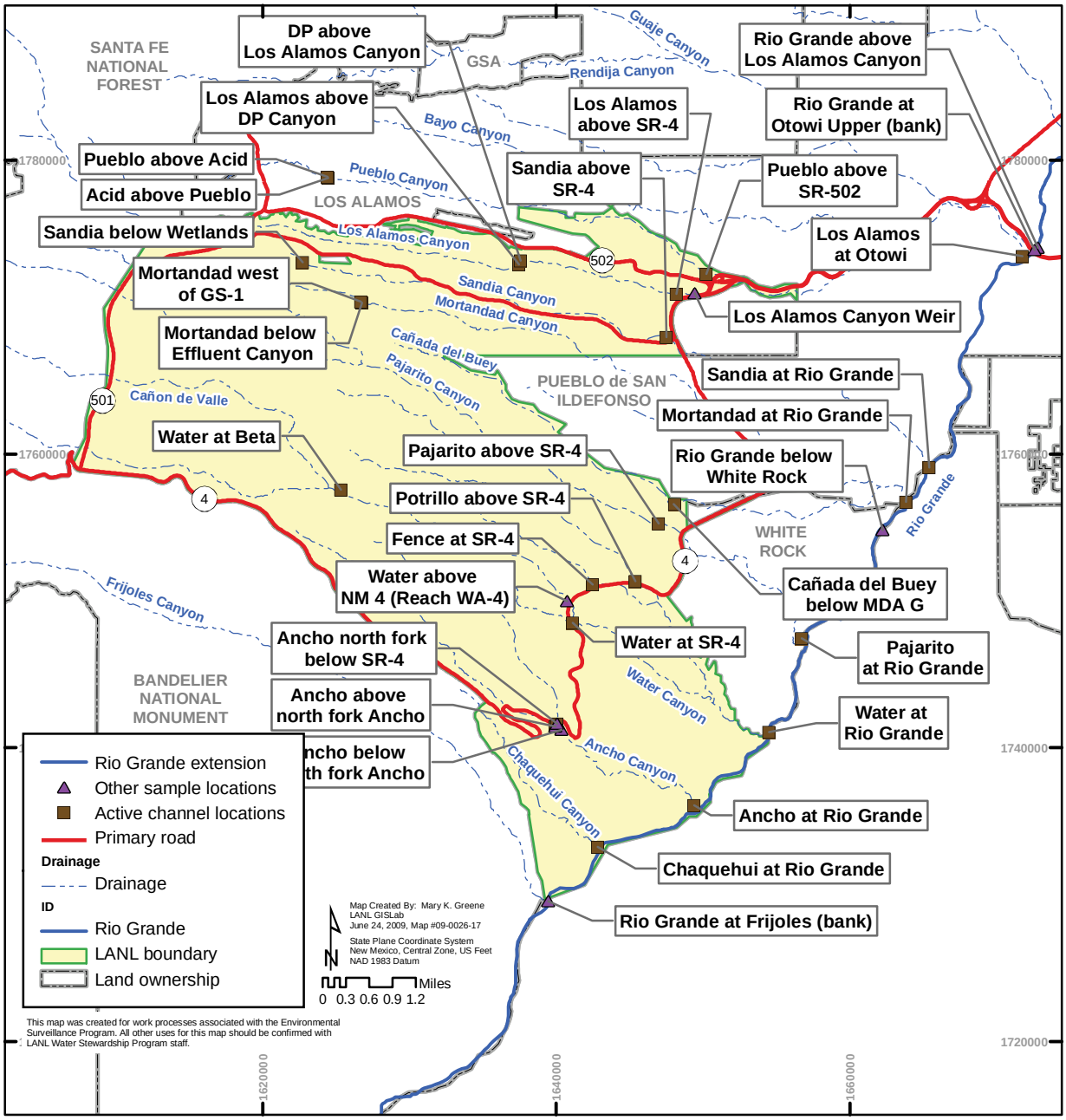


Figure 6-8. Sediment locations sampled in 2008 within and in the vicinity of Los Alamos National Laboratory. MDA G locations are shown in Figure 6-9.

LANL collected storm water runoff samples from mesa tops with buried single-stage runoff samplers or automated ISCO samplers at SMAs. All storm water samples are filtered and preserved in LANL's storm water operations facility because filtering highly sediment-laden waters in the field is difficult. These samples are then shipped to commercial analytical laboratories without compositing or splitting the samples.

LANL collected sediment samples from dry stream beds across the width of the main channel to a depth of approximately 2 cm. For flowing streams, samples were collected from the edge of the main channel. Deposits of fine-grained sediment outside the main channel that resulted from a large flood in 2008 and sediment from the Los Alamos Canyon weir were sampled from the sides of shallow hand-dug holes after identifying the base of the 2008 sediment. The Laboratory used a Ponar Grab sampler from a pontoon boat to collect sediment samples from reservoirs.

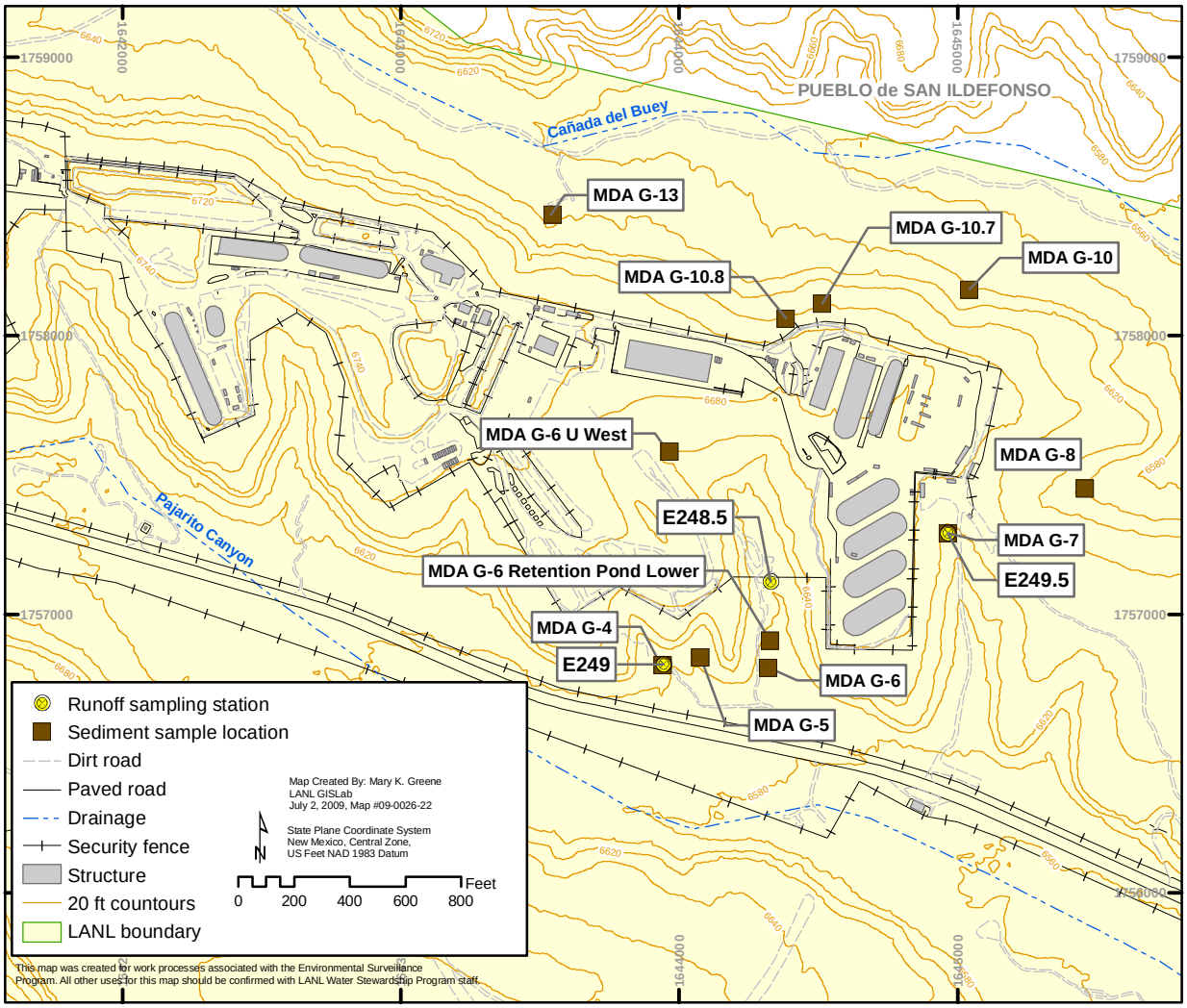


Figure 6-9. Sediment and storm water runoff sampling stations at TA-54 adjacent to MDA G.

E. WATERSHED SAMPLING RESULTS BY CONSTITUENTS

The supplemental data tables on the included compact disc present all the 2008 watershed-related surface water and sediment analytical results. The tables present radiological results in sequence for each of these media and then present the results for major water quality analytes, metals, and organic chemicals. Surface water and sediment samples are analyzed for gross alpha and gross beta radiation and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, uranium-235, uranium-238, tritium, cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22). The tables also list the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity, where available. For most radionuclide measurements, a detection is an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier code of X or U (indicating not detected). The tables are:

- Table S6-1 lists the results of radiochemical analyses of surface water.
- Table S6-2 presents the trace-level tritium results for surface water samples.
- Table S6-3 presents the results of radiochemical analyses of sediment.
- Table S6-4 presents the concentrations of major chemical constituents in surface water.

- Tables S6-5 and S6-6 present results of metals analyses for surface water and sediment, respectively.
- Table S6-7 presents the number and type of organic chemical analyses performed on surface water samples.
- Table S6 8 presents all detected organic chemical results in surface water.
- Tables S6-9 and S6-10 present summaries of organic chemical analyses of sediment samples.
- Table S6-11 presents results of particle size analyses of the sediment samples.

Qualifier codes are shown in some tables to provide additional information on analytical results that are not detections; in some cases, for example, the analyte was found in the laboratory blank, or there were other analytical issues. The tables show two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-5, S5-6, and S5-7).

The overall quality of most surface water in the Los Alamos area is good, with low levels of dissolved solutes. Of the more than 100 analytes reported in sediment and surface water within the Laboratory, most are at concentrations far below screening levels. However, nearly every major watershed indicates some impact from Laboratory operations, often for just a few analytes. The following sections present a Laboratory-wide overview of surface water and sediment quality and then discuss the key findings in more detail on a watershed-by-watershed basis. It should be noted that analytical results that are above screening levels can be derived from a variety of sources including Laboratory releases, runoff from developed areas such as the Los Alamos townsite, naturally occurring radionuclides and chemicals, or "false positives" from analytical laboratories. (Section H of Chapter 5 discusses quality issues that have occurred at analytical laboratories in more detail.) It is not always possible to identify specific sources, and results above screening levels are considered to represent potential Laboratory impacts unless the evidence is compelling for non-LANL sources.

1. Radionuclides in Surface Water and Sediment

a. Surface Water

In 2008, concentrations of radionuclides and levels of radiation in surface water were generally within ranges measured in recent years. In surface water samples from canyon bottoms, one result exceeded DOE BCGs. This was for plutonium-239/240 in a storm water sample from Los Alamos Canyon above DP Canyon on August 9 (gage E030). This result was less than two times greater than the BCG, and annual time-weighted concentrations that consider the combined effects of multiple radionuclides did not exceed DOE guidelines, as discussed later in this section. For mesa-top and hillside storm water monitoring locations (SMAs), one location had values for uranium isotopes that exceeded BCGs: PT-SMA-1 in the Potrillo Canyon watershed for uranium-234 and uranium-238 on August 23. Maximum results were less than four times greater than BCGs, and because flow is infrequent at this location, time-weighted averages that consider the extended periods of no flow are also below BCGs. One naturally occurring radionuclide, radium-226, had sample results above the BCG of 4 pCi/L in 28% of the surface water samples collected from the Pajarito Plateau in 2008. These include results from all major watersheds at LANL and one result from a location with no upstream releases of radionuclides from LANL activities, Guaje Canyon above NM 502 (gage E099). These results indicate naturally elevated levels of radium-226 on the Pajarito Plateau. No results from base flow or snowmelt runoff had radionuclide results above DOE DCGs.

Consistent with previous years, most surface water samples in 2008 had gross alpha radiation levels above the NMWQCC surface water standard of 15 pCi/L for livestock watering. Of the 195 non-filtered samples analyzed from the Pajarito Plateau, 73% exceeded 15 pCi/L, including sample sites with no upstream releases of radionuclides from Laboratory activities (such as Guaje Canyon). However, it has been previously shown that the majority of the alpha radiation in surface water on the plateau is due to the decay of naturally occurring isotopes in sediment and soil from uncontaminated areas carried in storm water runoff and that Laboratory impacts are relatively small (Gallaher 2007). Naturally occurring radionuclides that are alpha emitters include isotopes of radium, thorium, and uranium. As noted previously, livestock watering does not occur at the Laboratory except for some feral, trespassing cows near the Rio Grande.

Gross alpha radioactivity is a general screening measurement of limited value in assessing radiological hazards because specific alpha emitters in the water cannot be identified or quantified. Therefore, gross alpha radiation results are not discussed in detail in this report. Instead, this report focuses on specific individual radionuclides identified in LANL waste streams (Watkins and Del Signore 2005) or known to be associated with the nuclear industry (Langmuir 1997).

The highest concentrations of several radionuclides in surface water samples were measured in Mortandad Canyon downstream from the active TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) outfall, including americium-241, cesium-137, plutonium-238, and tritium. The highest concentration of strontium-90 was measured in DP Canyon downstream from a former outfall at TA-21 which also released radioactive effluent (gage E039). The highest concentration of plutonium-239/240 was measured in Los Alamos Canyon upstream from DP Canyon and downstream from the site at TA-21 that experienced erosion during the potable water line break on July 4–5, 2008 (gage E030). The highest concentrations of uranium-234, uranium-235, and uranium-238 were measured at an site monitoring area (SMA) in the Potrillo Canyon watershed associated with a firing site in TA-15 (PT-SMA-1). With the exception of the plutonium-239/240 in Los Alamos Canyon, all the other measurements discussed above are consistent with previous years.

Table 6-2 compares the estimated annual average concentrations of specific radionuclides in surface water downstream from past or current radioactive liquid waste discharge locations with the DOE BCGs. In order to compare surface water data with the BCGs, we calculated the time-weighted average annual radionuclide concentrations in waters, focusing on the wetter stream segments. This approach is consistent with DOE guidance (DOE 2003). Time-weighted average concentrations were calculated for the individual radionuclides of primary concern: americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235, and uranium-238. We also calculated the time-weighted average concentrations for the naturally occurring radionuclide radium-226, which can contribute a significant amount of the total dose. Concentrations measured during base flow, snowmelt runoff, and storm runoff periods were weighted proportionally after reviewing stream flow records to distinguish the flow regimes; periods with no flow were assigned concentrations of zero.

For waters containing more than one radionuclide, we calculated a ratio for each radionuclide by dividing the concentration of each radionuclide by its particular BCG. To be consistent with DOE Order 5400.5, the sum of the ratios should not exceed 1.0 (DOE 1990). Because the calculations are based on limited sample sets and hydrologic interpretation, these results should be viewed as approximations.

The estimated time-weighted annualized concentrations and sums of ratios for non-filtered surface water in the canyons that have received radioactive effluents were well below the BCGs (Table 6-2). Table 6-2 shows that the highest concentrations in relation to the BCGs were for radium-226, at 22% of the BCG in Mortandad Canyon below Effluent Canyon. Los Alamos Canyon above DP Canyon has the highest concentration relative to BCGs for a radionuclide with known releases from LANL, plutonium-239/240 at 6% of the BCG. When the mixtures of isotopes are considered, the largest sum of the ratios (0.27) was also found in Mortandad Canyon, due mostly to radium-226.

Although radium-226 measured on the Pajarito Plateau is probably of natural origin, it is of concern because it has the most stringent BCG for all the radionuclides monitored. The BCG was established to protect riparian animals that ingest radium-226 in calcium-deficient waters. However, surface water at Los Alamos is calcium-abundant, and the resultant dose from radium-226 is considerably less than calculated because calcium interferes with the uptake of radium-226.

b. Sediment

Analytical data on radionuclides in sediment were obtained from 68 samples in 2008 as part of the annual surveillance program, including 50 samples from canyons draining the Pajarito Plateau, 12 samples from banks, bars, and slackwater areas along the Rio Grande, and six samples from upriver (Abiquiu) or downriver (Cochiti) reservoirs. The Pajarito Plateau samples included 35 active channel locations that are typically dominated by coarse-grained sediment, seven samples from the Los Alamos Canyon weir (both coarse and fine sediment), six locations in Ancho Canyon where fine-grained sediment was deposited from a large flood in August 2008, and two locations with fine-grained sediment in Water Canyon.

The highest concentrations of several radionuclides in sediment were measured in one fine-grained sample we collected from the sediment retention basin behind the Los Alamos Canyon weir, including the highest values for americium-241, cesium-137, plutonium-239/240, and strontium-90. The sampled sediment was a thin layer (maximum of 7-cm thick) that was probably deposited by a flood in August 2008, which remobilized sediment associated with the potable water line break at TA-21. The highest concentration of thorium-228 was also measured in a fine-grained sample from the weir, the only result for this isotope above the LANL sediment background value (although less than concentrations in Bandelier Tuff). Except for the cesium-137 values, these values are higher than previous results from the weir (LANL 2008d) but are below recreational SALs.

The highest concentration of plutonium-238 was measured in drainages below MDA G at TA-54. The highest concentration of tritium was measured in a sample from Abiquiu Reservoir, on the Rio Chama upriver of LANL. For uranium-234 and uranium-235/236, the highest concentrations were measured in an active channel sample from Chaquehui Canyon above the Rio Grande; these are the highest concentrations that have been measured at this location. The highest concentration of uranium-238 was measured in a fine-grained sediment sample from the north fork of Ancho Canyon, deposited during a record flood on August 4, 2008. All of these values are below recreational SALs.

2. Metals in Surface Water and Sediment

a. Surface Water

During 2008, the Laboratory obtained analytical data on metals from 352 surface water sampling events at 161 locations on the Pajarito Plateau, each event consisting of the collection of one or more samples from a specific location. The monitoring included 97 SMAs, generally on mesa tops or hillsides, and 64 other sites (mostly canyon bottoms). These data were compared with various screening levels, as discussed in Section C.3. Some of these screening levels are for dissolved constituents, which are compared with filtered sample results, and some are for totals, which are compared with non-filtered sample results. A total of nine metals had maximum concentrations above wSALs, and one metal had concentrations above tap water screening levels. Under the Clean Water Act §303(d) list, the NMWQCC has listed parts of one or more canyons within or near LANL as impaired for nine metals: aluminum, arsenic, cadmium, copper, lead, mercury, selenium, vanadium, and zinc (NMWQCC 2006). These metals are discussed below, along with other metals that have results above screening levels. A summary of results and their significance for these metals is presented in Table 6-3.

The screening level for aluminum is based on aluminum dissolved in the water column, and 31% of filtered surface water samples collected on the Pajarito Plateau in 2008 contained aluminum concentrations above the acute wSAL of 750 µg/L, although most or all of this aluminum may be naturally occurring. For example, 40% of the filtered surface water samples collected from locations upstream of LANL or in canyons not affected by Laboratory activities also had aluminum concentrations over 750 µg/L. Other samples from locations with perennial water also exceed the chronic wSAL of 87 µg/L, including non-LANL affected areas such as Frijoles Canyon in Bandelier National Monument, with 4,850 µg/L in one filtered sample. Aluminum is a natural component of soil and is not known to be derived from Laboratory operations in any significant quantity. In the slightly alkaline waters on the Pajarito Plateau, aluminum rarely occurs in solution in natural water at concentrations greater than a few tens to hundreds of micrograms per liter (Hem 1986). Consequently, a large majority of the results above the wSAL are probably due to the presence of particulate aluminum (colloids) that pass through the filter, rather than aluminum dissolved in the water column.

The screening level for arsenic is based on arsenic dissolved in the water column, and no filtered surface water samples collected on the Pajarito Plateau in 2008 contained arsenic concentrations above the acute wSAL of 9 µg/L. These results differ from 2007, when 3% of the filtered samples had arsenic concentrations above 9 µg/L (Reneau and Koch, 2008, p. 220).

Table 6-2
Comparison of Estimated Annual Average Non-Filtered Surface Water Concentrations of Radionuclides in Selected Canyons with DOE BCGs

Radionuclide	BCG (pCi/L)	Acid Canyon above Pueblo Canyon (pCi/L)	Lower Pueblo Canyon (pCi/L)	DP Canyon below TA-21 (pCi/L)	Los Alamos Canyon above DP Canyon (pCi/L)	Los Alamos Canyon above Weir (pCi/L)	Los Alamos Canyon near Rio Grande (pCi/L)	Mortandad Canyon below Effluent Canyon (pCi/L)	Maximum percent of BCG
Stream gage		E056	E060	E039	E030	E042	E110	E200	-
Am-241	400	0.02	0.08	0.02	0.4	1.0	0.1	4	1%
Cs-137[a]	20,000	ND[b]	ND	ND	ND	1.2	ND	18	0.09%
H-3 (tritium)	300,000,000	2.7	1.2	38	ND	ND	1.1	580	< 0.01%
Pu-238	200	< 0.01%	0.01	ND	0.5	0.1	0.02	2.0	1%
Pu-239/240	200	0.5	2.0	0.03	11	1.3	3.0	3.2	6%
Ra-226	4	0.03	0.5	0.01	0.3	0.4	0.6	0.9	22%
Sr-90[a]	30,000	0.1	0.3	94	0.2	1.5	ND	1.1	0.3%
U-234	200	0.05	0.6	1.1	0.7	0.8	1.1	1.2	0.6%
U-235/236	200	ND	ND	ND	0.03	0.06	0.07	0.1	0.07%
U-238	200	0.02	0.5	0.4	0.6	0.5	1.0	1.1	0.5%
Sum of ratios to BCGs		0.01	0.13	0.01	0.14	0.10	0.18	0.27	-

[a] The BCG for Cs-137 and Sr-90 are site-specific modified BCGs from McNaughton et al. (2008)

[b] ND = not detected in 2008



The screening level for cadmium is based on cadmium dissolved in the water column, and no filtered surface water samples collected on the Pajarito Plateau in 2008 contained cadmium concentrations above the acute wSAL of 2.1 µg/L. In addition, there were no detected cadmium results from a designated perennial stream segment above the chronic wSAL of 0.28 µg/L. These results are consistent with results from 2007. Although Water Canyon had previously been listed as impaired for cadmium by the NMWQCC, the 2008 surface water data did not indicate any concerns with cadmium in this canyon.

The screening level for copper is based on copper dissolved in the water column, and no filtered surface water samples collected from a designated perennial stream segment on the Pajarito Plateau in 2008 contained copper concentrations above the chronic wSAL of 9.4 µg/L. However, 8% of the filtered samples from all surface waters had copper results above the acute dissolved wSAL of 14 µg/L, which is similar to the results from 2007 (11% of samples). These results are scattered among multiple watersheds, including Chaquehui, Effluent, Fence, Los Alamos, Mortandad, Pajarito, Potrillo, Twomile, Threemile, and Water Canyons, and Cañada del Buey. The highest value of 337 µg/L was obtained from an SMA in the Threemile Canyon watershed in TA-15 (3M-SMA-0.6), and all samples from this station had results for copper greater than 14 µg/L. Flow in this part of Threemile Canyon is entirely ephemeral, and runoff from the SMA infiltrates into the alluvium. Copper concentrations above 14 µg/L were all from SMAs or in small tributary drainages, and samples from the major stream channels all had copper less than 14 µg/L. The sources of copper in LANL watersheds have not been thoroughly evaluated, but its spatial distribution indicates copper is at least partly derived from firing sites.

The screening level for lead is based on lead dissolved in the water column, and no filtered surface water samples collected from a designated perennial stream segment on the Pajarito Plateau in 2008 contained lead concentrations above the chronic wSAL of 3.2 µg/L. Only a single filtered sample had a result above the acute dissolved wSAL of 81.7 µg/L: 143 µg/L from the same SMA in the Threemile Canyon watershed where copper is elevated (3M-SMA-0.6).

The screening level for mercury is based on total mercury, and no non-filtered surface water samples collected from the Pajarito Plateau in 2008 contained detected mercury concentrations above the wSAL of 0.77 µg/L. This represents an improvement over 2007, when 4% of non-filtered surface water samples had mercury detected above 0.77 µg/L.

The screening level for selenium is based on total recoverable selenium, and only one non-filtered surface water sample collected from the Pajarito Plateau in 2008 contained detected selenium above the wSAL of 5.0 µg/L (10.1 µg/L). This sample was collected from an SMA in the Water Canyon watershed at TA-11 (W-SMA-11) during the record rainstorm of August 4. Selenium was not detected in a second sampled runoff event at this station on August 31.

The screening level for vanadium is based on vanadium dissolved in the water column, and no filtered surface water samples collected from the Pajarito Plateau in 2008 contained vanadium concentrations above the chronic wSAL of 100 µg/L. These results are consistent with results from 2007. Although Water Canyon had previously been listed as impaired for vanadium by the NMWQCC, the 2008 surface water data did not indicate any concerns with vanadium in this canyon.

The screening level for zinc is based on zinc dissolved in the water column, and 4% of the filtered surface water samples collected from the Pajarito Plateau in 2008 had detected results above the acute wSAL of 120 µg/L. These included SMAs and channels with small drainage areas in the watersheds of Acid, Los Alamos, Mortandad, andia, Ten Site, and Twomile Canyons. No sample from a main stream channel in a larger canyon had results above 120 µg/L. The highest zinc concentration (1,400 µg/L) was from the head of Ten Site Canyon (gage E201.3). Although the main channel of Water Canyon had previously been listed as impaired for zinc by the NMWQCC, the 2008 surface water data did not indicate any concerns with zinc along the main stream in this canyon, which is consistent with the results from 2007.

In addition to the metals discussed above, several other metals have some results exceeding screening levels.

Table 6-3
Summary of Results for Select Metals in Surface Water Samples from 2008

Metal	Sample Preparation	Screening Level (µg/L)	Percentage of Samples above Screening Level	Watersheds with Results above Screening Levels	Significance
Aluminum	Filtered	750	31%	Ancho, Chaquehui, Frijoles, Los Alamos, Mortandad, Pajarito, Sandia, and Water Canyons	NMWQCC impaired listing, above wSAL in non-LANL affected canyons, indicating elevated local background
Arsenic	Filtered	9	0%	None	NMWQCC impaired listing; no results above wSAL is an improvement over 2007
Cadmium	Filtered	2.1	0%	None	NMWQCC impaired listing; no results above wSAL is consistent with 2007
Chromium	Non-filtered	580 (77 for perennial stream)	1%	Los Alamos, Mortandad, and Sandia Canyons	Two isolated results above wSAL of 580 µg/L from non-perennial streams, and one isolated result above wSAL of 77 µg/L from a designated perennial stream
Copper	Filtered	14	8%	Chaquehui, Los Alamos, Mortandad, Pajarito, and Water Canyons	NMWQCC impaired listing; results above wSAL are only from SMAs or small tributary drainages, not main stream channels
Cyanide	Non-filtered	5.2×10^{-6}	6%	Los Alamos, Mortandad, Sandia, and Water Canyons	Results above wSAL include non-LANL affected areas, indicating non-LANL sources
Lead	Filtered	81.7	0.3%	Pajarito Canyon	NMWQCC impaired listing; single result above wSAL from an SMA
Manganese	Filtered	880	2%	Los Alamos Canyon	Only metal above tap water screening level; naturally-occurring manganese associated with reducing conditions in alluvium
Mercury	Non-filtered	0.77	0%	None	NMWQCC impaired listing; no results above wSAL is an improvement over 2007
Nickel	Non-filtered	469	1%	Mortandad and Pajarito Canyons	Two isolated results above wSAL; nickel associated with suspended sediment
Selenium	Non-filtered	5.0	0.3%	Water Canyon	NMWQCC impaired listing; single result above wSAL from an SMA
Silver	Non-filtered	3.8	5%	Mortandad, Pajarito, Sandia, and Water Canyons	Highest results below a former photo-processing facility
Vanadium	Filtered	100	0%	None	NMWQCC impaired listing; no results above wSAL is consistent with 2007
Zinc	Filtered	120	4%	Los Alamos, Mortandad, Pajarito, and Sandia Canyons	NMWQCC impaired listing; results above wSAL are only from SMAs or small tributary drainages, not main stream channels

The screening levels for chromium are based on total recoverable chromium, and two non-filtered surface water samples collected from the Pajarito Plateau in 2008 contained detected chromium above the wSAL of 580 µg/L for ephemeral or intermittent streams (based on the acute aquatic life standard), and one sample from a designated perennial stream had a result above the wSAL of 77 µg/L (based on the chronic aquatic life standard). The maximum chromium concentration (879 µg/L) was measured from the main channel of Cañada del Buey above NM 4 (gage E230) on July 17. The second highest result (632 µg/L) was measured from the main channel of Los Alamos Canyon above DP Canyon (gage E030) on August 9. The source of the chromium in Los Alamos Canyon is sediment deposited during the potable water line break at TA-21, discussed previously, but the source of the chromium in Cañada del Buey is not known. Two other samples from each of these locations had chromium below the wSAL. Notably, dissolved chromium concentrations in both of these samples (≤ 1.5 µg/L) are well below the NMWQCC standards of 100 µg/L for irrigation and 1,000 µg/L for livestock watering, and the chromium in these samples is almost entirely associated with sediment particles. The single sample from a designated perennial stream that exceeded the applicable wSAL was from Sandia Canyon below the wetland (gage E123), with 425 µg/L in a non-filtered sample collected on July 27. Chromium was below the wSAL in seven other samples collected from this location in 2008.

The screening level for cyanide is for weak acid dissociable cyanide (cyanide amenable to chlorination) in non-filtered samples, and 6% of the non-filtered analyses obtained from the Pajarito Plateau in 2008 had amenable cyanide concentrations above the wSAL of 5.2 µg/L. These samples were collected from SMAs and main stream channels in the watersheds of Acid, Los Alamos, Mortandad, Pueblo, and Sandia Canyons and Cañon de Valle. The highest concentration (57.9 µg/L) was from the main stream channel of Los Alamos Canyon above DP Canyon on August 31. Notably, the second highest concentration (52.9 µg/L) was from the main channel of Pueblo Canyon above Acid Canyon in the same storm event. This Pueblo Canyon location receives runoff from part of the Los Alamos town site, as well as Santa Fe National Forest land within the Cerro Grande burn area, indicating a non-Laboratory source for cyanide.

Manganese was the only metal with concentrations above tap water screening levels in non-filtered base flow or snowmelt runoff samples in 2008, in two samples from two locations. The maximum manganese concentration (2,640 µg/L compared with the screening level of 880 µg/L) was measured in a sample collected at a location in Pueblo Canyon downstream from the Los Alamos County WWTP (Pueblo 3). The other sample (1,420 µg/L) was collected from DP Canyon below TA-21 (gage E039) at a location where alluvial groundwater discharges into the stream bed. Elevated manganese has been reported in these areas previously and represents naturally occurring manganese that is reduced in areas of persistent saturated conditions in the alluvium (LANL 2004a, p. 7-37).

The screening level for nickel is based on total recoverable nickel, and two non-filtered surface water samples collected from the Pajarito Plateau in 2008 contained detected nickel above the wSAL of 469 µg/L. The maximum result, 981 µg/L, was obtained from the main channel of Cañada del Buey above SR-4 on July 17, 2008. The other result above the wSAL, 565 µg/L, was obtained from an SMA in the Pajarito Canyon watershed, PJ-SMA-5, on August 31, 2008. Two other samples from the Cañada del Buey station had nickel below the wSAL. In contrast to the wSAL, applicable to total nickel concentrations, surface water quality standards are for dissolved nickel, which is much lower in both of these samples (< 15 µg/L). The nickel in these samples is, therefore, almost entirely associated with sediment particles.

The screening level for silver is based on total recoverable silver, and 5% of the non-filtered surface water samples collected from the Pajarito Plateau in 2008 contained detected silver above the wSAL of 3.8 µg/L. These samples were collected from SMAs and main stream channels in the watersheds of Cañada del Buey, Cañon de Valle, and Mortandad, Pajarito, Potrillo, Pueblo, and Sandia Canyons. The maximum result (294 µg/L) was measured at an SMA in the Cañon de Valle watershed below a former photo-processing facility, CDV-SMA-1.4. The two samples collected from this SMA were the only samples that had dissolved silver concentrations above the NMWQCC acute aquatic life standard of 3.2 µg/L, at 3.4 and 4 µg/L.

b. Sediment

For metals in sediment, analytical data were obtained from 59 samples in 2008 as part of the annual surveillance program, including 51 samples from canyons draining the Pajarito Plateau, two samples from banks along the Rio Grande, and six samples from upriver (Abiquiu) or downriver (Cochiti) reservoirs. The Pajarito Plateau samples included 36 active channel locations that are typically dominated by coarse-grained sediment, seven samples from the Los Alamos Canyon weir (both coarse and fine sediment), six locations in Ancho Canyon where fine-grained sediment was deposited from a large flood in August 2008, and two locations in Water Canyon with fine-grained sediment.

In 2008, 21 metals were detected in sediment at concentrations above the LANL sediment background values, although all results are below recreational SSLs. Sixteen of the maximum results for these metals were obtained from off-site samples collected from Abiquiu Reservoir (11 metals) or Cochiti Reservoir (five metals). Differing background conditions along the Rio Grande and Rio Chama than on the Pajarito Plateau contribute to these elevated values.

In 2008, maximum concentrations for five metals (antimony, chromium, lead, mercury, and silver) were measured in sediment samples collected from the Pajarito Plateau at LANL. The maximum results for antimony and silver came from samples collected in small drainages below MDA G at TA-54 within the Pajarito Canyon watershed, which is consistent with results from 2007 surveillance sediment samples (Reneau and Koch, 2008). The maximum result for chromium was obtained from the stream channel of Los Alamos Canyon above DP Canyon, and the maximum results for lead and mercury were obtained farther east in Los Alamos Canyon from fine-grained sediment in the sediment retention basin above the Los Alamos Canyon weir. The maximum result for lead is within the range measured previously at the weir, although the results for chromium and mercury are higher than previously measured in Los Alamos Canyon sediment (LANL 2004a, 2008g). The mercury was measured in the same sample with elevated radionuclides discussed previously in section E.1b, suggesting a source at SWMU 21-027(a). The source of the chromium is not known.

3. Organic Chemicals in Surface Water and Sediment

a. Surface Water

During 2008, analytical data for organic chemicals were obtained from 173 surface water sampling events at 83 locations on the Pajarito Plateau, each event consisting of the collection of one or more samples from a specific location. The monitoring included 35 SMAs or minor hillside drainages and 48 canyon bottom sites. The organic chemicals that were analyzed for varied depending on the location and included the following suites: dioxins and furans, explosive compounds, herbicides, pesticides, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), total petroleum hydrocarbons-diesel range organics (TPH-DRO), and volatile organic compounds (VOCs). These data were compared with wSALs established pursuant to the 2005 FFCA (EPA 2005a) and tap water screening values, as discussed in Section C.3. Under the federal Clean Water Act §303(d) list, the NMWQCC has listed parts of three canyons within LANL as impaired for PCBs in the water column: Los Alamos, Pueblo, and Sandia Canyons (NMWQCC 2006). These organic chemicals along with other organic chemicals that have results above screening levels are discussed below.

Analyses for dioxins and furans were obtained from 15 non-filtered surface water samples collected at 10 canyon bottom locations on the Pajarito Plateau in 2008. One or more dioxin or furan congeners were detected in 13 of these samples from locations in Effluent, Los Alamos, Mortandad, Pueblo, Ten Site, and Twomile Canyons. The highest concentrations were measured in Los Alamos Canyon above DP Canyon (gage E030), which is downstream of the potable water line break that occurred at TA-21 on July 4–5, 2008. The two detects for tetrachlorodibenzodioxin[2,3,7,8-] (2,3,7,8 TCDD) (3.15 and 3.36 × 10^{-5} µg/L), both from this station (August 9 and August 31), were above the wSAL of 5.1 × 10^{-8} µg/L. Sediment from these runoff events was deposited downstream above the Los Alamos Canyon weir, as discussed in a later section.

For explosive compounds, analyses were obtained from 59 non-filtered storm water samples collected at 31 locations on the Pajarito Plateau in 2008. A total of 13 different explosive compounds were detected at 12 locations. No results exceeded screening levels.

For herbicides, analyses were obtained from two non-filtered surface water samples collected at two canyon bottom locations on the Pajarito Plateau in 2008. No herbicides were detected in these samples, which is consistent with results from 2007.

For pesticides, analyses were obtained from 26 non-filtered surface water samples collected at 18 locations on the Pajarito Plateau in 2008. Pesticides were detected in four of these samples from three locations, in the Acid, Chaquehui, and Mortandad Canyon watersheds. The maximum detected concentrations for all pesticides came from an SMA in Acid Canyon, ACID-SMA-1, including results above wSALs for six pesticides (aldrin, chlordane[gamma], DDD[4,4'-], DDE[4,4'-], DDT[4,4'-], and dieldrin). This sampling station receives runoff from developed areas in the Los Alamos town site, which is the likely source of these pesticides. One sample from station M-1E in Mortandad Canyon also had results for three pesticides above wSALs (DDD[4,4'-], DDE[4,4'-], and DDT[4,4'-]).

For PCBs, analyses were obtained from 96 non-filtered surface water samples collected at 51 locations on the Pajarito Plateau in 2008, and 14% of the samples had detected PCBs. The most commonly detected PCBs were Aroclor-1254 and Aroclor-1260, which were detected in 7% and 8% of the samples, respectively. Two detects were also reported for Aroclor-1242. All samples with detected PCBs had concentrations above the wSAL of 0.00064 µg/L, including SMAs and canyon bottom locations in the watersheds of DP, Los Alamos, Mortandad, Sandia, and Ten Site Canyons. The highest PCB concentrations were measured in storm water at an SMA in the Los Alamos Canyon watershed, LA-SMA-2. Excavation of PCB-contaminated soil at a former transformer storage area in the Sandia Canyon watershed was conducted in 2001 (LANL 2001), and an interim measure to address the transport of PCBs in storm water in Los Alamos and Pueblo Canyons was begun in 2008 (LANL 2008e, 2008d).

For SVOCs, analyses were obtained from 63 non-filtered surface water samples collected at 39 locations on the Pajarito Plateau in 2008. Thirteen SVOCs were detected in one or more samples from 12 locations, and three storm water samples from SMAs had detected results above wSALs. These included results for benzo(a)anthracene, benzo(a)pyrene, and chrysene in the Water Canyon watershed (W-SMA-5); a result for benzo(b)fluoranthene in the Pajarito Canyon watershed (PJ-SMA-5); and a result for chrysene in the Sandia Canyon watershed (S-SMA-0.2). In addition, three base flow samples from Sandia Canyon had dioxane(1,4-) concentrations above the tap water screening level.

For TPH-DRO, analyses were obtained from five non-filtered storm water samples collected at four locations on the Pajarito Plateau in 2008, in the DP, Mortandad, Rendija, and Ten Site Canyon watersheds. All five samples had detected TPH-DRO. The maximum concentration in the 2008 samples (1,420 µg/L from an SMA in the Ten Site Canyon watershed [T-SMA-2.8]) was less than the maximum result from 2007. There are no TPH-DRO standards or screening levels for surface water.

For VOCs, analyses were obtained from 62 non-filtered surface water samples collected at 30 canyon bottom locations on the Pajarito Plateau in 2008. Nine VOCs were detected in one or more samples from 20 locations. None of these results exceed wSALs, but three results for two VOCs from one location exceed tap water screening levels. These include one result for bromodichloromethane and two results for chloroform in upper Sandia Canyon (gage E121.9).

b. Sediment

Analytical data on explosive compounds in sediment were obtained from 28 samples in 2008 as part of the annual surveillance program, including 20 samples from canyons draining the Pajarito Plateau, two samples from banks along the Rio Grande, and six samples from upriver (Abiquiu) or downriver (Cochiti) reservoirs.

The Pajarito Plateau samples included 10 active channel locations that are typically dominated by coarse-grained sediment, two samples from fine-grained sediment behind the Los Alamos Canyon weir, six locations in Ancho Canyon where fine-grained sediment was deposited from a large flood in August 2008, and two locations with fine-grained sediment in Water Canyon. There were no explosive compounds detected in these samples.

Analytical data on PCBs in sediment were obtained by the Aroclor method (EPA method 8082) from 41 samples in 2008 as part of the annual surveillance program, including 33 samples from canyons draining the Pajarito Plateau, two samples from banks along the Rio Grande, and six samples from Abiquiu and Cochiti Reservoirs. The Pajarito Plateau samples included 24 active channel locations that are typically dominated by coarse-grained sediment, seven locations at the Los Alamos Canyon weir (both coarse and fine sediment), and two locations with fine-grained sediment in Water Canyon. The PCB Aroclor-1242 was detected in two samples from the Pajarito Plateau; Aroclor-1248 was detected in one sample; Aroclor-1254 was detected in 16 samples; and Aroclor-1260 was detected in 20 samples. In addition, Aroclor-1248, Aroclor-1254, and Aroclor-1260 were detected in one sample from Cochiti Reservoir, and this sample had the highest detected 2008 results for Aroclor-1248 and Aroclor-1254, 0.196 and 0.152 mg/kg, respectively. This sample also had the highest value for total Aroclors (the sum of all detected Aroclors in each sample), 0.380 mg/kg. None of the Aroclor results was above recreational SSLs.

On the Pajarito Plateau, Aroclors were detected in sediment in the watersheds of Los Alamos, Pajarito, Pueblo, Sandia, and Water Canyons. For total PCBs, the highest concentrations were measured in Los Alamos Canyon in fine-grained sediment deposited above the weir. The next highest concentration was measured in Pueblo Canyon upstream of Acid Canyon, indicating a non-Laboratory source for some of the PCBs, which is consistent with results from 2007 (Reneau and Koch, 2008).

Analytical data for PCB congeners in sediment were obtained using EPA method 1668A on 10 samples along the Rio Grande in 2008 as part of the annual surveillance program, including five samples upriver from Los Alamos Canyon and five samples below White Rock, downriver from Los Alamos, Sandia, and Mortandad Canyons. The next section discusses these PCB congener data further.

Analytical data for dioxins and furans in sediment were obtained from 15 samples from the Los Alamos Canyon weir in 2008, seven samples from sediment deposited in 2008, and eight samples from deeper sediment deposited in 2000 to 2007. Dioxin and furan congeners were detected in all samples, and the highest concentrations of most analytes were measured in the same fine-grained sediment sample where elevated radionuclides and metals were measured, as discussed previously. These data are discussed in more detail in a subsequent section.

F. IMPACTS TO THE RIO GRANDE

In 2008, we assessed potential Laboratory impacts to the Rio Grande by comparing data from sediment and water samples collected upriver and downriver of LANL.

1. Sediment Sampling Results

For a large analytical suite including radionuclides, metals, and organic chemicals, LANL collected river sediment from the banks of the Rio Grande near Otowi Bridge (upriver of LANL) and near the confluence with Frijoles Canyon in Bandelier National Monument (downriver of LANL). LANL collected samples of bottom sediment at three separate locations each in Abiquiu Reservoir (upriver) and in Cochiti Reservoir (downriver) for the same analytical suite. In addition, we collected 10 samples of sediment from along the Rio Grande for PCB congeners and plutonium isotopes, five samples upriver from Los Alamos Canyon and LANL near Otowi Bridge, and five samples below White Rock, downriver from Los Alamos, Sandia, and Mortandad Canyons. These 10 samples included a similar range in geomorphic setting and particle size in each area, including low-water and high-water settings and fine silt to fine sand.

In these samples, two radionuclides were detected above the sediment background concentrations of McLin and Lyons (2002) and McLin (2004), including plutonium-239/240 in one sample from Cochiti Reservoir and tritium in three samples. The highest tritium concentration was from Abiquiu Reservoir, upriver from LANL along the Rio Chama. Tritium was also detected above the reported background concentrations in one Cochiti Reservoir sample and in the Rio Grande bank sample near Otowi Bridge. These tritium results probably represent background outliers (two out of three locations being upriver from LANL), and all of these radionuclide results are orders of magnitude below recreational SALs. In river sediment, no radionuclides were detected above background levels below the Laboratory. The plutonium-239/240 concentrations in Cochiti Reservoir were comparable to those measured in previous years after the May 2000 Cerro Grande fire and are slightly elevated above regional background levels that result from atmospheric fallout (Figure 6-10).

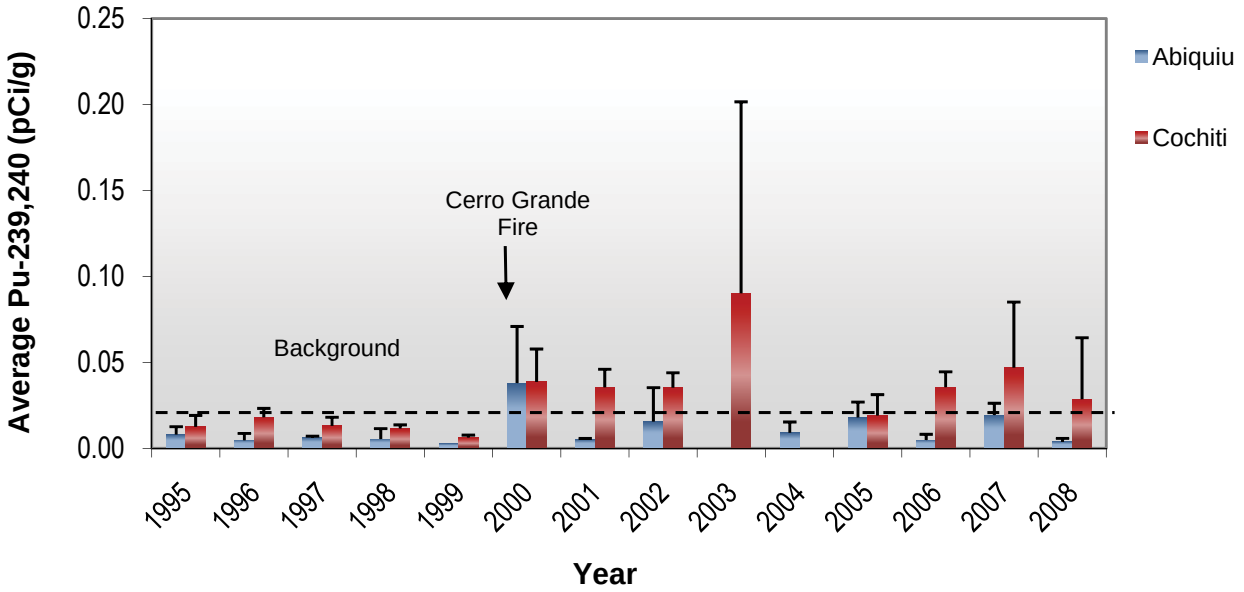


Figure 6-10. Plutonium-239/240 concentrations (mean ±1 standard deviation of results from 3 samples) in Abiquiu and Cochiti Reservoir bottom sediment from 1995 through 2008.

Concentrations of many metals are elevated in Rio Grande and Cochiti Reservoir bottom sediment compared with background levels in Pajarito Plateau sediment, but these differences may largely or entirely reflect different background conditions along the Rio Grande or upriver sources. For example, the highest concentrations in 2008 surveillance sediment samples came from Abiquiu Reservoir for 11 inorganic chemicals (arsenic, barium, cadmium, calcium, cobalt, copper, iron, magnesium, nickel, vanadium, and zinc), demonstrating regional differences in sediment background and non-LANL sources. Five inorganic chemicals have their highest concentrations in Cochiti Reservoir bottom sediment (aluminum, beryllium, manganese, potassium, and selenium), but these are also elevated in Abiquiu Reservoir compared with concentrations in Pajarito Plateau samples.

No explosive compounds were detected in sediment samples from the Rio Grande or from Abiquiu or Cochiti Reservoirs in 2008.

PCBs analyzed by the Aroclor method were detected in one of these samples, from bottom sediment in upper Cochiti Reservoir, which provided the highest concentration (0.38 mg/kg) of total Aroclors in any surveillance sediment sample from 2008. Over half of the total Aroclors were Aroclor-1248, which is usually not detected in samples from LANL, indicating a different (non-LANL) source for the PCBs.

We obtained PCB congener data from 10 sediment samples along the Rio Grande in December 2008, five upriver from Los Alamos Canyon and five downriver from Mortandad Canyon, below White Rock, all collected when the river was at low-water conditions. The congener data allow evaluation of similarities or differences in the PCBs present above and below the primary LANL sources and also allow further comparison with PCBs present in LANL canyons. PCB congeners were detected in all of the upriver samples and four of the downriver samples.

For the sum of detected congeners, the maximum result was obtained below White Rock, 199 pg/g (0.000199 mg/kg), which is slightly higher than the maximum upriver result of 168 pg/g. The average concentration upriver (85 pg/g) was slightly higher than downriver (60 pg/g). Variations in PCB concentrations in these samples are partly related to variations in silt and clay content, as shown in Figure 6-11. The sample with the highest PCB concentration had the highest silt and clay content (93%), and the sample with no detected PCB congeners had the lowest (5%).

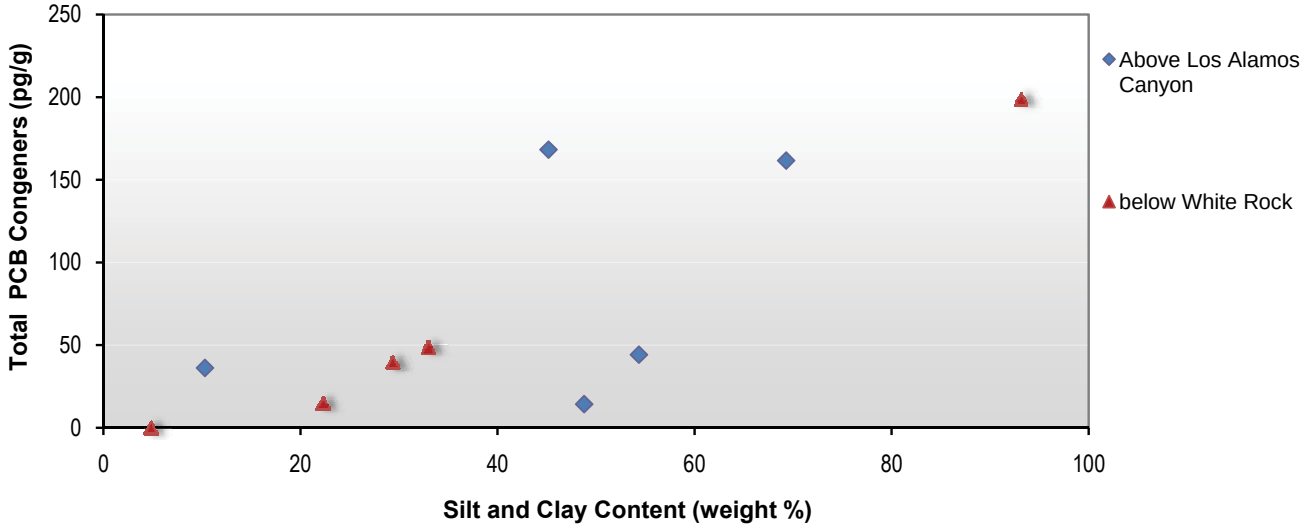


Figure 6-11. Total detected PCB congeners in sediment samples from the Rio Grande plotted against silt and clay content.

Figures 6-12 and 6-13 plot PCB congener homolog data from the samples collected along the Rio Grande. For comparison, Figure 6-14 plots homolog data from samples collected from Sandia Canyon where releases have occurred from a former transformer storage area at TA-3. To simplify comparisons between samples, these are plotted as percent of total. The Rio Grande samples have varied homolog patterns, indicating that different sediment layers have different sources for PCBs. In contrast, the Sandia Canyon samples show more similarity, consistent with a single source. Figure 6-15 uses average concentrations calculated from each area, indicating that the mixture of PCBs upriver and downriver from these LANL sources are essentially identical, but different than the Sandia Canyon homolog signature. These congener data, therefore, show no evidence of LANL contributions to PCBs along the Rio Grande.

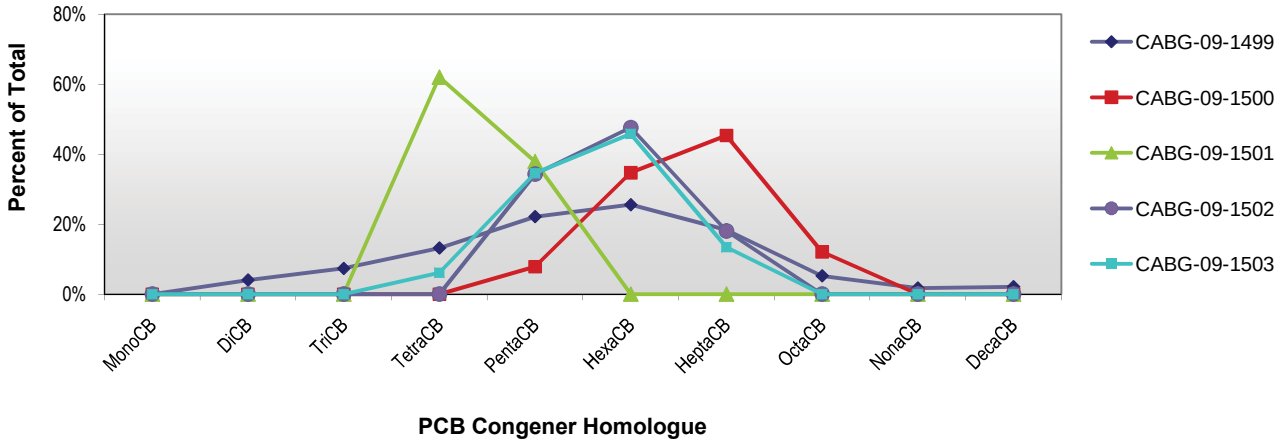


Figure 6-12. PCB congener homolog data from sediment samples collected along the Rio Grande near Otowi Bridge, upriver from Los Alamos Canyon.

