Environmental Surveillance at Los Alamos during 2005

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Los Alamos NATIONAL LABORATORY
EST. 1943

POLICY ON ENVIRONMENT

It is the policy of Los Alamos National Laboratory to be a responsible steward of our environment while conducting mission work. It is our commitment to operate in a manner that ensures compliance with legal and other environmental regulatory requirements; work to prevent pollution by proactively identifying and preventing environmental risk; set quantifiable objectives, monitor progress, minimize consequences to the environment stemming from our past, present, and future operations; and work in harmony with the natural and human environment.

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Environment & Remediation Support Services Division
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Ecology and Air Quality Group
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ABSTRACT

Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (LANL or the Laboratory) environmental organization, as required by US Department of Energy Order 5400.1, 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. Chapter 2 reports the Laboratory's compliance status for 2005. Chapter 3 provides a summary of the maximum radiological dose the public and biota populations could have potentially received from Laboratory operations. 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, new for this year, 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 enclosed a compact disc (CD) with a copy of the full report in Adobe Acrobat (PDF) form and detailed supplemental tables of data from 2005 in Microsoft Excel (.xls) format. These files are also available for download from the web.

Inquiries or comments regarding these annual reports may be directed to

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

Environmental Surveillance
at Los Alamos during 2005

Executive Summary

Los Alamos
NATIONAL LABORATORY
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EXECUTIVE SUMMARY

The Los Alamos National Laboratory (LANL) is located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure ES-1). The 40-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of 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 above the Rio Grande Canyon. Most Laboratory and 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; 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, the Bandelier National Monument, the US General Services Administration, and the County of Los Alamos. 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 the threat of weapons of mass destruction, proliferation, and terrorism, and (3) solve national problems in defense, energy, environment, and infrastructure. 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 the commitment to environmental stewardship and compliance. Part of LANL's commitment is to report on the environmental performance of the Laboratory. This report

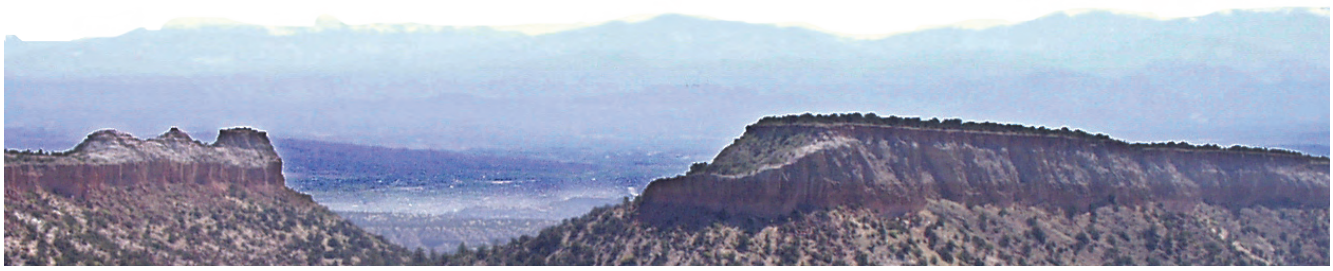
- Characterizes site environmental management,
- Describes compliance with environmental standards and requirements,
- Summarizes environmental occurrences and responses, and
- Highlights significant environmental programs and efforts.

► The Laboratory was certified as compliant with ISO 14001:2004 requirements for an Environmental Management System, the first DOE/NNSA Laboratory to achieve certification.

ENVIRONMENTAL MANAGEMENT SYSTEM (see Chapter 1)

LANL has implemented an Environmental Management System (EMS) pursuant to Department of Energy (DOE) Order 450.1 and the international standard International Standards Organization (ISO) 14001:2004. In early 2006, LANL was certified by a third-party auditor as compliant with the ISO standard, the first national laboratory operated by the DOE's National Nuclear Security Administration (NNSA) to be certified. 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 improvements, and measuring results.

The Laboratory developed a site-wide approach and framework for the EMS. Each division implemented the system within its organization and ensures internal systems are appropriate and tailored to its specific functions. The EMS core team supported divisions by facilitating meetings, providing standard procedures, tools, environmental subject matter expertise, and training as needed. The divisions evaluated products, activities, and processes to determine if they have significant potential environmental impacts. This evaluation guided development of objectives, targets, action plans, and continuous improvement plans.



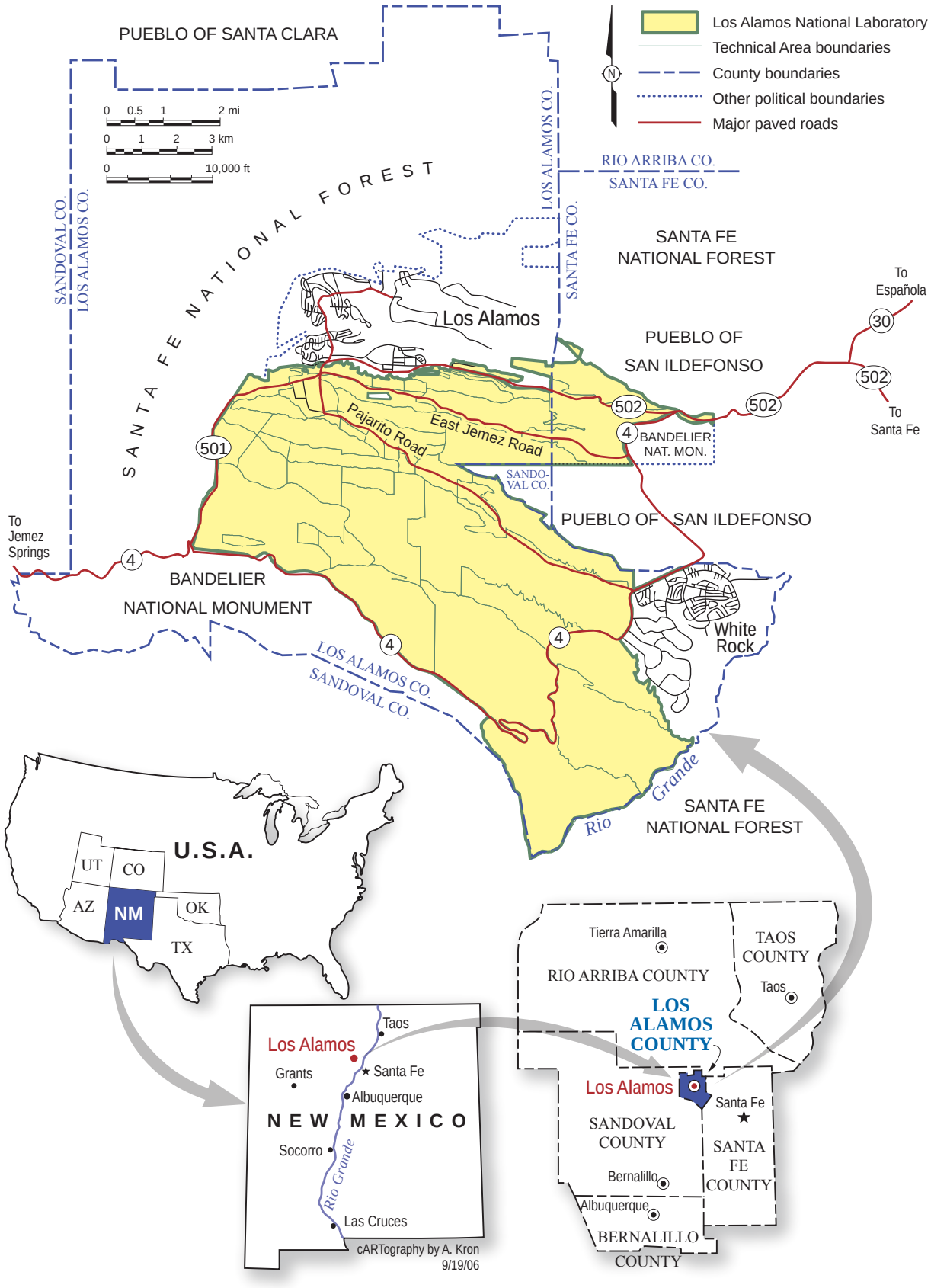


Figure ES-1. Regional location of Los Alamos National Laboratory.

ENVIRONMENTAL COMPLIANCE PROGRAMS (see Chapter 2)

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

Federal Facility Compliance Agreement

During 2005, the Laboratory continued to comply with the requirements of a Federal Facility Compliance Agreement (FFCA) between the Environmental Protection Agency (EPA) and the DOE. 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 until such time as those sources are subject to an individual storm water permit issued by the EPA. In good faith, the Laboratory began implementing the intent of the FFCA in 2004 before the FFCA was finalized.

Compliance Order on Consent (Consent Order)

A Compliance Order on Consent (Consent Order) was signed by the NMED, DOE, and University of California (UC) in March 2005. The Consent Order is the principal regulatory document for the Laboratory's Environmental Remediation and Surveillance Program and replaces the corrective action requirements of the Hazardous and Solid Waste Amendments Module of the Laboratory's Hazardous Waste Facility Permit (Module VIII). The Consent Order contains requirements for investigation and cleanup of solid waste management units and areas of concern at the Laboratory. The major activities conducted by the Laboratory included investigations and cleanup actions. All of the Laboratory deliverables were submitted on time.

- ***The Consent Order with the NMED, signed in March 2005, replaces the corrective action requirements of the Laboratory's Hazardous Waste Facility Permit and regulates non-radioactive constituents at contaminated sites and in water at the Laboratory.***
- ***The Order specifies actions that the Laboratory must complete to characterize and remediate contaminated sites and monitor the movement of contaminants.***
- ***All required deliverables and remediations were submitted or completed on time.***

Unplanned Releases

There were no reportable unplanned airborne releases from LANL in 2005. There were no unplanned releases of radioactive liquids. There were 10 spills or releases of non-radioactive liquids which included potable water (100,000 gallons), raw sewage (750 gallons), treated wastewater (7,000 gallons), boiler condensate (36,000 gallons), storm water (18,000 gallons), vegetable oil (10 gallons), and diesel fuel from leaking vehicles (2 gallons). All liquid releases were reported to NMED and will be administratively closed upon final inspection.

ENVIRONMENTAL SURVEILLANCE PROGRAMS

LANL uses a variety of materials to accomplish mission activities. Some materials are relatively benign, while other materials are hazardous or radioactive. Experiments and mission activities result in the release of some excess materials in the forms of air emissions and water discharges. These releases have the potential to affect different receptors or components of the environment including people, air, water, plants, and animals by one or many pathways, such as breathing in contaminants or coming into close proximity or contact with hazardous materials.

Environmental monitoring (surveillance of) the complex activities and multiple receptors (people, air, water, plants, and animals) over a long time period requires a comprehensive monitoring plan and strategy. In addition, monitoring information has several uses, including serving as a basis for policy, identifying actions to protect or improve the environment, and calculating the doses received by the public (Chapter 3).

Table ES-1
Environmental Statutes under which LANL Operates and Compliance Status in 2005

Federal Statute	What it Covers	Status
Resource Conservation and Recovery Act (RCRA)	Generation and management of hazardous waste and cleanup of inactive, historical waste sites.	NMED conducted one RCRA hazardous waste compliance inspection in 2005 and identified 4 alleged violations. The Laboratory completed 1,888 self-assessments that resulted in a nonconformance finding rate of less than 2% (3.5% in 2004). The Laboratory, DOE, and NMED signed the Compliance Order on Consent (Consent Order) in March 2005, which replaces Module VIII of the Hazardous Waste Facility Permit.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public's right to know about chemicals released into the community.	Only lead and mercury were used above reportable quantities. The Laboratory reported releases, waste disposal, and waste transfers totaling 9,033 lb of lead and 222 lb of mercury. No leaks, spills, or releases exceeded reporting thresholds. No updates to Emergency Planning Notifications were necessary in 2005. Chemical Inventory Reports were updated to the Los Alamos County fire and police departments for 32 chemicals or explosives.
Clean Air Act (CAA)	Air quality and emissions into the air from facility operations	The Laboratory met all permit limits for emissions to the air. Non-radiological air emissions continued to be reduced in comparison to previous years. LANL is ahead of schedule in implementing requirements designed to eliminate the use of refrigerants. The radiation dose to the maximum exposed individual (MEI) from LANL air emissions increased to 6.46 mrem during 2005, but was less than the EPA annual limit of 10 mrem. The Los Alamos Neutron Science Center (LANSCE) was the principal contributor to the dose.
Clean Water Act (CWA)	Water quality and effluent stormwater discharges from facility operations	Only one sample (a residual chlorine level) of 949 samples collected from industrial outfalls, and none of the 126 samples collected from the Sanitary Wastewater Systems Plant's outfall, exceeded effluent limits. About 93% of the Laboratory's permitted construction sites were compliant with National Pollutant Discharge Elimination System (NPDES) stormwater requirements.
Toxic Substances Control Act (TSCA)	Chemicals such as PCBs	The Laboratory shipped 88 containers 37 kg of capacitors for disposal at an EPA-permitted treatment and disposal facility, and 1,893 kg of fluorescent light ballasts for recycling.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Storage and use of pesticides	The Laboratory remained in compliance with regulatory requirements regarding use of pesticides and herbicides. Four internal inspections were conducted in 2005 and no violations were found.
Endangered Species Act (ESA) & Migratory Bird Treaty Act (MBTA)	Rare species of plants and animals	The Laboratory maintained compliance with the ESA and MBTA and they continued to monitor endangered species status.
National Historic Preservation Act (NHPA) and others	Cultural resources	The Laboratory maintained compliance with the NHPA. The Laboratory identified seven new archaeological sites and 19 historic buildings. Forty-one archaeological sites were determined eligible for the National Register of Historic Places, and 10 historic buildings were determined eligible.
National Environmental Policy Act (NEPA)	Projects evaluated for environmental impacts	The NEPA team completed two environmental evaluations. No non-compliances were reported.

The Laboratory employs a tiered approach to monitor the environment and identify impacts from LANL operations. First, the Laboratory monitors the general region to establish a baseline of environmental conditions not influenced by LANL operations. Regional monitoring also demonstrates if LANL operations are impacting areas beyond the Laboratory's boundaries. Examples of regional monitoring include the radiological air-sampling network (AIRNET) and foodstuff and biota sampling locations. The second level of environmental monitoring is at the Laboratory perimeter. This information helps determine if operations are impacting the general LANL property and neighboring property (e.g., pueblo and county lands). Perimeter monitoring also measures the highest potential impact to the public. The third level of monitoring is at specific project sites on LANL lands or property that are known or have the potential to result in emissions or discharges. Examples of locations with this type of monitoring include facility stacks for air emissions, 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 TA-54 (where waste is being handled and stored), and water discharge locations (outfalls). This tiered approach provides the data used to demonstrate compliance with applicable environmental laws and regulations. During 2005, the Laboratory collected over 10,800 samples and requested over 601,000 analyses or measurements on these samples.

Radiation doses to the public were mostly from LANSCE and were up substantially from the previous year because of

- ***over twice the operational run time at LANSCE***
- ***a defective valve (now repaired) on the emissions control system that allowed radioactive gases to bypass the delay system.***
- ***All emissions are doses were below DOE and EPA regulatory limits.***

RADIOLOGICAL DOSE ASSESSMENT (see Chapter 3)

Humans, plants, and animals receive radiation doses from natural sources and 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) over the last 13 years at an off-site location (East Gate). We calculated potential radiological doses to members of the public that resulted from LANL emissions and discharges. During 2005, the population within 80 km of LANL (approximately 280,000 people) received a collective dose of about 2.46 rem (called a person-rem), which is an increase from the dose of 0.90 person-rem reported for 2004. The dose to the hypothetical maximally exposed individual was approximately 6.46 millirem (mrem), compared to 1.68 in 2004 (Figure ES-2). The dose received in 2005 from Laboratory operations by an average Los Alamos residence and an average White Rock residence totaled about 0.11 mrem and 0.06 mrem, respectively. The increase in these doses was almost all attributable to emissions from the LANSCE accelerator facility which releases very short-lived radioactive gases from a location relatively close to the LANL boundary. The increase in emissions occurred because LANSCE operational time was over twice the previous year's level and a defective valve allowed some of the gases to bypass the emission control system. All emissions and doses were below DOE and EPA regulatory limits for the public.

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

Source or pathway (and receptor)	Dose	Location	Trends
Natural and man-made background (humans)	~500 mrem/yr	All sites	Not applicable
Air (humans)	6.46 mrem/yr	East Gate	Substantial increase from previous year but remains below DOE and EPA regulatory limits
Direct irradiation from Area G (humans)	0.9 mrem/yr	San Ildefonso – offsite	None
Food (humans)	<0.1 mrem/yr	All sites	None
Drinking water (humans)	<0.1 mrem/yr	All sites	None
All (terrestrial animals)	<10 mrad/day	TA-15 EF site, TA-21 MDA B	None
All (aquatic animals)	<11 mrad/day	LA Canyon between DP and SR-4	None
All (terrestrial plants)	<100 mrad/day	TA-15, TA-54 MDA G	None

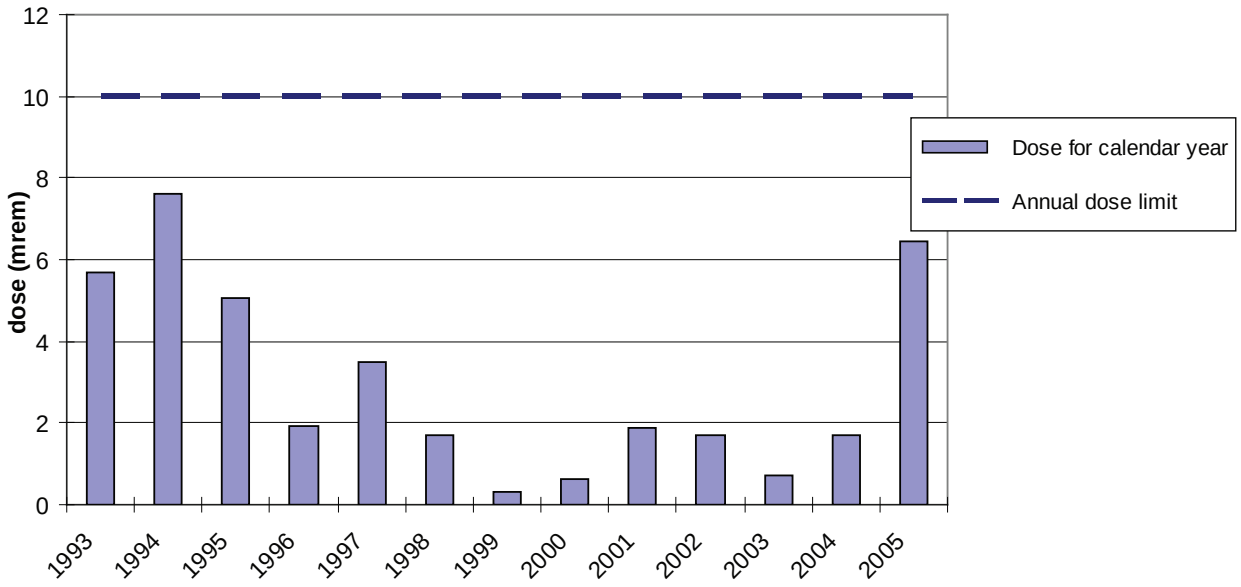


Figure ES-2. Annual dose (mrem) to the maximally exposed individual off-site over the past 13 years.

BIOTA DOSE (see Chapter 3)

The DOE biota dose limits are intended to protect populations, especially with respect to preventing the impairment of reproductive capability within the population, and are thus applied to biota populations rather than to individual plants and animals. Vegetation samples were collected from TA-54 Area G and DARHT, honey bees were collected in the area of DARHT, and surface waters were collected in specific canyons for purposes of comparing radionuclide concentrations with the DOE biota concentration guides (BCGs). Radionuclide concentrations in the vegetation and honey bee samples did not exceed 10 percent of the BCGs (and appropriate biota dose limits), which is the initial screening level. The time-weighted sum of ratios for estimated annual average surface water concentrations of radionuclides in the major canyons potentially affected by the Laboratory were well below the aquatic animal BCGs (less than 11 percent of the standard or 0.11 rad/day).

AIR EMISSIONS AND AIR QUALITY (see Chapter 4)

The Laboratory measures the emissions of radionuclides at the emission sources (building stacks) and categorizes its radioactive stack emissions into one of four types: (1) particulate matter, (2) vaporous activation products (radionuclides in gaseous state), (3) tritium, and (4) gaseous mixed activation products (air molecules made into radioactive isotopes by particle beam irradiation). Similarly, the Laboratory takes 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 plutonium, americium, uranium, and tritium.

- ***Stack emissions increased significantly in 2005 because of increased LANSCE operations and because of a malfunctioning valve in the LANSCE system.***
- ***About 98 percent of radioactive air emissions were from LANSCE operations.***
- ***The dose rate decreases very quickly with distance because of the very short half-lives of the radionuclides released by LANSCE.***

Gaseous activated air product emissions from the LANSCE stack were substantially increased from 2004 while emissions from all other stacks were comparable to previous years or slightly lower. Total stack emissions during 2005 increased to approximately 19,100 curies (Ci). Of this total, tritium emissions composed about 704 Ci (slightly less than in 2004), and short-lived air activation products from LANSCE stacks contributed nearly 18,400 Ci (a substantial increase from 2004 and 98 percent of total emissions). Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were about 0.00002 Ci and emissions of particulate/vapor activation products were less than 0.02 Ci (both about a fifth of 2004 emissions). Because of the close proximity of the LANSCE facility to the LANL site boundary, air activation emissions from LANSCE remain the greatest source of off-site dose from the airborne pathway, though this dose rate falls off very quickly with increasing distance.

- ***Measurable concentrations of radionuclides in ambient air were not detected at regional sampling locations nor at most perimeter locations.***
- ***The highest air concentrations at LANL and at perimeter locations were well below 1 percent of the applicable EPA and DOE dose guidelines.***

Radionuclide concentrations from ambient air samples in 2005 were generally comparable with concentrations in past years. Measurable concentrations of radionuclides were not detected at regional sampling locations nor at most perimeter locations. The highest annual mean radionuclide concentrations from air samples within LANL boundaries and at perimeter locations were well below one percent of the applicable EPA and DOE standards. Measurable amounts of tritium were reported at most on-site locations and at perimeter locations; the highest measurement was on-site at TA-16 near a known source and was less than 0.5 percent of the EPA public dose limit. We measured elevated tritium levels at a number of on-site stations, with the highest annual concentration, 950 picocuries per cubic meter (pCi/m^3) or about 0.005 percent of the DOE worker exposure limit, at TA-54, Area G, at a location near shafts containing tritium-contaminated waste. Plutonium was detected at two off-site stations: near Los Alamos Lodge at about 16 attocuries m^3 (aCi/m^3) or about 1 percent of the EPA public dose limit (from historical activities at LANL's old main technical area), and near the Los Alamos Airport (from remediation work at TA-21). On-site detections of plutonium occurred at TA-21 and at Area G and were substantially below 1 percent of the DOE limit for workplace exposure. Americium-241 was detected only at TA-21 and at TA-54 Area G at levels far less than 1 percent of public and worker exposure limits. The maximum annual uranium concentrations were from natural uranium at locations with high dust levels from local soil disturbances such as dirt roads at the Los Alamos County Landfill and LANL's TA-54, Area G. The regional and pueblo samples had higher average concentrations of uranium isotopes than the perimeter group at ratios that indicate natural sources.

- ***PM-10 and PM-2.5 particulate measurements in ambient air were well below EPA standards.***
- ***Beryllium air concentrations for 2005 were similar to past years and were equal to or less than 2 percent of the NESHAP standard; a natural origin is indicated by correlation with aluminum concentrations.***

Air monitoring continued at one White Rock and two Los Alamos locations 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). The annual average for PM-10 was about 13 $micrograms/m^3$ and about seven $micrograms/m^3$ for

PM-2.5 at all locations and was mostly caused by natural dust and wildfire smoke. These averages are well below the EPA standards. In addition, the 24 hour maxima for both PM-2.5 and PM 10 at all three locations were much less than the EPA standards.

The Laboratory analyzed filter samples from 23 sites for beryllium. These sites are located near potential beryllium sources at LANL or in nearby communities. Correlation with aluminum concentrations indicates that all measurements of beryllium are from naturally occurring beryllium in resuspended dust. Beryllium air concentrations for 2005 were similar to those measured in recent years. All values are equal to or less than 2 percent of the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard.

GROUNDWATER MONITORING (see Chapter 5)

Groundwater at the Laboratory occurs as a regional aquifer 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, groundwater quality is improving as

- ***outfalls are eliminated,***
- ***quantity of discharges are reduced, and***
- ***water quality of the discharges improves.***

However, contamination may be discovered in additional locations as contaminants migrate over time.

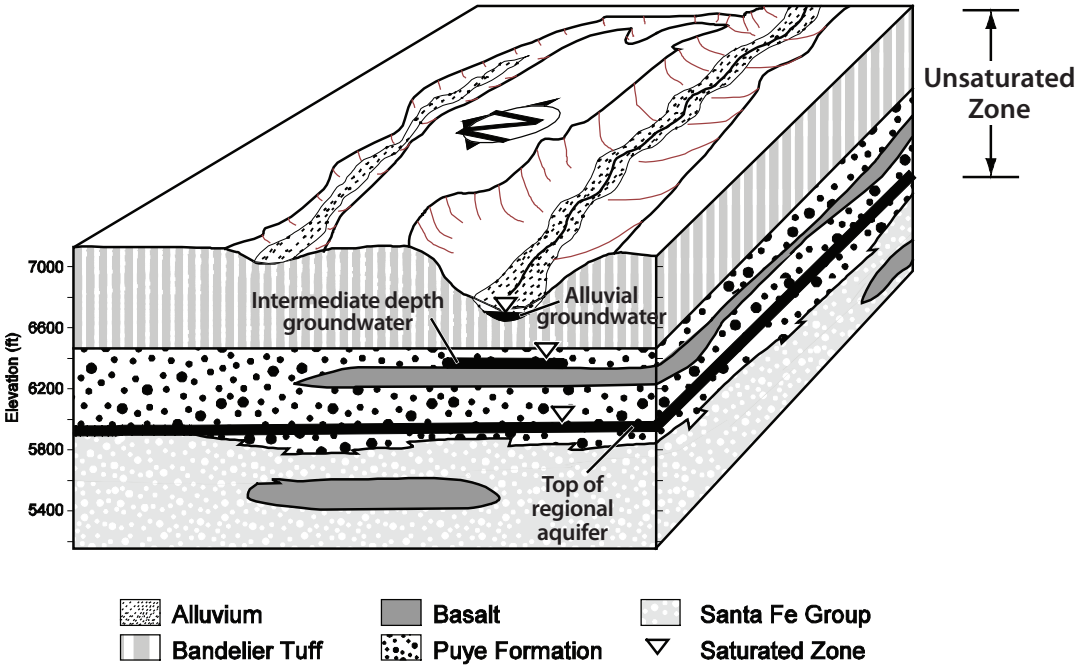


Figure ES-3. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

Monitoring of the groundwater increased substantially from previous years to work towards monitoring requirements specified in the Consent Order. Table ES-3 summarizes contaminants found 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 or Risk Levels?

Chemical	On-Site	Off-Site	Significance	Trends
Hexavalent chromium	Regional and intermediate groundwater in Mortandad Canyon, regional in Sandia Canyon	No	Exceeds NM groundwater standard by factor of 8 in regional aquifer beneath Mortandad Canyon; not seen above background in water supply wells	Insufficient data to evaluate trend, extent under investigation
Perchlorate	All groundwater zones in Mortandad Canyon, regional aquifer in Pueblo Canyon, alluvial groundwater in Cañon de Valle	Yes, in Pueblo Canyon	Values exceed EPA drinking water risk level in Mortandad Canyon alluvial and intermediate groundwater; supply well with values at 1/10th of risk level is permanently off line	Decreasing in Mortandad Canyon alluvial groundwater due to effluent quality improvement; insufficient data for other groundwater
Dioxane[1,4-]	Intermediate groundwater in Mortandad Canyon	No	Just below EPA drinking water risk level, not used as drinking water supply	Insufficient data to evaluate trend, extent under investigation
Nitrate	Intermediate groundwater in Mortandad Canyon, alluvial and intermediate groundwater in Pueblo Canyon	Yes, in Pueblo Canyon	Above NM groundwater standards in Mortandad Canyon intermediate groundwater; in Pueblo Canyon, may be due to LA County's Bayo Sewage Treatment Plant; just below EPA drinking water risk level	Insufficient data in Mortandad, source eliminated in 1999; values in Pueblo are variable
Barium	Alluvial and intermediate groundwater in Cañon de Valle	No	Exceeds NM groundwater standard by 10 times in alluvial groundwater, not used as drinking water supply	Values seasonably variable but remain high, most sources eliminated
High explosives	Alluvial and intermediate groundwater in Cañon de Valle	No	RDX exceeds EPA drinking water risk levels by 20 to 40 times in intermediate and alluvial groundwater, not used as drinking water supply	Values seasonably variable but remain high, most sources eliminated
Tritium	Intermediate groundwater in Mortandad Canyon	No	Exceeds MCL, not used as a drinking water supply	Insufficient data to evaluate trend, source eliminated in 2001
Other radionuclides	Alluvial groundwater in Mortandad Canyon	No	Not used as a drinking water supply; radionuclides have not moved to deeper groundwater	Some constituents are fixed in location; some are decreasing due to effluent quality improvements in 1999
Molybdenum	Alluvial groundwater in Los Alamos Canyon	No	Near NM groundwater standard, not used as drinking water supply, limited in extent	Fairly steady for over 10 years, source eliminated in 2002

▶ *Chromium contamination was recently detected in the regional aquifer at concentrations above drinking water standards.*

▶ *The contamination is likely the result of discharges made in the 1960s and early 1970s containing chromate in cooling tower discharges.*

▶ *No drinking water wells have been affected by the contamination.*

Chromium was detected in one well in the regional aquifer under Mortandad Canyon during 2005 at concentrations exceeding drinking water standards, though no drinking water wells are affected. The chromium is most likely from discharges of cooling water containing chromate (used to control corrosion) from TA-3 that took place from the 1960s until 1972. The Laboratory has started investigation of this contamination in cooperation with the NMED. High concentrations of naturally occurring uranium and arsenic are also found in groundwater samples from some regional aquifer wells and springs. Most other metals found at high concentrations (aluminum, manganese, and iron) in groundwater samples at LANL are due to well sampling and well construction issues rather than to LANL contamination. The use of fluids to assist with well drilling and the use of other materials in well completion has affected the chemistry of some groundwater samples.

Dioxane, a volatile organic compound used as a stabilizer for chlorinated organic solvents, was detected during June in two intermediate wells in Mortandad Canyon. The Laboratory has started investigation of this contamination in cooperation with the NMED.

Drainages that in the past received liquid radioactive effluents include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon; only Mortandad currently receives treated radioactive effluent, from the Radioactive Liquid Waste Treatment Facility. For the past six years, the facility has met all DOE radiological discharge standards and all NPDES requirements, and except during two weeks in 2003 (two weekly composite samples exceeded the fluoride standard) has voluntarily met NM groundwater standards for fluoride, nitrate, and total dissolved solids.

Water Canyon and its tributary Cañon de Valle formerly received effluents produced by high explosives (HE) 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.

Naturally occurring uranium was the main radioactive element detected in the regional aquifer, springs, and wells throughout the Rio Grande Valley. Other naturally occurring radioactivity in groundwater samples comes from members of the uranium isotope decay chains, including isotopes of thorium and radium.

We compared radionuclide levels in all groundwater with drinking water and human health standards even though these standards only apply to drinking water sources. Total LANL-derived radionuclide activity in alluvial groundwater in Mortandad and DP/Los Alamos was above the 4-mrem DOE derived concentration guide (which we use as a screening level) applicable to drinking water. The maximum strontium-90 values in Mortandad Canyon and DP/Los Alamos Canyon alluvial groundwater were also above the EPA drinking water standard.

LANL and the NMED DOE Oversight Bureau have detected perchlorate in most groundwater samples analyzed from across northern New Mexico. Numerous studies now show that perchlorate is formed naturally in the upper atmosphere, is deposited on the earth's surface by precipitation, and accumulates in soils and groundwater of arid regions. The EPA recently set a Drinking Water Equivalent Level of 24.5 micrograms per liter (μg/L) for perchlorate. Perchlorate in arid region groundwater may also arise from other sources such as fertilizers, or from natural sources like mineral weathering or electrochemical reactions. The naturally-occurring perchlorate concentrations range from about nondetect (<0.05 μg/L) to about 0.85 μg/L. Water samples from most LANL locations show low perchlorate concentrations in this range, but samples taken downstream from former perchlorate sources show higher values. Figure ES-4 illustrates the declining perchlorate values found in alluvial groundwater downstream of the radioactive liquid waste treatment facility (RLWTF) discharge

▶ *The Radioactive Liquid Waste Treatment Facility, which discharges into Mortandad Canyon, has met all DOE radiological discharge standards for six consecutive years; has met all NPDES requirements for six consecutive years; and has met NM groundwater standards for fluoride, nitrate, and total dissolved solids for six years except for fluoride in two weekly composite samples in 2003.*

in Mortandad Canyon. Discharge of perchlorate from the plant effectively ceased in 2002 with installation of equipment designed to remove perchlorate from the effluent and aggressive pollution prevention efforts to eliminate perchlorate from plant inflow.

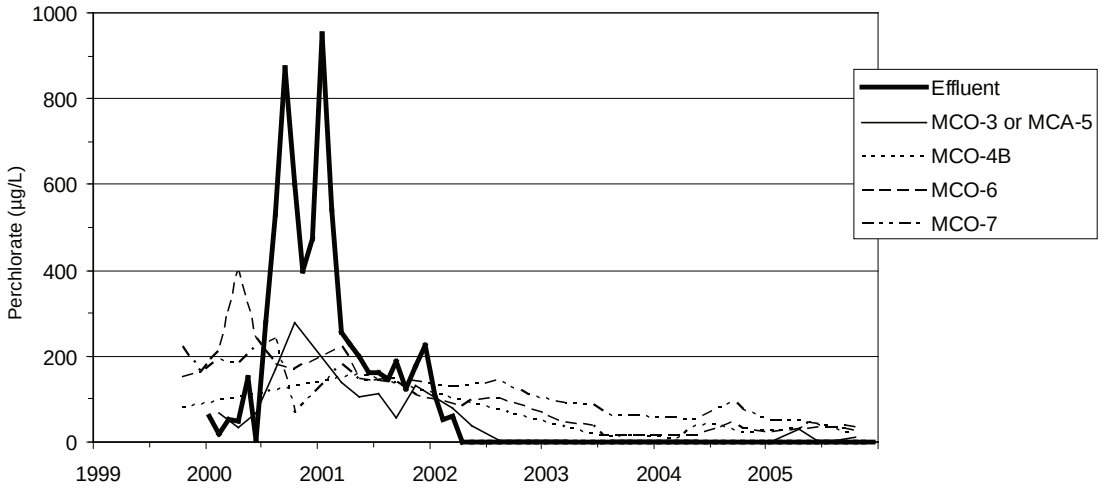


Figure ES-4. Perchlorate in Mortandad Canyon Alluvial Groundwater and RLWTF effluent, 1999–2005. Ion-exchange treatment was started in March 2002 to remove perchlorate to below 1 µg/L.

WATERSHED MONITORING (see Chapter 6)

Watersheds that drain the Laboratory are dry for most of the year. Of the 85 miles of watercourse, approximately two miles are naturally perennial, and approximately three miles are perennial waters created by effluent. No perennial surface water extends completely across the Laboratory in any canyon. Storm runoff occasionally extends across the Laboratory but is short-lived. Wildlife drink from the stream channels when water is present but the water is not used for any other purpose.

Hydrologic conditions in all LANL canyons and in Pueblo Canyon have recovered to near pre-fire levels. The overall quality of most surface water in the Los Alamos area is very good, with low levels of dissolved solutes. Of the more than 100 constituents (or "analytes") measured in sediment and surface water within the Laboratory, most are at concentrations far below regulatory standards or risk-based advisory levels. However, nearly every major watershed has some effect from Laboratory operations, often for just a few analytes. More data are available for 2005 than for prior years as a result of monitoring requirements of the Federal Facility Compliance Agreement.

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

LANL activities have caused contamination of sediments in several canyons, mainly because of past industrial effluent discharges. These discharges and contaminated sediments also affect the quality of storm runoff, which carries much of this sediment for short periods of intense flow. In some cases, sediment contamination is present from Laboratory operations conducted more than 50 years ago. Table ES-4 shows the locations of LANL-impacted surface water and sediments. All radionuclide levels are well below applicable guidelines or standards (Table ES-5).

The overall pattern of radioactivity in channel sediments, such as along lower Los Alamos Canyon, has not greatly changed in 2005. Sediment traps and other methods to slow or control sediment transport in these canyons reduce the potential for further transport down the canyons and potentially to the Rio Grande. Such a sediment trap, the Los Alamos Canyon Weir, decreased transport of sediments from lower Los Alamos Canyon by about two thirds in 2005.

Table ES-4
Where Can We See LANL Impacts on Surface Water and Sediments that Result in Values Near or Above Regulatory Standards or Risk Levels?

LANL Impact	On-Site	Off-Site	Significance	Trends
Radionuclides	Higher than background in sediments and storm runoff in Pueblo, DP, Los Alamos, and Mortandad canyons	Yes, in Los Alamos/Pueblo Canyons; slightly elevated in the Rio Grande and Cochiti Reservoir	Sediments well below recreation screening levels Minimal exposure potential to runoff because events are typically sporadic Concentrations below levels for protection of biota	Sediment concentrations in lower LA Canyon are stable Overall reduced transport in canyons due to post-fire recovery Expect increase in transport in Pueblo and DP Canyons due to new urbanization
Polychlorinated biphenyls (PCBs)	Detected in sediment in nearly every canyon Detected in runoff in several canyons above NM stream standards	Yes, in the Los Alamos/ Pueblo Canyons	Possible wildlife exposure in Los Alamos and Sandia Canyons when water is present. In Rio Grande, LANL contribution indistinguishable from high levels from upstream sources.	Insufficient data
Dissolved copper	Detected in many canyons above NM acute standards	Yes, in Los Alamos Canyon	Most probably of urban origin; Laboratory sources seen on localized basis	Insufficient data
High-explosive residues and barium	Detections near or above screening values in Cañon de Valle base flow and runoff	No	Minimal potential for exposure	Steady
Benzo(a)pyrene	Detections near or above industrial and recreational screening levels in Acid Canyon	Yes, in Los Alamos/ Pueblo/Acid Canyons	Associated with urban runoff; non-LANL sources contribute	Steady

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

Radionuclide	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon between DP and SR-4	Mortandad Canyon below Effluent Canyon	Pajarito Canyon above SR-4	Max percent of BCG[a]
Am-241	0.4	0.02	3.3	5.1		1%
Cs-137		2	24	20		0.1%
H-3				237		0.0%
Pu-238		0.06	0.17	2.1		1%
Pu-239,240	11	0.4	2.5	2.9		1%
Sr-90	0.4	3.5	1.7	3.4	0.4	1%
U-234	1.7	1.9	7.9	2.0	0.1	4%
U-235,236	0.1	0.1	7.1	1.1		4%
U-238	1.6	1.8	0.5	1.9	0.1	2%

[a] BCG = DOE's Biota Concentration Guides.
Blank cells mean no analytical laboratory detection in 2005.

- ***Radioactive elements from past Laboratory operations are being transported by runoff events.***
- ***PCBs and radionuclides adsorb onto sediment particles and thus occur in far higher concentrations in unfiltered than filtered samples.***

Figure ES-5 shows the frequency at which concentrations of 16 analytes in surface water samples were greater than the NM water quality standards. Consistent with previous years, most of the higher concentrations were measured in storm runoff samples because of the large sediment load carried by the storm runoff events. Analytes with concentrations above the standards as a result of natural or non-Laboratory causes include aluminum (occurs naturally in all rocks and soil), gross alpha (associated with native soils and sediments), benzo(a)pyrene (associated with urban runoff and possibly created through the Cerro Grande Fire), and selenium (in volcanic soils and ash). For most analytes shown in Figure ES-5, concentrations were above standards by less than five times. As with radionuclides, PCBs adsorb onto sediment particles and thus occur in far higher concentrations in unfiltered samples. Despite the higher PCB concentrations measured in runoff within the Laboratory, monitoring results show no measurable effects in the Rio Grande (see Biota discussion on page 16). No credible pathway to humans exists for the contaminants in streams and sediments on Laboratory property.

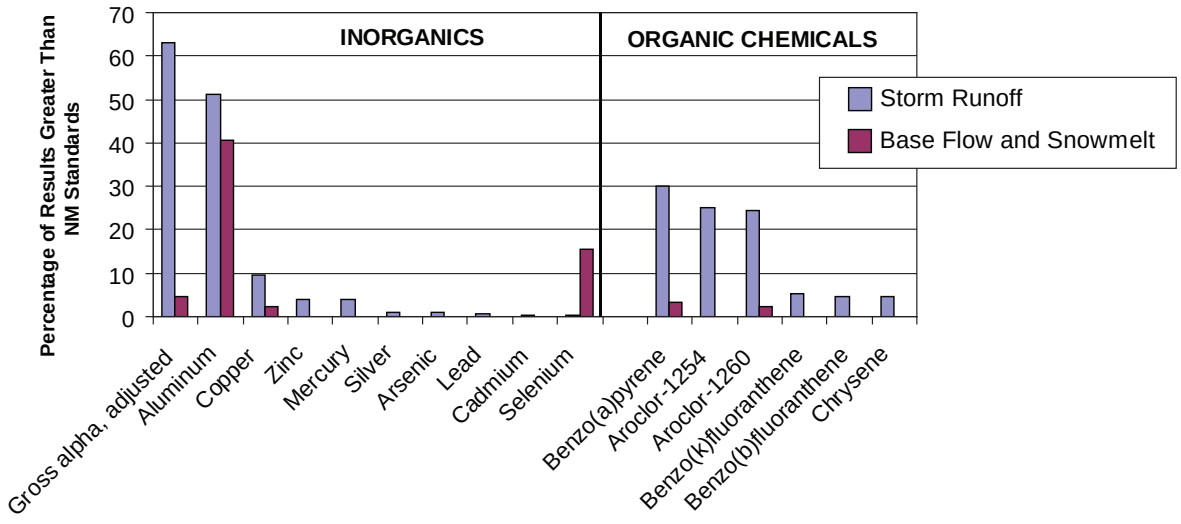


Figure ES-5. Frequency that storm runoff and base flow/snowmelt results were greater than New Mexico water quality standards.

SOIL MONITORING (see Chapter 7)

Soil sampling, as with foodstuffs and biota sampling, is performed on a rotating 3-yr cycle; the next soil sampling will occur in 2006. Data from previous years showed levels either not detectable or consistent with background levels except at some on-site locations where radionuclide contamination is expected.

Two perimeter soil samples were collected from Pueblo de San Ildefonso lands and showed concentrations of most radionuclides below the regional statistical reference levels (average plus three standard deviations). Only uranium in one sample was detected at values slightly above the regional statistical reference level but its isotopic distribution and location indicates it is not from Laboratory operations.

▶ Soil samples from off-site locations show radionuclides and metals have not increased over the past years and are mostly at background or non-detectable levels.

▶ Soil samples from on-site locations show no increases and some decreases of radionuclides and metals from previous years.

Soil samples were collected from around TA-54 Area G, the Laboratory's principal low-level waste disposal area, and TA-15 DARHT, the Laboratory's principal explosive test facility. At Area G, some radionuclides, principally tritium and plutonium, were measured above regional statistical reference levels but below LANL screening levels and are either consistent with levels measured in previous years or declining. Similarly, only a few radionuclides in samples from TA-15 were above regional statistical reference levels but below LANL screening levels and show no increases from levels measured in previous years.

FOODSTUFFS AND NONFOODSTUFFS BIOTA MONITORING (see Chapter 8)

▶ The levels of radionuclides and metals in soil, vegetation, and mice from the area above the LA Weir were mostly below background and indicate there is no significant impact to the biota in this area.

Foodstuffs samples that were collected in 2005 included fish from Cochiti Reservoir and purslane, an edible plant, from the Pueblo de San Ildefonso. We also collected nonfoodstuff biota such as native vegetation at Area G and at DARHT. Concentrations, trends, and doses were assessed.

Levels of radionuclides, non-radionuclide inorganic metals, and PCBs in fish upstream and downstream of LANL were similar to each other and support previous studies that imply LANL is not the source of significant contaminants. Radionuclides in the fish from upstream and downstream sources are near detection limits or nondetectable (the result is less than three times the analytical uncertainty), except for one sample from Cochiti Reservoir that contained uranium-234 and uranium-238 just

above the regional statistical reference levels (three standard deviations above background averages); however, the isotopic distribution indicates a natural origin of the uranium. Mercury levels in the fish upstream and downstream were similar but are at levels that have triggered fish consumption advisories on the Rio Grande. Similarly, PCB levels in bottom-feeding fish from both upstream and downstream sources exceed safe levels for regular consumption.

- ***Radionuclides, non-radionuclide metals, and PCBs in fish upstream and downstream of LANL are similar and do not indicate a measurable contribution to biota from LANL.***
- ***Levels of mercury in predator fish and PCBs in bottom-feeding fish upstream and downstream are similar and are above state consumption advisory levels.***

Data from past years on radionuclides in domestic crop plants (vegetables and fruits) from all communities surrounding the Laboratory were indistinguishable from natural or fallout levels. Similarly, all trace element concentrations in vegetable and fruit samples were within or similar to the regional statistical reference levels and showed no increasing trends in concentrations.

Wild edible plants (oak acorns, wild spinach, and purslane) were sampled in past years from Pueblo de San Ildefonso lands near the Laboratory boundary. Some radionuclides in these plants were at higher levels than natural or fallout levels; however, all were below levels that would result in a dose of 0.01 mrem for each pound of each consumed, which is 0.1 percent of the DOE dose limit of 100 mrem/yr. In 2005, additional purslane samples and soil samples were collected to investigate the slightly elevated strontium-90 levels. The results confirmed suspicions that lower calcium levels in the soil results in increased uptake of fallout strontium-90 by the plants.

All non-radionuclide contaminant concentrations, with the exception of barium, in these wild edible plants were either undetected or within the regional statistical reference levels. The additional samples of purslane from background locations confirmed elevated barium concentrations in these plants that are most likely due to bioaccumulation of barium by purslane plants.

Vegetation was collected at Area G and DARHT. All radionuclide concentrations in vegetation were indistinguishable from background reference levels except tritium and plutonium in plants next to the disposal area at Area G.

Honeybees sampled from hives on LANL property near a testing area where depleted uranium is used found only uranium-238 above regional statistical reference levels but at levels far below terrestrial animal dose screening levels (<0.01 rad/d). All other radionuclides and all non-radionuclides were below regional statistical reference levels.

We collected samples of soil, vegetation, and small mammals (deer mice) at the Los Alamos Canyon Weir, a low rock dam designed to trap sediment being transported off Laboratory property in Los Alamos Canyon. The levels of radionuclides and metals in these media were mostly below regional statistical reference levels and indicate that there is no measurable impact to the biota.

A special study of uranium uptake by ponderosa pine trees growing near firing sites at TA-15 was conducted to determine if variations in environmental uranium concentrations from open-air dynamic tests were similar to variations in uranium concentrations in trees. Results indicate that uranium concentrations were statistically similar in off-site and on-site ponderosa pine trees, indicating that dynamic tests conducted at LANL have not significantly impacted uranium concentrations in ponderosa pine pulp.

Moss samples were collected from several springs around northern New Mexico and analyzed for cesium-137 as part of another special study. Levels at two of the sampled springs were similar to those measured by other organizations at those springs. The varying levels of cesium-137 may be attributable to the exposure of the moss to dust or soil that contains fallout levels of cesium-137; the lowest levels were generally found on moss from springs that are relatively sheltered.

ENVIRONMENTAL RESTORATION PROGRAM (see Chapter 9)

- ***Characterization and cleanup of sites contaminated or potentially contaminated by past LANL activities is subject to the Consent Order with the NMED.***
- ***Fourteen investigation work plans and five investigation reports were approved by NMED in 2005.***
- ***Nine reports were submitted to NMED and are now under review.***

Corrective actions proposed and/or conducted at the Laboratory in 2005 are subject to the Consent Order signed by the NMED, the DOE, LANL, and the State of New Mexico Attorney General in March 2005. The goal of the investigation efforts is to ensure that past operations do not threaten human or environmental health and safety in and around Los Alamos County. Accomplishments include the completion of investigation activities, approvals of proposed investigation activities, and approvals of the work completed at some sites. Under the Consent Order, investigation work plans and investigation reports were submitted to NMED and were approved in 2005 or were under review. Proposed investigation activities were commenced and/or completed in 2005 at a number of complex sites including material disposal areas (MDAs) C, G, L, U, and V; Mortandad Canyon; Pajarito Canyon; TA-19; Mortandad/Ten Site Canyon Aggregate Area; and the TA-16-340 Complex. In addition, several individual sites (solid waste management units [SWMUs] and areas of concern [AOCs]) were investigated and remediated.

A total of 14 investigation work plans were approved by NMED with or without modifications in 2005. Of the work plans approved, seven were submitted in 2005. A total of five investigation reports were approved by NMED with or without modifications, which signifies that either the investigation has been completed or that additional activities are needed in order to complete the investigation. In addition, nine reports were submitted in 2005 and as of the end of the calendar year, are under review by NMED. These reports either recommended that corrective actions are completed or that additional sampling and/or remediation are warranted.

The investigation activities proposed are designed to characterize SWMUs, AOCs, consolidated units, aggregates, and watersheds. The characterization activities conducted include surface and subsurface sampling, drilling boreholes, geophysical studies, and installation of monitoring wells. Corrective actions performed included the removal of structures (e.g., buildings, septic systems, sumps, and drainlines), soil vapor extraction, excavation of contaminated media, and confirmatory sampling. These activities define the nature and extent of contamination and whether there are unacceptable risks to human health and the environment.

- ***Investigations at restoration sites included drilling a substantial number of boreholes, collecting hundreds of samples, and obtaining thousands of analytical results.***
- ***Cleanup activities included the removal of structures (e.g., buildings, septic systems, sumps, and drainlines), soil vapor extraction, excavation of contaminated media, and confirmatory sampling.***
- ***In 2005, 35 percent of all environmental samples collected and 74 percent of all analyses on the samples were for environmental characterization and remediation work at LANL.***

Major investigations conducted in 2005 included MDA L, MDA G, and the Mortandad/Ten Site Canyons Aggregate Area. The Mortandad/Ten Site Canyon Aggregate Area investigation included SWMUs, AOCs, and consolidated units associated with six technical areas including TA-35, which is a major Laboratory industrial complex. The documents for these sites were among the first major reports submitted under the Consent Order. The investigations included drilling a substantial number of boreholes, collecting hundreds of samples, and obtaining thousands of analytical results. Recommendations for MDAs L and G included the monitoring of subsurface vapors and a corrective measure evaluation. The majority of the aggregate area sites were recommended as having corrective action complete with controls, while some sites require additional sampling and/or remediation. Investigation and/or monitoring activities are continuing at these sites.

I. INTRODUCTION

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A. BACKGROUND AND REPORT OBJECTIVES

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 (UC) under a contract administered by the National Nuclear Security Administration (NNSA) of the Department of Energy (DOE) through the Los Alamos Site Office and the NNSA Service Center based in Albuquerque. In June 2006, a new management organization, Los Alamos National Security, 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, US 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 US nuclear deterrent;
- Reduce the threat of weapons of mass destruction, proliferation, and terrorism; and
- Solve national problems in defense, energy, environment, and infrastructure.

Los Alamos National Laboratory's vision is to be "The trusted, competitive scientific solution for today's and tomorrow's national security challenges." The Laboratory has identified seven national security goals to implement its vision and mission:

- Create an integrating core competency for science-based prediction of complex systems linking experiment, simulation, and theory.
- Design and engineer manufacturable and certifiable replacement nuclear weapons without new nuclear testing.
- Be acknowledged as the premier laboratory for nonproliferation research and development.
- Be the preferred laboratory for providing the defense, intelligence, and homeland security communities with revolutionary, success-enabling science and technology.
- Be the best materials science and technology laboratory in the world in support of our mission.
- Use LANL expertise and capability to solve national problems in energy security.
- Be a strategic partner of the Office of Science to benefit its national missions and the science base critical to our national security missions.

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 demonstration of the Laboratory's commitment is the April 2004 LANL environmental policy:

> *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; and work to increase the body of knowledge regarding our environment.*

2. Objectives

As part of the Laboratory's commitment to our environmental policy, we will 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 2003a, DOE 2004), are to

- Characterize site environmental management performance including effluent releases, environmental monitoring, and estimated radiological doses to the public.
- Summarize environmental occurrences and responses reported during the calendar year.
- Confirm compliance with environmental standards and requirements.
- Highlight significant programs and efforts, including environmental performance indicators and/or performance measures programs.

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

- Conduct the Laboratory mission while demonstrating rigorous compliance with federal and state environmental regulations and permits.
- Conduct the Laboratory mission through continuous and measurable environmental risk reduction to protect workers, the public, and the natural environment.
- Use an ISO 14001:2004 prevention-based EMS to improve environmental performance.
- Effectively manage waste, excess materials, and equipment generated during historical, current, and future Laboratory operations.

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, the Bandelier National Monument, the US General Services Administration, and the Los Alamos County. Pueblo de San Ildefonso borders the Laboratory to the east.

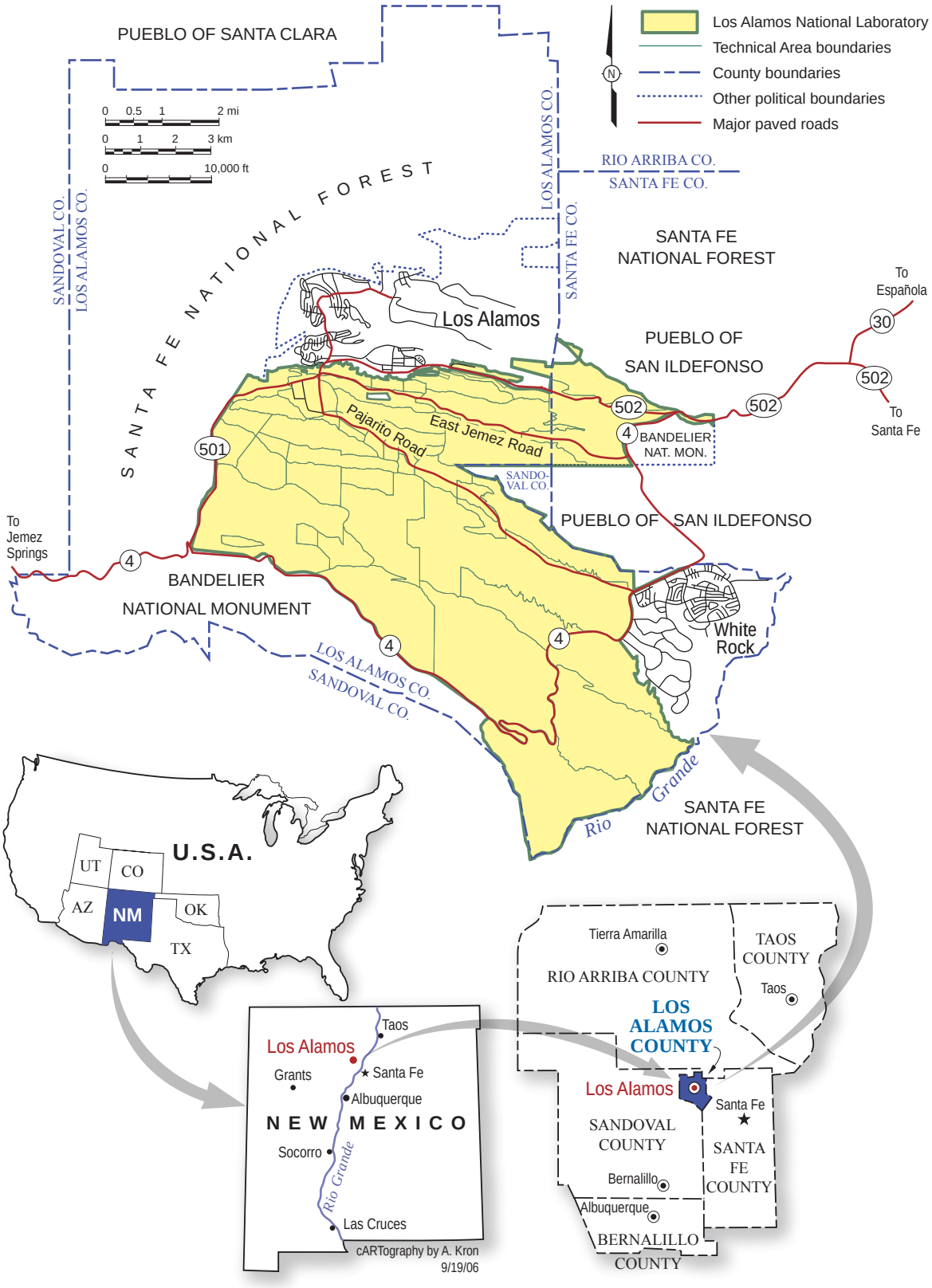

Figure 1-1. Regional location of Los Alamos National Laboratory.

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.

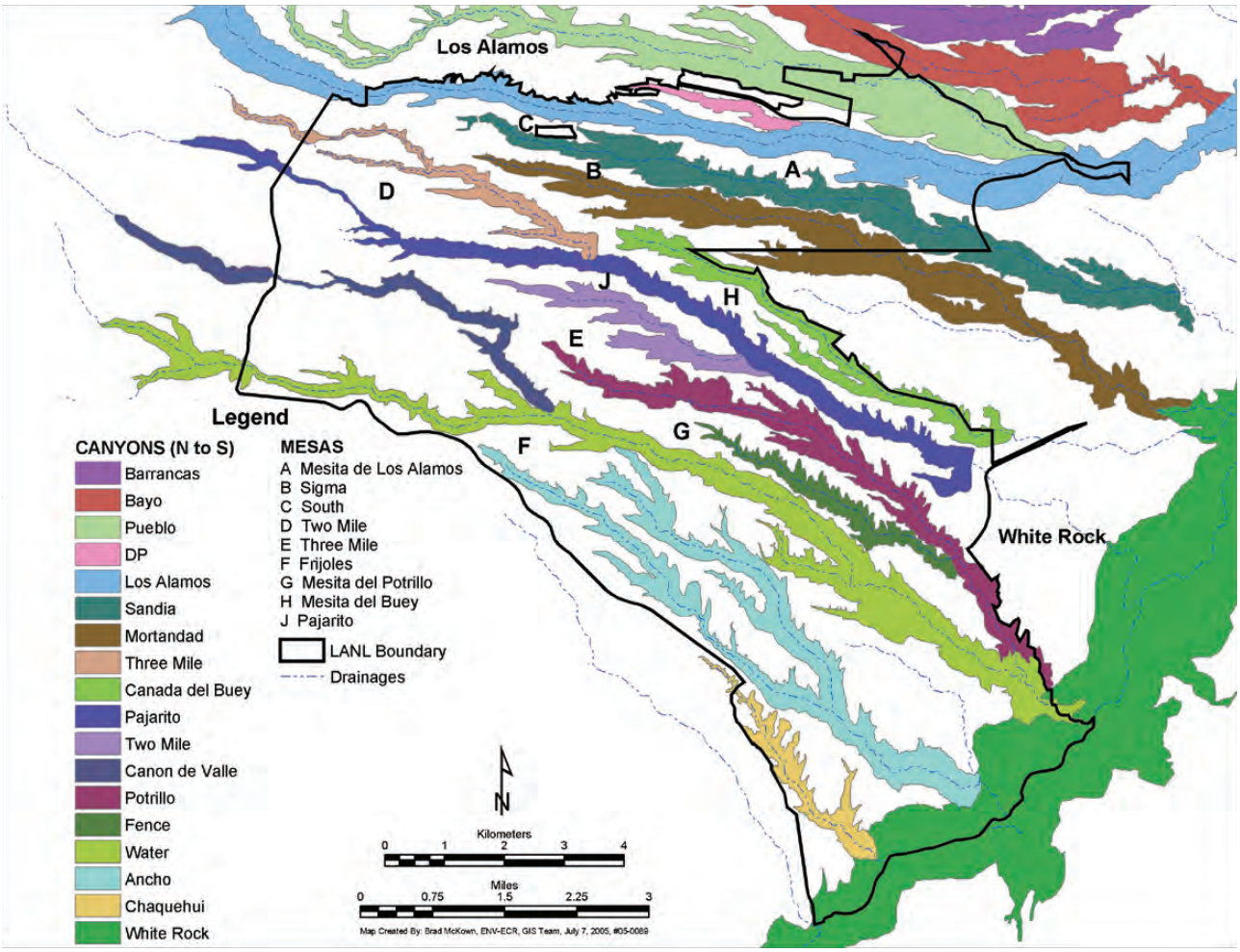

Figure 1-2. Major canyons and mesas on Laboratory land.

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.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) 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 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-mile 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 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 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 to 6,200 ft. The piñon (*Pinus edulis* Engelm.)-juniper cover type, generally in the 6,200- to 6,900-ft elevation range, 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 in the 6,900- to 7,500-ft elevation range. These three cover types predominate, each occupying roughly one-third of the LANL 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. Spruce (*Picea* spp.)-fir (*Abies* spp.) 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 LANL lands.

In May 2000, the Cerro Grande fire burned over 43,000 ac of forest on 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 percent of the vegetation at LANL was burned in some fashion during the fire. However, few areas on LANL were burned severely. Wetlands in Mortandad, Pajarito, and Water canyons received increased amounts of ash and hydromulch runoff because of the fire.

The extreme drought conditions prevalent in the Los Alamos area and all of New Mexico from 1998 to the present have resulted directly and indirectly in the mortality of many trees. To date, more than 90 percent of the piñon trees greater than 10 ft tall have died in the Los Alamos area. Lower levels of mortality are also occurring in ponderosa and mixed conifer stands. Mixed conifers on north-facing canyon slopes at lower elevations have experienced widespread mortality. These changes are ongoing and 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 percent of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1,900 sites have been recorded. More than 85 percent 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 percent lying 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 280 buildings have been evaluated to date. In addition, there are "key facilities" (facilities considered of national historic significance) dating from 1963 to the end of the Cold War in 1990.

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 percent 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 US, is estimated at 15 strikes per square mile per year. Lightning is most commonly observed between May and September (about 97 percent 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) that are used for building sites, experimental areas, support facilities, roads, and utility rights-of-way (see 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 ft under roof, spread over an area of approximately 40 square miles.

In its 1999 Site-Wide Environmental Impact Statement (SWEIS) (DOE 1999), 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 exposure risks associated with LANL operations. The facilities identified as "Key" for the purposes of the 1999 SWEIS and the new SWEIS in preparation during 2006 are those that house activities critical to meeting work assignments given to LANL and also include:

- In-house operations that could potentially cause significant environmental impacts,
- Activities or operations of most interest or concern to the public based on SWEIS scoping comments, or
- Activities or operations that would be the most subject to change because of programmatic decisions.

In the 1999 SWEIS and now in the new SWEIS, the remaining LANL facilities were identified as "Non-Key" facilities simply 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 acres of LANL's 26,480 acres (Table 1-1). The Non-Key Facilities also currently employ about 42 percent of the total LANL workforce. The Non-Key Facilities include such important buildings and operations as the Nicholas C. Metropolis Center for Modeling and Simulation, the Nonproliferation and International Security Center (NISC), the new National Security Sciences Building (NSSB) that is now the main administration building, and the TA-46 sewage treatment facility.

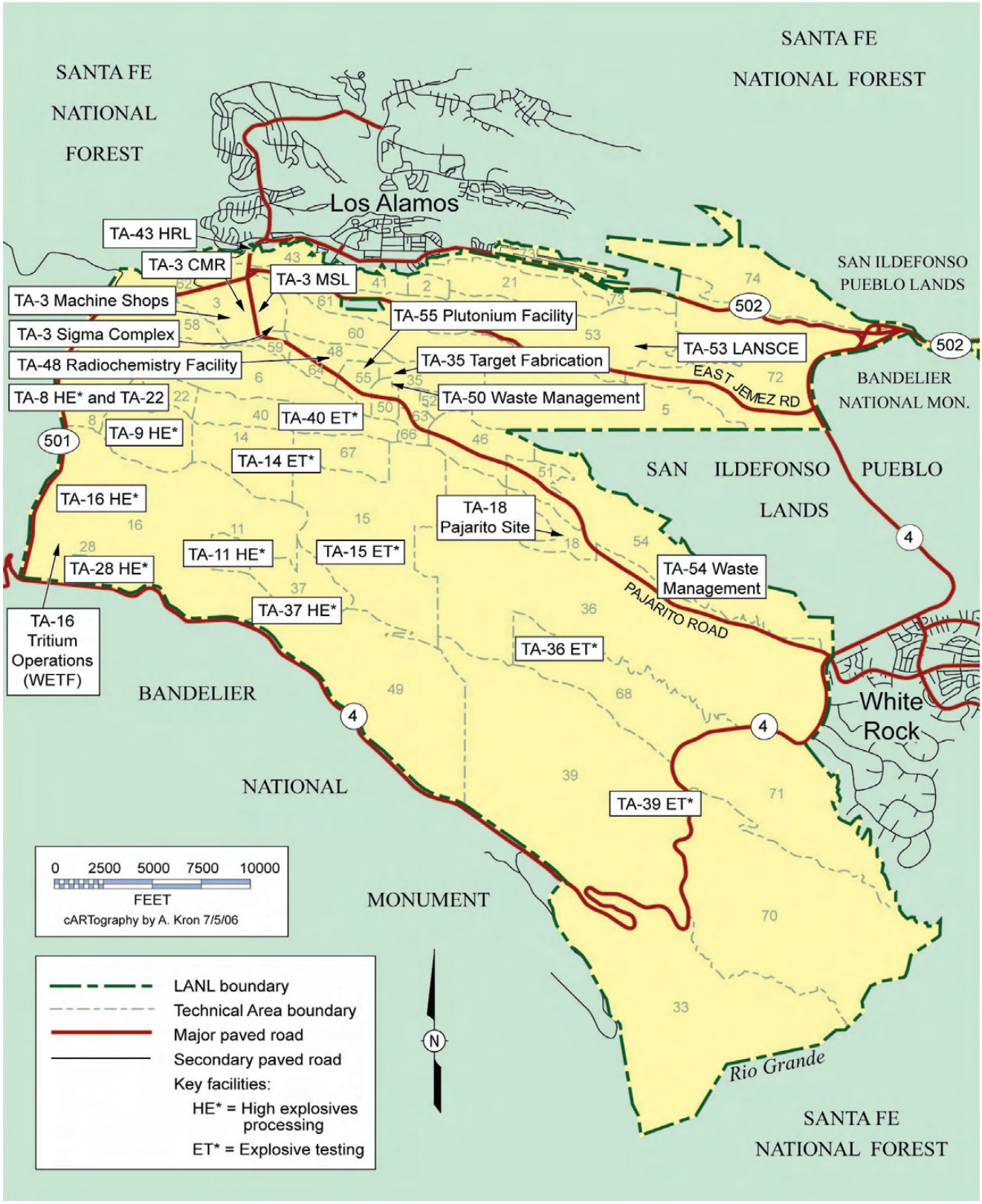

Figure 1-3. Technical Areas (TAs) and key facilities of Los Alamos National Laboratory in relation to surrounding landholdings.

Table 1-1
Key Facilities

Facility	Technical Areas	~Size (Acres)
Plutonium Complex	TA-55	93
Tritium Facilities	TA-16 & TA-21	312
Chemical and Metallurgy Research (CMR) Building	TA-03	14
Pajarito Site	TA-18	131
Sigma Complex	TA-03	11
MSL	TA-03	2
Target Fabrication Facility (TFF)	TA-35	3
Machine Shops	TA-03	8
High-Explosives Processing	TA-08, -09, -11, -16, -22, -28, -37	1,115
High-Explosives Testing	TA-14, -15, -36, -39, -40	8,691
LANSCE	TA-53	751
Biosciences Facilities (Formerly Health Research Laboratory)	TA-43, -03, -16, -35, -46	4
Radiochemistry Facility	TA-48	116
Radioactive Liquid Waste Treatment Facility (RLWTF)	TA-50	62
Solid Radioactive and Chemical Waste Facilities	TA-50 & TA-54	943
Subtotal, Key Facilities		**12,256**
Non-Key Facilities	30 of 48 TAs	14,224
LANL Acreage		**26,480**

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 1999 SWEIS for potential environmental impacts. For the purpose of the impact analysis provided by the new SWEIS, the identity of the LANL Key Facilities has been modified to reflect subsequent DOE decisions that resulted in changes to LANL facilities and operations. The Nicholas C. Metropolis Center for Modeling and Simulation (Metropolis Center) has been 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. Under either of the Action Alternatives evaluated in the new SWEIS, Security Category III and IV materials and operations would be removed from the Pajarito Site and it would be eliminated as a Key Facility. Under the No Action Alternative, the Pajarito Site would remain a Key Facility.

D. MANAGEMENT OF ENVIRONMENT, SAFETY, AND HEALTH

Integrated safety management (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 the safety and environmental management system is a normal and natural element of the performance of work. Safety, protection of the environment, and compliance with environmental, safety, and health (ES&H) laws and regulations are an integral part of how the Laboratory does business. ISM is the way that we meet the moral 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.

ISM is integral to accomplishing the Laboratory mission. The goal of ISM is to establish "safety" (used generically to encompass all aspects of environment, safety, and health) as a fundamental value for operating the Laboratory and that this value would be reflected in the attitudes and behaviors of all workers. ISM is structured

to manage and control work at the institutional, the facility, and the activity level. A seamless integration of ES&H with the work being done is fundamental. Inseparable from this concept is the important principle that line management is responsible for safety, with clear and unambiguous roles and lines of responsibility, authority, and accountability at all organizational levels and with full participation of the workforce. ISM requires that all work and all workers meet the safety and environmental requirements defined by the Laboratory requirements system.

1. Environmental Management Program

The Laboratory is committed to protecting the environment while conducting its important national security and energy-related missions. In support of this commitment, LANL has implemented a pollution-prevention-based EMS pursuant to DOE Order 450.1, Environmental Protection Program. An EMS is a systematic method for assessing mission activities, determining the environmental impacts of those activities, prioritizing improvements, and measuring results. DOE Order 450.1 defines an EMS as "a continuous cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental missions and goals." This order mandates that the EMS be integrated with an existing integrated management system already established pursuant to DOE Policy 450.4. Although it significantly exceeds DOE Order 450.1 requirements, LANL elected in November 2004 to seek ISO 14001:2004 registration of its EMS.

The EMS program met several milestones in 2005. New Implementing Procedures (IMP 401, 402, 403) governing communication, legal and other requirements and environmental aspects were developed by the EMS management and core teams and approved by the Laboratory's Executive Board in April 2005. These procedures defined EMS roles and responsibilities from the Laboratory Director to individual staff levels. In addition to these institutional policy changes, each Division Director was asked to sign an EMS charter for their Division that reiterated commitment to the process.

Using multi-disciplinary teams from each Division (all 31 LANL Divisions that existed in 2005), the major support services subcontractor (KSL, Inc.) and the security subcontractor (PTLA) identified their activities, products, and services and their potential environmental aspects. They then 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 Division teams were aided by a trained support person from the EMS Core Team, whose members were trained in ISO 14001:2004 systems (many became certified EMS professionals). All information on the LANL EMS is available to the public via Laboratory websites.

All 31 LANL Divisions, KSL, PTLA, and the Enterprise Project completed the Division Environmental Action Plans on schedule by September 30, 2005, a performance metric of LANL Appendix F contract requirements with NNSA. Those plans together commit to nearly 600 environmental improvement and pollution prevention actions beginning in fiscal year (FY) 2006. The Laboratory also met the DOE Order 450.1 requirement to have an EMS implemented by December 31, 2005. In December 2005, based on extensive documentation provided by the EMS Management Team and the positive results of a pre-assessment and desk audits, the NNSA Los Alamos Site Office certified to NNSA headquarters that LANL had met the requirements of DOE Order 450.1 and had a functioning EMS.

For five full days in March 2006, a team of five independent third-party auditors conducted the final ISO 14001:2004 audit of the Laboratory's EMS. The audit covered most of the Divisions and all major support contractors and included interviews conducted from the Director and Deputy Director level to individual staff and students chosen at random by the auditors. The auditors concluded that the LANL EMS meets all the requirements of the ISO 14001:2004 standard with no major nonconformities and recommended that LANL be fully certified. On April 13, 2006, LANL received full certification of its EMS to the ISO 14001:2004 standard. LANL is the first of the NNSA national laboratories and was the first UC-operated facility to receive this distinction.

NNSA recognized the success of the EMS Management and Core Teams' unique approach by giving the Laboratory the 2005 NNSA "Best in Class" Award. The Laboratory also received the US Department of Energy Pollution Prevention STAR Award for 2005.

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

a. 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. The Laboratory generates Resource Conservation and Recovery Act regulated waste, Toxic Substances Control Act regulated waste, low-level radioactive waste, mixed low-level waste, transuranic waste, wastewater, administratively controlled waste, medical waste, New Mexico Special Waste, and solid waste. Certain wastes are also treated and/or disposed of at the Laboratory.

The Laboratory's goal is to conduct waste management operations in a manner that minimizes hazardous and nonhazardous waste generation as much as is technically and economically feasible and maintains excellence in safety, compliance, environment, health, and waste management operations. This goal is accomplished through

- 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.

b. Pollution Prevention Program

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

- Collecting data and reporting on DOE P2 goals;
- Forecasting waste volume to identify P2 opportunities;
- Conducting P2 opportunity assessments for customer divisions;
- Funding specific waste reduction projects through the Generator Set-Aside Fund Program;
- Managing 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 five national NNSA Pollution Prevention awards for Laboratory projects in fiscal year (FY) 2005. Projects in FY 2005 yielded more than $4,000,000 in savings to the Laboratory. The P2 Program was instrumental in incorporating preventive measures into the EMS, and the Laboratory received ISO 14001:2004 certification. The Laboratory achieved a rating of "outstanding" for pollution prevention in FY 2005 as measured against DOE-mandated reduction of waste volume. The Pollution Prevention performance index for the 2005 DOE Pollution Prevention goals is to meet 97 percent of the DOE-mandated reductions of waste volumes compared to a 1993 baseline.

c. Environmental Remediation and Surveillance Program

The Laboratory's Environmental Remediation and Surveillance (ERS) Program (formerly the Environmental Restoration Project) is part of a national DOE effort to reduce risk to human health and the environment at its facilities. (In mid-2006, this program became part of the new Environment and Remediation Support Services

Division.) The goal of the program is to ensure that residual materials and 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. Fieldwork at several sites was either implemented, ongoing, or completed in calendar year 2005. Much of the work under the ERS Program is also subject to the requirements in the Compliance Order on Consent (see Chapter 2, Section B.1). A new chapter of this report, Chapter 9, summarizes ERS work conducted or completed in calendar year 2005.

d. Compliance and Surveillance Programs

Air Resources. The Laboratory maintains a vigorous air quality compliance program for the emissions of both radionuclide and nonradionuclide air pollutants. 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/operations by the Environmental Protection Agency (EPA). These permits and approvals require pollution control devices, stack emissions monitoring, and routine reporting. This report describes these permits and reports; they are also available online at http://www.lanl.gov/community/environment/air/. Proposals for new Laboratory operations and facilities are reviewed to determine the requirements for permitting, monitoring, and reporting of air emissions.

In addition to the compliance program, the Laboratory operates an extensive network of ambient air quality monitoring stations and direct penetrating radiation monitoring stations. The network includes station locations on-site, in adjacent communities, and in regional locations. These stations are operated to ensure that air quality and ambient radiation doses meet EPA and DOE standards. These data are published in this report (see Chapter 4) and online at http://www.lanl.gov/community/environment/air/.

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

Water Resources. The LANL Groundwater Protection Program and Water Quality and Hydrology (now part of the Water Stewardship program) monitoring program manages and protects groundwater and surface water resources (see Chapters 5 and 6). The Laboratory conducts these programs to comply with the requirements of DOE Orders and New Mexico and federal regulations.

Groundwater resource management and protection efforts at the Laboratory focus on (1) the regional aquifer underlying the region, (2) the 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 waste-discharge requirements and to evaluate any impact of Laboratory activities on groundwater resources. This program addresses environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations.

Surface water protection efforts focus on monitoring surface water and stream sediments in northern New Mexico in order to evaluate the potential environmental effects of Laboratory operations. 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. The Laboratory analyzes samples for several parameters such as radionuclides, high explosives, metals, a wide range of organic compounds, and general chemistry.

Biological Resources. 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 natural resources. DOE/NNSA and LANL administrators determined that management of natural resources strongly benefits the Laboratory (DOE 1996). The Mitigation Action Plan for the SWEIS for Continued Operation of the Los Alamos National Laboratory (DOE 1999) formalized this effort by requiring LANL to (1) mitigate the danger of wildfire and (2) develop a comprehensive plan for integrated natural resources management. One of the lasting results of wildfires that have occurred in and around LANL has been a significant increase in a regional, multi-agency approach to managing biological resources.

The current approach to managing biological resources at LANL includes developing an institutional Biological Resources Management Plan (LANL 2006) and on-the-ground resource management activities (e.g., forest thinning and fuels treatment). The plan is currently being developed to integrate short- and long-term mission activities and compliant and effective management of LANL's biological resources. The plan uses a combined discipline- and geographic-based approach to identify and integrate actions for management of biological resources. It addresses the following biological resources elements: forest and range, wildlife, sensitive species and habitats (including wetlands), and contaminants in biota. In addition, intensive forest management is currently being conducted under an institutional wildfire hazard reduction project that is implemented through the Wildfire Hazard Reduction Project Plan (LANL 2005a).

Soil, Foodstuffs, and Non-foodstuff Biota Resources. 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 the impact of Laboratory operations on human health via the food chain and the environment. The Laboratory conducts these programs to comply with the requirements of DOE Orders and New Mexico and federal regulations. Samples of the various media are collected on a three-year rotating basis and analyzed for radionuclides, heavy metals, and organic constituents to determine source terms (concentrations and distribution) in soils and potential uptake by plants, animals, and humans. Radiation doses to humans and biota and changes in contamination levels over time are also measured and analyzed. These data are published in this report (see Chapters 3, 7, and 8) and other Laboratory publications.

Cultural Resources. The Laboratory manages the diverse cultural resources according to the requirements of the National Historic Preservation Act and the other federal laws and regulations concerned with cultural resources protection. Cultural resources include archaeological sites, historic buildings and artifacts, and traditional cultural places of importance to Native American and other ethnic groups. The act's goal is for federal agencies to act as responsible stewards of our nation's resources when their actions potentially affect historic properties. Section 106 of the act requires federal agencies to take into account the effects their projects may have on historic properties and to allow for 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.

2. Organizations Implementing Environmental Management

Safety, environmental protection, and compliance with ES&H laws and regulations are underlying values in all Laboratory work. The Laboratory uses ISM to create a worker-based safety and environmental compliance culture where all workers are committed to safety and environmental protection in their daily work.

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.

The former Environmental Stewardship Division (ENV) was established in 2004 under the former Technical Services Directorate to represent the Laboratory on environmental issues with regulators and external stakeholders. ENV Division provided technical expertise and assistance in areas of environmental protection, waste management, pollution prevention, air quality, water quality, National Environmental Policy Act requirements, wildfire protection, and natural and cultural resources management. ENV Division was responsible for performing environmental monitoring, surveillance, and compliance activities to help ensure that Laboratory operations do not adversely affect human health and safety or the environment.

During the time period covered by this report, ENV Division developed and managed the Laboratory programs for environmental regulatory compliance. This work was conducted in five ENV Division groups: Meteorology and Air Quality (MAQ), Water Quality and Hydrology (WQH), Solid Waste Regulatory Compliance (SWRC), Ecology (ECO), and Environmental Characterization and Remediation (ECR). With assistance from Laboratory legal counsel, ENV Division worked to define and recommend Laboratory policies for applicable federal and state environmental regulations and laws and DOE orders and directives. The Division was responsible for communicating environmental policies to Laboratory employees and made appropriate environmental training programs available. The ENV Division groups worked with line managers to prepare and review required environmental documentation. The five groups also initiated and managed Laboratory programs for environmental assessment and were responsible for executing environmental surveillance work under the auspices of the ENV Division's Environmental Protection Program.

In mid-2006, the Laboratory underwent a reorganization of all environmental programs as part of the transition to a new management contractor (Los Alamos National Security, LLC). This new organization was not in place during the calendar year covered by this report. Under the new organizational structure, environmental surveillance and remediation programs are part of the Environment and Remediation Support Services Division and environmental permitting is part of the Environmental Protection Division.

The Laboratory conforms to applicable environmental regulatory and reporting requirements of DOE Orders 450.1 (DOE 2003b), 5400.5 (DOE 1993), and 231.1-1A (DOE 2004). Through 2005, ENV Division had the responsibility and the authority to serve as the central point of institutional contact, coordination, and support for interfaces with regulators, stakeholders, and the public, including the DOE/NNSA, NMED, US Environmental Protection Agency, and the US Defense Nuclear Facilities Safety Board.

The Laboratory routinely collects samples of air particles and gases, water, soils, sediments, foodstuffs, and associated biota. For 2005, the Laboratory requested more than 600,000 analyses for chemical and radiochemical constituents on more than 10,800 environmental samples from over 1,600 sampling locations (Table 1-2). By far, the largest number of samples was collected to characterize or assess sites being cleaned up as part of environmental restoration efforts. The remainder of the analyses help identify whether impacts occurred from LANL operations or whether emissions and releases were within limits. Trained personnel collect and analyze additional samples to obtain information about particular events, such as major surface-water runoff events, non-routine radiation releases, or special studies such as monitoring the continuing effects of the 2000 Cerro Grande fire, which burned more than 7,684 acres of Laboratory property.

Table 1-2
Approximate Number of Environmental Samples, Locations, and Analytes

Type	Locations	Samples	Analytes or Measurements
Ambient Air*	65	2,614	7,788
Stack Monitoring	29	1,892	26,578
Ground Water	150	545	59,435
Surface Water Base Flow	50	154	16,569
Surface Water Snowmelt	27	64	3,004
Surface Water Storm Runoff	123	847	26,682
Sediment	63	66	6,939
Soil, Foodstuffs, and Biota	66	195	7,078
Neutron Radiation	52	203	203
Gamma Radiation	91	348	348
Environmental Restoration	922	3,904	446,619
Totals:	**1,638**	**10,832**	**601,243**

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

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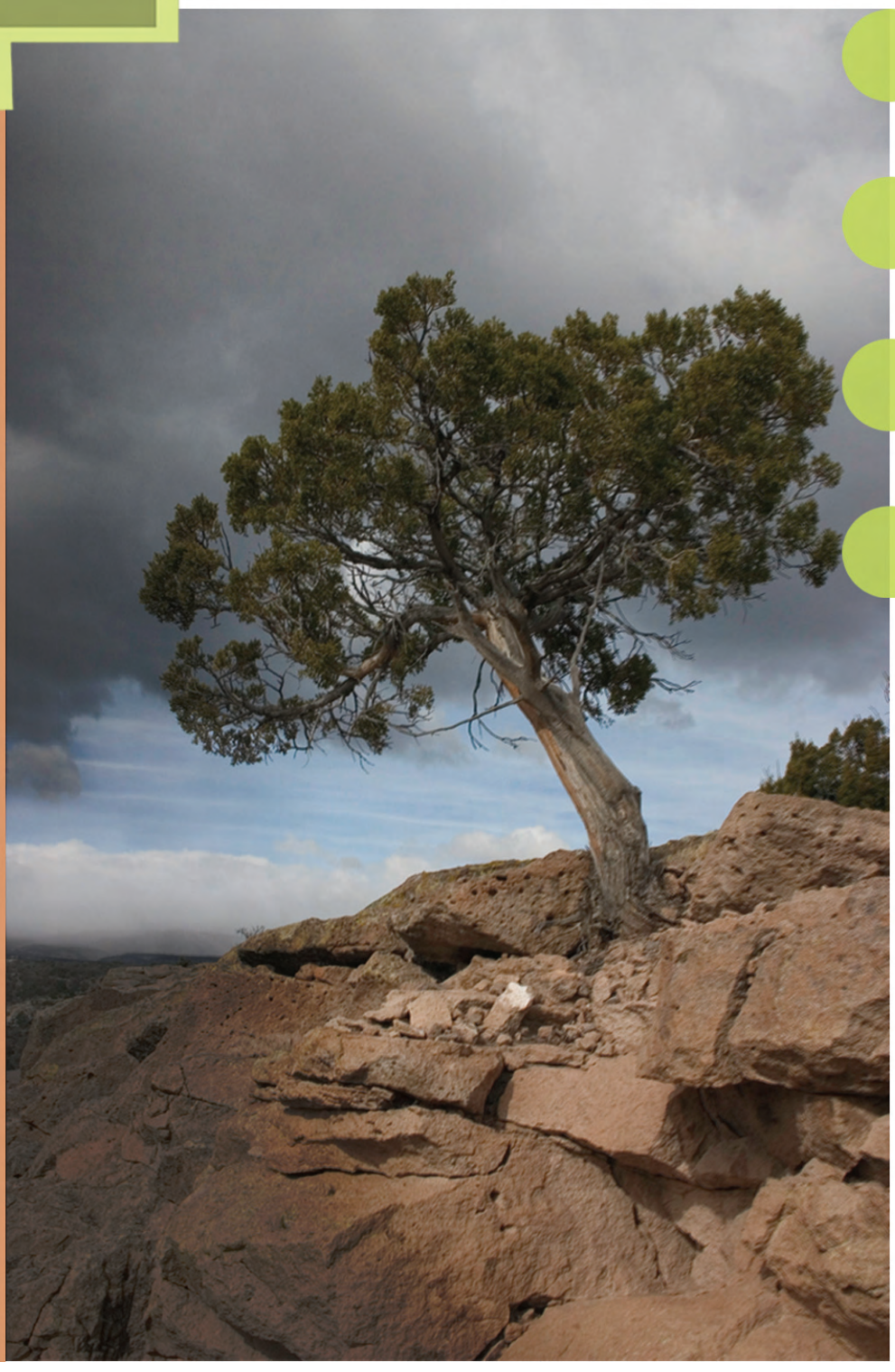
2. COMPLIANCE SUMMARY



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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 Department of Energy (DOE) requirements by directing employees to protect the environment and meet compliance requirements of applicable federal and state environmental protection regulations. Federal and state environmental laws address (1) handling, transporting, releasing, and disposing of contaminants, pollutants, 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 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 2005 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2005. The following sections summarize the Laboratory's regulatory compliance performance during 2005.

B. COMPLIANCE STATUS

The Laboratory continues to make progress on its goal of being in full compliance with all environmental regulations. The number of alleged violations or non-compliances has continued to drop compared to prior years.

The Laboratory completed 1,888 Resource Conservation and Recovery Act (RCRA) self-assessments in 2005 with a nonconformance finding rate of less than 2 percent (down from 3.5 percent in 2004). Similarly, the Laboratory's performance on NMED inspections continues to improve. NMED identified only four violations in 2005 compared with seven in 2004. The Laboratory met all permit limits for emissions to the air. The Laboratory continued to address cleanup and legacy waste issues in accordance with NMED requirements.

The Laboratory continues to meet requirements under the Clean Water Act. None of the 126 samples collected from the Sanitary Waste System Plant's outfall and only one (a residual chlorine measurement) of 949 samples collected from industrial outfalls exceeded Clean Water Act effluent limits. Compliance with National Pollutant Discharge Elimination System (NPDES) requirements at permitted construction sites improved substantially in 2005 to 93 percent overall (from 76 percent in 2004).