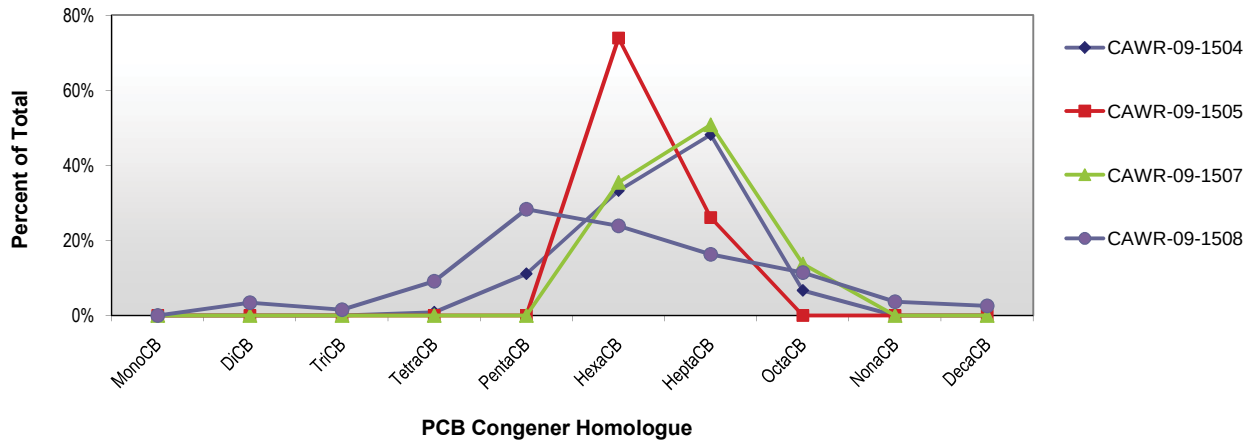


Figure 6-13. PCB congener homolog data from sediment samples collected along the Rio Grande below White Rock, downriver from Los Alamos, Sandia, and Mortandad Canyons.

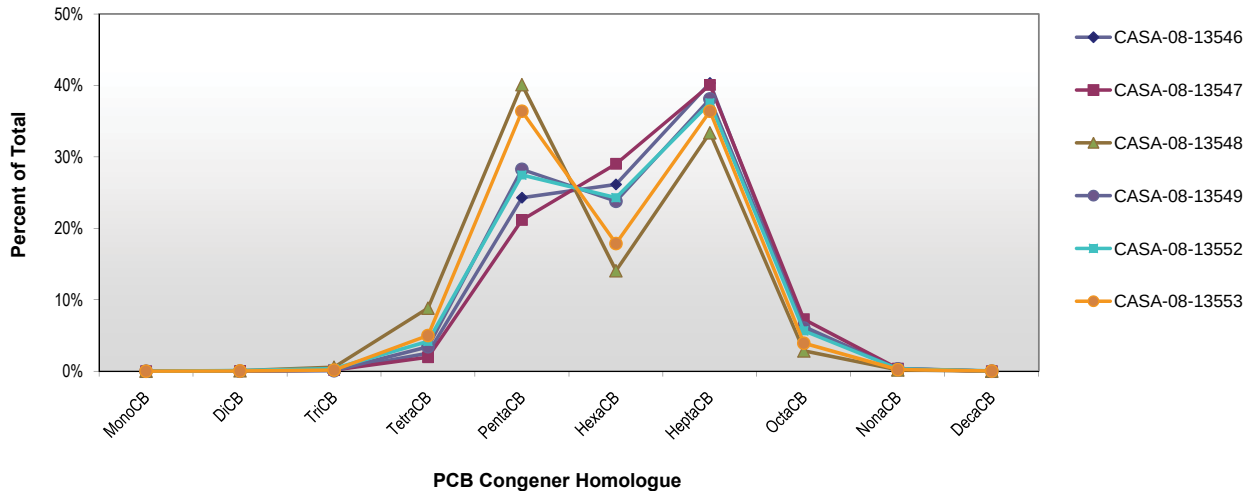


Figure 6-14. PCB congener homolog data from sediment samples collected in Sandia Canyon.

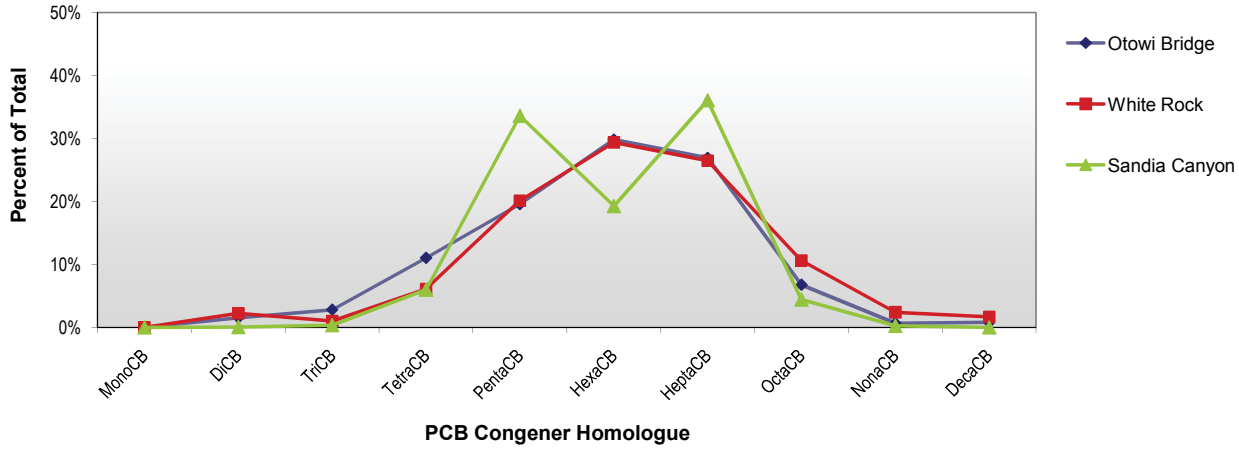


Figure 6-15. Average values for PCB congener homologs from sediment samples collected along the Rio Grande and in Sandia Canyon.

2. Surface Water Sampling Results

Natural stream flow and sediment loading in the Rio Grande are quite large compared with Los Alamos area streams. These factors reduce the possibility of identifying significant impacts from the Laboratory in the Rio Grande. Figure 6-16 shows a hydrographic comparison of 2008 flows in Los Alamos area canyons with flows in the Rio Grande. Daily average flow in the Rio Grande at the Otowi gage ranged from about 400 to 6,000 cfs. In contrast, the estimated combined flows from all the Los Alamos area canyons exceeded 5 cfs only on January 28–29 (18 cfs) and August 4 (15 cfs). Similarly, the average annual amounts of suspended sediment and bed sediment passing the Otowi gaging station has been calculated to be 1,000 and 100 times, respectively, that contributed by Los Alamos Canyon (Graf 1994).

For analysis of radionuclides, metals, and organic chemicals, surface water samples were collected from three locations along the Rio Grande in 2008. These locations are upriver of Los Alamos Canyon and LANL at Otowi Bridge, at a proposed surface water diversion site for Santa Fe at Buckman (at the mouth of Cañada Ancha, downriver from Los Alamos, Sandia, and Mortandad Canyons), and at the mouth of Frijoles Canyon in Bandelier National Monument (downriver from all canyons draining LANL). Three samples each were collected at Otowi Bridge and Buckman on the same days, and one sample was collected at Frijoles Canyon two days after one of the upriver samples. None of these samples exceeded screening levels for metals. No organic chemicals were detected except for PCBs analyzed by the congener method. For total PCBs, the screening level of 0.00064 µg/L was exceeded in non-filtered samples collected on September 29, 2008, from both the Otowi Bridge and Buckman locations. The highest result, 0.00136 µg/L, was obtained from the Otowi Bridge locations, which indicates PCB sources upriver from LANL.

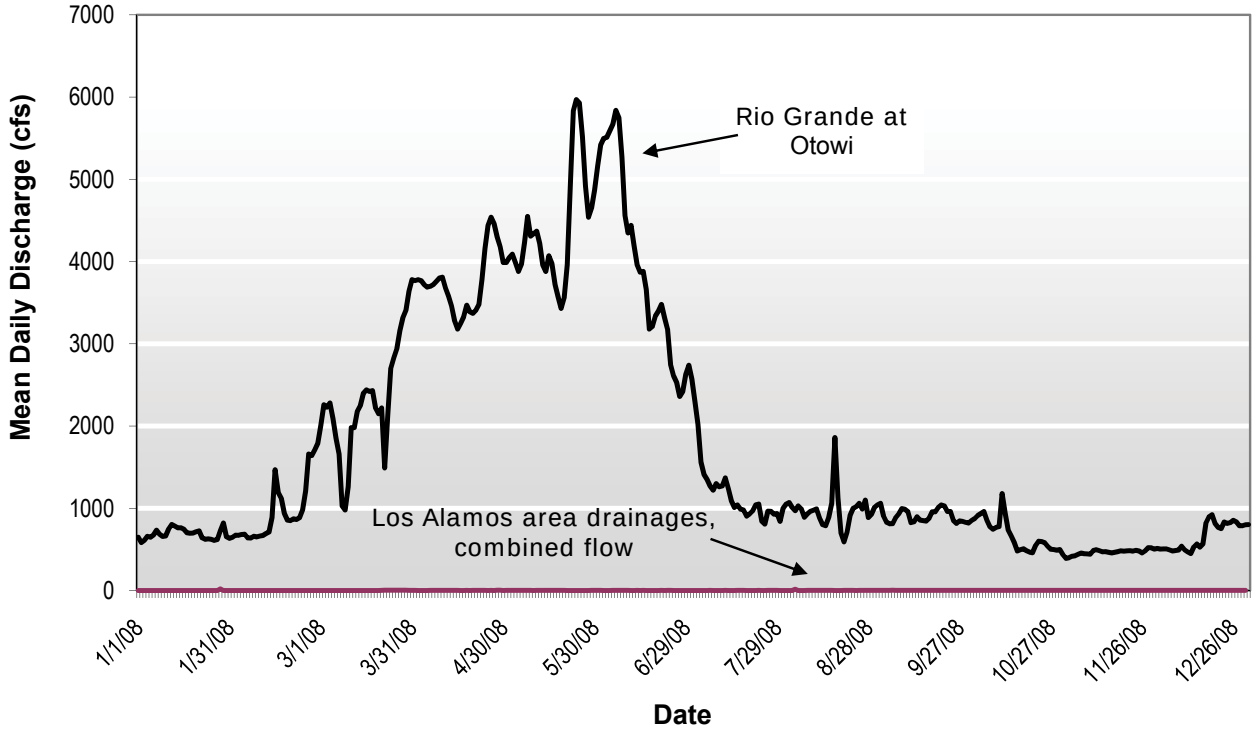


Figure 6-16. Discharge from Los Alamos drainages in 2008 in comparison to discharge in the Rio Grande at Otowi Bridge gaging station.

Five radionuclides were detected in the Rio Grande water samples: radium-226, tritium, uranium-234, uranium-235/236, and uranium-238. No screening levels were exceeded in these samples. The highest concentrations for tritium, uranium-234, and uranium-238 were measured at Otowi Bridge, upriver from LANL, whereas the highest radium-226 concentration was measured at Buckman and the highest uranium-235/236 concentration at Frijoles Canyon. These data indicate no recognizable LANL impact on water quality in the Rio Grande.

G. CANYON-SPECIFIC RESULTS

1. Guaje Canyon (includes Barrancas and Rendija Canyons)

Guaje Canyon is a major tributary of Los Alamos Canyon that heads in the Sierra de los Valles and lies north of Laboratory land. The total drainage area above Los Alamos Canyon is about 33 mi^2 (85 km^2), and the main Guaje Canyon stream channel has a length of about 16 mi (25 km). Guaje Canyon and its tributaries have not received any effluents from LANL activities, but contained some firing sites and other locations with potential Laboratory contaminants (LANL 2009a). In 2008, a surface water sample from a gage in lower Guaje Canyon (E099) had measured gross alpha radiation of 89.5 pCi/L, well above the NMWQCC livestock watering standard of 15 pCi/L. This result is consistent with measurements from previous years and is an indication of the pervasive nature of gross alpha radiation above the standard in storm water on the Pajarito Plateau due to the presence of naturally occurring radionuclides. Concentrations of metals in Guaje Canyon surface water in 2008 were below applicable screening levels except for aluminum, which was above the acute wSAL of 750 µg/L in a filtered sample, at 936 µg/L. Aluminum results above the wSAL are also widespread on the Pajarito Plateau, including other canyons not affected by LANL activities, and are the product of elevated background conditions.

2. Los Alamos Canyon (includes Acid, Bayo, DP, and Pueblo Canyons)

Los Alamos Canyon has a large drainage area that heads in the Sierra de los Valles. Excluding Guaje Canyon and its tributaries, the drainage area is about 28 mi^2 (72 km^2), and the master canyon has a stream channel length of about 17 mi (27 km). The Laboratory has used land in the Los Alamos Canyon watershed continuously since the early 1940s, with operations conducted at some time in the watersheds of several tributary canyons (Acid, Bayo, DP, and Pueblo Canyons). Several of the canyons within the watershed also receive urban runoff from the Los Alamos town site, and lower Pueblo Canyon receives treated sanitary municipal wastewater from the Los Alamos County WWTP.

Historical releases of radioactive liquid effluents into Acid, DP, and Los Alamos Canyons have introduced americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, and tritium, among other radionuclides, into the canyon bottoms. Most of these radionuclides bind to stream sediment and persist at concentrations well above atmospheric fallout levels. Cesium-137 and plutonium-239/240 are the most important radionuclides in the Los Alamos Canyon watershed from the perspective of potential human health risk, although concentrations are low enough that they do not pose an unacceptable risk to recreational users of the canyons (LANL 2004a; LANL 2005b). The main source for cesium-137 was discharges into DP Canyon from a treatment facility at TA-21 between 1952 and 1986. The main source for plutonium-239/240 was discharges into Acid Canyon from former TA-1 and former TA-45, located within the current Los Alamos town site, between 1945 and 1964. These radionuclides and other contaminants have been transported by floods down these canyons, off-site across Pueblo de San Ildefonso land, and to the Rio Grande near Otowi Bridge (Graf 1994, 1996; Reneau et al., 1998; LANL 2004a). Plutonium-239/240 from historic Acid Canyon discharges has been traced in sediment more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002). In 2001, the Laboratory conducted a major contaminated sediment removal effort in Acid Canyon to reduce concentrations of plutonium-239/240 in the canyon bottom (Reneau et al. 2002). In 2005, the Laboratory performed additional stabilization of sediment in Pueblo Canyon to reduce downstream transport of plutonium-contaminated sediment. In 2005, the Laboratory completed the installation of 3,000 linear feet of jute matting along channel banks that contained elevated radionuclide concentrations, and the planting of 3,000 willow stems to provide additional stream bank support (PPWP 2005). Additional actions to reduce the transport of contaminated sediment in the Los Alamos Canyon watershed began in 2008 (LANL 2008e, LANL 2008d, LANL 2009b). In the most recent actions, the Laboratory planted 4,000 additional willow stems in Pueblo Canyon in spring 2008 and another 6,000 willow stems in spring 2009, and excavated sediment behind the Los Alamos Canyon weir in May 2009. The excavation at the weir was accompanied by enhancements to increase sediment trapping efficiency.

Several notable hydrologic events occurred in the Los Alamos Canyon watershed in 2008. The first was on January 28, when a rain-on-snow event resulted in runoff past the LANL boundary and to the Rio Grande. The second was on July 4–5, associated with the potable water line break at TA-21 that was discussed in

Section B of this chapter. The third was on August 9, when storm water runoff in Los Alamos Canyon remobilized sediment deposited below the TA-21 water line break. Another runoff event on August 31 remobilized more of this sediment. Water from the July 4-5, August 9, and August 31 events did not reach the Rio Grande. Analytical data from water samples collected on January 28, August 9, and August 31 are discussed below, along with data from sediment samples collected from the Los Alamos Canyon weir after the August events.

Cesium-137 was detected in three out of 34 non-filtered surface water samples from the Los Alamos Canyon watershed in 2008. Two of these samples were collected from the gages above and below the Los Alamos Canyon weir (E042 and E050) on August 9, and the third was from an SMA in Pueblo Canyon (P-SMA-1) on August 8. The maximum cesium-137 result from this watershed in 2008, 16.4 pCi/L, was less than in 2007 (34.3 pCi/L) and 2006 (117 pCi/L).

Plutonium-239/240 was detected in 21 out of 33 non-filtered surface water samples from the Los Alamos Canyon watershed in 2008. The highest concentrations were in three samples collected in Los Alamos Canyon on August 9, associated with the remobilization of sediment deposited during the July 4–5 potable water line break. Concentrations decreased greatly downstream, from 341 pCi/L at the gage above DP Canyon (E030) to 31-55 pCi/L above and below the weir (E042 and E050) (Figure 6-17). Lower concentrations of plutonium-239/240 were detected in lower Los Alamos Canyon near the Rio Grande during the January 28 rain-on-snow runoff event (gage E110, 13.1 pCi/g), similar to concentrations measured in lower Pueblo Canyon (gage E060, 12.7 pCi/g).

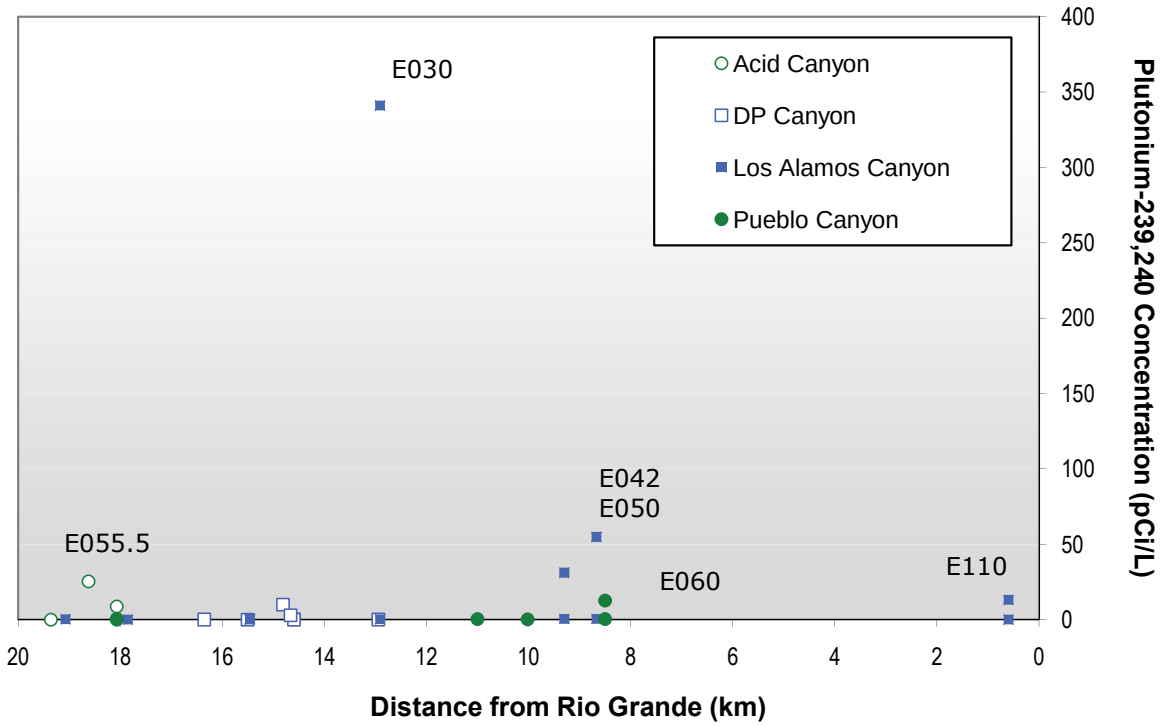


Figure 6-17. Spatial variations in plutonium-239/240 concentration in non-filtered surface water samples from the Los Alamos Canyon watershed in 2008; results below 0.07 pCi/L are non-detects.

Several other constituents are notable in storm water samples collected from Los Alamos Canyon above DP Canyon in August 2008 and may be associated with the erosion from the July 4–5 water line break. One of two results for chromium above the wSAL from the Pajarito Plateau in 2008 was from the E030 gage on August 9, although two downstream samples that day and a sample from this location on August 31 were below the wSAL. The maximum concentration of chromium in a sediment sample in 2008 was from

this same location. Maximum detected concentrations of dioxin and furans in surface water were measured at E030 on August 9 and August 31, with 2,3,7,8 TCDD concentrations on both days being above the wSAL. Chromium, dioxins, and furans had been previously reported at SWMU 21-027(a), along with plutonium-239/240 (LANL 2008f). The maximum detected concentration of cyanide in surface water in 2008 was also from E030 (0.0579 µg/L), in the sample collected August 31. However, cyanide was not reported at SWMU 21-027(a) and it has non-LANL sources in the Los Alamos Canyon watershed, as shown by a similar result from Pueblo Canyon above Acid Canyon on the same day (0.0529 µg/L).

The transport of PCBs in storm water is also of concern in the Los Alamos Canyon watershed, and an interim measure has been proposed to mitigate this transport (LANL 2008e, LANL 2008d). In 2008, PCBs were detected in four out of 26 samples from this watershed using the Aroclor method. The highest concentrations of PCBs in surface water were detected at a hillside monitoring station in Los Alamos Canyon below former Manhattan Project facilities in what is now the Los Alamos townsite (LA-SMA-2) (Figure 6-18). PCBs were detected at low levels in only one downstream sample in Los Alamos Canyon, above the weir (0.11 µg/L), and no PCBs were detected at boundary stations or downstream in lower Los Alamos Canyon. These results are generally consistent with 2007, although maximum concentrations at LA-SMA-2 in 2008 are lower than in 2007 (8.7 µg/L total detected PCBs on August 4, 2008, compared to a maximum of 24.8 µg/L in 2007).

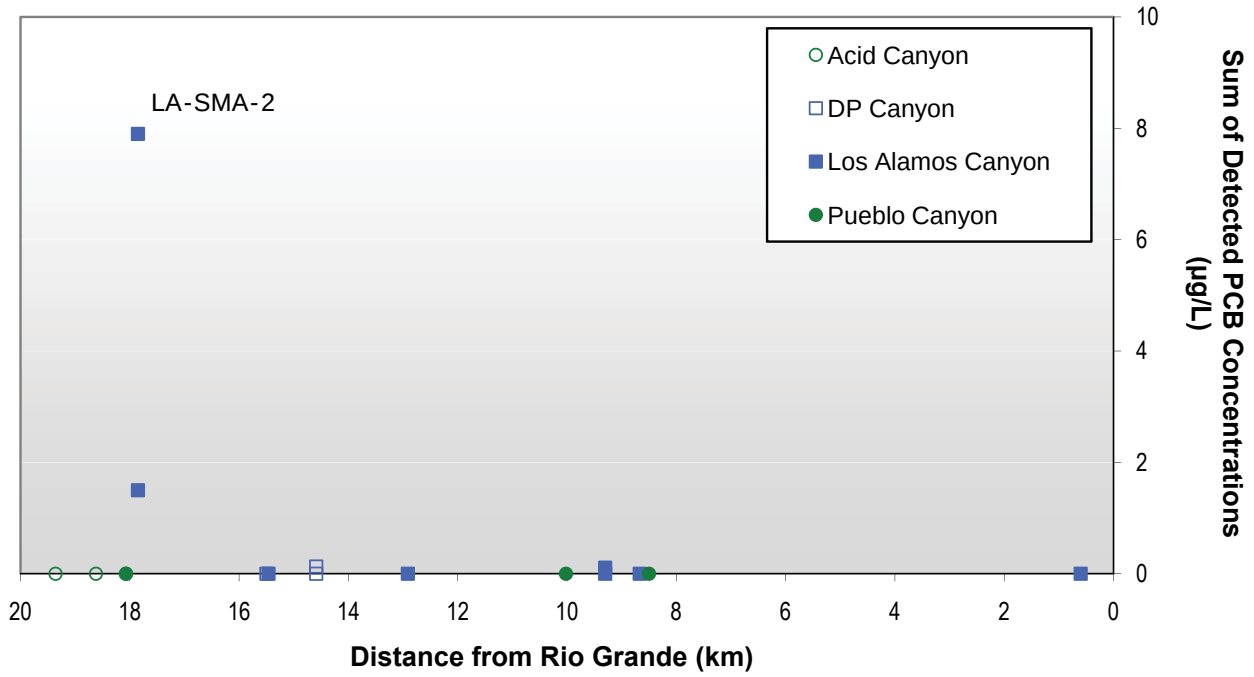


Figure 6-18. Spatial variations in detected PCB concentrations in non-filtered surface water samples from the Los Alamos Canyon watershed in 2008.

The highest detected concentration of PCBs at LANL in the 2008 surveillance sediment samples was also in Los Alamos Canyon, from fine-grained sediment collected from the sediment retention basin immediately west of the weir, above NM 4. This result, 0.197 mg/kg, is the sum of detected Aroclor-1248, Aroclor-1254 and Aroclor-1260 concentrations; concentrations are well below recreational SSLs for these PCBs (10.5, 6.65, and 10.5 mg/kg, respectively). Excluding the Los Alamos Canyon weir samples, the next highest result for total detected Aroclors from the Pajarito Plateau surveillance sediment samples in 2008, 0.088 mg/kg, was obtained from Pueblo Canyon upstream of the confluence with Acid Canyon, demonstrating a non-LANL source for some of the PCBs in this watershed. PCBs were also detected at lower concentrations in sediment in Acid Canyon above Pueblo Canyon, in DP Canyon above Los Alamos Canyon, and in Los Alamos Canyon above DP Canyon, demonstrating the presence of multiple sources in the watershed.

Plutonium-239/240 is the most important radionuclide in the Pueblo Canyon watershed from the perspective of potential human health risk (LANL 2004a) and plutonium-239/240 concentrations in sediment transported by floods today are much less than concentrations during the period of active releases of radioactive effluent into Acid Canyon from 1945 to 1964. In lower Acid Canyon, analyses of active channel sediment samples show an overall decrease in plutonium-239/240 concentrations between 1970 and 2008 (Figure 6-19, modified from LANL 2004a and Reneau et al. 2004), with inter-year and intra-year variability seen. The year-to-year variations seen in these samples may be due at least in part to variability in silt and clay percentages, as there are strong relations between sediment particle size and contaminant concentration. The plutonium-239/240 concentration measured here in 2008, 5.52 pCi/g, is similar to that in previous years. Downstream in lower Pueblo Canyon, the 2008 result for plutonium-239/240 was below the LANL sediment background value of 0.067 pCi/g. Farther downstream, in lower Los Alamos Canyon near the Rio Grande, plutonium-239/240 was not detected in the 2008 sample.

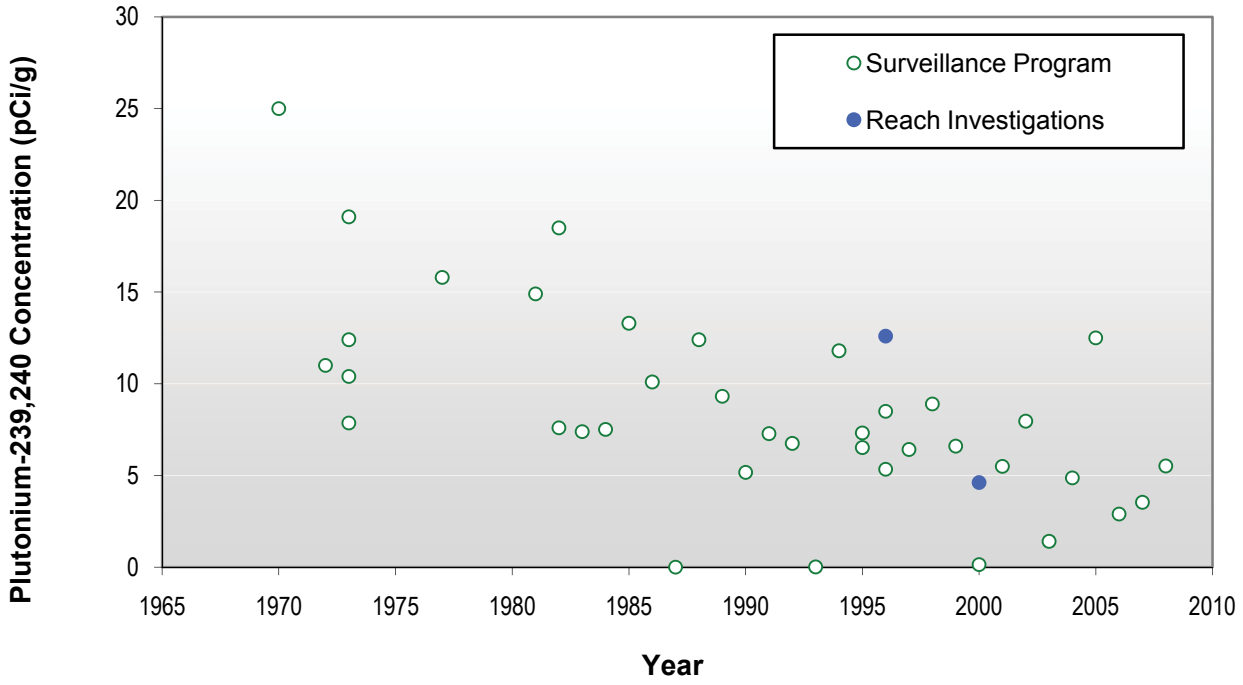


Figure 6-19. Variations in plutonium-239/240 concentration over time in active channel sediment in lower Acid Canyon; most values are detects and are above the background value of 0.067 pCi/g.

Cesium-137 is the most important radionuclide in Los Alamos Canyon from the perspective of potential human health risk (LANL 2004a), and cesium-137 concentrations in sediment transported by recent floods are much less than concentrations during the period of active releases of radioactive effluent into DP Canyon from 1952 to 1986. Figure 6-20 plots cesium-137 concentrations in samples from the active channel of lower DP Canyon since 1971 and shows that concentrations have been relatively low and constant since about 1989. Downstream, samples from the active stream channel in Los Alamos Canyon above NM 4 and near the Rio Grande in 2008 had cesium-137 concentrations below the background value of 0.9 pCi/g.

The sediment retention basin above the Los Alamos Canyon weir was constructed in summer 2000 after the Cerro Grande fire to reduce the transport of contaminated sediment across the LANL boundary. Essentially all of the coarse-grained sediment transported down Los Alamos Canyon is deposited there with a large portion of the fine-grained sediment. As of July 2007, approximately 5800 m^3 (7500 yd^3) of sediment had been deposited behind the weir, reaching a maximum thickness of about 2 m (6.5 ft). Repeat surveys indicate that a relatively small volume of sediment was deposited between July 2007 and September 2008, approximately 140 m^3 (180 yd^3) (although if compaction occurred then the actual volume of new sediment originally deposited would have been larger). A map showing sediment thickness variations at the weir as of September 2008 is presented in LANL (2008g). The Laboratory excavated and enhanced the basin in May 2009 to increase sediment trapping efficiency (LANL 2009b).

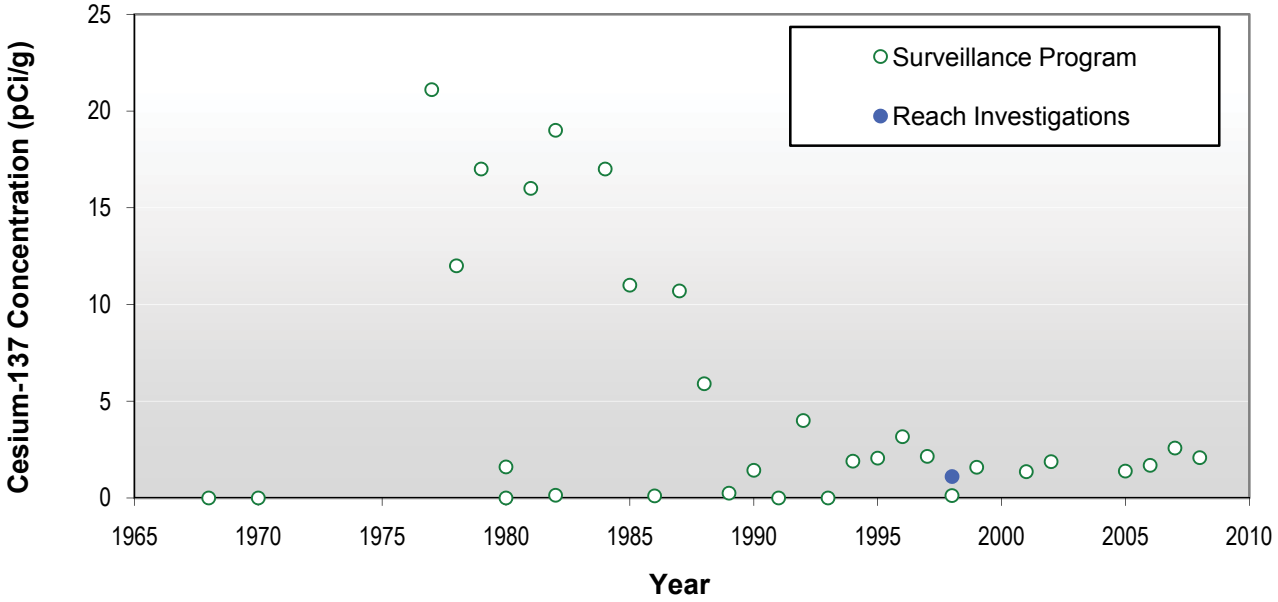


Figure 6-20. Variations in cesium-137 concentration over time in active channel sediment in lower DP Canyon; most values are detects and are above the background value of 0.9 pCi/g.

In 2008, 15 sediment samples were collected from the weir in preparation for excavation and to evaluate any changes in contaminant concentrations in 2008 relative to previous years. Data from two samples of sediment deposited in 2008 and eight samples of deeper pre-2008 sediment were presented in LANL (2008g), and an additional five samples of 2008 sediment were collected as part of the surveillance program. Additional sediment data from the weir from 2007 are also presented in LANL (2008g). The analytical suite in 2008 included dioxins and furans because they had been detected at SWMU 21-027(a) (LANL 2008f), which was partially eroded by the potable water line break on July 4–5, 2008, as well as other analytes identified as contaminants in Los Alamos Canyon.

The data from sediment deposited in 2008 indicated higher concentrations of several analytes than had been measured in older sediment at the weir, including the radionuclides americium-241, plutonium-238, plutonium-239/240, strontium-90, and uranium-234, and the metals arsenic, chromium, and mercury. Except for a single detect for Aroclor-1248 in the 2008 sediment, results for PCBs were lower than measured previously. All of these analytes with maximum results from 2008 sediment had been previously reported as contaminants at SWMU 21-027(a) except for strontium-90 and Aroclor-1248 (LANL 2008f).

The data on dioxins and furans also indicate higher concentrations in the sediment deposited behind the weir in 2008 than in older, deeper sediment, particularly in two thin (3-7 cm thick) fine-grained silt- and clay-rich layers that also had the highest concentrations for some radionuclides and metals. As examples, Figures 6-21 and 6-22 show variations in the total TCDD and total tetrachlorodibenzofuran (TCDF) concentrations as a function of sediment age and silt and clay content. Both TCDD and TCDF were detected in pre-2008 sediment but at lower concentrations for a given silt and clay content than in the 2008 sediment. As with many other contaminants, TCDD and TCDF concentrations are highest in samples with relatively high silt and clay content, whereas they were not detected in coarse-grained sediment with less than 20% silt and clay.

Plutonium-239/240 was measured above the BCG in the storm water sample collected August 9 in Los Alamos Canyon above DP Canyon (gage E030). In addition, the highest concentration of strontium-90 in surface water was measured from DP Canyon below TA-21 on August 28. However, the annual time-weighted average concentrations of radionuclides are well below the BCGs in non-filtered surface water collected from these location and other sites in Acid, Los Alamos, and Pueblo Canyons (Table 6-2). When the mixture of radionuclides is considered (see discussion in Section E.1), surface water along the stream channels in these canyons ranged from 1% to 18% of the BCGs. The highest percentage in the Los Alamos Canyon watershed occurred near the Rio Grande, dominated by radium-226, and the lowest in lower Acid Canyon and in DP Canyon below TA-21.

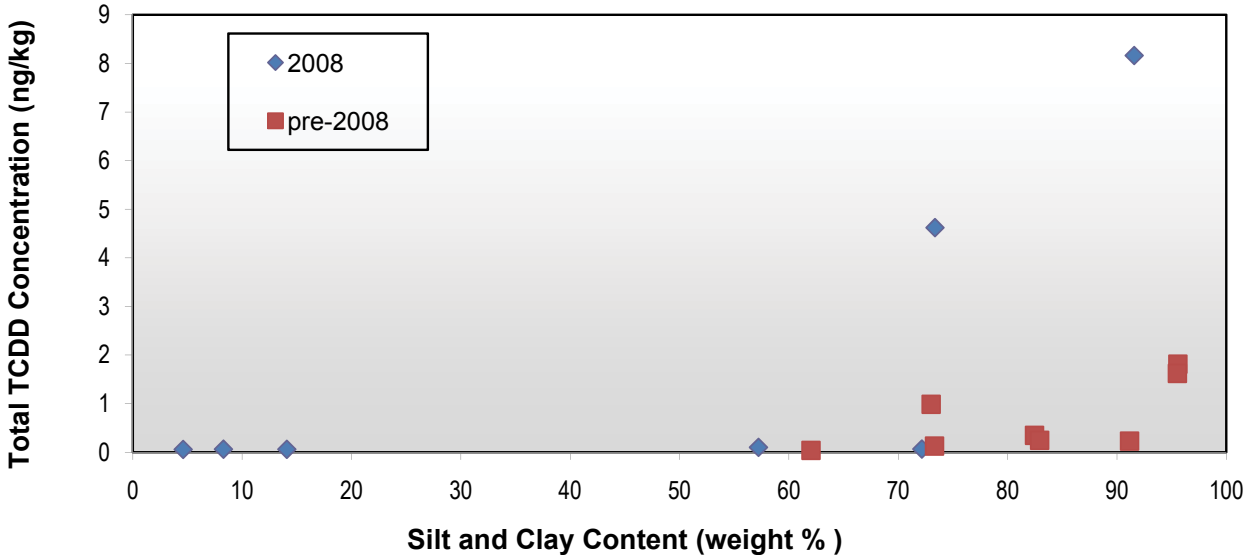


Figure 6-21. Variations in total TCDD concentration in sediment behind the Los Alamos Canyon weir as a function of sediment age and silt and clay content.

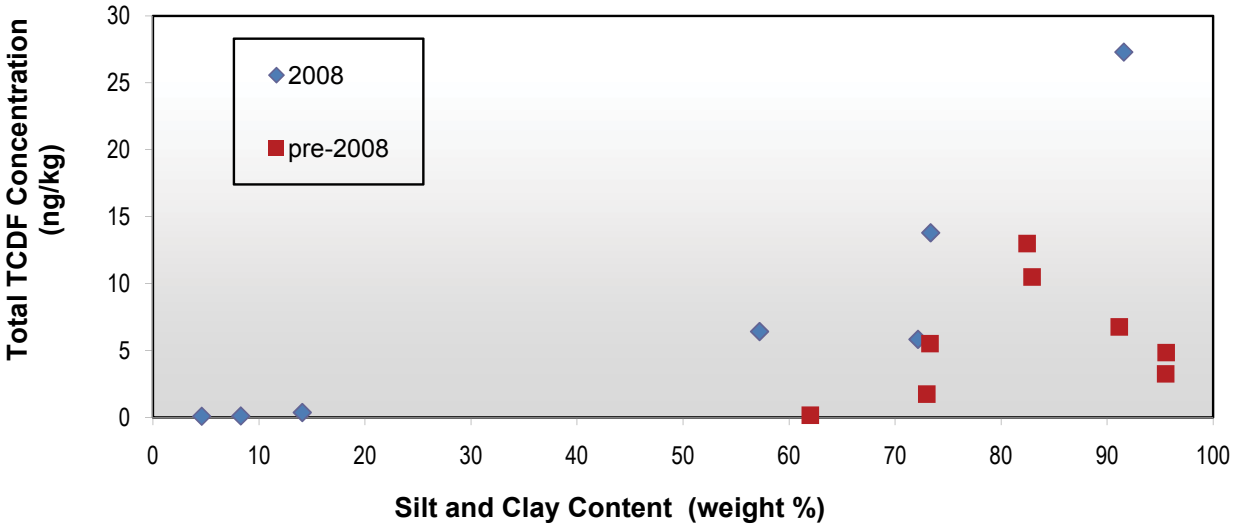


Figure 6-22. Variations in total TCDF concentration in sediment behind the Los Alamos Canyon weir as a function of sediment age and silt and clay content.

3. Sandia Canyon

Sandia Canyon heads on the Pajarito Plateau within TA-3 and has a total drainage area of about 5.5 mi^2 (14 km^2) and a channel length of about 11 mi (18 km). This relatively small watershed extends eastward across the central part of the Laboratory and crosses Bandelier National Monument and Pueblo de San Ildefonso land before ending at the Rio Grande. Effluent discharges from a sanitary wastewater treatment plant, supplemented by releases from a steam plant, create perennial flow conditions along a 2-mile reach below TA-3. Surface flow rarely extends past the Laboratory boundary, and only one runoff event, resulting from rain on snow, was recorded at the E125 gage above NM 4 in 2008, on January 28. Two contaminants that have been of concern in Sandia Canyon are chromium and PCBs. Chromium was discharged in water from the TA-3 power plant from 1956 to 1972, and is the focus of extensive ongoing investigations related to groundwater contamination (e.g., LANL 2008g). PCBs were released from a former transformer storage area at TA-3 and were the target of remediation activities involving excavation of soil near the source (LANL 2001). Contaminant concentrations in sediment deposits decrease downstream from TA-3, and relatively low levels of contaminants are present above NM 4, adjacent to the eastern Laboratory boundary (LANL 2007b).

In 2008, chromium was detected above the wSAL of 77 µg/L for a designated perennial stream segment in one of eight non-filtered surface water samples from gage E123 in Sandia Canyon below the wetland (collected on July 27). This chromium is almost entirely associated with sediment particles, and the concentration in the non-filtered sample (425 µg/L) is much higher than in a paired filtered sample (5.6 µg/L). Chromium was detected at a higher concentration in one downstream sample from a designated ephemeral stream reach (575 µg/L from gage E124 on August 10), slightly below the wSAL for ephemeral channels (580 µg/L). Runoff in these two events did not cross the eastern Laboratory boundary, and the chromium concentration was much lower in the one runoff event that occurred at the easternmost gage in 2008 (12.4 µg/L at gage E125 on January 28; Figure 6-23). The maximum 2008 result from Sandia Canyon channels is lower than in 2007 (1,040 µg/L). NMWQCC aquatic life standards, based on dissolved chromium, are not exceeded in any filtered sample from Sandia Canyon in 2008.

PCBs were detected in seven out of 29 surface water samples collected from Sandia Canyon in 2008; all detected concentrations were above the screening level of 0.00064 µg/L. The concentrations of detected PCBs in Sandia Canyon storm water in 2008 were highest at gage E123, below the wetland, and decrease downstream (Figure 6-24). PCBs were not detected at the gage near the eastern LANL boundary, above NM 4 (E125), in the one runoff event that occurred there in 2008 (January 28-29). The maximum concentration of detected PCBs at E123 in 2008 (0.4 µg/L) was less than the concentration detected in 2007 (2 µg/L).

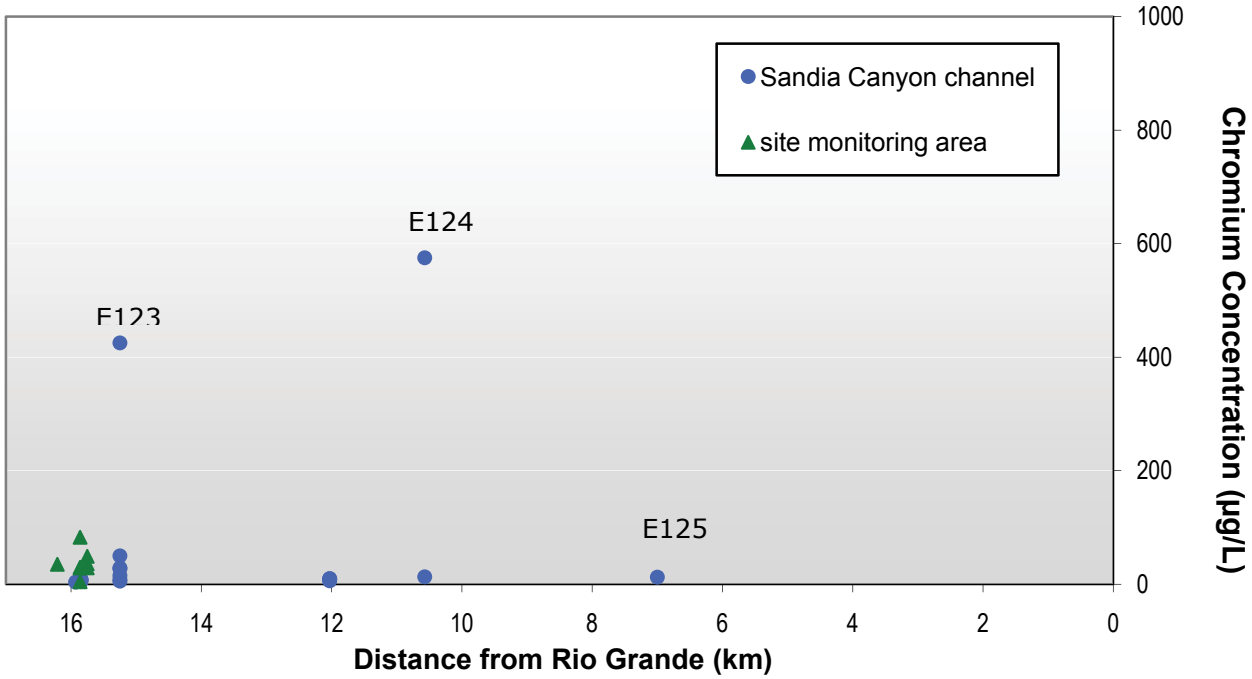


Figure 6-23. Spatial variations in detected chromium concentration in non-filtered surface water samples from the Sandia Canyon watershed in 2008.

Two metals of interest in the Sandia Canyon watershed are mercury and selenium, and the results from 2008 show improvements from 2007. All results for mercury and selenium in non-filtered water from this watershed in 2008 were below the wSALs, although in 2007, Sandia Canyon had the highest concentrations measured at the Laboratory, above wSALs.

Active channel sediment collected from three locations in Sandia Canyon had chromium and other metals within background ranges in 2008, a change from 2007 when chromium was measured above the background value of 10.5 mg/kg. Low concentrations of PCBs were detected in the active channel below the wetland (0.059 mg/kg) and at the Laboratory boundary (0.0086 mg/kg), but PCBs were not detected from the Sandia Canyon channel at the Rio Grande. These PCB results are consistent with previous years and are well below recreational SSLs. No radionuclides were detected above background values.

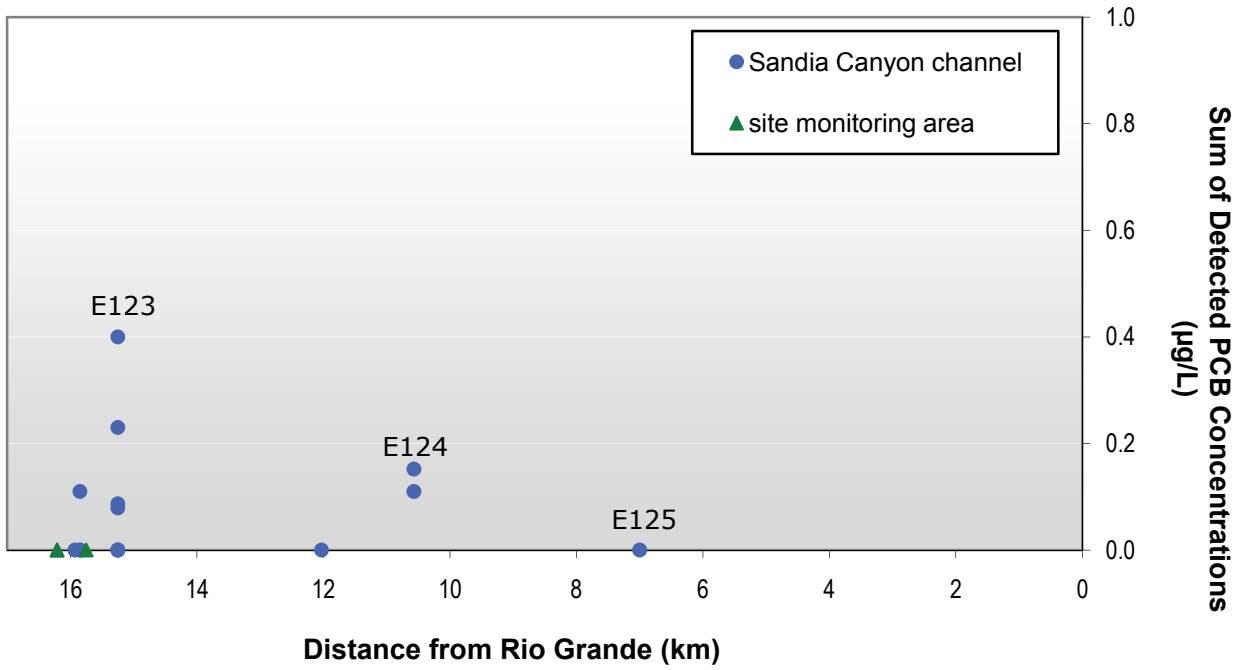


Figure 6-24. Spatial variations in total detected PCB concentration in surface water samples from the Sandia Canyon watershed in 2008.

4. Mortandad Canyon (includes Cañada del Buey and Effluent, Pratt, and Ten Site Canyons)

Mortandad Canyon heads on the Pajarito Plateau in the main Laboratory complex at TA-3 and crosses Pueblo de San Ildefonso land before reaching the confluence with the Rio Grande. It has a total drainage area of about 10 mi^2 (27 km^2) and a main channel length of about 10 mi (16 km). Mortandad Canyon receives treated water discharged into Effluent Canyon from the TA-50 RLWTF. No runoff events have crossed the Laboratory boundary in Mortandad Canyon proper since a stream gage was installed in 1993, and the only reported event that crossed the boundary occurred in 1952 (LANL 2006a). The Mortandad Canyon sediment traps are located approximately two miles upstream of the Laboratory's eastern boundary, and in most years, including 2008, runoff events have not extended past the sediment traps.

Cañada del Buey is a major tributary that heads in TA-63 and passes through the town of White Rock and Pueblo de San Ildefonso land before joining Mortandad Canyon near the Rio Grande. It has a drainage area of about 4 mi^2 (11 km^2) and a main channel length of about 8 mi (13 km). Runoff events have crossed the Laboratory boundary in Cañada del Buey every year since a gage (E230) was established above NM 4 in 1994, although in most years flow has not been recorded at the next upstream station (E225), indicating that the runoff originates in the lower part of the watershed.

The highest concentrations of several radionuclides in surface water samples collected in 2008 were measured in the Mortandad Canyon watershed, including americium-241, cesium-137, plutonium-238, and tritium. The highest concentrations for all these radionuclides were along the stream channel downstream from the TA-50 RLWTF outfall, between Effluent Canyon and the sediment traps (gage E200 or E201). As one example, Figure 6-25 shows the spatial distribution of cesium-137 results in the Mortandad Canyon watershed. The maximum concentration of cesium-137 was at gage E201 in a storm water sample from August 10. Cesium-137 was not detected in samples from Effluent Canyon, Ten Site Canyon, or Cañada del Buey. The annual time-weighted average concentrations of radionuclides are well below the BCGs in non-filtered surface water collected from Mortandad Canyon below Effluent Canyon (Table 6-2). When the mixture of radionuclides is considered (see discussion in Section E.1), the surface water here was at 27% of the BCGs, primarily from radium-226.

Stream sediment in Mortandad Canyon downstream of Effluent Canyon to near regional well R-28 (1 km above the eastern LANL boundary) contains above-background concentrations of radionuclides, with concentrations decreasing to at or near background levels at the Laboratory boundary (LANL 2006b). Results from 2008 samples are similar to those obtained in previous years and all are below the recreational SALs.

The highest concentrations of chromium and nickel measured in surface water at the Laboratory in 2008, above wSALs, were from a storm water sample collected on July 17 from Cañada del Buey above NM 4 (gage E230). The source of these metals is not known. Concentrations in two other samples from this location in 2008 were below wSALs. The highest concentration of zinc measured in surface water at the Laboratory in 2008, above the screening level, was from a storm water sample collected on August 6 from upper Ten Site Canyon below MDA C in TA-50 (gage E201.3). Three other samples collected from this location and all downstream samples had zinc concentrations below the wSAL. The source of this zinc is unknown.

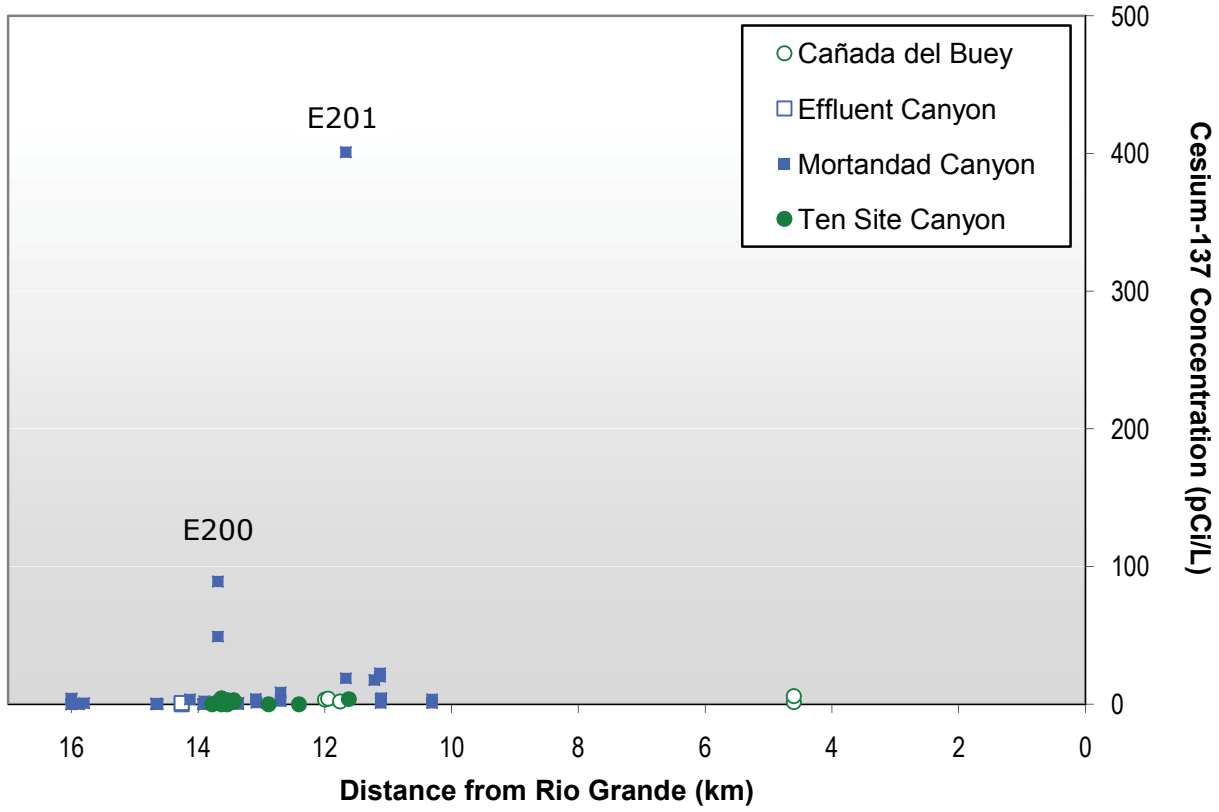


Figure 6-25. Spatial variations in cesium-137 concentration in non-filtered surface water samples from the Mortandad Canyon watershed in 2008; all values above 8 pCi/L are detects.

Several radionuclides (americium-241, plutonium-238, and plutonium-239/240) were measured at low concentrations above background levels in sediment in small drainages below MDA G in the Cañada del Buey watershed. Concentrations for these radionuclides in 2008 were all less than 1 pCi/g, which is consistent with previous years. All results are well below the recreational SALs. None of these radionuclides were detected above background levels downstream in the active channel of Cañada del Buey.

5. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads in the Sierra de los Valles in the Santa Fe National Forest and crosses the central part of the Laboratory before passing through the community of White Rock east of NM 4. It has a total drainage area of about 13 mi^2 (33 km^2) and a main channel length of about 15 mi (24 km). Major tributary canyons include Twomile Canyon, which also heads in the Sierra de los Valles, and Threemile Canyon, which heads on the Pajarito Plateau. The Pajarito Canyon watershed includes a variety of active and inactive Laboratory sites which are summarized in LANL (2008f).

Copper was measured at concentrations above the acute dissolved wSAL of 14 µg/L in filtered surface water collected from the Pajarito, Threemile, and Twomile Canyon watersheds in 2008, which is consistent with results from previous years. The maximum concentration of copper detected in surface water at the Laboratory in 2008, above the wSAL of 14 µg/L, was from a storm water sample collected from an SMA in the Threemile Canyon watershed at TA-15 (3M-SMA-0.6) on July 7. This sample also had the only detected concentration of lead above the wSAL. Copper and lead were also elevated at this location in 2007. Copper was also above the wSAL in other samples from SMAs in TA-22 (PJ-SMA-5) and TA-3 (2M-SMA-1.7) and in a tributary channel to Twomile Canyon at TA-3 (gage E243.5) (Figure 6-26). Concentrations downstream along main stream channels were all below the wSAL.

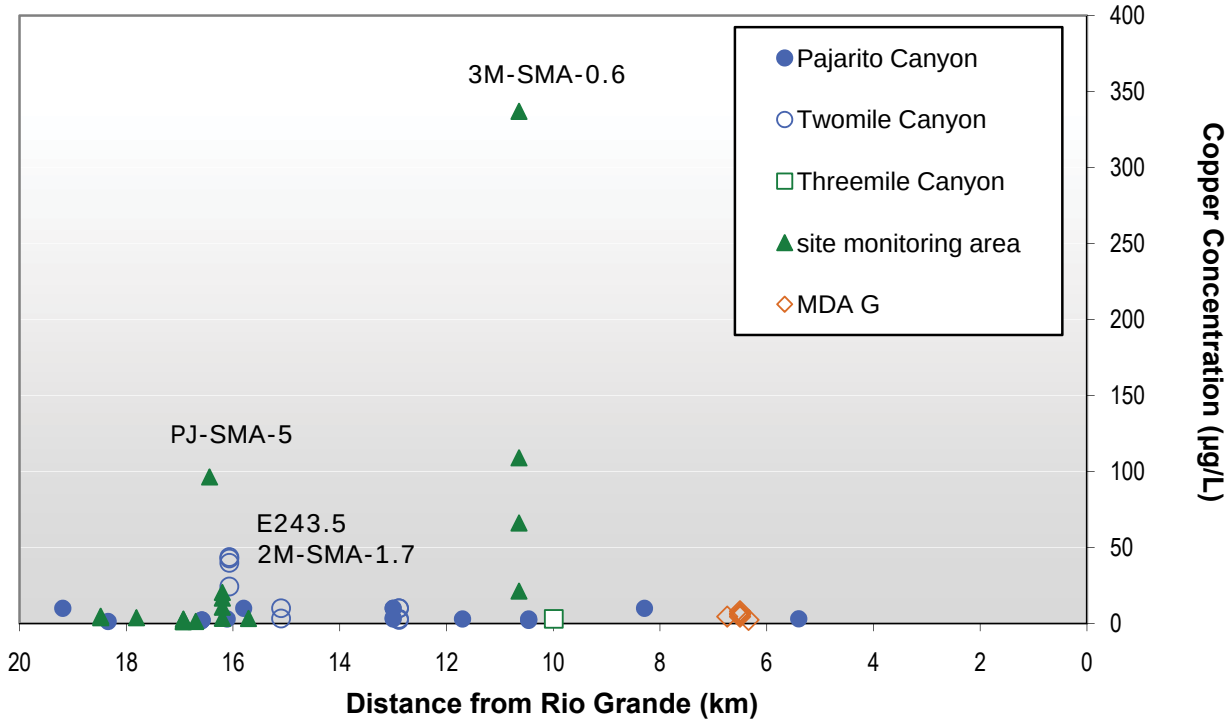


Figure 6-26. Spatial variations in copper concentration in filtered surface water samples from the Pajarito Canyon watershed in 2008; all values above 10 µg/L are detects.

Consistent with past years, americium-241, plutonium-238, and plutonium-239/240 were measured above background levels in sediment samples from channels in the Pajarito Canyon watershed draining MDA G at TA-54. These radionuclides were not detected downstream in a sample from the main stream channel of Pajarito Canyon above NM 4. All of these radionuclides were at concentrations of less than 1 pCi/g, below recreational SALs. In contrast to previous years, tritium was not measured above background levels in these samples.

The highest concentrations of antimony and silver in the 2008 surveillance sediment samples were measured in drainages below MDA G at TA-54 in the Pajarito Canyon watershed, which is consistent with results from 2007. Antimony was above the background value of 0.83 mg/kg in 2008 in the MDA G-7 drainage (6.47 mg/kg), which is higher than in 2007 (1.95 mg/kg). Silver was above the background value of 1 mg/kg in 2008 in the MDA G-6 retention pond (3.54 mg/kg) and was also elevated here in 2006 and 2007 (3.39 and 2.02 mg/kg, respectively). These concentrations are all below recreational SSLs.

Low concentrations of PCBs were detected in sediment in the Pajarito Canyon watershed in 2008. Three samples from the MDA G-6 drainage basin had total detected Aroclors ranging from 0.0059 to 0.021 mg/kg, consistent with previous years. A downstream sample from the main stream channel of Pajarito Canyon above

NM 4 had a higher concentration than measured at MDA G (0.0524 mg/kg), indicating a PCB source or sources farther upstream, as also indicated by other sediment data (LANL 2008c).

6. Water Canyon (includes Cañon de Valle and Fence, Indio, and Potrillo Canyons)

Water Canyon heads in the Sierra de los Valles in the Santa Fe National Forest and extends across the southern portion of the Laboratory to the Rio Grande. It has a total drainage area of about 19 mi^2 (49 km^2) and a main channel length of about 14 mi (23 km). Cañon de Valle is a major tributary that also heads in the Sierra de los Valles. The Water Canyon watershed also includes the shorter canyons of Fence, Indio, and Potrillo Canyons that head on the Pajarito Plateau within LANL. Explosives development and testing and other activities take place in this part of the Laboratory, and elevated concentrations of uranium isotopes, barium, silver, the HE compounds HMX and RDX, along with other analytes, have previously been measured in sediment and surface water in the watershed (LANL 2006c). Cañon de Valle has been the subject of focused Laboratory investigations to address barium and HE contamination in surface water and groundwater (LANL 2004b; LANL 2006c), and the Laboratory is planning a corrective measures investigation for the canyon (LANL 2007c).

The highest concentrations of RDX and other HE compounds in surface water at the Laboratory in 2008 were measured in non-filtered samples from the Cañon de Valle watershed in TA-16 in an area where development of explosive compounds has occurred. Concentrations of RDX are highest at an SMA below a HE machining facility (CDV-SMA-2) and are lower downstream along the Cañon de Valle and Water Canyon stream channels, which is consistent with analyses from previous years (Figure 6-27). All analyses for RDX and other HE compounds were below screening levels in 2008 and the maximum concentration for RDX (107 µg/L) was lower than in 2007 (169 µg/L).

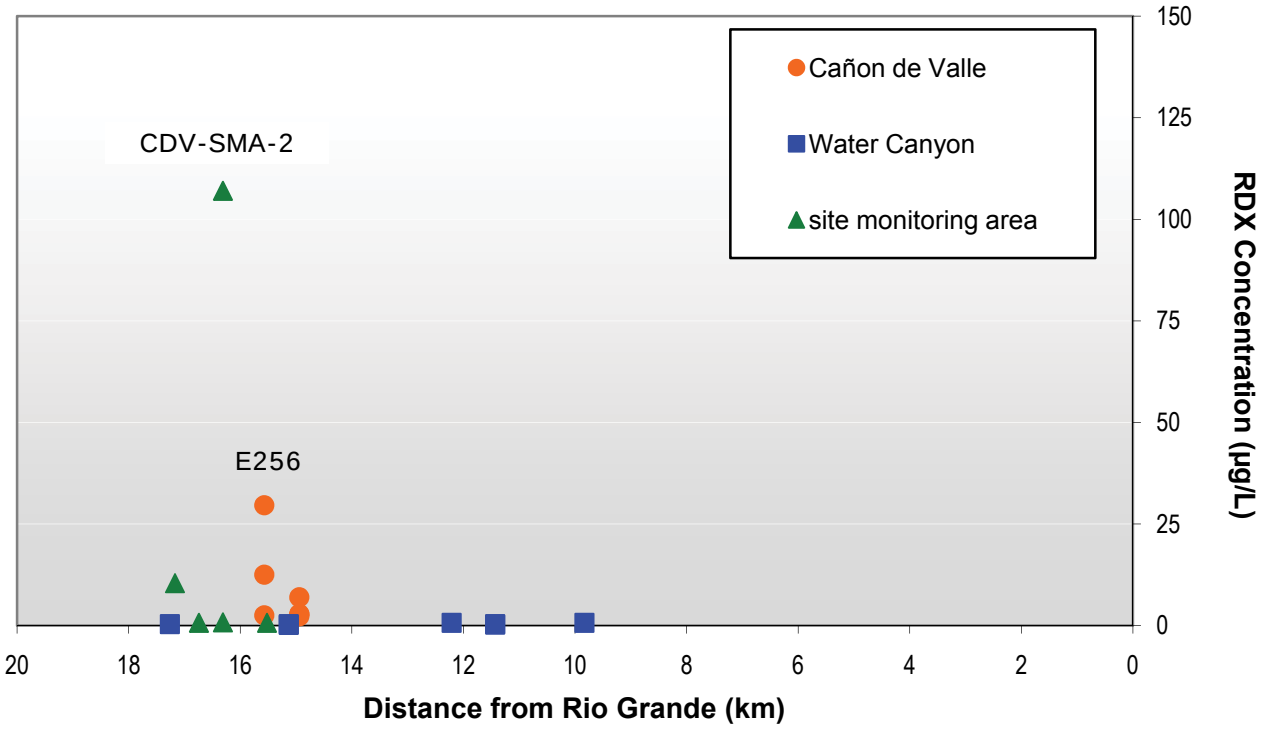


Figure 6-27. Spatial variations in RDX concentration in non-filtered surface water samples from the Water Canyon watershed in 2008; all values above 0.8 µg/L are detects.

Barium is also associated with explosive compounds at TA-16 and is elevated in the Cañon de Valle watershed. The highest concentrations in filtered surface water in 2008 were measured in the Cañon de Valle stream channel below MDA P (gage E256). Concentrations decrease rapidly downstream in Cañon de Valle and Water Canyon (Figure 6-28).

The highest concentrations of silver in non-filtered surface water from the Laboratory in 2008 were measured in two storm water samples at an SMA in the Cañon de Valle watershed at TA-16 (CDA-SMA-1.4), below a former photo-processing facility. Silver concentrations from this location (51.1 and 294 µg/L) are above the wSAL of 3.8 µg/L. The wSAL is based on the acute aquatic life standard for dissolved silver, and the concentration in only one filtered sample from this location (4 µg/L) is slightly above the wSAL. Silver concentrations are much lower downstream in Cañon de Valle, Water Canyon, and elsewhere in the Water Canyon watershed (Figure 6-29). These results are consistent with previous years.

The only selenium result above the screening level of 5 µg/L in 2008 was from a storm water sample collected at W-SMA-11 in TA-11, at 10.1 µg/L. Selenium was not detected in a second sample from this SMA in 2008 or in three samples collected there in 2007. The source of this selenium is not known.

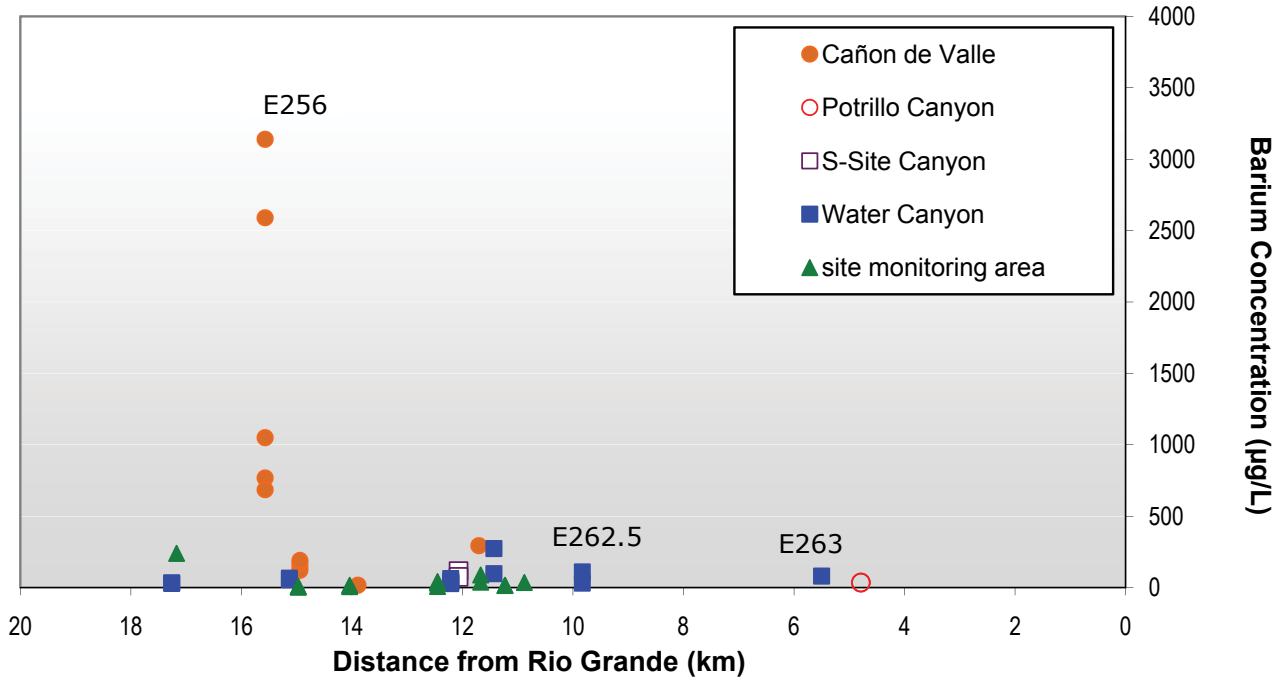


Figure 6-28. Spatial variations in barium concentration in filtered surface water samples from the Water Canyon watershed in 2008; all values are detects.

The highest concentrations of uranium-234 and uranium-238 in surface water in 2008, and the only results above BCGs for these isotopes, were measured in a sample from an SMA in the Potrillo Canyon watershed at a TA-15 firing site (PT-SMA-1, 395 and 758 pCi/L, respectively, compared with BCGs of 200 pCi/L). These concentrations are similar to, but slightly below, results from 2007 at this SMA (545 and 945 pCi/L, respectively). Surface water is ephemeral in Potrillo Canyon, and there is little opportunity for biological exposure from this water.

Within sediment samples collected from the Water Canyon watershed in 2008, several metals had concentrations above background levels. These include barium, which is a known contaminant upstream in Cañon de Valle. The highest result for barium in the 2008 data set (264 mg/kg) came from a fine-grained sample from Water Canyon above NM 4. All other samples from Water Canyon had barium concentrations below the background value of 127 mg/kg, including a second fine-grained sample from the same area. Other metals above background values included antimony, arsenic, cobalt, iron, and vanadium. Low levels of the PCB Aroclor-1260 were detected in both fine-grained sediment samples collected from this location (0.0029 and 0.0032 mg/kg) but not from three active channel locations. These concentrations are below recreational SSLs. No explosive compounds were detected in the 2008 sediment samples from the Water Canyon watershed and no radionuclides were detected at concentrations above background levels.

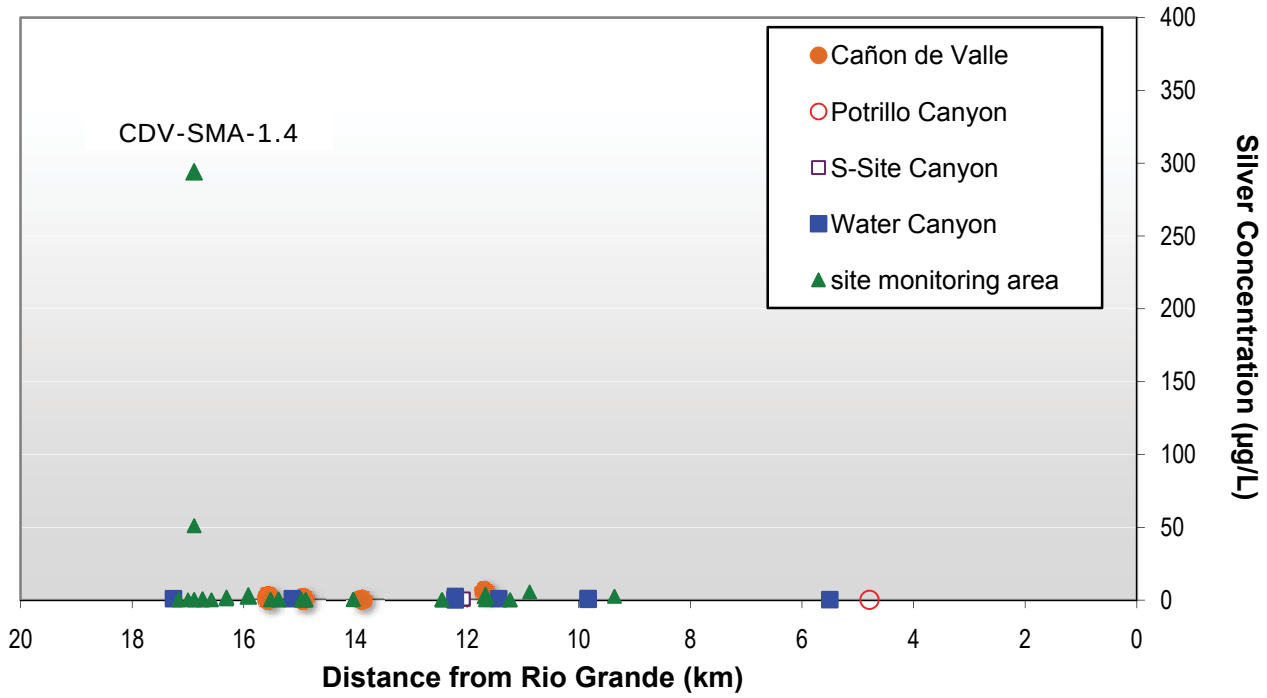


Figure 6-29. Spatial variations in silver concentration in non-filtered surface water samples from the Water Canyon watershed in 2008; all values above 1 µg/L are detects.

7. Ancho Canyon

Ancho Canyon heads on the Pajarito Plateau in TA-49 and extends across the Laboratory to the Rio Grande. It has a total drainage area of about 7 mi^2 (17 km^2) and a main channel length of about 7 mi (12 km). Potential Laboratory sources of contamination in the Ancho Canyon watershed include MDA AB in TA-49, the site of underground testing from 1959 to 1961, and firing sites in the north fork of Ancho Canyon in TA-39 (LANL 2006b).

An exceptionally intense rain storm occurred in the headwaters of Ancho Canyon on August 4, 2008, totaling three in. of rain in a four-hour period at the TA-49 meteorological station, the most ever recorded at LANL. This rain storm resulted in floods in both the main southern fork of Ancho Canyon and the north fork of Ancho Canyon. The gage below their confluence had the largest estimated flood discharge in its 14-year period of record, 537 cfs. This was also the largest flood recorded at LANL in 2008. To evaluate sediment deposits resulting from this flood, we collected six fine-grained sediment samples from Ancho Canyon below NM 4 in 2008: two each in main Ancho Canyon and the north fork above the confluence, and two samples below the confluence. We also collected two coarse-grained samples from the stream beds above the confluence.

Uranium-238 was detected above the background value of 2.29 mg/kg, at 4.26 mg/kg, in one of the two fine-grained samples from the north fork, but not from the downstream samples. Uranium is a known contaminant upstream at firing sites in TA-39 (LANL 2006b). Tritium was detected slightly above the background value in the other fine-grained sample from the north fork (0.098 vs. 0.093 pCi/g), but not in other samples. Arsenic was detected above the sediment background value of 3.98 mg/kg in all six fine-grained samples, at 4.79 to 6.39 mg/kg. Soils at LANL have high background levels of arsenic (Longmire et al. 1996; Ryti et al. 1998), and most or all of the arsenic in this watershed may be naturally occurring. No explosive compounds were detected in these sediment samples.

The only radionuclide exceeding a BCG in surface water samples from the Ancho Canyon watershed in 2008 was radium-226, which is also elevated in areas not affected by releases of radionuclides from Laboratory activities. Similarly, gross alpha radiation and aluminum exceeded wSALs in some surface water samples from this watershed in 2008, but they are also elevated in background areas. No other analytes exceeded wSALs.

8. Chaquehui Canyon

Chaquehui Canyon heads on the Pajarito Plateau near the Bandelier National Monument entrance station and extends across the Laboratory to the Rio Grande. It has the smallest of the primary watersheds at LANL, with a total drainage area of about 1.6 mi^2 (4 km^2) and a main channel length of about 3 mi (5 km). Potential Laboratory sources of contamination in the Chaquehui Canyon watershed are located at TA-33 and include firing sites and outfalls (LANL 2006d).

The only analyte of note in surface water samples from the Chaquehui Canyon watershed in 2008 is copper. Copper was detected in one filtered storm water sample from one SMA (CHQ-SMA-6) above the wSAL of 14 µg/L, at 76.2 µg/L on July 20. Copper was also above the wSAL at this location in 2007.

Uranium-234 and uranium-235 were detected above background values in a sediment sample from the active stream channel of Chaquehui Canyon in 2008 (3.17 and 0.208 pCi/g in the sample vs. background values of 2.59 and 0.20 pCi/g, respectively), although the concentrations were below the background values in 2007. These concentrations are below recreational SALs. Uranium is a known contaminant at TA-33 (LANL 2006b). Several metals, including arsenic, chromium, cobalt, copper, manganese, nickel, and vanadium, were detected above background levels but below recreational SSLs in a sediment sample from the active stream channel of Chaquehui Canyon. Of these metals, only nickel was detected above the background value in 2007. The sources of these metals are uncertain but may include locally elevated background levels associated with differing geologic conditions in lower Chaquehui Canyon than farther west on the Pajarito Plateau. No explosive compounds were detected in this sediment sample.

H. QUALITY ASSURANCE

To process watershed samples, the same quality assurance (QA) protocols and analytical laboratories described in Chapter 5 were used. Chapter 5 also describes the QA performance for the year.

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7. Soil Monitoring



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A. INTRODUCTION

A soil sampling and analysis program offers the most direct means of determining the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities (DOE 1991). Soil is an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous emissions, indirectly from re-suspension of contamination, or through liquid effluents released to a stream that may be used for irrigation on farmlands. Consequently, soil contaminant data may provide information about potential pathways (e.g., soil ingestion, food ingestion, re-suspension into the air, and groundwater contamination) that could deliver radioactive materials or chemicals to humans and biota.

The overall soil surveillance program implemented by Los Alamos National Security, Inc. (LANS) at the Los Alamos National Laboratory (LANL or the Laboratory) consists of

1) An institutional component that monitors soil within and around the perimeter of LANL in accordance with US Department of Energy (DOE) Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993);
2) A facility component that monitors soil (and sediment) within and around the perimeter of two Laboratory sites:
   - Principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) in accordance with the Mitigation Action Plan (DOE 1996); and
   - Principal radioactive waste disposal area (Area G) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and
3) A special studies component that investigates cases where there may be an absence of data concerning a localized contaminant source that has the potential to impact human health and/or the environment as mandated by special mitigation action plans (DOE 2000).

The objectives of LANL's soil surveillance program are to determine

1) Radionuclide and chemical (inorganic and organic chemicals) concentrations in soil collected from potentially impacted areas (institution-wide and facility-specific) and compare them to the appropriate soil standards (e.g., regional background levels, screening levels, and standards);
2) Concentration trends over time (i.e., whether radionuclide and/or chemical concentrations are increasing or decreasing); and
3) The committed effective dose equivalent potentially received by surrounding area residents and biota (see Chapter 3 for the potential radiation doses that individuals and biota may receive from exposure to soil).

B. SOIL COMPARISON LEVELS

To evaluate potential Laboratory impacts from radionuclides and chemicals in soil, we first compare the analytical results of samples collected from the Laboratory's on-site and perimeter areas with regional background levels. Where the results exceed these background levels, we then compare the concentrations with human health screening levels (SLs) and, finally, if needed, with the appropriate regulatory standard, if available. Descriptions of the levels and/or the standard used to evaluate the results of radionuclides and chemicals in soil are given below. An overall summary can be found in Table 7-1.

- Regional Statistical Reference Levels (RSRLs): RSRLs are the mean plus three standard deviations (= 99% confidence level) of the average background for radionuclides and chemicals in soil collected from regional locations away from the influence of the Laboratory over at least the last five sampling periods. RSRLs, which represent natural and fallout levels, are calculated as additional data become available and can be found in the supplemental data tables of this report.
- Screening Levels (SLs): SLs for radionuclides are set below the DOE single-pathway dose limit of 25 mrem/yr (DOE 1993, DOE 1999c) so that potential human health concerns may be identified in advance, i.e., a "yellow flag." If a radionuclide exceeds the SL, we investigate the basis for the exceedance. LANL developed SLs to identify radionuclides of potential human health concern on the basis of a 15-mrem/yr protective dose limit for several scenarios (LANL 2005) using the residual radioactive (RESRAD) computer model (Yu et al. 1995). We compare chemical concentrations to the New Mexico Environment Department (NMED) SLs that are set at a 10^{-5} risk level for carcinogens and a hazard quotient (HQ) of one for non-carcinogens (NMED 2006). To evaluate radionuclide and chemicals in soil in the most conservative manner, the results from on-site and perimeter areas are compared to SLs based on a residential scenario, which assumes that a family lives at these locations on a year-round basis.
- Standard: If an SL for a radionuclide is exceeded, then a dose to a person is calculated using RESRAD and all of the measured radionuclide concentrations available for a given year. (These data are presented in Table S7-1.) The calculated dose is based on a residential scenario with soil ingestion, inhalation of suspended dust, external irradiation, and ingestion of homegrown fruits and vegetables as the exposure pathways. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis we used are presented in a report by Fresquez et al. (1996). This calculated dose is compared to the 25-mrem/yr DOE dose constraint standard.

Table 7-1
Application of Soil Standards and Other Reference Levels to LANL Monitoring Data

Constituent	Sample Location	Standard	Screening Level	Background Level
Radionuclides	Perimeter, On-site, and Area G	25 mrem/yr	15 mrem/yr (resident)	RSRL
	DARHT	25 mrem/yr	15 mrem/yr (resident)	RSRL/BSRL[a]
Chemicals	Perimeter, On-site, Area G	na[b]	10^{-5} risk (resident) or HQ = 1	RSRL
	DARHT	na	10^{-5} risk (resident) or HQ = 1	RSRL/BSRL[a]

[a] Baseline Statistical Reference Levels (BSRL), a discussion of these levels is provided in Section D.3.

[b] na= Not available.

C. INSTITUTIONAL MONITORING

1. Monitoring Network

Institutional surface soil samples are collected from 17 on-site, 11 perimeter, and six regional (background) locations on a triennial basis (every third year) (Figure 7-1). Our last soil survey, which included the analysis of radionuclides, target analyte list (TAL) elements (mostly metals), polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), and high explosives (HEs), occurred in 2006 (Fresquez 2007a). The next planned full-scale institutional soil assessment will occur in 2009.

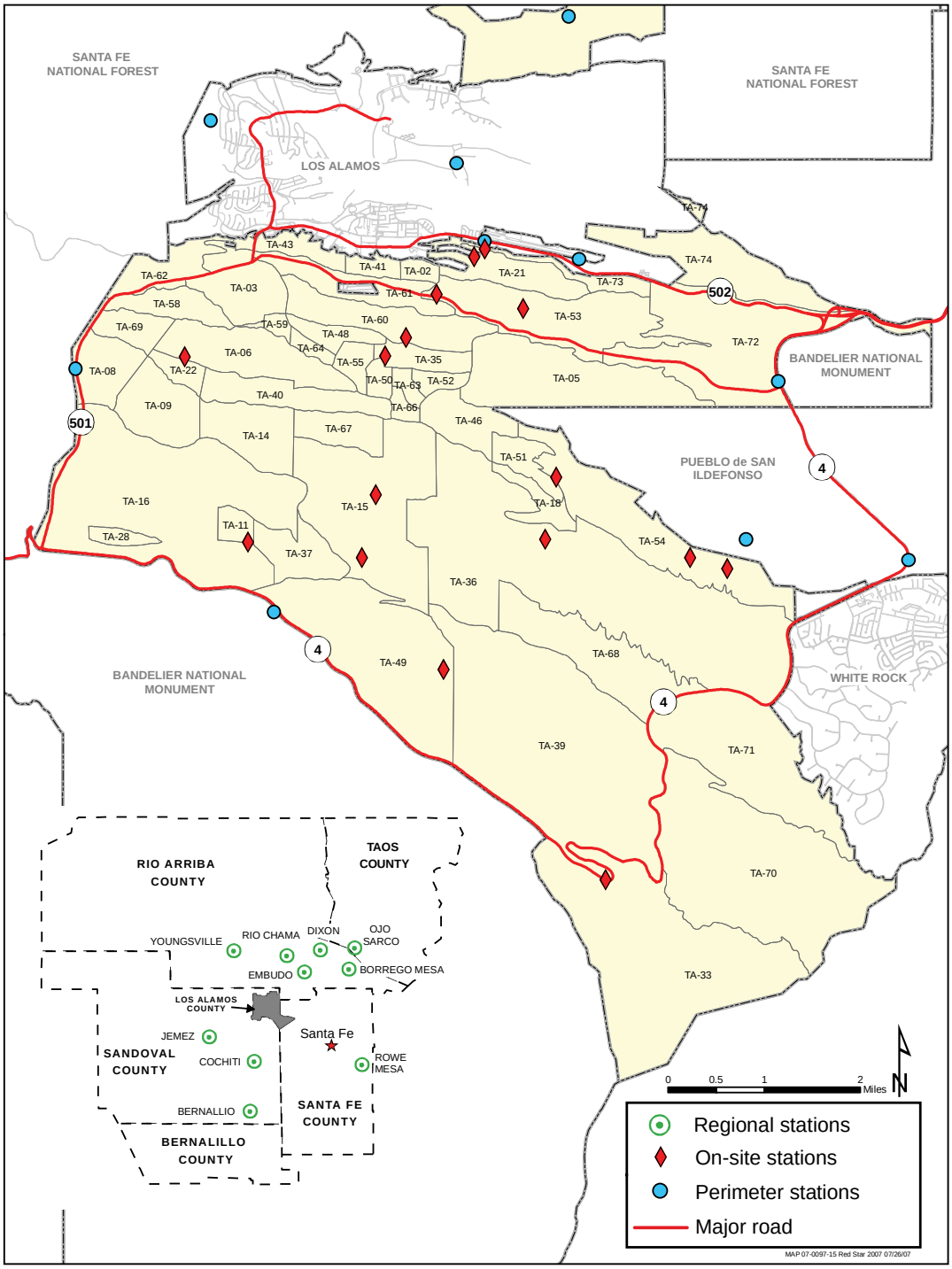


Figure 7-1. On-site, perimeter, and off-site regional soil sampling locations. (The two perimeter soil samples collected in 2008 are north of TA-54.)

Although the institutional soil sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we collect two perimeter soil samples for radionuclides and TAL elements on Pueblo lands that are downwind of Area G, the Laboratory's principal low-level radioactive waste disposal site, on an annual basis. Area G, approximately 63 acres in size, is located in Technical Area (TA) 54 at the Laboratory's eastern boundary. Soil samples on Pueblo de San Ildefonso lands were collected from relatively level, open (unsheltered by trees or buildings), and rock-free areas. One sample, identified as "San Ildefonso," was collected across Cañada del Buey about one-half mile north of Area G, and the other sample, identified as "Tsankawi/PM-1," was collected just a little over two miles away and is also located north of Area G.

Soil samples from these two perimeter stations were compared with RSRLs. These RSRLs are derived from soil samples collected from regional areas that surround the Laboratory in all major directions and where radionuclides and chemicals are mostly from natural sources or worldwide fallout events. These regional areas are located near Ojo Sarco, Dixon, and Borrego Mesa (near Santa Cruz dam) to the northeast; Rowe Mesa (near Pecos) to the southeast; Youngsville to the northwest; and Jemez to the southwest. All locations are at similar elevations as LANL, are more than 20 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations as required by the DOE (DOE 1991).

The two Pueblo de San Ildefonso perimeter samples were analyzed by Paragon Analytics, Inc., for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, and uranium-238. The soil samples were also analyzed for 23 TAL 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). The results from these sample analyses are presented in supplemental Tables S7-1 and S7-2.

2. Radionuclide Analytical Results

All radionuclide (activity) concentrations in soil collected at the two perimeter locations on Pueblo de San Ildefonso lands downwind of Area G in 2008 were either not detected or detected below RSRLs (Table S7-1). A nondetected value is one in which the result is lower than three times the counting uncertainty and is not significantly different ($\alpha = 0.01$, or 99% confidence level) from zero (Keith 1991, Corely et al. 1981) or less than the minimum detectable activity. These data, particularly tritium and plutonium-239/240 which are consistently detected above RSRLs in soil at Area G, are very similar to past years. At the location nearest to Area G (PSI), the concentrations of tritium and plutonium-239/240 are not increasing over time (Figures 7-2 and 7-3). In fact, the levels of tritium after 2002 decrease in almost all years to the present time.

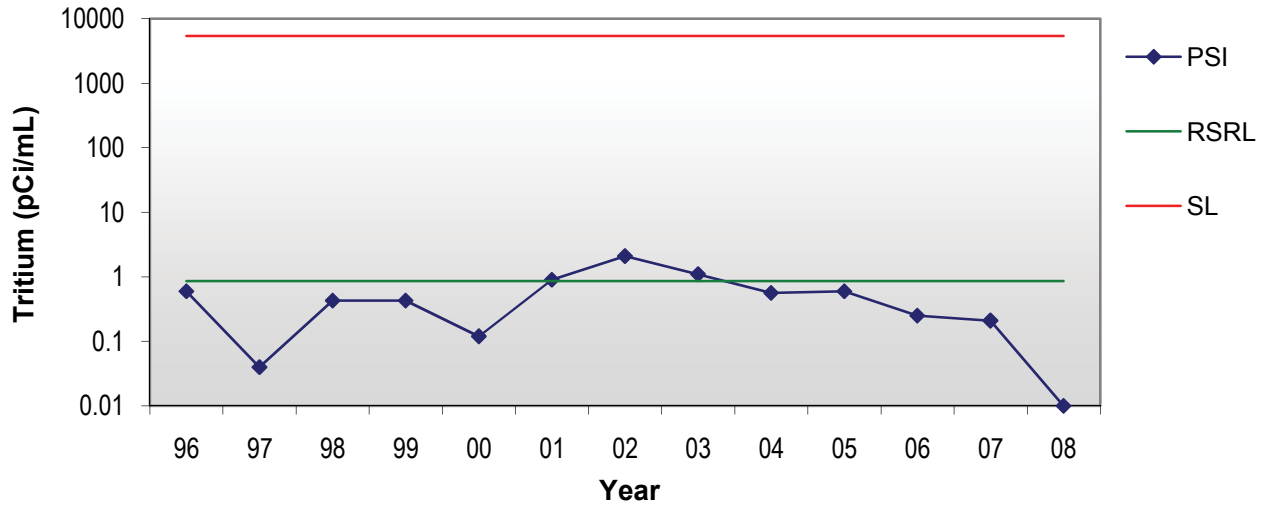


Figure 7-2. Tritium concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately one-half mile northeast of Area G from 1996 through 2008 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL).

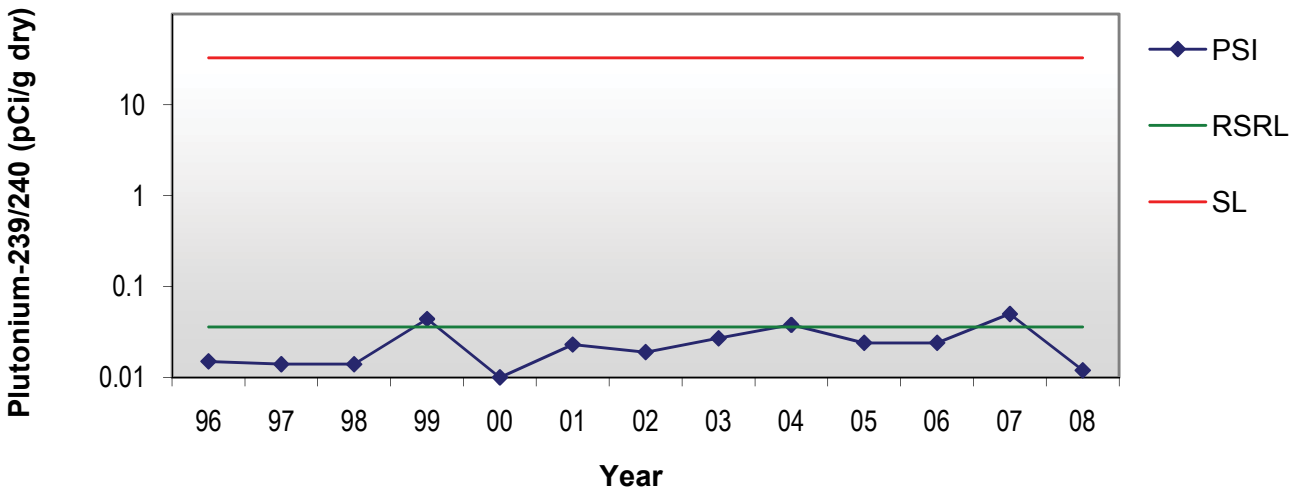


Figure 7-3. Plutonium-239/240 concentrations in soil samples collected from Pueblo de San Ildefonso (PSI) lands approximately one-half mile northeast of Area G from 1996 through 2008 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL).

3. Chemical Analytical Results: Trace and Abundant Elements

Table S7-2 shows the results of the TAL element analyses in surface soil collected from the two perimeter sites located on Pueblo de San Ildefonso lands in 2008. All metal concentrations from these two areas, with the exception of silver in the San Ildefonso sample, were detected below RSRLs. The concentration of silver at this location (330 µg/kg), however, was just 26 µg/kg dry (parts per billion) above the RSRL of 304 µg/kg and far below the residential SL of 391,000 µg/kg.

D. FACILITY MONITORING

1. Monitoring Network for Area G at TA-54

The Laboratory conducts facility-specific soil monitoring on an annual basis at Area G (Lopez 2002). Area G is a 63-acre radioactive waste processing area located on the east end of Mesa del Buey at TA-54 (Figure 7-1). Established in 1957, Area G is the Laboratory's primary low-level radioactive solid waste burial and storage site (Hansen et al. 1980, Soholt 1990). Tritium, plutonium, americium, uranium, and a variety of fission and activation products are the main radionuclides in waste materials disposed at Area G (DOE 1979). Facility monitoring at Area G includes sample collection and analysis of air, sediment, surface water runoff, soil, vegetation, and small mammals for contaminants. Section D.2, below, reports on the 13 surface soil samples collected in 2008 at designated locations around the perimeter of Area G and one surface soil sample (site #T-3) collected at the LANL/Pueblo de San Ildefonso boundary line approximately 800 feet northeast of Area G (Figure 7-4).

All samples were analyzed by Paragon Analytics, Inc., for tritium, plutonium-238, plutonium-239/240, americium-241, uranium-234, uranium-235, and uranium-238. The results from these samples are presented in supplemental Tables S7-3.

TAL elements were not analyzed in 2008, but in 2006 extensive sampling and analysis for TAL elements were conducted. Results from that sampling period showed that most metals (478 out of 483 measurements) were similar to RSRLs (Fresquez 2007a), and the few detected above RSRLs were far below the residential SLs.

2. Radionuclide Analytical Results for Area G

a. Perimeter Results

Tritium, americium-241, plutonium-238, and plutonium-239/240 were detected at concentrations above the RSRLs in many of the 13 soil samples collected around the perimeter of Area G in 2008 (Table S7-3).

Specifically, tritium was detected above the RSRL (0.86 pCi/mL) in 57% of the samples collected around Area G. The highest concentrations (538 and 38 pCi/mL) occurred in the southern portion (around sites #29-03 and #30-01) where the tritium shafts are located. Although these data are within the range of concentrations detected in past years (Fresquez et al. 2004, Fresquez and Lopez 2004, Fresquez et al. 2005, Fresquez 2007) they are quite variable from year to year (Figure 7-5). The degree of variability in tritium concentrations in surface soil from year to year may be influenced by engineering (leaking underground storage shafts) and environmental factors (geology, precipitation, temperature, and barometric pressure) (Purtymun 1973, Abeele and Nyhan 1987, Vold 1997, Childs and Conrad 1999, Budd et al. 2004). Nonetheless, with the exception of 2002 and 2003, the concentrations of tritium in soil at Area G have been below the residential SL of 5,400 pCi/mL (equivalent to 750 pCi/g), and the migration of tritium from the Area G boundary, at least at surface depths, is not extensive. In a 2003 study, the measurement of tritium in trees at the southern portion of Area G starting from the perimeter fence line outward (approximately 33, 165, 330, 490, and 660 feet) showed that the concentrations of tritium decreased greatly with distance; and at about 330 feet away, the concentrations were similar to the RSRL (Fresquez et al. 2003).

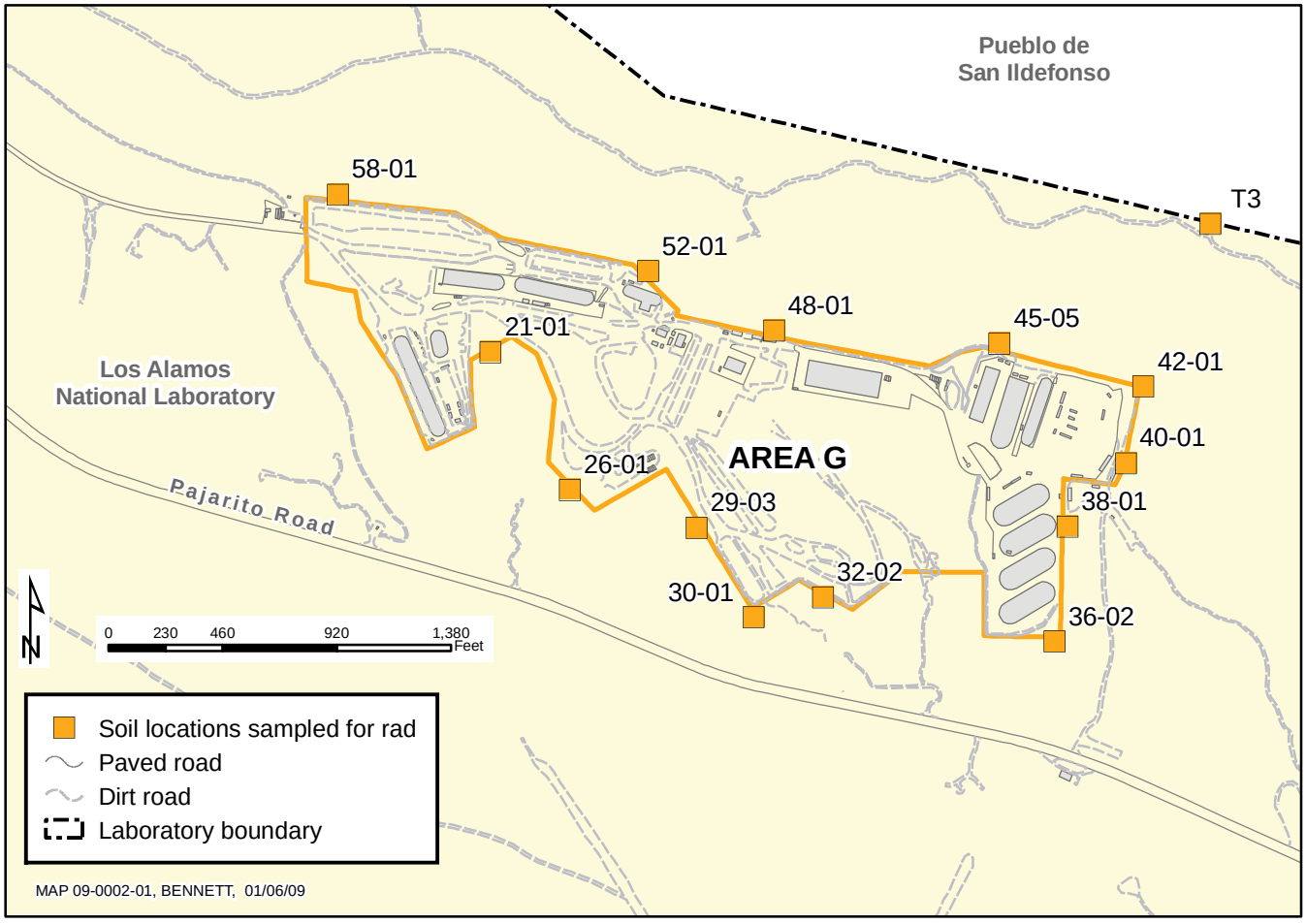


Figure 7-4. Locations of soil samples collected around Area G in 2008.

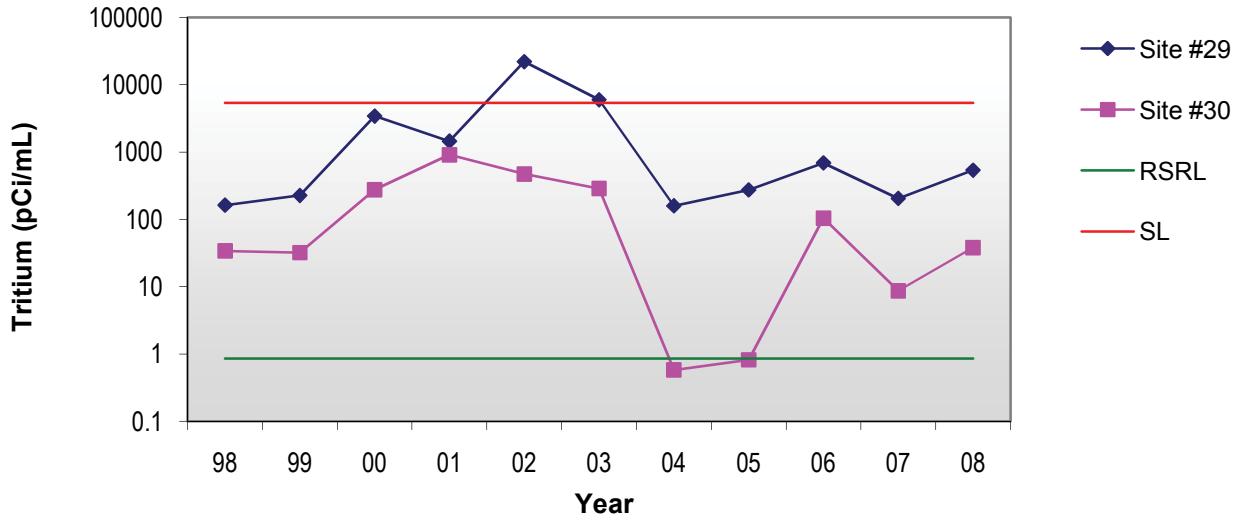


Figure 7-5. Tritium in surface soil samples collected from the southern portions of Area G at TA-54 from 1998 through 2008 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL).

With respect to the concentrations of americium-241, plutonium-238, and plutonium-239/240 in soil at Area G, about 50% of the samples collected contained higher amounts than the respective RSRLs, particularly around the perimeter of the northern, northeastern, and eastern sections (Table S7-3). The highest concentrations of americium-241 (0.34 pCi/g dry), plutonium-238 (0.24 pCi/g dry), and plutonium-239/240 (1.2 pCi/g dry) were detected in soil samples located on the perimeter of the eastern side of Area G near the Transuranic Waste Inspection Project (TWISP) domes. Site #38-01, in particular, contained slightly higher concentrations of plutonium-239/240 than other areas in 2006 and 2007 but decreased sharply in 2008 (Figure 7-6). Nonetheless, all radionuclide levels, including plutonium-239/240, in all soil samples at Area G are still far below the residential SLs and generally have been stable over time.

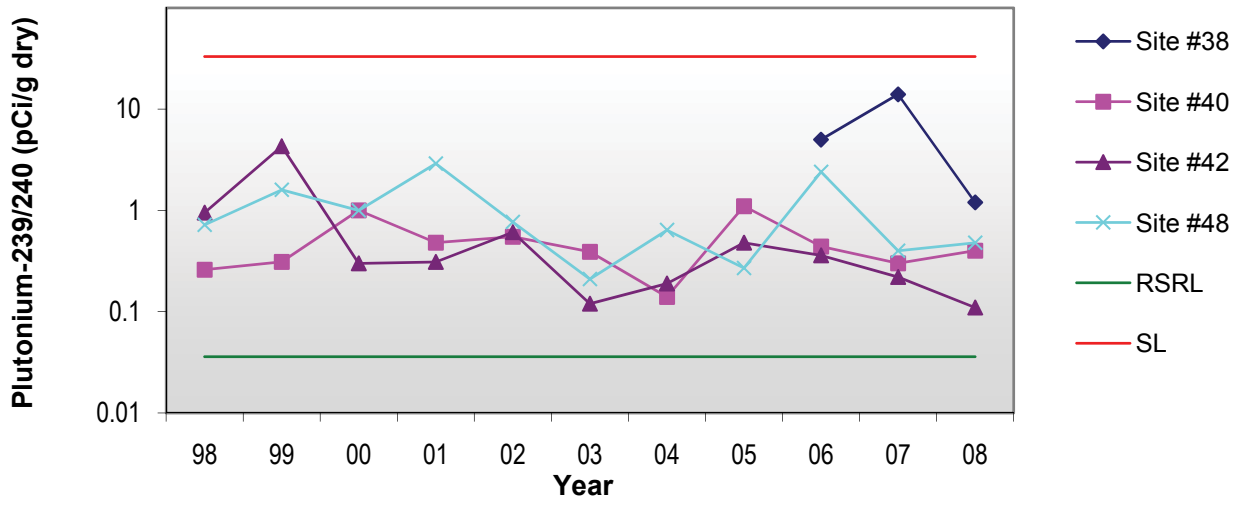


Figure 7-6. Plutonium-239/240 in surface soils collected from the northeastern and eastern portions of Area G at TA-54 from 1998 through 2008 as compared with the regional statistical reference level (RSRL) and the residential screening level (SL).

b. Results at the Pueblo de San Ildefonso Boundary

Americium-241, plutonium-238, and plutonium-239/240 were detected in the soil sample collected at the LANL/Pueblo de San Ildefonso boundary northeast and down gradient of Area G (Site #T-3) at concentrations above the RSRLs (Table S7-3). The levels of these radionuclides were generally similar to past years and all were far below the residential SLs (Figure 7-7). Moreover, the concentrations of all of these radionuclides on Pueblo de San Ildefonso lands decrease to RSRLs within a relatively short distance from the San Ildefonso/Laboratory fence line. For example, most (10 out of 13) plutonium-239/240 concentrations in soil samples collected as part of the institutional monitoring program about 800 feet northeast of the fence line on the mesa top (the "San Ildefonso" site) from 1996 through 2008 were below the RSRL (Figure 7-3).