Table 2-1
Environmental Permits or Approvals under which the Laboratory Operated during 2005

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Hazardous Waste Facility	Hazardous waste Facility Permit and mixed-waste storage and treatment permit	November 1989	November 1999***	NMED[b]
	TA-50 Part B Permit Renewal Application Revision 3.0	Submitted August 2002	—	NMED
	General Part B Permit Renewal Application, Revision 2.0	Submitted August 2003	—	NMED
	TA-54 Part B Permit Renewal Application, Revision 3.0	Submitted June 2003	—	NMED
	TA-16 Part B Permit Renewal Application, Revision 4.0	Submitted June 2003	—	NMED
	TA-55 Part B Permit Application, Revision 2.0	Submitted September 2003	—	NMED
	General Part A Permit Application, Revision 4.0	Submitted December 2004	—	NMED
HSWA[c]	RCRA corrective activities	March 1990	December 1999***	NMED
TSCA[d]	Disposal of PCBs[e] at TA-54, Area G	June 25, 1996	June 25, 2001***	EPA[f]
CWA[g]/NPDES[h]	Outfall permit for the discharge of industrial and sanitary liquid effluents	February 1, 2001	January 31, 2005***	EPA
	MSGP[i] for the discharge of stormwater from industrial activities	October 30, 2000	October 30, 2005*	EPA
	Federal Facility Compliance Agreement for storm water discharges from Solid Waste Management Units (SWMUs)	February 5, 2005	—	EPA
	Construction General Permits (24) for the discharge of stormwater from construction activities	Varies	July 1, 2008**	EPA
CWA Sections 404/401	COE[j] Nationwide Permits (2)	Varies	varies	COE[j]/NMED
Groundwater Discharge Plan, TA-46 SWWS Plant[k]	Discharge to groundwater	January 7, 1998	January 7, 2003***	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid-Waste Treatment Facility	Discharge to groundwater	Submitted August 20, 1996	—	NMED

Table 2-1 (continued)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality Operating Permit (20.2.70 NMAC[l])	LANL air emissions	April 30, 2004	April 29, 2009	NMED
Air Quality (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	TA-3 Power Plant	September 27, 2000; Revised, November 26, 2003; Modified, July 30, 2004	None	NMED
	Generator at TA-33	October 10, 2002	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
	Chemistry and Metallurgy Research Replacement (CMRR)	September 16, 2005	None	NMED
	Radiological Laboratory, Utility, Office Building		None	NMED
	TA-11 Fuel/wood fire testing and TA-16 flash pad	March 29, 2005	None	NMED
	TA-36 sled track	March 29, 2005	None	NMED
Air Quality (NESHAP)[m]	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
	Radiological air emissions at CMRR	July 14, 2005	None	EPA
	Radiological Laboratory, Utility, Office Building			
Open Burning	TA-11 Fuel/wood fire testing	December 27, 2002	December 27, 2007	NMED
	TA-14 Burn cage	December 27, 2002	December 27, 2007	NMED
	TA-16 Flash pad	December 27, 2002	December 27, 2007	NMED
	TA-36 Sled track and open burn area	December 27, 2002	December 27, 2007	NMED

[a] Resource Conservation and Recovery Act
[b] New Mexico Environment Department
[c] Hazardous and Solid Waste Amendments
[d] Toxic Substances Control Act
[e] Polychlorinated biphenyls
[f] Environmental Protection Agency
[g] Clean Water Act
[h] National Pollutant Discharge Elimination System
[i] Multi-Sector General Permit
[j] US Army Corps of Engineers
[k] Sanitary Wastewater Systems Plant
[l] New Mexico Administrative Code
[m] National Emission Standards for Hazardous Air Pollutants

*MSGP expiration date
**Construction General Permit (CGP) expiration date
***Permit has been administratively continued

Table 2-2
Environmental Inspections and Audits Conducted at the Laboratory during 2005

Date	Purpose	Performing Agency
02/28/05-03/28/05	Hazardous waste compliance inspection (Closeout 4/07/2005)	NMED[a]
3/30/2005	PCB[b] inspection for compliance with TSCA[c] requirements	EPA Region 6
05/24/05–05/25/05	NPDES outfall compliance evaluation inspection	NMED-SWQB[d]
5/25/2005	CGP[e] compliance inspection, TA-50 Pumphouse Project	NMED[a]
6/28/2005 and 7/19/2005	Above-ground storage tank inspections at various Laboratory facilities	NMED[a]
9/14/2005	CGP[e] compliance inspection, TA-60 Roads & Grounds Relocation Project	NMED[a]
9/16/05	Asbestos management inspection of building TA-3, SM-31 demolition project	NMED[a]

(No FIFRA[f], Section 401/404, or Groundwater Discharge Plan inspections were conducted in 2005.)
[a] New Mexico Environment Department
[b] Polychlorinated biphenyls
[c] Toxic Substances Control Act
[d] Surface Water Quality Bureau
[e] Construction General Permit
[f] Federal Insecticide, Fungicide, and Rodenticide Act

The Laboratory signed a Compliance Order on Consent (Consent Order) with NMED in March 2005. The Consent Order replaced the RCRA permit under which the Laboratory operated with respect to corrective action activities (Permit Module VIII). The Consent Order contains requirements for investigation and, as necessary, cleanup of solid waste management units (SWMUs) and areas of concern (AOCs) at the Laboratory. The Laboratory signed a Federal Facility Compliance Agreement (FFCA) and Administrative Order (AO) with EPA in February 2005. The FFCA/AO included monitoring, corrective actions, and reporting requirements for certain SWMUs and AOCs at the Laboratory.

1. Resource Conservation and Recovery Act

a. Introduction

The Laboratory produces a variety of hazardous wastes, mostly in small quantities relative to 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 of New Mexico Administrative Code (NMAC) Title 20, Chapter 4, Part 1, as revised October 1, 2003 (20.4.1 NMAC). Federal and state laws regulate management of hazardous wastes based on a combination of the facility's status; large- or small-quantity generation; and the types of treatment, storage, and disposal conducted by the facility.

Certain operations may require an operating permit, called a hazardous waste facility permit, or a RCRA permit. The LANL hazardous waste facility permit expired in 1999 but was administratively continued beyond the expiration date as allowed by the permit and by 20.4.1.900 NMAC. In anticipation of the permit's expiration, and by agreement with NMED, the Laboratory submitted preliminary permit renewal applications for NMED review starting in 1996. The permit renewal applications have been revised as needed; the final set of revised Part B permit applications was submitted in 2003 for final NMED review.

b. Resource Conservation and Recovery Act Permitting Activities

The Laboratory submitted several proposed modifications to the LANL hazardous waste facility permit in 2005. These included Class III modifications removing the corrective action requirements in Module VIII of the permit in response to the March 1, 2005, Consent Order and to remove three TA-21 SWMUs approved by NMED for No Further Action. The modifications were presented for comment in public review periods in the fall of 2005. Additional permit-related activities included the submittal of supplemental information to NMED for TA-55 storage area upgrades and for additional facilities to support Waste Isolation Pilot Plant (WIPP) transuranic waste characterization and transport project activities at TA-54, Area G, Dome 375, and Pad 10.

Closure reports for the TA-16 Filter Vessels 401/406 and the TA-55, Room B38 Container Storage Unit were completed and submitted. NMED approved the closure of the filter vessels in September 2005. Closure activities proceeded for the TA-54 Area L treatment tanks and the Area L 36 and 37 lead stringer shafts.

c. Other Resource Conservation and Recovery Act Activities

The compliance assurance program, managed by the regulatory compliance group, performed Laboratory self-assessments to determine whether hazardous and mixed waste is managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. RCRA staff 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 2005, the Laboratory completed 1,888 self-assessments with a nonconformance finding rate of 1.96 percent.

d. Resource Conservation and Recovery Act Compliance Inspection

From February 28 to March 28, 2005, NMED conducted a hazardous waste compliance inspection at the Laboratory (Table 2-2). NMED identified four alleged RCRA violations for this inspection in a Notice of Violation issued on April 20, 2005.

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 (UC), requiring compliance with the Site Treatment Plan. 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. The Laboratory met all 2005 Site Treatment Plan deadlines and milestones by treating and disposing of more than 5.4 cubic meters of Site Treatment Plan low-level mixed waste.

f. Solid Waste Disposal

LANL sends sanitary solid waste (trash), concrete/rubble, 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 2005 included 1788 metric tons of trash and 411 metric tons of construction and demolition debris. Through LANL recycling efforts, 4,607 tons of material did not go to the landfill in 2005.

g. Compliance Order on Consent (Consent Order)

At the beginning of 2005, under its Environmental Remediation and Surveillance Program, the Laboratory continued to operate in accordance with the corrective action requirements of Module VIII of the Laboratory's hazardous waste facility permit, which specifies conditions for compliance with the Hazardous and Solid Waste Amendments to RCRA. Effective March 1, 2005, the corrective action requirements of Module VIII were replaced by a Consent Order signed by NMED, DOE, and UC. Prior to March 1, 2005, the Laboratory voluntarily complied with the provisions of a draft Consent Order negotiated by NMED, DOE, and UC and issued by NMED on September 1, 2004.

The Consent Order is the principal regulatory driver for the Laboratory's Environmental Remediation and Surveillance Program. The Consent Order contains requirements for investigation and, as necessary, cleanup of SWMUs and AOCs at the Laboratory. The Consent Order includes the following major activities:

- Investigation of canyon watersheds;
- Investigation of material disposal areas (MDAs) at TAs-21, -49, -50, and -54;
- Completion of ongoing investigations and cleanups begun under Module VIII; and
- Investigation of SWMUs and AOCs within watershed aggregate areas.

The Consent Order contains enforceable deadlines for submitting the investigation work plans associated with the above investigations and for completing corrective actions in each watershed. The Consent Order also contains specific technical requirements for implementing investigations, conducting corrective measures, and preparing documents. It establishes cleanup levels for groundwater, soil, and surface water. NMED is the administrative authority for all corrective actions conducted at SWMUs and AOCs under the Consent Order. DOE is the administrative authority for corrective actions associated with radionuclides, which are specifically excluded from the Consent Order.

All of the Laboratory deliverables (plans and reports) required by the Consent Order were submitted on time or early to NMED (see Tables 9-1 and 9-2 in Chapter 9 of this report). In addition, the Laboratory submitted several other plans and reports not specifically required by the Consent Order to NMED during 2005. The new Chapter 9 in this report describes the investigation and cleanup activities conducted under the Environmental Remediation and Surveillance Program during 2005.

h. Hazardous Waste Report

The Hazardous Waste Report covers hazardous and mixed waste generation, treatment, and storage activities performed at LANL during 2005 as required by RCRA, under 40 CFR 262.41, Biennial Report. In 2005, the Laboratory generated about 89,000 kg of RCRA hazardous waste, 570 kg of which were generated by the Environmental Remediation and Surveillance Program. The waste is recorded for more than 10,000 waste movements, treatment, or storage actions resulting in more than 640 Waste Generation and Management forms in the Hazardous Waste Report. The entire report is available on the web at http://www.lanl.gov/community/environment/docs/waste/2005LANLBiennial.pdf

2. Comprehensive Environmental Response, Compensation, and Liability Act

As part of its Conveyance and Transfer Project, the Laboratory prepared environmental baseline survey documents for three subparcels of land during 2005. One survey was completed for A-5 Airport South. The other two surveys (A-10 DP Road East and A-18 TA-74 South) are waiting for "no further action" determinations from DOE's Los Alamos Site Office for an AOC at these sites. These documents contain the Comprehensive Environmental Response, Compensation, and Liability Act 120(h) information required to transfer these properties to private ownership and indicate that "no hazardous substances exist on these sites," that "all remedial action necessary to protect human health and the environment has been taken," or that certain restrictions on use are required. These documents provide sufficient information to demonstrate that no environmental impacts exist that would trigger actions under the Comprehensive Environmental Response, Compensation, and Liability Act.

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 13148, Greening the Government Through Leadership in Environmental Management. Executive Order 13148 supersedes Executive Order 12856.

b. Compliance Activities

For 2005, the Laboratory submitted two annual 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 2005

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 2005.
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 32 hazardous materials stored at LANL over specified quantities in 2005 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.	Use of lead and mercury exceeded the reporting thresholds in 2005, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the state emergency response commission.

Emergency Planning Notification. Title III, Sections 302–303, of Emergency Planning and Community Right-to-Know Act 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) of any changes at the Laboratory that might affect the local emergency plan or (2) if the Laboratory's emergency planning coordinator changes. No updates to this notification were made in 2005.

Emergency Release Notification. Title III, Section 304, of Emergency Planning and Community Right-to-Know Act 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. The Laboratory did not have any leaks, spills, or other releases that exceeded any reporting thresholds in 2005.

Material Safety Data Sheet/Chemical Inventory Reporting. Title III, Sections 311–312, of Emergency Planning and Community Right-to-Know Act require facilities to provide an annual inventory of the quantity and location of hazardous chemicals that are above specified thresholds present at the facility. The inventory includes hazard information and 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 32 chemicals and explosives at the Laboratory that were stored on-site in quantities that exceeded threshold limits during 2005.

Toxic Release Inventory Reporting. Executive Order 13148 requires all federal facilities to comply with Title III, Section 313, of the Emergency Planning and Community Right-to-Know Act. 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 two thresholds in 2005 and therefore reported the uses and releases of these chemicals. The reported materials were lead and mercury. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. The largest use of reportable mercury is at the reservoirs of mercury that Los Alamos Neutron Science Center (LANSCE) uses as shields on the neutron beam shutter system. In contrast to previous years, nitric acid use was below reporting thresholds because the plutonium processing facility was not operating for much of the year due to facilities upgrades and maintenance activities. Table 2-4 summarizes the reported releases for the two EPCRA Section 313 reportable chemicals for 2005.

Table 2-4
Summary of 2005 Reported Releases under EPCRA Section 313

	Lead (lb)	Mercury (lb)
Air Emissions	7.1	0.3
Water Discharges	542	0.8
On-Site Land Disposal	7,007	0
Off-Site Waste Transfers	1,477	221

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 concern under the Toxic Substances Control Act (TSCA) is the regulations covering polychlorinated biphenyls (PCB) and 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, soils, and materials contaminated by spills.

During 2005, the Laboratory shipped 88 containers of PCB waste off-site for disposal or recycling. The quantities of waste disposed of included 37 kg of capacitors and 1,893 kg of fluorescent light ballasts. The Laboratory manages all wastes in accordance with 40 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 Laboratory disposes of nonliquid wastes that contain PCBs and are contaminated with radioactive constituents at its TSCA-authorized landfill located at TA-54, Area G. Radioactively contaminated PCB liquid wastes are stored at the TSCA-authorized storage facility at TA-54, Area L. Although some of these items have exceeded TSCA's one-year storage limitation, radioactively contaminated PCB liquid wastes are currently in storage as allowed by TSCA.

The five-year letter of authorization to use Area G for PCB disposal expired in July 2001, and EPA granted an administrative extension to LANL for continued use of Area G during the review process. The renewal request for the Area G PCB disposal authorization was withdrawn in 2006. During 2005, EPA performed one PCB site inspection, and approximately 55 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 regulates pesticides manufacturing and the protection of workers who use these chemicals. Sections of this act that apply to the Laboratory include requirements for certifying 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 certifying of pesticide workers, record keeping, applying of pesticides, inspecting of equipment, storing of pesticides, and disposing of pesticides.

The New Mexico Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2005. The Laboratory conducted four quarterly inspections of the pesticide storage area in 2005 and found that the storage area was being maintained in accordance with RCRA regulations.

Table 2-5 shows the amounts of pesticides the Laboratory used during 2005.

Table 2-5
Pesticides and Herbicides Used at LANL in 2005

Herbicides		Insecticides	
VELPAR L (Liquid)	148 gal	TEMPO (Powder)	1.3 oz
CONFRONT	3 oz	MAXFOURCE ANT BAIT	5 oz
		TALSTAR F	18.3 oz
		HIGHYIELD WASP	9 oz
		PT250 BAYGON	3.5 oz
		POWDER KEG	3 oz

6. Clean Air Act

Pursuant to the federal Clean Air Act (CAA) Amendments and Title 20 of NMAC, Chapter 2, Part 70, Operating Permits (20.2.70 NMAC), UC is authorized to operate LANL per the terms and conditions as defined in Operating Permit No. P100. The operating permit conditions mirror existing source-specific permit conditions applicable to operating requirements, record keeping, monitoring, and reporting. Compliance with the conditions of the Title V Operating Permit is deemed to be in compliance with any applicable air requirements existing at the date of permit issuance.

As part of the Title V Operating Permit program, LANL reports annual emissions for sources included in the Operating Permit. These sources, as defined in the Title V Operating Permit Application, include multiple boilers, two steam plants, a paper shredder (decommissioned in July 2004), a data disintegrator (initial start-up in August 2004), carpenter shops, three degreasers, a rock crusher (retired in July 2004), multiple storage tanks, and asphalt production. LANL also reports emissions from chemical use associated with R&D and permitted beryllium activities.

According to reporting requirements in the Title V Operating Permit's terms and conditions, the Laboratory must submit an Annual Compliance Certification report. 2005 was the first full year in which LANL was required to meet these reporting requirements. LANL demonstrated full compliance with the permit's applicable terms and conditions and met all reporting requirement deadlines.

In 2005, LANL initiated the process to modify Operating Permit No. P100. This modification was specifically for incorporating the permit conditions from the combustion turbine New Source Review (NSR) Permit 2195B-M1, incorporating the permit conditions from the data disintegrator NSR Permit 2195H, implementing new permit conditions for the soil vapor extraction system processed as Notice of Intent (NOI) 2195L, and removing the rock crusher from the Title V permit application as this source was retired. A permit modification is expected in 2006.

According to the terms and conditions of NSR air quality permit GCP3-2195, LANL performed start-up and began operations of a BDM Engineering Model Number TM2000 asphalt plant. This replaced an existing unit and does not represent a new capability.

Under the Title V Operating Permit program, LANL is a major source, based on the potential to emit, for nitrogen oxides (NOX), carbon monoxide (CO), and volatile organic compounds (VOCs). In 2005, the TA-3 steam 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 pollutants emissions. A summation of the data is present in Table 2-6.

Table 2-6
Calculated Actual Emissions for Regulated Pollutants (Tons) Reported to NMED for Operating Permit Compliance

	Pollutants					
Emission Units	NO_x	SO_x	PM	CO	VOC	HAPs
Asphalt Plant[a]	0.02	0.004	0.008	0.32	0.007	0.006
TA-21 Steam Plant	1.58	0.016	0.12	1.33	0.09	0.03
TA-3 Steam Plant	16.2	0.17	2.13	11.2	1.54	0.53
Regulated Boilers	6.7	0.04	0.62	4.6	0.39	0.13
R&D Chemical Use	NA	NA	NA	NA	11.2	5.4
Degreaser	NA	NA	NA	NA	0.011	0.011
Data Disintegrator	NA	NA	0.29	NA	NA	NA
Rock Crusher	0	0	0	0	0	0
Carpenter Shops	NA	NA	0.085	NA	NA	NA
Storage Tanks	NA	NA	NA	NA	0.05	NA
Stationary Standby Generators[b]	7.0	1.55	0.32	1.7	0.35	0.003
Miscellaneous Small Boilers[b]	19.0	0.11	1.44	15.9	1.0	0.36
TOTAL	**50.5**	**1.9**	**5.0**	**35.1**	**14.6**	**6.5**

[a] The old asphalt plant was shut down in 2003. A new asphalt plant began operation in July 2005.

[b] 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 documentation. Calculated emissions are based on actual production rates, fuel and fuel usage, and/or material throughput. To satisfy requirements set forth in the Title V Operating Permit, LANL completed its annual Emissions Inventory Report and submitted the report to NMED. Figure 2-1 depicts the historical emissions of criteria pollutants. The only appreciable change from 2004 is the small increase in VOC emissions from R&D chemical use.

a. New Mexico Air Quality Control Act

i. Construction Permits. LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to revise the operating permit application, to apply for construction permits, or to submit notifications to NMED. During 2005, the Laboratory performed approximately 200 air quality reviews and received an NSR air quality permit for open burning activities for the TA-11 fuel/wood fire testing and the TA-16 flash pad and a second permit for the TA-36 sled track. LANL also submitted and received a NSR air quality permit for the Chemistry and Metallurgy Research Replacement (CMRR) radiological laboratory and utility and office buildings. LANL did not submit to or receive from NMED any exemption notifications. LANL currently operates under the air permits listed in Table 2-1.

ii. Open Burning. LANL performed open burns under both 20.2.60 and 20.2.72 NMAC regulations. LANL has four open burning permits (20.2.60 NMAC) for operational burns conducted to thermally treat or dispose of high explosives or material contaminated with high explosives and to test accident scenarios involving fire.

Under 20.2.72 NMAC, in 2005 LANL received from NMED one New Source Review air quality permit for the open burn activities at the TA-11 fuel/wood fire testing and the TA-16 flash pad as well as a NSR air quality permit for the TA-36 sled track. These permits were appealed and a hearing before the Environmental Improvement Board was scheduled for 2005 but postponed until 2006 to allow for a potential agreement between the interested parties.

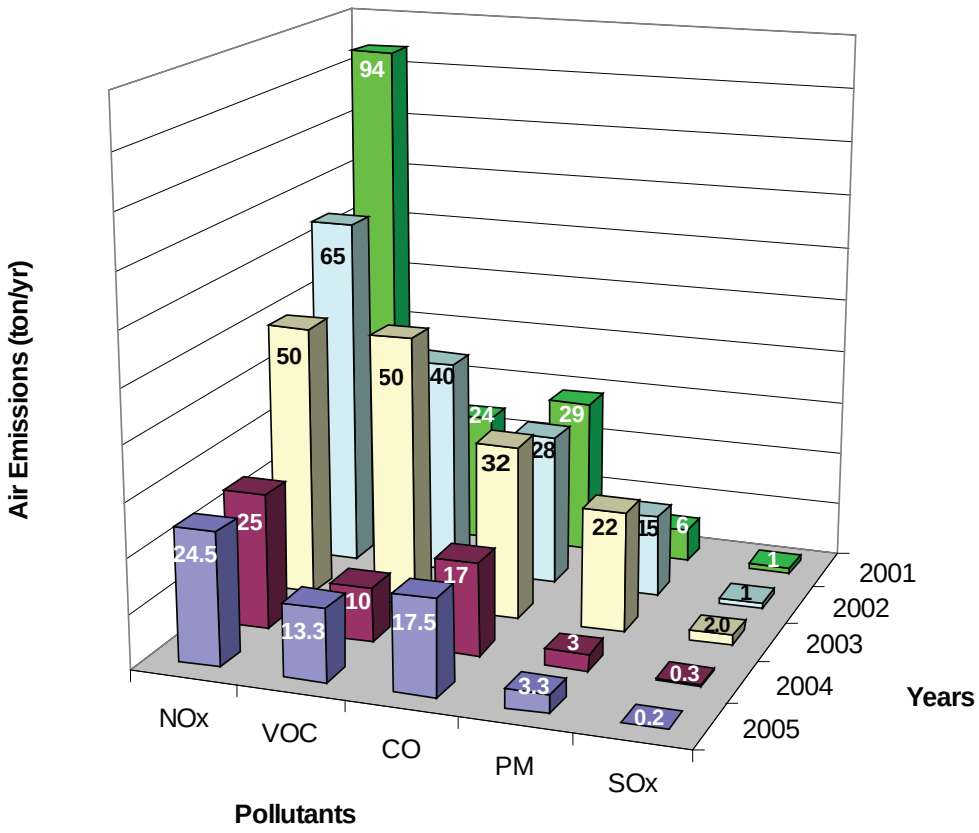


Figure 2-1. Criteria pollutant emissions from LANL 2001 to 2005 for emissions inventory reporting.

All operational burns for 2005 were conducted within the terms specified in the permits. To document compliance with permit requirements, the Laboratory reports the results of these operations to NMED.

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 2005 included 48 large renovation jobs and demolition projects of which NMED received advance notice. These projects, combined with other smaller activities, generated approximately 694.39 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. In addition, NMED conducted one inspection during the year and identified no violations. The Quality Assurance Project Plans for the Asbestos Report Project and the National Emission Standard for Hazardous Air Pollutants for Radionuclides (Rad-NESHAP) Compliance Project are available online at http://www.lanl.gov/community/environment/air/.

b. Federal Clean Air Act

i. Ozone-Depleting Substances. Title VI of the Clean Air Act contains specific sections that establish regulations and requirements for ozone-depleting substances, such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting an ozone-depleting substance into the atmosphere

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 Operations and Maintenance manual.

In addition to routine compliance demonstration, DOE has established two goals to eliminate usage of class 1 refrigerants. In 2004, the Laboratory met the first goal, which was to retrofit or replace all chillers with greater than 150 tons of cooling capacity and manufactured before 1984 by 2005 (Figure 2-2). The second goal is to eliminate the procurement of the remaining equipment containing class 1 refrigerants by 2010.

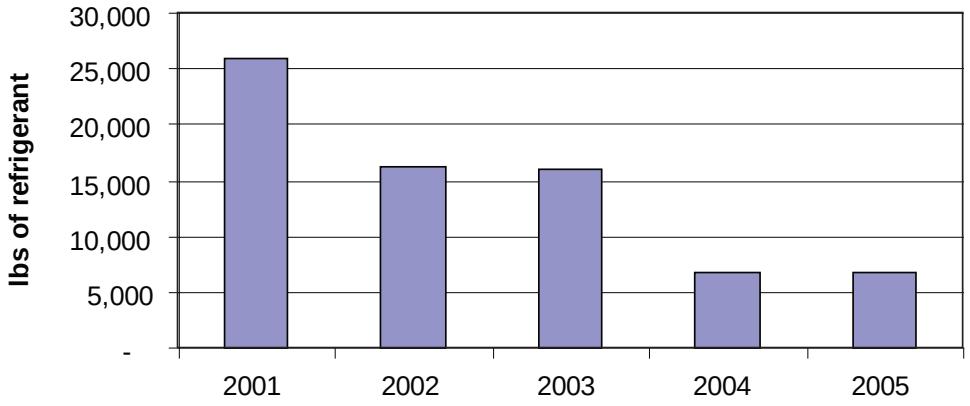


Figure 2-2. Amounts of total class 1 refrigerants in LANL equipment from 2001 to 2005.

ii. Radionuclides. Under 40 CFR 61 Subpart H (Rad-NESHAP), the EPA establishes a framework of requirements for DOE facilities using radioactive materials and limits the effective dose equivalent of radioactive airborne releases from a DOE facility, such as LANL, to any member of the public to 10 mrem/yr. The 2005 dose to the maximally exposed individual (MEI) (as calculated using EPA-approved methods) was 6.46 mrem. The location of the highest dose was at East Gate. Operations at LANSCE made the principal contribution to that highest dose.

7. Clean Water Act

a. NPDES Industrial Point Source Outfall Self-Monitoring Program

The primary goal of the Clean Water Act (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.

In 2005, UC and the DOE/National Nuclear Security Administration (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. The Laboratory's current industrial point-source NPDES permit contains 21 permitted outfalls that include one sanitary outfall and 20 industrial outfalls. To view the Laboratory's NPDES permit, go online to http://www.lanl.gov/community/environment/h2o/.

The Laboratory's long-term objectives require that outfall owners continue evaluating outfalls for possible elimination and that new construction designs and modifications to existing facilities provide for reduced or no-flow effluent discharge systems (Figure 2-3). No NPDES outfalls were deleted in 2005; however, four outfalls were eliminated and not included in the Laboratory's NPDES Permit re-application submitted to EPA on July 30, 2004. The Laboratory's new NPDES point-source permit is anticipated to be issued in 2006 and will include one sanitary outfall and 16 industrial outfalls for a total of 17 permitted outfalls.

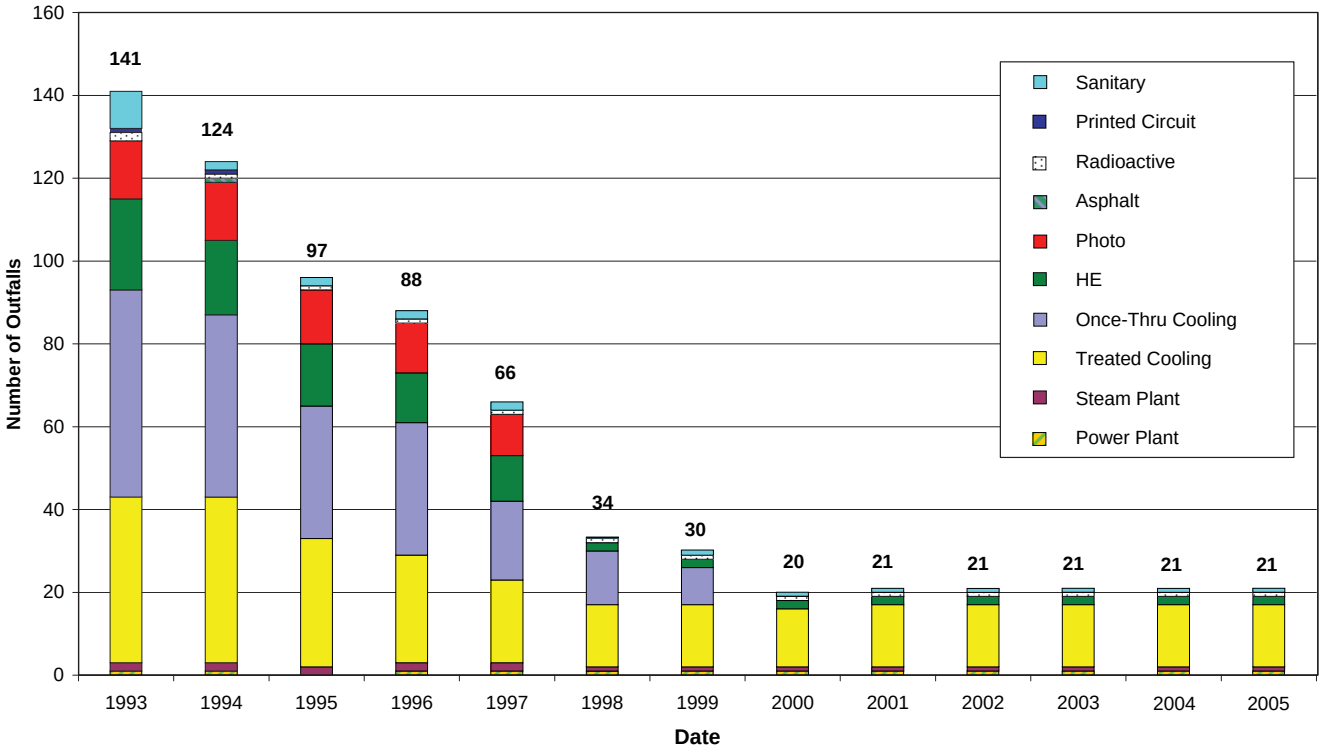


Figure 2-3. Number and type of permitted NPDES outfalls at LANL over the past 13 years.

The Laboratory's NPDES outfall permit requires weekly, monthly, and quarterly sampling to demonstrate compliance with effluent quality limits. The Laboratory also collects annual water-quality samples at all outfalls. The Laboratory reports analytical results to EPA and NMED at the end of the monitoring period for each respective outfall category. During 2005, none of the 126 samples collected from the Sanitary Wastewater Systems (SWWS) Plant's outfall exceeded effluent limits for residual chlorine; however, one of the 949 samples collected from industrial outfalls exceeded effluent limits. Figure 2-4 shows the number of effluent exceedances over the past 12 years. Monitoring data obtained from sampling at NPDES permitted outfalls are available online at http://www.lanl.gov/community/environment/h2o/.

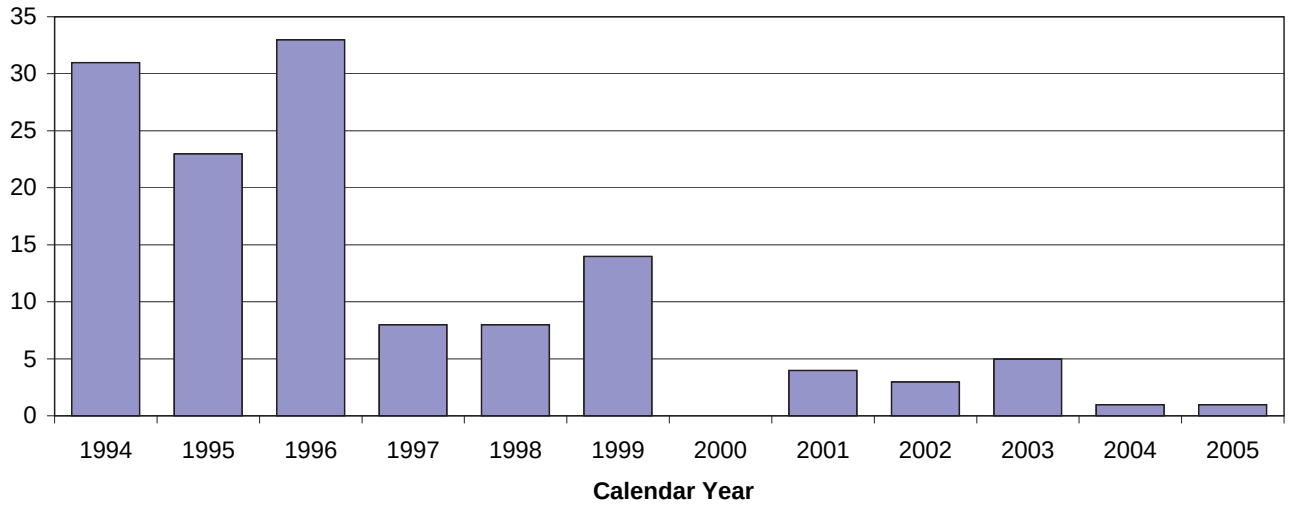


Figure 2-4. Number of exceedances of NPDES outfall effluent limits over the past 12 years.

The following is a summary of the corrective actions taken by the Laboratory during 2005 to address the NPDES outfall permit noncompliance cited above.

TA-3-22 Outfall 001Power Plant. On December 12, 2005, a total residual chlorine concentration of 0.34 mg/L exceeded the NPDES daily maximum permit limit of 11 µg/L and the Minimum Quantification Level (MQL) of 100 µg/L in NPDES Permit NM0028355. The noncompliance was attributed to fluctuating levels of chlorine in the treated re-use water coming from the sanitary plant and inadequate operational sampling. The immediate corrective action was to increase the drip-rate of the chlorine neutralizer. The long-term corrective actions are to change the sampling point for operational samples and to install an automated monitoring system that will inject chlorine neutralizer based on flow rate coming from the sanitary plant.

b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program

The Laboratory's WA-Site (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 then disposed of as a New Mexico Special Waste. Monitoring data obtained from routine characterization of SWWS Plant sludge is available online at http://www.lanl.gov/community/environment/h2o/. During 2005, the SWWS Plant generated approximately 36.89 dry tons (73,790 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. National Pollutant Discharge Elimination System Industrial Point Source Permit Compliance Evaluation Inspection

NMED's Surface Water Quality Bureau conducted an NPDES Outfall Compliance Evaluation Inspection (CEI) on May 24 and 25, 2005, at 15 facilities throughout the Laboratory.

From the inspections, NMED prepared three reports: a report for Outfall 051, a report for Outfall 13S, and a report for the other 13 outfalls. Evaluation ratings were 4, 3, and 4 respectively on a scale of 1 to 5, with 5 for very reliable self-monitoring programs, 3 for satisfactory, and 1 for very unreliable programs. Below is a summary of the corrective actions taken by the Laboratory to address some deficiencies noted in the CEI Reports.

1. **DOE/LANL reporting "0" on Discharge Monitoring Reports (DMRs) without EPA authorization for parameters not on the list in Part II.B.** The Laboratory will include the "<" symbol and will report non-detects as < DL (detection limit) for those parameters not specified in Part II of the permit.
2. **TA-46 sanitary treatment facility not sufficiently operated or maintained at all times to minimize upsets.** Sanitary treatment plant personnel will include a check of clarifier short-circuiting and the rubber components on the daily inspections. If any problems are noted, a corrective maintenance ticket will be written to correct the problem(s) as soon as possible, instead of waiting until a preventive maintenance request is issued. The sanitary treatment facility operators will also consider an increase in the frequency of solid wasting and/or increasing the return activated sludge pump rate.
3. **Within the chlorine contact chamber, there were grease balls, approximately 3 mm in size, as well as some grit observed before effluent exited the treatment system via the Parshall flume.** A new grease interceptor and discharge line were installed in July 2005. Installation of the inlet line to the grease interceptor from the Otowi kitchen was completed in late 2005. Several lines into the old grease trap will be removed and connected to the new grease interceptor before it can become fully operational.
4. **Requested documentation for Outfall 051 was not provided.** Per NMED's request on May 31, 2005, sampling documentation from data packages for 2004 water quality standards, October, November, and December was provided to the inspector for Outfall 051. The complete data packages for October, November, and December 2004 for Outfall 051 were provided to NMED with the Laboratory's response letter. Also included with the response were the logbook entries for supporting pH measurements recorded on the October, November, and December DMRs.

5. **The pH on DMRs conflict with pH on summary sheets for Outfall 051.** The Laboratory's permit requires a weekly grab sample for pH at Outfall 051. TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF) personnel also collect "operational" pH samples using a continuous pH monitor. The "internal summary sheet" will be modified to clarify that the continuous pH readings are operational samples.
6. **Contradictory and largely incomprehensible language describing tritium results in the second paragraph of the cover letter accompanying the yearly Water Quality Standards DMR.** The Laboratory will address NMED's concern by re-writing the language in future DMRs.
7. **Samples obtained at the sample sink inside the RLWTF apparently do not qualify as "representative" of the permitted activity.** Corrective actions have been completed to address NMED concerns regarding representative sampling.

d. NPDES Storm Water Construction 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 permittees at most construction sites. Compliance with the NPDES CGP includes the development and implementation of a Storm Water Pollution Prevention (SWPP) Plan before soil disturbance begins and site inspections once soil disturbance has commenced. A SWPP Plan describes the project activities, site conditions, and Best Management Practices (BMPs) 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 inspections and reports that document the condition of the site and corrective actions required to keep pollutants from moving off the construction site. Data collected from these reports is tabulated monthly and annually in the form of Site Inspection Compliance Reports.

During 2005, the Laboratory implemented and maintained 64 construction site SWPP Plans and addendums to SWPP Plans and performed 833 storm water inspections. The Laboratory uses a geographic information system (GIS) to manage project information and generate status reports that facilitate Appendix F reporting. During the final quarter of 2005, 97.3 percent of the Lab's construction projects were in compliance with NPDES CGP requirements. At the end of 2005, 100 percent of the Laboratory's permitted sites were in compliance with the CGP. Corrective actions implemented in 2005 account for the improved compliance status from 2004. The overall compliance percentage in 2005 was 93 percent for all inspections compared to 76 percent in 2004. The LANL storm water team identified problems leading to noncompliances and difficulties with stabilizing disturbed landscapes. These mitigating factors have been incorporated into the team's Quality Improvement Performance Report. To further reduce future CGP noncompliances and increase Laboratory project manager and construction personnel awareness of CGP requirements, the storm water team is revising the BMP guidance document, developing a CGP training program, revising business and Request for Proposal contract language, and providing presentations on environmental requirements to contractors at pre-bid presentations. In addition, construction site representatives and/or LANL project managers are now required to attend storm water inspections to raise awareness of noncompliances and potential noncompliances and to ensure appropriate corrective measures for BMPs are implemented.

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; landfilling operations; vehicle and equipment maintenance; recycling activities; electricity generation; and asphalt manufacturing.

LANL, UC, and the DOE are co-permittees under the EPA 2000 NPDES Storm Water Multi-Sector General Permit for Industrial Activities (MSGP-2000). The MSGP-2000 requires the development and implementation of site-specific SWPP Plans, which must include identification of potential pollutants and activities and implementing BMPs. Permit requirements also include the monitoring of storm water discharges from permitted sites.

In 2005, LANL implemented and maintained 15 SWPP Plans under the MSGP-2000 covering 25 facilities and site-wide SWMUs. Compliance with the MSGP-2000 requirements for these sites is achieved primarily by implementing the following:

- Identifying potential pollutants and activities that may impact surface water quality and identifying and providing controls (BMPs) to limit the impact of those pollutants.
- Developing and implementing facility-specific SWPP Plans.
- 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. Flow-discharge information is reported in Shaull et al. (2006) and in DMRs submitted to EPA and NMED.

The MSGP-2000 expired October 30, 2005, without EPA issuing a new permit. Administrative continuance of the MSGP-2000, which requires continued compliance with the expired permit requirements, was granted to existing permit holders. This continuance will remain in effect until a new permit is issued. On December 1, 2005, EPA issued a draft MSGP with expected issuance of the final permit sometime in 2006. Proposed changes to the permit include increased storm water monitoring requirements, changes in benchmark monitoring parameters, increased inspection frequencies, additional SWPP Plan content requirements, and increased requirements for BMP selection, implementation, and maintenance.

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 Facility Compliance Agreement (FFCA). The FFCA establishes 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. All 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 establishes a schedule for monitoring and reporting requirements and requires the Laboratory to minimize erosion and the transport of pollutants or contaminants from Sites in storm water runoff.

The FFCA/AO requires 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 Laboratory 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 Storm Water Pollution Prevention Plan (SWMU/SWPPP) over a four year period. The purpose of storm water monitoring is to determine if there is a release or transport of pollutants/contaminants into surface water that could cause or contribute to a violation of applicable surface water quality standards. 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 2005, the Laboratory completed the following tasks:

1. Submitted the annual modification of the SWMP that describes how the telemetry-based network of monitoring stations would be used to implement watershed-scale monitoring at the Laboratory;
2. Submitted the annual modification of the SWPP for SWMU/AOCs that describes site-specific monitoring and erosion control program at SWMU/AOCs;
3. Submitted administratively complete individual permit application for storm water discharges from SWMUs, March 2005;
4. Submitted all monthly water screening action level exceedance reports and quarterly status reports required by the FFCA on schedule;

5. Completed the following fieldwork:
   - Installed 40 new site-specific samplers to bring the total to 80;
   - Collected 312 storm water samples at site-specific locations;
   - Collected 191 storm water samples at gauge locations;
   - Conducted 1,087 inspections at 294 Sites;
   - Completed 248 new BMP installations; and
   - Completed maintenance of BMPs at 151 sites.

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 (CWA, 40 CFR, Part 112) and NMED Petroleum Storage Tank Bureau Regulations (20.5 NMAC). During 2005, the Laboratory was in full compliance with both EPA and NMED requirements.

The Spill Prevention Control and Countermeasures (SPCC) Plan establishes 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 extending 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 October 31, 2007. The primary modifications address AST storage capacity, inspection frequency, and integrity testing requirements. The Laboratory has completed all modifications to existing and new SPCC Plans and continues to implement those modifications.

On August 15, 2003, NMED implemented new regulations that combined requirements for underground storage tanks and ASTs (20.5 NMAC). The Laboratory continues to maintain and operate ASTs in compliance with 20.5 NMAC. In July 2005, the Laboratory paid annual AST registration fees ($100 per AST) to NMED.

During 2005, the Laboratory continued to work on removing and decommissioning ASTs that were no longer in service. In 2005, we developed a quarterly assessment program for AST systems to assist Laboratory AST owners and operators in meeting regulatory compliance requirements and associated deadlines.

NMED conducted AST inspections on June 28, 2005 and July 19, 2005 at various Laboratory facilities. The NMED cited no violations during these inspections.

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 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 2005, the Laboratory worked on developing a Sampling and Analysis Plan to conduct additional characterization of the TA-21-57 diesel release site to further evaluate subsurface diesel contamination. Additional characterization will provide information needed for establishing current conditions for the subsurface diesel contamination. Upon evaluation of additional characterization, the Laboratory intends to develop applicable processes for site mitigation.

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 initial characterization of the diesel contaminated soil in April 2004 and is continuing to work with NMED on a path forward for additional characterization and mitigation efforts. In 2005, the Laboratory began developing a Sampling and Analysis Plan to conduct secondary characterization at the TA-3-26 site to further evaluate nature and extent of the diesel contaminated soil.

h. Dredge and Fill Permit Program

Section 404 of the CWA 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 CWA requires states to certify that Section 404 permits issued by the Corps will not prevent attainment of state-mandated stream standards. NMED reviews Section 404/401 joint permit applications and then 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 2005, two Section 404/401 permits were issued to the Laboratory for (1) the Pueblo Canyon Channel Stabilization Project in Pueblo Canyon (Nationwide Permit No. 13, Bank Stabilization) and (2) the Security Perimeter Road Project in an ephemeral tributary to Twomile Canyon (Nationwide Permit No. 14, Road Crossings). In addition, LANL reviewed 916 excavation permits and 132 project profiles for potential impacts to watercourses, floodplains, or wetlands. No Floodplain/Wetland Assessments were prepared in 2005.