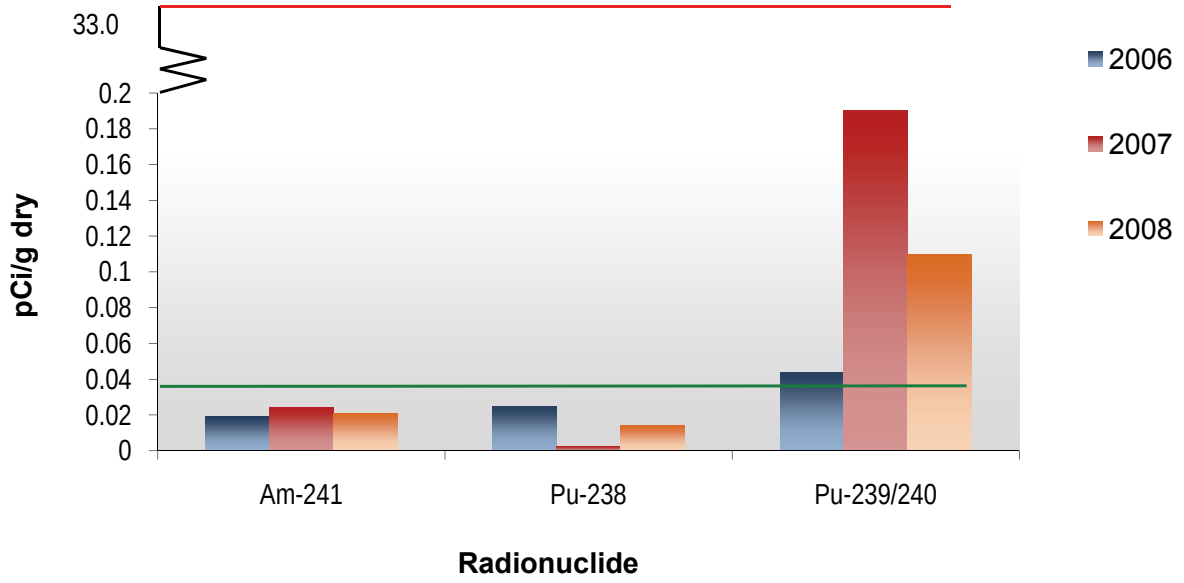


Figure 7-7. Transuranic radionuclides in surface soil collected from the LANL/Pueblo de San Ildefonso boundary northeast of Area G at TA-54 from 2006 through 2008. The regional statistical reference level (green line) and the residential screening level (red line) are shown with respect to plutonium-239/240 levels.

3. Monitoring Network for DARHT at TA-15

The Laboratory conducts facility-specific soil and sediment monitoring on an annual basis at DARHT (Nyhan et al. 2001). Approximately 20 acres in size, DARHT is located at R-Site (TA-15) at the Laboratory's southwestern side (Figure 7-1). Activities at DARHT include the use of very intense X-rays to radiograph a full-scale non-nuclear mock-up of a nuclear weapon's primary during the late stages of the explosively driven implosion of the device (DOE 1995). Open-air detonations occurred from 2000 to 2006; foam mitigation was used from 2002 to 2006; and closed steel containment vessels were used starting in 2007. Since May 2007, four hydrodynamic test shots at DARHT have been conducted within steel containment vessels. Potential contaminants include radionuclides, beryllium (and other heavy metals), and possibly organic chemicals like PCBs, HE, and SVOCs.

Soil samples analyzed for radionuclides and inorganic chemicals are collected around the perimeter of the DARHT facility on the north, east, south, and west sides (Figure 7-8). An additional soil sample is collected on the north side near the firing point. Sediment samples were collected on the north, east, south, and southwest sides. All samples were analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, TAL elements, and HEs. (Note: we report on the analyses of vegetation, small mammals, bees, and birds collected around the DARHT facility in Chapter 8, Section B.4.b.)

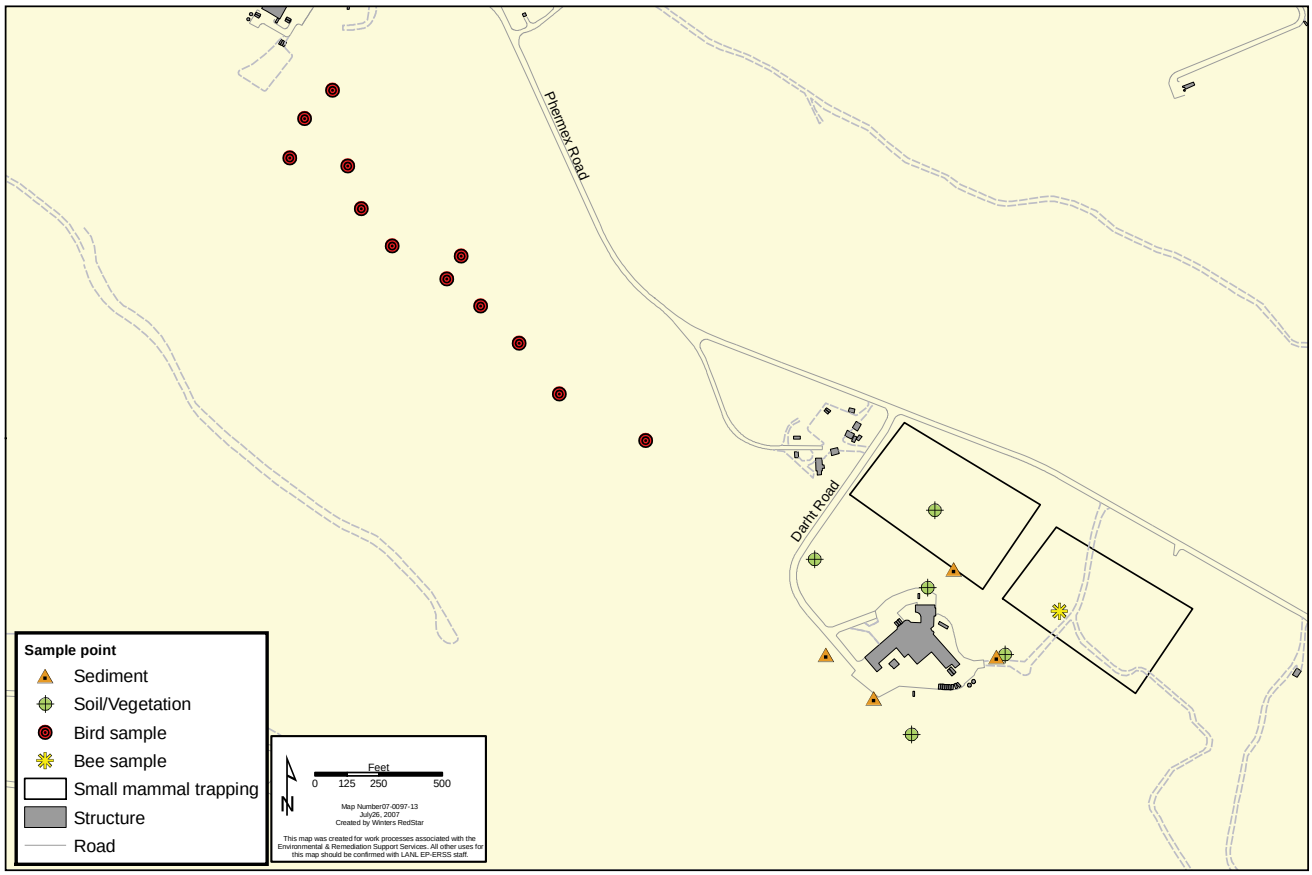


Figure 7-8. Soil, sediment, and biota sample locations at DARHT in 2008.

We compared the radionuclide and inorganic chemical results in soil and sediment from the DARHT sampling to both RSRLs and baseline statistical reference levels (BSRLs). BSRLs are the concentrations of radionuclides and inorganic chemicals (mean plus three standard deviations) in soil and sediment collected from around the DARHT facility from 1996 through 1999 before the start-up of operations (Fresquez et al. 2001), per the DARHT Mitigation Action Plan (DOE 1996). Both reference levels are employed because the BSRLs for some elements may be biased as a result of changes in pre- and post-sampling locations and a change in analytical techniques. A comparison of BSRLs with RSRLs, for example, shows some baseline radionuclide concentrations, like cesium-137, may be biased low and some baseline inorganic chemical concentrations, like silver, may be biased high irrespective of DARHT activities. Moreover, some TAL elements analyzed recently have no baseline levels at all. To accommodate parking spaces and storage areas within the DARHT complex after operations began, soil sampling locations had to be moved from within the fenced perimeter boundary (<100 feet from the facility) to sites located outside the perimeter fence boundary (>300 feet from the facility). This may have affected the concentrations of some radionuclides, particularly cesium-137, because the pre-operation samples were collected in mostly disturbed soil and the post-operation samples were collected in mostly undisturbed soil.

Higher amounts of fallout radionuclides would be expected in the undisturbed soil rather than the disturbed soil because of the mixing associated with disturbed soil. Moreover, the change in analytical techniques may have improved detection capabilities for some metals. The use of inductively coupled plasma mass spectrometry instrumentation to analyze post-operation samples, for example, substantially decreased the detection limits of silver, from 2 to 0.2 mg/kg.

4. Radionuclide and Chemical Analytical Results for DARHT

With the exception of one sample, radionuclides in sediment and soil samples collected from around the perimeter of the DARHT facility were either not detected or below both the statistical reference levels (Table S7-4). Tritium and uranium-238 were detected above both statistical reference levels in the one soil sample collected near the firing point. Whereas the detection of uranium-238 above the statistical reference levels was not unexpected based on past results, the detection of tritium above statistical reference levels was not expected given that tritium has never been detected in past surveys. The amounts of tritium and uranium-238 in this soil sample, however, are far below the residential SLs.

The isotopic distribution of uranium-234 to uranium-238 in one soil sample at DARHT indicates that the uranium is from a depleted source (i.e., depleted uranium). The one soil sample that contained depleted uranium was collected near the firing point and the concentrations over time show an increasing trend (Figure 7-9). Although open air detonations were not employed after 2006, this increase of uranium-238 near the firing point may reflect an accumulation of uranium from past operations. In contrast, the uranium-238 concentrations in soil collected from around the perimeter of DARHT have decreased since 2006. This decrease may be associated with the change in contaminant mitigation procedures at the DARHT facility from open and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation in 2007.

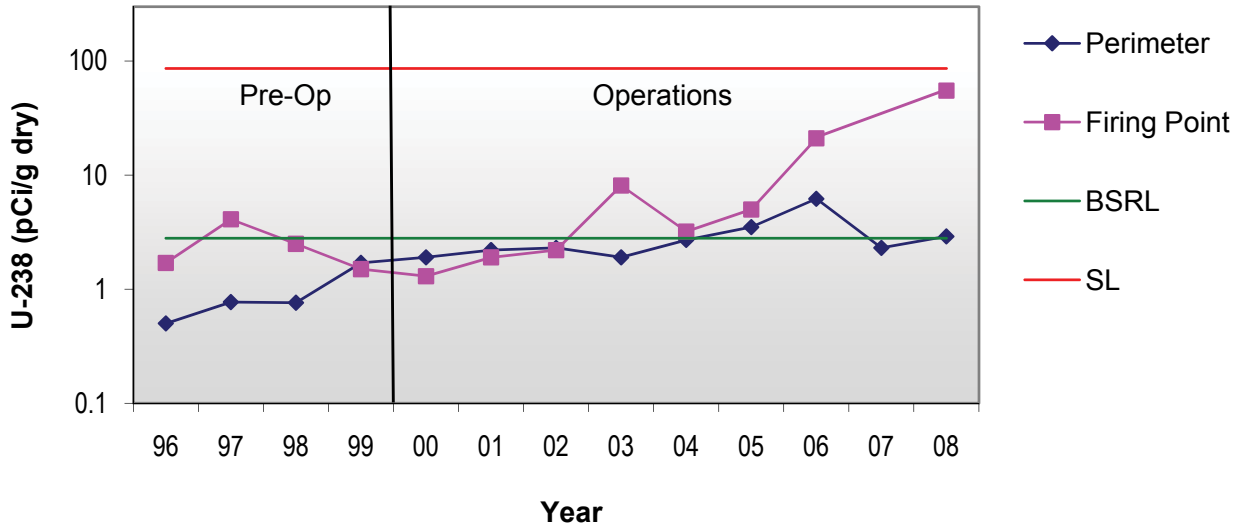


Figure 7-9. Uranium-238 concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and west side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2008 (operations) as compared with the baseline statistical reference level (BSRL) and the residential screening level (SL).

Most of the TAL elements analyzed in soil and sediment samples collected within and around the DARHT facility were below both the statistical reference levels (Table S7-5). This includes beryllium which has been listed as a chemical of concern at DARHT; but over time has remained stable (Figure 7-10).

The only elements above either of the statistical reference levels were copper in the sample nearest the firing site, calcium in a sediment sample on the south side, and sodium in three of five samples. Only copper is considered a hazardous metal at very high levels, while sodium and calcium are essential nutrients. The one sample contained copper levels slightly above the RSRL but far below the residential SL.

HE was not detected in any of the soil or sediment samples collected within and around the perimeter of the DARHT facility, including those closest to the firing point (Table S7-6). Although not analyzed for in 2008 samples, PCBs and SVOCs were not detected in soil and sediment samples collected within and around the perimeter of the DARHT facility in 2007 (Fresquez et al. 2008).

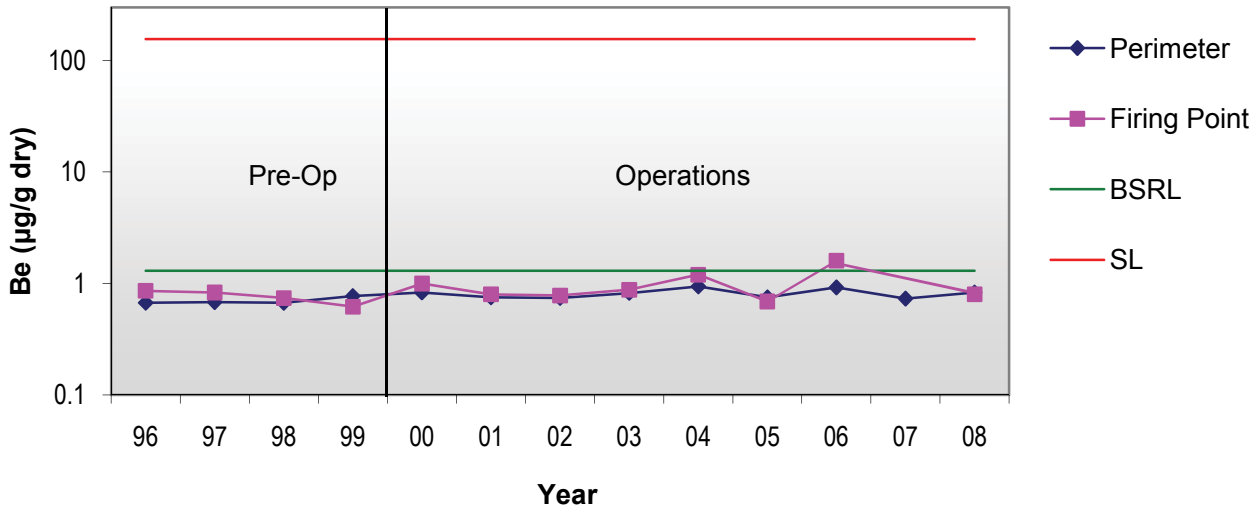


Figure 7-10. Beryllium concentrations in soil collected within (near the firing point) and around the DARHT perimeter (north, west, south, and east side average) at TA-15 from 1996–1999 (pre-operations) to 2000–2008 (operations) as compared with the regional statistical reference level (BSRL) and the residential screening level (SL).

E. SPECIAL MONITORING STUDIES

1. Los Alamos Canyon Weir and Pajarito Flood Control Structure: Four-Year Results

Special monitoring studies of sediment (and biota) were conducted at the Los Alamos Canyon Weir and the Pajarito Canyon Flood Control Structure; this is the fourth year of sampling at these sites since 2005. The Los Alamos Canyon Weir is located at the northeastern boundary of LANL within TA-72 near the junction of NM State Road 4 and NM State Road 502. The Pajarito Canyon Flood Control Structure is located downstream of the confluence of Two-Mile and Pajarito Canyons at TA-18. Sediment samples along with vegetation and small mammals were collected upgradient (upstream) of the structures to assess potential impacts to the biota as a result of potentially contaminated surface water runoff and accumulated sediment. Because sediment was collected and analyzed in support of the biota monitoring, the results are presented in Chapter 8, Section C.1 and C.2.

F. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND BIOTA MONITORING PROGRAM

1. Quality Assurance Program Development

The sampling team collects soil, foodstuffs, and biota (SFB) samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the *LANL Quality Assurance Project Plan for the Soil, Foodstuffs, and Biota Monitoring Project* and in the following LANL standard operating procedures:

- Collection of Soil and Vegetation Samples for the Environmental Surveillance Program
- Sampling Soil and Vegetation at Facility Sites
- Produce Sampling
- Fish Sampling
- Game Animal Sampling
- Processing Biota Samples for Analysis
- Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota
- Analytical Data Verification/Validation Process

These procedures, which are available on the LANL public website (http://www.lanl.gov/environment/all/qa.shtml), 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 manner 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.

2. Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of the carefully documented procedures, listed above, which govern all aspects of the sample-collection program.

The team collects all samples under full chain-of-custody procedures to minimize the chances of data transcription errors. Once collected, we hand-deliver the samples to the LANL Sample Management Office, which ships them via express mail directly to an external analytical laboratory under full chain-of-custody control. The project leader tracks all samples. Upon receipt of data from the laboratory (electronically and in hard copy), the completeness of the field-sample process along with other variables are assessed. A quality assessment document is created, attached to the data packet, and provided to the project leader.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical services after the Data Quality Objective process has identified and quantified the program objectives. These statements of work are sent to potentially qualified analytical laboratories, which undergo a pre-award, on-site assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality-system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are the primary criteria used to award contracts for specific types of radiochemical, inorganic chemical, and organic chemical analyses.

Each analytical laboratory conducts chain-of-custody and analytical processes under its own quality plans and analytical procedures. Each laboratory returns data by email in an electronic-data deliverable with a specified format and content. The analytical laboratory also submits a full set of paper records that serves as the legal copy of the data. Each set of records contains all the internal quality control data the analytical laboratory generates during the analyses (including laboratory control standards, method blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and immediately subjected to a variety of quality and consistency checks. Analytical completeness is determined, tracking and trending of all blank and control-sample data are performed, and all the data are included in the quality assessment memo mentioned in the field sampling section. We track all parts of the data management process electronically and prepare periodic reports to management.

4. Field Data Quality Assessment Results

Field data completeness for SFB in 2008 was near 99%.

5. Analytical Data Quality Assessment Results

Analytical data completeness for all SFB sampling programs was near 99% in 2008. We track, trend, and report all quality control data in specific quality evaluation memos which we submit to project staff along with each set of analytical data received from our chemistry laboratories. Overall results of the 2008 quality program indicate that all analytical laboratories maintained the same high level of control observed in the past several years.

6. Analytical Laboratory Assessments

During 2008, three external laboratories performed all analyses reported for SFB samples:

- Paragon Analytics, Inc., Fort Collins, Colorado, provided radiological and TAL element (mostly metals) analysis of soil, sediment, and biota.
- Vista Analytical Laboratory, Inc., El Dorado Hills, California, provided PCB analysis of biota.
- General Engineering Laboratories, Charleston, South Carolina, provided HE analysis of soils and sediments.

We performed an assessment of Paragon Analytics, Inc., in 2004. The laboratory participated in national performance-evaluation studies in 2004 and 2005. Detailed results of these performance evaluations are included in the assessment report. Overall, the study sponsors judged the analytical laboratory to have acceptable performance for almost all analytes attempted in all matrices.

7. Program Audits

In 2005, we hosted a data quality assessment and evaluation to evaluate whether the procedures in various programs were being implemented as written. The auditors (Time Solutions 2) were professional external quality assurance experts (ISO 9000 and 14000 certified) and they examined all aspects of the SFB program procedures. While it was noted that improvements had been made to the SFB program ever since a previous audit (performed by auditors external to the sampling group but internal to LANL), several observations led to recommendations on improving processes for keeping procedures up-to-date and meeting internal commitments made in quality assurance plans. Since the data quality assessment, we have implemented all the recommendations.

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8. Foodstuffs and Biota Monitoring



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A. FOODSTUFFS MONITORING

1. Introduction

A wide variety of wild and domestic crops, including vegetables, fruits, berries, nuts, and grains are grown and/or harvested at many locations surrounding Los Alamos National Laboratory (LANL or the Laboratory). Also, many food products from animals are available (e.g., milk, honey, and eggs), and fishing and hunting for small and big game animals (e.g., rabbits, deer, and elk) on neighboring properties around LANL is a common occurrence.

These foodstuffs within and around LANL may become contaminated through air (stack emissions and fugitive dust), soil (directly from the source), and water (storm water runoff and irrigation) exposures. Elk and deer, for example, may graze through areas on LANL land or drink from water catchments that may contain radioactive or chemical contamination, and fish can be exposed to potential contaminants entering the Rio Grande from runoff discharging from the many canyons that cross Laboratory property. The ingestion of these foods constitutes an important exposure pathway by which radionuclides (Whicker and Schultz 1982) and chemicals (Gough et al. 1979) may be taken in by humans.

The purpose of the foodstuff monitoring program is to determine whether Laboratory operations are impacting human health via the food chain. US Department of Energy (DOE) Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993) mandate this monitoring program, and we accomplish this effort through the following tasks:

1. Measuring radioactive and chemical concentrations in foodstuffs on Laboratory land, if available, and from neighboring communities and compare these results to regional background levels, screening levels, and, if available, standards;
2. Determining concentration trends over time; and
3. Providing data used to estimate potential dose and risk from the consumption of the foodstuffs (see Chapter 3 for dose and risk estimates to individuals from the ingestion of foodstuffs).

In general, foodstuffs such as crops and fish are collected on a three-year rotating schedule (i.e., a triennial basis) with soil and native vegetation. Other foodstuffs like honey, milk, eggs, wild edible plants, ungulates, and large game animals are analyzed as they become available from the public and an adequate number of samples can be submitted to the laboratory. We collected soil and native vegetation in 2006 (Fresquez 2007) and domestic crops (along with wild edible plants and goat milk) in 2007 (Fresquez et al. 2008). This year, we focused on the collection and analysis of radionuclides, target analyte list (TAL) elements (mostly metals), and polychlorinated biphenyls (PCBs) in predator and bottom-feeding fish in the Rio Grande upstream and downstream of LANL. Our main objective was to determine the potential impacts to fish downstream of three major canyon systems:

Los Alamos, Sandia, and Mortandad, which cross LANL land to the Rio Grande. Also, a major retention structure for water and sediment (and potential contaminants) on the Rio Grande downstream of LANL, Cochiti Reservoir, was investigated for potential fish impacts.

2. Fish Comparison Levels

To evaluate potential Laboratory impacts from radionuclides and chemicals to fish downstream of LANL, we first compared the analytical results of fish to regional statistical reference levels (RSRLs). RSRLs are the background concentrations (mean plus three standard deviations = 99% confidence level) derived from fish collected upstream and away from the influence of the Laboratory (DOE 1991) over at least the last five sampling periods. RSRLs, which represent natural and fallout levels and are not related to LANL operations, are calculated as data become available and can be found in each of the supplemental data tables of this report.

If any radionuclide concentrations in fish exceed RSRLs, we would then compare the concentrations to screening levels (SLs). SLs, in concentration units, are based on 4% (= 1 mrem/yr) of the 25 mrem/yr DOE single-pathway constraint (DOE 1999) so that potential concerns may be identified in advance of a potential human health problem, i.e., a "yellow flag." If a radionuclide concentration exceeds an SL, the basis for that increase is investigated. For TAL elements, with the exception of mercury, there are no SLs for fish. The SL for mercury in fish, based on US Environmental Protection Agency (EPA) guidelines, is 0.30 mg/kg wet (or parts per million [ppm] wet) (EPA 2001). Similarly, for PCBs we used EPA guidelines for SLs; in this case, we compared Toxicity Equivalent Quotients (TEQs) which are calculated from the 12 dioxin-like PCB compounds (Van den Berg et al. 2006) to the EPA risk-based fish consumption limits for human health (EPA 2007).

If radionuclides, mercury or PCB concentrations exceed an SL, they would then be compared to the applicable standard. In the case of radionuclides, a dose to a person would be calculated from all the radionuclides measured and compared with the 25-mrem/yr DOE single-pathway dose constraint (DOE 1999). In the case of mercury and PCBs, the concentrations would be compared to the Food and Drug Administration (FDA) standards of 1 ppm and 2 ppm, respectively (FDA 2000).

A summary of the RSRLs, SLs and the standards used to evaluate the results of radionuclides, mercury, and PCBs in fish is presented in Table 8-1.

Table 8-1
Standards and Other Reference Levels Applied to Fish

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	Perimeter	Fish	25 mrem/yr	1.0 mrem/yr	RSRLs
TAL Elements					
Mercury	Perimeter	Fish	FDA: 1 ppm (wet) in edible portion (complete consumption restrictions)	EPA: 0.30 ppm (wet) in edible portion (limited consumption restrictions)	RSRLs
Other elements	Perimeter	Fish	na*	na	RSRLs
Organic Compounds					
Polychlorinated Biphenyls	Perimeter	Fish	FDA (total PCBs): 2 ppm (wet) (complete consumption restrictions)	EPA (TEQs from 12 dioxin-like PCBs): 0.019–1.2 pg/g wet (limited consumption restrictions)	RSRLs

* na = Not available.

3. Fish Monitoring Network

For background measurements, we collected fish from three locations upstream of LANL (Abiquiu Reservoir on the Rio Chama and from reaches near Lyden [L] and San Ildefonso [SI] on the Rio Grande). We then collected fish from three locations on the Rio Grande downstream of LANL (at the confluence of Los Alamos Canyon [LAC], at the confluence of Sandia/Mortandad Canyons [S/MCs], and from Cochiti Reservoir) (Figure 8-1). LAC and S/MCs confluences were chosen because these canyon systems have been identified as containing the highest amounts of potential contaminants, although flow within S/MCs does not normally pass beyond the Laboratory boundary (Reneau and Koch 2008, Fresquez et al. 2008). Site descriptions as related to the location of LANL and the types of fish collected can be found in Table 8-2.

Two types of fish were collected for study based on their principal feeding strategy: top feeders or predator fish and bottom feeders. Predator fish are mostly carnivorous (eat other fish) and include the northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), white crappie (*Pomoxis annularis*), brown trout (*Salmo trutta*), white bass (*Morone chrysops*), and walleye (*Stizostedion vitreum*). Bottom feeders are mostly omnivores and feed at the bottom of lakes and rivers; they are represented by the white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*).

At each collection site, fish were processed according to standard procedures to obtain samples for radionuclide, TAL elements, and PCB analysis. In general, samples of fish for radionuclide analysis were processed by removing the viscera and head, rinsing the fish thoroughly, and then placing the remaining muscle plus bone tissues into Ziploc plastic bags. (Note: A fish sample for radionuclide analysis sometimes contained more than one fish of the same species to obtain an adequate sample size; about three lbs. of material were required.) Samples for TAL elements and PCB analysis were obtained from the same single fish. A fillet (muscle plus skin) for TAL elements was collected from one side of the fish and placed in a Ziploc bag and a sample for PCBs was collected from the other side and placed into a 500-mL amber glass jar. All radionuclide, TAL elements, and PCB samples were placed into a cooled ice chest and submitted under full chain-of-custody procedures to our Sample Management Office (SMO) where they were then sent to Paragon Analytical, Inc. for radionuclide and TAL metal analysis and to Vista Analytical, Inc., for PCB analysis.

The radionuclides analyzed were tritium, strontium-90, cesium-137, plutonium-238, plutonium-239/240, uranium-234, uranium-235, and uranium-238. Tritium concentration results are reported on a per mL basis. Results of the other radionuclides were reported in pCi/g dry after multiplying the results obtained from the analytical laboratory (in ash) by the ash-to-dry weight conversion factor of 0.12 for predator fish and 0.095 for bottom-feeding fish (Fresquez et al., 2007a).

TAL elements analyzed were aluminum, barium, beryllium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, sodium, vanadium, zinc, antimony, arsenic, cadmium, lead, selenium, silver, thallium, and mercury. These elements are reported on a wet weight basis (e.g., mg/kg [ppm] or µg/kg [parts per billion (ppb)] wet).

PCBs were analyzed for 209 possible chlorinated structures or congeners. A congener is a specific PCB compound with a certain number of chlorine atoms in certain positions and is reported on a pg/g (or parts per trillion [ppt]) wet weight basis.

TEQs, a measure of the degree of toxicity based on the similarity of the 12 dioxin-like PCB congeners (# 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189) to the most toxic dioxin, tetrachlorodibenzodioxin (TCDD), was calculated for each fish sample by multiplying the concentration of each of the 12 dioxin-like PCBs by a toxicity equivalency factor (TEF) and then summing the values (Van den Berg et al. 2006).

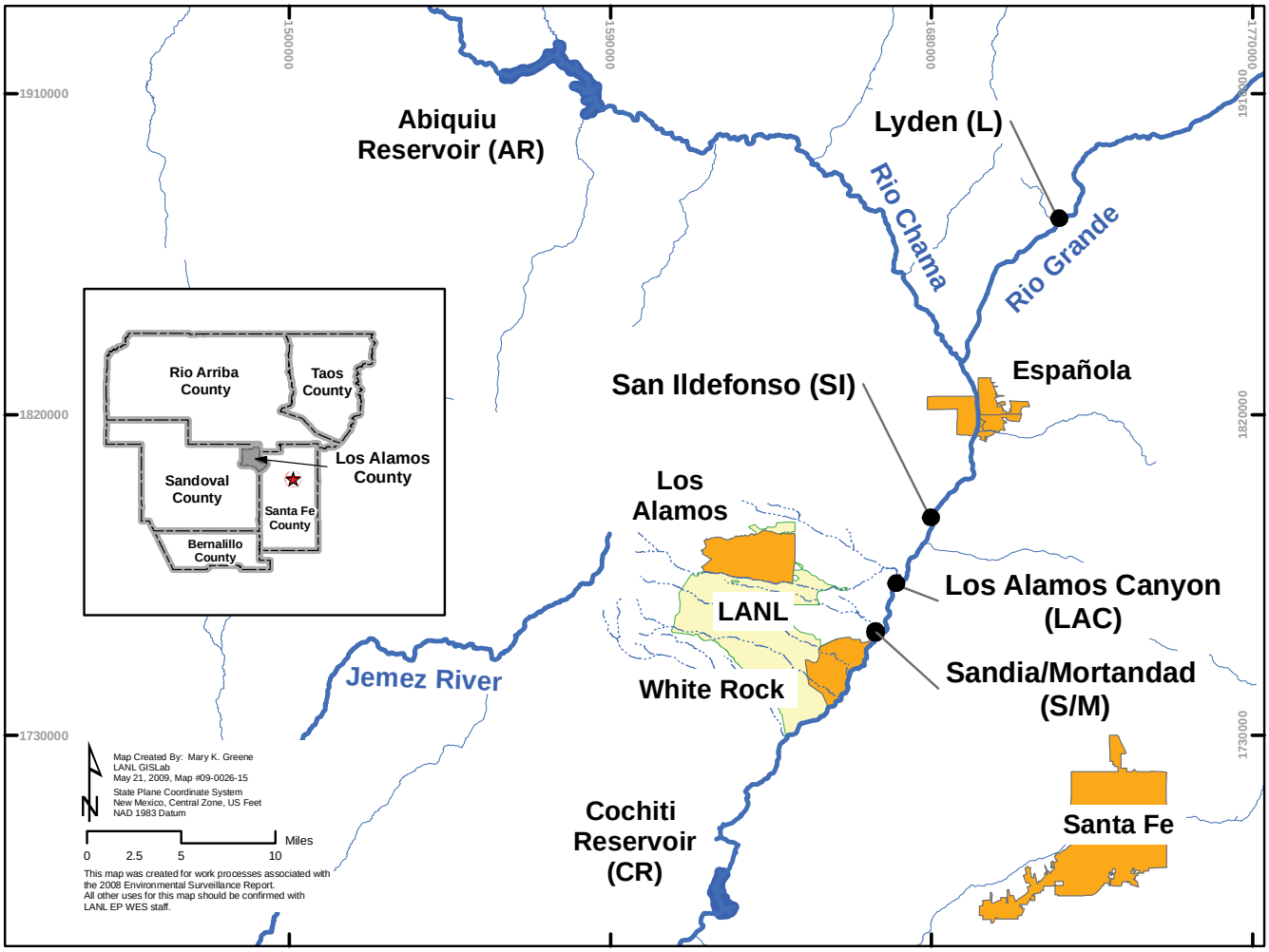


Figure 8-1. Locations of fish collected upstream and downstream of LANL.

Table 8-2
Locations, Types, and Numbers of Fish Collected

Location/River System	Location as related to LANL confluences	Type and (number of Fish Collected)
Abiquiu Reservoir on the Rio Chama	Approximately 44 miles upstream of LAC (the first LANL/canyon confluence)	Predator (6) and Bottom Feeders (12)
Lyden on the Rio Grande (L)	Approximately 25 miles upstream of LAC	Bottom Feeders (5)
San Ildefonso on the Rio Grande (SI)	Approximately 2 to 4 miles upstream of LAC (above the Otowi Bridge). Some of the carp sucker samples were collected from a pond immediately adjacent and open to the Rio Grande.	Bottom Feeders (8)
Los Alamos Canyon on the Rio Grande (LAC)	First LANL canyon confluence (below Otowi Bridge)	Bottom Feeders (6)
Sandia and Mortandad Canyons on the Rio Grande (S/MC)	Second and third LANL canyon confluences	Bottom Feeders (5)
Cochiti Reservoir on the Rio Grande	Downstream of all LANL canyon confluences	Predator (6) and Bottom Feeders (6)

4. Fish Results

a. Radionuclides

All radionuclide concentrations in predator fish and most radionuclide concentrations in bottom-feeding fish collected at all locations but especially in waters downstream of LANL (LAC, S/MC and Cochiti Reservoir) were either not detected or were detected below the RSRLs (Table S8-1 and S8-2, respectively). A nondetected value is one in which the result is lower than three times the counting uncertainty and is not significantly different ($\alpha = 0.01$, or 99% confidence level) from zero (Keith 1991, Corely et al. 1981) or less than the minimum detectable activity. These data, for the most part, are similar to past fish surveys (Fresquez e al. 1994, Fresquez et al. 1999a and b, Fresquez et al. 2006)

The only radionuclides in fish that were detected above the RSRLs were strontium-90 in a catfish from the confluence of LAC with the Rio Grande; uranium-234 and uranium-238 in a carp from the confluence of LAC with the Rio Grande; and uranium-234 and uranium-238 in a carp from the confluence of S/MCs with the Rio Grande. However, all concentrations were far below SLs. The isotopic uranium in the two carp samples, in particular, was just above the RSRLs and mostly derived from a naturally occurring source and not Laboratory-derived (e.g., the isotopic distribution of uranium-234 and uranium-238 were at 1:1 at <3s) (Figure 8-2) (see Fresquez and Armstrong 1996 for more information to naturally occurring uranium in fish).

Although all of the radionuclides in both predator and bottom-feeding fish at all locations downstream of the Laboratory were either detected below the RSRLs or the SLs and not a concern at the present time, it is important to evaluate whether potential contaminants are increasing or decreasing over time. With this in mind, we present the radionuclide data for the bottom-feeders—the more sensitive fish type of the two because of their feeding habits at the bottom of the reservoir where radionuclides readily bind with the sediment—collected since 1981 at Abiquiu Reservoir and Cochiti Reservoir (a nearly 30 year span). Total uranium (uranium 234, 235 and 238 isotopes combined) is presented in Figure 8-3, cesium-137 in Figure 8-4, strontium-90 in Figure 8-5, plutonium-238 in Figure 8-6, plutonium-239/240 in Figure 8-7, and americium-241 in Figure 8-8. (Note: Tritium is not presented because of the relatively short time period of study and because most of the concentrations were at or below zero.)

In general, the mean concentrations of all of these radionuclides in bottom-feeding fish from Abiquiu Reservoir and Cochiti Reservoir are similar to one another and are below the RSRLs in the later years reported. There are no increasing trends in radionuclides measured in fish samples from Cochiti Reservoir, except for a slight increase in uranium during the more recent years. In fact, a decreasing trend in cesium-137 and strontium-90 concentrations in bottom-feeding fish from Abiquiu Reservoir and Cochiti Reservoir are clearly evident. This decrease is probably due to the relatively short half-lives (30 years) of these radionuclides (Whicker and Schultz 1982). The other radionuclides are stable over time.

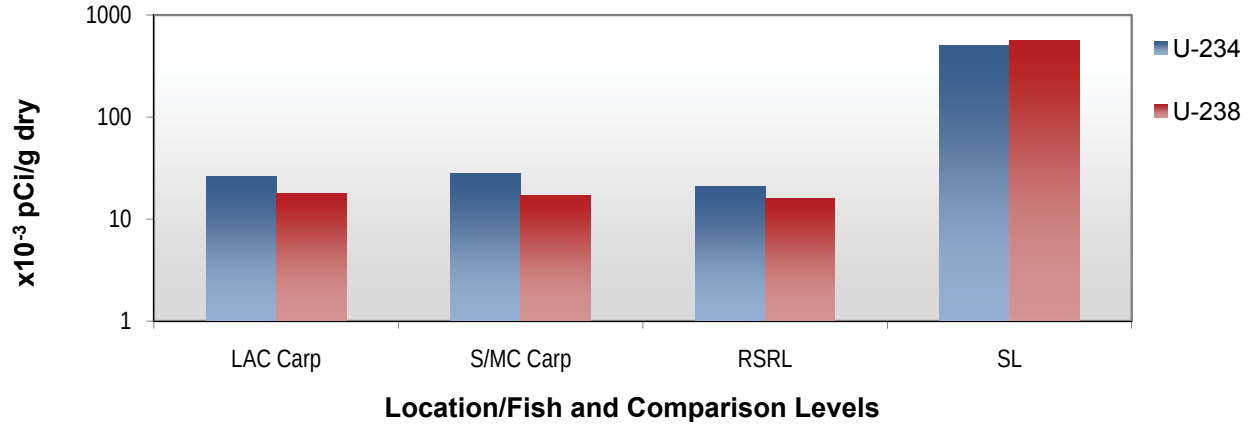


Figure 8-2. Uranium-234 and uranium-238 concentrations in two bottom-feeding fish downstream of LANL at the confluence of LAC and S/MC with the Rio Grande compared with the regional statistical reference levels (RSRLs) and screening levels (SL).

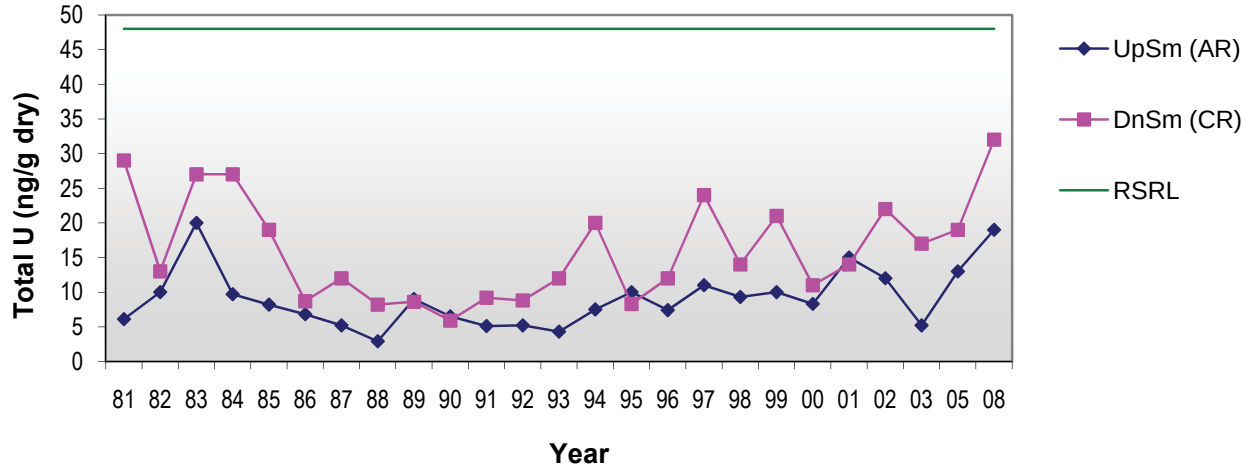


Figure 8-3. **Mean total uranium concentrations (all isotopes combined) in bottom-feeding fish upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1981 through 2008 compared with the regional statistical reference level (RSRL; this level is based on the five most recent sampling events).**

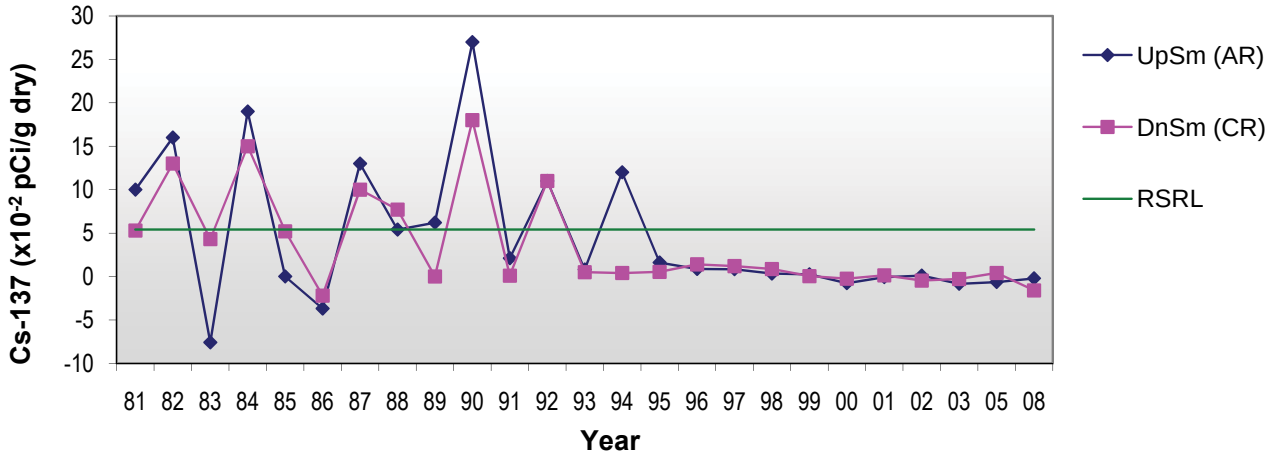


Figure 8-4. **Mean cesium-137 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1981 through 2008 compared with the regional statistical reference level (RSRL; this level is based on the five most recent sampling events). (Note: The high variability during the early years compared with the latter years was mainly due to the stabilization of instrument background, normalization in counting times, and improvements in the counting technology.)**

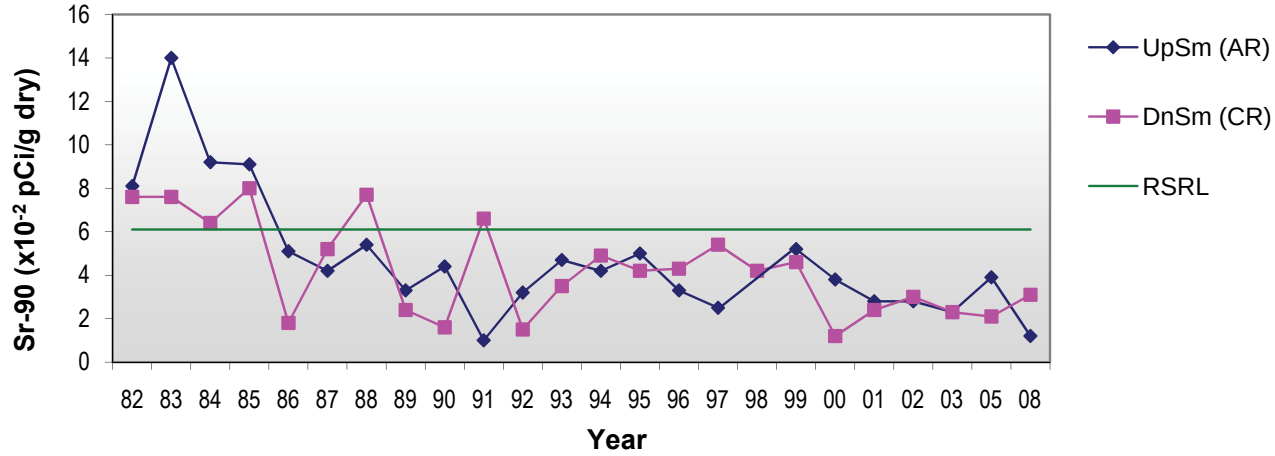


Figure 8-5. **Mean strontium-90 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1982 through 2008 compared with the regional statistical reference level (RSRL; this level is based on the five most recent sampling events).**

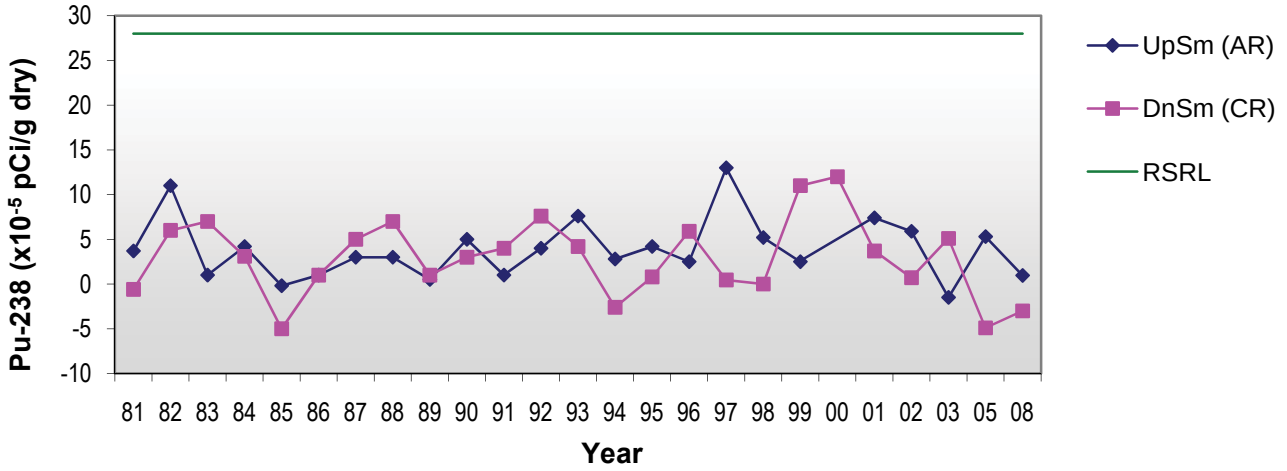


Figure 8-6. **Mean plutonium-238 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1981 through 2008 compared with the regional statistical reference level (RSRL; this level is based on the five most recent sampling events).**

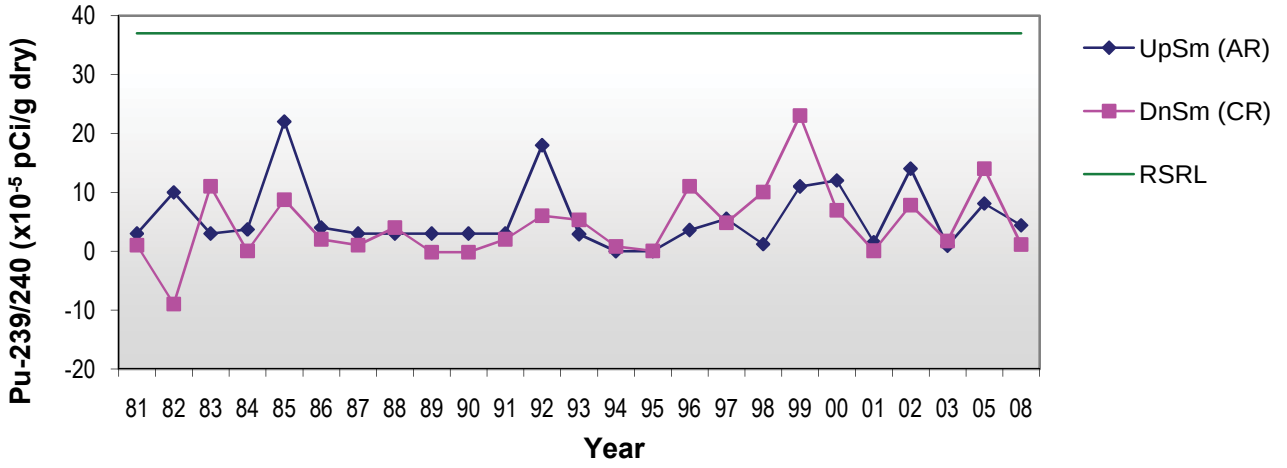


Figure 8-7. **Mean plutonium-239/240 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1981 through 2008 compared with the regional statistical reference level (RSRL; this level is based on the five most recent sampling events).**

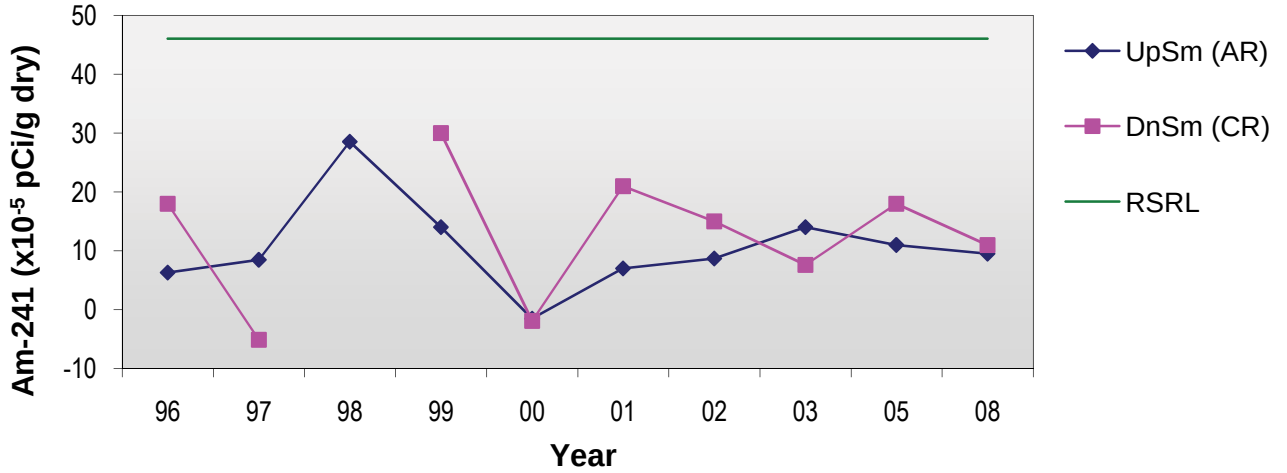


Figure 8-8. **Mean americium-241 concentrations in bottom-feeding fish upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1996 through 2008 compared with the regional statistical reference level (RSRL; this level is based on the five most recent sampling events).**

b. TAL Elements

Most of the 23 TAL elements analyzed in the muscle fillet of both predator and bottom-feeding fish collected upstream and downstream of LANL were either not detected or below the RSRLs (Tables S8-3 and S8-4). And the very few elements in fish downstream of LANL that were above the RSRLs were not at substantially higher concentrations or detected in a pattern (e.g., the majority of fish) that would indicate a significant contamination problem. Instead, the only TAL element that was detected consistently above the SL in both fish types and at most locations, but primarily at the two reservoirs, was mercury. The main sources of mercury into the water systems in New Mexico are from natural sources and the burning of fossil fuels (NMED 1999). After entering water systems the inorganic mercury is converted to methylmercury by anaerobic sulfate reducing bacteria using carbon from flooded vegetation as an energy source. Virtually all of the mercury found in the edible portions of fish is methylmercury (EPA 2001), a highly toxic neurotoxin in humans, where it may bioaccumulate (larger fish > smaller fish) and biomagnify (carnivorous fish > omnivorous fish) up the aquatic food chain (Ochiai 1995).

The levels of total mercury in the majority of predator fish (Table S8-3) and in some bottom-feeding fish (Table S8-4) collected from both upstream and downstream locations are above the SL of 0.30 mg/kg wet (Figure 8-9). Predator fish would be expected to contain more mercury than the bottom-feeding fish because mercury normally biomagnifies up the food chain and in fact, two of the predator fish from Cochiti Reservoir were above the FDA standard of 1 mg/kg wet. Also, since the conversion of inorganic mercury to methylmercury is primarily conducted by bacteria under anaerobic conditions, it would be expected that there would be higher amounts in reservoir fish than in river fish (Driscoll et al 1994, Bunce 1991).