No violations of the DOE Floodplains/Wetlands Environmental Review Requirements were recorded. NMED and the Corps of Engineers did not inspect active sites permitted under the Section 404/401 regulations during 2005.

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 2002). 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 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. In 2005, the Laboratory conducted additional confirmation monitoring of the Los Alamos water supply system for quality assurance purposes. Chapter 5 presents these data.

In 2005, Los Alamos County and NMED conducted sampling for microbiological organisms, nitrate+nitrite (as N), radionuclides, total trihalomethanes, total haloacetic acids, volatile and semi-volatile organic compounds, and heavy metals in drinking water for SDWA compliance purposes. In addition, lead and copper samples were collected from 34 residential taps. Results showed that all samples were compliant with SDWA MCLs. More information on the quality of the drinking water from the Los Alamos Water Supply System is in the County's annual Consumer Confidence Report, available online at: http://www.lac-nm.us/.

NMED did not conduct an inspection of the drinking-water system in 2005.

9. Groundwater

a. Groundwater Protection Compliance Issues

DOE Order 450.1 requires the Laboratory to prepare a groundwater protection management program plan to protect groundwater resources in and around the Los Alamos area and ensure that all groundwater-related activities comply with the applicable federal and state regulations. The March 2005 Consent Order superseded Module VIII of the RCRA Hazardous Waste Facility Permit, which required the Laboratory to collect information about the environmental setting at the facility and to collect data on groundwater contamination.

The Laboratory completed activities under the Hydrogeologic Workplan (LANL 1998a) in 2004. The Hydrogeologic Workplan defined a multiyear drilling and hydrogeologic analysis program to characterize the hydrogeologic setting of the Pajarito Plateau. The program provided a greater understanding of the geology, groundwater flow, and geochemistry beneath the 40-square-mile Laboratory area. The program culminated in a report, entitled "Los Alamos National Laboratory's Hydrogeologic Studies of the Pajarito Plateau: A Synthesis of Hydrogeologic Workplan Activities (1998-2004)," which was published in December 2005. This report

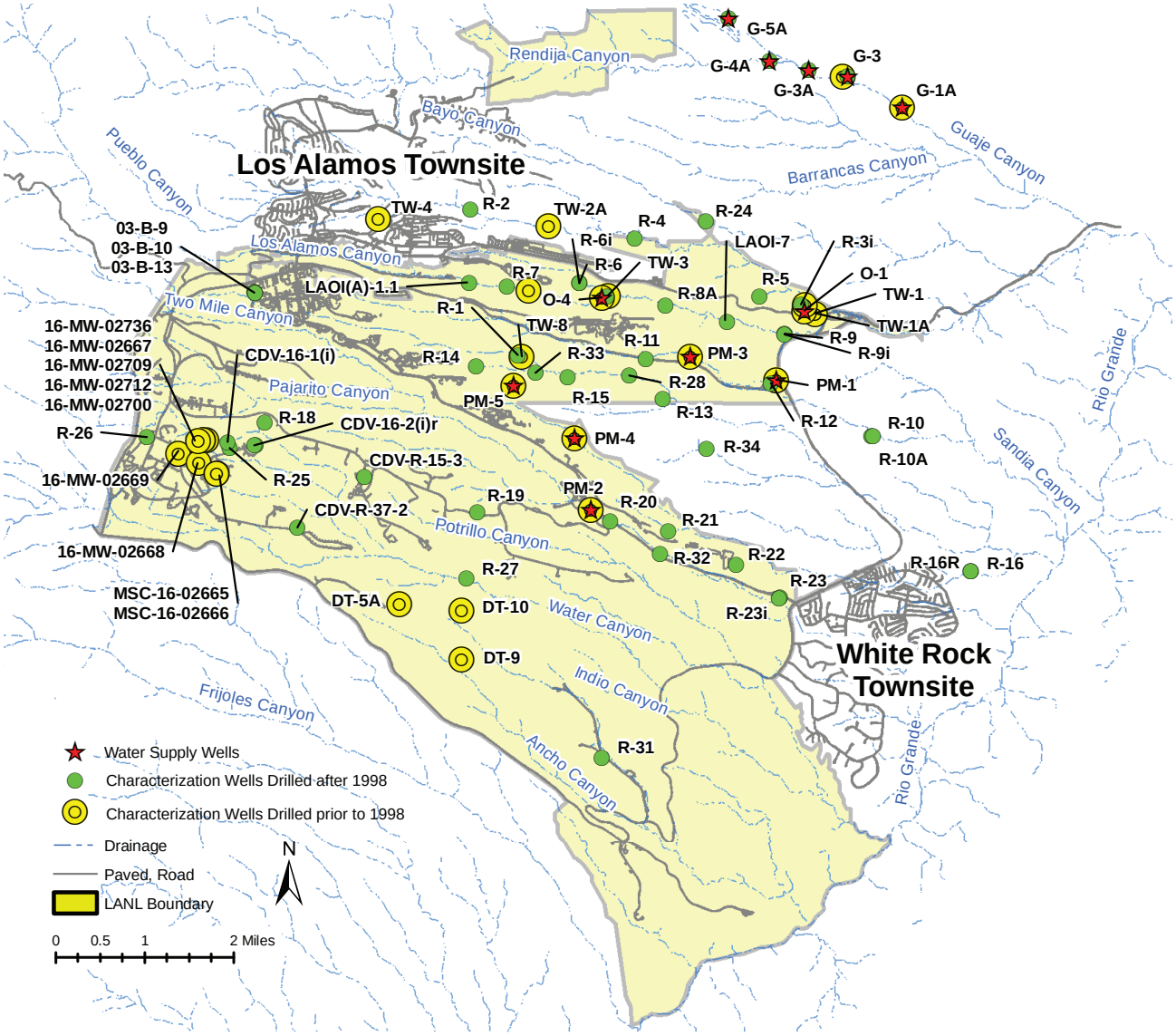


Figure 2-5. Intermediate-perched and regional aquifer characterization wells at LANL and vicinity.

summarizes all information on groundwater data collected as part of Hydrogeologic Workplan activities. Figure 2-5 below depicts the location the intermediate-perched and regional groundwater aquifer characterization wells and supply wells installed before and after 1998 (i.e., the initiation of the Hydrogeologic Workplan).

Sample analytical, water-level, well-construction, and other programmatic data can be reviewed online on the Laboratory's Water Quality Database website, http://www.lanl.gov/community/environment/h2o/.

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 Oil Conservation Division for energy/mineral-extraction activities). Subsequent discharges must be consistent with the terms and conditions of the discharge plan.

In 2005, the Laboratory had one approved groundwater discharge plan (Table 2-1) for the TA-46 SWWS Plant. On August 27, 2002, the Laboratory submitted a renewal application for the SWWS Plant groundwater discharge plan. NMED approval was pending at the end of 2005. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the RLWTF at TA-50. As of December 31, 2005, NMED approval of the plan was still pending.

b. Compliance Activities

Early in 2005, the Laboratory conducted work as part of the Hydrogeologic Characterization Program, as described in the Hydrogeologic Workplan (LANL 1998). However, the Laboratory performed most of the work in 2005 pursuant to the Consent Order, which was signed by NMED, DOE, and UC in March 2005. By the end of 2005, LANL installed 21 additional characterization wells. The characterization wells were drilled using air rotary in the vadose zone and rotary with water, foam, mud, or EZ-MUD (a polymer) in the saturated zone. Geologic core was collected in the upper vadose zone in some of the wells and geologic cuttings were collected at defined intervals during the drilling operations and described to record the stratigraphy encountered. Geophysical logging was conducted in each well to enhance the understanding of the stratigraphy and rock characteristics.

The characterization borehole and wells include the following:

- CdV-16-2(i)r in Cañon de Valle,
- LADP-5 in DP Canyon,
- LAOI-3.2 in Los Alamos Canyon,
- LAOI-7 in Los Alamos Canyon,
- R-3i in Los Alamos Canyon,
- R-10 and R-10A in Sandia Canyon,
- R-16A in Cañada del Buey,
- R-17 on a Pajarito Canyon bench,
- R-23i in Pajarito Canyon,
- R-24 in Bayo Canyon, and
- R-27 in Water Canyon.

Intermediate well CdV-16-2(i)r is located on the mesa top in TA-16. It replaces well CdV-16-2(i), which was drilled and installed in December 2003 but did not sustain water in the well. CdV-16-2(i)r was drilled in an attempt to complete a monitoring well at the same location to evaluate water quality in the deep intermediate perched zone. It was drilled approximately 50 ft northwest of the original well. The area's primary chemicals of potential concern are high explosives that have been discharged from TA-16 and possibly from other nearby sites. The single screened well was installed within the upper portion of the Puye Formation. The depth to water remained steady at a depth of approximately 840 ft after the well was completed at a total depth of 863.2 ft.

Intermediate borehole LADP-5 was drilled in November 2005 on the south rim of DP Canyon within TA-21. LADP-5 was drilled to identify the western extent of tritium, nitrate, and perchlorate contamination found in monitoring wells R-6/6i and production well Otowi-4. However, measurable groundwater was not encountered in either the corehole or borehole. Therefore, a monitoring well was not installed at the LADP-5 location. Subsequently, both the borehole and corehole were plugged and abandoned.

Intermediate well LAOI-3.2 is located in Los Alamos Canyon in the northern portion of the Laboratory. Well LAOI-3.2 was drilled to define the lateral extent of the deeper perched groundwater found in the Puye Formation at wells Otowi-4 (O-4) and R-6i. LAOI-3.2 was drilled in February 2005 with a target depth of 300 ft below ground surface (bgs); however, drilling was halted at 165 ft bgs to install an intermediate perched zone monitoring well for groundwater encountered in the Guaje Pumice Bed. LAOI-3.2 was installed to 165 ft bgs with a single screened interval from 153.3 to 162.8 ft bgs; the water level after well installation was approximately 136 ft bgs.

Intermediate well LAOI-7 was drilled in August and September 2005 in lower Los Alamos Canyon within TA-72. The well was drilled to identify the western extent of perched-intermediate groundwater within the Cerros del Rio basalt found at wells R-9/R-9i and to help define the eastern extent of contamination in the vadose zone in lower Los Alamos Canyon. The well was constructed with a single screen approximately 20 ft below the perched-intermediate water zone at a total completed depth of 264.9 ft.

Regional well R-3i is located in Los Alamos Canyon, west of the White Rock "Y." The primary purpose of the well is to target the zone(s) within the regional aquifer that contain the same contaminants (nitrate, perchlorate, and tritium) as well O-1. Drilling started in August 2005 and was completed in the Puye Formation at a total of 268.3 ft. The regional aquifer table is at a depth of 190.9 ft in the Cerros del Rio Basalt. The well was constructed with a single screened interval from 215.2 to 220 ft bgs.

Regional wells R-10a and R-10 are located in lower Sandia Canyon on Pueblo de San Ildefonso property. R-10a was installed to monitor water quality in the upper portion of the regional aquifer; R-10 was installed to monitor water quality and to evaluate the effects of nearby water supply pumping on the deeper portions of the regional aquifer. The majority of the fieldwork for these wells was conducted between June 27 and November 4, 2005. R-10a was drilled to a total depth of 765 ft using air-rotary and fluid-assisted air-rotary techniques. A well was installed with one screened interval from 690 to 700 ft bgs. The depth to water after the installation of R-10a was 623.83 ft bgs. R-10 was drilled 56 ft east of R-10a to a total depth of 1,165 ft bgs using air rotary and mud rotary drilling techniques; it was completed with two screened intervals, one between 874 and 897 ft bgs and one between 1,042 and 1,065 ft bgs.

Regional well R-16A (also known as R-16R) was drilled in September 2005 south of Cañada del Buey, approximately 3,000 ft northwest of the Rio Grande and near the town of White Rock. R-16A was drilled to monitor the upper portion of the regional aquifer, replacing the blocked upper screened interval in R-16. The purpose of R-16 (and R-16A) was to determine the depth of the water table and vertical gradients for the regional aquifer near the Rio Grande, serve as monitoring points between TA-54 and the Rio Grande, and aid in determining the relationship between the regional water table and springs in White Rock Canyon. The well was constructed with a single screen at the water table at a total completed depth of 631.4 ft.

Regional well R-17 is located in Pajarito Canyon and was installed to evaluate perched intermediate and regional groundwater in the west-central region of the Laboratory downstream of release sites in TA-03, -06, -59, and -69. A corehole was advanced to 300.9 ft bgs and the R-17 borehole was drilled to a total depth of 1,167 ft bgs. A well was installed with two screened intervals, one from 1,057 to 1,080 ft bgs and one from 1,124 to 1,134 ft bgs, in the regional aquifer within the Puye Formation. The depth to water for the isolated upper screen is approximately 1,036.2 ft bgs and for the isolated lower screen it is 1,037.7 ft bgs.

Intermediate well R-23i was drilled in October 2005 in lower Pajarito Canyon, south of Pajarito Road. The well was drilled to sample perched intermediate groundwater encountered during the drilling of R-23. The 550.7-ft well was constructed with a dual-screened inner well, and a shallow single-screened well in the annular space. Perched intermediate water in the inner wells was at 405.8 ft after well completion.

Regional well R-24 was drilled in August 2005 in Bayo Canyon, near the northeastern portion of the Laboratory. The purpose of R-24 was to drill and sample 300-ft-deep corehole and to drill and install a regional aquifer monitoring well. The well was constructed with a single screen approximately 100 ft below the regional water table at a total completed depth of 861 ft.

Regional well R-27 was drilled in October 2005 in Water Canyon within TA-36 in the south-central portion of the Laboratory. The purpose of R-27 is to monitor regional groundwater for potential contamination from TA-16 and other nearby sites. The well was constructed with a single screen approximately 40 ft below the regional water table at a total completed depth of 878.7 ft.

In addition to the site-wide hydrogeologic characterization wells, the Laboratory made substantial progress in 2005 on investigating groundwater in Mortandad Canyon and at two TA-3 SWMUs (see the Mortandad Canyon Groundwater Work Plan, LANL 2003d and Investigation Report for Solid Waste Management Units 03-010(a) and 03-001(e) at Technical Area 3, LANL 2005a).

Seven wells were installed on Laboratory property in and adjacent to Mortandad Canyon as part of investigation of Mortandad Canyon groundwater. The purpose of these intermediate wells was to improve the conceptual model of the geology, hydrogeology, and hydrochemistry of the area and to provide data for numerical models that address contaminant migration in the vadose (unsaturated) zone.

The alluvial wells were planned to characterize groundwater flow and determine contaminant distributions within alluvial perched water systems, and the piezometers were planned to evaluate the water table response to seasonal infiltration and to characterize hydraulic gradients and conductivities.

Intermediate well MCOI-1 is located in TA-35 within Mortandad Canyon, approximately 0.25 miles east of the TA-50 outfall. It was specifically installed to determine if contaminant releases have affected the quality of intermediate perched groundwater between the TA-50 outfall and Test Well 8. Air-rotary drilling started in November 2004 and was completed in January 2005 at a total of 843.2 ft. The well was constructed with a single screen at the water table. However, water has not accumulated in this well so well development, aquifer testing, and pump installation have not been performed.

Intermediate well MCOI-6 is located in TA-5 within Mortandad Canyon and was drilled from November 2004 through January 2005 to a total depth of 720 ft bgs using air-rotary drilling. The well was constructed with a single-screened interval from 686 to 708 ft bgs, near the base of the Cerros del Rio basalt. The total depth of the well was 713 ft bgs. On January 21, 2005, the depth to water after well installation was 665.80 ft bgs.

Intermediate well MCOI-8 is located in TA-5 within Mortandad Canyon and was drilled from November 2004 through January 2005 to a total depth of 745 ft bgs using air-rotary and fluid-assisted drilling methods. The well was completed in the Cerros del Rio Basalt with a single screened-interval from 665 to 675 ft bgs. The depth to water after installation of the well screen was 656.7 ft bgs.

Intermediate borehole MCOI-10 is located on the mesa top south of Mortandad Canyon, approximately 3,500 ft east of water production well PM-5. MCOI-10 was drilled from November 2004 through February 2005 to a total depth of 1,050 ft bgs using air-rotary and fluid-assisted air-rotary drilling methods. The well was completed 76 ft into the Puye Fanglomerate; however, no intermediate-perched groundwater was observed entering the borehole, so the borehole was plugged and abandoned.

Alluvial well MCA-1 is located in upper Mortandad Canyon and was hand-augered to a total depth of 5.9 ft bgs where the Tshirege Member of the Bandelier tuff was encountered in January 2005. Water was encountered at 3.3 ft bgs in the surficial alluvium. The well was cased to a depth of 5.9 ft bgs and constructed with a single screened interval from 2.4 to 5.4 ft.

Alluvial well MCA-4 is located in middle Mortandad Canyon and was hand-augered to a total depth of 5.4 ft bgs where the Tshirege Member of the Bandelier tuff was encountered in February 2005. Water was encountered at 5 ft bgs in the alluvium. The well was cased to a depth of 5.4 ft bgs and constructed with a single screened interval from 3.3 to 5.3 ft.

Alluvial well MCA-5 is located in upper Mortandad Canyon and was hand-augered to a total depth of 6 ft bgs in February 2005. Water was encountered at 4 ft bgs in the alluvium. The well was cased to a depth of 6 ft bgs and constructed with a single screened interval from 1.75 to 5.75 ft.

In June 2005, monitoring wells were installed in three of the 14 boreholes drilled near SWMU 03-010(a) and SWMU 03-001(e) to monitor shallow alluvial groundwater. Monitoring wells 03-B-9, 03-B-10 and 03-B-13 were completed with single screens and range in depth from 30.6 to 31.5 ft bgs.

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 the DOE/NNSA must consider the environmental impacts of proposed projects and assure public participation as part of the decision-making process. The Laboratory's Ecology Group devotes considerable resources to assist NNSA in compliance with the NEPA, pursuant to DOE Order O451.1B. Proposed projects and actions at LANL are reviewed by the group to determine if there are resource impacts, and the appropriate coverage under NEPA, and provides these recommendations to NNSA. NEPA has made a positive contribution in support of LANL's ongoing missions.

The following NEPA analyses were prepared or reviewed in 2005:

a. NEPA Compliance Review for Proposed Modifications to the Security Perimeter Project at Los Alamos National Laboratory

Recent proposed Security Perimeter Project modifications would have altered some aspects of the original Security Perimeter Project as it was described in the DOE Environmental Assessment (EA)-1429 and subsequently revised in the March 2004 NEPA Compliance Review. Specifically, this project would relocate the proposed access control station near the intersection of West Jemez Road (also known as State Road 501) with State Road 4 to a location just west of the intersection of West Jemez Road and Camp May (the Ski Hill Road). The Pajarito Road access control stations would remain in operation as previously analyzed in DOE/EA-1429. This analysis compared the potential environmental consequences to resources that would result from implementing the proposed modifications to the Security Perimeter Project with EA-1429 and the five other applicable subject EAs previously identified. In all cases, the consequences would likely be less than previously analyzed and therefore are bounded by DOE/EA-1429 and the other applicable EAs. The analysis concluded that the proposed modifications would not result in changes to affected resources that exceed what has previously been analyzed and determined to have no significant impacts. Therefore, a new EA was not required. Subsequent legal actions by the Incorporated County of Los Alamos have resulted in an agreement between the NNSA and the County regarding specific design aspects of the proposal.

b. NEPA Compliance Review for Proposed Modifications to DOE/EA-1409

On July 30, 2002, DOE/NNSA issued a Finding of No Significant Impact (FONSI) for DOE/EA-1409, Proposed Modifications to the Environmental Assessment for the Proposed Issuance of an Easement to Public Service Company of New Mexico for the Construction and Operation of a 12-in. Natural Gas Pipeline within Los Alamos National Laboratory (DOE 2002). Further changes, primarily to the proposed alignment of the natural gas line, have been proposed since that time, and these require a subsequent NEPA review. Construction of this project was delayed through 2003 and 2004 due to wildfire concerns and drought conditions. Recent modifications proposed for the alignment of the natural gas line within Los Alamos Canyon would have altered some aspects of the original project as it was described in the EA-1409. Specifically, the proposed natural gas line would not run in an easement under the electrical lines within Los Alamos Canyon, but underneath the existing unpaved access road. The analysis concluded that the proposed modifications would not result in changes to affected resources that exceed what has previously been analyzed and determined to have no significant impacts. Therefore, a new EA was not required.

c. New LANL Site-Wide Environmental Impact Statement (SWEIS)

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 performed to examine whether the SWEIS still adequately covers site operations. DOE/NNSA LASO produced a Supplemental Analysis in September 2004 that was reviewed by DOE-HQ. In October 2004, DOE-HQ made the decision to expand the Supplement Analysis to a Supplemental SWEIS. In April 2005, DOE-HQ decided to convert the Supplemental SWEIS to a full SWEIS and consider three alternatives for future operations at LANL. The new SWEIS would consider operations for a period of five years, 2007–2011. The three SWEIS alternatives being considered are as follows:

1. **The No Action Alternative:** This alternative would continue operations at current levels. This alternative considers the levels of operation covered in the 1999 SWEIS Record of Decision Expanded Operations Alternative. This alternative would include updates on the operations of the 15 Key Facilities defined in the 1999 SWEIS to anticipate operational levels over the next five years and consideration of new facilities proposed for construction over this period.
2. **The Expanded Operations Alternative:** This alternative would include the No Action Alternative plus new or enhanced facilities for ongoing operations. Waste management levels would increase. The major change in this alternative would be the increase in pit production to 50 pits/year in the current TA-55 facilities (same PF-4 facility).

3. **The Reduced Operations Alternative:** This alternative would include operational reductions at certain facilities while enhancing some facilities for ongoing operations. Pit production would remain at the 1999 SWEIS Record of Decision levels of 20 pits/year. The major changes considered in this alternative are the closing of LANSCE and a reduction in operations of approximately 20 percent for DARHT and a 20 percent reduction in firing site operations.

The three alternatives will be analyzed and a preferred alternative will be selected. The preferred alternative could include elements from all three of the alternatives, but no decisions have been made on what elements of the three alternatives will be included.

The SWEIS document is being prepared by Science Applications International Corporation (SAIC) under contract with DOE/NNSA LASO. Data gathering to support this effort and three project specific analyses are being prepared by LANL staff. A concurrence draft of the SWEIS was produced in February 2006. The date for the issuance of a Record of Decision on the new SWEIS is April 2007.

11. Endangered Species Act

The Endangered Species Act requires, among other things, federal agencies to ensure that agency action is not likely to jeopardize the continued existence of any threatened or endangered species and to consult with the US Fish and Wildlife Service on any prospective action that will likely affect a listed threatened or endangered species.

The Laboratory was in full compliance with the Endangered Species Act during 2005. During 2005, LANL reviewed 962 excavation permits and 125 project profiles (Permits and Requirements Identification System) for potential impacts to threatened or endangered species. LANL prepared Biological Assessments for the following four NNSA/DOE projects in support of informal consultations with the US Fish and Wildlife Service:

- Asphalt Batch Plant and Rock Crushing Operation on Sigma Mesa
- RedLANLNet (classified computing) Infrastructure Expansion Program
- Construction and Monitoring of Permeable Reactive Barriers
- Mexican Spotted Owl habitat redelineation

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. The unauthorized take of migratory birds is a strict liability criminal offense that does not require knowledge or specific intent on the part of the offender. As such, even when engaged in an otherwise legal activity where the intent is not to kill or injure migratory birds, violations can occur if bird death or injury results. The US Fish and Wildlife Service has enforced the Migratory Bird Treaty Act with discretion, focusing on individuals or organizations that take birds with disregard for the law, particularly where no valid conservation measures have been employed. In doing so, the Service has been able to focus its limited resources on working cooperatively with various industries, agencies, and individuals to reduce impacts on migratory birds.

The Laboratory incorporated best management practices (BMPs) for protecting migratory birds into its Job Hazard Analysis Tool. Personnel from LANL received training for migratory bird protection measures at the annual New Mexico Avian Protection Workshop.

13. Cultural Resources

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

In 2005, the Laboratory conducted 33 projects that required some field verification of previous survey information. In addition to the seven new archaeological sites identified this fiscal year, we identified 19 historic buildings. Forty-one archaeological sites and 10 historic buildings were determined eligible for the National Register of Historic Places.

The Laboratory began the fourth year of a multiyear program of archaeological excavation in support of the Land Conveyance and Transfer project. The DOE/NNSA is in the process of conveying to the County of Los Alamos approximately 2,000 acres of Laboratory lands. Thirty-nine archaeological sites have been excavated during the four field seasons, with more than 200,000 artifacts and 2,000 samples being recovered. Together, these sites provide new insights into past lifeways on the Pajarito Plateau from 5000 BC to AD 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 Pueblo people. Therefore representatives from the Pueblos of San Ildefonso and Santa Clara acted as tribal consultants and monitors on the project.

In support of LANL's fiscal year 2005 decontamination and decommissioning program, the Laboratory conducted historic building assessments and other documentation work related to eight proposed projects as required under the provisions of the National Historic Preservation Act. (Buildings include TA-3-31; TA-9-35 and -43; TA-15-8; TA-15-46, -138, and -141; TA-16-467, -477, and -478; TA-28-1 through -5; TA-49-23 and -121; and TA-40-4 and -19). This work included field visits to historic properties (including interior and exterior inspections), digital 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 Environmental Characterization and Remediation reading room, and previously conducted oral interviews.

The long-term monitoring program at the ancestral pueblo of Nake'muu continued as part of the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility Mitigation Action Plan (USDOE 1996). Nake'muu is the only pueblo at LANL that still contains its original standing walls. During the eight-year monitoring program, the site has witnessed a 0.9 percent displacement rate of chinking stones and 0.3 percent displacement of masonry blocks. Statistical analyses indicate that these displacement rates are significantly correlated with annual snowfall, but not with annual rainfall or shots from the DARHT facility.

Native American consultation is ongoing with respect to identifying and protecting Traditional Cultural Properties, human remains, and sacred objects in compliance with the National Historic Preservation Act of 1990 and Native American Graves Protection and Repatriation Act. Work for the Land Conveyance and Transfer Project included consultation with San Ildefonso and Santa Clara Pueblos for project monitoring, the implementation of a Native American Graves Protection and Repatriation Act intentional excavation agreement, identification of potential reburial locations, protection of Traditional Cultural Properties, and student internships. Other projects include the Nake'muu noise vibration study, the development of a draft management plan for the TA-3 University House Traditional Cultural Properties, and the Cerro Grande Rehabilitation project.

C. CURRENT ISSUES AND ACTIONS

1. New Mexico Hazardous Waste Management Notice of Violation

In April 2005, NMED's Hazardous Waste Bureau issued the UC and DOE a Notice of Violation identifying four alleged violations noted during the 2004 inspection and four alleged violations noted during the 2005 inspection. The initial penalty assessed was $63,578. UC and DOE provided information to the NMED and admitted five of the allegations. UC, DOE, and NMED agreed to settle the matter for $60,328, which was paid in October 2005.

D. UNPLANNED RELEASES

1. Air Releases

There were no reportable unplanned airborne releases from LANL in 2005.

2. Water Releases

There were no unplanned releases of radioactive liquids in 2005. There were 10 unplanned releases of non-radioactive liquids in 2005:

- Approximately 100,000 gallons of potable water from a broken water main near Building 21-346 to a Solid Waste Management Unit (SWMU) and upper DP Canyon
- Approximately two gallons of diesel fuel to surface water streams from a leaking vehicle that impacted TA-3, TA-15, TA-16, and TA-40
- Approximately 700 gallons of raw sewage to an excavated area at Building 16-340
- Approximately 7,000 gallons at Building 60-175 from a ruptured line carrying treated wastewater for recycle use to the TA-3 Power Plant
- Approximately 10 gallons of boiler steam condensate from Building 3-22 Power Plant to upper Sandia Canyon
- Approximately 36,000 gallons of condensate over a period of time from an HVAC unit at Building 21-152
- Approximately one-half gallon of diesel at Building 3-30 and TA-54 to storm water drains from a leaking vehicle
- Approximately 18,000 gallons to Ten-Site Canyon of storm water that had collected at TA-50 Pump House construction site
- Approximately 10 gallons of overflowed recycled vegetable oil from a storage bin near Building 3-261 (Otowi Complex)
- Approximately 50 gallons of raw sewage from a plugged line from Building 60-175

The Laboratory investigated all unplanned releases of liquids as required by the NMWQCC Regulations 20.6.2.1203 NMAC. Upon cleanup, personnel from NMED and NMED's DOE Oversight Bureau inspected the unplanned release sites to ensure adequate cleanup. As of mid-2006, the Laboratory is in the process of administratively closing out all releases for 2005 with the NMED Oversight Bureau and anticipates these unplanned release investigations will be closed out after final inspections.

E. REFERENCES

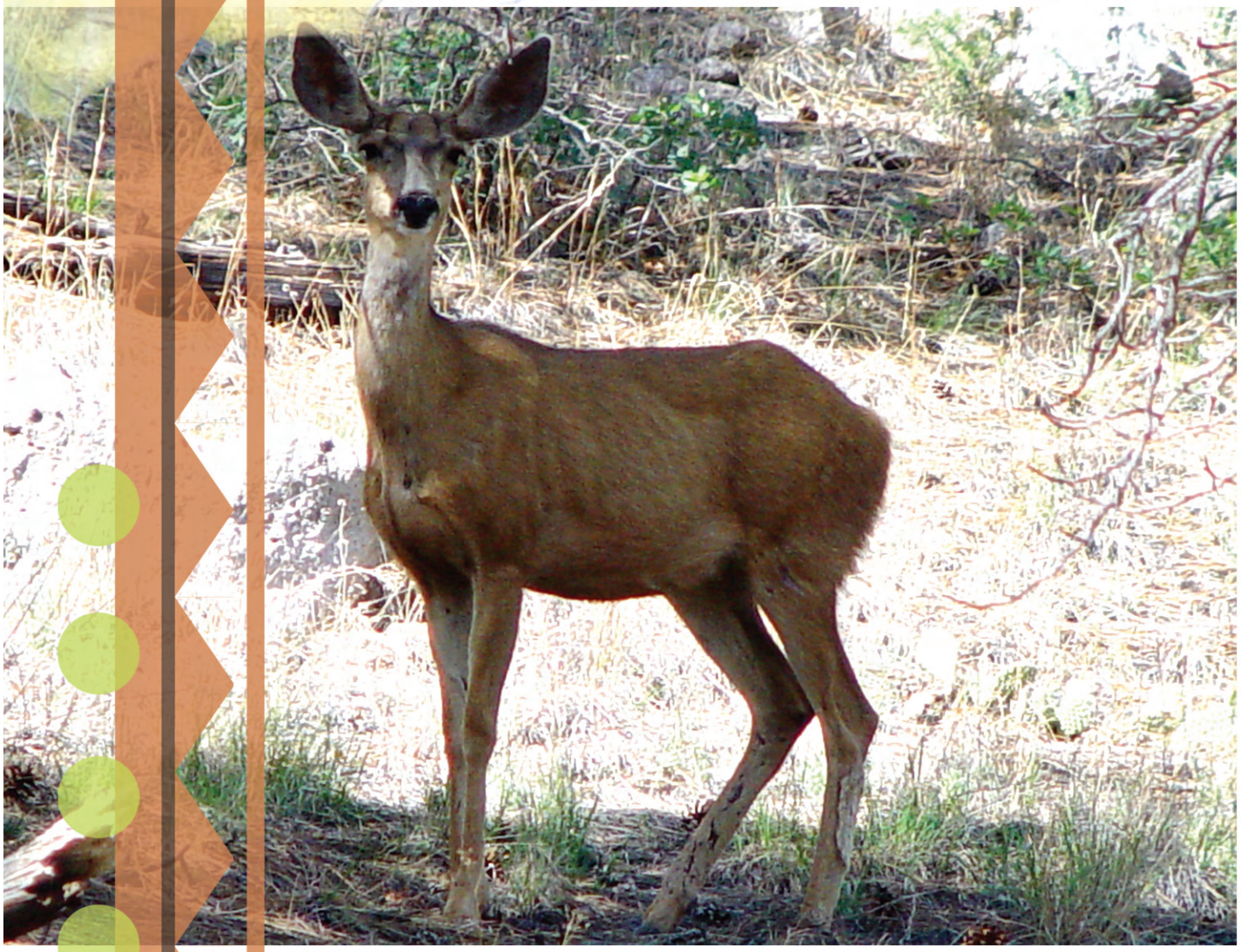
USDOE 1996: USDOE (US Department of Energy), "Dual-Axis Radiographic Hydrodynamic Test Facility Final Environmental Impact Statement Mitigation Action Plan," United States Department of Energy report USDOE/EIS-0228 (1996).

LANL 1998: Water Quality and Hydrology Group, "Hydrogeologic Workplan," Final Version, Los Alamos National Laboratory (May 1998).

NMEIB 2002: New Mexico Environmental Improvement Board, State of New Mexico, "Drinking Water Regulations" (as amended through December 2002).

Shaull et al. 2006: D. A. Shaull, D. Ortiz, M. R. Alexander, and R. P. Romero, "Surface Water Data at Los Alamos National Laboratory: 2005 Water Year," Los Alamos National Laboratory report LA-14239-PR (May 2006).

3. RADIOLOGICAL DOSE ASSESSMENT



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A. INTRODUCTION

The purpose of this chapter is to determine if the doses to the public and to biota are below the limits of the federal government. This chapter also provides a measure of the significance of environmental radioactivity in the context of its importance to humans and biota. In this respect, the human dose assessment provides a different perspective from the biota dose assessment. The human dose is received near the publicly accessible boundaries, whereas the biota dose is potentially received throughout the interior of the Los Alamos National Laboratory (LANL or the Laboratory), usually at locations rarely visited by humans.

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

B. HUMAN DOSE ASSESSMENT

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented here are calculated using standard methods specified in DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997; and 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 receiving the radiation. 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 (DOE 1993) public dose limit to any individual is 100 mrem/year received from all pathways (i.e., all ways in which people can be exposed to radiation, such as inhalation, ingestion, and direct radiation). The dose received from airborne emissions of radionuclides is further restricted by the Environmental Protection Agency's (EPA's) dose standard of 10 mrem/year (40 CFR 61, EPA 1986). These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from community drinking water supplies are also limited according to the Clean Water Act, either by established maximum contaminant levels (MCLs) for some radionuclides, or by dose (4 mrem/year for man-made radionuclides, beta/photon emitters) (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:

- The entire population within 80 km of the Laboratory;
- The maximally exposed individual (MEI) who is not on LANL/DOE property;
- Residents in Los Alamos and White Rock.

b. General Considerations

We begin with environmental measurements 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 400 mrem/year (additional man-made sources of radiation raise the total background dose to about 500 mrem/year). It is extremely difficult to measure doses from LANL that are less than 0.1 percent (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/year is essentially zero.

i. Direct Radiation Exposure. Direct radiation from gamma photons or neutrons is measured at about 100 locations near LANL (Chapter 4, Section C). Direct radiation doses above natural background are observed near Technical Area (TA) -54.

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 1 km, 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/year, which cannot be distinguished from natural background radiation. This means the only significant doses from direct radiation are near TA-54 (section B.3.b of this chapter).

To estimate the dose to the public, we combine the measurements of gamma and neutron dose with an occupancy factor. The measurements reported in Chapter 4 would apply to an individual who is at a particular location continuously (i.e., 24 hours/day and 365 days/year). We follow standard guidance and assume continuous occupancy for residences and places of business. For all other locations, we multiply the measured dose by an occupancy factor of 1/16 (NCRP 1976).

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 standard model CAP88, 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 (Chapter 4, Section B), and the resulting doses are calculated with CAP88 (Chapter 3, Section B.3.b). These doses decrease steeply with distance because the radioactive half-lives are short (e.g., the annual dose is 6.46 mrem at East Gate from LANSCE, 1 km to the north of LANSCE, and 0.079 mrem at an average Los Alamos residence, about 4 km to the west-northwest of LANSCE).

iii. Water (Ingestion Pathway). The majority of radionuclides detected in ground water samples collected from known or potential drinking water sources (e.g., Los Alamos County drinking water supply wells and natural springs) during 2005 resulted from the presence of natural radioactivity in these sources. These radionuclides include natural uranium and its decay products, such as radium-226. Tritium was the only radionuclide detected in these ground water samples that could possibly be attributed to Laboratory operations. The highest concentration of tritium from known or potential drinking water sources (349 pCi/L) was measured in a sample from an alluvial spring in Upper Los Alamos Canyon, which is not a recognized drinking water supply. This concentration is far

below the EPA MCL of 20,000 pCi/L; this results in a dose less than 0.1 mrem/year. The highest concentration of tritium detected in a Los Alamos County drinking water supply well was 33 pCi/L in a sample collected from the Otowi-1 well located in Pueblo Canyon (this well was out of service much of the year).

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 were collected on the perimeter of Pueblo de San Ildefonso land within Mortandad Canyon downwind of Area G. No samples had radionuclide concentrations above the Regional Statistical Reference Levels (RSRLs). RSRLs represent background radionuclide concentrations plus three standard deviations in media, such as soil, sediments, and crops, collected or harvested in regional areas far from the influence of the Laboratory averaged over a period of five years. Therefore, the soil concentrations measured in 2005 are essentially indistinguishable from regional background, and the resulting dose from soil (external gamma exposure, dust inhalation, and soil ingestion) at the sample location would be less than 0.1 mrem/year. As the strontium-90 and cesium-137 soil concentrations at the sample location are less than the RSRLs for both radionuclides, it is probable that all or almost all of the strontium-90 and cesium-137 are from global fallout and not from LANL. The tritium mainly comes from three sources: cosmic rays, nuclear weapons testing, and LANL; however, the dose from tritium in soil is virtually nonexistent at the Pueblo de San Ildefonso sample site. Similarly, the measured transuranics (plutonium-238, -239/240, and americium-241) may include a small contribution from LANL, but the dose from these radionuclides is much less than 0.1 mrem/year. Finally, the isotopic mixture of uranium is consistent with natural uranium. In summary, we conclude that the LANL contribution to the dose from soil is less than 0.1 mrem/year, and the majority of the radionuclides detected are primarily due to fallout.

v. Food (Ingestion Pathway). We report measurements of the radioactive content of foods in Chapter 8. During 2005, predator and bottom-feeding fish were caught at Abiquiu and Cochiti Reservoirs. Purslane, a wild edible plant, was also collected on the perimeter of Pueblo de San Ildefonso within Mortandad Canyon, downwind of Area G. No other foodstuffs were collected during 2005.

Fish caught at Abiquiu Reservoir serve as a background population essentially removed from the influence of the Laboratory because the reservoir is upstream of the Laboratory. Cochiti Reservoir is downstream of the Laboratory and fish caught there are potentially impacted by Laboratory operations. Therefore, the concentrations of radionuclides in fish caught at Abiquiu Reservoir are subtracted from the concentrations of radionuclides in fish caught at Cochiti Reservoir (LANL 2006). Review of these background-subtracted radionuclide concentrations indicates that the dose received from consuming predator and bottom-feeding fish caught at Cochiti Reservoir would be much less than 0.1 mrem per year. Refer to Supplemental Tables S8-1 and S8-2 for specific radionuclide concentration values.

The concentration of strontium-90 in three samples of purslane collected from Pueblo de San Ildefonso lands in Mortandad Canyon were high compared with domestic edible plant RSRLs. Refer to Supplemental Table S8-3 for specific radionuclide concentration values. The total dose received from consuming a pound of purslane would be much less than 0.01 mrem. Assuming consumption of approximately 30 pounds (expected consumption of produce from a contaminated area in accordance with LANL 2000) of purslane per year, a dose of approximately 0.1 mrem would be received.

We conclude that the LANL contribution to the dose from consuming foodstuffs is small relative to the all-pathways dose limit of 100 mrem/year and would be on the order of 0.1 mrem/year if wild foodstuffs were collected and consumed from the perimeter of Pueblo de San Ildefonso land within Mortandad Canyon.

vi. Release of Items. 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 2002. It is a Laboratory goal to not knowingly release any items with residual radioactivity. All items destined for release from known or potentially contaminated areas are screened for radioactive contamination. Items from a known or potentially contaminated area that cannot be completely surveyed are not released. Therefore, there is no known additional dose to the general public through the release of items for uncontrolled use by the general public.

3. Dose Calculations and Results

a. Population within 80 Kilometers

We used the local population distribution to calculate the dose from 2005 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 county population estimates provided by the University of New Mexico Bureau of Business and Economic Research. These statistics are 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 3 mrem, the collective dose is 6 person-mrem. This 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 2005 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 2.46 person-rem, which is significantly higher than the dose of 0.90 person-rem reported for 2004. Tritium contributed about 17 percent of the dose, and short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 83 percent of the dose. The increase in the 2005 collective population dose was attributable to a longer beam operation time at LANSCE (over twice that of 2004) and a malfunction in the LANSCE air emissions control system as described below in section 3.b. LANSCE has historically been the major contributor to the population dose. Until 2005, population doses for the past 12 years had declined from a high of about 4 person-rem in 1994 to less than 1 person-rem in 2004 (Figure 3-1). The collective population dose is expected to decrease in 2006 to the 2004 level. No observable health effects in the local population are expected from this dose.

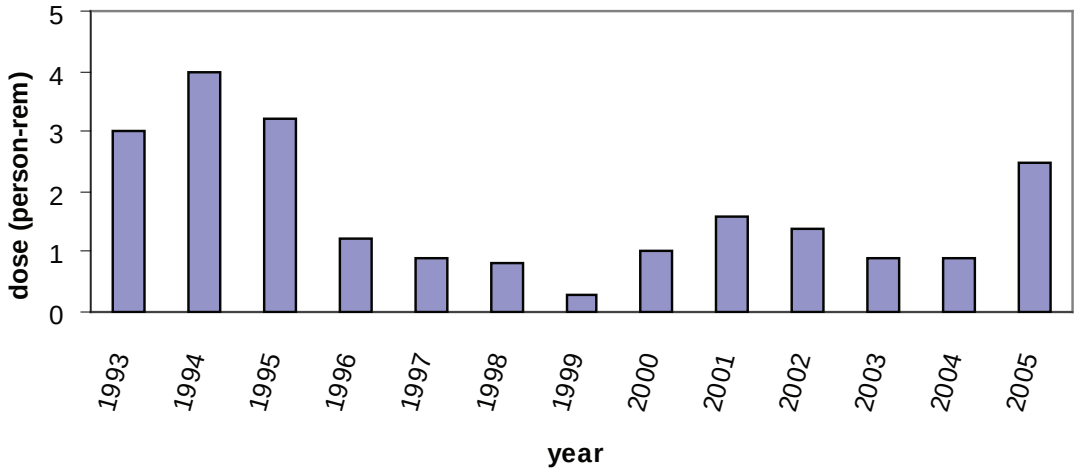

Figure 3-1. Annual collective dose (person-rem) to the population within 80 km of LANL. This represents the total dose received by the total population (about 280,000) within 90 km.

b. Maximally Exposed Individual

The MEI is a hypothetical member of the public who, while not on DOE/LANL property, received the greatest dose from LANL operations. During 2005, there were two potential MEI locations: one location was at East Gate along State Road 502 entering the east side of Los Alamos County; the other is the boundary between LANL TA-54 and the Pueblo de San Ildefonso Sacred Area, north of Area G.

East Gate is normally 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. We modeled the dose from LANSCE and from the LANL stacks using CAP88. The CAP88-modeled doses (Jacobson 2006) were approximately 6.31 mrem from LANSCE and 0.11 mrem from other LANL stacks and diffuse emissions sources. We added 0.039 mrem from the radionuclides measured at the Eastgate AIRNET station, though this dose is primarily from tritium, most of which was in the CAP88 modeled doses. Therefore, the total dose at East Gate was approximately 6.46 mrem.

Emissions of radioactive gases from LANSCE stacks were greatly elevated during 2005, relative to emissions in 2004. This is due to two factors. First, the beam operation time in 2005 was much longer: almost 10 months in 2005 versus four months in 2004. Second, there was a cracked valve in the air emissions control system, which holds up the short-lived gas emissions and allows for radioactive decay before they are released. This malfunction was repaired in late November 2005 and the rate of emissions returned to 2004 rates after this repair. We expect 2006 emissions to return to the 1–2 mrem range because of the repair and due to additional emissions controls implemented in 2005 that will compensate for any increased beam operations time.