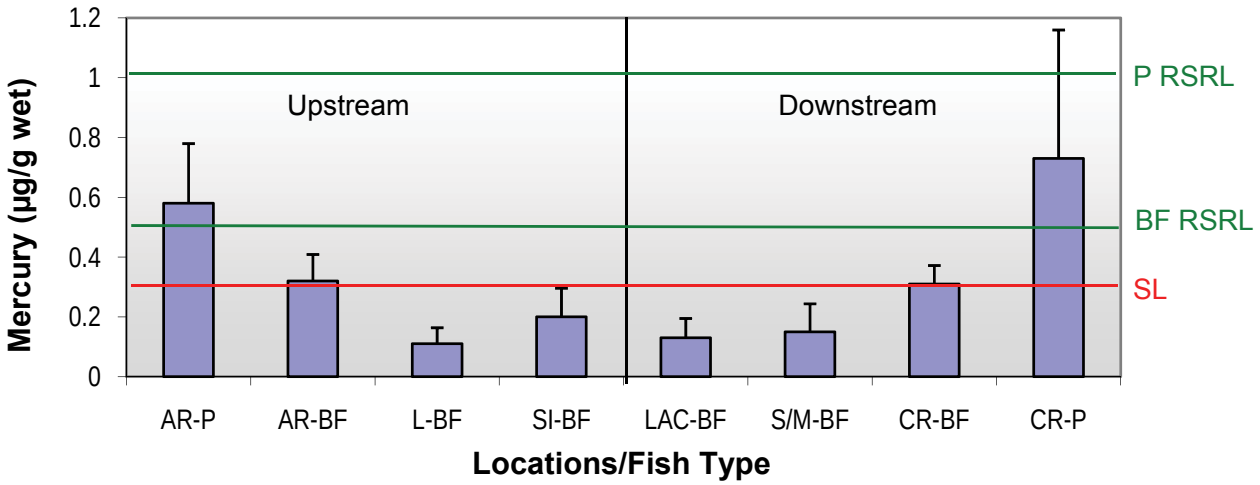


Figure 8-9. Mean (±1 standard deviation) total mercury concentrations in predator (P) and bottom-feeding (BF) fish upstream (Abiquiu Reservoir, Lyden and San Ildefonso) and downstream of LANL (Los Alamos Canyon, Sandia/Mortandad Canyons and Cochiti Reservoir), compared with the regional statistical reference levels (RSRLs) for P and BF and the screening level (SL).

There is no indication that the mercury in fish downstream of the Laboratory is from LANL operations because bottom-feeding fish from upstream locations, particularly those directly upstream of LANL at SI, generally have higher concentrations than bottom-feeding fish directly downstream of LANL at LAC and S/MC (Figure 8-10). Moreover, long-term evaluations of mercury in fish from Abiquiu Reservoir and Cochiti Reservoir show no significant differences (p=0.05) in mercury concentrations between the two locations (Fresquez 2004a, Fresquez et al. 1999c).

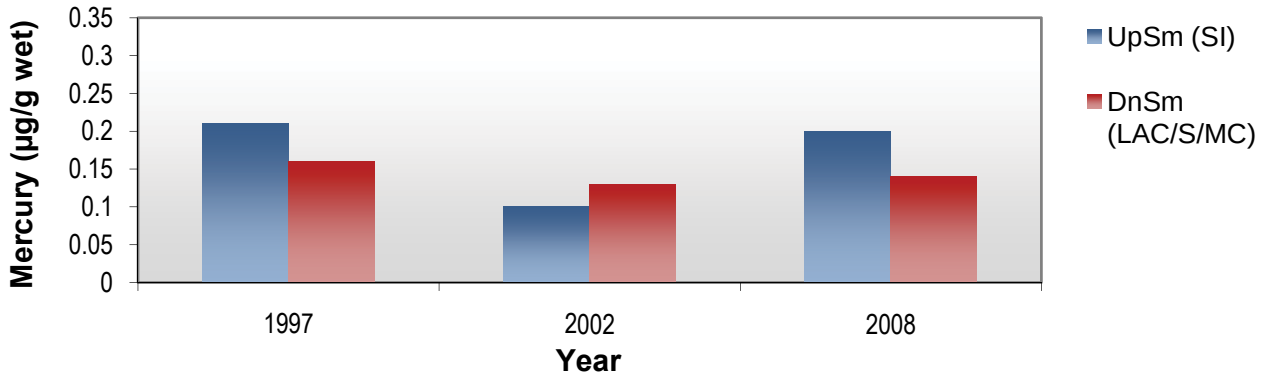


Figure 8-10. **Mean (±1 standard deviation) mercury concentrations in bottom-feeding fish directly upstream (San Ildefonso) and directly downstream (Los Alamos and Sandia/Mortandad canyon confluences) of LANL from 1997 through 2008. Data from 1997 is from Fresquez et al. 1999a and b, and data from 2002 is from Fresquez et al 2004a.**

With respect to long-term trends (1991 through 2008), the concentrations of mercury in both predator and bottom-feeding fish at both Abiquiu Reservoir and Cochiti Reservoir locations show a general decrease in the early years until 2002 (Figure 8-11 and 8-12). Whereas the bottom feeders remain stable during the latter years, the predator fish show a sharp increase starting in 2002 to the present. This increase may be a result of rising water levels burying newly growing vegetation which would be a source of carbon for the sulfate reducing bacteria (Driscoll et al, 1994).

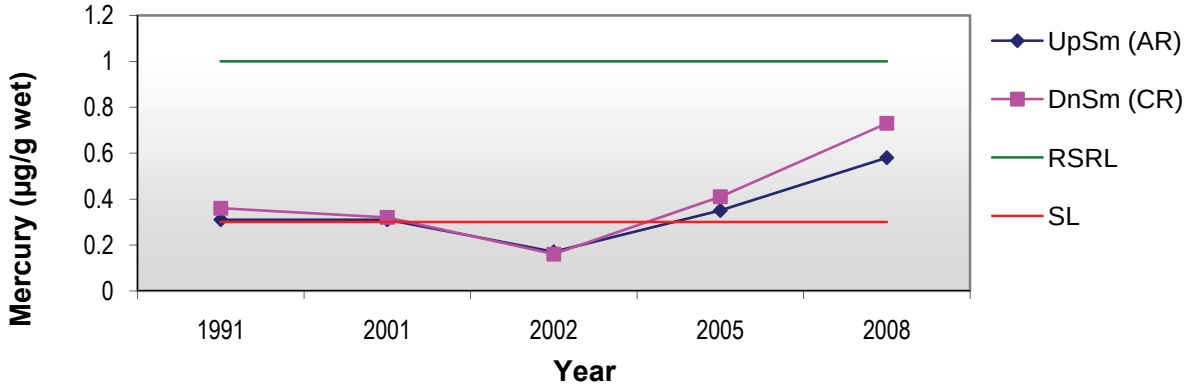


Figure 8-11. **Mean mercury concentrations in predator fish collected from upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 1991 through 2008 compared with the regional statistical reference level (RSRL) and screening level (SL).**

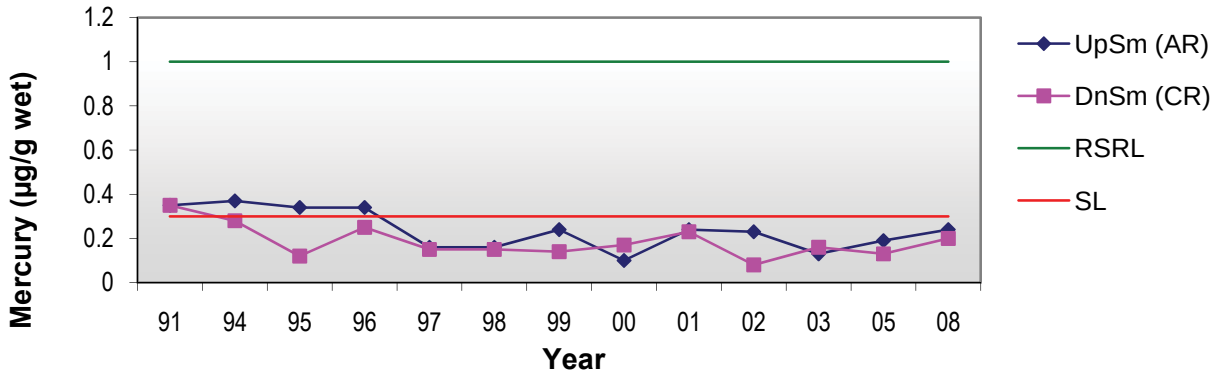


Figure 8-12. **Mean mercury concentrations in bottom-feeding fish collected upstream (Abiquiu Reservoir [AR]) and downstream (Cochiti Reservoir [CR]) of LANL from 1991 through 2008 compared with the regional statistical reference level (RSRL) and screening level (SL).**

These data were reported to the New Mexico Environmental Department (NMED) in September 2008 so that an update and/or an expansion of the fish consumption advisory for Abiquiu Reservoir, Cochiti Reservoir and parts of the Rio Grande could be made, if appropriate. Currently, there are 26 fish consumption advisories for mercury in New Mexico, including the Rio Grande (NMDG&F et al. 2009).

c. Polychlorinated Biphenyls

i. General Background

PCBs are a category of toxic, long-lived synthetic organic chemicals manufactured in the United States between 1930 and 1976 (ATSDR 2001). They were developed predominantly for use as coolants and lubricants because of their general chemical inertness and heat stability in electrical equipment such as capacitors and transformers (EPA 1996, 2002). Also, they have been used in oil in motors and hydraulic systems, flame retardants, inks, adhesives, carbonless copy paper, paints, wood-floor finishes, pesticide extenders, plasticizers, polyolefin catalyst carriers, slide-mounting mediums for microscopes, surface coatings, wire insulators, and metal coatings. Although banned over three decades ago, PCBs continue to enter the environment from various sources (e.g., landfills, urban runoff, sewage sludge, incineration of municipal refuse and illegal disposal).

Aroclor was the trade name for technical mixtures of PCBs manufactured in the United States; nine Aroclor mixtures were produced with the bulk being Aroclor-1016 (13%), 1242 (52%), 1248 (7%), 1254 (16%), and 1260 (11%); each was prepared to a specific chlorine weight percentage given in the last two digits of its name, with the exception of Aroclor 1016 which contains 41% chlorine by weight; each contains a specific mixture of 209 congeners—a congener is a specific PCB compound with a certain number of chlorine atoms in certain positions on the molecule (EPA 1996).

With respect to their behavior in the aquatic environment, PCBs are hydrophobic and tend to accumulate in the sediment, are highly soluble in lipids (lipophilic), and are absorbed and retained by fish.

We collected twelve predator fish from Abiquiu Reservoir and Cochiti Reservoir and 42 bottom-feeding fish from six locations along the Rio Chama (Abiquiu Reservoir) and Rio Grande (L, SI, LAC, S/MCs, and Cochiti Reservoir) for the analysis of 209 PCB congeners.

In general, our results showed that total PCB concentrations (all congeners combined) in muscle fillet tissue of the bottom feeders are higher than in muscle fillet tissue of the predator fish. The higher concentrations of PCBs in muscle tissue of the bottom-feeding fish (omnivores) compared with predator fish (carnivores) may be a reflection of their feeding habits (location of food sources) and/or the higher amounts of lipid content (fat) in their tissues. Owing to their low solubility in water, PCBs are most prevalent in sediment at the bottom of lakes and rivers (Ashley and Baker 1999) and fish with higher lipid (fatty tissues) content usually contain higher PCB levels than fish with lower lipid content (Grafton et al. 2008).

To varying degrees, both predator and bottom-feeding fish from all collection points, including upstream locations, exceeded the SLs, based on EPA risk-based consumption limits for PCBs. Although the standard was not exceeded, these data were reported to the NMED in September 2008 so that they may be used to update the fish advisory levels for these sections of waters (NMDG&F et al. 2009). The levels of PCBs varied with the type of fish collected.

ii. Predator Fish

A summary table showing physical data (weight, length, girth) and chemical data (percent lipids and total PCBs) for each of the six predator fish from Abiquiu Reservoir (upstream) and Cochiti Reservoir (downstream) is presented in Table S8-5. Individual PCB congener data (209 total) for all fish samples collected from Abiquiu Reservoir and Cochiti Reservoir can be found in Tables S8-6 and S8-7, respectively.

Results show that 50% of the predator fish at Cochiti Reservoir contained total PCBs at higher concentrations than the RSRL. Based on the normalized lipid data (PCB concentration in fillet divided by percent lipids), all

predator fish from Cochiti Reservoir had higher PCB concentrations than the RSRL and a Pearson's correlation coefficient (r) of PCBs in the fillet versus lipid-normalized data was relatively high at 0.77. These data are similar to the difference in PCB levels in predator fish collected from Abiquiu Reservoir and Cochiti Reservoir in 2005 (Gonzales and Fresquez 2006). While the difference between reservoirs in 2008 was similar to the differences in 2005, the concentrations in 2008 were higher than in 2005. Abiquiu Reservoir was about 1.6 times higher and Cochiti Reservoir was about 2.2 times higher (Figure 8-13).

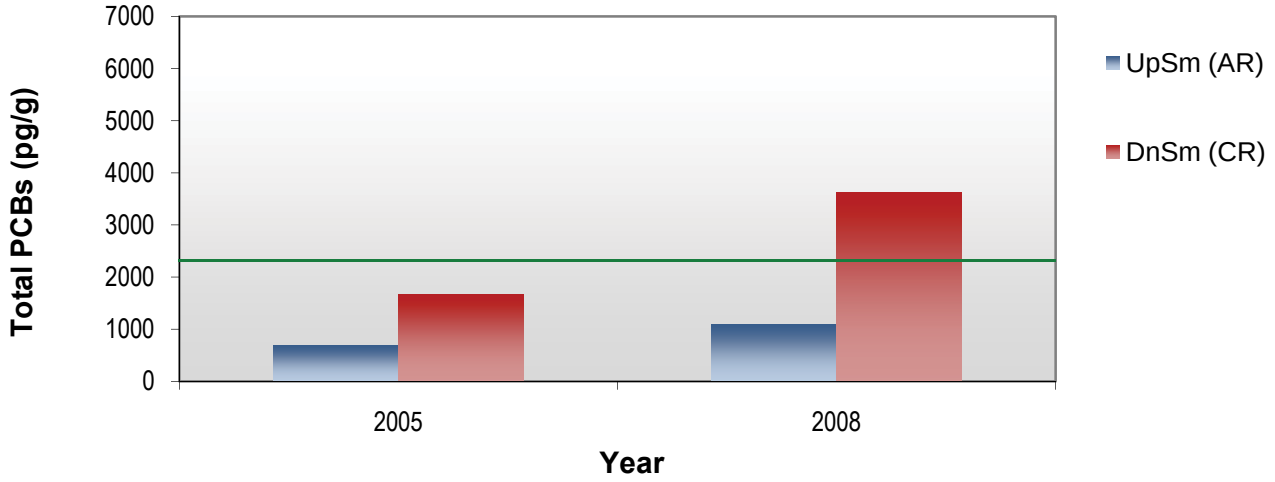


Figure 8-13. Mean (±1 standard deviation) total PCBs in muscle fillets of predator fish collected upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL in 2005 and 2008 compared with the regional statistical reference level (green line).

A comparison of the mean PCB congener (Figure 8-14) and homolog (groups of congeners with the same number of chlorine substituents) (Figure 8-15) distributions in muscle fillets of predator fish between Abiquiu Reservoir and Cochiti Reservoir show that the profiles are very similar to one another (a high correlation coefficient of r = 98 was calculated using the full 209 congener list) with fish from both locations peaking at the hexa chlorinated biphenyl level. These data agree with the fish results obtained in 2005 (Gonzales and Fresquez 2006) and indicate that there is no difference in the PCB sources between sites.

In general, studies have shown that the PCB congener composition in aquatic animals of lower trophic levels (e.g., crab, clams, and sturgeon) remains very similar to the original Aroclor patterns, whereas in animals of higher trophic levels (e.g., seals and killer whales) the original Aroclor profiles are increasingly modified (Newman et al. 1998, Sather et al. 2001). Indeed, a comparison of the predator fish homolog distributions from both reservoirs shows that the general patterns overlap Aroclors 1248, 1254, and 1260 but appears to contain more of the higher chlorinated 1260 than the other forms (Figure 8-15). In comparison, samples of sediment from (upper) Cochiti Reservoir in 2008 show that the dominant forms of PCBs detected were Aroclor 1248 (196,000 pg/g), 1254 (152,000 pg/g), and 1260 (32,000 pg/g) (Chapter 6, Section F).

Based on the TEQs in muscle fillets of predator fish from both Abiquiu Reservoir and Cochiti Reservoir, the number of fish meals per month a person can consume were calculated from the 12 dioxin-like PCB congeners that were detected. Using this EPA-approved risk-based method, the consumption limits ranged widely depending on fish species, but in general, it was a little more restrictive at Cochiti Reservoir (ranging from one to more than 16 fish meals per month with an average of five) than at Abiquiu Reservoir (ranging from two to 16 fish meals per month with an average of seven) (Table S8-5). These calculations are used in this study for SL and comparative purposes only. In contrast, the most current NM fish consumption advisories, which are partly from these same LANL data, were calculated by the NMED by replacing all values below the detection limit with half of the detection limit, thus resulting in lower fish consumption limits (NMDG&F et al. 2008).

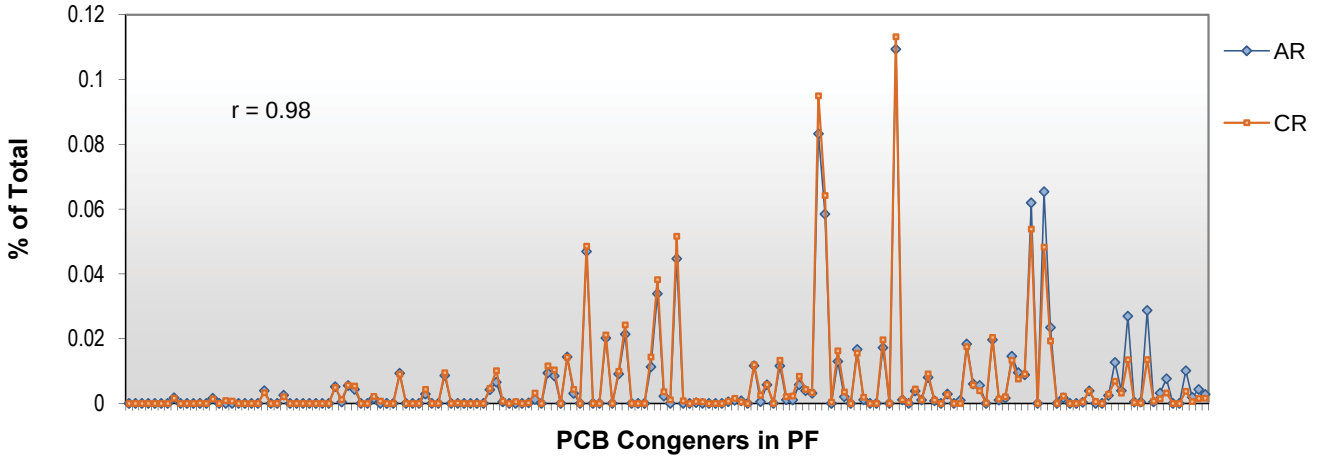


Figure 8-14. The mean PCB congener distribution in muscle fillets of predator fish (PF) collected upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL in 2008.

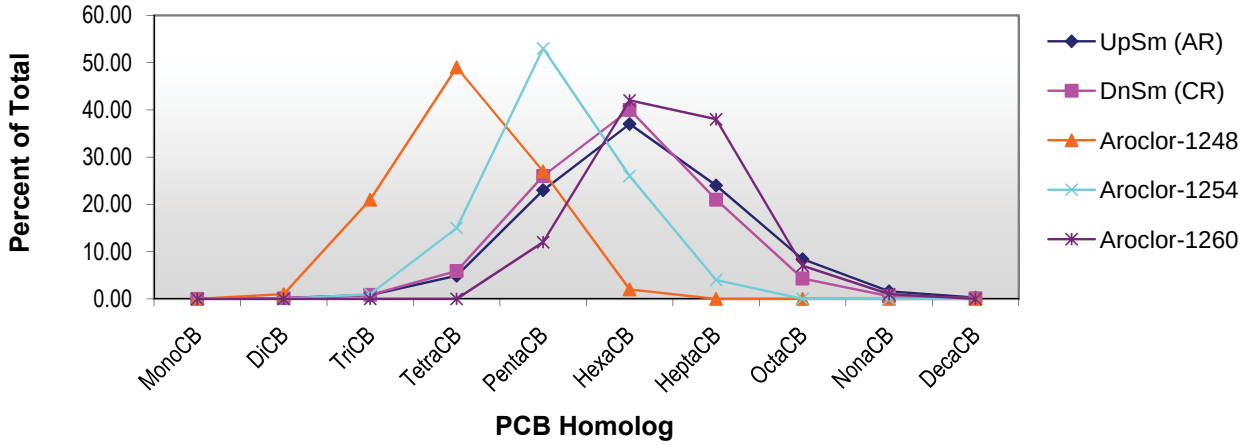


Figure 8-15. The mean homolog distribution in muscle fillets of predator fish collected upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL in 2008 compared with various Aroclor profiles detected in a sediment sample from Cochiti Reservoir in 2008 (see Chapter 6, Section E.3.b).

iii. Bottom-Feeding Fish

A table summarizing physical and chemical data, including total PCBs, in muscle fillets and lipids (normalized) in bottom-feeding fish from three upstream (Abiquiu Reservoir, L, and SI) and three downstream (LAC, S/MC, and Cochiti Reservoir) locations relative to LANL are presented in Table S8-8. The individual PCB congener list (209 total) associated with each fish sample at each location can be found in Tables S8-9 (upstream) and S8-10 (downstream).

The mean total PCB concentrations in muscle fillets of bottom-feeding fish from six locations along the Rio Chama and Rio Grande varied widely depending on location. In general, the mean levels are lowest at the two most upstream locations, Abiquiu Reservoir (2,925 pg/g wet) on the Rio Chama and L (6,250 pg/g wet) on the Rio Grande; then increase at SI (24,575 pg/g wet) (a combination of Rio Chama and Rio Grande waters upstream of LANL); then decrease at LAC (17,813 pg/g wet) and S/M (6,520 pg/g wet); lastly, the concentrations substantially increase to the highest levels at Cochiti Reservoir (51,800 pg/g wet) (Figure 8-16). All mean total PCB concentrations in muscle fillets of bottom-feeding fish, however, were below the RSRL (calculated from SI 2002 and 2008 data). (Note: The lipid normalized data show the same trend and a Pearson's correlation coefficient (r) of PCBs in the fillet versus lipid normalized data was relatively high at 0.74.)

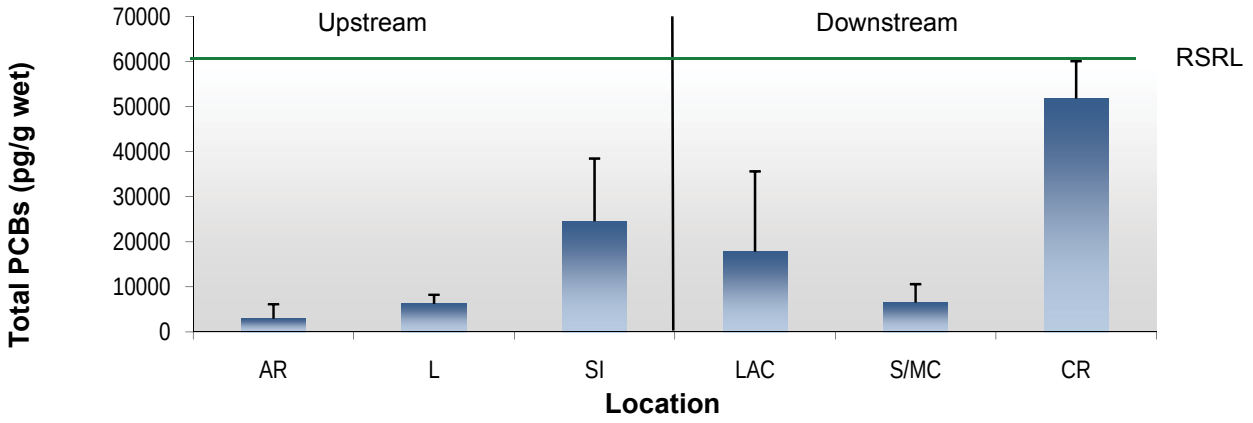


Figure 8-16. Mean (±1 standard deviation) total PCB concentrations in muscle fillets of bottom-feeding fish collected upstream (Abiquiu Reservoir, Lyden and San Ildefonso) and downstream (Los Alamos Canyon, Sandia/Mortandad Canyons and Cochiti Reservoir) of LANL in 2008 compared with the regional statistical reference level (RSRL).

With respect to bottom-feeding fish collected at Abiquiu Reservoir and Cochiti Reservoir over time, there is considerable variability in mean total PCB concentrations in bottom-feeding fish at Cochiti Reservoir compared with Abiquiu Reservoir (Figure 8-17). At Cochiti Reservoir, the PCB concentrations in bottom-feeding fish over the years vary widely and show definite inputs of PCBs from upstream sources. In contrast, the PCB concentrations in bottom-feeding fish at Abiquiu Reservoir are consistently lower and do not vary by much from year to year.

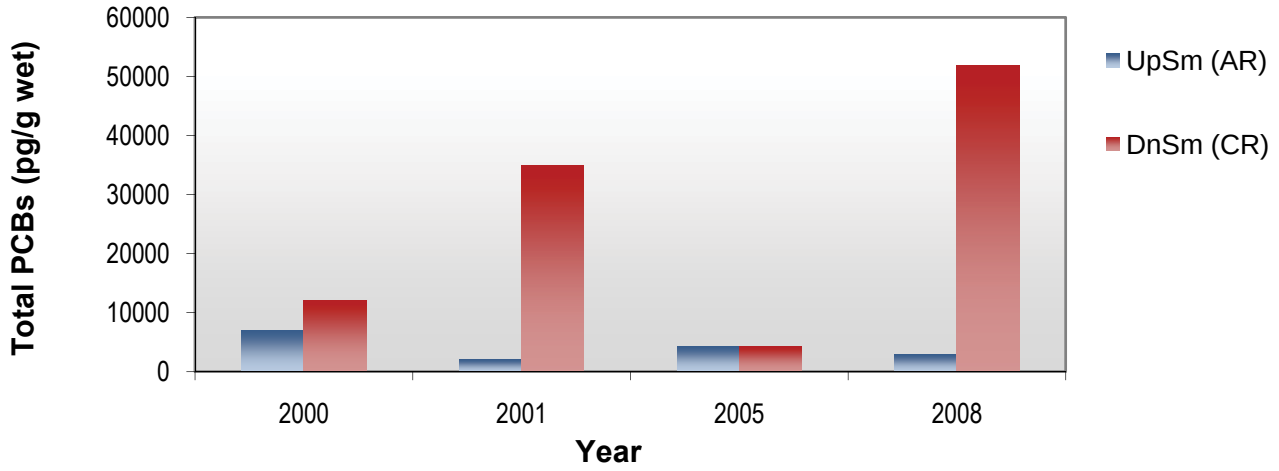


Figure 8-17. Mean total PCB concentrations in bottom-feeding fish collected upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL from 2000 through 2008.

With respect to fish collected in the Rio Grande directly upstream (SI) versus directly downstream (LAC and S/MCs) of LANL, the total concentrations of PCBs in bottom-feeding fish were detected in generally higher concentrations upstream than downstream and at about the same levels in two seasons of study—in 2002 (Gonzales and Fresquez, 2008) and in 2008 (Figure 8-18). These data agree with other studies, mainly: (1) the placement of stationary semipermeable membrane devices (e.g., artificial fat bags) upstream and downstream of LANL that showed similar PCB concentrations between locations (Gonzales and Montoya 2005) and (2) the collection of sediment samples along the same general reach of waters upstream and downstream of LANL in 2007 and 2008 that showed generally higher mean PCB concentrations in sediment collected upstream of

LANL as compared to downstream of the Laboratory (Reneau and Koch 2008, Reneau and Koch, Chapter 6, Section F). Moreover, the mean congener (Figure 8-19) and homolog (Figure 8-20) distributions in bottom-feeding fish collected directly upstream of LANL (SI) are very similar to the patterns directly downstream of LANL (LAC) (a high correlation coefficient of r = 0.95 was calculated from the full 209 congener list) and overlap the profiles of Aroclors 1248, 1254, and particularly 1260. As with the predator fish, the overall PCB patterns observed with the bottom-feeding fish are probably from a mixture of various PCB Aroclors with some degree of accumulation of the higher chlorinated forms. Indeed, sediment samples collected upstream and downstream of LANL on the Rio Grande at generally the same locations as the fish shows differing Aroclor types (Chapter 6, Figures 6-12 and 6-13) and when averaged together (Chapter 6, Figure 6-15) generally resemble the fish PCB profiles. Thus, overall, based on the total PCB concentrations and congener data of upstream bottom-feeding fish compared with downstream fish (and sediment), LANL does not appear to be the major source of PCBs to the Rio Grande. Rather, it appears that the major inputs of PCBs to the Rio Grande may be from sources upstream of the Laboratory.

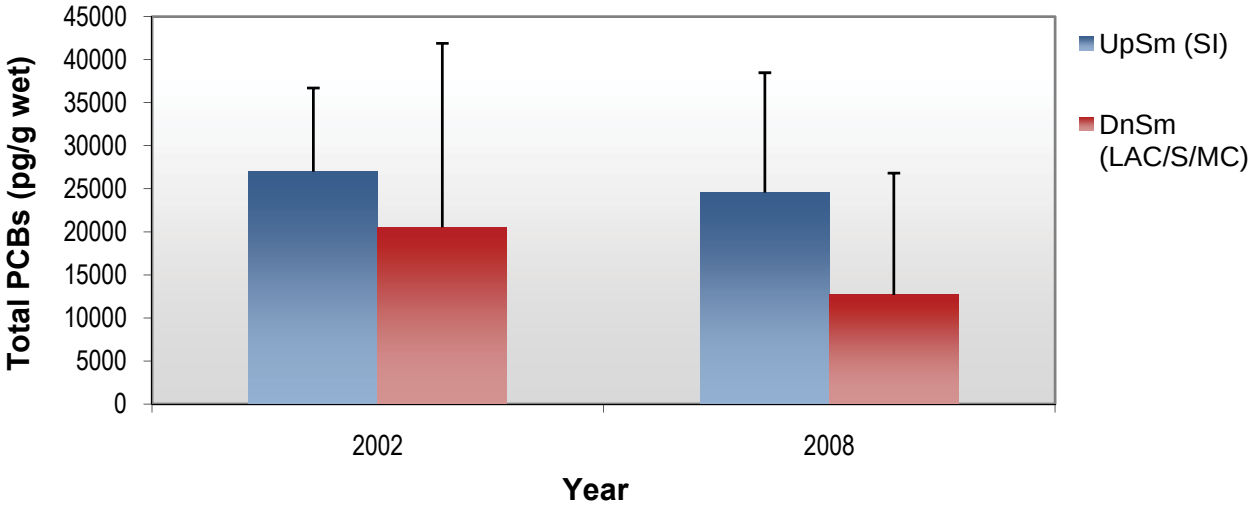


Figure 8-18. Mean (±1 standard deviation) total PCB concentrations in bottom-feeding fish collected directly upstream (San Ildefonso) and directly downstream (Los Alamos Canyon and Sandia/ Mortandad) of LANL in 2002 and 2008. Data from 2002 is from a report by Gonzales and Fresquez (2008) but a high upstream outlier was not used.

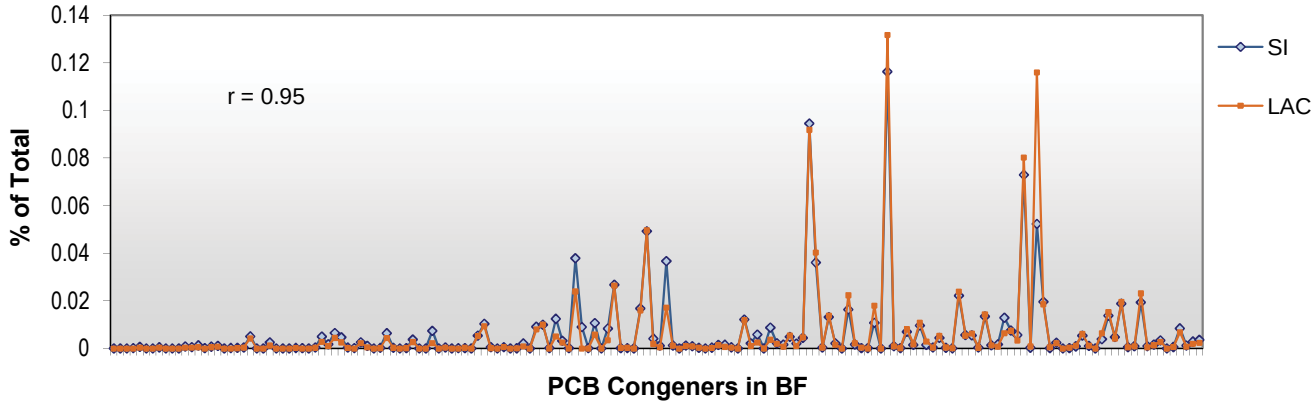


Figure 8-19. The mean congener distribution in muscle fillets of bottom-feeding (BF) fish collected directly upstream (San Ildefonso) and downstream (Los Alamos Canyon) of LANL in 2008.

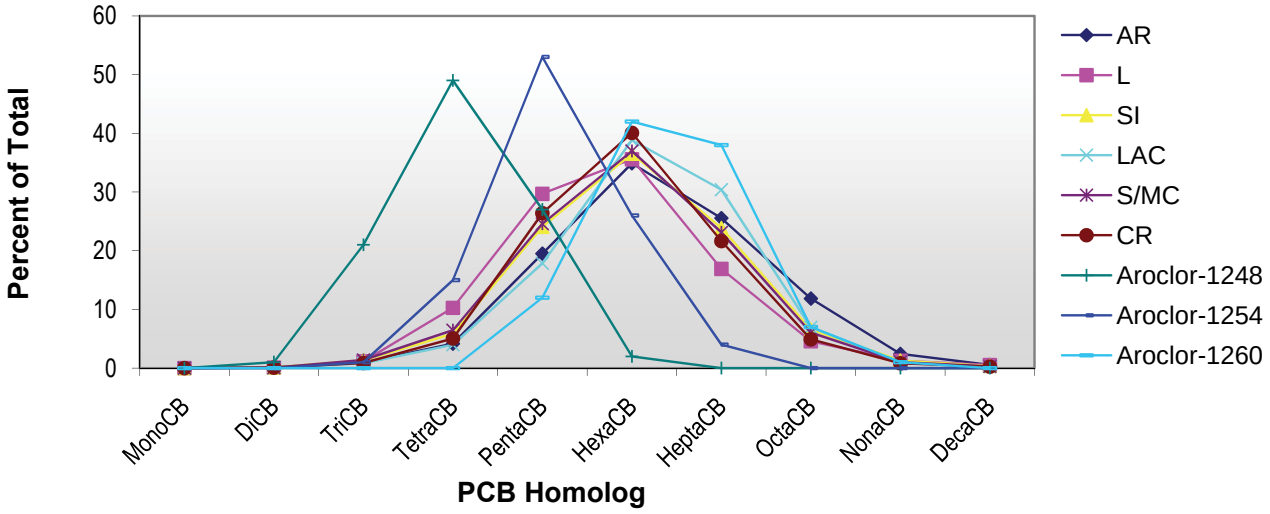


Figure 8-20. The mean homolog distribution in the muscle tissues of bottom-feeding fish collected upstream (Abiquiu Reservoir, Lyden, and San Ildefonso) and downstream (Los Alamos Canyon, Sandia/Mortandad Canyons, and Cochiti Reservoir) of LANL in 2008 compared with various Aroclor profiles detected in a sediment sample from Cochiti Reservoir in 2008 (see Chapter 6, Section E.3.b).

Based on the TEQs in muscle fillets of bottom-feeding fish collected at locations along the Rio Chama and Rio Grande, the average number of fish meals per month according to the EPA fish consumption limits are six per month at Abiquiu Reservoir, 1.2 per month at L, 0.31 per month at SI, 0.67 per month at LAC, 1.6 per month at S/MC and 0.0 meals per month at Cochiti Reservoir (Table S8-8). As discussed earlier, these values were calculated from the 12 dioxin-like PCB congeners that were detected and are used in this study for SL and for comparative purposes only. In contrast, the most current NM fish consumption advisories, which are partly from these same LANL data, were calculated by the NMED by replacing all non-detectable values with values that were one half of the detection limit, thus resulting in lower fish consumption limits (NMDG&F et al. 2008).

B. BIOTA MONITORING

1. Introduction

DOE Orders 450.1A (DOE 2008) and 5400.5 (DOE 1993) mandate the monitoring of biota (plants and animals not normally ingested by humans) for the protection of ecosystems. Monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, while site-wide native vegetation monitoring started in 1994. Presently, in addition to native vegetation, we also monitor small mammals, amphibians, reptiles, birds, and bees within and around LANL on a systematic basis or for special studies. Detection of contaminants in biota may indicate that these animals may be entering contaminated areas (e.g., burrowing in waste burial grounds) or that material is moving out of contaminated areas (e.g., blowing dust, transported soil/sediment via storm water, or food-chain transport).

The three objectives of the biota program are as follows:

1. Determine radionuclide and chemical concentrations in biota from on-site (LANL property) and perimeter areas and compare these results to regional (background) areas,
2. Determine concentration trends over time, and
3. Estimate potential dose to plants and animals. (Chapter 3 presents the results of the 2008 biota dose assessments at LANL.)

2. Biota Comparison Levels

Like the foodstuffs biota data, potential Laboratory impacts from radionuclides and chemicals in biota were first compared to RSRLs. If the levels exceed RSRLs, we compared the concentrations with SLs, if available, and then to standards, if available. Comparison levels are summarized below and presented in Table 8-3:

- Regional background levels: RSRLs are the upper-level background concentrations (mean plus three standard deviations) for radionuclides and chemicals calculated from biota data collected from regional locations away from the influence of the Laboratory (>nine miles away) (DOE 1991) over the past five sampling periods. RSRLs represent natural and fallout levels; they are calculated annually and presented in Tables S8-11 through S8-34 of this report.
- Screening Levels: SLs are set below DOE dose standards so that potential concerns may be identified in advance, i.e., a "yellow flag." If a constituent exceeds an SL, then the reason for that exceedance is thoroughly investigated. For radionuclides in biota, SLs were set at 10% of the standard by the dose assessment team at the Laboratory to identify the potential contaminants of concern (McNaughton 2006). For chemicals, there are no SLs based on biota tissue concentrations. Instead, if a chemical in biota tissue exceeds the RSRL (or Baseline Statistical Reference Levels [BSRL]), then the chemical concentrations in the soil at the place of collection are compared with ecological screening levels (ESLs) (LANL 2008a).
- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1 rad/day DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/day for terrestrial animals (DOE 2002).

Table 8-3
Standards and Other Reference Levels Applied to Biota

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1 rad/d	0.1 rad/d	RSRLs/BSRLs[a]
	On-site and perimeter	Terrestrial animals	0.1 rad/d	0.01 rad/d	RSRLs
	DARHT	Terrestrial animals	0.1 rad/d	0.01 rad/d	BSRLs
Chemicals	On-site and perimeter	Biota	na[b]	ESLs[c]	RSRLs
	DARHT	Biota	na	ESLs	RSRLs/BSRLs

[a] Baseline Statistical Reference Levels (BSRL) and a discussion of these levels can be found in Section 4.b.i.

[b] na = Not available.

[c] Ecological Screening Levels (ESLs) are based on the concentration in the soil.

3. Institutional Monitoring

No wide-scale institutional monitoring of native vegetation was performed in 2008. Native understory (grasses and forbs) and overstory (trees) vegetation are collected on a triennial basis at the same time and at the same locations as the soil (17 on-site, 11 perimeter, and six regional locations) described in Chapter 7, Section C.1 (Figure 7-1). The next sampling period for the collection of native vegetation is in 2009. For a discussion of past results, see Gonzales et al. (2000) for 1998 sampling results, Fresquez and Gonzales (2004) for 2002 and 2003 sampling results, and Fresquez et al. (2007a) for 2006 sampling results. In general, all radionuclide and TAL element concentrations in native understory and overstory vegetation sampled from Laboratory and perimeter areas are very low and most concentrations are indistinguishable from regional background areas.

4. Facility Monitoring

a. Area G at TA-54

Native vegetation around Area G was not collected in 2008. The last collection and analysis was in 2007 (Fresquez et al. 2008) and in general, results showed that overstory and understory plants collected around the southern portions of Area G (see Chapter 7, Figure 7-4 for location points) contained higher amounts of tritium than the RSRL but the levels are not increasing over time (Figure 8-21). Similarly, plants collected around the east and northeastern perimeter sections of Area G contained higher amounts of plutonium (and americium) than RSRLs and are also not increasing over time (Figure 8-22). All concentrations of tritium and plutonium-239/240 were similar to previous years (Fresquez and Lopez 2004, Fresquez et al. 2004b, Fresquez et al. 2005a) and although these radionuclides in vegetation at Area G are higher than the RSRLs, the amounts are still far below the SLs.

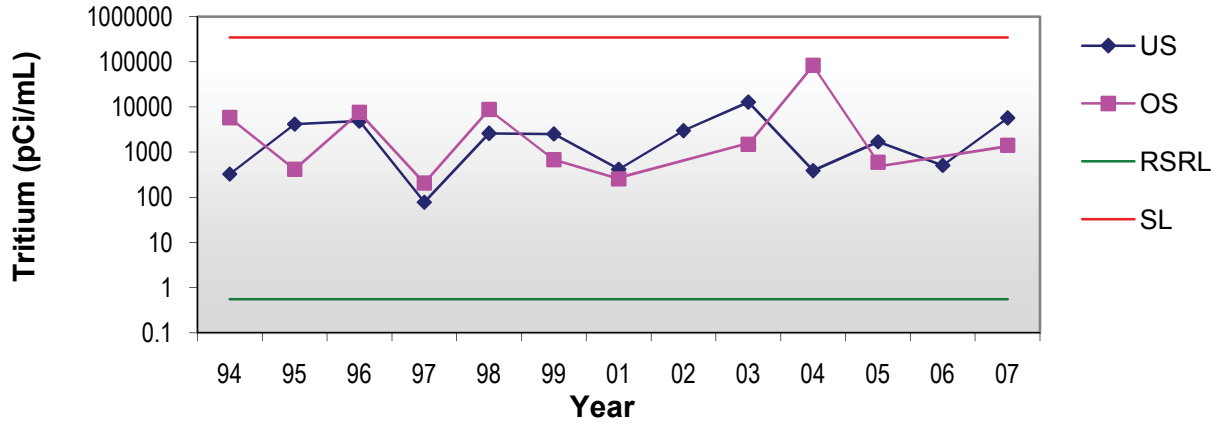


Figure 8-21. Tritium in understory (US) and overstory (OS) vegetation collected from the south side (see Chapter 7, Figure 7-4 for location information associated with site[s] near #29-03) of Area G at TA-54 from 1994 through 2007 compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

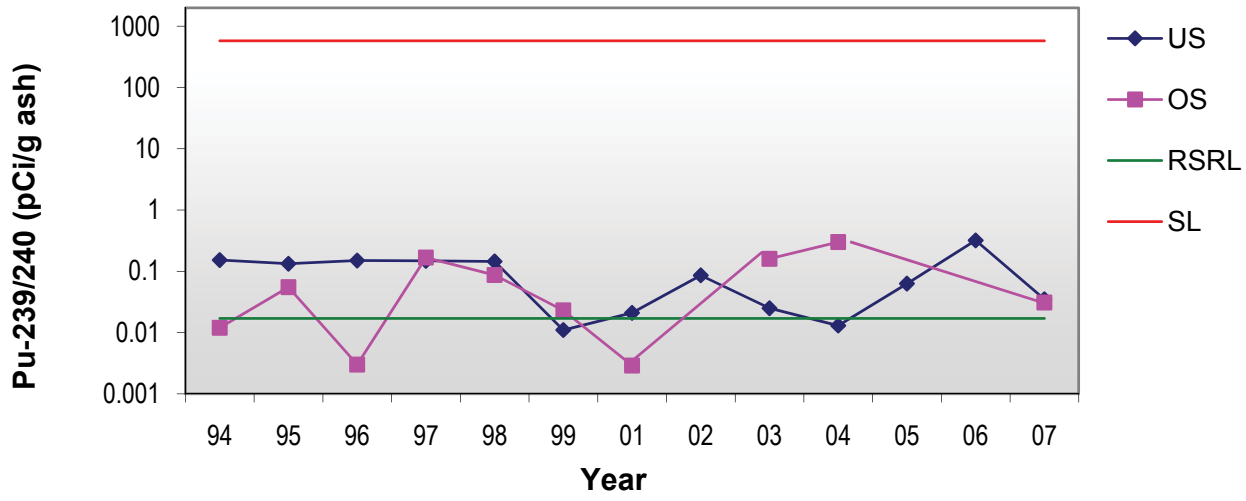


Figure 8-22. Plutonium-239/240 in understory (US) and overstory (OS) vegetation collected from the northeast side (see Chapter 7, Figure 7-4 for location information associated with site[s] near #41-02) of Area G at TA-54 from 1994 through 2007 compared with the regional statistical reference level (RSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

b. DARHT at TA-15

i. Monitoring Network

The Laboratory conducts facility-specific biota monitoring on an annual basis at the DARHT facility—the principal firing site at LANL (Nyhan et al. 2001, DOE 1996). The history of operations at the site have included open air detonations from 2000–2006; detonations using foam mitigation from 2002–2006; and detonations within closed steel containment vessels starting in 2007.

The biota samples collected at DARHT for radionuclide and TAL metal analysis included overstory vegetation (trees), small mammals, bees, and birds. Birds were collected for population, composition, and diversity estimates and released (see Chapter 7, Figure 7-8). Overstory vegetation samples were collected on the north, south, west, and east sides of the complex perimeter; small mammals, mostly deer mice (*Peromyscus* spp.), were collected from two sample grids located on the north and northeast side of the DARHT perimeter; honey bee samples were collected from three hives located just northeast of the DARHT facility; and bird samples were collected using 12 mist capture net traps spaced about 200 ft to 1,600 ft outward from the west side of the DARHT facility (spacing of the nets was about 150 ft from one another).

Vegetation, small mammal, and bee samples were submitted to Paragon Analytics, Inc., where they were processed and analyzed for tritium, plutonium-238, plutonium-239/240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235, uranium-238, and TAL elements. Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g ash basis; results for the TAL elements in vegetation are reported on a mg/kg dry basis; and results for the TAL elements in field mice and bees are reported on a mg/kg wet basis.

Results of the biota chemical analysis were compared with either RSRLs or BSRLs. BSRLs are the upper-limit baseline data established over a four-year period (1996–1999) prior to the start-up of DARHT operations in 2000. The BSRLs, at the three sigma level, are based on a report by Fresquez et al. (2001) for vegetation, Haarmann (2001) for bees, and Bennett et al. (2001) for small mammals. Similarly, the population, composition, and diversity of birds collected from DARHT were compared with bird samples collected prior to the operation of the DARHT facility (Fresquez et al. 2007c).

ii. Vegetation Results at DARHT

Most radionuclides in overstory vegetation collected from around the perimeter of the DARHT facility were either not detected or detected below the BSRLs (or RSRLs) (Table S8-11). The only radionuclide in overstory vegetation that was detected above the statistical reference levels was uranium-238 in vegetation collected from the north, east, and west sides of the DARHT perimeter. All of the concentrations, however, were far below the SL. Based on the isotopic distribution of uranium-234 to uranium-238, the higher amounts were due to depleted uranium. Depleted uranium, which is used as a substitute for enriched uranium in weapon components tested at LANL, has also been detected at DARHT in previous years in soil (Fresquez 2004), bees (Hathcock and Haarmann 2004), small mammals (Fresquez 2005), and birds (Fresquez et al. 2007a).

Although concentrations of uranium-238 in most vegetation samples appear to be increasing over time up to 2006, particularly on the north and east sides (principal wind directions), the 2007 and 2008 results reveal a slight decrease (Figure 8-23). These results correlate well with the soil perimeter data (Table S7-4) and may be associated with the change in contaminant mitigation procedures at DARHT from open and/or foam mitigation (2000–2006) to closed steel containment (vessel) mitigation in 2007.

The TAL element results, including heavy metals like beryllium and mercury, in overstory vegetation collected from around the DARHT facility are summarized in Table S8-12. All of the metals were either not detected or detected below the BSRLs (or below the RSRLs when BSRL data were not available).

iii. Small Mammal Results at DARHT

All radionuclides, including uranium-238, were either not detected or detected below the BSRLs in a composite field mouse sample (five mice per sample) collected from the north and northeast side of the DARHT facility (Table S8-13). The uranium-238 data correlate well with the soil (Table S7-4) and vegetation (Table S8-11) data in that the sample contains depleted uranium, which decrease in concentration after the 2007 year to preoperational levels (Figure 8-24). (Note: The baseline preoperational data (BSRLs) indicated that field mice contained depleted uranium. This was probably a result of field mice foraging within the operational range of the PHERMEX facility a short distance away. PHERMEX, which is currently inactive, contains depleted uranium within its operational area.) The decrease in uranium-238 concentrations in field mice at the perimeter of the DARHT facility may be due to the change in detonation mitigation practices in 2007 from open detonations and foam-mitigated detonations to closed vessel containment.

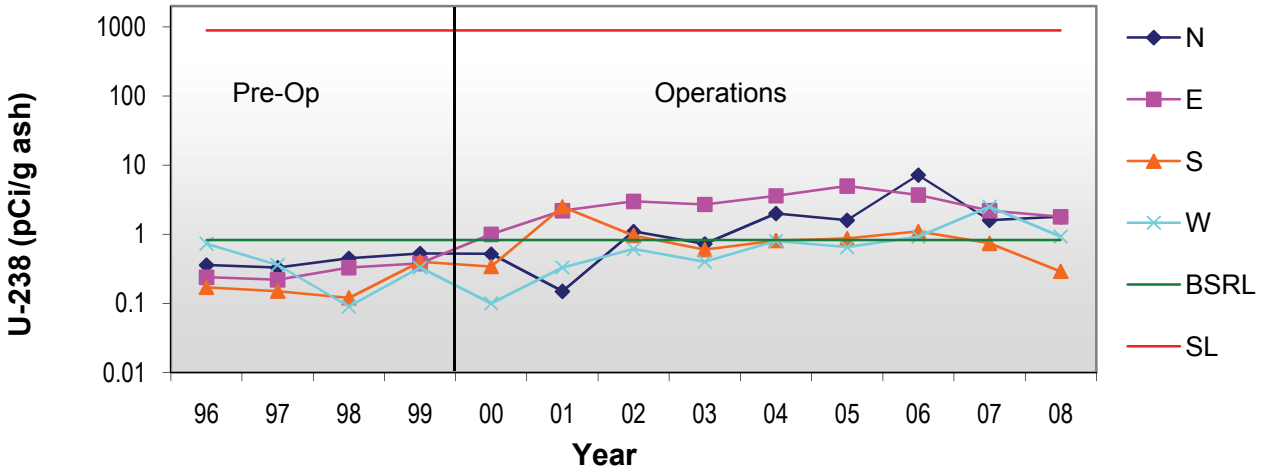


Figure 8-23. Uranium-238 in overstory vegetation collected from the north (N), east (E), south (S), and west (W) side of the DARHT facility at TA-15 from 1996–1999 (pre-operations) through 2000–2008 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

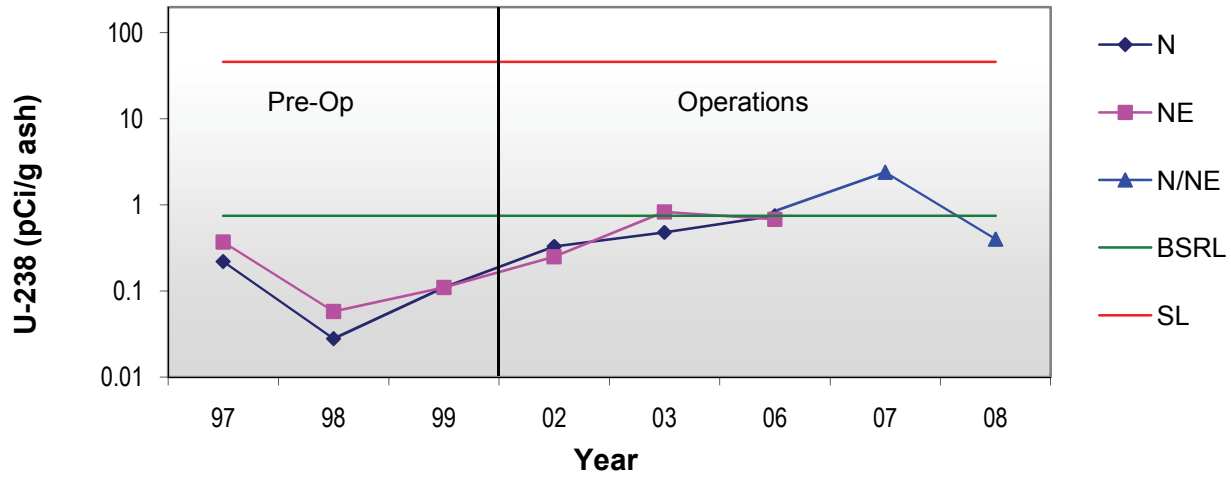


Figure 8-24. Uranium-238 concentrations in (whole body) mice collected from the north (N) and northeast (NE) side of the DARHT facility at TA-15 from 1997–1999 (pre-operations) through 2002–2008 (during operations) compared with the baseline statistical reference level (BSRL) and the screening level (SL). Note the logarithmic scale on the vertical axis.

With respect to TAL elements in field mice, some inorganic chemical concentrations for aluminum, barium, beryllium, iron, vanadium, cadmium, and lead were higher than the RSRLs (Table S8-14). These data do not correlate well with the 2007 analysis of the field mice nor do they correlate with the 2008 soil (Table S7-5) and vegetation (Table S8-12) data collected in the northern area (Table S7-5). However, the highest concentration of these inorganic chemicals in the soil around the DARHT facility (Table S7-5) do not exceed the ESLs for the field mouse (LANL 2005).

iv. Bee Results at DARHT

All concentrations of radionuclides, including uranium-238, in bee samples from the three hives located northeast of the DARHT facility were either not detected or detected below the BSRLs (Table S8-15). These data correlate well with the soil (Table S7-4), vegetation (Table S8-11), and small mammal (Table S8-13) data in that the uranium detected in bees was depleted uranium and the concentrations of uranium-238 in all bee samples decrease after 2007 to preoperational levels. (Note: The baseline preoperational data (BSRLs) indicated that bees were contaminated with depleted uranium. This was probably a result of bees foraging within the operational range of the PHERMEX facility a short distance away. PHERMEX, which is currently inactive, contains depleted uranium within its operational area.) Again, the decrease in uranium-238 in bee samples may be mainly due to the change in detonation mitigation practices from open/foam to closed vessel containment.