The second location evaluated as the potential MEI is the boundary of the Pueblo de San Ildefonso Sacred Area north of 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. After subtracting a 2-mrem neutron background value and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual neutron dose was 14/16 = 0.88 mrem. A gamma photon dose was not calculated for this location because the low-energy photons emitted from the transuranic waste are absorbed in the intervening air layer between Area G and the Sacred Area. To estimate the contributions from airborne radionuclides at this location, we modeled the dose contribution from the LANL stacks as 0.040 mrem/16 = 0.003 mrem. We then added the maximum dose derived from measurements at the AIRNET stations along the northern boundary of Area G (0.18 mrem) and applied the occupancy factor of 1/16 to obtain a dose of 0.011 mrem. Thus, we conclude the dose at this location was approximately 0.9 mrem, which is less than the MEI dose at East Gate.

The MEI dose of 6.46 mrem is below the 10 mrem/year EPA airborne emissions dose limit for the public (40 CFR 61, EPA 1986), and based on previous studies, it will cause no observable health effects.

Until 2005, the MEI dose for the past 12 years had declined from a high of nearly 8 mrem in 1994 to less than 2 mrem in 2004 (Figure 3-2). LANSCE is the major contributor to the MEI dose. Generally, the year-to-year fluctuations are the result of variations in the number of hours that LANSCE runs, whereas the overall downward trend is the result of efforts to reduce the LANSCE emissions by installing delay lines and fixing small leaks. In comparison, the total annual dose from sources other than LANL is approximately 500 mrem.

An on-site MEI location had been evaluated in previous years, but because of increased security restrictions preventing access by members of the public to many of the technical areas and the relocation of significant external radiation sources, an on-site MEI is no longer applicable.

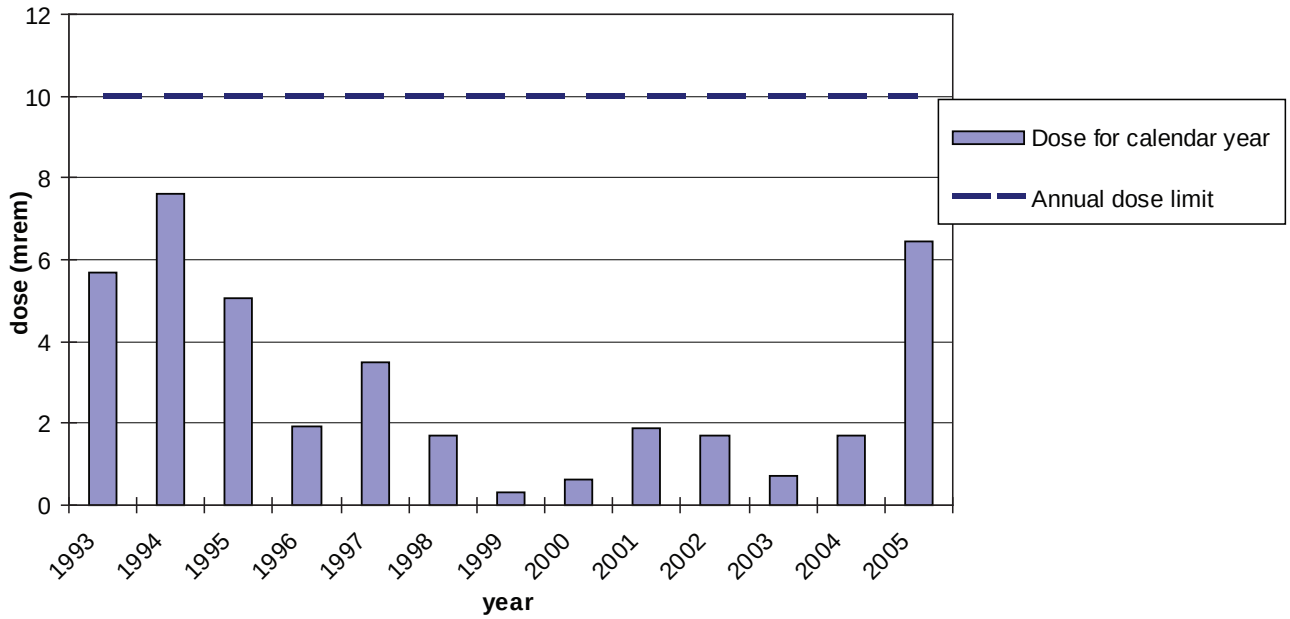

Figure 3-2. Annual dose (mrem) to the maximally exposed individual off-site over the past 13 years.

c. Doses in Los Alamos and White Rock

We used AIRNET data (reported in Chapter 4, Section A) to calculate an annual dose at each of the AIRNET stations for the perimeter stations that represent the Los Alamos resident and the White Rock resident. We then converted the AIRNET concentrations to doses using the factors in EPA 1986 and added the dose contributions from LANSCE (calculated using CAP88 for these Los Alamos and White Rock perimeter AIRNET station locations). Averaging the summed AIRNET and CAP88 doses provided the representative Los Alamos resident and the White Rock resident air pathway doses.

i. Los Alamos. During 2005, the measurable contributions to the dose at an average Los Alamos residence were 0.013 mrem from tritium and 0.079 mrem from LANSCE. Other radionuclides contributed about 0.021 mrem, amounting to a total of 0.11 mrem.

ii. White Rock. During 2005, the measurable contributions to the dose at an average White Rock residence were 0.013 mrem from tritium and 0.041 mrem from LANSCE. Other radionuclides contributed less than 0.01 mrem, amounting to a total of 0.06 mrem.

The contributions from direct radiation, food, water, and soil are discussed in Chapter 3, Section B.2; each contribution was too small to measure. In summary, the total annual dose to an average Los Alamos/White Rock resident from all pathways was about 0.1 mrem. 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 LANL 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 from cosmic radiation range from 50 mrem/year at lower elevations near the Rio Grande to about 90 mrem/year in the Jemez mountains west of Los Alamos. Doses from terrestrial radiation range from about 50 to 150 mrem/year, depending on the amounts of natural uranium, thorium, and potassium in the soil.

The largest dose from radioactive material is from the inhalation of naturally occurring radon and its decay products, which contribute about 200 mrem/year. An additional 40 mrem/year results from naturally occurring radioactive materials in the body, primarily potassium-40, which is present in all food and in all living cells.

In addition, members of the US population receive an average dose of 50 mrem/year from medical and dental uses of radiation, 10 mrem/year from man-made products such as stone or adobe walls, and less than 1 mrem/year from global fallout from nuclear-weapons tests (NCRP 1987a). Therefore, the total annual dose from sources other than LANL is approximately 500 mrem. The estimated LANL-attributable 2005 dose to the MEI, 6.46 mrem, is less than 2 percent of this dose.

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). However, doses to the public from LANL operations are much smaller. According to the 1996 Position Statement of the Health Physics Society (HPS 1996), "Below 10 rem, risks of health effects are either too small to be observed or are nonexistent." Therefore, the doses reported here and summarized in Table 3-1 are not expected to cause observable health effects.

Table 3-1
LANL Radiological Dose for Calendar Year 2005

Pathway	Dose to Maximally Exposed Individual mrem (mSv)	% of DOE 100 mrem/year Limit	Estimated Population Dose person-rem (person-Sv)	Population within 80 km	Estimated Background Radiation Population Dose (person-rem)
Air	6.46 (6.46×10^{-2})	7%	2.46 (2.5×10^{-2})	~280,000	~56,000[a]
Water	<0.1 (<1.0×10^{-3})	<0.1%	0	~280,000	~1,300[b]
Other Pathways	<0.1 (<1.0×10^{-3})	<0.1%	0	~280,000	~76,000[c]
All Pathways	6.46 (6.46×10^{-2})	7%	2.46 (2.5×10^{-2})	~280,000	~133,300

[a] Based on 200 mrem/year from inhalation of radon and its decay products (see section B.4)
[b] Based on U-234 and U-238 concentrations detected in White Rock Canyon and Buckman Field water supply samples
[c] Based on approximately 270 mrem/year total from cosmic radiation (70 mrem/year), terrestrial radiation (100 mrem/year), K-40 (40 mrem/year), medical and dental uses of radiation (50 mrem/year), and man-made products (10 mrem/year) (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 (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/community/environment/air/), and McNaughton 2005 describes in detail the application of these methods to specific locations at LANL.

It is not possible to assess the dose to every animal and every plant at LANL. Therefore, we calculate the dose to selected plants and animals following the guidance of the DOE Standard (DOE 2002) and the environmental restoration program (LANL 2004). Trees of the pine family (pinaceae) are representatives for plants because they

are radiosensitive (UNSCEAR 1996) and because their deep roots tap into buried contamination (Foxx 1984a, b; Tierney 1987). Deer mice are representatives for animals because of their relatively small home range, which means the maximally exposed mouse spends a large fraction of its time in the most contaminated location. These plants and animals are common and widespread at LANL and in the region.

b. Biota Dose Limits

The DOE biota dose limits (DOE 2002) are applied to biota populations rather than to individual plants and animals 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 use the population area for deer mice of 3 ha (30,000 m^2) (Ryti 2004; LANL 2004). We also average the dose to plants over this same area.

The DOE dose limits to biota populations are:

- Terrestrial animals: 100 mrad/day
- Terrestrial plants: 1,000 mrad/day
- Aquatic animals: 1,000 mrad/day

c. Methods

To ensure that the assessment is comprehensive, we begin with an initial screening (DOE 2002) that compares the maximum radionuclide concentrations in soil, sediment, and 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 site-specific assessment is conducted that uses average concentrations and incorporates site-specific bioaccumulation factors. Following the guidance of the DOE Standard (DOE 2002), we do not include external-radiation dose from experimental facilities such as the Dual Axis Radiographic HydroTest (DARHT) facility and LANSCE. To provide further refinement of the screening process, we screen on a radionuclide-by-radionuclide basis and compare each radionuclide concentration to the appropriate BCG. If the concentration exceeds 10 percent of the BCG (or biota dose limit) for any one radionuclide, a full-scale screening is performed using the sum of the fractions approach.

2. Biota Dose Results

Vegetation samples were collected at TA-54 in 2005. Tritium above the RSRL was detected in some overstory and understory vegetation collected near the tritium shafts in the south section of TA-54. Plutonium-238 and plutonium-239 were also detected above the RSRL in vegetation collected from the north and northeastern sections of TA-54. However, none of these concentrations exceeded the 0.1 rad/day biota dose screening level for terrestrial plants. Refer to Chapter 8, section B.4.b.i. (page 223), for more information.

Similarly, uranium-238 above the baseline statistical reference level (BSRL) was detected in some overstory and understory vegetation at the DARHT facility (TA-15). (Note: BSRLs are essentially the same as RSRLs and represent background levels prior to the initiation of operations at the facility.) Again, these concentrations did not exceed the 0.1 rad/day screening level for terrestrial plants. Refer to Chapter 8, section B.4.c.i. (page 224), for more information.

During 2005, honey bees were collected from five hives located just northeast of the DARHT facility at LANL. The only radionuclides detected in these bees above the BSRL were isotopes of uranium, especially uranium-238. The concentrations of uranium in these bees did not exceed the biota dose screening level of 0.01 rad/day for terrestrial animals. Refer to Chapter 8, section B.4.c.ii. (page 224), for more information.

Surface waters in canyons potentially affected by the Laboratory were also collected in 2005 and analyzed for radionuclides. Specifically, these samples were collected in Pueblo Canyon above Acid Canyon, Lower Pueblo Canyon, DP Canyon below TA-21, LA Canyon at Skate Rink, LA Canyon between DP and SR-4, LA Canyon at Rio Grande, Mortandad Canyon below Effluent Canyon, and Pajarito Canyon above SR-4. The time-weighted sum of ratios for estimated annual average surface water concentrations of radionuclides in these major canyons were

well below the aquatic animal BCGs (no greater than 11 percent or 0.11 rad/day). Refer to Chapter 6, Table 6-2, for more information regarding specific radionuclide concentrations and associated BCG ratios.

Data quality objective evaluation determined that soil, vegetation, and other related samples may be collected on a three-year frequency because data from previous years showed no upward trends or exceedances of DOE limits. Because of this evaluation, other non-foodstuff biota (e.g., pine trees and deer mice) and media such as soil were not collected in 2005 for purposes of assessing biota dose. A full suite of biota doses will be reported next year for 2006.

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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 activation products, that may be released from Los Alamos National Laboratory (LANL or the Laboratory) operations. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by LANL's air sampling program. Most of the regional airborne radioactivity comes from the following sources: (1) fallout from past atmospheric nuclear weapons tests conducted by several countries, (2) natural radioactive constituents in particulate matter, such as uranium and thorium, (3) terrestrial radon diffusion out of the earth and its subsequent decay products, and (4) material formation from interactions with cosmic radiation, such as natural tritiated water vapor produced by interactions of cosmic radiation and common atmospheric gases. Table 4-1 summarizes regional levels of radioactivity in the atmosphere for the past 5 years, which can be useful in interpreting current air sampling data.

Particulate matter in the atmosphere is primarily caused by aerosolized soil. Windy, dry days can increase soil entrainment, but precipitation, such as rain or snow, can wash particulate matter out of the air. Consequently, changing meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity concentrations. Natural events can also have major impacts: the 2000 Cerro Grande fire dramatically increased short-term ambient concentrations of particulate matter (ESP 2001).

Air quality group personnel compared ambient air concentrations, as calculated from the AIRNET sample measurements, with environmental compliance standards for publicly accessible locations or with workplace exposure standards for on-site locations. We usually compare annual concentrations in areas accessible to the public with the 10-mrem equivalent concentration established by the Environmental Protection Agency (EPA) (EPA 1989). Concentrations in controlled access areas are usually compared with Department of Energy (DOE) Derived Air Concentrations (DACs) for workplace exposure (DOE 1988a) because access to these areas is generally limited to workers with a need to be in the controlled area.

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

	Units	EPA Concentration Limit[b]	Annual Averages[c] 2001	2002	2003	2004	2005
Alpha	fCi/m^3	NA[d]	0.8	0.8	0.8	1.1	0.9
Beta	fCi/m^3	NA	13.9	13.3	13.7	18.3	16.3
Tritium[e]	pCi/m^3	1500	0.0	-0.1	-0.1	0.1	0.1
Pu-238	aCi/m^3	2100	0.0	0.0	-0.1	0.09	0.0
Pu-239	aCi/m^3	2000	0.1	0.3	-0.1	-0.07	0.1
Am-241	aCi/m^3	1900	-0.2	0.3	-0.7	-0.47	0.1
U-234	aCi/m^3	7700	17.9	21.7	20.9	17.4	12.4
U-235	aCi/m^3	7100	1.3	2.4	1.8	1.17	1.2
U-238	aCi/m^3	8300	17.7	21.8	20.1	17.0	13.2

[a] Data from regional air sampling stations operated by LANL during the last 5 years (locations can vary by year).
[b] Each EPA Concentration Limit is from 10 CFR 40 and corresponds to 10 mrem/yr
[c] Gross alpha and beta annual averages are calculated from gross air concentrations. All other annual averages are calculated from net air concentrations.
[d] Not available.
[e] Tritium annual averages have been corrected for the tritium lost to bound water in the silica gel.

2. Air Monitoring Network

During 2005, LANL operated 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as regional, pueblo, perimeter, waste site Technical Area 54 (TA-54), or other on-site locations.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures

Generally, each AIRNET sampler continuously collects particulate matter and water-vapor samples for approximately two weeks per sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates of about 0.11 m^3 per minute. These filters are analyzed for various radionuclides.

Vertically mounted canisters that contain about 135 g of silica gel, with an airflow rate of about 0.0002 m^3 per minute, are used to collect water vapor samples. We dry this silica gel in a drying oven to remove most residual water before using in the field. The gel is a desiccant that removes moisture from the sampled air. After use in the field, the gel is removed from the canister and shipped to the analytical laboratory where the moisture is distilled, condensed, and collected as a liquid. This liquid is analyzed for the presence of tritium. The AIRNET quality assurance project plan and the numerous procedures through which the plan is implemented provide details about the sample collection, sample management, chemical analysis, and data management activities.

b. Data Management

In the field, personnel recorded the sampling data on a palm-held microcomputer, including timer readings, volumetric airflow rates at the start and stop of the sampling period, and comments pertaining to these data. These data are transferred to an electronic table format within the AIRNET database.

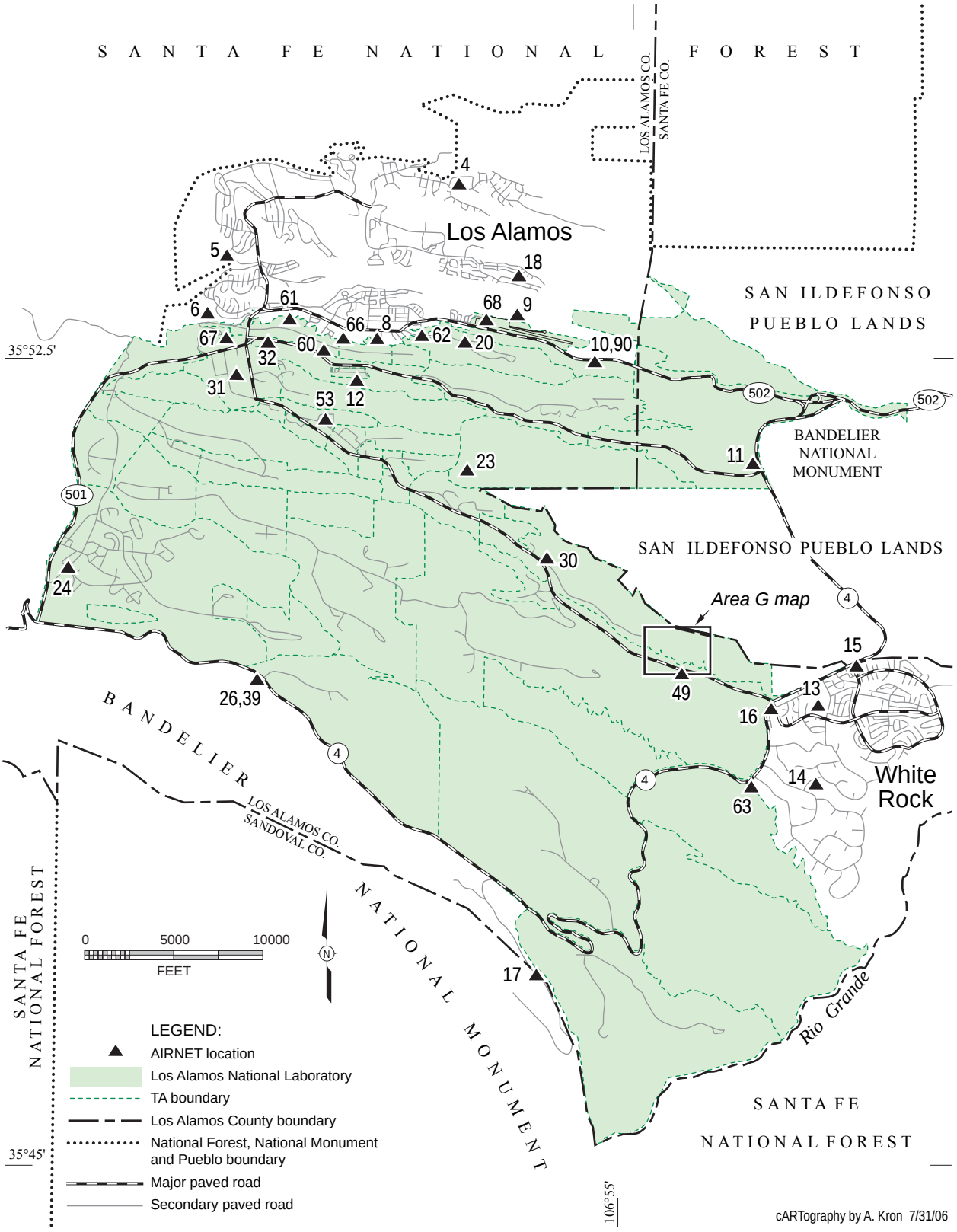

Figure 4-1. Off-site perimeter and on-site LANL AIRNET locations.

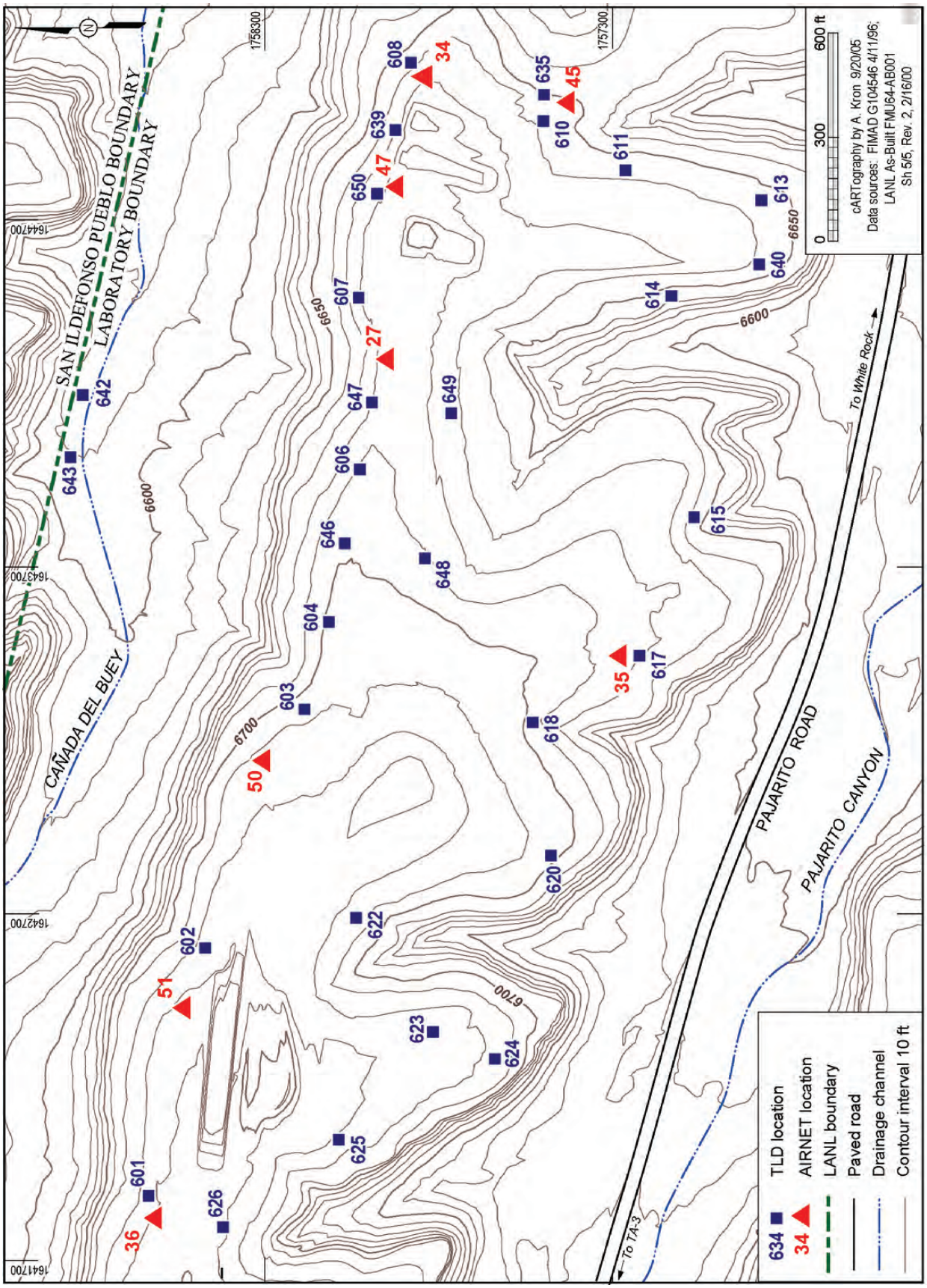

Figure 4-2. AIRNET and thermoluminescent dosimeter locations at TA-54, Area G.

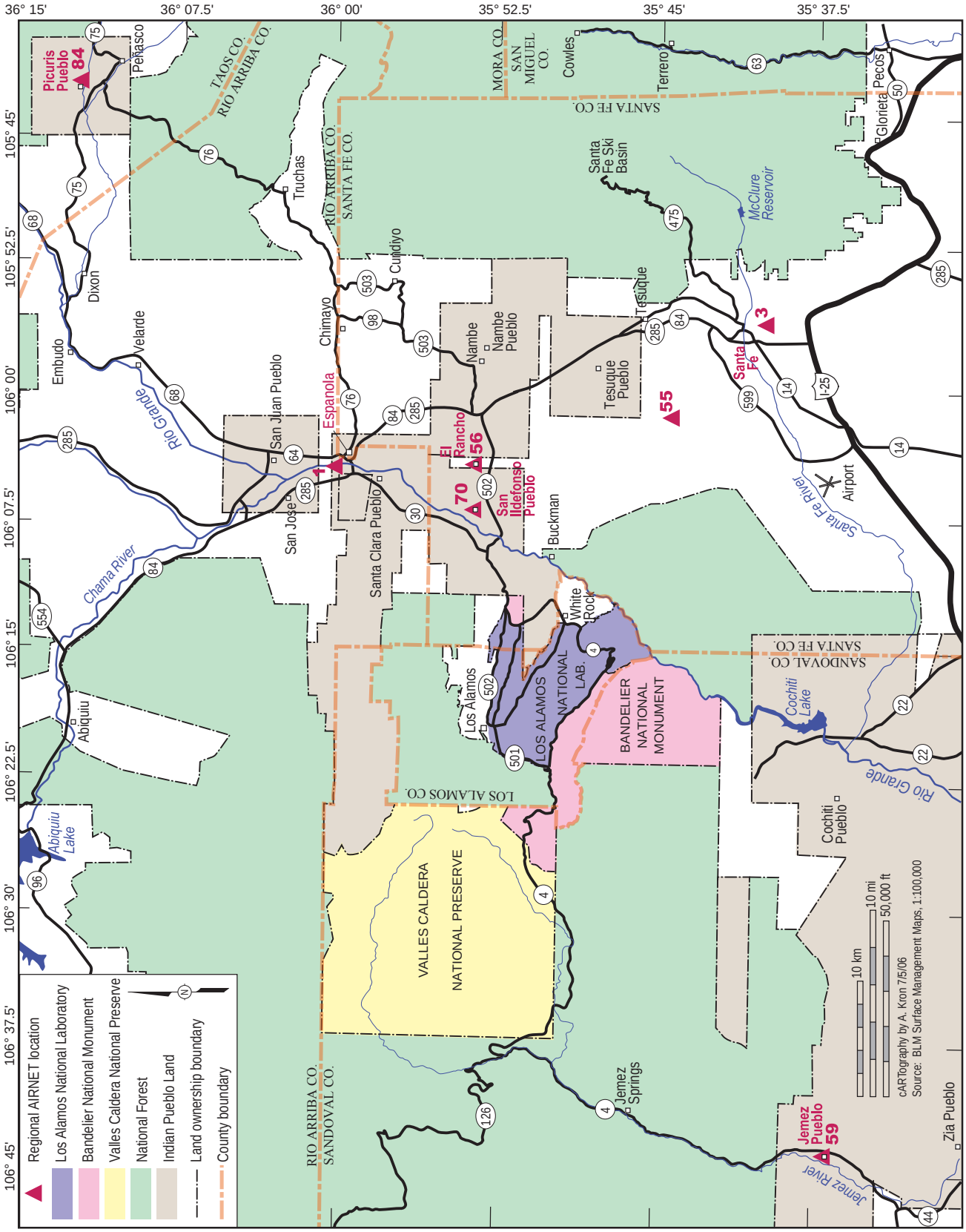

Figure 4-3. Regional and pueblo AIRNET locations.

c. Analytical Chemistry

A commercial laboratory analyzed each particulate-matter filter for gross alpha and gross beta activities. These filters were also grouped by region across sites, designated as "clumps," and analyzed for gamma-emitting radionuclides. During 2005, clumps usually ranged from six to nine filters. To prepare a quarterly composite for isotopic gamma analyses for each AIRNET station, half-filters from the six or seven sampling periods at each site were combined during the quarter. Analysts dissolved these composites, separated them chemically, and then analyzed them for isotopes of americium, plutonium, and uranium using alpha spectroscopy. After a two-week collection period, water was distilled from the silica gel that had been used to collect water vapor in the field. A commercial laboratory used liquid scintillation spectrometry to analyze this distillate for tritium. All analytical procedures met the requirements of Title 40 Code of Federal Regulations (CFR) Part 61, Appendix B. The AIRNET quality assurance project plan provided a summary of the target minimum detectable activity for the biweekly and quarterly samples.

d. Laboratory Quality Control Samples

For 2005, the air sampling team and the analytical laboratories maintained a program of blank, spike, duplicate, and replicate analyses. This program provided information on the quality of the data received from analytical laboratories. These data were reviewed by technical staff and experienced chemists to ensure the sample data met all quality assurance requirements for the AIRNET program.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations

Tables 4-2 through 4-12 summarize the 2005 ambient air concentrations calculated from the field and analytical data. 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 = standard deviation, or sigma) of the measurement's uncertainty. The minimum detectable amounts are the levels that the instrumentation could detect under ideal conditions. All AIRNET concentrations and doses are total measurements without any type of regional background subtractions. However, the air concentrations include corrections for radioactivity from the filter material and the analytical process. The net concentrations are usually somewhat lower because small amounts of radioactivity are present 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 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (fCi/m^3)	Interval[a] (fCi/m^3)	Station	(fCi/m^3)
Regional	103	103	103	0.93	±0.09	01	1.04
Pueblo	76	76	76	0.92	±0.09	59	1.06
Perimeter	573	573	573	0.80	±0.03	18	1.54
Waste Site	208	208	208	0.84	±0.04	36	0.94
On-site	138	138	138	0.79	±0.06	20	0.90

[a] 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 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (fCi/m^3)	Interval[a] (fCi/m^3)	Station	(fCi/m^3)
Regional	103	103	103	16.3	±0.9	01	17.7
Pueblo	76	76	76	15.5	±1.0	70	16.7
Perimeter	573	573	573	14.9	±0.3	18	22.0
Waste Site	208	208	208	14.8	±0.5	50	16.0
On-site	138	138	138	14.9	±0.6	53	17.4

[a] 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 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (pCi/m^3)	Interval[a] (pCi/m^3)	Station	(pCi/m^3)
Regional[b]	99	11	7	0.1	±0.25	03	0.4
Pueblo[b]	73	8	5	0.2	±0.30	59	0.3
Perimeter[b]	550	267	169	2.8	±0.26	39	8.3
Waste Site	199	178	160	127	±84	35	940
On-site	133	88	66	6.9	±4.6	25	62

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 1,500 pCi/m^3.

Table 4-5
Airborne Plutonium-238 Concentrations for 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m^3)	Interval[a] (aCi/m^3)	Station	(aCi/m^3)
Regional[b]	16	0	0	-0.01	±0.31	03	0.3
Pueblo[b]	12	1	0	0.01	±0.56	70	0.3
Perimeter[b]	87	0	0	-0.07	±0.12	14	0.4
Waste Site	32	1	0	0.07	±0.31	50	0.7
On-site	22	0	0	0.03	±0.28	24	0.6

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 2,100 aCi/m^3.

Table 4-6
Airborne Plutonium-239,240 Concentrations for 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m^3)	Interval[a] (aCi/m^3)	Station	(aCi/m^3)
Regional[b]	16	0	0	0.09	±0.28	56	0.3
Pueblo[b]	12	1	0	0.04	±0.44	70	0.4
Perimeter[b]	87	14	5	1.04	±0.97	66	15.9
Waste Site	32	14	5	2.77	±2.79	36	11.7
On-site	22	4	2	8.86	±12.36	20	47.4

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 2,000 aCi/m^3.

Table 4-7
Airborne Americium-241 Concentrations for 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m^3)	Interval[a] (aCi/m^3)	Station	(aCi/m^3)
Regional[b]	16	2	0	0.07	±0.51	01	0.7
Pueblo[b]	12	1	0	-0.10	±0.43	70	0.0
Perimeter[b]	87	9	1	0.02	±0.21	68	1.1
Waste Site	32	7	0	0.25	±0.34	51	0.9
On-site	22	4	3	0.48	±1.25	20	4.5

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 1,900 aCi/m^3.

Table 4-8
Airborne Uranium-234 Concentrations for 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m^3)	Interval[a] (aCi/m^3)	Station	(aCi/m^3)
Regional[b]	16	16	16	12.4	±3.5	03	20.3
Pueblo[b]	12	12	11	15.4	±7.7	59	27.3
Perimeter[b]	87	86	80	7.1	±1.9	32	39.5
Waste Site	32	31	30	13.9	±5.0	50	31.4
On-site	22	20	20	16.1	±15.9	20	59.0

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 7,700 aCi/m^3.

Table 4-9
Airborne Uranium-235 Concentrations for 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m³)	Interval[a] (aCi/m³)	Station	(aCi/m³)
Regional[b]	16	7	1	1.20	±0.55	56	2.0
Pueblo[b]	12	3	2	1.11	±0.88	59	2.6
Perimeter[b]	87	18	3	0.33	±0.26	32	3.1
Waste Site	32	7	2	0.75	±0.53	50	2.4
On-site	22	8	2	1.20	±1.08	20	4.5

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 7,100 aCi/m³.

Table 4-10
Airborne Uranium-238 Concentrations for 2005 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of samples exceeding uncertainty		95% Confidence		Maximum Annual Concentration	
		>2s	>3s	Mean (aCi/m³)	Interval[a] (aCi/m³)	Station	(aCi/m³)
Regional[b]	16	16	16	13.2	±3.4	03	19.8
Pueblo[b]	12	12	11	16.5	±7.3	59	29.1
Perimeter[b]	87	86	75	8.9	±2.2	32	44.9
Waste Site	32	32	29	13.6	±4.5	50	27.4
On-site	22	21	20	13.8	±6.6	20	28.9

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Concentration Limit is 8,300 aCi/m³.

Table 4-11
Airborne Gamma-emitting Radionuclides Potentially Released by LANL Operations

Nuclide	Number of Biweekly Samples	Number of samples > MDA[a]	Mean Concentration (fCi/m³)	Measured MDA as % of required MDA[b]
As-73	160	0	2.11	0.38
As-74	159	0	.005	0.004
Cd-109	160	0	-.006	0
Co-57	160	0	.004	0.006
Co-60	160	0	-.02	0
Cs-134	158	0	-.02	0
Cs-137	160	0	-.03	0
Mn-54	160	0	-.0001	0
Na-22	160	0	.01	0.9
Rb-83	160	0	-.001	0
Rb-86	160	0	-.003	0
Ru-103	160	0	-.015	0
Se-75	160	0	-.01	0
Zn-65	160	0	-.06	0

[a] Minimum detectable activity.
[b] Required MDA is for 0.5 mrem annual dose.

Table 4-12
Airborne Concentrations of Gamma-emitting Radionuclides That Occur Naturally in Measurable Quantities

Nuclide	Number of Biweekly Samples	Number of samples > MDA[a]	Mean[b] Concentration (fCi/m^3)
Be-7	160	160	94
Pb-210	160	0	31

[a] Minimum detectable activity.
[b] Measurements less than the MDA are not included in the average.

All data in this AIRNET section, whether in the tables or the text, that are expressed as a value plus or minus (±) another value represent a 95 percent confidence interval. Because these confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurement and analytical errors but also seasonal and spatial variations. As such, the calculated 95 percent confidence intervals are overestimated for the average concentrations and probably represent confidence intervals that approach 100 percent. All ambient concentrations are activity concentrations per actual cubic meter of sampled air. Some values in the tables are negative. See Appendix B for an explanation of negative values.

Air concentrations greater than their 3s uncertainties are used to identify samples of interest or detected concentrations. Other multiples of uncertainties could be used, but 3s is consistent with the widely accepted practice of using 3s control limits for statistical quality control charts (Duncan 1986, Gilbert 1987). It also eliminates most of the false positives or detections that occur about 5 percent of the time at 2s, but less than 0.3 percent of the time at 3s.

b. Gross Alpha and Gross Beta Radioactivity

We use gross alpha and gross beta analyses primarily to: (1) evaluate general radiological air quality, (2) identify potential trends, and (3) detect sampling problems. If the gross analytical results appear to be elevated, then analyses for specific radionuclides may be performed to investigate a potential problem, such as an unplanned release.

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

In 2005, we collected and analyzed approximately 1,100 air samples for gross alpha and gross beta activity. The annual mean for all of the stations is about half of the NCRP's estimated average for gross alpha concentrations (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 is dependent on variations in 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-estimated 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 the particulate matter samples is the bismuth-210 in the radon-222 decay chain.

Figures 4-4 and 4-5 show the temporal variability of gross alpha and beta activities in air, respectively. Variability among sites within AIRNET is usually much less than variability over time. For example, in winter, at lower elevations around LANL, the radon may be trapped below an inversion layer, resulting in higher levels of radon near the ground, and therefore higher gross alpha and beta count rates.

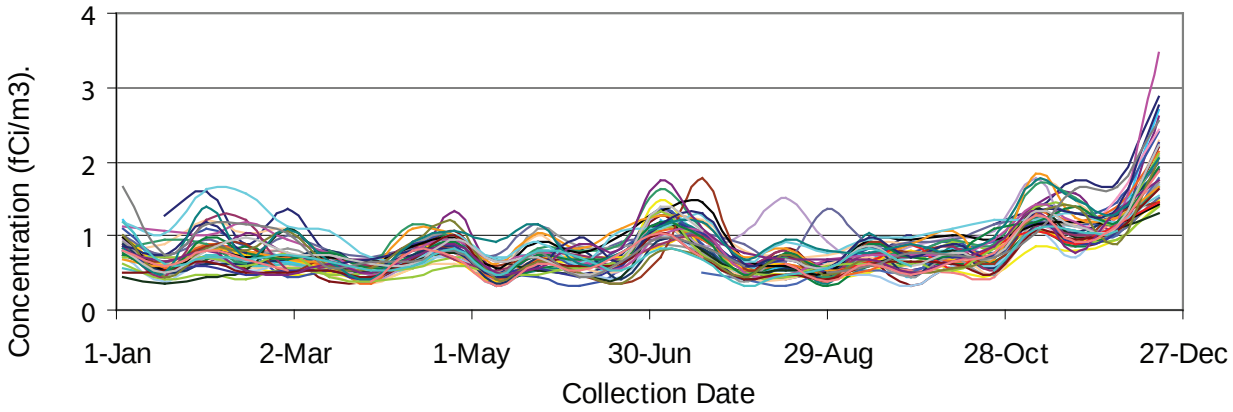

Figure 4-4. Gross alpha measurements (fCi/m3) for all sampling sites by date collected.

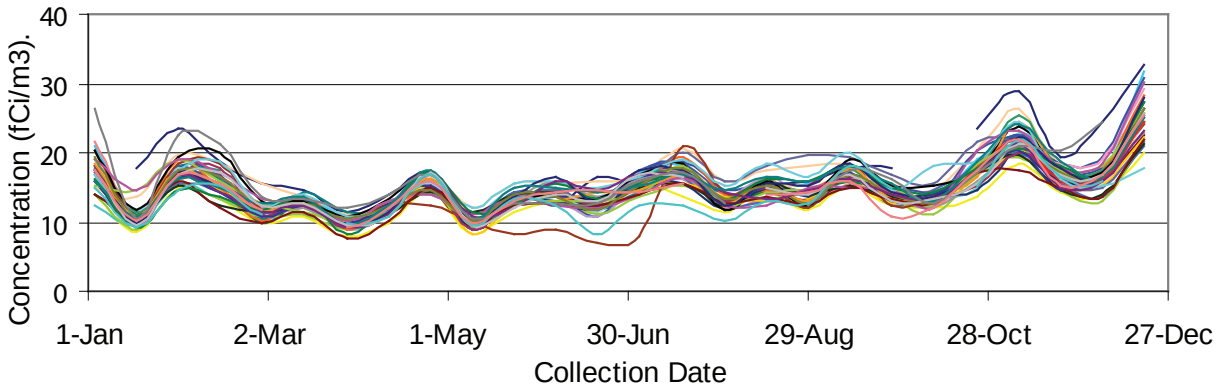

Figure 4-5. Gross beta measurements (fCi/m3) for all sampling sites by date collected.

c. Tritium

Tritium is present in the environment primarily as the result of 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 14,000 times higher than if it were hydrogen gas (HT or tritium) (DOE 1988b).

Water-vapor concentrations in the air and tritium concentrations in the water vapor were used to calculate ambient levels of tritium. Corrections for blanks, bound water in the silica gel, and isotopic distillation effects are included in this calculation (ESP 2002).

The annual concentrations of tritium for 2005 at the regional and pueblo stations were not significantly greater than zero (Table 4-4). The average concentration of tritium for the perimeter samplers was significantly greater than zero, as were the average concentrations for the on-site groups. The highest concentrations were measured at the TA-54 waste site in Area G. These data indicate that LANL release very low but measurable amounts of tritium. All annual mean concentrations at all sampling sites were well below the applicable EPA and DOE guidelines.

Figure 4-6 shows the measured stack emissions at TA-21 and also maximum and average off-site AIRNET measurements in nearby and generally downwind east Los Alamos.

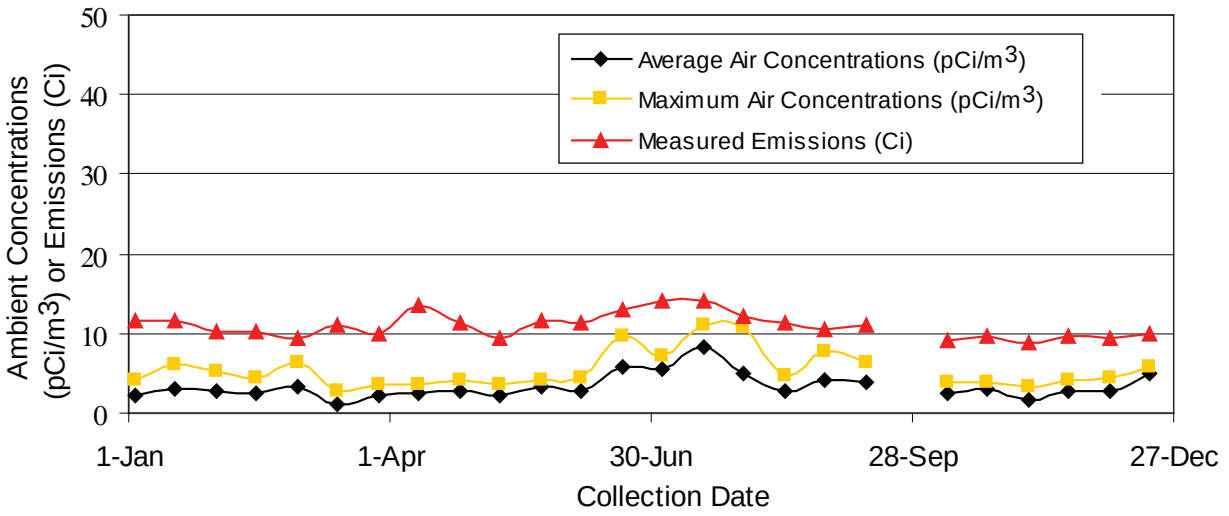

Figure 4-6. Tritium oxide stack emissions at TA-21 and ambient concentrations in east Los Alamos.

The highest off-site annual tritium concentration in 2005, 8.3 picocuries (pCi)/m^3 at station 39, was near TA-16, a known source of tritium. This concentration is equivalent to about 0.5 percent of the EPA public dose limit of 1,500 pCi/m^3. Emissions from TA-16 seldom caused concentrations to exceed investigation levels as described in section A.5 of this chapter (investigation levels are set at values of 5-yr averages plus 3s). We measured elevated tritium concentrations at a number of on-site stations, with the highest annual concentration (940 pCi/m^3) at TA-54, Area G. This annual mean concentration, 950 pCi/m^3, is well below the applicable limits for worker exposure of 20,000,000 pCi/m^3 and is measured at a location near shafts containing tritium-contaminated waste.

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 2005. No concentrations of plutonium-238 more than 3s from zero were measured at any station in any quarter. The highest quarterly concentration was 2.2 ±2.8 aCi/m^3, which, because the uncertainty exceeds the value, is consistent with zero.

No detectable concentrations of plutonium-239, 240 greater than 3s were found at any of the regional or pueblo samplers (Table 4-6). Five perimeter quarterly concentrations were above their 3s uncertainties, three of which were collected at station 66 (Los Alamos Lodge-South). The annual mean concentration at this location was 16 aCi/m^3, or about 1 percent of the EPA public dose limit. These higher ambient concentrations are from historical activities at LANL's old main Technical Area (TA-1) that deposited plutonium on the hillside below the Los Alamos Lodge. The other two perimeter concentrations above 3s were measured at station 68 near the Los Alamos Airport and are due to remediation work at TA-21.

The on-site station at TA-21 (station 20) exceeded 3s for its quarterly concentrations for two quarters – also due to the work at TA-21. Finally, five quarterly concentrations at Area G exceeded 3s. All on-site and waste site concentrations were substantially below 1 percent of the DOE DAC for workplace exposure.

e. Americium-241

As with the plutonium isotopes, americium is present in very low concentrations in the environment. No detected concentrations of americium-241 were measured at any of the regional or pueblo sampling stations (Table 4-7).

One perimeter (at station 11) and three on-site quarterly samples (all at station 20, see section above on plutonium) with a concentration of americium-241 greater than 3s were measured. Both the off-site and on-site concentrations were significantly less than 1 percent of the public and worker limits, respectively.

f. Uranium

Three isotopes of uranium are normally found in nature: uranium-234, uranium-235, and uranium-238. In natural uranium, relative isotopic abundances are constant and well characterized. Uranium-238 and uranium-234 are essentially in radioactive equilibrium, with a measured uranium-238 to uranium-234 isotopic activity ratio of 0.993 (as calculated from Walker et al., 1989). Comparisons of isotopic concentrations are used to estimate LANL contributions because known LANL emissions in the past 50 years are not of natural uranium, but enriched (EU–enriched in uranium-234 and -235) or depleted (DU–depleted of uranium-234 and -235).

All annual mean concentrations of the three uranium isotopes were well below 1 percent of the applicable EPA and DOE guidelines (Tables 4-8 through 4-10). The highest annual uranium concentrations were at locations with high dust levels from local soil disturbances, such as dirt roads at the Los Alamos County Landfill and LANL's TA-54, Area G. The regional and pueblo groupings had higher average concentrations of uranium isotopes than the perimeter group because of increased particulate matter concentrations associated with unpaved roads, unpaved parking lots, and other soil disturbances, such as construction activities and grazing, but not any known man-made sources of uranium.

During 2005, five samples downwind of the firing sites detected DU, as shown in Figure 4-7. Firing sites use DU in tests and so there is DU dust in the surrounding areas. These excess uranium-238 concentrations were identified by statistically comparing the uranium-234 and uranium-238 concentrations. If the concentrations in a sample were more than 3s apart, the sample was considered to have significant concentrations of EU or DU (see Section A.6). We measured one instance of EU during 2005 at station 20 near the remediation work at TA-21. EU remaining from Manhattan era work is expected in this area.

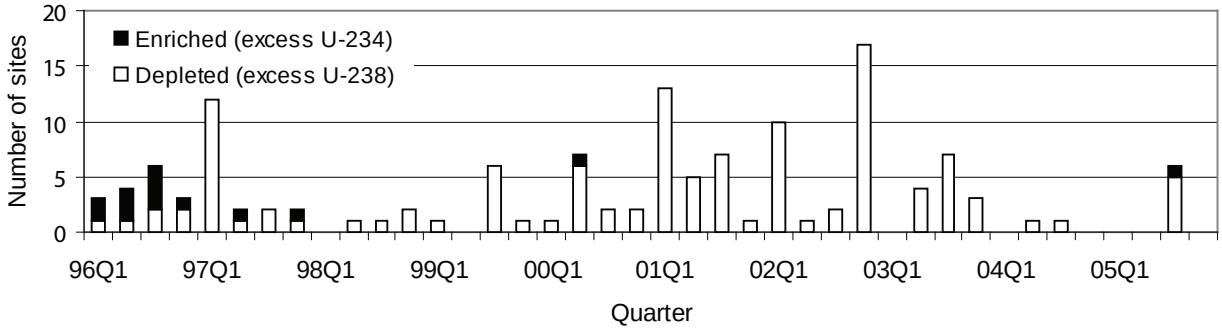

Figure 4-7. AIRNET sites with excess isotopic uranium.

g. Gamma Spectroscopy Measurements

In 2005, the air sampling team requested gamma spectroscopy measurements (Tables 4-11 and 4-12) on biweekly filters grouped across sites for a single sampling period, which are identified as "clumps." We investigated the measurement of any analyte (listed in Table 4-11) above its minimum detectable amount, but we did not investigate detectable quantities of beryllium-7, potassium-40, and lead-210, which are natural radionuclides normally present in measurable concentrations. Any other measurable concentration was highly unlikely unless an actual release occurred. In 2005, beryllium-7 was routinely detected.

5. Investigation of Elevated Air Concentrations

Two action levels have been established to determine the potential occurrence of an unplanned release: "investigation" and "alert." "Investigation" levels are based on historical measurements and are designed to indicate that an air concentration is higher than expected. These levels are set at values equal to a 5-yr rolling average plus 3s. "Alert" levels are based on dose and require a more thorough, immediate follow-up.

When a measured air concentration exceeds an action level, the air quality group verifies that the calculations were done correctly and that the sampled air concentrations are likely to be representative, i.e., that no cross contamination has taken place. Next, we work with personnel from the appropriate operations to assess potential sources and possible mitigation for the elevated concentrations. In 2005, no air sampling values exceeded alert action levels.

Some investigations were related to elevated tritium concentrations; others were of elevated uranium levels caused by wind. A number of investigations, discussed in the previous sections, were caused by the remediation work at TA-21.

a. El Rancho Plutonium-238 Investigation Concluded

An analytically rejected and unexpected value was noted at the El Rancho station in 2004. As part of the investigation into this occurrence, we reevaluated all plutonium measurements over the last two years. In 2003, an unexpected detection of plutonium at the same station had been rejected. We initiated a more thorough investigation: a re-analysis of samples from the same time periods at the same location, as well as a suite of swipes taken on the AIRNET housing. All negative results confirmed our suspicion that there was no real plutonium contamination at this site.

6. Long-Term Trends

a. Uranium

Even though the annual and quarterly concentrations of uranium isotopes vary, peak concentrations for all three isotopes occur during the second quarter of each year (Figure 4-8). For years, the uranium-238 concentrations have been consistently higher than the uranium-234 concentrations, indicating the presence of DU. Figure 4-7 shows that DU has been detected regularly.

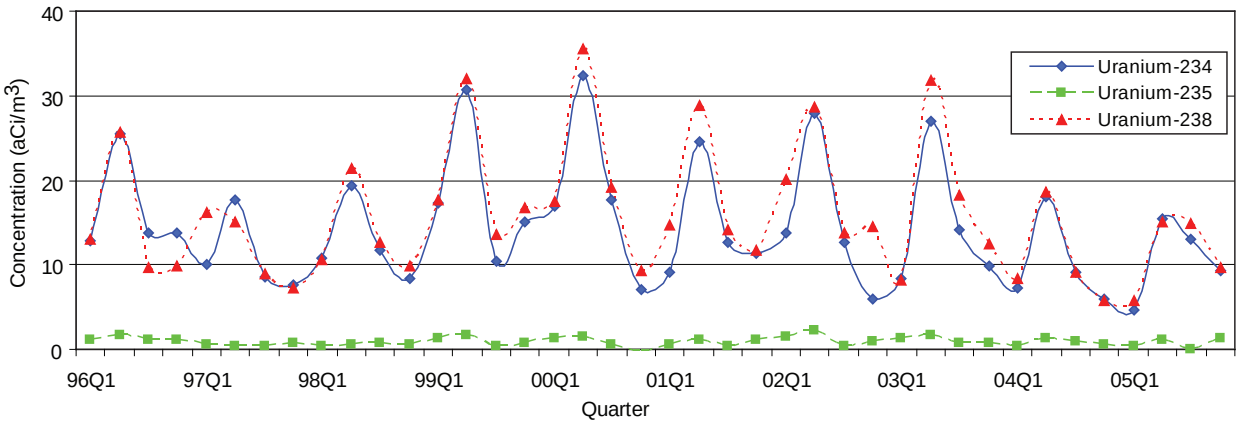

Figure 4-8. AIRNET quarterly uranium concentrations (network-wide excluding site at TA-36).

All of the samples with DU were collected on Laboratory property or within Los Alamos County. From 1995 to 2000, 15 quarterly composite samples with DU were collected off-site. From 2001–2003, 23 off site DU samples were collected—a notable increase since the 2000 Cerro Grande fire. The ongoing drought in the years following the fire has kept DU and other dust ready for resuspension. However, in 2004, rainfall was substantially above the levels of preceding years, and no DU was detected off-site. In 2005 rainfall was low again; one EU and five DU detections were reported. Off-site concentrations of DU are comparable to, or less than, historical natural uranium concentrations.

b. Plutonium and Americium

Only two quarterly measurements during the last nine years for the regional and pueblo samples were above their 3s analytical uncertainties. However, on-site measurements of plutonium-238, plutonium-239, and americium-241 are clearly higher for the TA-21 and TA-54, Area G, sampling stations, where about one-third of the measurements are detected concentrations of these radionuclides. Perimeter samplers are somewhere in between, with occasional samples having detected concentrations. Figures 4-9, 4-10, and 4-11 are graphs of the annual concentrations by isotope and general station locations. The remediation activities at TA-21 are the cause for the increase in the on-site americium-241 and plutonium-239 annual averages.

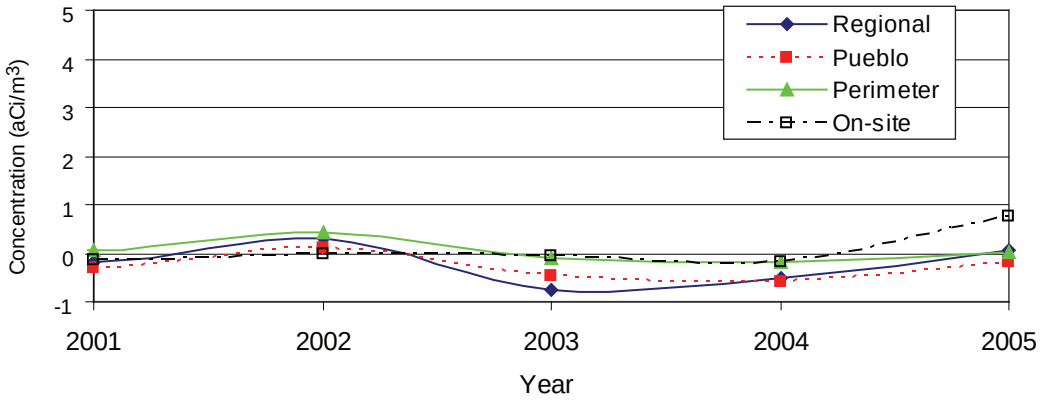

Figure 4-9. Am-241 concentration trends.

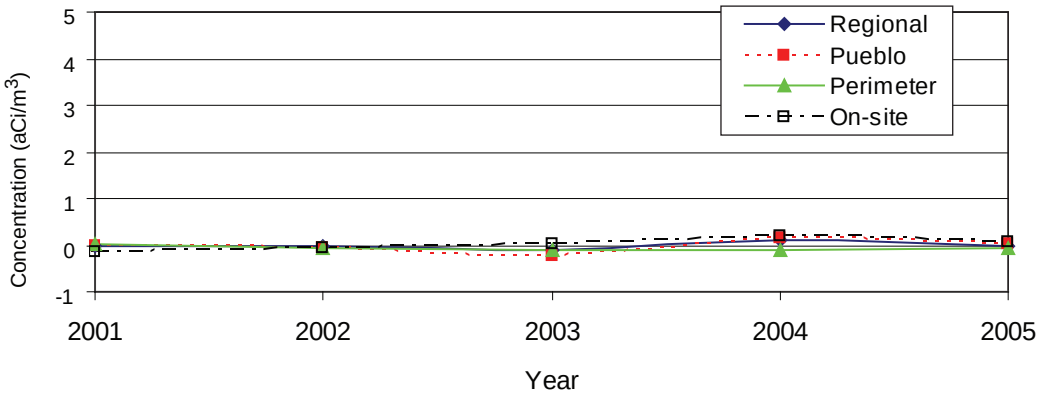

Figure 4-10. Pu-238 concentration trends.

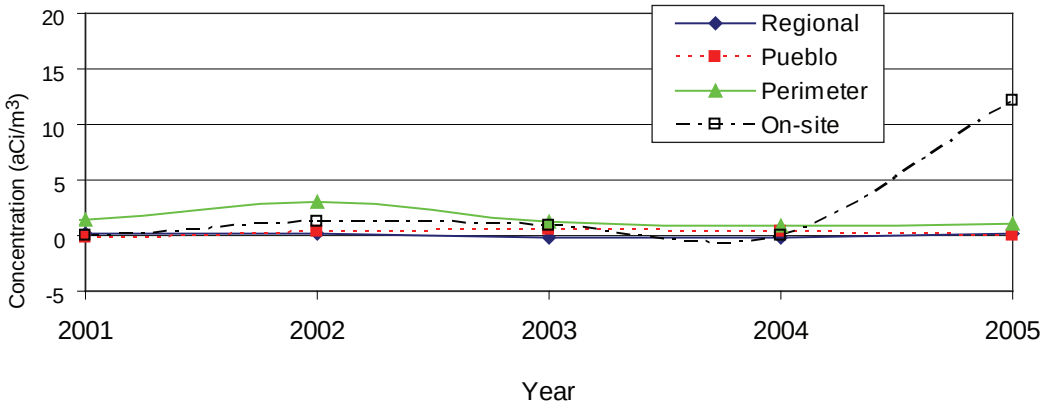

Figure 4-11. Pu-239,240 concentration trends.

Annual average concentrations for plutonium-239 and americium-241 are above zero for the TA-54, Area G sampling stations. Concentrations at the TA-54 samplers have been low for several years, except for the soil-screening operation in 2002 (Figure 4-12) (ESP 2002). The average concentrations for the other sample groupings vary but remain near zero, with occasional samples and/or locations having detected concentrations.

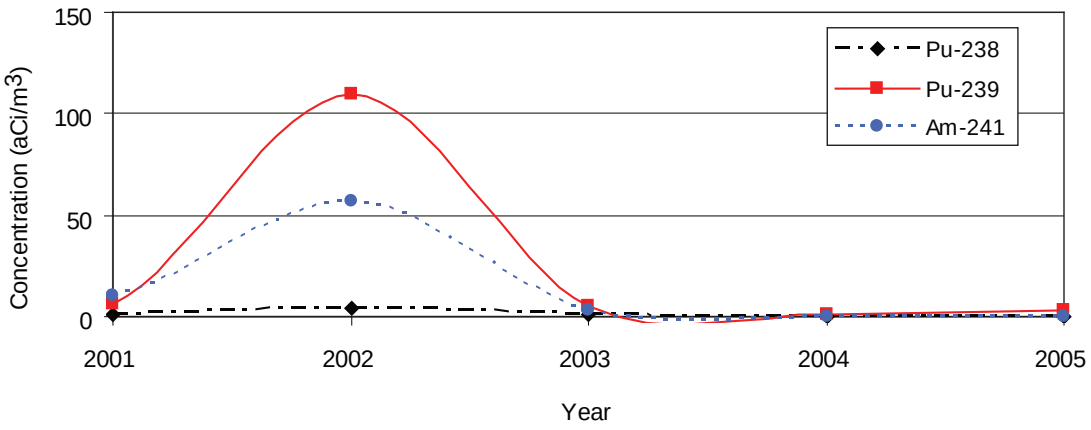

Figure 4-12. Americium and plutonium concentration trends for TA-54, Area G.

c. Tritium

Unlike other radionuclides, tritium concentrations are strongly influenced by current operations and emissions with no distinctive trends over this period. The trend in concentrations at Area G has been down over the last five years (Figure 4-13). With fewer decommissioning and decontamination activities at TA-21 during 2005, we currently see lower ambient values nearby.

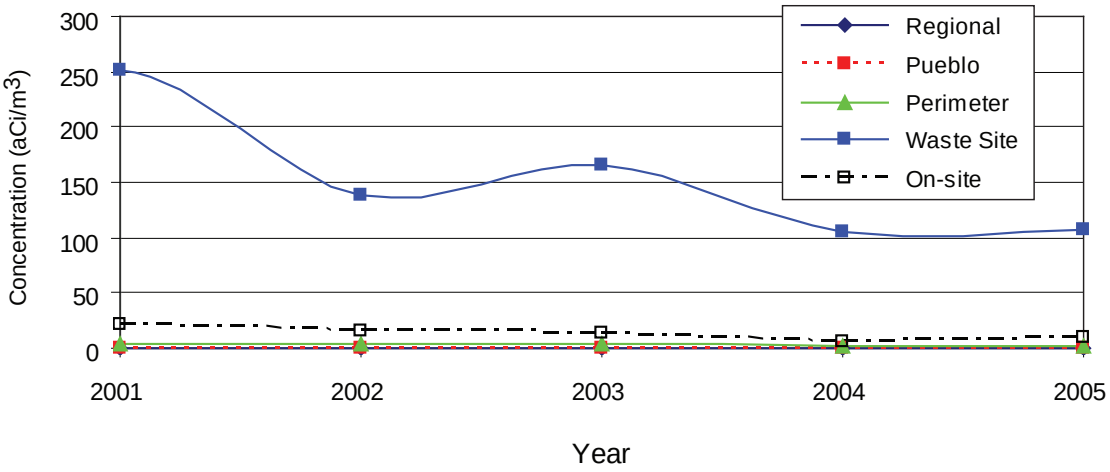

Figure 4-13. Tritium concentration trends.

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. Limits and requirements for these emissions are put forth in the Clean Air Act, specifically the National Emission Standards for Hazardous

Air Pollutants (Radionuclides), referred to as Rad-NESHAP. Under Rad-NESHAP regulations, the LANL site is limited to 10 millirem per year to the maximally exposed off-site receptor. Members of the Rad-NESHAP team at LANL evaluate Laboratory operations to determine impacts on the public and the environment. 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 Title 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989). During 2005, we identified 27 stacks meeting this criterion. One additional sampling system is in place to meet DOE requirements for nuclear facilities prescribed in their respective technical or operational safety requirements. Where sampling is not required, emissions are estimated using engineering calculations and radionuclide materials usage information. The 2005 Rad-NESHAP compliance report contains a complete description of radionuclide emissions from LANL (RN 2005).

2. Sampling Methodology

In 2005, we continuously sampled 28 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 the appropriate sampling method, as described below.

Emissions of radioactive particulate matter generated by operations at facilities, such as the Chemistry and Metallurgy Research Building and the TA-55 Plutonium Facility, are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through a filter that captures small particles of radioactive material. These samples are collected weekly and shipped to an off-site analytical laboratory. This 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 laboratory composites these samples and analyzes them to determine the total activity of materials, such as uranium-234, -235, and -238, plutonium-238 and -239,240, and americium-241. These isotopic data are used to calculate emissions from each 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 cartridge that adsorbs vaporous emissions of radionuclides. This charcoal cartridge is mounted downstream of a glass-fiber filter (discussed above) that removes any particulates from this sample media. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present in the cartridge.

We measure tritium emissions from LANL's tritium facilities with a collection device known as a bubbler. This device enables LANL 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 elemental tritium. The air is passed through a palladium catalyst that converts the elemental tritium to HTO. The sample is pulled through three additional vials containing ethylene glycol, which collect the newly formed HTO. Liquid scintillation counting determines the amount of HTO and HT by analyzing the ethylene glycol for the presence of tritium.

In previous years, stacks at LANSCE were monitored 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 2005 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 were used to identify specific radioisotopes.

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis

Analytical methods used comply with EPA requirements (40 CFR 61, Appendix B, Method 114). See Section F in this chapter for the results of analytical quality assurance measurements. General discussions on the sampling and analysis methods for each of LANL's emissions follow.

b. Particulate Matter Emissions

We removed and replaced the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions weekly and shipped them to an off-site analytical laboratory. Prior to shipping, each sample was screened with a hand-held instrument to determine if there were any unusually high levels of alpha or beta radioactivity. The laboratory performed analyses for the presence of alpha and beta radioactivity after the sample had been allowed to decay for approximately one week. In addition to alpha and beta analyses, the laboratory performed gamma spectroscopy analysis to identify specific isotopes in the sample.

The glass-fiber filters were composited every six months for radiochemical analysis because gross alpha/beta counting cannot identify specific radionuclides. We used the data from these composite analyses to quantify emissions of radionuclides, such as the isotopes of uranium and plutonium. The Rad-NESHAP team compared 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.) identified 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.

c. Vaporous Activation Products Emissions

We removed and replaced the charcoal cartridges that sample facilities with the potential for significant vaporous activation products emissions weekly. Samples were shipped to the off-site analytical laboratory where gamma spectroscopy identified and quantified the presence of vaporous radioactive isotopes.

d. Tritium Emissions

Tritium bubbler samples, used to sample facilities with the potential for significant elemental and oxide tritium emissions, were collected and transported weekly to LANL's Health Physics Analytical Laboratory. The Health Physics Analytical Laboratory added an aliquot of each sample to a liquid scintillation fluid and determined the amount of tritium in each vial by liquid scintillation counting.

e. GMAP Emissions

Continuous monitoring was used, rather than sample collection with off-line analysis, to record and report GMAP emissions 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 during transit 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 were measured with the ionization chamber. The real-time current this ionization chamber measured was recorded on a strip chart, and the total amount of charge collected in the chamber over the entire beam operating cycle was integrated on a daily basis. The gamma spectroscopy system analyzed the composition of these GMAP emissions. Using decay curves and energy spectra to identify the various radionuclides, we determined the relative composition of the emissions. Decay curves were typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes were made at LANSCE, new decay curves and energy spectra were recorded.

4. Analytical Results

Measurements of LANL stack emissions during 2005 totaled approximately 19,100 Ci. Of this total, tritium emissions composed approximately 704 Ci, and air activation products from LANSCE stacks contributed nearly 18,400 Ci. Combined airborne emissions of materials, such as plutonium, uranium, americium, and thorium, were less than 0.00002 Ci. Emissions of particulate/vapor activation products (P/VAP) were less than 0.02 Ci.

Table 4-13 provides detailed emissions data for LANL buildings with sampled stacks.

Table 4-14 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and P/VAP.

Table 4-15 presents the half-lives of the radionuclides typically emitted by LANL. During 2005, LANSCE facility (TA-53) non-point source emissions of activated air comprised approximately 530 Ci carbon-11 and 22 Ci argon-41. TA-18, usually a source of non-point emissions, had no operations in 2005.

Table 4-13
Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2005 (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		1.32E-07	4.39E-06	9.84E-06	3.86E-07	2.17E-05		3.86E-07
TA-03-102				4.42E-09				
TA-16-205	3.70E+02							
TA-21-155	2.29E+02							
TA-21-209	6.12E+01							
TA-48-001				6.52E-09		3.01E-03		
TA-50-001								
TA-50-037								
TA-50-069		7.61E-10	5.30E-09		1.21E-09			
TA-53-003	6.72E-01						1.83E+00	
TA-53-007	7.20E+00					1.60E-02	1.84E+04	
TA-55-004	4.45E+01			1.57E-07	3.35E-08			
Total[h]	7.12E+02	1.32E-07	4.39E-06	1.00E-05	4.21E-07	1.90E-02	1.89E+04[i]	3.86E-07

[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 yttrium-90 short-lived radioactive progeny.
[h] Some differences may occur because of rounding.
[i] Total for GMAP includes 555 curies released from diffuse sources at TA-53.

5. Long-Term Trends

Figures 4-14 through 4-17 present radioactive emissions from sampled LANL stacks. These figures 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 since 2000, varying slightly each year but staying in the low-microcurie range. Tritium emissions were about the same in 2005 as in 2004. GMAP emissions are quite high relative to recent years, and are explained more below. Note that with the suspension of work activity in July 2004, most operations ceased for long periods of time. Operations ramped up to full production in late 2004 and into 2005. One side effect of this work suspension was a drop in air emissions from these operations in 2004, as noted by the tritium, uranium, and plutonium emissions plots. For tritium, uranium, and plutonium emissions, the 2005 level is the anticipated steady-state level for the next few years.

Table 4-14
Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2005 (Ci)

TA-Building	Nuclide	Emission
TA-03-0029	Ga-68	1.09E-05
TA-03-0029	Ge-68	1.09E-05
TA-48-0001	Ga-68	1.50E-03
TA-48-0001	Ge-68	1.50E-03
TA-48-0001	Se-75	1.42E-05
TA-53-0003	C-11	1.81E+00
TA-53-0003	Ar-41	2.26E-02
TA-53-0007	Ar-41	2.76E+01
TA-53-0007	As-73	1.05E-05
TA-53-0007	Be-7	6.96E-06
TA-53-0007	Br-76	3.23E-03
TA-53-0007	Br-77	2.41E-04
TA-53-0007	Br-82	3.56E-03
TA-53-0007	C-10	8.98E-01
TA-53-0007	C-11	1.56E+04
TA-53-0007	Hg-197	4.41E-03
TA-53-0007	Hg-197m	4.41E-03
TA-53-0007	N-13	4.36E+01
TA-53-0007	N-16	5.31E-01
TA-53-0007	Na-24	4.62E-05
TA-53-0007	O-14	2.33E+01
TA-53-0007	O-15	2.73E+03
TA-53-0007	Os-191	4.99E-05
TA-53-0007	Se-75	1.45E-05

Table 4-15
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-24	14.96 h
K-40	1,277,000,000 yr
Ar-41	1.83 h
Co-60	5.3 yr
Ga-68	1.1 d
Ge-68	271 d
As-73	80.3 d
Br-76	16 h
Br-77	2.4 d
Br-82	1.47 d
Se-75	119.8 d
Sr-90	28.6 yr
Cs-137	30.2 yr
Os-191	15.4 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

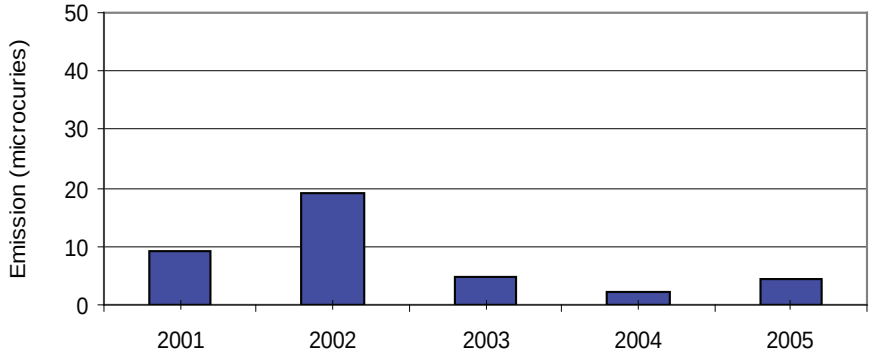

Figure 4-14. Plutonium emissions from sampled LANL stacks.

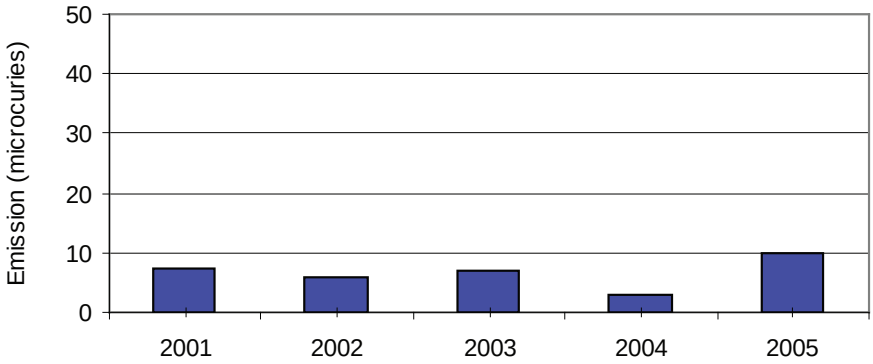

Figure 4-15. Uranium emissions from sampled LANL stacks.

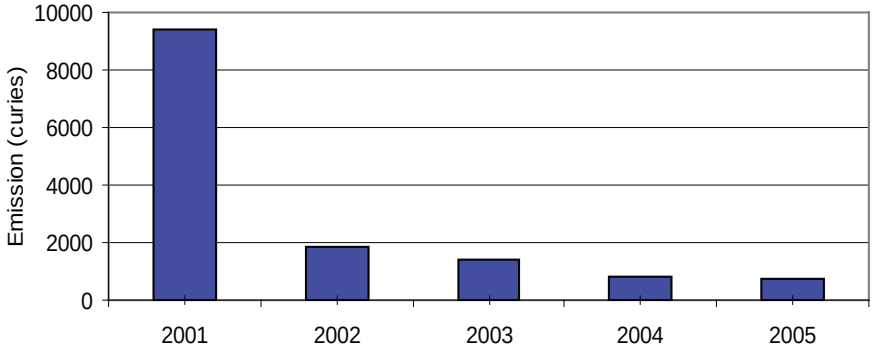

Figure 4-16. Tritium emissions from sampled LANL stacks.

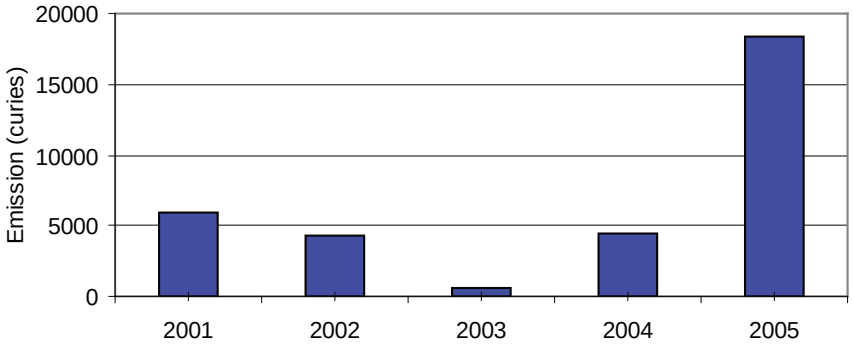

Figure 4-17. GMAP Emissions from sampled LANL stacks.

Site-wide tritium emissions are staying low due to the consolidation of most tritium operations at TA-16. In 2005, source removal activities were completed at building 21-155. Similar activities were ongoing at building 21-209 and should be completed in 2006. Continued emissions from these facilities result from off gassing of contaminated equipment remaining in the building. Monitoring will continue until the potential emissions levels from these buildings are fully characterized. As tritium-contaminated systems are dismantled and prepared for removal and disposal, increased releases of tritium are expected. However, overall long-term emissions from these facilities will decrease following decontamination and decommissioning.

The large spike in tritium emissions from 2001 is due to a single release of 7600 curies of tritium gas (HT) on January 31, 2001 (when the valve on a legacy waste bottle failed during handling and vented the contents). No such large-scale releases have occurred since that time. The release in 2001, as well as routine operational releases before and since that time, was well below regulatory limits.

In 2005, LANSCE operated in the same configuration as 2001–2004, 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 January through December, with a four-week maintenance outage in July. Emissions from this target area were greatly elevated over 2004 levels for a variety of reasons. First, the beam operation time was higher: almost 10 months of beam delivery in 2005 versus less than 4 months in 2004. Second, as the target coolant water filtration system became saturated over time, the buildup of pollutants in the water system increased the rate of radioactive gas generation over the course of the run cycle. Finally, a hairline crack in a valve at the inlet of the emissions controls system resulted in a significant portion of the radioactive gases bypassing this control system and venting straight to the stack.

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. The cracked valve at the delay line inlet was fixed in late November 2005. The result was an immediate drop in the emissions rate back to predicted levels. It is anticipated that emissions in 2006 will be similar to the 2002–2004 levels. The overall total emissions from 2005 remained below the Rad-NESAHP regulatory limits described above.

Figure 4-18 shows the individual contribution of each of these emission types 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 cleanup operations and LANSCE operations vary from year to year. GMAP emissions remain the greatest source of off-site dose from the airborne pathway because of the close proximity of the LANSCE facility to the LANL site boundary.

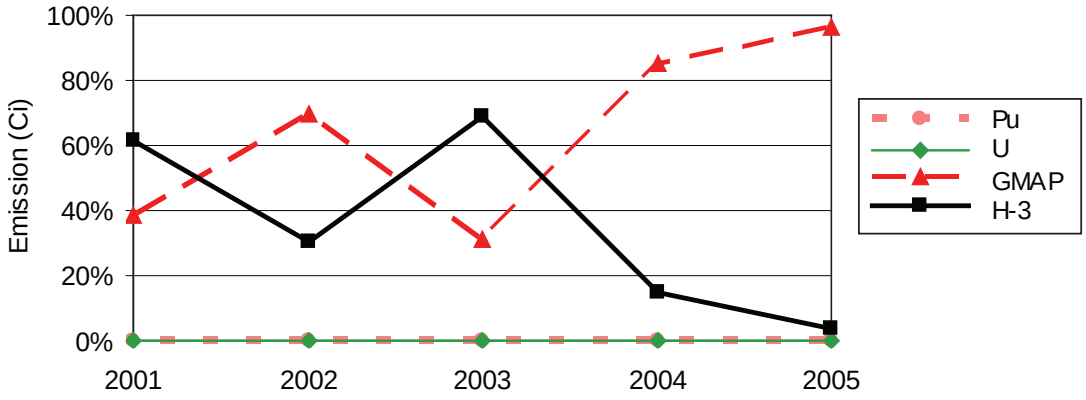

Figure 4-18. Fraction of total annual stack emissions resulting from plutonium, uranium, tritium, and GMAP.

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). 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 dose rate from natural terrestrial and cosmic sources measured by the dosimeters (does not include radon and internal sources) 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 surrounding communities (Figures 4-2 and 4-19).

b. Neutron Dosimeters

We monitor potential neutron doses with 52 albedo TLD stations. 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. However, at stations with no LANL contribution, the neutron dosimeters record a dose of approximately 2 mrem/yr, because the environmental dosimeters are calibrated with a D_2O-moderated neutron source with a different energy spectrum from cosmic-ray neutrons. Therefore, a neutron reading of 2 mrem/yr is a normal background reading.

3. Quality Assurance

Division operating procedures outline the quality assurance/quality control (QA/QC) protocols. In the air sampling group, guidance is provided by the group's quality management plan (see http://www.lanl.gov/community/environment/air/). The Health Physics Measurements Group (HSR-4) calibration laboratory calibrates the dosimeters every quarter of the calendar year. The DOE Laboratory Accreditation Program has accredited the dosimeters that HSR-4 provides, and HSR-4 provides 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 percent.

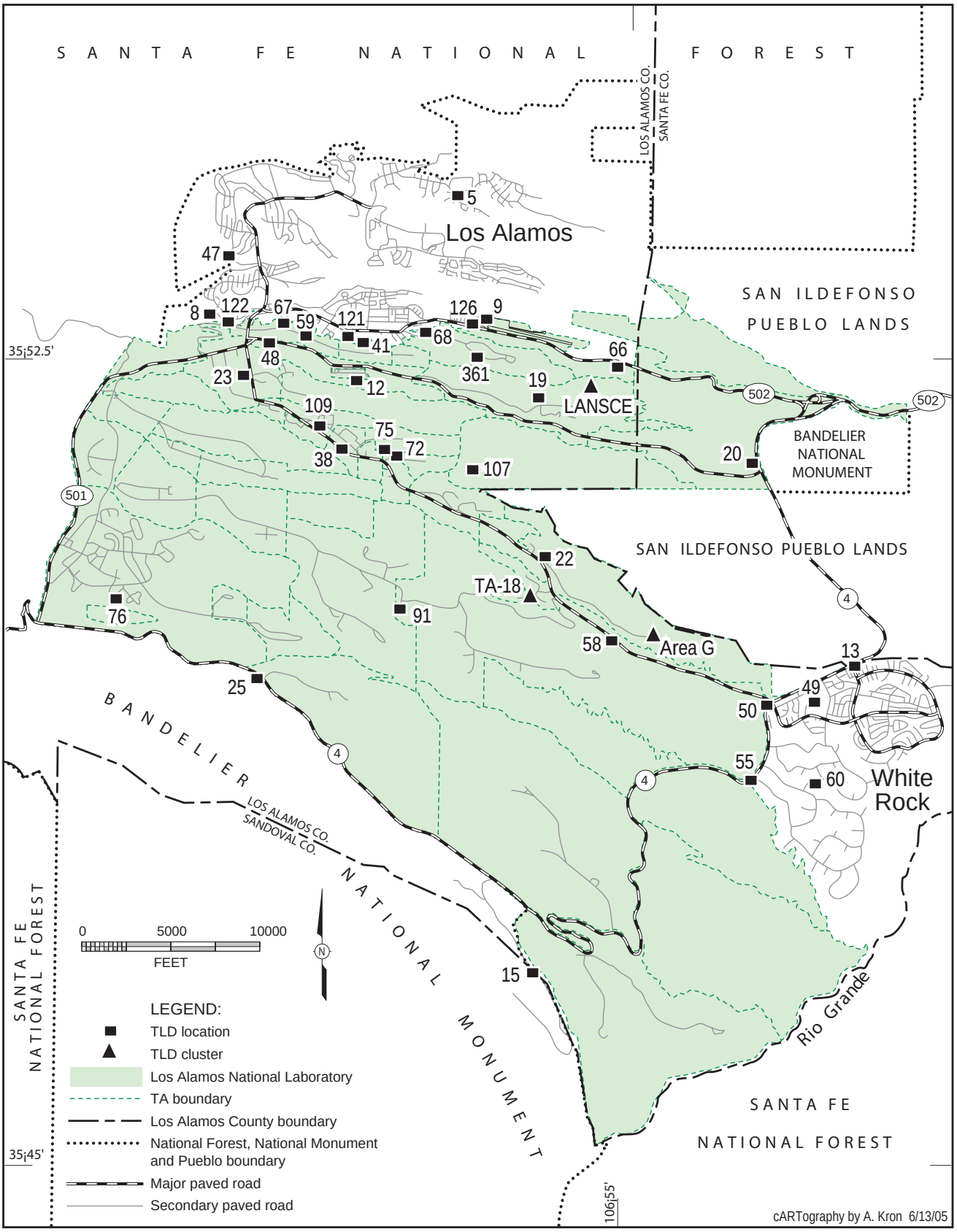

Figure 4-19. Off-site perimeter and on-site LANL TLD locations.

4. Results

The annual dose equivalents at all stations, except those at or near Area G are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Data Supplement Table S4-10 and at http://www.lanl.gov/community/environment/air/.

The only location with a measurable contribution from LANL operations is near TA-54, Area G.

Figure 4-2 shows the locations of the stations at TA-54, Area G, which is a temporary storage area for transuranic waste awaiting shipment to the Waste Isolation Pilot Plant. Area G is a controlled-access area, so Area G data are not representative of a potential public dose. The public dose near this location is reported in Chapter 3.

D. NONRADIOLOGICAL AMBIENT AIR MONITORING

1. Introduction

During 2005, we continued a reduced version of the Non-Radiological Air Sampling Network (NonRadNet) implemented in 2001. Currently, the objectives of NonRadNet are to conduct monitoring to develop a database of typical background levels of selected nonradiological species in the communities nearest LANL, and to measure LANL's potential contribution to nonradiological air pollution in the surrounding communities. We retain the capability to analyze for volatile organic compounds.

2. Air-Monitoring Network

During 2005, ambient particulate matter monitoring continued at three locations—one in White Rock and two in Los Alamos. The White Rock sampling location is at the White Rock Fire Station (at AIRNET station 15). One Los Alamos station is at the Los Alamos Medical Center (at AIRNET station 61), the other near 48th Street (AIRNET station 6). Both of these latter locations lie between TA-3 and the population center of the Los Alamos town site. Two monitors are operated at each location: one for particles with diameters of 10 micrometers (μm) or less (PM-10), and another for particles with diameters of 2.5 μm or less (PM-2.5).

3. Sampling Procedures, Data Management, and Quality Assurance

A tapered-element oscillating microbalance ambient particulate monitor, fitted with either PM-10 or PM-2.5 sample inlets, collects continuous PM-10 and PM-2.5 concentrations (micrograms per cubic meter). The microbalance has an oscillating ceramic "finger" with a filter that collects particles. The added mass of the particles changes the resonant frequency of the oscillator. The change in frequency is measured and an associated mass of accumulated particulate matter is recorded and saved. The data are later downloaded to a database. Personnel use these data as an indicator of natural dust loading in the atmosphere. The sampled air volumes are calculated and the ambient air concentrations derived.

4. Ambient Air Concentrations

We achieved an overall data collection efficiency exceeding 90 percent for 2005. Annual averages and 24-hour maxima for both particle sizes at the three locations are shown in Table 4-16. The annual average for PM-10 is about 13 $\mu g/m^3$ at all locations; PM-2.5 about 7 $\mu g/m^3$. These averages are well below EPA standards (see Table 4-16). The 24-hour maxima for both PM-2.5 and PM-10 at all three locations are also much less than EPA standards.

5. Detonation and Burning of Explosives

LANL tests explosives by detonating them at firing sites operated by the Dynamic Experimentation Division and maintains records that include the type of explosives used and other material expended at each site. Table S4-11 (in the Data Supplement) summarizes the amounts of expended materials for the last five years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2005, 6.5 tons of high explosives was burned.

Table 4-16
PM-2.5 and PM-10 Concentration Data Summary for 2005 (µg/m³)

Station Location	PM-2.5		PM-10	
	Maximum 24 hour	Annual Average	Maximum 24 hour	Annual Average
48th Street, Los Alamos	20	7	34	12
Los Alamos Medical Center	27	8	55	15
White Rock Fire Station	20	7	34	13
EPA Standard	<65	<15[a]	<150	<50[a]

[a] EPA 40 CFR Part 50

An assessment of the ambient impacts of high-explosives testing (DOE 1999) indicates that high-explosives testing produces no adverse air-quality impacts. The quantities of materials detonated during 2005 were less than the amounts for which impacts are analyzed in the DOE (1999) report.

6. Beryllium Sampling

The State of New Mexico has no ambient-air-quality standard for beryllium. For comparison purposes, we use the NESHAP standard of 10 ng/m³ (40 CFR Part 61). Beryllium air concentrations for 2005 are very similar to those measured in recent years. All values are 2 percent or less of the NESHAP standard.

During 2005, we analyzed quarterly composite samples from 23 sites for beryllium, aluminum, and calcium (see Table S4-12 in the Data Supplement). These sites are located near potential beryllium sources at LANL or in nearby communities. Beryllium and aluminum concentrations in soil occur in a fairly constant ratio: note the linear dependence in Figure 4-20 (correlation coefficient = 0.94). Non-natural occurrences of beryllium would appear far from the straight line. We believe all the measured beryllium concentrations are of a natural origin and represent resuspended soil and dust.

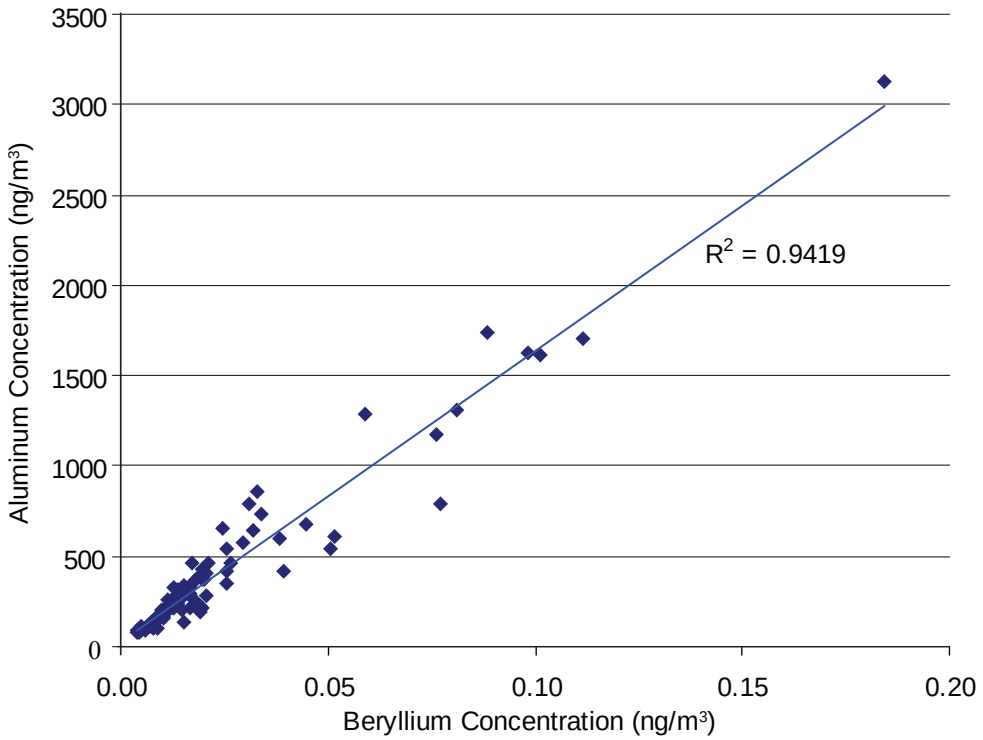

Figure 4-20. Correlation between aluminum and beryllium concentrations in AIRNET samples.