The TAL elements in bee samples from hives northeast of the DARHT facility show that barium and copper exceeded the BSRL and agree with past results (Table S8-16). There are no ESLs listed for barium and copper in soil for bees, but the highest levels of barium in soil around the grounds at DARHT (Table S7-5), are far below ESLs for other indicator biota receptors. In contrast, the highest levels of copper in soil at DARHT, 21 mg/kg at the firing point, exceed the ESLs for some biota receptors.

iv. Bird Results at DARHT

Populations, composition, and the diversity of birds collected just west of the DARHT facility in 2008 (operations phase) compared with 1999 (preoperational phase) is presented in Table S8-17. The objective of bird monitoring is to determine if there is general ecological stress around the vicinity of DARHT caused by facility operations (e.g., noise, disturbance, traffic, etc.).

The number of birds, number of bird species, and bird diversity and evenness (distribution) collected in 2008 are nearly identical to the data collected prior to the start-up of operations at DARHT in 1999 (Figure 8-25). The most common bird species collected regardless of time periods were the chipping sparrow (*Spizella passerina*), the Virginia's warbler (*Vermivora virginiae*), the western bluebird (*Sialia mexicana*), the broad-tailed hummingbird (*Selasphorus platycercus*), the sage sparrow (*Amphispiza belli*), and the western tanager (*Piranga ludoviciana*).

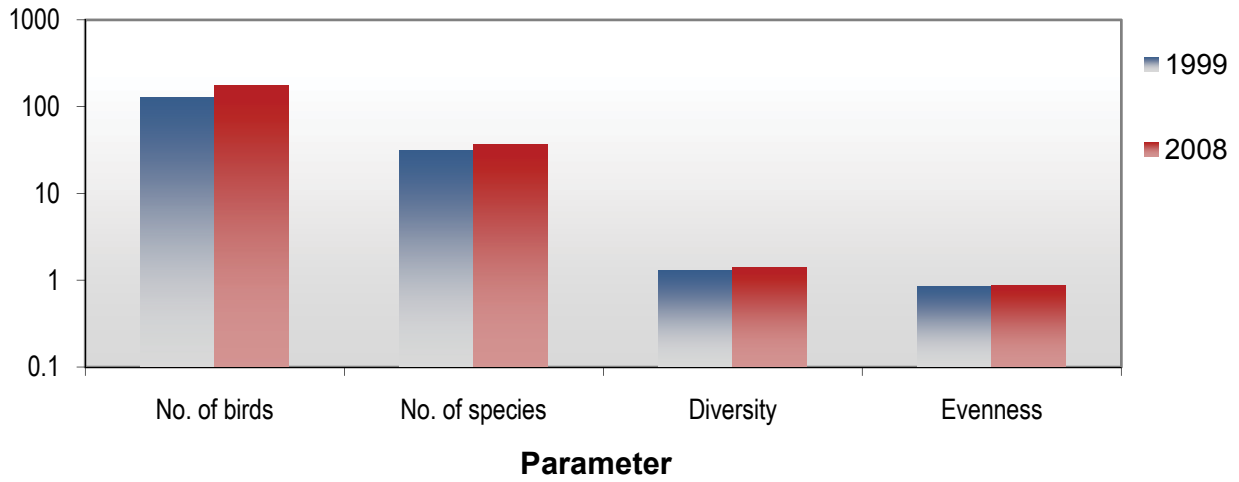


Figure 8-25. Populations, number of species, diversity and evenness of birds occurring before (1999) and after (2008) operations at DARHT. Note the logarithmic scale on the vertical axis.

C. SPECIAL STUDIES OF BIOTA

1. Characterization of Biotic and Abiotic Media Upstream of the Los Alamos Canyon Weir and the Pajarito Flood Control Retention Structure

In May 2000, a prescribed burn at Bandelier National Monument went out of control and burned nearly 50,000 acres of federal and pueblo land, including approximately 7,500 acres on LANL property. Because the Cerro Grande fire burned substantial amounts of vegetative cover, the Laboratory became concerned about increased sediment (and potential contaminant) transport from LANL to off-site locations. As a preventive measure, the US Army Corps of Engineers constructed two large erosion control structures to control storm water and sediment runoff from burned areas. These structures consist of (1) a low-head, rock-filled gabion weir that lies across the stream bed in Los Alamos Canyon near the junction of NM State Road 4 and NM State Road 502, and (2) a large cement flood retention structure located downstream of the confluence of Two-Mile and Pajarito Canyons.

As part of the Special Environmental Analysis of actions taken in response to the Cerro Grande fire at LANL (DOE 2000), the DOE identified various mitigation measures that must be implemented under the Mitigation Action Plan as an extension of the fire suppression, erosion, and flood control actions. One of the tasks identified in the Plan Section 2.1.7, "Mitigation Action for Soil, Surface and Ground Water, and Biota," mandates the monitoring of soil, surface water, groundwater, and biota at areas of silt or water retention upstream (upgradient) of flood control structures, within silt retention basins, and within sediment traps to determine if there has been an increase in contaminant concentrations in these areas and to determine to what extent they impact the biota. To this end, we collected samples of sediment (0- to 6-in. depth), native grasses and forbs (unwashed), and deer mice (*Peromyscus sp.*) in the areas upgradient of the Los Alamos Canyon Weir (LACW) and the Pajarito Canyon Flood Retention Structure (PCFRS). Native understory vegetation is monitored because it is the primary food source of biota and field mice are monitored because they have the smallest home range of the mammals.

Samples were analyzed for some or all of the following constituents: radionuclides, TAL elements (mostly metals), high explosives (HEs), semi-volatile organic compounds (SVOCs), and PCBs. Paragon Analytics, Inc. processed and analyzed the sediment, vegetation, and field mice (whole body) samples for radionuclides and TAL elements as well as for HE, SVOCs, and PCBs in sediments. The form of PCBs analyzed in sediment were mixtures (or "formulations") of individual PCBs (congeners) called Aroclors. Specifically, Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 were analyzed in sediment. Vista Analytical Laboratory, Inc., analyzed the field mice (whole body) for individual PCB congeners. A congener is a specific PCB compound with a certain number of chlorine atoms in certain positions; theoretically, there are 209 possible congeners based on the possible number and position of chlorine atoms. The analytical method used by Vista Analytical Laboratory, Inc., was EPA Method 1668A—high resolution gas chromatography (GC) and high resolution mass spectrometry (MS). (Note: For additional clarification of the make-up of Aroclors and PCB congeners, see reports by the US EPA and the Agency for Toxic Substances and Disease Registry) (EPA 2002, EPA 1996, ATSDR 2001).

The following two sections report the 2008 results of this monitoring.

a. Los Alamos Canyon Weir Results

Concentrations of radionuclides, TAL elements, and organic compounds in a composite sediment sample collected on the upgradient side of the LACW in 2008 are presented in Tables S8-18, S8-19, and S8-20, respectively.

In general, cesium-137, plutonium-238, plutonium-239/240, americium-241, mercury, selenium, Aroclor 1254 and Aroclor 1260 in sediment collected upgradient of the LACW were above the RSRLs (Figure 8-26). All of these constituents, however, are far below SLs (based on Table 7-1) and are mostly decreasing in concentration since peaking in 2006.

The results of the radionuclides and TAL elements in a composite understory vegetation sample collected on the upgradient side of the LACW in 2008 are presented in Table S8-21 and Table S8-22, respectively. In general, the slightly higher radionuclides and TAL element concentrations in the sediment upgradient of the LACW did not affect the native vegetation as all radionuclides and TAL elements in plants were either not detected or detected below the RSRLs. Normally, the actinides (isotopic plutonium and americium) are not readily taken up by plants and cesium-137 is taken up in the absence of potassium (Whicker and Schultz 1982).

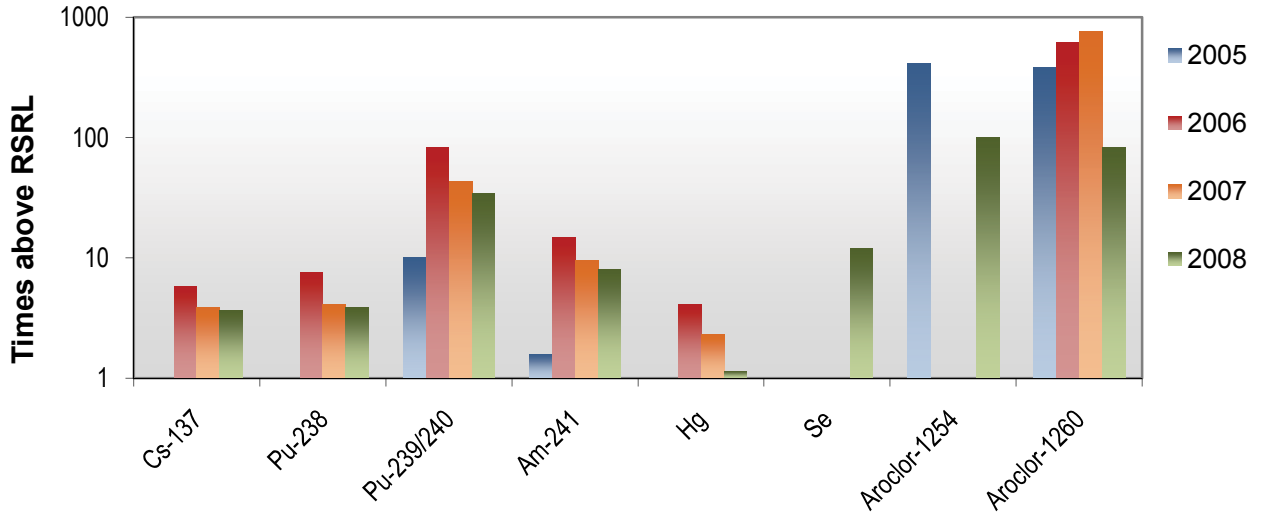


Figure 8-26. Times above the regional statistical reference levels (RSRL) for radionuclides, TAL elements, and PCBs in sediment collected upgradient (upstream) of the Los Alamos Canyon Weir from 2005 through 2008. Note the logarithmic scale on the vertical axis.

The concentrations of radionuclides (composite of five field mice), TAL elements (n=3), and PCBs (n=3) in whole body field mice samples collected upgradient of the LACW can be found in Tables S8-23, S8-24, and S8-25, respectively. Most concentrations of radionuclides in the field mouse sample were either not detected or detected below the RSRLs. The only radionuclides that were found in higher concentrations than the RSRLs were americium-241, uranium-234, uranium-235, and uranium-238 (Figure 8-27). All concentrations of these radionuclides, however, were below the SLs, are mostly decreasing over time since 2006. The distribution of uranium-234 to uranium-238 indicates that the uranium is naturally occurring. Thus, the dose to the mice is minimal and presents no unacceptable ecological health threat.

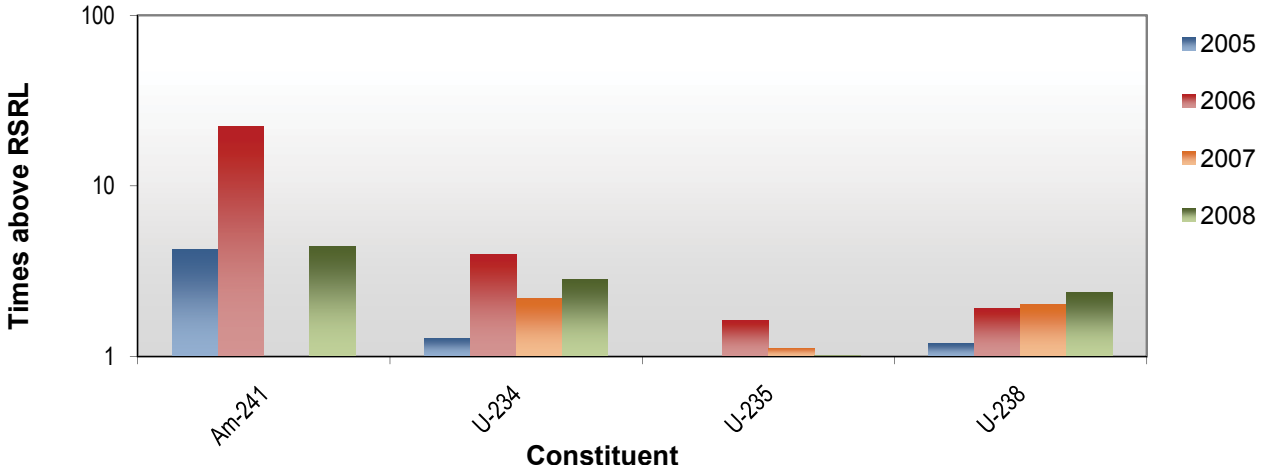


Figure 8-27. Times above the regional statistical reference levels (RSRL) for radionuclides in a composite whole body mouse sample (n=5) collected on the upgradient side of the Los Alamos Canyon Weir from 2005 through 2008. Note the logarithmic scale on the vertical axis.

Of the three field mouse samples collected, only one sample contained TAL elements (mainly aluminum, beryllium, cobalt, iron, manganese, vanadium, antimony, cadmium, lead, selenium, silver, thallium and mercury) that were above the RSRLs. The extent of contamination of these TAL elements in field mice, however, is probably minimal because these elements were not detected consistently in all field mouse samples and most of these elements detected in the one sample did not correlate well with the sediment (Table S8-18) and vegetation (Table S8-22) data. Only selenium and mercury were detected in both sediment and the one field mouse sample, and based on the highest concentrations in the sediment (3.6 mg/kg for selenium and 0.031 mg/kg for mercury), only selenium exceeded the ESL for the deer mouse (>0.83 mg/kg) (LANL 2005).

Total PCB concentrations in all three of the field mouse samples collected on the upgradient side of the LACW were above the RSRL (Table S8-25). These data, with the exception of one sample that had much higher concentrations, are generally within the same order of magnitude as last year's results (Figure 8-28). Although there are no SLs for a field mouse based on PCB concentrations in tissues, the soil levels of Aroclor 1254 (8.8 µg/kg) and Aroclor 1260 (5.7 µg/kg) detected upgradient of the LACW are well below the deer mouse ESLs for Aroclor 1254 (ESL = 880 µg/kg) and for Aroclor 1260 (ESL = 20,000 µg/kg) (LANL 2008a).

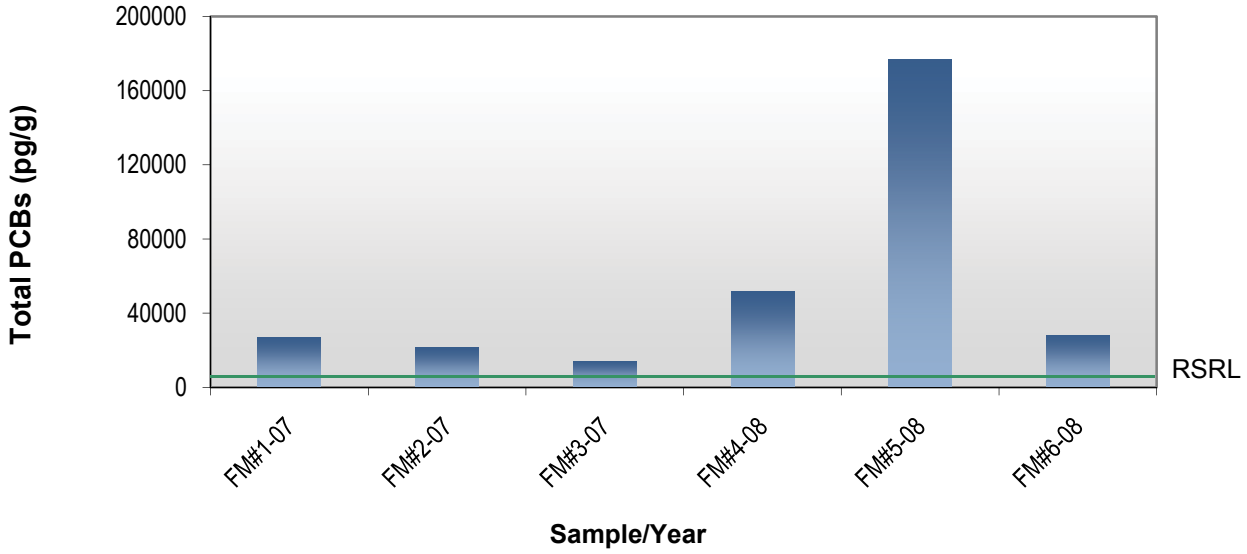


Figure 8-28. Total PCB concentrations in field mice (FM#) collected upgradient of the Los Alamos Canyon Weir in 2007 and 2008 compared to the regional statistical reference level (RSRL).

A comparison of the mean PCB homolog distribution show that the field mice contained higher levels of total hepta chlorinated biphenyls than the other homolog groups and matches the 2007 results (Figure 8-29). Although differing biota may alter the distribution of PCB congeners, these changes may be greater in animals of higher trophic levels than in lower trophic levels (Sather et al. 2001). Field mice are more closely related to a lower trophic level species, and the average homolog distribution, as a percentage of the total, most closely matches the formulation of Aroclor 1260. Aroclor 1260 has been the most consistently detected PCB formulation in sediment collected upgradient of the LACW since the studies began in 2006 (Table S8-20); it is also detected in sediment further upgradient in Los Alamos Canyon (Reneau and Koch 2008).

Overall, the concentrations of all radionuclides, TAL elements, and PCBs in all biotic and abiotic media sampled upgradient of the LACW were mostly below SLs and/or ESLs and do not pose a potential unacceptable dose from radionuclides or risk from chemicals to humans (sediment) or to the biota sampled. Only selenium was above the ESL for the deer mouse (0.83 mg/kg); however, the extent of selenium contamination is not considered to be widespread because it was detected in only one of three samples. Nevertheless, we will continue to monitor for selenium in future years.

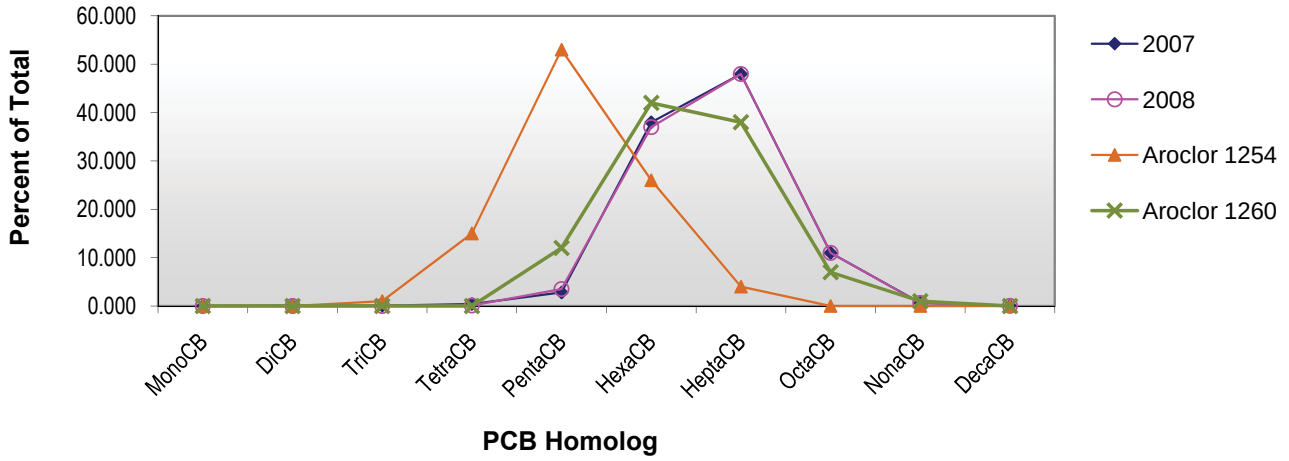


Figure 8-29. Mean PCB homolog distribution for field mice samples collected upgradient (upstream) of the Los Alamos Canyon Weir in 2007 (n=3) and 2008 (n=3) compared with the two major Aroclor formulations detected in sediments from Los Alamos Canyon (see Chapter 8, Section C.1.a. and Chapter 6, Section G.b.).

b. Pajarito Canyon Flood Retention Structure Results

Concentrations of radionuclides, TAL elements, and PCBs in composite sediment, native vegetation, and small mammal samples collected from the upgradient side of the PCFRS in 2008 are presented in Tables S8-26 through Table S8-33. In general, most concentrations of radionuclides and TAL elements in sediment and native vegetation collected on the upgradient side of the PCFRS were either not detected or detected below the RSRLs. The few exceptions included plutonium-239/240, silver, Aroclor 1254, and Aroclor 1260 in sediment, and antimony in vegetation (Figure 8-30). All concentrations, however, were far below SLs for sediment (based on Table 7-1) and ESLs for vegetation (based on soil levels) and mostly decreasing in concentration since 2006.

The following radionuclides and TAL elements were detected above the RSRLs in at least two of the three field mouse samples: uranium-234, uranium-235, uranium-238, aluminum, barium, beryllium, cobalt, iron, nickel, vanadium, antimony, cadmium, silver, and thallium (Figure 8-31). Only the uranium isotopes have been detected in past years, whereas the majority of the TAL elements have not been detected. Nevertheless, the uranium isotopes are below SLs and have greatly decreased in concentrations from past years. Also, the TAL elements, with the exception of silver, do not correlate with the sediment (Table S8-27) and vegetation (Table S8-30) data, and the amount of silver in the sediment (0.50 mg/kg) does not exceed the ESL for the deer mouse (>77 mg/kg) (LANL 2005).

All field mouse samples (n=3) that were collected on the upgradient side of the PCFRS contained total PCB concentrations above the RSRL (Table S8-33). These data match closely one of the three samples collected in 2007 (Figure 8-32) and the mean homolog distribution of the field mice collected in 2008 overlaps the distribution pattern of Aroclor 1260 almost identically (Figure 8-33). Trace amounts of Aroclor 1254 and Aroclor 1260 in the sediment collected upgradient of the PCFRS were detected in 2008 (Table S8-28). Also, these types of PCBs were detected in sediment further downstream in 2008 (Chapter 6, Section G.e) and in other sections of Pajarito Canyon in past years (LANL 2008b).

Overall, the concentrations of all radionuclides, TAL elements, and PCBs in all biotic and abiotic media sampled upgradient of the PCFRS were below SLs and/or ESLs and do not pose a potential unacceptable dose from radionuclides or risk from chemicals to humans (sediment) or to the biota sampled.

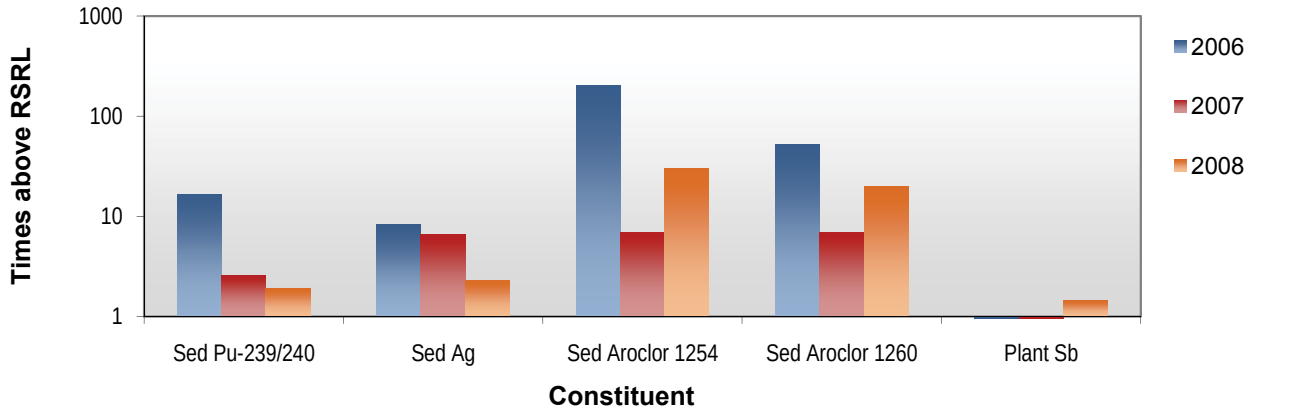


Figure 8-30. **Times above the regional statistical reference levels (RSRLs) for plutonium-239/240, silver (Ag), Aroclor 1254 and Aroclor 1260 in sediment and antimony (Sb) in understory vegetation collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2006 through 2008. Note the logarithmic scale on the vertical axis.**

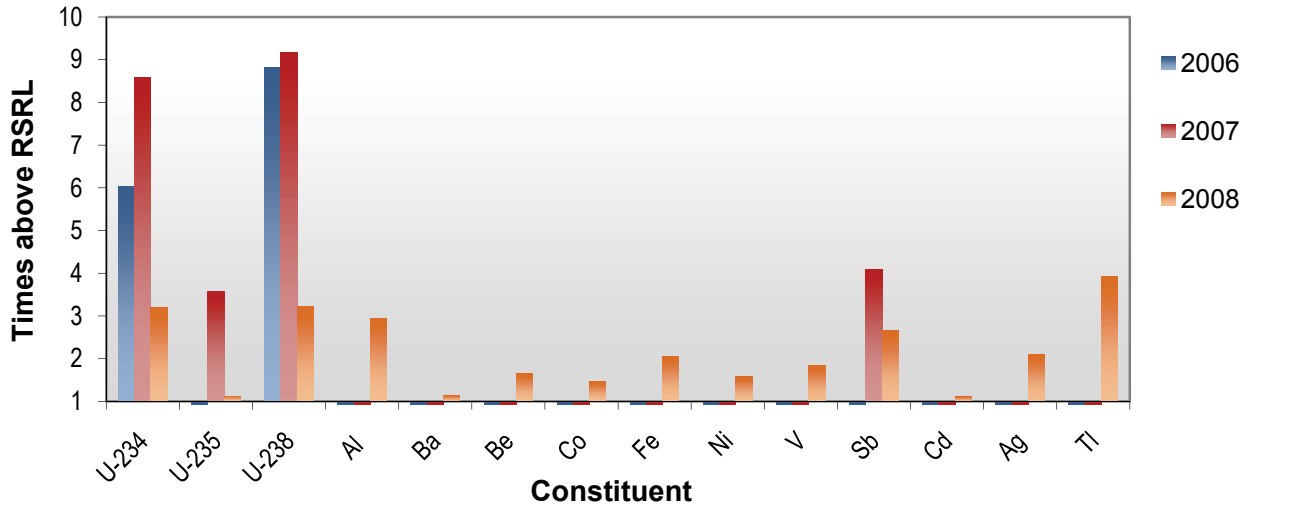


Figure 8-31. **Times above the regional statistical reference levels (RSRLs) for uranium isotopes and some TAL elements in whole body field mouse samples (n=3) collected on the upgradient side of the Pajarito Canyon Flood Retention Structure from 2006 through 2008.**

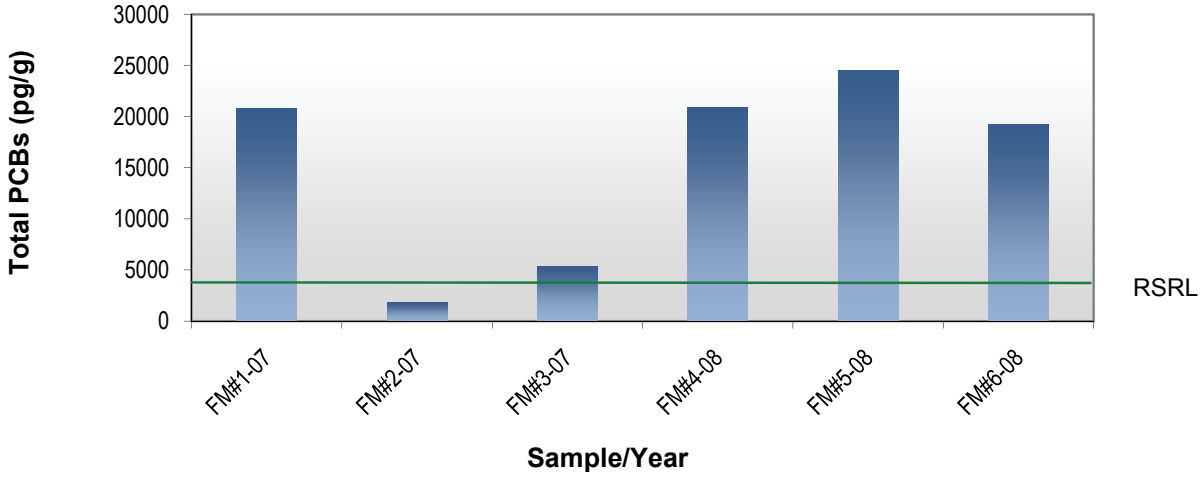


Figure 8-32. **Total PCB concentrations in whole body field mouse samples (FM#) collected on the upgradient side of the Pajarito Canyon Flood Retention Structure in 2007 and 2008 compared with the regional statistical reference level (RSRL).**

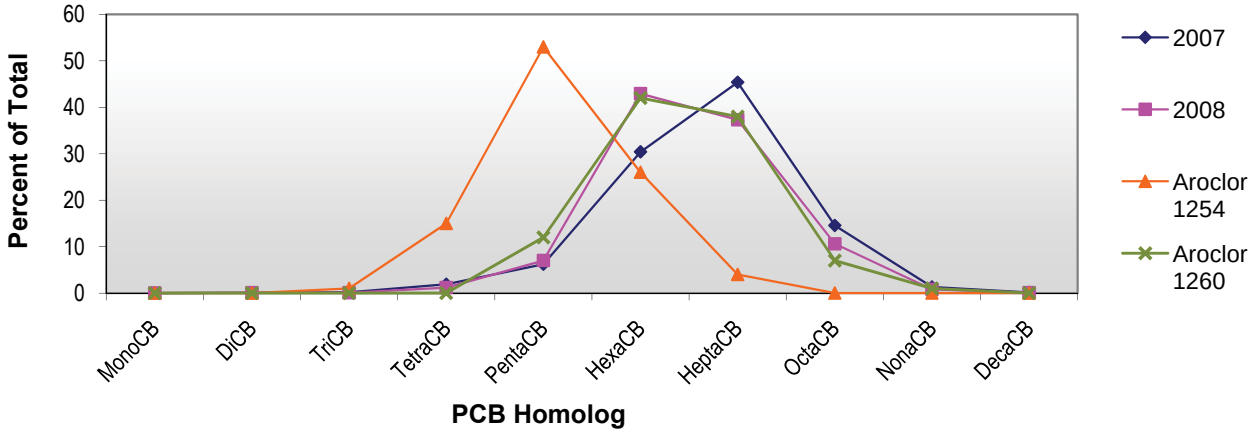


Figure 8-33. Mean PCB homolog distribution of whole body field mouse samples collected on the upgradient side of the Pajarito Canyon Flood Retention Structure in 2007 (n=3) and 2008 (n=3) compared with the two major Aroclor formulations detected in sediments from Pajarito Canyon (see Chapter 8, Section C.1.b and Chapter 6, Section G.e.).

2. Polyaromatic Hydrocarbons in Fish from Abiquiu and Cochiti Reservoirs

In 2001, we presented data on radionuclides, TAL elemens, and PCBs in fish collected from Abiquiu Reservoir, which is upstream of LANL, and Cochiti Reservoir, which is downstream of LANL (Fresquez et al. 2002). Data on polyaromatic hydrocarbons (PAHs) were also analyzed, but the data were received late and not reported in the annual environmental report for 2001. PAHs, particularly benzo[a]pyrene, were identified in a risk assessment conducted by Risk Assessment Corporation as one of the five potential contaminants of concern in runoff from LANL as a result of the Cerro Grande fire (Rocco et al. 2002, Mohler et al. 2002). Because the PAH data was never formally documented, we are presenting here the PAH data from five catfish from Abiquiu Reservoir and eight catfish from Cochiti Reservoir for completeness.

PAHs were analyzed by AXYS Analytical, Inc. by Method PH-T-01.Ver.3 which was an approved high-resolution variation of EPA Method 8270. The five Abiquiu catfish samples were whole body and collected in June and the eight Cochiti catfish samples were collected in April and August. Of the eight Cochiti catfish samples, three were whole body (April samples) and five were fillets (August samples). Analyses of other organic contaminants (PCBs) in fish has shown that the nonedible portions (viscera, bone, gills, fins, etc.) of fish can contain up to ~75% of the body burden of organic contaminants.

Table S8-34 is a summary of the analytical PAH results. Of the 18 PAHs analyzed in samples of catfish from Cochiti Reservoir, 11 were in sufficient quantities to measure in at least one sample. Comparing PAHs in catfish samples from Cochiti with RSRLs, only two PAHs in more than two catfish samples from Cochiti were detected above the upper level regional concentrations. The two PAHs that were above the RSRLs were flourene and phenanthrene. Fluorene and phenanthrene are common pollutants derived from the incomplete combustion of fossil fuels (including coal, oil, gasoline, wood and vehicular emissions) and refuse; and the most common source is from runoff from asphalt roads. Benzo[a]pyrene, a chemical of concern from LANL runoff as a result of the Cerro Grande fire, was not detected in any of the catfish samples from Cochiti Reservoir.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS AND BIOTA PROGRAM

This program uses the same quality assurance (QA) protocols and analytical laboratories described in Chapter 7.

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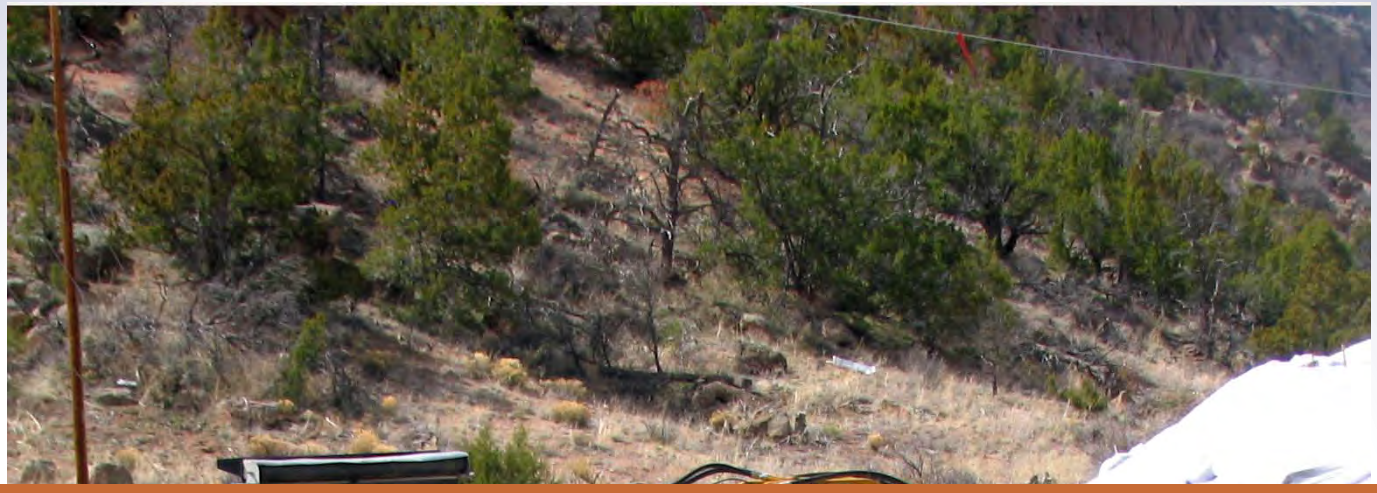
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9. Environmental Restoration



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A. INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) through the Environmental Programs (EP) Directorate is involved with the cleanup of sites and facilities formerly involved in weapons research and development. Corrective actions for the releases of hazardous waste and hazardous constituents at the Laboratory are subject to the March 1, 2005, Compliance Order on Consent (the Consent Order), issued pursuant to the New Mexico Hazardous Waste Act (New Mexico Statutes Annotated [NMSA] 1978, § 74-4-10) and the New Mexico Solid Waste Act (NMSA 1978, §74-9-36[D]). Radionuclides are regulated under the Atomic Energy Act implemented through US Department of Energy (DOE) Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management."

The corrective action process starts with investigating each site by sampling the appropriate environmental media and laboratory analyses of the samples. The sample data are then evaluated to determine whether the type of contamination (i.e., nature) and the location of the contamination (i.e., extent) are defined and whether any contamination present poses an unacceptable risk or dose to human and ecological receptors. Depending on the results, appropriate action(s) may include additional sampling, site closure, short-term or long-term monitoring, remediation, installation of best management practices, evaluation of corrective measure alternatives, and/or engineering and institutional controls.

1. Projects

LANL conducts investigation and remediation activities under three projects: the Corrective Actions Project, the LANL Water Stewardship Project, and the Technical Area (TA)-21 Closure Project. The sites under investigation are designated as consolidated units, solid waste management units (SWMUs), or areas of concern (AOCs). The projects collect, manage, and report environmental data and then use this data to support site decisions.

The Corrective Action Project addresses consolidated units, SWMUs, and AOCs intermixed with active Laboratory operations as well as sites located within the Los Alamos town site (property currently owned by private citizens, businesses, or Los Alamos County) and property administered by the US Forest Service (USFS), the National Park Service, and the DOE. The LANL Water Stewardship Project includes the canyons investigations, the groundwater monitoring program (implemented through the Interim Facility-Wide Groundwater Monitoring Plan), storm water monitoring, and the implementation of best management practices to minimize erosion. The TA-21 Closure Project involves all of the sites associated with TA-21 and includes Material Disposal Areas (MDAs) A, B, T, U, and V; various process waste lines; a radioactive waste treatment system; and the Delta Prime (DP) Site Aggregate Area sumps, outfalls, leach fields, historic container storage areas, and other former facilities.

2. Work Plans and Reports

The projects wrote and/or revised 24 work plans and 22 reports and submitted them to the New Mexico Environment Department (NMED) during 2008. A work plan proposes investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregate areas, canyons, or watersheds. An investigation report presents the data, evaluates the results, determines the site status, and recommends additional investigation, remediation, monitoring, or no further action, as appropriate.

Tables 9-1 and 9-2 summarize the work plans and reports submitted and approved in 2008, the work plans and reports submitted prior to 2008 but approved in 2008, and the work plans and reports submitted in 2008 but not yet approved. Table 9-3 summarizes other reports, plans, and documents submitted in 2008. Thirteen SWMUs and AOCs were granted Certificates of Completion under the Consent Order by NMED in 2008 (Table 9-4). The remainder of this section presents summaries of the investigations for which activities were started, continued, and/or completed in 2008 and those investigations for which reports were submitted in 2008. Figures 9-1 and 9-2 show the locations where significant environmental characterization and/or remediation work was performed in 2008.

Table 9-1
Work Plans Submitted and/or Approved in 2008

Document Title	Date Submitted	Date Approved	Status
S-Site Aggregate Area Investigation Work Plan, Revision 1	12/21/2007	1/23/2008	Work scheduled to start in 2009
Middle Cañada del Buey Aggregate Area Investigation Work Plan, Revision 1	12/21/2007	Not formally approved	Work completed in 2008
Investigation Work Plan for Sites at Technical Area 49 Outside the Nuclear Environmental Site Boundary, Revision 1	1/31/2008	2/14/2008[a]	Work scheduled to start in 2009
Investigation Work Plan for Sites at Technical Area 49 Inside the Nuclear Environmental Site Boundary, Revision 1	1/31/2008	2/14/2008[a]	Work scheduled to start in 2009
Investigation Work Plan for Upper Mortandad Canyon Aggregate Area, Revision 1	2/29/2008	3/24/2008[a]	Work scheduled for 2009
Interim Measures Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons	2/29/2008	7/18/2008[a]	Implemented in 2008, work continues in 2009
Pilot Test Work Plan for Evaluating Vapor-Sampling Systems at Material Disposal Area C	3/19/2008	3/28/2008[a]	Work completed
Investigation Work Plan for Upper Sandia Canyon Aggregate Area	3/31/2008	n/a[b]	Work plan revised
Historical Investigation Report for Upper Sandia Canyon Aggregate Area	3/31/2008	n/a	n/a
Drilling Work Plan for Nature and Extent of Chromium Contamination in Groundwater Investigations	4/30/2008	5/8/2008[a]	Implemented in 2008
Summary of Storm Water Sampling Work Plan for Guaje/Barrancas/Rendija Canyons Aggregate Area	4/30/2008	n/a	Storm water will be monitored periodically
Asphalt Monitoring and Removal Plan for Area of Concern C-00-041, Guaje/Barrancas/Rendija Canyons Aggregate	4/30/2008	7/2/2008	Periodic monitoring and removal of asphalt will be conducted

Table 9-1 (continued)

Document Title	Date Submitted	Date Approved	Status
Pilot Test Work Plan for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G	5/15/2008	5/28/2008[a]	Pilot test completed
Work Plan for the Implementation of an In Situ Soil-Vapor Extraction Pilot Study at Technical Area 54, Material Disposal Area G, Revision 1	5/23/2008	6/11/2008[a]	Soil-Vapor Extraction pilot test completed
Supplemental Investigation Work Plan for Intermediate and Regional Groundwater at Consolidated Unit 16-021(c)-99	6/30/2008	1/26/2009[a]	Drilling started in 2008, other activities to continue in 2009 and 2010
Investigation Work Plan for Upper Cañada del Buey Aggregate Area	6/30/2008	n/a	Work plan revised
Historical Investigation Report for Upper Cañada del Buey Aggregate Area	6/30/2008	n/a	n/a
Technical Area 21 Subsurface Vapor Moisture Monitoring Plan for Tritium	7/21/2008	7/2008 by DOE	Installing two new tritium pore-gas monitoring wells at MDAs V and T; collecting organic and tritium quarterly pore-gas samples at MDA T
Investigation Work Plan for Upper Sandia Canyon Aggregate Area, Revision 1	7/25/2008	8/12/2008[a]	Work scheduled to start in 2009
Investigation Work Plan for Threemile Canyon Aggregate Area	7/31/2008	n/a	Work plan revised
Historical Investigation Report for Threemile Canyon Aggregate Area	7/31/2008	n/a	n/a
Investigation Work Plan for Upper Cañada del Buey Aggregate Area, Revision 1	9/29/2008	10/20/2008	Work scheduled to start in 2010
Delta Prime Site Aggregate Area Phase II Work Plan	9/30/2008	n/a	Work plan revised
Supplemental Interim Measures Work Plan to Mitigate Contaminated Sediment Transport in Los Alamos and Pueblo Canyons	10/17/2008	2/20/2009[a]	Under review in 2008; approved in 2009 and will be implemented in 2009
Investigation Work Plan for Threemile Canyon Aggregate Area, Revision 1	10/23/2008	11/20/2008[a]	Work scheduled for 2010
Pueblo Canyon Aggregate Area Phase II Investigation Work Plan	10/24/2008	12/26/2008[a]	Work scheduled to start in 2010
Phase II Investigation Work Plan for Middle Los Alamos Canyon Aggregate Area	11/14/2008	3/25/2009	Under review in 2008; approved in 2009
Supplemental Investigation Work Plan for Consolidated Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16	11/25/2008	12/31/2008[a]	Work scheduled to start in 2009
Delta Prime Site Aggregate Area Phase II Work Plan, Revision 1	12/12/2008	1/12/2009	Under review in 2008; approved in 2009

[a] Work plans approved with modifications or directions.

[b] n/a = Not applicable.



Table 9-2
Reports Submitted and/or Approved in 2008

Document Title	Date Submitted	Date Approved	Status
Corrective Measures Evaluation Report for Intermediate and Regional Groundwater Associated with Consolidated Unit 16-021(c)-99	8/31/2007	Pending	Supplemental work plan submitted and drilling started in 2008 (Table 9-1)
Final Status Report for Supplemental Sampling at MDA A, TA-21	12/5/2007	1/23/2008[a]	Proceeding with additional vapor monitoring and corrective measures evaluation
Corrective Measures Evaluation Report for Material Disposal Area L at Technical Area 54	1/18/2008	—[b]	Need to complete characterization of groundwater
Investigation Report for Middle Los Alamos Canyon Aggregate Area	1/22/2008	n/a[c]	Revised
Investigation Report for Consolidated Units 16-007(a)-99 and 16-008(a)-99 at Technical Area 16, Revision 1	1/22/2008	2/11/2008[a]	Submitted supplemental investigation work plan (Table 9-1)
Supplemental Investigation Report for Consolidated Unit 21-018(a)-99, Material Disposal Area V, at Technical Area 21	2/8/2008	n/a	Revised
Investigation Report for Middle Mortandad/Ten Site Aggregate, Revision 2	2/13/2008	4/1/2008[a]	Sites will be monitored for storm water runoff
Phase II Investigation Report for Consolidated Unit 21-016(a)-99, Material Disposal Area T, at Technical Area 21, Revision 1	2/29/2008	3/28/2008[a]	Conduct quarterly pore-gas monitoring and a vapor intrusion assessment
Investigation Report for Bayo Canyon Aggregate Area	3/3/2008	n/a	Revised
Delta Prime Site Aggregate Area Investigation Report, Revision 1	3/27/2008	6/27/2008	Submitted Phase II investigation work plan in 2008 and approved in 2009 (Table 9-1)
Investigation Report for Pueblo Canyon Aggregate Area	3/28/2008	n/a	Revised
Supplemental Investigation Report for Consolidated Unit 21-018(a)-99, Material Disposal Area V, at Technical Area 21, Revision 1	4/30/2008	Directed to modify	Provided TA-21-Wide Vapor-Monitoring Plan for Tritium (see Table 9-1 for approved work plan)
Investigation Report for Middle Los Alamos Canyon Aggregate Area, Revision 1	5/5/2008	5/23/2008	Submitted Phase II investigation work plan in 2008; approved in 2009 (Table 9-1)
Investigation Report for Bayo Canyon Aggregate Area, Revision 1	5/16/2008	Directed to modify	Pending input from DOE and Los Alamos County
Investigation Report for Pueblo Canyon Aggregate Area, Revision 1	7/25/2008	8/22/2008[a]	Submitted Phase II investigation work plan and approved in 2008 (Table 9-1); certificates of completion received for eight sites; additional sampling and remediation required on other sites

Table 9-2 (continued)

Document Title	Date Submitted	Date Approved	Status
Pilot Test Investigation Report for Evaluating Vapor-Sampling Systems at Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50	7/25/2008	9/10/2008	Work completed in 2008
Fate and Transport Investigations Update for Chromium Contamination in Sandia Canyon	7/31/2008	n/a	Work on chromium fate and transport continues
Pilot Test Report Evaluating Type 4 Vapor-Sampling Systems at Material Disposal Area G	8/15/2008	n/a	Work completed in 2008
Pilot Test Report for Evaluating FLUTe Vapor-Sampling Systems in Use at Material Disposal Area G	8/20/2008	9/30/2008	Work completed in 2008
Corrective Measures Evaluation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99, at Technical Area 54	9/12/2008	—	Undergoing revision in 2009
Pilot Test Report Comparing Packer and FLUTe Vapor-Sampling Systems at Material Disposal Area H	9/16/2008	n/a	Work completed; continue to monitor pore gas quarterly
Pajarito Canyon Investigation Report	9/30/2008	n/a	Revision submitted in 2009
Phase II Investigation Report for the TA-16-340 Complex (Consolidated Units 13-003[a]-99 and 16-003[n]-99 and Solid Waste Management Units 16-003[o], 16-026[j2], and 16-029[f])	9/30/2008	2/9/2009[a]	Revision submitted in 2009 and approved
Pilot Test Report for Evaluating Soil-Vapor Extraction at Material Disposal Area G at Technical Area 54	10/31/2008	—	Under review in 2008; revised in 2009

[a] Reports approved with modifications or directions.

[b] — = Approval not received.

[c] n/a = Not applicable.

Table 9-3
Additional Plans and Reports Submitted in 2008

Document Title	Date Submitted
Periodic Monitoring Reports	
Los Alamos Watershed	2/28/2008
Pajarito Watershed	2/28/2008
White Rock Watershed	2/28/2008
Mortandad Watershed	2/28/2008
Sandia Watershed	2/28/2008
Ancho Watershed	5/30/2008
Water Canyon/ Cañon de Valle Watershed	5/30/2008
Mortandad Watershed	7/30/2008
Sandia Watershed	7/30/2008
Los Alamos Watershed	7/30/2008
Pajarito Watershed	7/30/2008
Mortandad Watershed	9/26/2008
Sandia Watershed	9/26/2008

Table 9-3 (continued)

Document Title	Date Submitted
Pajarito Watershed	9/26/2008
Water Canyon/ Cañon de Valle Watershed	9/26/2008
White Rock Watershed	9/26/2008
Ancho Watershed	11/26/2008
Mortandad Watershed	11/26/2008
Sandia Watershed	11/26/2008
Pajarito Watershed	11/26/2008
Monthly Groundwater Data Reviews	Monthly
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, for First Quarter Fiscal Year 2008	5/16/2008
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, for Second Quarter Fiscal Year 2008	7/28/2008
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area L, Solid Waste Management Unit 54-006, at Technical Area 54, for Third Quarter Fiscal Year 2008	10/27/2008
Periodic Monitoring Report for Vapor Sampling Activities at Material Disposal Area G for Fiscal Year 2008	12/18/2008
Well Work Plans and Reports	
Well R-20 Rehabilitation and Conversion Summary Report	1/7/2008
Well R-12 Rehabilitation and Conversion Summary Report, Revision 1	1/30/2008
Evaluation of the Suitability of Wells near Technical Area 16 for Monitoring Contaminant Releases from Consolidated Unit 16-021(c)-99, Revision 1, Addendum	2/14/2008
Drilling Work Plan for Well R-25c	2/15/2008
Los Alamos and Pueblo Canyons Groundwater Monitoring Well Network Evaluation and Recommendations, Revision 1	2/29/2008
R-36 Well Construction Diagram and Well Summary Data Sheet Borehole Stratigraphy Fact Sheets	3/13/2008
Drilling Work Plan for Well CdV-R-15-1	3/14/2008
Drilling Work Plan for Well CdV-R-16-3i	3/14/2008
Well R-14 Rehabilitation and Conversion Summary Report	3/31/2008
Well Completion Report for Regional Aquifer Well R-36	4/30/2008
Drilling Work Plan for Los Alamos and Pueblo Canyons Groundwater Monitoring Wells	5/5/2008
Well R-14 Rehabilitation and Conversion Summary Report, Revision 1	6/27/2008
Well R-33 Rehabilitation and Conversion Summary Report	8/29/2008
Well Rehabilitation Plan for Fiscal Year 2009	9/19/2008
Well Construction Diagram and Well Summary Data Sheet for R-42	9/26/2008
Well Construction Diagram and Well Summary Data Sheet for SCI-2	9/26/2008
Well Completion Report for R-25c	9/30/2008
Well Completion Report for R-25b	10/27/2008

Table 9-3 (continued)

Document Title	Date Submitted
Well Summary Data Sheet R-43 Borehole Stratigraphy and R-43 As-Built Well Construction Diagram	11/17/2008
Completion Report for R-25b, Revision 1	12/15/2008
Well Construction Diagram and Well Summary Data Sheet for R-39	12/22/2008
Well Completion Report for Regional Aquifer Well R-38	12/22/2008
Miscellaneous Reports/Plans	
General Facility Information (Annual Update)	3/27/2008
Interim Facility-Wide Groundwater Monitoring Plan (Annual Update)	5/30/2008
Los Alamos Site Monitoring Area 2 Interim Measure and Monitoring Plan	11/3/2008
CMS Progress Reports [16-021(c)-99 the 260 Outfall]	Monthly

Table 9-4
SWMUs and AOCs Granted Certificates of Completion in 2008

Site	Corrective Action Complete with Controls	Corrective Action Complete without Controls	Date Approved
SWMU 03-011		X	1/23/2008
SWMU 03-046		X	1/23/2008
SWMU 16-026(f)		X	1/23/2008
SWMU 16-030(c)		X	1/23/2008
SWMU 73-004(c)		X	1/23/2008
AOC 00-030(eN)		X	12/31/2008
AOC 00-030(j)		X	12/31/2008
AOC 00-030(n)		X	12/31/2008
AOC 00-030(o)		X	12/31/2008
AOC 00-030(p)		X	12/31/2008
SWMU 00-039		X	12/31/2008
AOC 00-043		X	12/31/2008
AOC 00-030(d)		X	12/31/2008



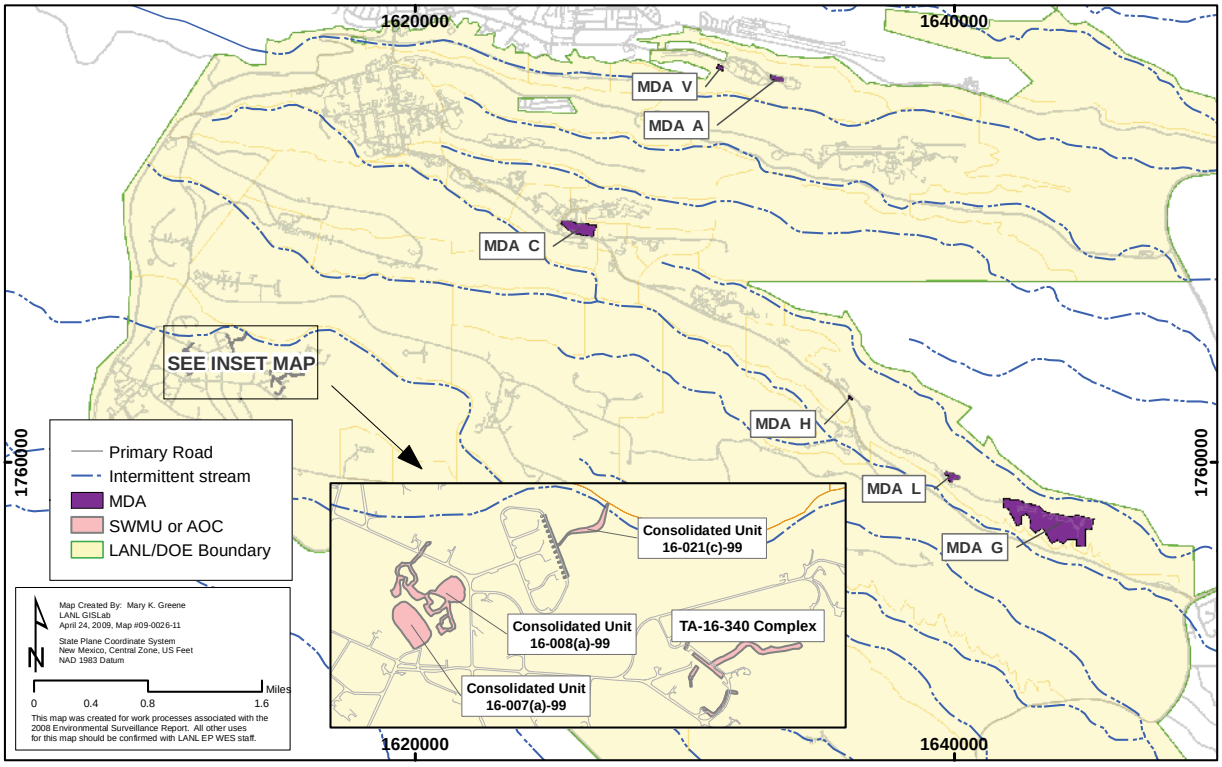


Figure 9-1. Location of MDAs and other SWMUs or AOCs where remediation and/or characterization work was performed in 2008.