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 (Rishel et al. 2003) 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 six towers gathers meteorological data (winds, atmospheric state, precipitation, and fluxes) at the Laboratory. Four of the towers are located on mesa tops (TA-6, TA-49, TA-53, and TA-54), one is in a canyon (TA-41), and one is on top of Pajarito Mountain (figure 4-21). 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. Precipitation is also measured at TA-16, TA-74, and in North Community of the Los Alamos town site.

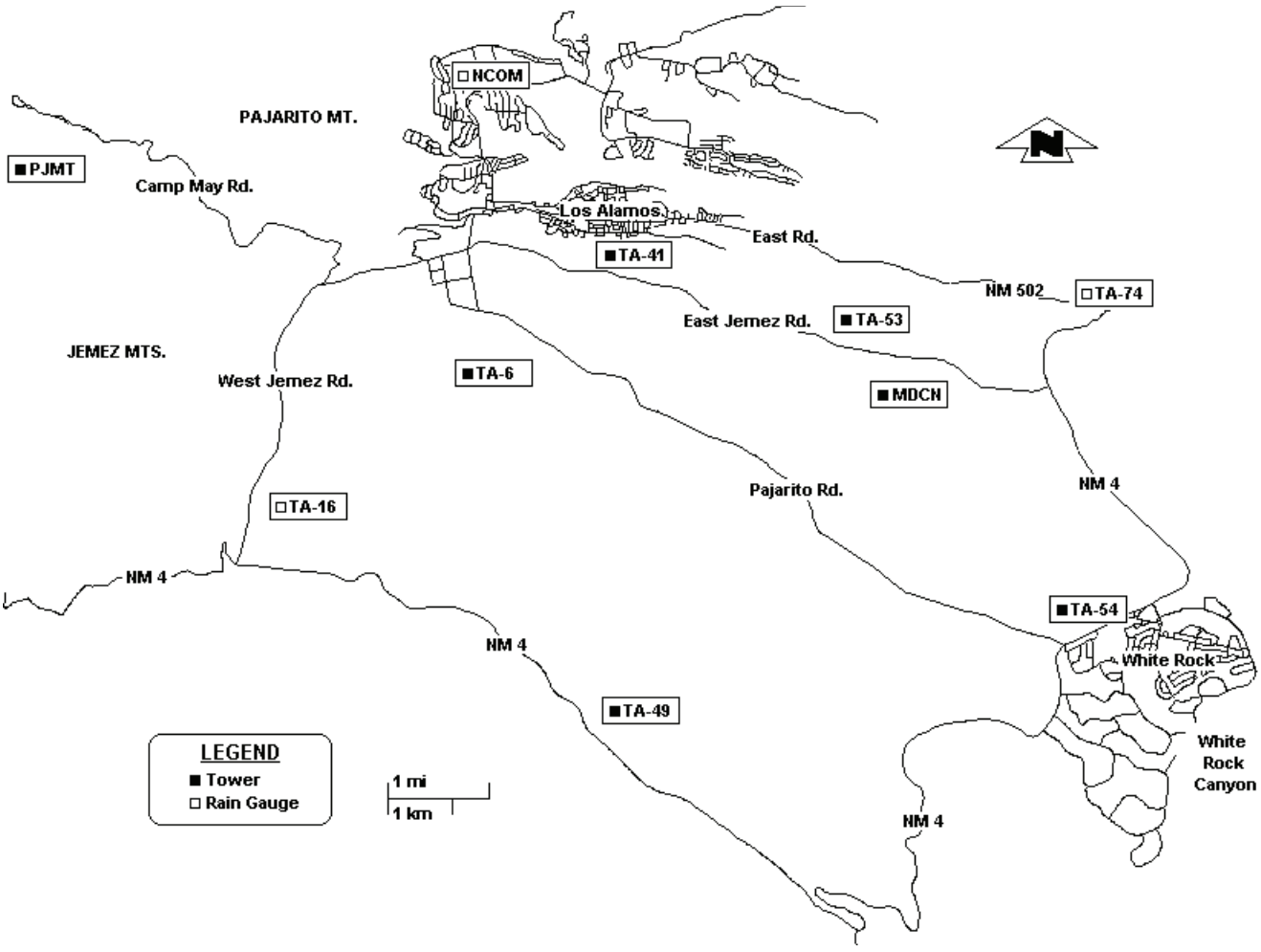

Figure 4-21. Meteorological network.

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 (from trees and structures) 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 every 3 seconds (0.33 hertz), store the data, average the samples over a 15-min period, and transmit the data to a Hewlett-Packard workstation by telephone or cell phone. The workstation automatically edits measurements that fall outside of allowable 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. During the past 46 years, a similar once-daily set of statistics has been telephoned to the National Weather Service. Observers log cloud type and percentage cloud cover three times daily.

All meteorological instruments are annually refurbished and calibrated 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. All instrument calibrations are traceable to the National Institute of Standards and Technology. An external audit is typically performed once every 2–3 years, with the most recent audit performed (on only the TA-54 tower) in 2003.

4. Climatology

Los Alamos has a temperate, semiarid mountain climate. However, large differences in locally observed temperature and precipitation exist because of the 1,000-ft elevation change across the Laboratory site. Four distinct seasons occur in Los Alamos. 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 provided in Bowen (1990 and 1992) and from historical meteorological databases maintained by the meteorology team.

Temperatures at Los Alamos have wide daily variations (a 23˚F range on average) because of the semiarid climate. Atmospheric moisture levels are low, and clear skies are present about 75 percent of the time. These conditions lead to high solar heating during the day and strong long-wave radiative cooling at night.

Winter temperatures range from 30˚F to 50˚F during the daytime and from 15˚F to 25˚F during the nighttime, with a record low temperature of -18˚F recorded in 1963. 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. Winds during the winter are relatively light, so extreme wind chills are uncommon. Summer temperatures range from 70˚F to 88˚F during the daytime and from 50˚F to 59˚F during the nighttime, with a record high temperature of 95˚F recorded in 1998.

1971 to 2000 represents the time period over which the climatological standard normal is defined, according to the World Meteorological Organization (WMO 1984). Our averages are calculated according this standard. The average annual precipitation, which includes both rain and the water equivalent for frozen precipitation, is 18.95 in. The average annual snowfall is 58.7 in.

Winter precipitation in Los Alamos is often caused by storms approaching from the Pacific Ocean, or by cyclones forming and/or intensifying leeward of the Rocky Mountains. Large snowfalls may occur locally 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 am on January 15th, 1987, and 11 am the next day. The record single-season snowfall is 153 in. set in 1986–87.

The two months of July and August account for 36 percent 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 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 be displaced by cooler air from aloft and tends to rise and 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. Daytime upslope flow of heated air on the Pajarito Plateau adds a southerly component to the winds on the plateau as it flows up the Rio Grande valley. Nighttime downslope flow of cooled air from the mountains and plateau adds a light westerly-to-northerly component to local winds. Flow in the east-west-oriented canyons that interrupt the Pajarito Plateau is often aligned with the canyons, so winds are usually from the west at night as katabatic flow and from the east during the day.

5. 2005 in Perspective

Figure 4-22 presents a graphical summary of Los Alamos weather for 2005. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared to monthly normals (averages for each of 12 calendar months during the standard 1971–2000 time period).

The year 2005 was unusual in that it was both warmer than normal and wetter than normal. Generally, warm years are dry years and cool years are wet years. Good recent examples include 1997 (cool and wet) and 2003 (warm and dry) (see Figures 4-23 and 4-24). The average annual temperature in 2005 of 49.5˚F exceeded the normal annual average of 47.9˚F by 1.6˚F. The total precipitation in 2005 of 21.30 in. was 12 percent above normal (18.95 in.), making 2005 the wettest year since 1997. January, July, September, November, and December stand out as warm months and no months stand out as cooler than normal. The year began very wet, with January, February, and March bringing more than twice the normal precipitation. There was some worry in July, however, when the monsoon appeared to be failing. The monsoon finally arrived in August, dispelling the myth that late monsoons are weak monsoons. August and September brought the total monsoon rainfall to more than normal and secured 2005 as the wettest year in almost a decade. Ominous signs of a returning drought appeared in November, when precipitation nearly stopped entirely, a trend that continued into 2006. The annual snowfall total of 48.3 in. was 82 percent of normal (58.7 in.). The less-than-usual snowfall total in 2005 was due in part to warmer winter temperatures and in part to a return to drought conditions late in the year.

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-23 shows the historical record of temperatures in Los Alamos from 1925 through 2005. 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 4-23. With the exception of 2004, years since 2000 have clearly been warmer than normal. To aid in showing longer-term trends, the five-year running mean is also shown. With five-year averaging, for example, it can be seen that the warm spell during the past few years is not as severe as the warm spell during the early-to-mid 1950s. On the other hand, it was three out of four warm years then while the recent warm spell has been five out of six years.

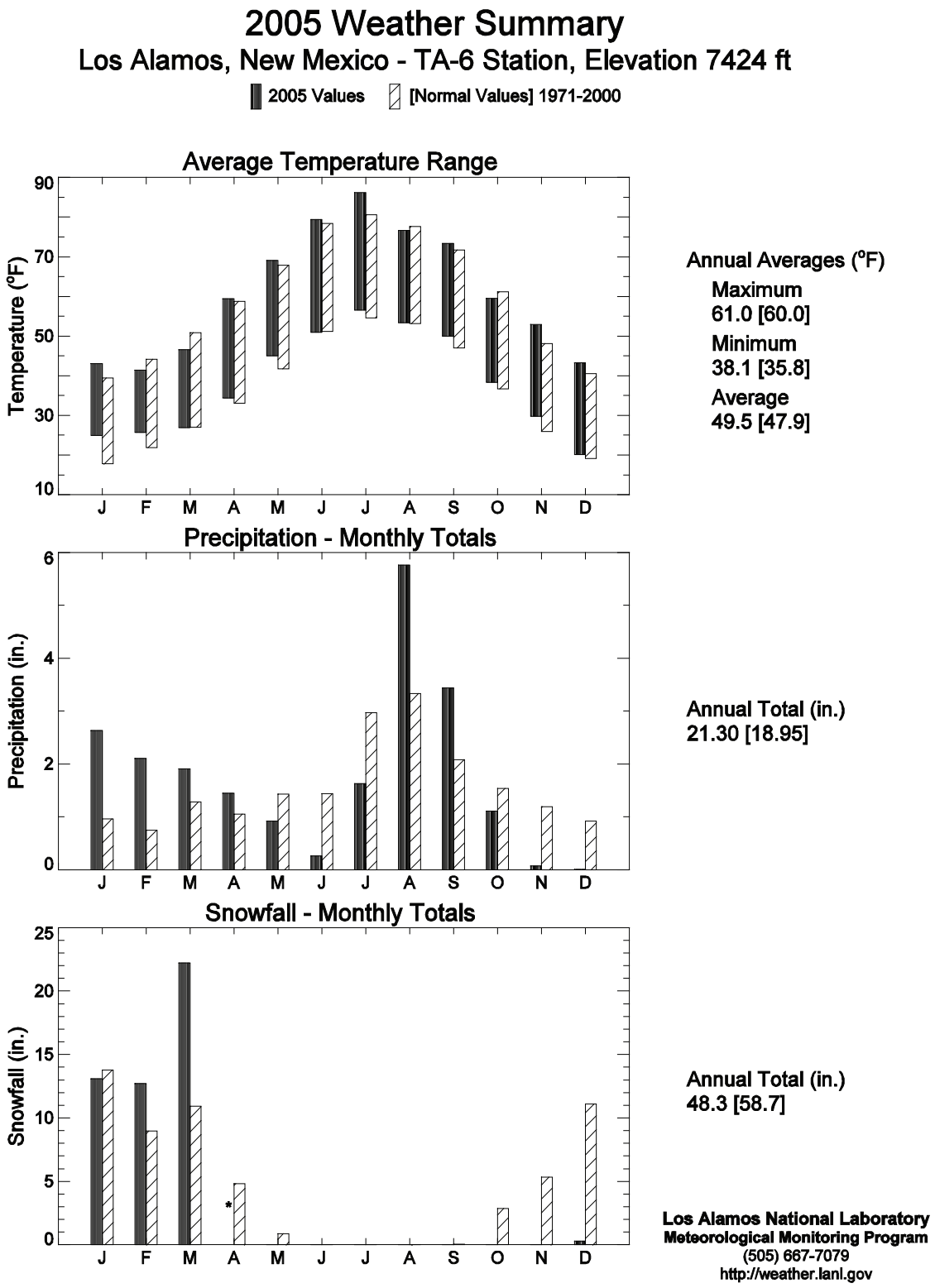

Figure 4-22. Weather summary for Los Alamos in 2005 at TA-6 station, elevation 7,424 ft.
(Numbers in brackets are 30-yr averages, and non-bracketed numbers are 2005 figures.)

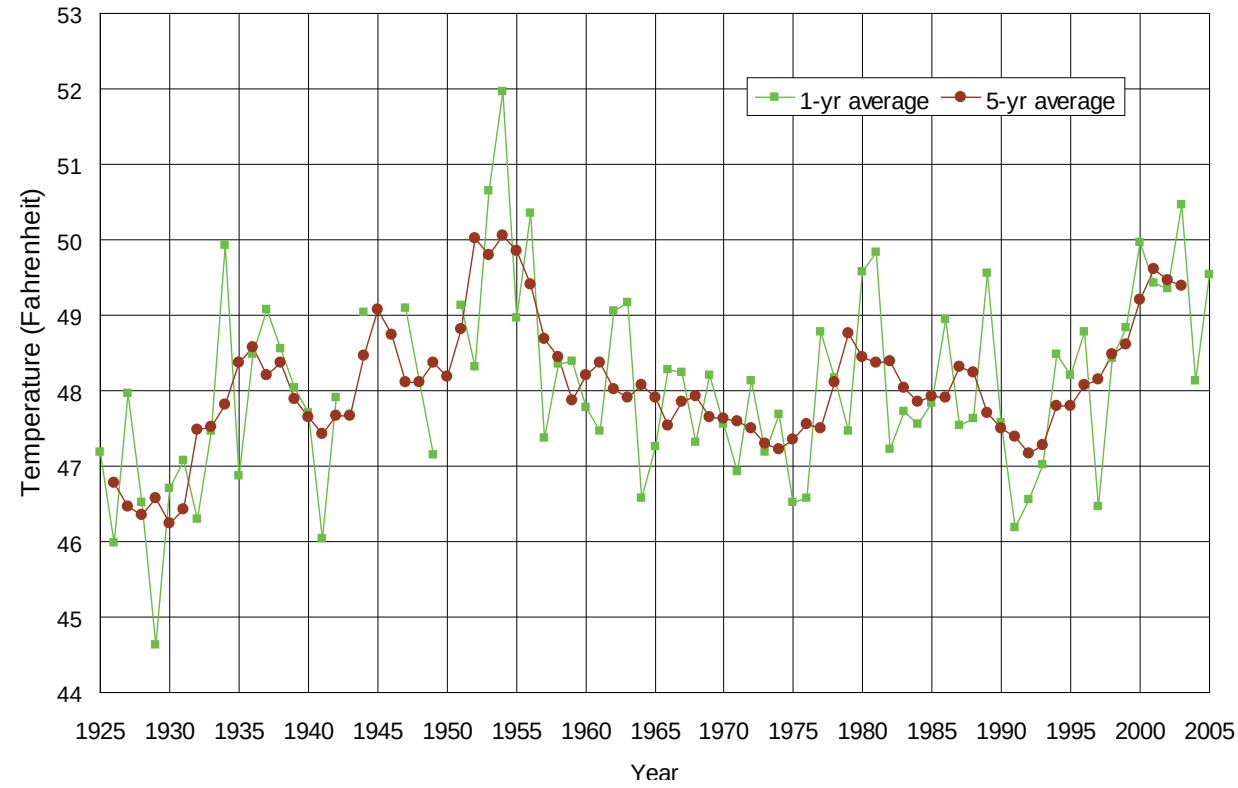

Figure 4-23. Temperature history for Los Alamos.

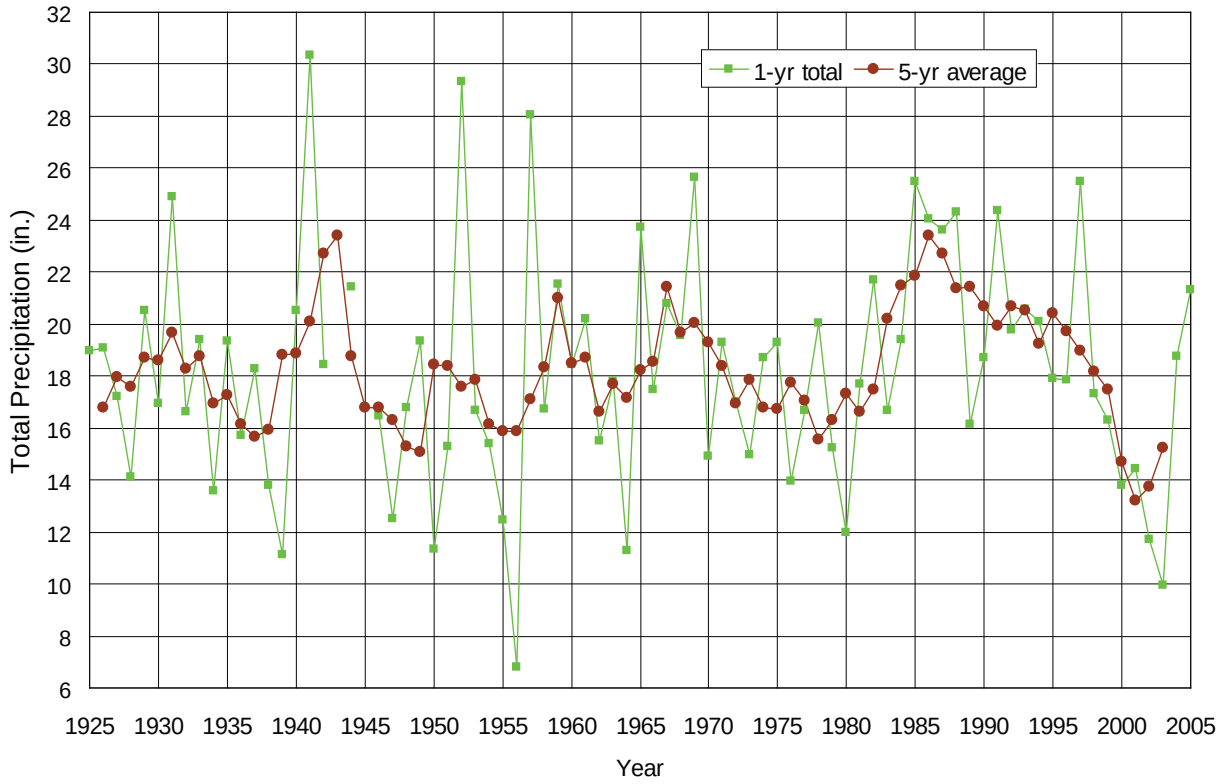

Figure 4-24. Total precipitation history for Los Alamos.

Figure 4-24 shows the historical record of the annually summed total precipitation. The drought appeared to end with 2003, as 2004 and 2005 have shown strong returns to nearly normal conditions. As with the historical temperature profile, the five-year running mean is also shown. The five-year average shows that the recent drought appears quite clearly to be the most severe drought on record in Los Alamos.

Daytime winds (sunrise to sunset), based on 15-minute-averaged wind observations for 2005 at the four Pajarito Plateau towers and the Pajarito Mountain tower, are shown in the form of wind roses (Figures 4-25 and 4-26). The wind roses depict the percentage of time that the wind blows from each of 16 compass rose points and the distribution of wind speed for each of the 16 directions, represented by shaded wind-rose barbs. Unlike temperature and precipitation, graphics of wind (wind roses) from different years are almost identical.

Daytime winds measured by the four Pajarito Plateau towers are predominately from the south (Figure 4-25), 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 were lighter and more variable than daytime winds and typically from the west, resulting from a combination of prevailing winds from the west and downslope katabatic flow of cooled mountain air (Figure 4-26). Winds atop Pajarito Mountain are more representative of upper-level flows and primarily ranged from the northwest to the southwest, mainly because of the prevailing westerly winds.

F. QUALITY ASSURANCE PROGRAM IN THE AIR QUALITY GROUP

1. Quality Assurance Program Development

During 2005, the air quality group revised four quality plans that affect collection and use of air-quality-compliance data. We also issued three new implementing procedures and revised approximately 38 procedures to reflect the constant improvements in the processes. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that processes perform satisfactorily. All current quality-related documents are available on the public website: http://www.lanl.gov/community/environment/air/.

2. Field Sampling Quality Assurance

Overall quality of this portion of the program is maintained through the rigorous use of carefully 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 EPA 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. They are then delivered to internal and external 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 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 quality-assessment memo that is prepared by stack monitoring staff to evaluate every data group received from a supplier.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical-chemistry services after the Data Quality Objective process has identified and quantified our program objectives. These statements of work are sent to potentially qualified suppliers who then 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 lab, including recent past performance on nationally conducted performance-evaluation programs, are primarily used to award contracts for specific types of radiochemical and inorganic analyses.

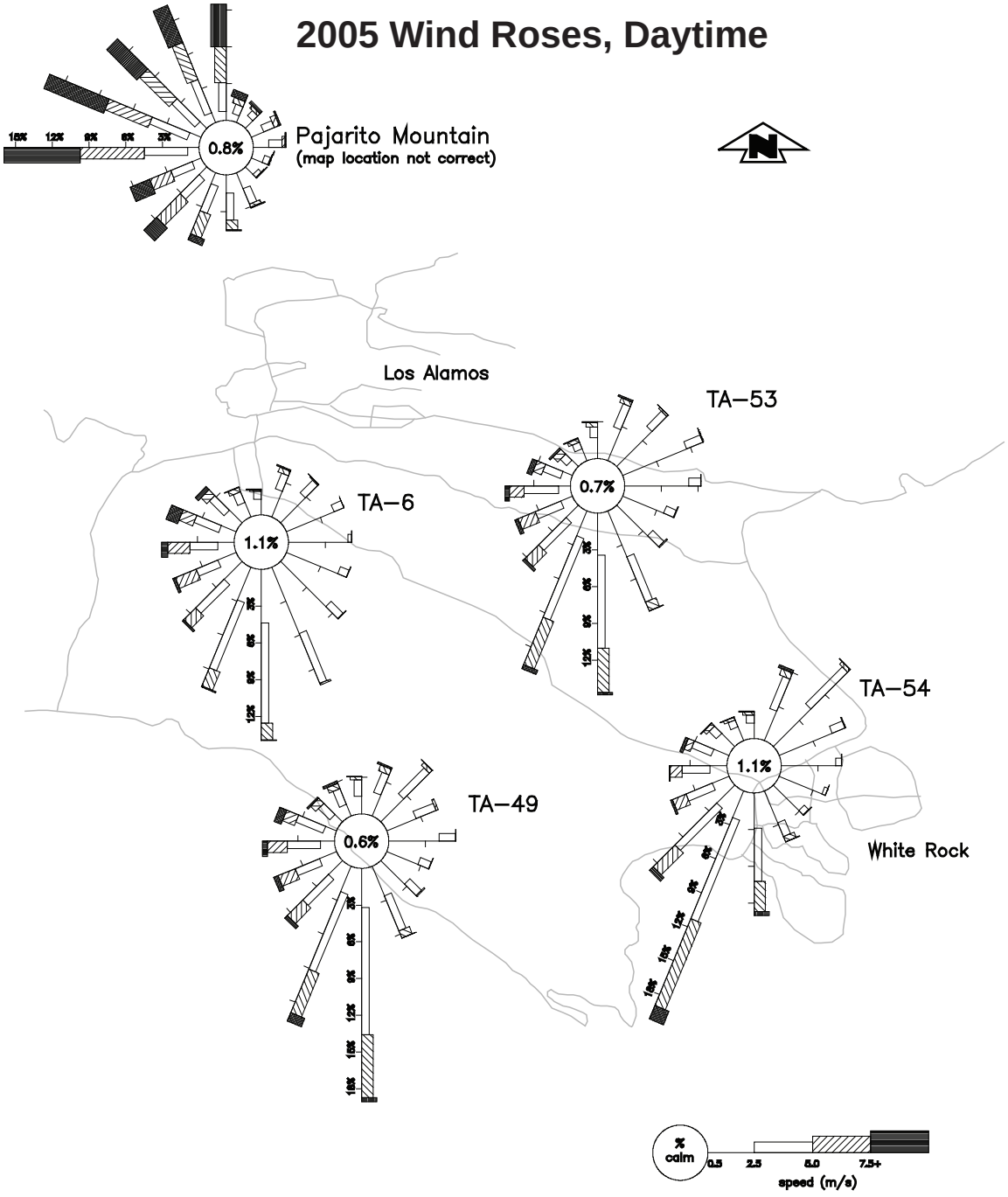

Figure 4-25. Daytime wind roses, 2005.

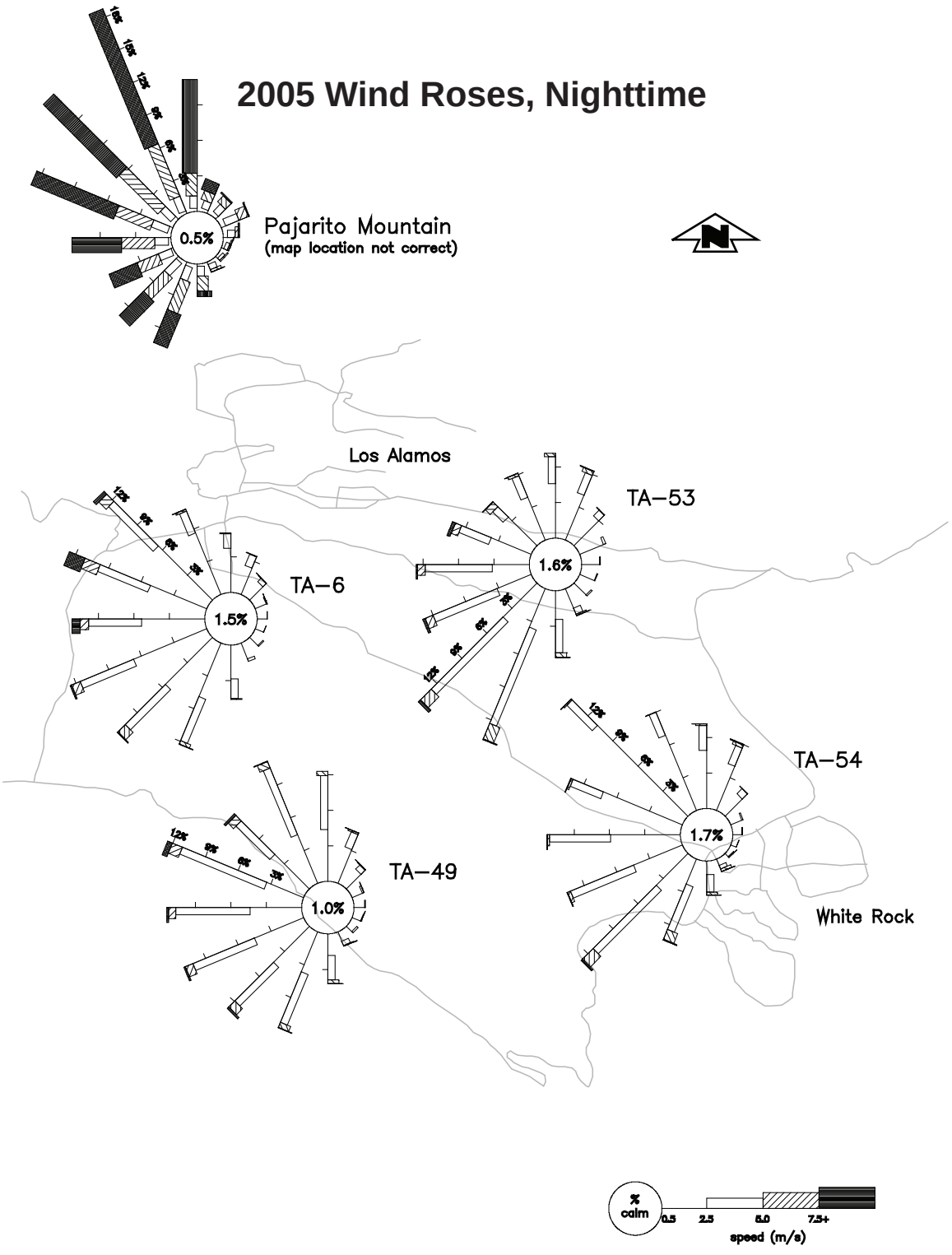

Figure 4-26. Nighttime wind roses, 2005.

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 e-mail 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/QC data the analytical laboratory generates during each phase of chemical 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 are 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.

4. Field Data Quality Assessment Results

Field data completeness for AIRNET and stacks was 100 percent. Sample run time was greater than 98.6 percent for AIRNET and 99.7 percent for stacks.

5. Analytical Data Quality Assessment Results

Analytical data completeness was >98.5 percent for AIRNET stations and 99.9 percent for stacks. The Clean Air Act requires an EPA-compliant program of QC samples be included as an integral part of the sampling and analysis process. Sample- and data-management procedures document the specific evaluations of each type of QC sample for each analytical measurement. All QC data are tracked, trended, and reported in specific QC evaluation memos that are submitted to project staff along with each set of analytical data received from our chemistry laboratories. The overall results of the 2005 program of quality monitoring indicate that all analytical laboratories maintained the same high level of control that has observed in the past several years.

6. Analytical Laboratory Assessments

During 2005, one internal and one external laboratory performed all chemical analyses reported for AIRNET and RADAIR 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, Am-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 in HSR-4 performed instrumental analyses of tritium in stack emissions.

No assessment of Paragon Analytics was performed during 2005, but previous annual assessments have shown the laboratory performs consistently well. The laboratory participated in national performance-evaluation studies during 2005. The detailed results of these performance evaluations are included in the assessment report. Overall, the study sponsors judged the analytical lab to have acceptable performance for almost all analytes attempted in all 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 on the Pajarito Plateau and in 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 and federal regulations. The objectives of the Laboratory's groundwater programs 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 the regional aquifer (found at depths of 600 to 1,200 feet). Groundwater protection efforts at the Laboratory focus on (1) the regional aquifer underlying the region and include (2) the shallow perched groundwater found within canyon alluvium and (3) the perched groundwater at intermediate depths above the regional aquifer.

Since the 1940s, liquid effluent disposal by the Laboratory has affected water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. These water quality impacts extend in some cases to perched groundwater at depths of a few hundred feet beneath these canyons and to the underlying regional aquifer. 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 the shallow perched groundwater bodies, and impacts on the regional aquifer are reduced.

In 2005, sampling at one regional aquifer monitoring well beneath Mortandad Canyon found contamination by hexavalent chromium at a concentration that is over four times the Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 100 μg/L and eight times the NM groundwater standard. Past cooling tower discharges in Sandia Canyon are identified as the likely hexavalent chromium source (ERSP 2006). The Laboratory also discovered a volatile organic compound, dioxane[1,4-], at values just below Consent Order-specified risk levels in two intermediate wells in Mortandad Canyon. This compound is commonly used as a stabilizer for organic solvents. The Laboratory has begun investigation of these issues in cooperation with New Mexico Environment Department (NMED).

With one exception, drinking water wells in the Los Alamos area have not been adversely impacted by Laboratory discharges. The exception is well O-1 in Pueblo Canyon, where perchlorate is found at concentrations that average 1/10th of the EPA's Drinking Water Equivalent Level of 24.5 µg/L. 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 requirements.

To comply with the requirements of the NMED Consent Order, LANL significantly expanded the number of monitored groundwater locations during 2005. The Laboratory collected groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo de San Ildefonso.

B. HYDROGEOLOGIC SETTING

1. Geologic Setting

Los Alamos National 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).

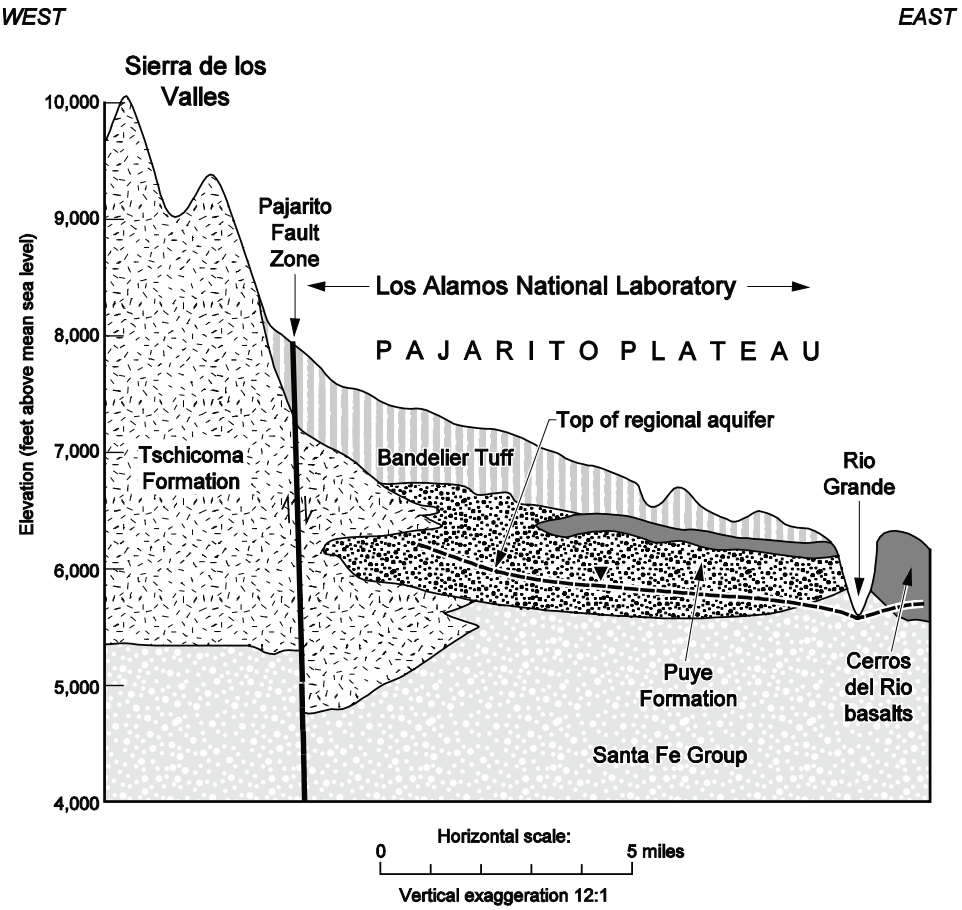

Figure 5-1. Generalized geologic cross section of the Pajarito Plateau.

The Rio Grande borders the Laboratory on the east. Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff formed from volcanic ashfall deposits and pyroclastic flows 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.

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 lies atop a thick zone of mainly unsaturated rock, with the principal aquifer found 600 to 1200 ft below the ground. Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater 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) 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.

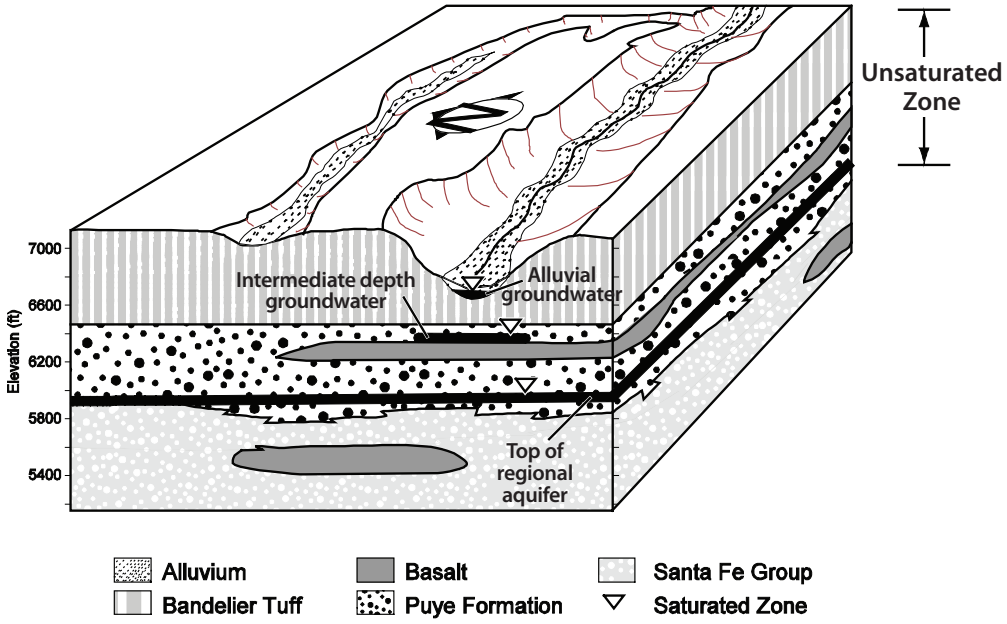

Figure 5-2. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

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 100 ft thick. In wet canyons, runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff or other rocks, maintaining shallow bodies of perched groundwater within the alluvium. Evapotranspiration and infiltration into underlying rocks deplete the alluvial groundwater as it moves down the canyon. The chemical quality of some of the alluvial groundwater shows the effects of Laboratory discharges.

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. Intermediate groundwater occurrence is controlled by availability of recharge and variations in permeability of the rocks underlying the plateau. Depths of the intermediate perched groundwater vary: approximately 120 ft in Pueblo Canyon, 450 ft in Sandia Canyon, and 500–750 ft in Mortandad Canyon.

Some intermediate perched water occurs in volcanics on the flanks of the Sierra de los Valles to the west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from a gallery in Water Canyon. Intermediate perched water also occurs in the southwest portion of the Laboratory just east of the Sierra de los Valles, in the Bandelier Tuff at a depth of approximately 700 ft. The source of this perched water may be infiltration from streams that discharge from canyons along the mountain front and also underflow of recharge from the Sierra de los Valles.

The regional aquifer of the Los Alamos area 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 aquifer is the only aquifer in the area capable of serving as a municipal water supply. Water in the aquifer flows generally east or southeast toward the Rio Grande, and groundwater model studies indicate that underflow of groundwater from the Sierra de los Valles is the main source of recharge for the regional aquifer (Nylander et al., 2003). 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 (<10 percent) moisture content. 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 contaminants that 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, limits their volumetric contribution to recharge reaching the regional aquifer.

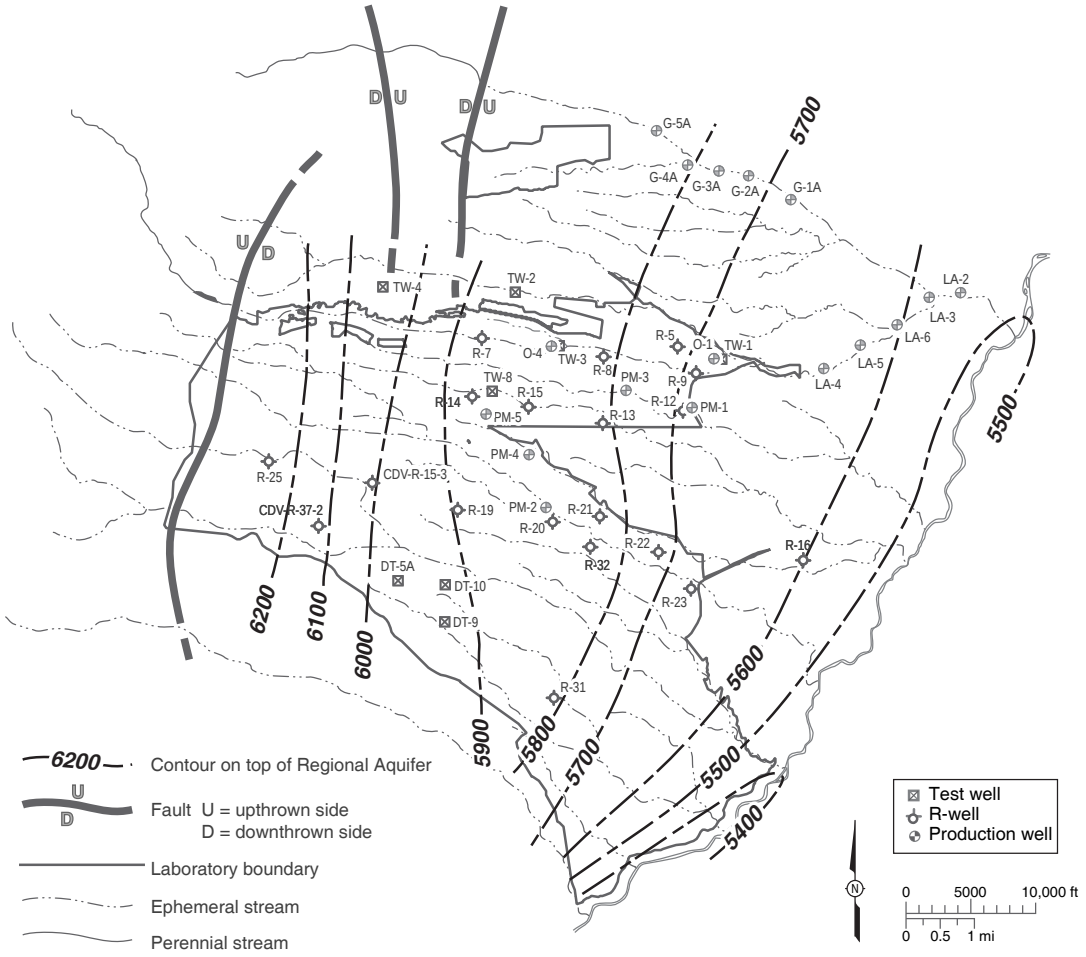

Figure 5-3. Generalized water level contours for the regional aquifer (Nylander et al., 2003).

3. Overview of Groundwater Quality

Liquid effluent disposal is the primary means by which Laboratory contaminants have impacted deep groundwater, including intermediate perched zones and the regional aquifer. 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 beneath a mesa-top site where large amounts of liquid effluent have been discharged. The discharge of effluents to canyons or mesa-top locations in the Laboratory's semiarid setting initiates or increases downward percolation of water. Even under unsaturated flow conditions, this percolation may move significant amounts of water and contaminants to the regional aquifer within a few decades.

Liquid effluent disposal at the Laboratory has impacted the quality of alluvial groundwater in several canyons (Figure 5-4). Groundwater contamination is primarily the result of past effluent discharges. 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 percent). 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). The quality of the remaining discharges has been improved through treatment process improvements so that it meets applicable standards.