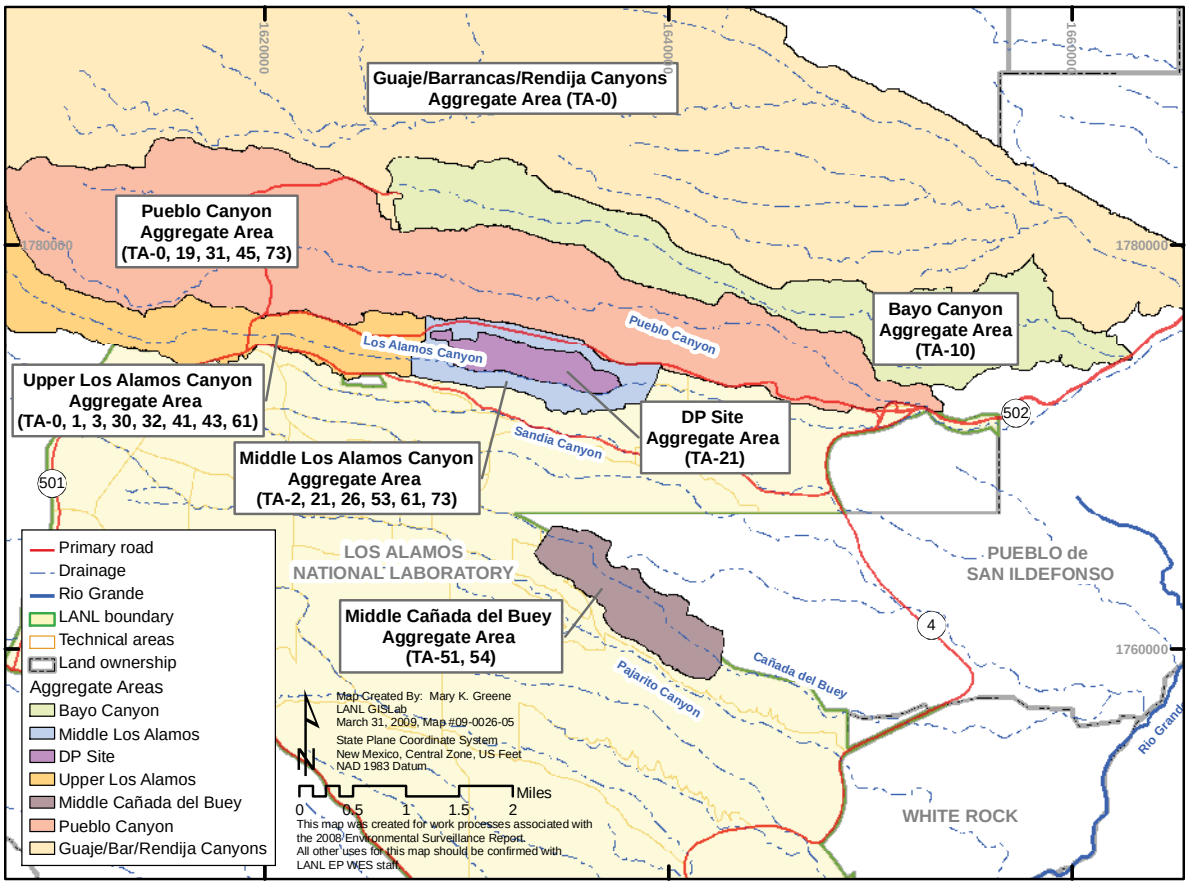


Figure 9-2. Location of canyons and aggregate areas where remediation and/or characterization work was performed in 2008.

B. CORRECTIVE ACTIONS PROJECT

The Laboratory conducted the following investigations and activities in 2008:

- Sampling and remediation of sites comprising the Upper Los Alamos Canyon Aggregate Area were started.
- Work plans detailing the periodic monitoring of asphalt and tar in the drainage of AOC C-00-041 and storm water discharges from SWMUs and AOCs in the Guaje/Barrancas/Rendija Canyons Aggregate Area were submitted.
- A Phase II investigation of the TA-16-340 Complex sites was conducted, additional soil-removal and sampling was completed, and the investigation report submitted.
- A supplemental investigation work plan was developed and submitted for Consolidated Units 16-007(a)-99 (the 30s Line) and 16-008(a)-99 (the 90s Line) to collect additional samples and to remove areas of high explosive (HE) and hexavalent chromium contamination.
- Supplemental work plan for intermediate and regional groundwater at Consolidated Unit 16-021(c)-99 was submitted, and two wells were drilled.
- The investigation report and revision 1 for the Bayo Canyon Aggregate Area (TA-10) sites were submitted.
- The investigation report of the Middle Los Alamos Canyon Aggregate Area and revision 1 of the report were submitted. A Phase II investigation work plan was also submitted.
- The investigation report of the Pueblo Canyon Aggregate Area and revision 1 of the report were submitted. A Phase II investigation work plan was also submitted.
- Investigation sampling was conducted and completed at the Middle Cañada del Buey Aggregate Area sites.
- Phase II investigation sampling and quarterly vapor monitoring for volatile organic compounds (VOCs) and tritium were started, and pilot tests were conducted to evaluate several subsurface vapor-sampling systems at MDA C.
- A corrective measures report for MDA L and continued monitoring of VOCs and tritium in subsurface pore gas continued.
- A soil vapor extraction (SVE) pilot study at MDA G was conducted and the report submitted. A pilot test was conducted to evaluate Type 4 vapor monitoring systems at MDA G and a report submitted. The corrective measure report for MDA G was submitted.
- A study was conducted at MDA H to clarify whether the different pore-gas sampling systems produced comparable pore-gas data and a report was submitted.

The following sections summarize the investigations started, continued, and/or completed in 2008.

1. Upper Los Alamos Canyon Aggregate Area

a. Site Description and History.

The Upper Los Alamos Canyon Aggregate Area is located within and south of the Los Alamos town site in TA-0, TA-1, TA-3, TA-30, TA-32, TA-41, TA-43, and TA-61 and includes a total of 115 SWMUs and AOCs. Of this total, 61 sites require additional characterization and/or remediation activities and are addressed in the investigation work plan. Sites include septic tanks and outfalls; sanitary waste lines and sewage treatment facilities; industrial waste lines, drains, and outfalls; storm drains and outfalls; soil contamination areas from Laboratory operations; landfills and surface disposal areas; transformer sites; and incinerators.

b. Remediation and Sampling Activities

All field activities proposed in the approved work plan were conducted using a phased approach. The objectives of the investigation work plan are to define the nature and extent of contamination associated with the sites within the aggregate area and to remove inactive structures, such as pipes or septic tanks related to the sites, where appropriate, and to conduct confirmatory sampling after removing the structures.

Most of the mesa-top sites in the Los Alamos town site (also TA-32) have been developed as commercial or residential properties. As a result, many sites addressed in the work plan, or portions of them, are inaccessible. In addition, because many of the previous activities were sparsely documented—in terms of exact locations and volumes of material excavated or placed as fill—the locations or even the existence of some Laboratory-related structures is not well known. Samples of soil, fill, sediment, and tuff were collected using the most efficient and least disruptive methods appropriate to the conditions at the site.

c. Conclusions and Recommendations

Sampling and other investigation/remediation activities were started in 2008 and completed in 2009. The results of the Upper Los Alamos Canyon Aggregate Area investigation will be provided in an investigation report in 2009.

2. Guaje/Barrancas/Rendija Canyons Aggregate Area

a. Site Description and History

The Guaje/Barrancas/Rendija Canyons Aggregate Area includes SWMU 00-011(a), a mortar impact area; SWMU 00-011(c), a possible mortar impact area; SWMU 00-011(d), a bazooka firing area; SWMU 00-011(e), an ammunition impact area; AOC C-00-020, a possible mortar impact area; AOC C-00-041, an asphalt batch plant and tar remnant site; and AOC 00-015, the Sportsmen's Club small-arms firing range.

b. Remediation and Sampling Activities

The Laboratory conducted field investigations in 2006 based on the approved work plan. The Laboratory completed investigation activities and submitted both the investigation report and a revised report in 2007.

Because of erosion during storms or other runoff events in the future, the potential exists for continued exposure of asphalt or tar in the vicinity of AOC C-00-041. A work plan was, therefore, developed to monitor, by visual inspection, the asphalt contamination at the surface of the site every two years and remove visible asphalt and tar, if exposed (LANL 2008a). The visual inspections will start in the fall of 2009 and involve walk-overs of the site and drainage to identify asphalt or tar exposed at the surface. Visible asphalt or tar will be containerized, managed, and disposed of in accordance with all applicable LANL waste management procedures. The work plan was approved by NMED (NMED 2008a).

Storm water discharges from SWMUs and AOCs in the Guaje/Barrancas/Rendija Canyons Aggregate Area subject to permitting under the Clean Water Act will be monitored under the annual update to the LANL Storm Water Pollution Prevention Plan for SWMUs and AOCs and Storm Water Monitoring Plan (LANL 2008b). Following precipitation events that produce a discharge in volumes large enough to allow for sample collection, a maximum of four samples (filtered and unfiltered) will be collected during each calendar year (collected quarterly). Fewer than four samples may be collected if four precipitation events of sufficient magnitude do not occur. One of the four samples may be collected during snowmelt runoff.

c. Conclusions and Recommendations

A monitoring report will be submitted to NMED following each inspection. The need to continue inspection and asphalt removal activities will be reevaluated with the USFS and NMED after every third inspection (i.e., every six years).

3. TA-16-340 Complex (Consolidated Units 13-003[a]-99 and 16-003[n]-99 and Solid Waste Management Units 16-003[o], 16-026[j2], and 16-029[f])

a. Site Description and History

The TA-16-340 Complex is located near the eastern end of the TA-16 mesa, close to the head of Fishladder Canyon, and consists of Consolidated Unit 13-003(a)-99, the septic system associated with the western area of the P-Site Firing Site; Consolidated Unit 16-003(n)-99, the sump and drain line for former building 16-342; SWMU 16-003(o), the sumps and drain lines for former building 16-340; and SWMUs 16-029(f) and 16-026(j2), the sump and drain line for former building 16-345. The TA-16-340 Complex operated from 1952 to 1999 and processed and produced large quantities of plastic bonded explosives. The plastic-bonded explosives were produced by slurrying HE and solvents together with inert binders. HE and solvent-contaminated washwater was routed to six sumps associated with building 16-340 and to the single sump and outfall associated with building 16-342. Historically, discharges from these sumps were routed to the building 16-340 and 16-342 outfalls.

b. Remediation and Sampling Activities

The 2005 investigation included remediation followed by confirmation sampling. Man-made fixtures (manholes, a sump, drain lines, and the former fishladder structure) and contaminated soil were removed at Consolidated Unit 16-003(n)-99 and SWMU 16-003(o). Approximately 100 yd^3 of contaminated soil was removed from four locations at SWMU 16-026(j2) and from seven locations within SWMU 16-003(o). Results of the confirmation sampling indicated the vertical and/or lateral extent of contamination was not defined for Consolidated Units 13-003(a)-99 and 16-003(n)-99; and SWMUs 16-003(o), 16-026(j2), and 16-029(f) and their associated drainages. The vertical extent of contamination also was not defined, particularly for areas near the outfalls. In addition, the risk assessments indicated potential unacceptable risk under the industrial scenario at SWMU 16-003(o).

To address the potential risk and extent issues, a Phase II investigation was conducted, which involved additional soil removal actions and sampling to complete the investigation of the TA-16-340 Complex sites.

The Phase II investigation was conducted to (1) define vertical and lateral extent of potential contamination present in soil and tuff at Consolidated Units 13-003(a)-99 and 16-003(n)-99 and SWMUs 16-003(o), 16-026(j2), and 16-029(f); and (2) remove soil containing elevated concentrations of organic and inorganic chemicals of potential concern (COPCs) (specifically arsenic and benzo[a]pyrene) within SWMU 16-003(o) (LANL 2008c). Eighteen boreholes (17 shallow and one intermediate depth) were drilled, 106 samples were collected, and 88 yd^3 of soil and tuff was excavated during the Phase II investigation.

c. Conclusions and Recommendations

The lateral and vertical extent of inorganic and organic COPCs was defined using data from previous and 2008 investigations (LANL 2008c). In addition, the lateral and vertical extent of isotopic uranium was defined at SWMU 16-003(o). VOCs were detected in the 2008 pore-gas samples in the intermediate borehole next to the former TA-16-340 drain line. The results of the screening evaluation indicate that VOCs in subsurface pore gas are not a potential source of groundwater contamination (LANL 2008c). Several inorganic chemicals, radionuclides, and organic chemicals were detected in surface water and alluvial groundwater but were sporadically above standards or screening levels with no clear trends.

The human health risk screening assessments concluded there are no potential unacceptable risks or doses under the industrial and construction worker scenarios. The ecological risk screening assessment indicated no potential risk to ecological receptors.

The NMED approved the investigation report in early 2009 (NMED 2009a).

4. Consolidated Units 16-007(a)-99 (30s Line) and 16-008(a)-99 (90s Line)

a. Site Description and History

TA-16 is located in the southwest corner of the Laboratory and covers approximately 2,410 acres (3.8 mi^2). Consolidated Units 16-007(a)-99 (the 30s Line) and 16-008(a)-99 (the 90s Line) are located near the western end of TA-16. These consolidated units consist of former HE processing buildings, former materials storage buildings, production facilities, sumps, drainlines, and outfall systems (drainages) associated with the 30s and 90s Lines. Historically, the 30s Line and the 90s Line were used for HE processing operations, including electroplating and machining. The settling ponds were used to store wastewater generated in the nearby buildings during HE processing operations. All the ponds were/are unlined and likely received wastes contaminated with HE and barium and, possibly uranium, organic cleaning agents, and machining oils.

Consolidated Unit 16-007(a)-99 operated from 1944 to the early 1950s and Consolidated Unit 16-008(a)-99 operated from 1950 to 1970. The 90s Line Pond is all that remains of the 30s Line and 90s Line production facilities. Buildings associated with the discharge to the 30s Line Ponds were destroyed by burning. The buildings associated with the discharge to the 90s Line Pond were decommissioned, which included the demolition of buildings and the removal of sumps, blast shields, drainlines, earthen berms, and asphalt roadways.

b. Remediation and Sampling Activities

The recommendations in the investigation report were approved by NMED (NMED 2008b). A supplemental investigation work plan (LANL 2008d) was submitted to NMED.

The supplemental work plan proposed the following actions:

- Excavate and remove areas of HE contamination at Consolidated Unit 16-007(a)-99 and hexavalent chromium contamination at Consolidated Unit 16-008(a)-99.
- Collect samples to confirm cleanup and characterize the lateral and vertical extent of any residual contamination at both sites.
- Advance a single 300-ft depth borehole at the confluence of a prominent drainage and the 90s Line Pond to determine the vertical extent of copper, RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine), trinitrobenzene(1,3,5-), and acetone in soil and tuff.
- Develop and sample the monitoring well south of the 90s Line Pond on a quarterly basis for 1 yr and install a pressure transducer to monitor water-level fluctuations on a continuous basis following well development.
- Provide a strategy for collecting sediment samples within the 90s Line Pond and above the best management practices installed in June 2008 in the tributary drainages to the pond to minimize transport of contaminated sediment into the pond. Collect samples at periodic intervals (every five years) to evaluate whether contaminant concentrations in sediment in the pond are increasing.

c. Conclusions and Recommendations

The supplemental work plan was approved by NMED in 2008 (NMED 2008c). Work is scheduled for 2009, and the supplemental investigation report is scheduled for early 2010.

5. Consolidated Unit 16-021(c)-99 (260 Outfall) Groundwater Investigation

a. Site Description and History

Building 16-260, located on the north side of TA-16, has been used for HE processing and machining since 1951. Wastewater from machining operations contained dissolved HE and may have contained entrained HE cuttings. At building 16-260, wastewater treatment consisted of routing the water to 13 settling sumps for recovery of any entrained HE cuttings. From 1951 through 1996, the water from these sumps was discharged to the 260 Outfall, which drained into Cañon de Valle.

As a result of the discharge, both the 260 Outfall and the drainage channel from the outfall were contaminated with HE and barium. The sumps and drain lines of this facility are designated as SWMU 16-003(k), and the 260 Outfall and drainage are designated as SWMU 16-021(c) and comprise Consolidated Unit 16-021(c)-99. SWMU 16-021(c) consists of three portions: an upper drainage channel fed directly by the 260 Outfall, a former settling pond, and a lower drainage channel leading to Cañon de Valle.

b. Remediation and Sampling Activities

Groundwater analytical results show that the 260 Outfall discharges have affected intermediate and regional groundwater quality in limited areas. A corrective measures evaluation (CME) report for intermediate and regional groundwater was submitted in 2007 to address the groundwater contamination.

A supplemental work plan (LANL 2008e) was submitted to address uncertainties identified in the CME report for Consolidated Unit 16-021(c)-99 intermediate and regional groundwater. The additional investigations include installing wells, sampling and monitoring existing and new wells, screening existing and new well groundwater data against applicable standards, performing single-well pump tests in all new wells, and conducting a multi-well pump test.

c. Conclusions and Recommendations

The supplemental work plan was approved by NMED in 2009 (NMED 2009b). Wells R-25b and R-25c were drilled in 2008 and activities will continue in 2009 and 2010. All data from the additional investigation activities will be used to update the CME.

6. Bayo Canyon Aggregate Area

a. Site Description and History

The Bayo Canyon Aggregate Area consists of former TA-10 in the lower central portion of Bayo Canyon, between Kwage Mesa to the south and Otowi Mesa to the north, approximately 0.5 mi. west of the Los Alamos County Sewage Treatment Plant. TA-10 was used as a firing test site from 1943 through 1961, and the area and related structures were constructed to test assemblies that contained conventional HE, including components made from depleted or natural uranium. TA-10 also included ancillary facilities associated with waste disposal, particularly for the radiochemistry laboratory. Associated facilities included sanitary and radioactive liquid waste sewage lines, manholes, septic tanks, seepage pits, and solid radioactive waste disposal pits.

Former TA-10 includes Consolidated Unit 10-001(a)-99 (SWMUs 10-001[a–e] and 10-005, and AOCs 10-001[e] and 10-008), Consolidated Unit 10-002(a)-99 (SWMUs 10-002[a, b], 10-003[a–o], 10-004[b], and 10-007), SWMU 10-004(a), and AOCs C-10-001 and 10-009. The SWMUs and AOCs include firing sites, disposal pits, industrial waste manholes and lines, septic tanks and drainlines, a leach field, soil contamination areas, and landfills. The area underwent extensive decontamination and decommissioning (D&D) from 1960 to 1963; all explosive testing ceased in 1961. After D&D, the site was released to Los Alamos County in 1967 but remains under DOE administrative control.

b. Remediation and Sampling Activities.

The Laboratory conducted field investigations in 2007 based on the approved work plan. A geodetic survey, a site-wide radiological survey, and geophysical surveys were conducted before the start of characterization and remediation activities. Drilling and core sampling, surface and shallow subsurface sampling, and trenching and sampling activities were conducted.

Borehole sampling was conducted to characterize SWMU 10-005, Consolidated Unit 10-002(a)-99, SWMU 10-004(a), and AOC 10-009. Fifty-five boreholes were drilled to depths ranging from 30 to 68.5 ft below ground surface (bgs) and sampled at 5-ft intervals. During the 2007 drilling investigation, 117 samples were collected.

Surface and shallow subsurface samples were collected at Consolidated Unit 10-001(a)-99, Consolidated Unit 10-002(a)-99, and AOC C-10-001. Forty-eight samples were collected across Consolidated Unit 10-001(a)-99, 16 samples were collected across Consolidated Unit 10-002(a)-99, and 10 samples were collected across AOC C-10-001.

Six test pits were excavated at AOC 10-009 to identify the location and physical extent of the AOC 10-009 landfill and to characterize the type of buried debris. Seven exploratory test pits were excavated in the vicinity of SWMU 10-007 to confirm the physical extent of the debris landfill, to verify the depth to debris, and to characterize the physical, chemical, and radiological characteristics of the debris. Debris (including concrete, rebar, and asphalt) was encountered from 3 to 12 ft bgs, and three debris samples were collected for chemical analysis. One debris sample (a composite sample from test pits 1–5) was collected from the 5-ft-deep test pits, and one sample was collected from the 10.5-ft-deep and 12-ft-deep test pits (test pits 6 and 7, respectively).

During both the radiological and geophysical walk-over surveys at Consolidated Unit 10-002(a)-99, no anomalous features indicating the presence of SWMU 10-006, such as a former pit or depression or area of former burning activities, were observed.

c. Conclusions and Recommendations

The Laboratory completed investigation activities and submitted the investigation report and revision 1 of the report in 2008 (LANL 2008f; LANL 2008g). Based on the characterization data from the investigation, the nature and extent of surface and subsurface contamination are defined for all sites within the aggregate area.

The sites do not pose potential unacceptable risks or doses to human health under the recreational and construction worker scenarios or to ecological receptors (LANL 2008g). Consolidated Unit 10-001(a)-99, SWMU 10-004(a), and AOCs 10-009 and C-10-001 do not pose potential unacceptable risks or doses to human health under the residential scenario. However, the estimated residential dose was potentially unacceptable at Consolidated Unit 10-002(a)-99 (LANL 2008g). The ecological risk screening assessments indicated no potential risk to ecological receptors.

Based on the results of the risk assessments conducted for the Bayo Canyon Aggregate Area sites, the Laboratory requested Certificates of Completion for Corrective Action Complete without Controls for Consolidated Unit 10-001(a)-99, SWMU 10-004(a), and AOCs 10-009 and C-10-001 (LANL 2008g). Efforts were also made to locate SWMU 10-006, but there is no indication that the SWMU exists and it may have been cleaned up during D&D of former TA-10. As a result, the Laboratory requested a Certificate of Completion for Corrective Action Complete without Controls for SWMU 10-006. In addition, pending DOE and Los Alamos County approval, the following actions are being planned for Consolidated Unit 10-002(a)-99 (LANL 2008g):

- Maintain the Central Area (comprised of SWMUs 10-003[a–g, i–o], 10-004[b], and 10-007) under DOE administrative control, implement institutional controls to limit site access and potential strontium-90 mobilization, and negotiate additional actions, if needed, between DOE and the property owner (Los Alamos County).
- Remove two isolated areas of elevated strontium-90 activity identified outside of the Central Area but within Consolidated Unit 10-002(a)-99 as a good stewardship practice.

7. Middle Los Alamos Canyon Aggregate Area

a. Site Description and History

The Middle Los Alamos Canyon Aggregate Area includes TA-2, TA-21, former TA-26, TA-53, TA-61, and TA-73, and is located on the northern boundary of the Laboratory, immediately east-southeast of the Los Alamos town site. The aggregate area extends from the mesa top to the stream channels in two adjacent canyons: DP Canyon to the north and Los Alamos Canyon to the south. The sites under investigation within this aggregate area are in TA-2, TA-21, and former TA-26.

TA-2 is located in Los Alamos Canyon at the western end of the aggregate area. A small, intermittent stream (Los Alamos Creek) passes through the bottom of the canyon. TA-2 was used to house a series of research reactors from 1943 through 2003. The main reactor building was constructed in 1943 and housed five separate nuclear reactors: three iterations of water-boiler-type reactors located on the east side of the building, one plutonium-fueled reactor (the Clementine reactor) followed by an enriched uranium reactor, and the Omega West Reactor (OWR). The facility was active from 1943 through 1993. The OWR was put on standby status in 1993 and remained inactive until decommissioned in 2003. All TA-2 facilities remaining on-site underwent D&D in September 2003. The former reactor site is fenced and access is controlled by the Laboratory.

TA-21 is located on DP Mesa on the northern boundary of the Laboratory, immediately east-southeast of the Los Alamos town site. DP West operations began in September 1945, primarily to produce metal and alloys of plutonium. Other operations performed at DP West included nuclear fuel reprocessing. In 1977, a transfer of work to the new plutonium facility at TA-55 began, and much of the DP West complex was vacated. DP East operations also began in September 1945. These facilities were used to process polonium and actinium and to produce initiators. TA-21 sites within the aggregate area addressed by this investigation include Consolidated Unit 21-006(e)-99 and AOC 21-028(c). Consolidated Unit 21-006(e)-99 consists of SWMU 21-006(e), a seepage pit, and AOC 21-006(f), a gravel seepage pit. AOC 21-028(c) consists of four satellite container storage areas that stored a wide variety of chemicals including depleted uranium salts, metal salts, organic chemicals, inorganic chemicals, and other reagents.

TA-26 is a former technical area located south of State Highway 502, to the east and south of the Los Alamos County airport, and to the west of the East Gate Industrial Park. Former TA-26 sites within the aggregate area include four SWMUs: SWMU 26-001(a disposal area); SWMU 26-002(a) (an acid sump system); SWMU 26-002(b) (equipment room drainage system); SWMU 26-003 (sanitary septic system). The area was demolished in 1965 and 1966.

b. Remediation and Sampling Activities

Samples were collected in 2007 in accordance with the approved investigation work plan. The investigation activities conducted at the sites comprising this aggregate area included the collection of 1255 surface and shallow subsurface soil, sediment, and rock samples from 407 locations, from the surface to a maximum depth of 39 ft bgs (LANL 2008h). In addition, data from the samples collected in 2007 were combined with data collected before 2007 that met current Laboratory data quality requirements.

c. Conclusions and Recommendations

Although the extent of contamination was not defined at any of the sites, the nature of contamination was defined by the data collected (LANL 2008h). Because the extent of contamination was not defined, human health and ecological risk-screening assessments were not conducted. However, preliminary risk-screening assessments were conducted to identify contaminants present at concentrations that are likely to contribute to potential unacceptable risk. AOCs 2-004(a), 2-004(f), 2-011(a), and 2-010, and Consolidated Unit 21-006(e)-99 were identified as having contaminant concentrations likely to result in potential unacceptable risk or dose above established target levels.

The Laboratory recommended that the five sites identified as potentially having unacceptable risk or dose above target levels be remediated (LANL 2008h). The Laboratory provided an investigation work plan to address additional sampling required to define the extent of contamination at all the sites (LANL 2008i). The Phase II work plan identified specific remediation goals and specific sampling locations, sampling depths, and analytical suites required to define the extent of contamination for all sites.

NMED approved the investigation report and the recommendations (NMED 2008d), and a Phase II investigation work plan was submitted (LANL 2008i). The Phase II work plan is pending NMED approval in 2009.

8. Pueblo Canyon Aggregate Area

a. Site Description and History

The Pueblo Canyon Aggregate Area consists of SWMUs, AOCs, and consolidated units located within the Pueblo Canyon watershed or on the mesa top that discharged directly to the watershed. The sites include wastewater treatment plants, septic systems, outfalls and drainages, landfills, underground storage tanks, and manholes located in Pueblo Canyon or on former Laboratory property, which is now part of the Los Alamos town site. The approved work plan proposed and described the investigation of 14 SWMUs/AOCs and one consolidated unit (consisting of four SWMUs and one AOC). DOE investigated an additional 11 SWMUs/AOCs, located at the Los Alamos County Airport, which were reported separately in 2007 (North Wind and Weston Solutions, 2007; LANL 2007a).

b. Remediation and Sampling Activities

The Laboratory started and completed investigations in 2006 based on the approved work plan with modifications. The objectives of the investigations were to determine the nature and extent of contamination at the SWMUs and AOCs, provide site characterization data for evaluating potential corrective actions, and conduct characterization/confirmatory sampling. Investigation activities included the removal of septic tank structures and lines, where possible. Characterization/confirmation activities consisted of surface and shallow subsurface sampling, the drilling of angled and/or vertical boreholes, and subsequent sampling of core from the boreholes.

c. Conclusions and Recommendations

The nature and extent of contamination is defined at 11 of the Pueblo Canyon Aggregate Area sites (LANL 2008j). Furthermore, these sites do not pose potential unacceptable risks or doses to human health under the residential scenario. The ecological risk screening assessments determined that none of the sites pose potential risks to ecological receptors. Because these sites do not pose a potential unacceptable risk to human health under a residential scenario and no potential risk to the environment, neither site controls nor future actions are necessary. Therefore, the Laboratory requested Certificates of Completion (corrective action complete without controls) from NMED for SWMUs 00-018(a) and 00-039; and AOCs 00-018(b), 00-030(d), 00-030(eN), 00-030(j), 00-030(n), 00-030(o), 00-030(p), and C-00-043 (LANL 2008i).

Four sites were recommended for additional characterization or remediation (LANL 2008j). The vertical extent of some inorganic COPCs was not defined at SWMU 31-001, AOC 00-030(eS), and Consolidated Unit 45-001-01. Additional sampling was proposed at all three sites to determine the extent of inorganic COPCs. AOC 00-030(h) presents a potential unacceptable risk for the residential scenario and a limited removal action in the former tank and outfall areas was also proposed.

NMED granted Certificates of Completion for Corrective Action Complete without Controls for SWMU 00-039 and AOCs 00-030(d), 00-030(eN), 00-030(j), 00-030(n), 00-030(o), 00-030(p), and C-00-043 (NMED 2008f, g, h, i, j k l, m). A Phase II investigation work plan was submitted and approved by NMED to conduct the additional characterization or remediation at SWMU 31-001, AOC 00-030(eS), and Consolidated Unit 45-001-01, as well as at SWMU 00-018(a) and AOC 00-018(b) (LANL 2008k; NMED 2008e).

9. Middle Cañada del Buey Aggregate Area

a. Site Description and History

Middle Cañada del Buey Aggregate Area is located in the central portion of Cañada del Buey and Mesita del Buey and incorporates parts of TA-51 and TA-54. Middle Cañada del Buey Aggregate Area consists of 23 SWMUs and AOCs located on the mesa top. Of these 23 sites only four AOCs require additional characterization activities and are addressed in the investigation work plan (LANL 2007b).

AOC 51-001 was an inactive/abandoned septic system that served several buildings. The septic system consisted of a 1,000-gal. concrete septic tank, drain lines, and a 4-ft-wide by 50-ft-deep seepage pit.

AOC 18-005(b) and AOC 18-005(c) were explosives magazines. These wooden structures were surrounded by earthen berms on three sides and on top. By the early 1960s, these structures had been removed or destroyed, and the site was made part of TA-54.

AOC 54-007(d) was an inactive/abandoned septic system that served the Radiation Exposure Facility at TA-54 West. The septic system consisted of a 1,500-gal. concrete septic tank, drain lines, a distribution box, and a split drain field. A 4-in. drain line from the septic tank connected to a reinforced concrete distribution box, which diverted the effluent east and west into the drain field. The drain field consists of two 60-ft-long, 4-in.-diameter tile drain lines running east and west from the distribution box.

b. Remediation and Sampling Activities

AOCs 18-005(b) and 18-005(c) have not been investigated previously, while AOCs 51-001 and 54-007(d) were previously investigated and remediated. The investigation objective for these four sites is to determine the nature and extent of any releases from these sites.

Eight samples were collected at AOCs 18-005(b) and 18-005(c) from four locations in/around the footprints of each former magazine for a total of 16 samples. Samples were collected from two depths at each location.

Samples at AOC 51-001 were collected from directly beneath the former inlet and outlet drain line connections to the septic tank from two depths. Samples were collected from three locations within the septic tank footprint from two depths at each location. Four samples were collected from two boreholes drilled adjacent to the seepage pit from two depths to a maximum of 60 ft bgs.

Activities at AOC 54-007(d) consisted of samples collected directly beneath the former inlet and outlet drain line connections to the septic tank from two depths. Samples were collected from three locations within the septic tank footprint from two depths at each location. Twenty-four samples were collected from 12 locations in trenches or with hand augers within the drain field from two depths.

c. Conclusions and Recommendations

Investigation sampling was conducted and completed in December 2008. The results were presented in an investigation report submitted to NMED in early 2009 (LANL 2009a).

10. MDA C

a. Site Description and History

MDA C, an inactive 11.8-acre landfill, is located within TA-50 at the head of Ten Site Canyon. MDA C consists of seven disposal pits and 108 shafts; the depths of the pits range from 12 to 25 ft and the shafts range from 10 to 25 ft below the original ground surface. Ten shafts in Shaft Group 3 (Shafts 98–107) are lined with 12-in.-thick concrete, while the rest of the pits and shafts are unlined. MDA C operated from May 1948 to April 1974 but received waste only intermittently from 1968 until the site was decommissioned in 1974. Wastes disposed of at MDA C consisted of liquids, solids, and containerized gases generated from a broad range of nuclear energy research and development activities conducted at the Laboratory. These wastes included uncontaminated classified materials, metals, hazardous materials, and radioactively contaminated materials.

b. Remediation and Sampling Activities

Investigation activities at MDA C began in 2005 and continued in 2006 and 2007. All activities were conducted in accordance with the approved MDA C investigation work plan. The field activities, data review, and risk assessments conducted through 2006 are presented in the investigation report. Additional characterization activities in 2007 included the drilling of four vertical boreholes between Pits 2 and 3 and the collection of soil, tuff, and pore-gas samples. The submission of these data completed the requirements in the approved MDA C work plan.

The Laboratory submitted a Phase II investigation work plan in 2007, which was approved by NMED and implemented in 2008. The activities proposed in this Phase II work plan were designed to provide the additional data needed to define the extent of contamination at MDA C by collecting subsurface tuff and pore-gas samples at greater depths and at additional locations. Surface soil samples were also collected and analyzed for inorganic chemicals to confirm the results of previous screening-level sample analyses. Specific activities included drilling five new boreholes outside the boundary of MDA C and extending nine existing boreholes to greater depths to define the lateral and vertical extent of contamination, collecting surface soil samples at multiple locations across MDA C to be analyzed for inorganic chemicals, installing vapor monitoring wells using the five new boreholes and nine extended boreholes, and collecting fracture-density and orientation data to evaluate the potential role of fractures in contaminant transport.

A pilot test was conducted at MDA C to evaluate three subsurface vapor-sampling systems: the packer system, the Flexible Liner Underground Technology (FLUTe) system, and the stainless-steel (SS) tubing system (LANL 2008l; NMED 2008n). Subsurface vapor samples were collected from four sets of paired boreholes inside the MDA C boundary and to the north and south outside of the MDA C boundary. At each set of paired boreholes, subsurface vapor samples were collected from the same or similar depth interval(s) using different vapor-sampling systems. Vapor samples were analyzed for VOCs and tritium, and the results of samples collected using the different sampling systems were compared.

Because of possible adsorption of contaminants to sampling tubing, a second pilot test was conducted to evaluate and compare three different vapor-sampling systems (LANL 2008m; NMED 2008o), all of which have been used at the Laboratory. The objective of the pilot test was to evaluate three subsurface vapor-sampling systems: the current or new FLUTe system, the older FLUTe monitoring system installed in MDA G during the 1990s (vintage FLUTe), and a SS system. The vintage FLUTe system was installed adjacent to new FLUTe and SS vapor-monitoring systems, which were installed in support of the approved MDA C pilot test (LANL 2008l; NMED 2008n) mentioned in the previous paragraph.

c. Conclusions and Recommendations

The results of the Phase II investigation of MDA C will be presented in an investigation report in 2009. The vapor-monitoring wells will be sampled for VOCs and tritium on a quarterly basis for one year. The Laboratory and NMED will review the pore-gas data to determine the subsequent frequency of sampling.

In multiple direct comparisons between the various combinations of two sampling systems, the SS system tended to have higher concentrations of individual VOCs than either the packer system or the FLUTe system (LANL 2008n). No significant difference was observed between the packer and the FLUTe systems or between the two types of tubing used in the FLUTe system. There is also overlap in concentrations of VOCs among samples collected by all the systems. Based on the pilot test results, the packer system is adequate for initial measuring of pore-gas concentrations, while the FLUTe system and the SS tubing system are preferable for subsurface vapor monitoring (LANL 2008n). Because none of the systems result in adsorption of VOCs and tritium in the sampling train, all systems tested are appropriate for sampling VOCs and tritium in pore gas.

Based on the results of the second pilot test investigation, it cannot be concluded that significant differences exist between vintage FLUTe and new FLUTe samples or between vintage FLUTe and SS samples (LANL 2008o). Although there was a slight trend toward higher results in the SS system samples, statistically significant differences were found in only four of 16 VOC comparisons in each side-by-side sampling system comparison. The comparison of VOC data from the vintage FLUTe system with data from the SS sampling system does not support the proposition that adsorption of VOCs in the vintage FLUTe sampling trains is occurring that would bias samples collected using MDA G FLUTe systems (LANL 2008o). The vintage FLUTe sampling system produced results similar to those from the SS sampling system.

NMED approved both pilot test reports (NMED 2008p; NMED 2008q).

11. MDA L

a. Site Description and History

MDA L (SWMU 54-006) is located at TA-54 in the east-central portion of the Laboratory on Mesita del Buey, within an 1,100 ft by 3,000 ft (2.5-acre) fenced area known as Area L. MDA L is a decommissioned (removed from service) area established for disposing of nonradiological liquid chemical waste, including containerized and uncontainerized liquid wastes; bulk quantities of treated aqueous waste; batch-treated salt solutions; electroplating wastes, including precipitated heavy metals; and small-batch quantities of treated lithium hydride.

The MDA consists of one inactive subsurface disposal pit (Pit A); three inactive subsurface treatment and disposal impoundments (Impoundments B, C, and D); and 34 inactive disposal shafts (Shafts 1 through 34) excavated into the overlying soil and unit 2 of the Tshirege Member of the Bandelier Tuff. When the shafts were filled to within approximately 3 ft of the surface, they were capped with a 3-ft concrete plug. Upon decommissioning, the pit and impoundments were filled and covered with clean, crushed, consolidated tuff.

b. Remediation and Sampling Activities

An interim subsurface vapor monitoring plan was submitted and approved with modifications. The plan describes proposed subsurface monitoring activities and the frequencies at which sampling is conducted within the vadose zone beneath MDA L. The eight boreholes drilled in 2004–2005 and the three boreholes drilled in 2007 provide complete coverage across the site and encompass all the subsurface rock units down to and including the basalt.

c. Conclusions and Recommendations

The Laboratory developed a CME report (LANL 2008p) and continued to monitor VOCs and tritium in subsurface pore gas at MDA L. Pore-gas monitoring data are reported in periodic monitoring reports.

The CME uses recent and historical characterization data as a basis for defining the nature and extent of contamination at MDA L. The present-day risk assessment for MDA L, presented in the MDA L investigation report, concluded that surface and subsurface contamination at the site does not currently pose an unacceptable risk to human health or the environment. The CME identifies and evaluates corrective measure alternatives that address potential unacceptable future risk/dose from MDA L and recommends implementing one or more alternatives for implementation. Several of the alternatives considered include a monitoring component to confirm that the corrective measure alternative is effective. Actions to be taken if the corrective measure alternative is ineffective are also included. The CME also involves the public in corrective measure alternative selection and implementation to ensure that the proposed remedy addresses public concerns about the site.

The CME report for MDA L was submitted to NMED in early 2008 (LANL 2008p). Additional characterization of groundwater beneath MDA L must be accomplished before NMED can completely review and comment on the CME report.

12. MDA G

a. Site Description and History

MDA G (Consolidated Unit 54-013[b]-99), which is located in the east-central portion of the Laboratory at TA-54, Area G, on Mesita del Buey, is a decommissioned (removed from service) subsurface site at TA-54 established for disposition of low level waste, certain radioactively contaminated infectious waste, asbestos-contaminated material, and polychlorinated biphenyls (PCBs). The MDA was also used for the retrievable storage of transuranic waste and consists of inactive subsurface units that include 32 pits, 194 shafts, and four trenches. When operations ceased, the Laboratory backfilled the remaining capacity of the pits, shafts, and trenches with clean, crushed, compacted tuff. The disposal shafts were capped with a concrete plug. Portions of the disposal units at MDA G are covered with concrete to house ongoing waste-management activities conducted at Area G; surface runoff from the site is controlled and discharges into drainages to the north (towards Cañada del Buey) and the south (towards Pajarito Canyon).

b. Remediation and Sampling Activities

The Laboratory continued to monitor VOCs and tritium in subsurface pore gas at MDA G. The VOC and tritium pore gas results are reported in periodic monitoring reports. In 2007, the Laboratory submitted a work plan for the implementation of an SVE pilot study, which may be implemented as a remedial option. The work plan was approved with direction by NMED in 2007, revised (LANL 2008q), and subsequently approved with modifications (NMED 2008r). The MDA G SVE pilot study was conducted in accordance with the NMED-approved work plan.

The primary goal of the SVE pilot test was to evaluate the effectiveness of SVE and to determine whether SVE is a suitable alternative for remediating the MDA G vapor plumes. The MDA G SVE pilot test consisted of the following activities:

- Two boreholes were drilled and configured specifically to be used as vapor-extraction boreholes. The shallow- and deep-extraction boreholes were configured to extract vapor from the Tshirege and Otowi Members of the Bandelier Tuff, respectively.
- Existing borehole locations 54-01116, 54-01117, 54-24378, and 54-24388 were constructed with pore-gas monitoring ports located in each geologic unit and instruments to facilitate pore-gas and differential-pressure monitoring.
- Pretest pore-gas and differential-pressure monitoring were conducted to establish baseline conditions.
- Active extraction was performed on the shallow vapor-extraction borehole for 30 days, followed by a two-week rebound monitoring period; active extraction was then performed at the deep-extraction borehole for 30 days after the two-week shallow test rebound period.
- Following the active extraction tests at both extraction boreholes (and the shallow test rebound period), pore-gas and airflow monitoring were conducted at the shallow-extraction borehole for 2 weeks to evaluate the effectiveness of passive venting on the removal of vapor-phase VOCs from the subsurface; airflow monitoring was conducted only at the deep-extraction borehole during this period.

A second pilot test was conducted to evaluate Type 4 vapor monitoring systems at MDA G. NMED requested the evaluation to determine the potential for short-circuiting between sampling port depths. The two Type 4 monitoring systems currently included in the annual monitoring network (locations 54-02032 and 54-02033) were evaluated during the annual vapor monitoring at MDA G in July 2008.

c. Conclusions and Recommendations

The results of the MDA G SVE pilot test indicate that SVE is an effective method for extracting vapor-phase VOC contamination from higher permeability geologic units in the vadose zone beneath MDA G (LANL 2008r; LANL 2009b). Approximately 260 lbs of VOCs were removed from the shallow-extraction borehole. Lower airflow was observed in the deep-extraction borehole installed within the Otowi Member. Low airflow, combined with historically lower concentrations of VOCs at this depth, resulted in the removal of approximately 15 lbs of VOCs from the deep-extraction borehole. The SVE pilot test also provided sufficient data to validate the conceptual model for vapor transport at MDA G.

Passive airflow monitoring in the shallow-extraction borehole indicates that changes in barometric pressure can result in airflow out of the Tshirege Member (LANL 2008r; LANL 2009b). The results indicate that an SVE remediation strategy using both active and passive extraction phases may increase the overall removal of vapor-phase VOCs from the subsurface. This conclusion is consistent with the US Environmental Protection Agency (EPA) directive on the use of SVE as a presumptive remedy for VOCs in soil (EPA 1996). However, the pilot test results were inconclusive with respect to the effectiveness of SVE in removing subsurface tritium (LANL 2008r; LANL 2009b).

The Type 4 vapor monitoring system pilot test indicated a potential for short-circuiting between ports that are 17 ft and 20 ft apart during sampling at location 54-02033 (LANL 2008s). No discernible short-circuiting was found between ports greater than 20 ft apart. However, because the next closest sampling port distance was 40 ft in this borehole, it is difficult to determine the maximum distance between ports where the effects of purging occur. The pilot test indicates there is the potential for short-circuiting at distances up to 20 ft above and below each port and therefore creates uncertainty as to the actual depth of collected samples (LANL 2008s).

The Laboratory submitted and revised a CME plan for MDA G, which was approved by NMED in 2007. The CME report was submitted in 2008 (LANL 2008t). The CME screened 12 corrective measure alternatives based on their ability to meet regulatory thresholds and other qualitative screening criteria. Four of the 12 alternatives met the screening criteria and were retained: (1) monitoring and maintenance of the existing cover combined with an SVE system; (2) construction of an engineered evapotranspiration (ET) cover combined with an SVE system for the removal of vapor-phase VOCs; (3) partial waste excavation, ex situ treatment and disposal of excavated waste, monitoring and maintenance of an engineered ET cover, and extraction of vapor-phase organic compounds using an SVE system; and (4) complete excavation and off-site disposal of all MDA G waste combined with an SVE system. The alternatives must meet the cleanup objectives of the Consent Order, Resource Conservation and Recovery Act (RCRA) closure standards, and DOE performance objectives for low-level waste disposal sites. The alternatives also assume that the subsurface RCRA units will be closed using alternative closure requirements developed through the CME and corrective measure implementation processes.

The CME report underwent NMED review in 2008 and was revised in 2009.

13. MDA H

a. Site Description and History

MDA H is a 70-ft by 200-ft (0.3-acre) fenced area located within TA-54 on Mesita del Buey, a small mesa that lies between Pajarito Canyon and Cañada del Buey. The MDA consists of nine inactive vertical disposal shafts arranged in a line approximately 15 ft inside the southern fence. Each shaft is cylindrical with a diameter of 6 ft and a depth of 60 ft. When filled to within 6 ft of the surface, the space above the waste in Shafts 1 through 8 was filled with 3 ft of concrete, over which an additional 3 ft of crushed tuff was placed. In Shaft 9, the space above the waste was filled with 6 ft of concrete.

From May 1960 until August 1986, MDA H was the Laboratory's primary disposal area for classified, solid-form waste. Disposal of solid-form waste materials at MDA H was restricted to items or materials that were determined by authorized personnel to be both classified and no longer required for their intended use. This determination was recorded on disposal forms that accompanied the waste to MDA H. Liquids were prohibited from disposal.

b. Remediation and Sampling Activities

Since the third quarter of fiscal year (FY) 2006, subsurface pore-gas samples have been collected in boreholes next to MDA H using the FLUTe system for vapor monitoring. Prior to the third quarter of FY2006, a packer sampling system with Teflon tubing was used to collect pore-gas samples at MDA H. The 2007 periodic monitoring report for vapor sampling at MDA H reported substantially lower VOC concentrations, particularly for trichloroethene (TCE), than had been reported before the FLUTe system was installed.

A study was conducted to clarify whether the pore-gas sampling systems produced comparable pore-gas data. The objective of the comparison was to determine whether the FLUTe sampling system is removing VOCs from the extracted air so as to substantially underestimate the VOC concentrations measured in the pore gas beneath MDA H (LANL 2008u). Subsurface vapor samples were collected from the boreholes at MDA H using the currently deployed FLUTe system and the previously used packer system, and the TCE concentrations collected from both systems were compared.

c. Conclusions and Recommendations

The comparison of the VOC results during the second and third quarter monitoring events in FY2008 found no substantial difference in pore-gas concentrations using the FLUTe or the packer sampling systems (LANL 2008u). The outlier TCE concentrations appear to be the result of cross-contamination of the packer systems used to sample the vapor plume beneath MDA L before they were used in two boreholes at MDA H. This conclusion is in agreement with the results from recent comparisons of the FLUTe and packer systems at MDA C (LANL 2008l) and supports the conclusion that the FLUTe system is reliable for providing representative results.

C. LANL WATER STEWARDSHIP PROJECT

The Laboratory conducted the following investigations and activities in 2008:

- Los Alamos and Pueblo Canyons interim measure and supplemental interim measure work plans to reduce the migration of contaminated storm water and sediment within the watershed as part of an overall watershed-scale approach were submitted.
- Pajarito Canyon investigation report was submitted.
- Phase 2 sediment investigations in Sandia Canyon were completed and the biota investigation work plan was implemented. An updated fate and transport report of chromium was submitted. Several regional groundwater wells (R-42, R-43, R-44, and R-45) and one perched-intermediate well (SCI-2) were drilled.
- Phase 1 sediment sampling was conducted in the Cañada del Buey reaches.

The following section includes brief summaries of the investigation activities started, continued, or completed in 2008.

1. Los Alamos/Pueblo Canyons

a. Site Description and History

The portion of the canyon watershed investigated as the Los Alamos and Pueblo Canyons watershed includes Los Alamos, Pueblo, DP, and Acid Canyons (inclusive of the South Fork of Acid Canyon). The watershed heads on USFS land in the Sierra de los Valles west and northwest of the Laboratory. The entire watershed, inclusive of Los Alamos, Pueblo, Guaje, Rendija, Bayo, and Barrancas Canyons, as well as smaller tributary canyons (e.g., Acid and DP Canyons), has a combined drainage area of 153 km^2 (59 mi^2). The other canyons (Guaje, Rendija, Bayo, and Barrancas) were investigated as the north canyons system. The highest point in the watershed is at the summit of Pajarito Mountain at an elevation of 3,182 m (10,441 ft) above sea level (asl). The watershed extends eastward from the headwaters across the Pajarito Plateau for approximately 30.4 km (18.9 mi) to the confluence with the Rio Grande at an elevation of 1,678 m (5504 ft) asl.

Contaminants consisting of inorganic chemicals, organic chemicals, and radionuclides have been released into the Los Alamos and Pueblo Canyons watershed from a variety of sources, including Laboratory operations in several TAs (primarily TA-0, TA-1, TA-2, TA-3, TA-21, TA-41, TA-45, TA-53, and TA-73) and non-Laboratory sources in the Los Alamos town site, such as roads and other paved areas, application of pesticides in headwater areas in the Santa Fe National Forest and within the town site, and atmospheric fallout of radionuclides. Regardless of the source(s), the contaminants have been dispersed down canyon in sediments, surface water, and alluvial groundwater. Many constituents found naturally or derived from anthropogenic sources were concentrated in ash during the Cerro Grande fire in May 2000 and also were dispersed down canyon.

b. Remediation and Sampling Activities

The investigation report and supplemental report for the Los Alamos and Pueblo Canyons watershed were submitted in 2004–2005. The supplemental report was approved with direction in 2007 by NMED. The approval directed the Laboratory to implement actions in Los Alamos and Pueblo Canyons to mitigate migration of contaminated sediment.

A Los Alamos and Pueblo Canyons interim measure work plan was developed to reduce the migration of contaminated storm water and sediment within the watershed as part of an overall watershed-scale approach (LANL 2008v; NMED 2008s). Further watershed-scale evaluations of hydrologic processes in Los Alamos and Pueblo Canyons will be conducted to identify additional actions that may be undertaken to further control migration of contaminated sediment. Proposed interim measures include the following:

- Stabilization and enhancement of the Pueblo Canyon wetland; construction of a grade-control structure in lower Pueblo Canyon in the vicinity of the NM 4–NM 502 interchange;
- Enhancement of the upstream wetland between the current Los Alamos County wastewater treatment plant (WWTP) outfall and the existing Pueblo Canyon wetland;
- Construction of a pilot wing ditch in the part of the Pueblo Canyon wetland near the access road to enhance the spread of water over the wetland, dissipation of flood energy, and deposition of suspended sediment;
- Excavation and enhancement of basin above the Los Alamos Canyon Low-Head Weir; construction of a new gaging station in Pueblo Canyon west of the current WWTP outfall and east of Kwage Canyon and upgrading existing gaging stations immediately above and below the Los Alamos Canyon low-head weir; and
- Stabilization of stream banks containing contaminated sediment.

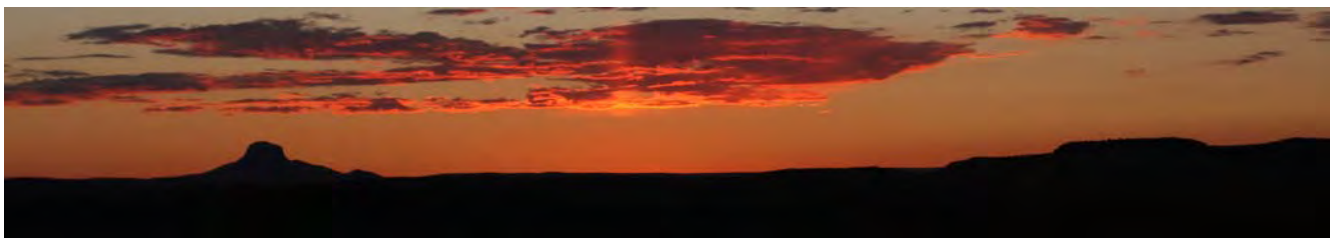
The effectiveness of the actions for reducing the transport of PCBs and other contaminants will be evaluated using stream discharge data and sampling and analysis of storm water collected up canyon and down canyon from the primary sediment deposition areas in Los Alamos and Pueblo Canyons.

A supplemental interim measure work plan was also developed, which provides details of additional mitigation actions that will be implemented in the Los Alamos and Pueblo Canyon watershed to reduce the transport of contaminated sediment (LANL 2008w; NMED 2009c). These mitigation measures are intended to substantially reduce off-site transport of contaminated sediment and complement other actions implemented by the Laboratory and Los Alamos County. Proposed supplemental interim actions include the following:

- A DP Canyon grade-control structure to reduce erosive flood energy and to cause upstream aggradation that will fill the channel and bury existing floodplain deposits;
- Three cross-vane structures to be located in Pueblo Canyon between the confluences of Graduation and Kwage Canyons to decrease flood peaks before floods enter the downstream wetland;
- Extensive planting of willows along the west end of reach P-4W to aid in surface stabilization, flow reduction, and sediment accumulation, building on the successful planting of willows upstream and monitoring of the geomorphic response to the restoration activities upstream from the planned grade-control structure in lower Pueblo Canyon; and
- Planting additional willows downstream from the new Los Alamos County WWTP extending from Hamilton Bend to near the pilot wing ditch proposed in the interim measures work plan.

c. Conclusions and Recommendations

Results of the interim measure activities will be reported in an interim measure report submitted to NMED in 2009 and will include documentation of all activities conducted in 2008.



2. Pajarito Canyon

a. Site Description and History

Pajarito Canyon is located in the central part of the Laboratory. The canyon heads in the Santa Fe National Forest west of the Laboratory boundary and empties into the Rio Grande in White Rock Canyon. The main channel is approximately 14.8 miles long and the watershed area is approximately 8 mi^2. In addition, Twomile and Threemile Canyons are major tributaries that join Pajarito Canyon and have watershed areas of 3.1 mi^2 and 1.7 mi^2, respectively. Sites within the Pajarito Canyon watershed are located at TA-3, TA-8, TA-9, TA-12, TA-15, TA-18, TA-23, TA-27, TA-48, TA-54, TA-55, TA-59, TA-64, and TA-69.

b. Remediation and Sampling Activities

The Laboratory conducted phased investigations of sediment deposits in the Pajarito Canyon watershed from 2006 into 2008 in accordance with the Pajarito Canyon summary reports. The Pajarito Canyon biota studies were implemented in 2007 according to the approved work plan and continued into 2008. The studies are based on assessment endpoints developed to protect the terrestrial and aquatic ecosystems within canyons in the watershed and complement previous studies conducted in the Los Alamos and Pueblo Canyons, Cañon de Valle, and Mortandad Canyon watersheds.

c. Conclusions and Recommendations

The Pajarito Canyon investigation report (LANL 2008x) was submitted to NMED and presented the results of sediment, groundwater, surface water, and biota sampling and analyses. The objectives of the investigations included defining the nature and extent of COPCs in sediment, surface water, and groundwater and assessing the potential risks to human health and the environment from these COPCs. The investigations also address the sources, fate, and transport of COPCs in the canyon watershed.

Sediment COPCs in the Pajarito Canyon watershed are derived from a variety of sources, including Laboratory SWMUs and AOCs, runoff from developed areas, ash from the area burned in the May 2000 Cerro Grande fire, and natural sources such as uncontaminated soil, sediment, and bedrock. Transport of contaminants released from technical areas in upper Pajarito Canyon above the confluence with Twomile Canyon increased after the May 2000 Cerro Grande fire and is associated with increased magnitude and frequency of floods and erosion of post-1942 sediment deposits along the main channels. Monitoring COPC concentrations transported in sediment will continue, particularly in fine-grained sediment deposited after large flood events that have the highest potential for erosion and down canyon transport.

The outfalls, septic systems, and surface releases primarily responsible for contaminants in surface water and groundwater are no longer active. Surface water and groundwater will continue to be monitored because contaminants in soil and alluvium and in bedrock media near the primary release sites continue to be secondary sources of contaminants to surface water and groundwater. The configuration of wells in the existing monitoring network is sufficient to meet the groundwater monitoring objectives for the watershed.

The results of the Pajarito Canyon investigation indicate that human health risks and doses based on a recreational exposure scenario are acceptable (LANL 2008x). In addition, no adverse ecological effects were observed within terrestrial and aquatic systems in the Pajarito Canyon watershed. Therefore, corrective actions are not needed to mitigate unacceptable risks. However, additional monitoring of sediment, surface water, groundwater, and cavity-nesting birds and their food is recommended.

3. Sandia Canyon

a. Site Description and History

Sandia Canyon is located in the central part of the Laboratory, heads within TA-3, trends east-southeast across the Laboratory, Bandelier National Park, and Pueblo de San Ildefonso land, and empties into the Rio Grande in White Rock Canyon. The main channel is approximately 9.4 miles long and the watershed area is approximately 5.5 mi^2. Sandia Canyon on Laboratory property extends for a distance of 5.6 mi and has a watershed area of 2.65 mi^2.

Sites within the Sandia Canyon watershed are located at TA-3, TA-53, TA-60, TA-61, TA-72, and former TA-20.

b. Remediation and Sampling Activities

Phase 2 sediment investigations in Sandia Canyon were completed in 2008 and focused on evaluating the source and extent of contamination and on improving estimates of average concentrations of contaminants. Sampling in each Phase 2 reach included both surface and subsurface sediment layers, depending on the thickness of historical (post-1942) sediment in each reach. Phase 2 sampling was conducted in reaches S-1N & S-1S (near TA-3, 10 samples each), S-6W and S-6E (on Pueblo de San Ildefonso land, 10 samples each), and S-2 (six resampled locations).

The biota investigation work plan for Sandia Canyon investigation reaches was implemented in 2008. The proposed studies are based on assessment endpoints developed to protect the terrestrial and aquatic ecosystems within the watershed and complement previous studies conducted in the Los Alamos and Pueblo Canyons, Cañon de Valle, and Mortandad Canyon watersheds. Studies conducted included nest box monitoring and collection of biota samples for laboratory analyses.

c. Conclusions and Recommendations

The results of the sediment sampling and the biota investigation will be reported in 2009 as part of the Sandia Canyon investigation report.

A fate and transport report was submitted in 2007, which is part of an ongoing investigation to address the chromium and other contaminants detected in surface water and groundwater beneath Sandia and Mortandad Canyons. An updated report presenting new results from investigations that assess the fate and transport of chromium in the environment, including modeling, laboratory experiments, and field observations, was submitted (LANL 2008y). Development of the fate and transport models helps refine the conceptual model of how various physical, hydrological, and geochemical elements lead to the present-day distribution of chromium in the subsurface. In addition, model development, experimental studies, and data collected from monitoring wells and characterization coreholes are used together to integrate site knowledge about chromium migration. The models simulating the fate and transport of chromium in the subsurface were successfully calibrated to observed water levels and chromium concentrations at the monitoring wells in the regional aquifer. The calibrated models were applied to estimate the area in the regional aquifer that may be affected by the contamination. The estimated distribution of chromium mass in the regional aquifer can be used to site new monitoring wells.

The chromium project investigation includes the installation of several additional monitoring wells to further refine the extent of contamination in the regional groundwater. In 2007, three regional groundwater wells (R-35a, R-35b, and R-36) were drilled down gradient of regional well R-28 to define the extent of contamination and to monitor for potential migration of chromium towards the Laboratory boundary or towards water-supply wells. In 2008, additional regional groundwater wells and one perched intermediate well were drilled to further refine the extent of contamination in the regional groundwater (LANL 2008z). Regional well R-42 located in Mortandad Canyon was drilled with the objective of further characterizing the chromium contamination in the regional groundwater upgradient (west) of R-28. This location is also thought to be within the primary chromium infiltration zone. Regional well R-43, located in Sandia Canyon, was drilled with the objective of further characterizing the chromium concentrations upgradient (northwest) of R-28. R-43 is situated adjacent to perched-intermediate well SCI-2, which was drilled in Sandia Canyon to characterize the fate and transport of chromium along the infiltration pathway. Regional wells R-44 and R-45 also drilled in 2008 are intended to supplement the information from regional wells R-35a, R-35b, R-36, R-13, and R-28 (LANL 2008aa; NMED 2008t). R-44 is located on the mesa south of R-28 and is intended to define the southern limit of chromium contamination in the vicinity of R-28. R-45 is located east of R-28 and south of R-11 and will investigate and characterize the down gradient extent of the chromium contamination.

4. Cañada del Buey

a. Site Description and History

Cañada del Buey, which is located in the central part of the Laboratory, is the largest tributary to Mortandad Canyon. The canyon heads within TA-52 and TA-36 and trends east-southeast across the Laboratory, Pueblo de San Ildefonso land, and Los Alamos County ending at the confluence with Mortandad Canyon. The main channel is approximately 8.2 miles long and the watershed area is approximately 4.3 mi^2. On Laboratory property, Cañada del Buey extends for a distance of 5 mi, has a watershed area of 2.1 mi^2, has one main tributary (south fork of Cañada del Buey), and a smaller tributary referred to as the Sanitary Wastewater Systems Consolidation or SWSC tributary. Sites within the Cañada del Buey watershed are located at TA-18, TA-46, TA-51, TA-52, and TA-54, and former TA-4.

b. Remediation and Sampling Activities

Sampling of the canyon reaches in Cañada del Buey was performed as proposed in the work plan and addendum to the work plan and as modified by several subsequent documents all approved by the NMED. Phase 1 sediment sampling was conducted in Cañada del Buey reaches in 2008; extra sampling was performed in 2008 but no Phase 2 sampling is planned. The Cañada del Buey sampling included six new reaches with 20 samples each (reaches CDB-1, CDB-2W, CDB-2C, CDB-3W, CDBS-1W, CDBS-1E), plus two prior reaches (reaches CDB-3E and CDB-4) with 10 samples each.

c. Conclusions and Recommendations

The results of the investigations will be reported in the Cañada del Buey investigation report in 2009.

D. TA-21 CLOSURE PROJECT

Investigations and activities conducted in 2008 included the following:

- Sampling and remediation of an area of elevated radioactivity near absorption bed 3 within and around MDA V was conducted and the report submitted.
- A corrective measures report for MDA A was submitted.
- Revision 1 of the investigation report for the DP Site Aggregate Area was submitted. A Phase II investigation work plan and revision 1 of the work plan were submitted.

The following sections summarize the investigations started, continued, and completed in 2008.

1. MDA V

a. Site Description and History

Consolidated Unit 21-018(a)-99 is a 0.88-acre fenced area located on the south side of DP Road west of the TA-21 main gate. The consolidated unit is comprised of four SWMUs and one AOC.

- SWMU 21-018(a) (MDA V) consists of three absorption beds that received radioactive liquid waste derived from the TA-21 laundry facility (SWMU 21-018[b]). The Laboratory constructed the absorption beds in 1945 and operated them until 1961.
- SWMU 21-018(b), is the former laundry facility located south of DP Road. The Laboratory operated the laundry facility from 1945 to 1961.
- SWMU 21-023(c) is a former septic system consisting of a tank, inlet and outlet lines, and an outfall, that served a waste treatment laboratory. The Laboratory put the septic system into service in 1948 and removed it in 1965.

- SWMU 21-013(b) and AOC 21-013(g) are surface disposal sites located on the south-facing slope above BV Canyon, which received building debris from TA-21. It is not known how long these sites received building debris; however, they did not receive wastes later than 1994.

b. Remediation and Sampling Activities

Investigation and remediation of an area of elevated radioactivity identified north of former absorption bed 3 (SWMU 21-018[a]) during the post-remediation walk-over survey was completed. The supplemental remediation and investigation finalized surface and subsurface chemical cleanup and characterization of Consolidated Unit 21-018(a)-99 and included removal of soil and tuff from an area of elevated radioactivity identified in a 2006 surface radiological survey. A total volume of approximately 420 yd^3 of excavated material was removed during the remediation of this area. The data evaluated supplement the data collected in 2005–2007 at Consolidated Unit 21-018(a)-99. Post-excavation confirmation data were used to define the nature and extent of contamination associated with the area of elevated radioactivity and to determine whether this area of the site poses a potential unacceptable risk or dose to human health or the environment.

c. Conclusions and Recommendations

The results of the investigation and remediation of the area of elevated radioactivity north of former absorption bed 3 were provided in a supplemental investigation report (LANL 2008bb). The extent is defined for radionuclide, inorganic, and organic COPCs in both surface and subsurface media. Based on the human health risk assessment results, concentrations of COPCs in soil and tuff in the area of elevated radioactivity at Consolidated Unit 21-018(a)-99 do not pose a potential unacceptable risk/dose to human health under a residential scenario. The ecological risk screening assessment of the area of elevated radioactivity at Consolidated Unit 21-018(a)-99 indicated no potential risk/dose to ecological receptors.

Based on the results of this and previous investigations, no additional corrective action is planned for Consolidated Unit 21-018(a)-99, specifically SWMUs 21-018(a), 21-018(b), 21-023(c), 21-013(b), and AOC 21-013(g) (LANL 2008bb).

2. MDA A

a. Site Description and History

MDA A is comprised of a 1.25-acre, fenced, and radiologiocally controlled area situated on the eastern end of DP Mesa between DP Canyon to the north and Los Alamos Canyon to the south. The Laboratory used MDA A between 1945 and 1978 to store solid and liquid wastes.

MDA A currently contains the following features:

- Two 50,000-gal. cylindrical steel storage tanks (referred to as the General's Tanks) are buried at the western end of MDA A. The tanks received waste solutions containing plutonium-239/240 and americium-241 from 1947 to 1974. Liquid waste was removed from the tanks in 1975 and 1976, but an unknown volume of sludge remains at the bottom of the tanks.
- Two 4-ft diameter, 65-ft deep vertical shafts located south of the General's Tanks. The shafts were constructed in 1975 but never used and were filled with soil in 1977.
- Two eastern disposal pits were constructed in 1945 to receive radioactive solid waste from DP East. In 1946, crushed Bandelier Tuff was used to backfill and cover the pits.
- One central pit was excavated in the center of MDA A to receive and store TA-21 decontamination and decommissioning debris potentially contaminated with radionuclides. This pit received waste from 1969 to 1977. The pit was decommissioned in 1978 and a soil cover (crushed tuff) was placed over the pit.

Several hundred 55-gal. drums containing iodide waste were stored on the surface at the eastern end of MDA A. These drums contained sodium hydroxide solution and stable iodine. The drum storage area was used from the late 1940s until 1960.

b. Remediation and Sampling Activities

The Laboratory began and concluded investigation activities in 2006 at MDA A, in accordance with the approved work plan. The Laboratory submitted the investigation report for MDA A to NMED in 2006. Following review of the report, NMED requested additional drilling and sampling for pore-gas.

The 2007 supplemental sampling field activities included deepening one borehole and sampling pore gas from it, collecting an additional round of pore-gas samples from five other existing boreholes, and plugging and abandoning 12 open boreholes. VOC pore-gas results from 2007 indicate fewer VOCs detected and at lower concentrations than reported in the MDA A investigation report. The vertical extent of pore-gas VOCs also is defined by the two deeper boreholes. Lateral extent of VOCs in pore gas is defined. Tritium results from 2007 are over an order of magnitude lower than the levels measured at the same locations in 2006. The vertical and lateral extent of tritium in pore gas is defined at MDA A. Assessment of the pore-gas data indicate that the VOCs and tritium in subsurface pore gas at MDA A are not a potential source of groundwater contamination.

c. Conclusions and Recommendations

Additional quarterly monitoring of the pore gas for VOCs and tritium will be conducted to provide a more accurate assessment of vapor phase contamination beneath MDA A and reveal any trends in concentrations over time.

Other than vapor monitoring, characterization and investigation activities at MDA A are complete. The Laboratory submitted a CME report for MDA A to NMED (LANL 2008cc).

The objectives of the CME are to (1) provide an evaluation of corrective measure alternatives that are protective of human health and the environment, (2) describe how alternatives will be monitored to ensure the effectiveness of the corrective measure implemented, and (3) recommend a corrective measure alternative (LANL 2008cc). Technologies were screened for applicability to MDA A and combined into corrective measure alternatives. Three corrective measure alternatives were developed for MDA A using the results of the technology screening process and were evaluated against balancing and evaluation criteria (LANL 2008cc).

A revised CME report was submitted in early 2009 following NMED review and comment.

3. DP Site Aggregate Area

a. Site Description and History

TA-21 is located on DP Mesa on the northern boundary of LANL and is immediately east-southeast of the Los Alamos town site. From 1945 to 1978, TA-21 was used primarily for plutonium research, metal production, and related activities. Since 1978, various administrative and research activities have been conducted at TA-21. The DP Site Aggregate Area consists of SWMUs and AOCs located throughout TA-21. The SWMUs and AOCs include container storage areas, surface disposal areas, a PCB storage area, septic systems, sumps, drainlines, outfalls, a waste treatment laboratory, a sewage treatment plant, and seepage pits.

b. Remediation and Sampling Activities

Site characterization and remediation activities were conducted for this aggregate area in 2006 and 2007 based on the approved work plan. The scope of activities at the investigation sites included surface and shallow subsurface sampling and excavation of the septic tank and drainline at one site. Scope of activities for the sites not impacted by the facility (identified as facility-unimpacted corrective action sites in the investigation report) included surface and subsurface sampling as well as the removal of the blowdown pits, the seepage pits, the blowdown tank, and pipelines at one site; removal of several septic tanks and the associated pipelines; removal of sumps and all pipelines; removal of a dosing siphon chamber and the main pipeline extending to the outfall; and removal of several pipelines.

The vertical and lateral extent of contamination at three of the investigation sites and all of the sites not impacted by the facility are not defined (LANL 2007c; LANL 2008dd). All of these sites require additional sampling to determine the vertical and lateral extent of contamination. PCB concentrations are above the Toxic

Substances Control Act cleanup level of 1 mg/kg at two investigation sites and will be remediated (LANL 2007c; LANL 2008dd).

A Phase II investigation work plan was submitted to NMED in 2008 (LANL 2008ee). The Phase II work plan refined the proposed extent sampling presented in the investigation report. Sampling and analyses will take place in 2009. Lateral and vertical extent samples will be collected at Consolidated Unit 21-003-99 and SWMU 21-024(c) for PCB analyses to define the areas to be excavated. Environmental media containing total PCBs at concentrations greater than the 1-mg/kg cleanup level will be excavated. Confirmatory samples will be collected to verify that the cleanup goal has been met.

c. Conclusions and Recommendations

The Phase II investigation report will present all of the data collected but will discuss only the results of the Phase II sampling as it defined extent. The Phase II investigation report will include human health and ecological risk-screening assessments for each site using all of the data that reflects current site conditions. The Phase II investigation report is scheduled to be submitted in early 2010.

E. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

The EP Directorate's quality assurance objectives are to perform work in a quality manner while minimizing potential hazards to the environment, public, and workers. All work is performed by using approved instructions, procedures, and other appropriate means that implement regulatory or contractual requirements for technical standards, administrative controls, and other hazard controls. The Quality Management Plan establishes the principles, requirements, and practices necessary to implement an effective quality assurance program.

The use of a graded approach in accordance with DOE Order 414.1C determines the scope, depth, and rigor of implementing the quality assurance criteria for a specific activity. Activities are managed through systems that are commensurate with the quality requirements, risk, and hazards involved in the activity. Such a selective approach allows the Laboratory to apply extensive controls to certain elements of activities and limited controls to others. The control measures applied to any particular activity are covered in documents such as procedures, statements of work, project-specific work plans, and procurement contracts associated with the activity.

2. Field Sampling Quality Assurance

Overall quality is maintained through the rigorous use of carefully documented procedures that govern all aspects of the sample collection activities.

Soil, water, vapor, and biota samples are (1) collected under common EPA chain-of-custody procedures using field notebooks and sample collection logs and (2) prepared and stored in certified pre-cleaned sampling containers in a secure and clean area for shipment. Samples are delivered to analytical laboratories under full chain-of-custody, including secure FedEx shipment to all external vendors, and tracked at all stages of their collection and analysis.

3. Analytical Laboratory Quality Assessment

The Laboratory writes specific statements of work to govern the acquisition and delivery of analytical chemistry services after the Data Quality Objective process defines the project needs. These statements of work are sent to potentially qualified suppliers who are National Environmental Laboratory Accreditation Conference (NELAC)-certified for a pre-award assessment by experienced and trained quality systems and chemistry laboratory assessors. Statement of work specifications, professional judgment, and quality system performance at each laboratory (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical, organic chemical, and inorganic chemical analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. The analytical laboratory also submits a full set of hard copy records that serves as the legally binding copy of the data. Each set of samples contains all the internal quality assurance/quality control data the analytical laboratory generates during each phase of chemical analysis (such as laboratory control samples, process blanks, matrix spikes, duplicates, replicates, and calibration records). The electronic data are uploaded into the database and verified and validated according to its corresponding variety of quality and consistency checks. All parts of the data-management process are tracked electronically, and periodic reports are prepared for management.

Most analytical laboratories are required to participate in independent national performance evaluation programs. These programs measure each analytical laboratory's performance when analyzing analytes in different media. The laboratories participate in the Mixed Analyte Performance Evaluation Program (MAPEP) and other pertinent programs as available for the analytical methods conducted under contract with LANL.

Two MAPEP studies and two Environmental Laboratory Approval Program (ELAP) studies were conducted on analytical performance on soil samples. The vast majority of the results of the MAPEP and ELAP samples passed. If the results for an analyte or group of analytes did not pass, the analytical laboratory director investigated the cause of the laboratory's performance, provided an explanation of the results, and established a remedial plan, if appropriate. All less than satisfactory results were explainable and addressed by the laboratory. The investigation report and remedial plan are on file in the relevant laboratory and available for review during on-site assessments.

4. Analytical Laboratory Assessments

The EP Directorate has eight contracts with external analytical laboratories. The laboratories are expected to keep their NELAC and DOE Contract Audit Program (DOECAP) certifications and, as long as they do, are audited only every few years by LANL. During 2008, five external laboratory audits were performed; St. Louis Severn Trent, Paragon Analytics, Inc., General Engineering Laboratories, Inc., American Radiation Services, and Vista Analytical Laboratory. Overall, the analytical laboratories were judged to have acceptable performance for almost all analytes attempted in all matrices. Corrective action plans, if appropriate, have been approved and are available on the DOECAP website.

F. REFERENCES

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LANL 2007a: "Investigation Report for Consolidated Unit 73-002-99 and Corrective Action of Solid Waste Management Unit 73-002 at Technical Area 73," Los Alamos National Laboratory document LA-UR-07-4479 (July 2007).

LANL 2007b: "Investigation Work Plan for Middle Cañada del Buey Aggregate Area, Revision 1," Los Alamos National Laboratory document LA-UR-07-8316 (December 2007).

LANL 2007c: "Delta Prime Site Aggregate Area Investigation Report," Los Alamos National Laboratory document LA-UR-07-5459 (November 2007).

LANL 2008a: "Asphalt Monitoring and Removal Plan for Area of Concern C-00-041, Guaje/Barrancas/Rendija Canyons Aggregate Area," Los Alamos National Laboratory document LA-UR-08-2666 (April 2008).

LANL 2008b: "Summary of Storm Water Monitoring Activities at Site Monitoring Areas in the Guaje/Barrancas/Rendija Canyons Aggregate," Los Alamos National Laboratory (April 2008).

LANL 2008c: "Phase II Investigation Report for the TA-16-340 Complex (Consolidated Units 13-003[a]-99 and 16-003[n]-99 and Solid Waste Management Units 16-003[o], 16-026[j2], and 16-029[f]),"Los Alamos National Laboratory document LA-UR-08-6071 (September 2008).

LANL 2008d: "Supplemental Investigation Work Plan for Consolidated Units 16-007(a)-99, (30s Line) and 16-008(a)-99 (90s Line) at Technical Area 16," Los Alamos National Laboratory document LA-UR-08-6892 (November 2008).

LANL 2008e: "Supplemental Investigation Work Plan for Intermediate and Regional Groundwater at Consolidated Unit 16-021(c)-99," Los Alamos National Laboratory document LA-UR-08-3991 (June 2008).

LANL 2008f: "Investigation Report for Bayo Canyon Aggregate Area," Los Alamos National Laboratory document LA-UR-08-1134 (March 2008).

LANL 2008g: "Investigation Report for Bayo Canyon Aggregate Area, Revision 1," Los Alamos National Laboratory document LA-UR-08-3202 (May 2008).

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Appendix A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

General Formation of a Standard

Standards are created to protect a target group from a variety of contaminants in a given exposure pathway for a specific time frame. A target group may refer to the general public, animals, or a sensitive population like adolescents, the elderly, or asthmatics. Contaminants of concern are addressed by a governing body, such as the EPA, which takes into consideration occurrence in the environment, human exposure and risks of adverse health effects, available methods of detection, cost of implementation, geographic location, and public health. After a contaminant of concern has been identified, all exposure pathways are considered to determine the most probable instances and the need for regulation. Pathways of exposure include air, water, soil, biota, and foodstuffs that can be ingested, absorbed, or inhaled. Time of exposure is also an important factor in the formation of standards because prolonged exposure to low levels of a contaminant can have similar health effects as a short exposure to a high level of a contaminant.

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, or foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 450.1A, "Environmental Protection Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1A, "Environmental Safety and Health Reporting" (DOE 2008, DOE 1999, DOE 2003).

Radiation Standards

DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the EPA dose factors from Federal Guidance Report No. 13 (EPA 1999). The dose factors EPA adopted are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard for the public (NCRP 1987). Table A-1 lists currently applicable radiation protection standards, now referred to as public dose limits, for operations at the Laboratory. DOE's comprehensive public dose limit for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem per year. For one specific activity or pathway, DOE guidance specifies a "dose constraint" of 25 mrem per year (DOE 1999.) The public dose limits and the DOE occupational dose limits are based on recommendations in ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure. External dose factors were obtained from Federal Guidance Report No. 12 (EPA 1993).

Radionuclide concentrations in water are compared with DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for water are those concentrations in water that if consumed at a maximum rate of 730 liters per year, would give a dose of 100 mrem per year. Table A-2 shows the DCGs. For comparison with drinking-water systems, the DCGs are multiplied by 0.04 to correspond with the EPA limit of 4 mrem per year.

In addition to DOE standards, in 1985 and 1989, the EPA established the National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities, 40 CFR 61, Subpart H. This regulation states that emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. DOE has adopted this dose limit (Table A-1). This dose is calculated at the location of a residence, school, business, or office. 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.

Table A-1
DOE Dose Limits for External and Internal Exposures

Exposure pathway	Dose Equivalent[a] at Point of Maximum Probable Exposure
Exposure of Any Member of the Public[b]	
All Pathways	100 mrem/yr[c]
One Specific Pathway (dose constraint)	25 mrem/yr[d]
Air Pathway Only[e]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem/yr (TEDE)[f]
Nonstochastic Effects	
Lens of eye	15 rem/yr
Extremity	50 rem/yr
Skin of the whole body	50 rem/yr
Skin of the whole body	50 rem/yr
Embryo/Fetus of Declared Pregnant Worker	0.5 rem/gestation period

[a] Refer to Glossary for definition.

[b] In keeping with DOE policy, exposures must be limited to as small a fraction of the respective annual dose limits as practicable. DOE's public dose limit applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from DOE Order 5400.5 (DOE 1990). Limits for occupational exposure are taken from 10 CFR 835, Occupational Radiation Protection.

[c] Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem per year.

[d] Guidance (DOE 1999.)

[e] This level is from EPA's regulations issued under the Clean Air Act (40 CFR 61, Subpart H) (EPA 1989a).

[f] Refer to Glossary for definition.

Table A-2
DOE's Derived Concentration Guides for Watera

Nuclide	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)[b]
^{3}H	2,000,000	80,000
^{7}Be	1,000,000	40,000
^{89}Sr	20,000	800
^{90}Sr	1,000	40
^{137}Cs	3,000	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] Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990). Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.

[b] Drinking water DCGs are 4% of the DCGs for non-drinking water.

National Pollutant Discharge Elimination System

The types of monitoring required under National Pollutant Discharge Elimination System (NPDES) and the limits established for sanitary and industrial outfalls can be found at http://www.lanl.gov/environment/h2o/cw_npdes.shtml.

Drinking Water Standards

For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (NMEIB 1995). To view the New Mexico Drinking Regulations go to http://www.nmenv.state.nm.us/Common/regs_idx.html. EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

Nonradioactive Air Quality Standards

Table A-3 shows federal and state ambient air quality standards for nonradioactive pollutants.

Table A-3
National (40 CFR 50) and New Mexico (20.2.3 NMAC) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards	
				Primary	Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total Suspended Particulates	Annual	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours	$\mu g/m^3$	150		
PM-10[a]	Annual	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
PM-2.5[b]	Annual	$\mu g/m^3$		15	15
	24 hours	$\mu g/m^3$		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	$\mu g/m^3$		1.5	1.5

[a] Particles ≤10 μm in diameter.
[b] Particles ≤2.5 μm in diameter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards

Concentrations of radionuclides in surface water samples may be compared with either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering

and Wildlife Habitat stream standards (NMWQCC 1995) (http://www.nmenv.state.nm.us/NMED_regs/swqb/20_6_4_nmac.pdf). The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

Organic Analysis of Surface and Groundwaters: Methods and Analytes

Organic analyses of surface waters, groundwaters, and sediments are made using SW-846 methods. The specific compounds analyzed in each suite are listed in the supplemental tables for Chapters 5 and 6.

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NMWQCC 1995: New Mexico Water Quality Control Commission, "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," Section 3-101.K (as amended through January 23, 1995).

Appendix B

UNITS OF MEASUREMENT

Throughout this report the US Customary (English) system of measurement has generally been used because those are the units in which most data and measurements are collected or measured. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively. Table B-1 presents conversion factors for converting US Customary Units into SI units.

Table B-1
Approximate Conversion Factors for Selected US Customary Units

Multiply US Customary units	by	to Obtain SI (Metric) Unit
Fahrenheit (°F)	5/9 - 32	Celsius (°C)
inches (in.)	2.54	centimeters (cm)
cubic feet (ft^3)	0.028	cubic meters (m^3)
acres	.4047	hectares (ha)
ounces (oz)	28.3	grams (g)
pounds (lb)	0.453	kilograms (kg)
miles (mi)	1.61	kilometers (km)
gallons (gal.)	3.785	liters (L)
feet (ft)	0.305	meters (m)
parts per million (ppm)	1	micrograms per gram (μg/g)
parts per million (ppm)	1	milligrams per liter (mg/L)
square miles (mi^2)	2.59	square kilometers (km^2)
picocurie (pCi)	37	millibecquerel (mBq)
rad	0.01	gray (Gy)
millirem (mrem)	0.01	millisievert (mSv)

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 2,000. 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-3 presents abbreviations for common measurements.

Table B-2
Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
mega	1 000 000 or 10^{6}	M
kilo	1 000 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

Table B-3
Common Measurement Abbreviations and Measurement Symbols

Symbol	Abbreviation	Symbol	Abbreviation
aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu	British thermal unit	nCi	nanocurie
Ci	curie	nCi/dry g	nanocurie per dry gram
cm^3/s	cubic centimeters per second	nCi/L	nanocurie per liter
cpm/L	counts per minute per liter	ng/m^3	nanogram per cubic meter
fCi/g	femtocurie per gram	pCi/dry g	picocurie per dry gram
ft	foot or feet	pCi/g	picocurie per gram
ft^3/min	cubic feet per minute	pCi/L	picocurie per liter
ft^3/s	cubic feet per second	pCi/m^3	picocurie per cubic meter
kg	kilogram	pCi/mL	picocurie per milliliter
kg/h	kilogram per hour	pg/g	picogram per gram
m^3/s	cubic meter per second	pg/m^3	picogram per cubic meter
μCi/L	microcurie per liter	PM_{10}	small particulate matter (less than 10 μm diameter)
μCi/mL	microcurie per milliliter	$PM_{2.5}$	small particulate matter (less than 2.5 μm diameter)
μg/g	microgram per gram	R	roentgen
$μg/m^3$	microgram per cubic meter	*s*, SD, or σ	standard deviation
mL	milliliter	sq ft (ft^2)	square feet
mm	millimeter	>	greater than
μm	micrometer	<	less than
μmho/cm	micro mho per centimeter	≥	greater than or equal to
mCi	millicurie	≤	less than or equal to
mg	milligram	±	plus or minus
mR	milliroentgen	~	approximately
mrad	millirad		

DATA HANDLING OF RADIOCHEMICAL SAMPLES

Measurements of radiochemical 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. Consequently, individual measurements can result in values of positive or 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 station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{½}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1*s*) for the station and group means.

REFERENCE

Gilbert 1975: R. O. Gilbert, "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

DESCRIPTION OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-2. The main programs conducted at each of the areas are listed in this Appendix.

Technical Area	Activities
TA-0 (Off-site Facilities)	This TA designation is assigned to structures leased by DOE that are located outside LANL's boundaries in the Los Alamos townsite and White Rock.
TA-2 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-MW nuclear research reactor, was located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor was decontaminated and decommissioned in 2002.
TA-3 (Core Area or South Mesa Site)	This TA is LANL's core scientific and administrative area, with approximately half of LANL's employees and total floor space. It is the location of a number of the LANL'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.
TA-5 (Beta Site)	This TA is largely undeveloped. Located between East Jemez Road and the San Ildefonso Pueblo, it contains physical support facilities, an electrical substation, and test wells.
TA-6 (Two-Mile Mesa Site)	This TA, located in the northwestern part of LANL, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, and aging vacant buildings that are awaiting demolition.
TA-8 (GT-Site [Anchor Site West])	This TA, 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.
TA-9 (Anchor Site East)	This TA is located on the western edge of LANL. Fabrication feasibility and the physical properties of explosives are explored at this TA, and new organic compounds are investigated for possible use as explosives.
TA-11 (K-Site)	This TA 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.
TA-14 (Q-Site)	This TA, located in the northwestern part of LANL, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high explosives machining, and permitted burning.
TA-15 (R-Site)	This TA, located in the central portion of LANL, is used for high explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. TA-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.
TA-16 (S-Site)	TA-16, in the western part of LANL, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. The TA is also the location of high explosives research, development, and testing, and the High Explosives Wastewater Treatment Facility.

Technical Area	Activities
TA-18 (Pajarito Site)	This TA, located in Pajarito Canyon, is the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. It is the location of the Solution High-Energy Burst Assembly and is also used for teaching and training related to criticality safety and applications of radiation detection and instrumentation. All Security Category I and II materials and activities have been relocated to the Nevada Test Site.
TA-21 (DP-Site)	TA-21 is on the northern border of LANL, next to the Los Alamos townsite. In the western part of the TA is the former radioactive materials (including plutonium) processing facility that has been partially decontaminated and decommissioned. In the eastern part of the TA are the Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility. Operations from both facilities have been transferred elsewhere as of the end of 2006.
TA-22 (TD-Site)	This TA, located in the northwestern portion of LANL, houses the Los Alamos Detonator Facility. Construction of a new Detonator Production Facility began in 2003. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
TA-28 (Magazine Area A)	TA-28, located near the southern edge of LANL, was an explosives storage area. The TA contains five empty storage magazines that are being decontaminated and decommissioned.
TA-33 (HP-Site)	TA-33 is a remotely-located TA at the southeastern boundary of LANL. The TA 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 TA.
TA-35 (Ten Site)	This TA, located in the north central portion of LANL, 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 this TA, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at TA-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 TA-35.
TA-36 (Kappa-Site)	TA-36, a remotely-located area in the eastern portion of LANL, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
TA-37 (Magazine Area C)	This TA is used as an explosives storage area. It is located at the eastern perimeter of TA-16.
TA-39 (Ancho Canyon Site)	TA-39 is located at the bottom of Ancho Canyon. This TA is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
TA-40 (DF-Site)	TA-40, centrally located within LANL, is used for general testing of explosives or other materials and development of special detonators for initiating high explosives systems.
TA-41 (W-Site)	TA-41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.
TA-43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	TA-43 is adjacent to the Los Alamos Medical Center at the northern border of LANL. Two facilities are located within this TA: the Bioscience Facilities (formerly called the Health Research Laboratory) and NNSA's local Site Office. The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at LANL. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.

Technical Area	Activities
TA-46 (WA-Site)	TA-46, located between Pajarito Road and the San Ildefonso Pueblo, is one of LANL'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 TA.
TA-48 (Radiochemistry Site)	TA-48, located in the north central portion of LANL, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
TA-49 (Frijoles Mesa Site)	TA-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. A fire support building and helipad located near the entrance to the TA are operated by the U.S. Forest Service.
TA-50 (Waste Management Site)	TA-50, located near the center of LANL, 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 TA.
TA-51 (Environmental Research Site)	TA-51, located on Pajarito Road in the eastern portion of LANL, 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 TA.
TA-52 (Reactor Development Site)	TA-52 is located in the north central portion of LANL. 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 TA.
TA-53 (Los Alamos Neutron Science Center)	TA-53, located in the northern portion of LANL, includes the LANSCE. LANSCE 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 contributes to defense programs. LANSCE has also produced medical isotopes for the past 20 years.
TA-54 (Waste Disposal Site)	TA-54, located on the eastern border of LANL, is one of the largest TAs at LANL. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage, treatment, decontamination, and disposal operations.
TA-55 (Plutonium Facility Complex Site)	TA-55, located in the center of LANL, 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. The Chemistry and Metallurgy Research Building Replacement, currently under construction, will provide chemistry and metallurgy research, actinide chemistry, and materials characterization capabilities.
TA-57 (Fenton Hill Site)	TA-57 is located about 20 miles (32 kilometers) west of LANL on land administered by the U.S. Forest Service. The primary purpose of the TA is observation of astronomical events. TA-57 houses the Milagro Gamma Ray Observatory and a suite of optical telescopes. Drilling technology research is also performed in this TA.
TA-58 (Twomile North Site)	TA-58, located near LANL's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to TA-3. The TA houses a few LANL-owned storage trailers and a temporary storage area.

Technical Area	Activities
TA-59 (Occupational Health Site)	This TA is located on the south side of Pajarito Road adjacent to TA-3. This 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 TA-59 includes a clinical laboratory and provides bioassay sample analytical support.
TA-60 (Sigma Mesa)	TA-60 is located southeast of TA-3. The TA is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located here. Due to the moratorium on testing, these buildings have been placed in indefinite safe shutdown mode.
TA-61 (East Jemez Site)	TA-61, located in the northern portion of LANL, contains physical support and infrastructure facilities, including a sanitary landfill operated by Los Alamos County and sewer pump stations.
TA-62 (Northwest Site)	TA-62, located next to TA-3 and West Jemez Road in the northwest corner of LANL, serves as a forested buffer zone. This TA is reserved for future use.
TA-63 (Pajarito Service Area)	TA-63, located in the north central portion of LANL, contains physical support and infrastructure facilities. The facilities at this TA serve as localized storage and office space.
TA-64 (Central Guard Site)	This TA is located in the north central portion of LANL and provides offices and storage space.
TA-66 (Central Technical Support Site)	TA-66 is located on the southeast side of Pajarito Road in the center of LANL. The Advanced Technology Assessment Center, the only facility at this TA, provides office and technical space for technology transfer and other industrial partnership activities.
TA-67 (Pajarito Mesa Site)	TA-67 is a forested buffer zone located in the north central portion of LANL. No operations or facilities are currently located at the TA.
TA-68 (Water Canyon Site)	TA-68, located in the southern portion of LANL, is a testing area for dynamic experiments that also contains environmental study areas.
TA-69 (Anchor North Site)	TA-69, located in the northwestern corner of LANL, serves as a forested buffer area. The new Emergency Operations Center, completed in 2003, is located here.
TA-70 (Rio Grande Site)	TA-70 is located on the southeastern boundary of LANL and borders the Santa Fe National Forest. It is a forested TA that serves as a buffer zone.
TA-71 (Southeast Site)	TA-71 is located on the southeastern boundary of LANL and is adjacent to White Rock to the northeast. It is an undeveloped TA that serves as a buffer zone for the High Explosives Test Area.
TA-72 (East Entry Site)	TA-72, located along East Jemez Road on the northeastern boundary of LANL, is used by protective force personnel for required firearms training and practice purposes.
TA-73 (Airport Site)	TA-73 is located along the northern boundary of LANL, adjacent to Highway 502. The County of Los Alamos manages, operates, and maintains the community airport under a leasing arrangement with DOE. Use of the airport by private individuals is permitted with special restrictions.
TA-74 (Otowi Tract)	TA-74 is a forested area in the northeastern corner of LANL. A large portion of this TA has been conveyed to Los Alamos County or transferred to the Department of the Interior in trust for the Pueblo of San Ildefonso and is no longer part of LANL.

Appendix D

RELATED WEBSITES

For more information on environmental topics at Los Alamos National Laboratory, access the following websites:

Environmental Surveillance reports and supplemental data tables	http://www.lanl.gov/environment/all/esr.shtml
Los Alamos National Laboratory website	http://www.lanl.gov
DOE/NNSA Los Alamos Site Office website	http://www.doeal.gov/laso/default.aspx
Department of Energy website	http://www.energy.gov
LANL's air quality pages	http://www.lanl.gov/environment/air/index.shtml
LANL's water quality pages	http://www.lanl.gov/environment/h2o/index.shtml
LANL's waste pages	http://www.lanl.gov/environment/waste/index.shtml
LANL's biological resources pages	http://www.lanl.gov/environment/bio/index.shtml
LANL's risk reduction pages	http://www.lanl.gov/environment/risk/index.shtml
LANL's clean-up pages	http://www.lanl.gov/environment/cleanup/index.shtml
LANL's environmental database	http://www.lanl.gov/environment/all/racer.shtml

Glossary

activation products	Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.
alpha particle	A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
ambient air	The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.
AOC	Area of concern.
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
artesian well	A well in which the water rises above the top of the water-bearing bed.
background radiation	Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.
beta particle	A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.
biota	The types of animal and plant life found in an area.
blank sample	A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.
blind sample	A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

CAA	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
CFR	Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the Federal Register.
contamination	(1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
Ci	Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DCG	Derived Concentration Guides. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem. DCGs do not consider decay products when the parent radionuclide is the cause of the exposure (DCG values are presented in DOE Order 5400.5).
DOE	US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production. Los Alamos National Laboratory is managed by the NNSA, an agency within the DOE.

dose	A term denoting the quantity of radiation energy absorbed.
absorbed dose	The energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
dose equivalent	The product of absorbed dose in rad (or gray) in tissue, a quality factor, and other modifying factors. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).
TEDE	Total effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to 100 × 0.12 = 12 mrem.
Maximum individual dose	The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.
population dose	The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)
whole body dose	A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).
effluent	A liquid waste discharged to the environment.
EIS	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
emission	A gaseous waste discharged to the environment.
environmental compliance	The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.

environmental monitoring	The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.
environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.
EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains (½ × ½), after three half-lives, one-eighth (½ × ½ × ½), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.
ionizing radiation	Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.
isotopes	Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.
long-lived isotope	A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
short-lived isotope	A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).
MCL	Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.
MDA	Material disposal area.
MEI	Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.

mixed waste	Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).
mrem	Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.
NEPA	National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.
NESHAP	National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.
NNSA	National Nuclear Security Agency. An agency within the DOE that is responsible for national security through the military application of nuclear energy.
nonhazardous waste	Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.
NPDES	National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.
nuclide	A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.
outfall	The location where wastewater is released from a point source into a receiving body of water.
PCB	Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976.

PDL	Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).
PE Curie	One PE curie is the quantity of transuranic material that has the same radiation inhalation hazard as one curie of Pu-239. The PE curie is described in Appendix B of http://www.wipp.energy.gov/library/wac/WAC.pdf
perched groundwater	A groundwater body above a slow-permeability rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.
person-rem	A quantity used to describe the radiological dose to a population. Population doses are calculated according to sectors, and all people in a sector are assumed to get the same dose. The number of person-rem is calculated by summing the modeled dose to all receptors in all sectors. Therefore, person-rem is the sum of the number of people times the dose they receive.
pH	A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
pollution	Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).
point source	An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.
ppb	Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or µg/kg.
ppm	Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as µg/g or mg/kg.
QA	Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.
QC	Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

rad	Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body. 1 rad = 1,000 millirad (mrad)
radionuclide	An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.
RCRA	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
release	Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.
rem	Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation. rem = rad × quality factor 1 rem = 1,000 millirem (mrem)
SARA	Superfund Amendments and Reauthorization Act of 1986. This Act modifies and reauthorizes CERCLA. Title III of this Act is known as the Emergency Planning and Community Right-to-Know Act of 1986
saturated zone	Rock or soil where the pores are completely filled with water, and no air is present.
SWMU	Solid waste management unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).
terrestrial radiation	Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.

TLD	Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.
TRU	Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.
TSCA	Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the Act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this Act for controlling substances found to be detrimental to human health or to the environment.
tuff	Rock formed from compacted volcanic ash fragments.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
unsaturated zone	See vadose zone in this glossary.
UST	Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.
vadose zone	The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.
water table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.
watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.

wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

Acronyms and Abbreviations

AIRNET	Ambient Air Monitoring Network
AOC	area of concern
AQA	Analytical Quality Associates
BCG	Biota Concentration Guides
BSRL	baseline statistical reference level
CFR	Code of Federal Regulations
CGP	Construction General Permit
CMR	Chemistry and Metallurgy Research (LANL building)
CWA	Clean Water Act
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
DOE	Department of Energy
DOECAP	Department of Energy Contract Analytical Program
DRO	diesel-range organic compound
DPRNET	Direct penetrating radiation monitoring network
DU	depleted uranium
EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
EU	enriched uranium
FFCA	Federal Facility Compliance Agreement
FY	fiscal year
GEL	General Engineering Laboratory
GMAP	gaseous mixed air activation products
HE	high-explosive
HMX	cyclotetramethylenetetranitramine
HSWA	Hazardous and Solid Waste Amendments
HT	elemental tritium
HTO	tritium oxide
ISM	Integrated Safety Management (LANL)
LANL	Los Alamos National Laboratory (or the Laboratory)
LANSCE	Los Alamos Neutron Science Center (TA-53)

LASO	Los Alamos Site Office (DOE)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	material disposal area
MDL	method detection limit
MEI	maximally exposed individual
MSGP	Multi-Sector General Permit
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
ODS	Ozone depleting substances
P2	Pollution Prevention Program
PCB	polychlorinated biphenyls
PM	particulate matter
ppb	parts per billion
P/VAP	particulate/vapor activation products
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SAL	screening action level
SL	screening level
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
SWEIS	Site-Wide Environmental Impact Statement
SWPPP	Storm Water Pollution Prevention Plan
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act

Elemental & Chemical Nomenclature

Actinium	Ac	Helium	He	Praseodymium	Pr
Aluminum	Al	Holmium	Ho	Promethium	Pm
Americium	Am	Hydrogen	H	Protactinium	Pa
Argon	Ar	Hydrogen oxide	H_2O	Radium	Ra
Antimony	Sb	Indium	In	Radon	Rn
Arsenic	As	Iodine	I	Rhenium	Re
Astatine	At	Iridium	Ir	Rhodium	Rh
Barium	Ba	Iron	Fe	Rubidium	Rb
Berkelium	Bk	Krypton	Kr	Ruthenium	Ru
Beryllium	Be	Lanthanum	La	Samarium	Sm
Bicarbonate	HCO_3	Lawrencium	Lr (Lw)	Scandium	Sc
Bismuth	Bi	Lead	Pb	Selenium	Se
Boron	B	Lithium	Li	Silicon	Si
Bromine	Br	Lithium fluoride	LiF	Silver	Ag
Cadmium	Cd	Lutetium	Lu	Sodium	Na
Calcium	Ca	Magnesium	Mg	Strontium	Sr
Californium	Cf	Manganese	Mn	Sulfate	SO_4
Carbon	C	Mendelevium	Md	Sulfite	SO_3
Cerium	Ce	Mercury	Hg	Sulfur	S
Cesium	Cs	Molybdenum	Mo	Tantalum	Ta
Chlorine	Cl	Neodymium	Nd	Technetium	Tc
Chromium	Cr	Neon	Ne	Tellurium	Te
Cobalt	Co	Neptunium	Np	Terbium	Tb
Copper	Cu	Nickel	Ni	Thallium	Tl
Curium	Cm	Niobium	Nb	Thorium	Th
Cyanide	CN	Nitrate (as Nitrogen)	NO_3-N	Thulium	Tm
Carbonate	CO_3	Nitrite (as Nitrogen)	NO_2-N	Tin	Sn
Dysprosium	Dy	Nitrogen	N	Titanium	Ti
Einsteinium	Es	Nitrogen dioxide	NO_2	Tritiated water	HTO
Erbium	Er	Nobelium	No	Tritium	^3H
Europium	Eu	Osmium	Os	Tungsten	W
Fermium	Fm	Oxygen	O	Uranium	U
Fluorine	F	Palladium	Pd	Vanadium	V
Francium	Fr	Phosphorus	P	Xenon	Xe
Gadolinium	Gd	Phosphate (as Phosphorus)	PO_4-P	Ytterbium	Yb
Gallium	Ga	Platinum	Pt	Yttrium	Y
Germanium	Ge	Plutonium	Pu	Zinc	Zn
Gold	Au	Polonium	Po	Zirconium	Zr
Hafnium	Hf	Potassium	K		

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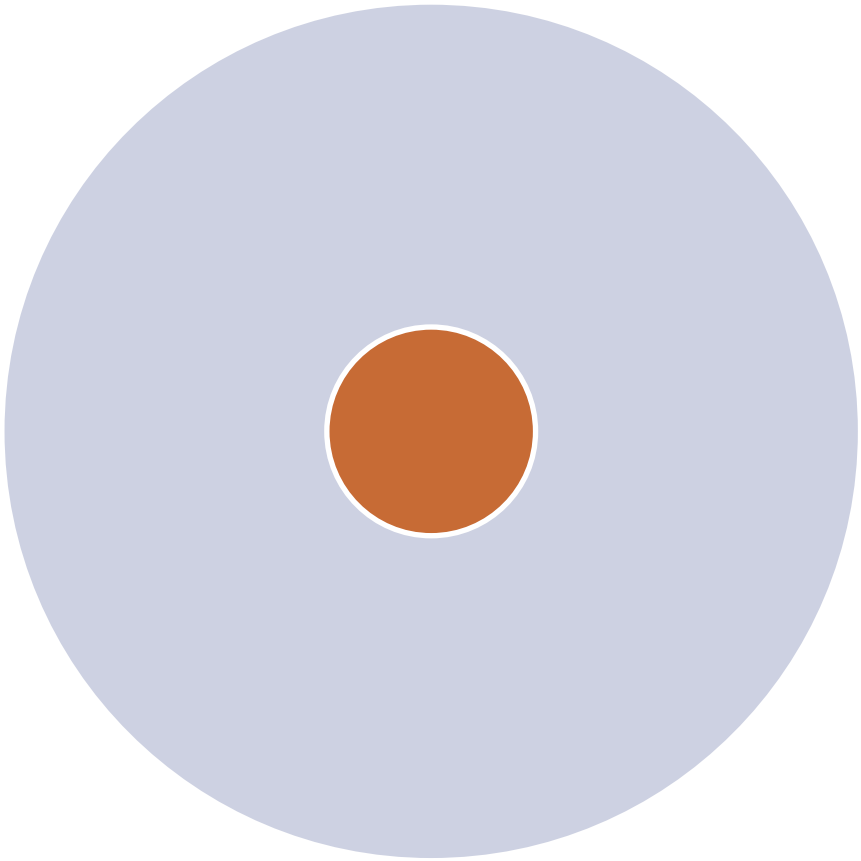
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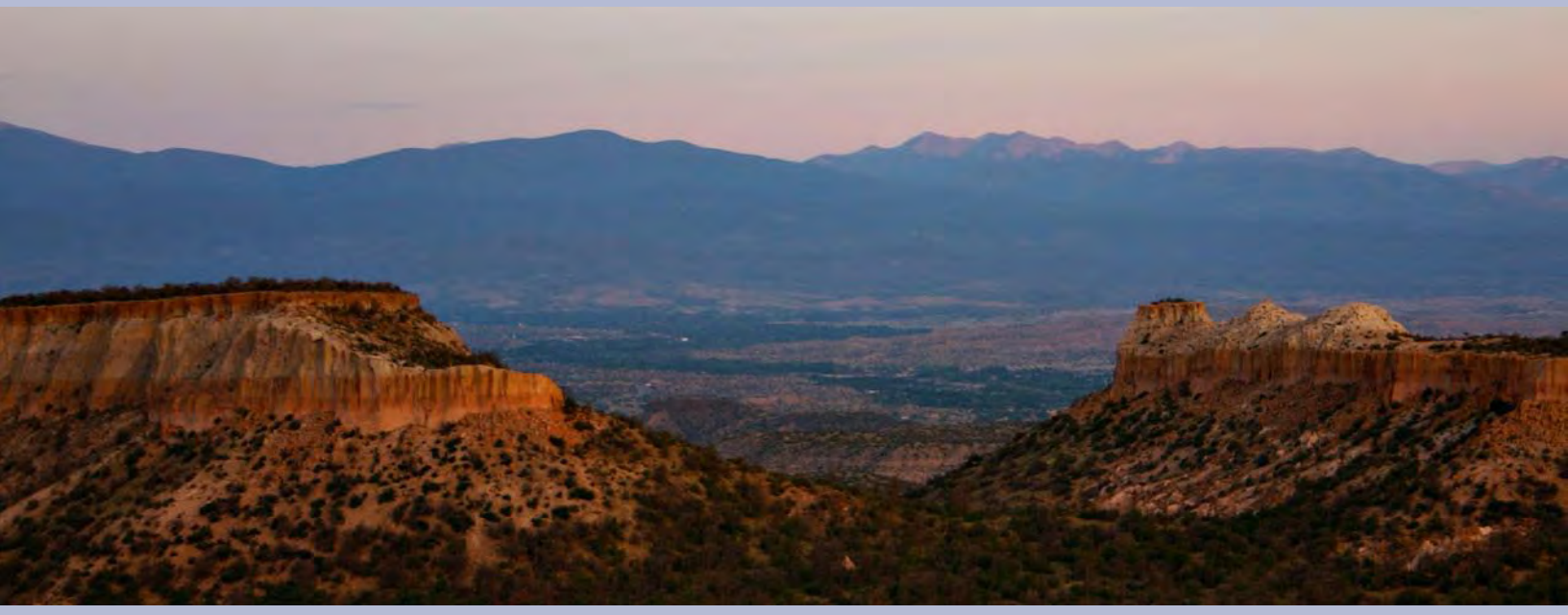
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