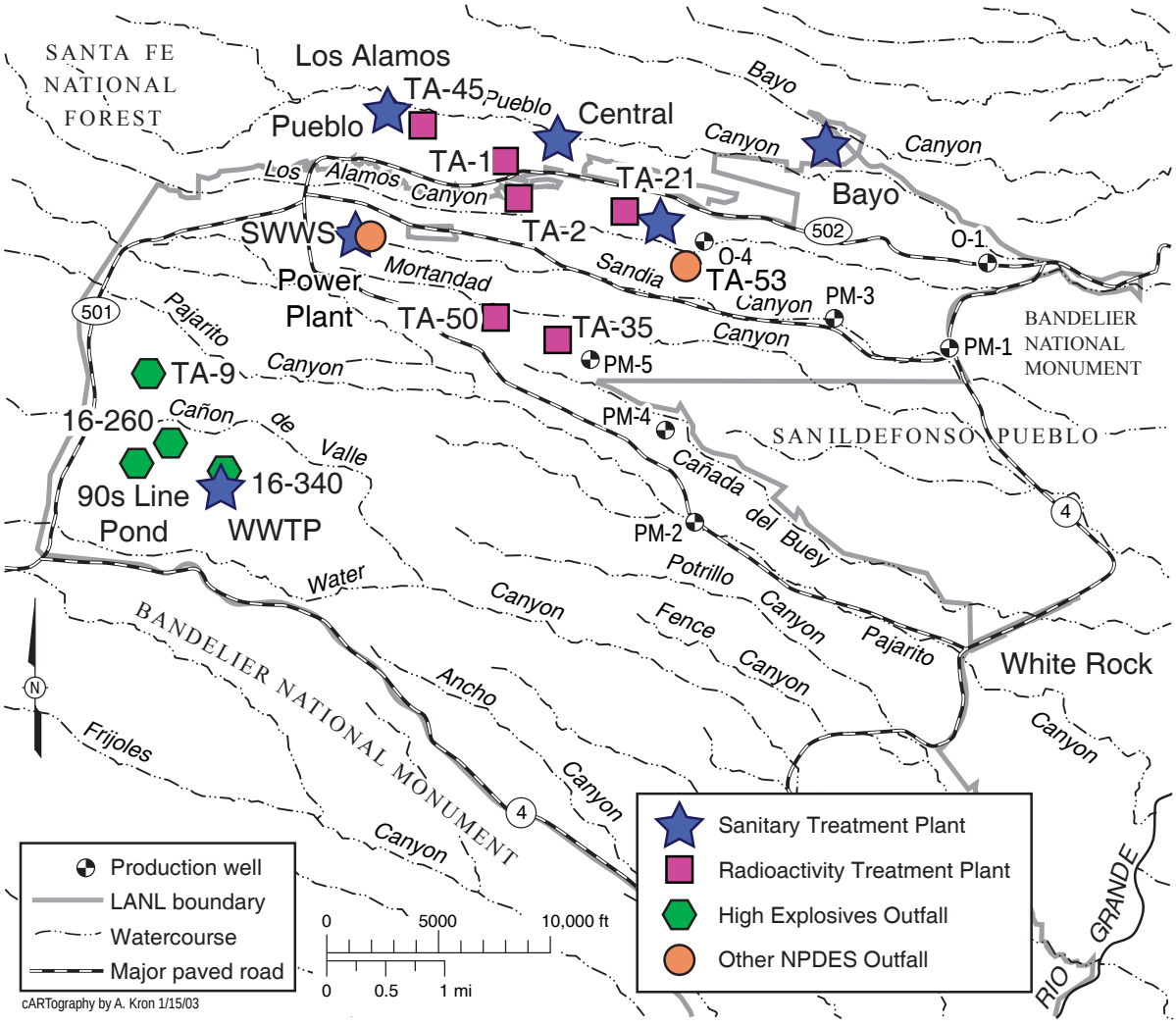

Figure 5-4. **Major liquid release sources (effluent discharge) potentially affecting groundwater. Most outfalls shown are inactive.**

Liquid effluent discharges have affected intermediate perched groundwater and the regional aquifer to a lesser degree. The intermediate groundwater in various locations shows localized radioactive (tritium), organic (high explosives [HE], chlorinated solvents, dioxane[1,4-]), and inorganic (hexavalent chromium, barium, boron, perchlorate, and nitrate) contamination from Laboratory operations. Traces of HE, tritium, perchlorate, and nitrate are also found in the regional aquifer. Hexavalent chromium has been found in several wells, including one well at concentrations above state and federal drinking water standards.

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. Rogers (2001) and Emelity (1996) summarize radioactive effluent discharge history at the Laboratory.

Because of release 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 HE processing and experimentation (Glatzmaier 1993; Martin 1993). Over the years, Los Alamos County has operated three sanitary treatment plants in Pueblo Canyon (ESP 1981). Only the Bayo sanitary treatment plant is currently operating. The Laboratory has also operated numerous sanitary treatment plants, three of which are shown in Figure 5-4.

C. GROUNDWATER STANDARDS

We apply regulatory standards and risk levels to evaluation of groundwater samples according to Table 5-1. For water supply wells, which draw water from the regional aquifer, we compare concentrations of radionuclides in samples to (1) the derived concentration guides (DCGs) for ingested water calculated from DOE's 4-mrem drinking water dose limit and (2) the EPA MCLs. For risk-based radioactivity screening, groundwater samples from sources other than water supply wells may be compared with DOE's 4-mrem drinking water DCGs and with EPA MCLs.

The New Mexico drinking water regulations and EPA MCLs apply as regulatory standards to nonradioactive constituents in water supply samples and 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. Following requirements of the Consent Order, we screened the toxic pollutants listed in the NMWQCC groundwater standards at a risk level of 10^{-5} for cancer-causing substances or a hazard index of one (HI = 1) for non-cancer-causing substances. A hazard index value of 1 or less indicates that no (noncancer) adverse human health effects are expected to occur. We used the EPA Region VI tap water screening levels to screen the NMWQCC toxic pollutant compounds (http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm). For cancer-causing substances, the Region VI tap water screening levels are at a risk level of 10^{-6}, so we use 10 times these values to screen for a risk level of 10^{-5}.

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

D. MONITORING NETWORK

In 2005 the Laboratory signed a Consent Order with the NMED, which specifies the process for conducting groundwater monitoring at the Laboratory. The Consent Order requires that the Laboratory submit an Interim Facility Groundwater Monitoring Plan (Interim Plan) to the department for its approval. The first Interim Plan was approved in June 2006. Prior to approval of the Interim Plan, the Laboratory expanded the number of groundwater locations monitored during 2005 to comply with the draft Consent Order.

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

Constituent	Sample Location	Standard or DCG	Risk-Based Screening Level	Reference	Location	Notes
Radionuclides	Water Supply Wells	DOE 4-mrem Derived Concentration Guides, EPA MCLs		DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/year dose rate limit and EPA MCLs apply to drinking water systems
Radionuclides	Effluent samples	DOE 100-mrem Derived Concentration Guides		DOE Order 5400.5	On site	DOE Public Dose Limit is 100 mrem/yr, applies to effluent discharges.
Radionuclides	Other groundwater samples		4-mrem Derived Concentration Guides, EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	A 4-mrem/year dose rate limit and EPA MCLs are for comparison because they apply only to drinking water systems
Non-radionuclides	Water Supply Wells	EPA MCLs, NM groundwater standards, EPA 10^{-5}, and HI = 1 risk levels for NM toxic pollutants with no NM standard		40 CFR 141-143, 20.6.2 New Mexico Administrative Code, NMED Consent Order	On-site and off-site	EPA MCLs apply to drinking water systems. Use EPA Region VI table for 10^{-5} and HI = 1 risk values
Non-radionuclides	Other groundwater samples	NM groundwater standards, EPA 10^{-5} and HI = 1 risk levels for NM toxic pollutants with no NM standard	EPA MCLs	40 CFR 141-143, 20.6.2 New Mexico Administrative Code, NMED Consent Order	On-site and off-site	NMED regulations protect all groundwater. EPA MCLs are for comparison because they apply only to drinking water systems. Use EPA Region VI table for 10^{-5} and HI = 1 risk values

Groundwater sampling locations are divided into three principal groups related to the three modes of groundwater occurrence: the regional aquifer, perched alluvial groundwater in the bottom of some canyons, and localized intermediate-depth perched groundwater systems (Figures 5-5, 5-6, and 5-7). The springs and wells are described by Purtymun (1995), Nylander et al. (2003), and individual well completion reports. 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 5-8 and mainly sample the regional aquifer. Basalt Spring is an intermediate groundwater sampling point, and wells LLAO-1B and LLAO-4 sample alluvial groundwater.

Water quality monitoring results are given in accompanying supplemental data tables, which include results for several boreholes. The water quality results for these borehole samples are for screening purposes indicating a need for further investigation; they cannot be used to evaluate aquifer conditions because they reflect a mixture of high-turbidity water affected by drilling fluids water and rock material from a large portion of the borehole. Following well installation, well development is used to remove aquifer and drilling materials from the well before sampling.

LANL conducts a regular program of water level measurement for monitoring wells. A summary of groundwater level measurements for 2005 is given in Allen et al. (2006).

1. Regional Aquifer and Intermediate Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring wells, supply wells, and springs. Wells recently constructed under the Hydrogeologic Workplan (LANL 1998) are intended for additional groundwater characterization efforts and to extend the Laboratory's groundwater monitoring system. Several of these wells were added to the monitoring well network beginning in 2002. New wells completed in 2005 are described in Chapter 2, Section B.9.b (page 56).

In the 1950s and 1960s, the Laboratory located the first regional aquifer monitoring wells where they might detect contaminants infiltrating from areas of effluent disposal or underground weapons-testing operations. These wells penetrate only a few tens or hundreds of feet into the upper part of the regional aquifer. Although the wells have surface casing to seal off entrance of surface water or shallow groundwater, the casings were not cemented, which would prevent deeper infiltration along the boreholes. The newer characterization wells were installed beginning in 1998 (Nylander et al., 2003). Some of these newer wells penetrate down to 600 ft into the regional aquifer, and several have multiple sampling ports within intermediate perched zones and the regional aquifer. A column on the supplemental data tables identifies the groundwater zones sampled by different ports of these wells and gives the depth of the port or top of the well screen.

The Laboratory collects samples from 12 deep water supply wells in three well fields that produce 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 the wells draw samples that integrate water over a large depth range. Los Alamos County owns and operates these wells. The county 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. Koch and Rogers (2003) summarized operation of the water supply system for the years 1998–2001.

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

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

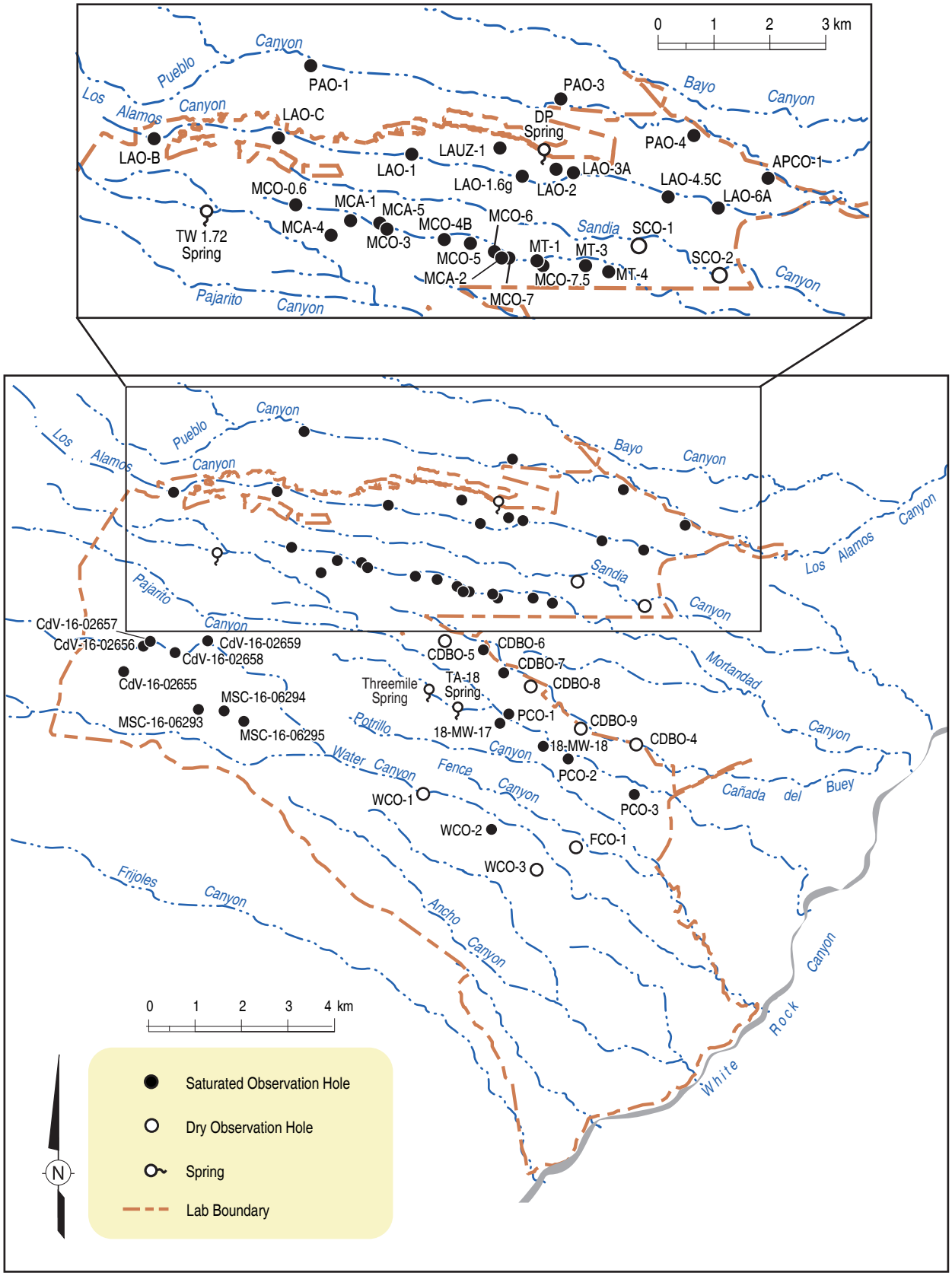

Figure 5-5. Springs and wells used for alluvial groundwater monitoring.

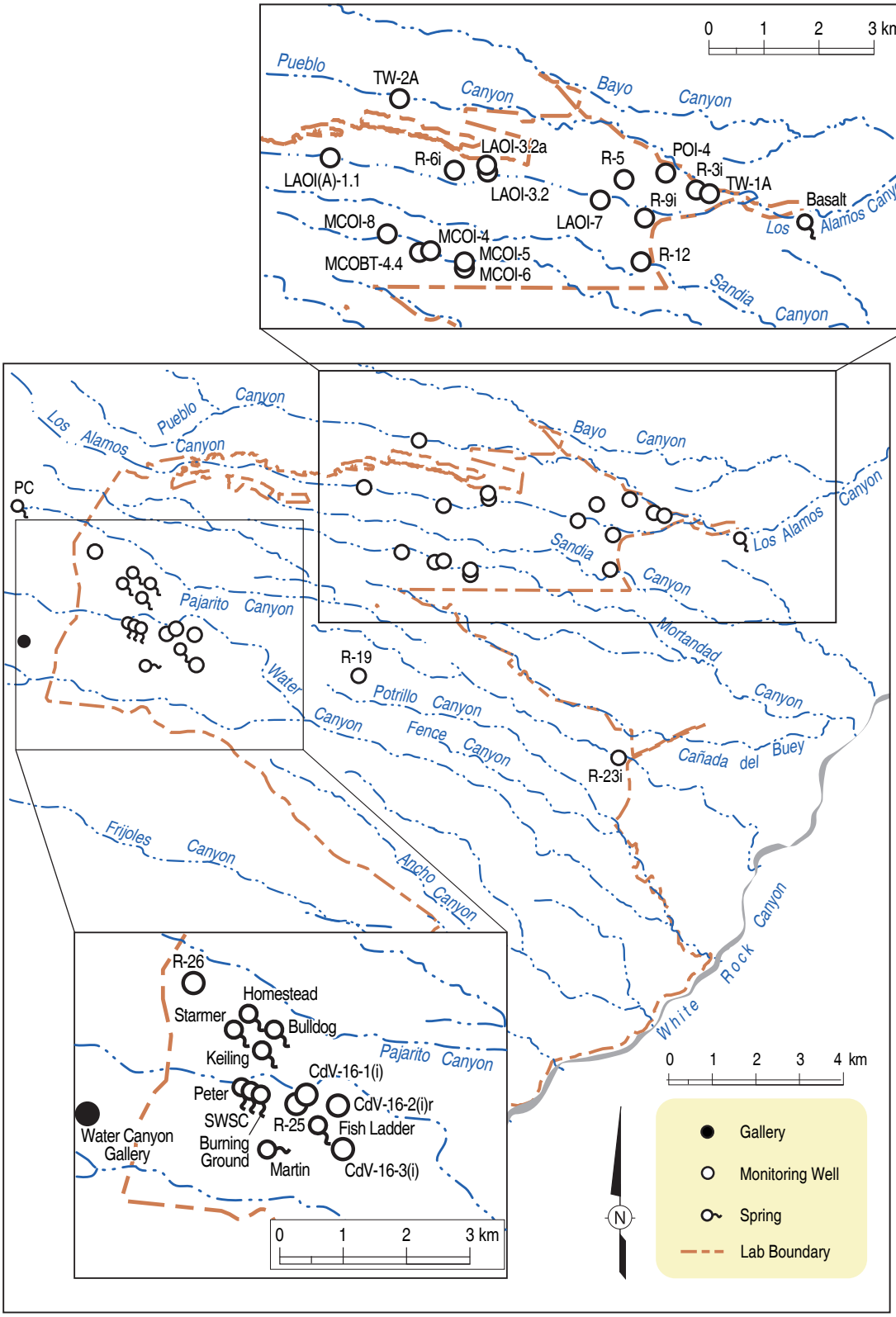

Figure 5-6. Springs and wells used for intermediate perched zone monitoring.

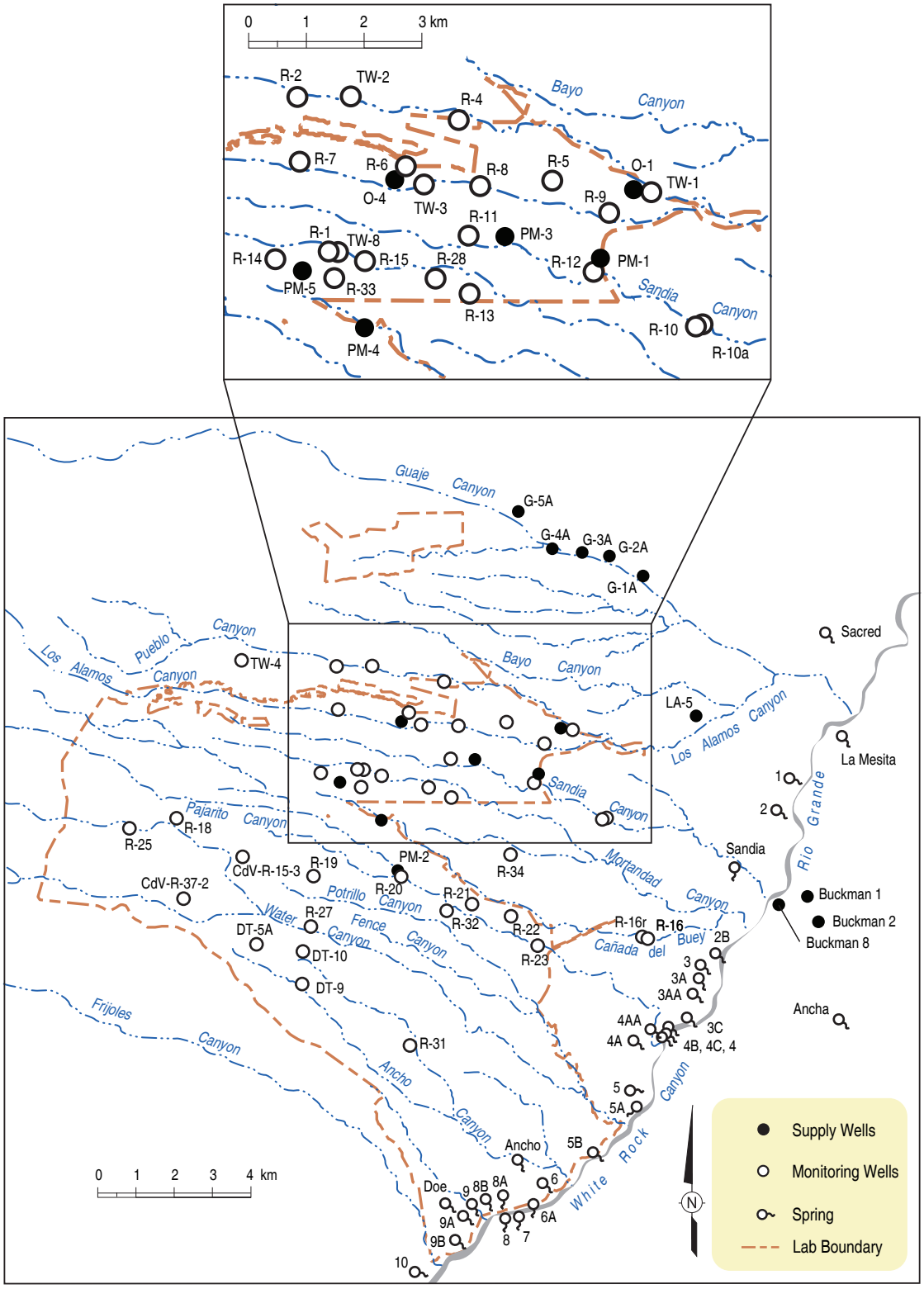

Figure 5-7. Springs and wells used for regional aquifer monitoring.

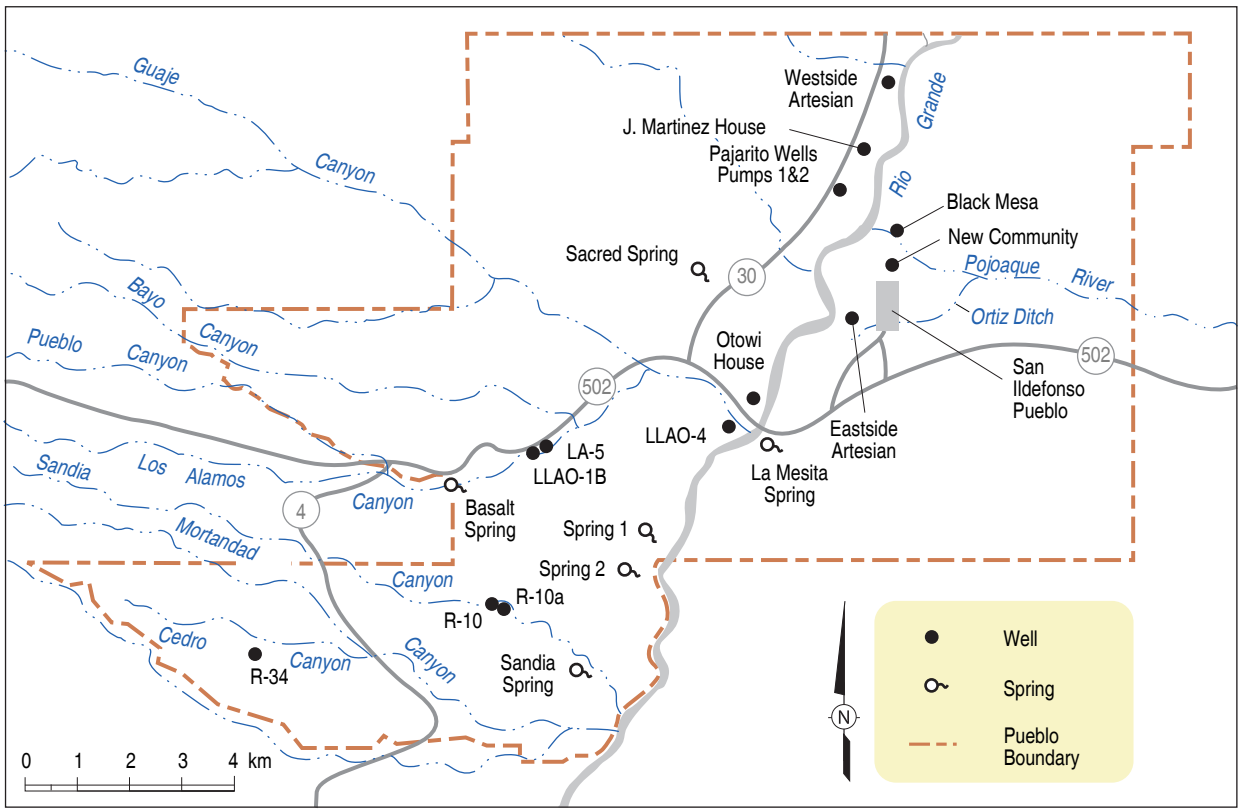

Figure 5-8. Springs and wells used for groundwater monitoring on Pueblo de San Ildefonso.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, we use shallow wells and some springs to sample perched alluvial groundwater in several canyons (Pueblo, Los Alamos, Mortandad, and Pajarito Canyons, Cañon de Valle, and Cañada del Buey). 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 most often been dry since their installation in 1989. All but one of the wells in Cañada del Buey are generally dry.

E. GROUNDWATER SAMPLING RESULTS BY CONSTITUENTS

Supplemental data tables present groundwater monitoring data for 2005. Columns on the data tables identify the groundwater zones sampled—whether alluvial, intermediate, or regional—and indicate if the location is a spring. For wells with several sampling ports, the 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, 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.

Supplemental data Table S5-2 lists the results of radiochemical analyses of groundwater samples for 2005. The table also gives the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. Uranium was analyzed by chemical methods and by isotopic methods. Table S5-3 shows low-detection-limit tritium results from analyses done by the University of Miami. Table S5-4 lists radionuclides detected in groundwater samples.

Two analytical methods are reported for University of Miami tritium laboratory results (Table S5-3): a higher detection limit analysis, method "LL," and the low detection method results by method "LLEE." If we are not certain that a sample has an activity less than 100 pCi/L, the tritium laboratory first counts the sample using LL until they are satisfied that it is below 100 pCi/L. In this case, they stop the counts and analyze the sample with

LLEE. The tritium laboratory no longer reports the LL values in cases where the sample is analyzed by LLEE, as the LL samples are only screening results in those cases.

A data interpretation issue relates to comparing values determined by the two methods, as the incomplete count for the less-sensitive method indicates an apparent detection at a higher value. One example is a result for the regional aquifer at R-22, at 907 ft, of 86 pCi/L by LL, with a corresponding LLEE result of 3 pCi/L. Both results are presented as detections. This LL value is well below the 10 sigma quantitation limit (meaning that it is not quantified), but above the 3 sigma detection limit based on the reported uncertainties. Thus, the LL and LLEE results are in agreement given the uncertainties, but the LL results have far less precision. The LLEE results are similar to earlier values from R-22.

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 that case, a result is reported as detected when analytical results are greater than three times the reported (one sigma) uncertainty.

Qualifier codes are shown in Supplemental Table S5-4 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 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 in the Data Supplement). After we receive the analytical laboratory data packages, the packages receive secondary validation by an independent contractor, Analytical Quality Associates (AQA). 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, are documented, and are within contract requirements.

Because gross alpha and gross beta are usually detected in water samples, Table S5-4 indicates occurrences of these measurements above threshold values. 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. The right-hand columns of Table S5-4 compare results to the standards shown on the table. For gross alpha, the DCG assumes that the radioactivity comes solely from americium-241 plus plutonium-239,240 and for gross beta, from strontium-90; thus, the gross alpha and gross beta DCG values are for screening purposes and are conservative.

Supplemental Table S5-8 lists the results of general chemical analyses of groundwater samples for 2005. Table S5-9 lists groundwater perchlorate results. We analyzed samples for perchlorate by two methods. This table includes all perchlorate results determined by the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method (now EPA 6850 Modified, formerly SW-846:8321A[M]) and all detections by the ion chromatography (IC) method (EPA:314.0). The method detection limit (MDL) for the IC method is 4 μg/L; the LC/MS/MS method MDL is 0.05 μg/L or larger if the sample had higher concentrations and was analyzed using sample dilution. We use both methods because LC/MS/MS by SW-846 6850 (or EPA 6850 Modified) for perchlorate has not yet been officially promulgated by the EPA (expected in December of 2006). The results of trace metal analyses appear in Table S5-10.

In the following sections, we discuss groundwater quality results for each of the three groundwater modes in the major watersheds that encompass the Laboratory. The accompanying maps depict the extent of groundwater contaminants that exceed regulatory or risk levels. The maps provide a spatial context for distribution of groundwater contamination. Rather than showing data for 2005 alone, the maps represent a synthesis of the last several years of groundwater data collected for Laboratory groundwater monitoring and characterization programs.

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.

1. Organic Chemicals in Groundwater

In 2005, we analyzed samples from selected springs and monitoring wells for organic constituents. Table S5-11 summarizes 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 (DROs), and HEs. The quality assurance section of this chapter, Section G, covers analytes and analytical methods.

a. Organic Sample Quality Control Program

Because of the sensitive nature of organic chemical sampling and analysis, a carefully designed field and analytical laboratory quality control program is essential for evaluating the presence of organic constituents in environmental samples. Organic analytes may be detected in field quality control 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 quality control samples because of inadvertent contamination of sampling or analytical laboratory equipment by organic constituents that come from other sources.

We rejected many of the possible organic detections that the analytical laboratory reported because the compounds were either detected in method blanks (that is, they were introduced during laboratory analysis) or were detected in field quality control (QC) samples, including equipment and trip blanks. Equipment blanks use distilled water with which sampling equipment is rinsed before sampling to check for organic contamination acquired during sampling. Trip blanks accompany samples during sample preparation, transportation, and shipment to determine if organic contamination occurs. Table S5-12 shows organic compounds detected in 2005 and results from field QC samples.

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 compounds 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, butanone[2-], and hexanone[2-], which indicates inadvertent sample contamination in either the field or analytical laboratory.

2. Radioactivity in Groundwater

In 2005, no regional aquifer radioactivity analyte activity or concentration values exceeded the 4-mrem DOE DCGs applicable to drinking water in groundwater samples, other than naturally occurring radionuclides (for example, radium-226 and uranium-234). The main radioactive element detected in the regional aquifer is naturally occurring uranium, found in springs and wells throughout the Rio Grande Valley. The large gross alpha values found in samples from springs and wells in the Rio Grande Valley result from the decay of naturally occurring uranium in the water. Other naturally occurring radioactivity in groundwater samples comes from members of the uranium-235, uranium-238, and thorium-232 decay chains. Potassium-40 is also a source of natural radioactivity.

For well samples from intermediate perched groundwater, several wells in Mortandad Canyon had tritium activities that were close to or above screening levels. Tritium in MCOBT-4.4 was above the EPA MCL of 20,000 pCi/L and three other wells had tritium values ranging from 20 percent to 65 percent of the MCL.

For radioactivity from a DOE (LANL) source, perched alluvial groundwater results for the following constituents were near or exceeded the 4-mrem DOE DCGs applicable to drinking water (which we use as a screening level because the DCGs are not applicable to the alluvial groundwater itself, which is not a source of drinking water): strontium-90 from alluvial groundwater in Mortandad and DP/Los Alamos Canyons; total uranium in Mortandad Canyon (likely an outlier) and Cañon de Valle; and americium-241, plutonium-238, and plutonium-239,240 in Mortandad Canyon. The maximum strontium-90 values in alluvial groundwater from Mortandad and DP/Los Alamos Canyon were also above the EPA MCL which we use as a screening level (Figure 5-9). Total LANL-

derived radioactivity exceeded the 4 mrem screening level in alluvial groundwater samples from Los Alamos Canyon (due to strontium-90 in DP Spring and well LAUZ-1) and Mortandad Canyon (wells MCA-5, MCO-4B, MCO-5, MCO-6 and MCO-7) (Figure 5-10). Gross beta values in some samples from alluvial wells in Mortandad and DP/Los Alamos Canyon exceeded the EPA 50 pCi/L drinking water screening level.

Our analytical laboratory (GEL) indicates that the MDA for tritium analysis by liquid scintillation counting lies between about 140 pCi/L and 230 pCi/L, averaging about 200 pCi/L. For 2005, using this analytical method, several groundwater results between 145 and 238 pCi/L are indicated as detections but reanalyses at a detection limit of 1 pCi/L resulted in no detection of tritium for many of these samples.

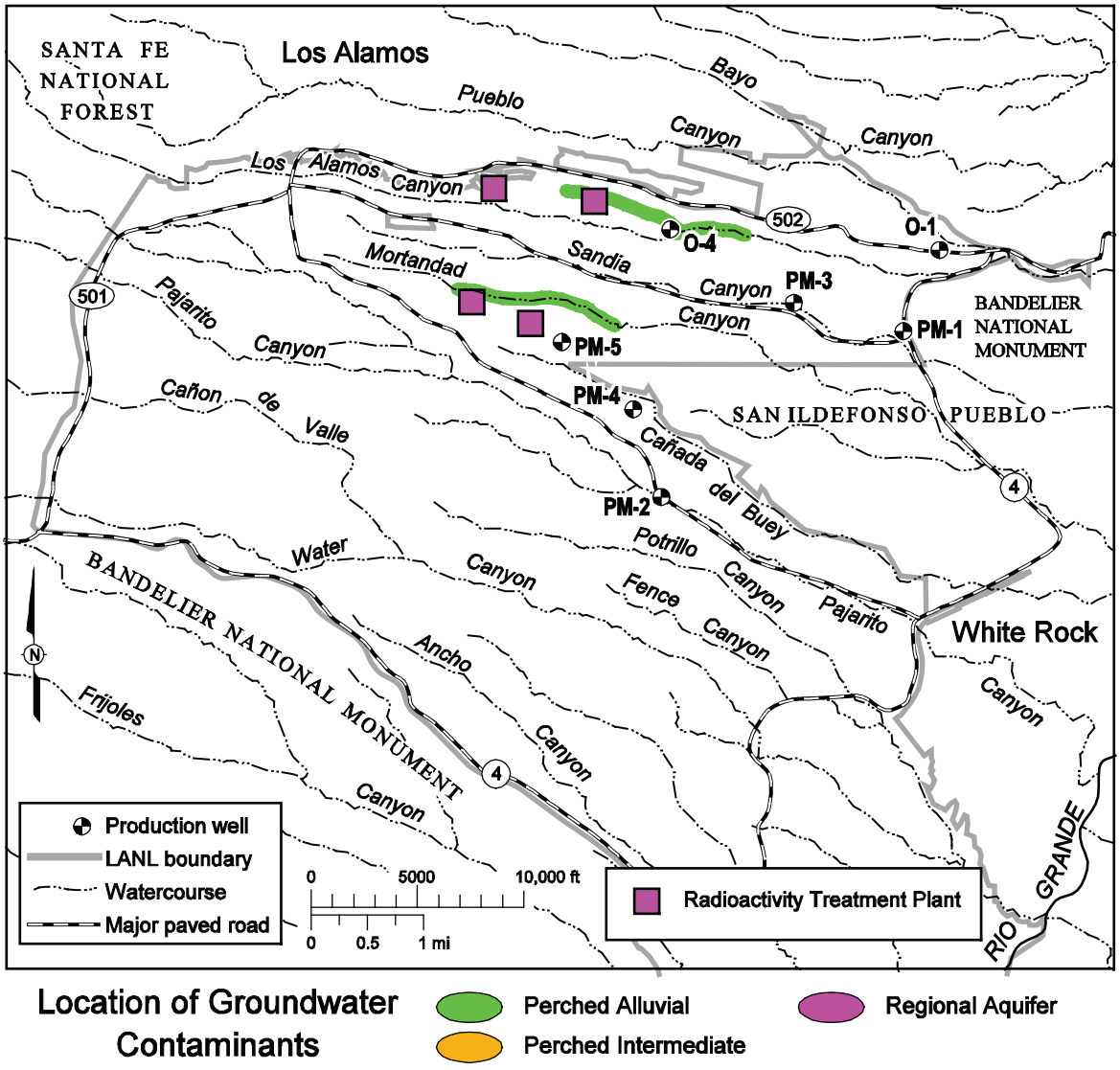

Figure 5-9. Location of by strontium-90 above the 8 pCi/L EPA MCL. Different colors indicate the affected groundwater zones. Along canyons, the extent of alluvial groundwater contamination lateral to the canyon is not to scale: contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.

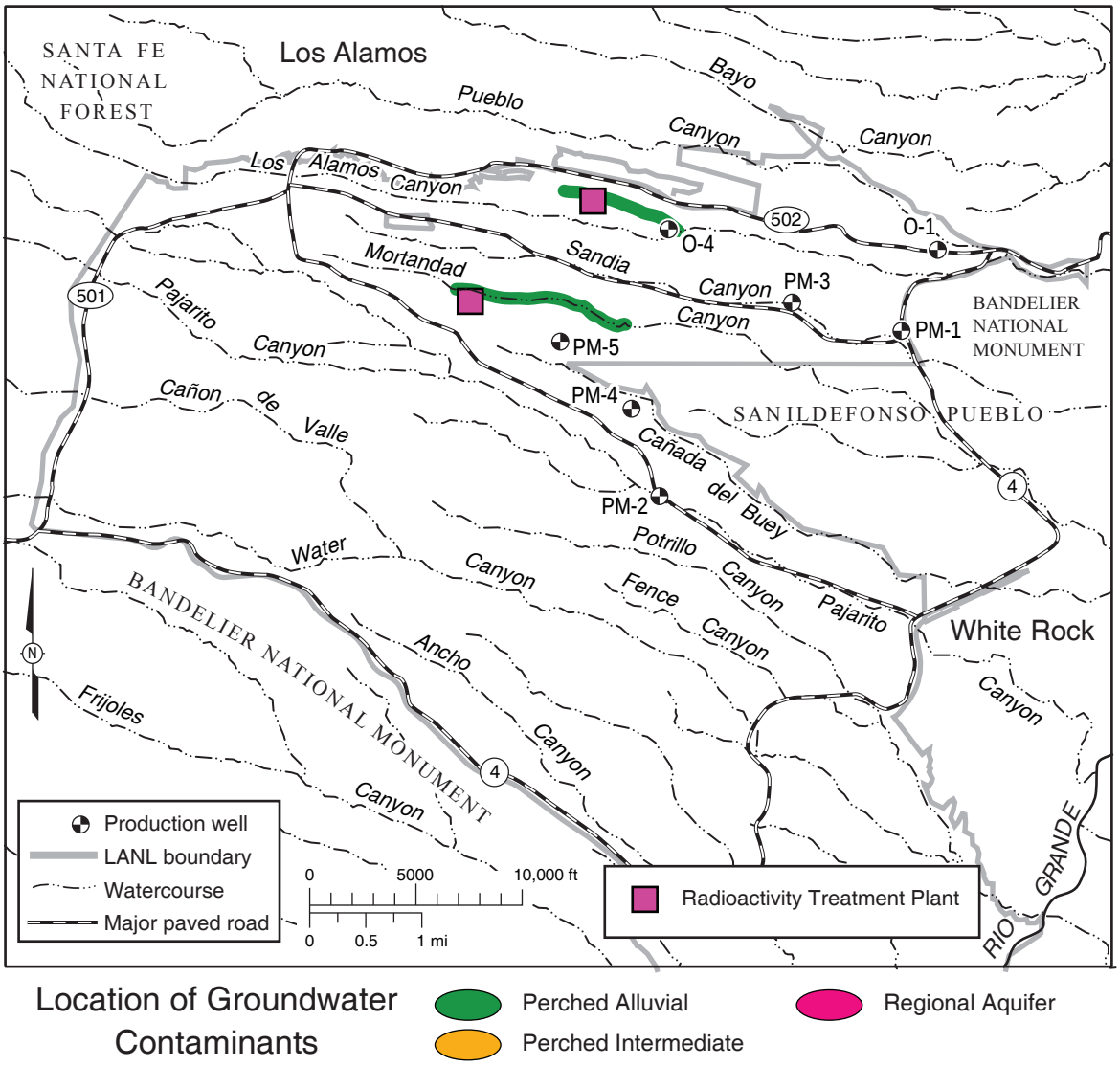

Figure 5-10. Location of strontium-90, plutonium-238, plutonium-239,240, and americium-241 above the screening level of 4-mrem DOE DCG for drinking water. The 2005 maximum value was in Mortandad Canyon alluvial groundwater at well MCA-5. Different colors indicate the affected groundwater zones.

3. Perchlorate in Groundwater

During the last decade, the EPA has recognized the potential for perchlorate toxicity at concentrations in the µg/L range. Based on a new 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.

LANL and the NMED DOE Oversight Bureau have found perchlorate in most groundwater samples analyzed from across northern New Mexico. This result suggests that perchlorate has widespread occurrence in groundwater at concentrations below 1 µg/L. Numerous studies (Bao et al. 2004; Michelski et al. 2004, Plummer et al., 2006) show that perchlorate is formed naturally in the upper atmosphere, is deposited on the earth's surface by precipitation, and accumulates in soils and groundwater of arid regions. Perchlorate in arid region groundwater may also arise from other sources such as fertilizers, or from natural sources like mineral weathering or electrochemical reactions (Jackson et. al 2005). Jackson reported that perchlorate was present in 73 percent of 217 public water supply wells across a large portion of northwest Texas, with 35 percent at levels near or above 4 µg/L.

The NMED DOE Oversight Bureau's recent unpublished study concluded that a value of 0.6 µg/L constitutes an upper limit for background for naturally occurring perchlorate in local groundwater samples. The perchlorate concentrations in samples not affected by known contaminant sources range from nondetect (<0.05 µg/L) to 0.85 µg/L. Several wells and a spring upstream of LANL and east of the Rio Grande (hence unaffected by LANL discharges) have perchlorate values of 0.52 µg/L, 0.60 µg/L, and 0.85 µg/L. Plummer et al. (2006) found perchlorate concentrations ranging from 0.12 µg/L to 1.8 µg/L in samples of north-central New Mexico groundwater that have ages predating anthropogenic influence and are not affected by industrial perchlorate sources. Whether or not it is an accurate delimiter of background, the value of 0.6 µg/L appears to be a useful dividing line. Many, but not all, water samples from LANL locations show perchlorate concentrations below 0.6 µg/L, but samples taken downstream from inactive perchlorate release sites show concentrations above that value.

4. Metals in Groundwater

In 2005 LANL found hexavalent chromium in Mortandad Canyon monitoring well samples from the regional aquifer at levels above the NM groundwater standard and in intermediate depth groundwater at levels just below the NM groundwater standard. Barium occurs at concentrations above the NM groundwater standard in alluvial groundwater beneath Cañon de Valle, and molybdenum concentrations have been near the NM groundwater standard in Los Alamos Canyon alluvial groundwater for over a decade. Other metals occur in groundwater at concentrations near or above regulatory standards because of well-sampling and well-construction-related issues rather than LANL releases. In some LANL characterization wells, the use of fluids to assist well drilling impacted chemistry of groundwater samples (Bitner 2004, ERSP 2005). New wells undergo extensive well development to reduce the turbidity of water samples and to remove drilling fluids from the rock formations. Effects of drilling fluid on water quality appear to linger longer in multiple completion wells than in single completion wells because the latter can be developed more vigorously. Well screens installed in lower permeability zones are also difficult to develop.

Most Pajarito Plateau groundwater is under chemically oxidizing conditions, meaning that free oxygen is dissolved in the water. Addition of organic matter in drilling fluids into the aquifer near a well stimulates bacterial activity, which reduces available oxygen and changes the chemical behavior of several constituents found in groundwater and adjacent aquifer material. With reducing conditions (absence of oxygen), the solubility of metals such as manganese and iron increases, and they are dissolved from the surface of minerals that make up the aquifer's rock framework or possibly from well fittings. Several other chemical constituents may also increase or decrease in concentration as a result of the mainly temporary effect of the drilling fluids on the region near the well (Bitner 2004, ERSP 2005).

In addition to the effect of drilling fluids, well samples may have relatively high turbidity. The presence in water samples of residual aquifer material leads to detection of metals, such as aluminum, iron, and manganese, which are primary constituents of the silicate and other minerals that make up the aquifer framework. These effects of turbidity on water quality (with high values of iron, manganese, and aluminum) are also seen in many samples from alluvial wells and springs (in the case of springs, because they incorporate surrounding soil material).

The older LANL test wells have steel casings and galvanized metal well fittings that are subject to rust and metal flaking. Over time and with wear, corrosion, and work on the wells, water samples have shown increasing content of metals like iron, lead, manganese, and zinc.

A number of groundwater samples have selenium results that exceed the NM Livestock Watering Standard of 5 µg/L. All but one of these results were analyzed using SW-846:6010B, which has a nominal detection limit of 6 µg/L. Nearly all of the detections using this method were estimated. We plan to revise methods used for analysis of selenium in surface and groundwater to obtain more sensitive results.

F. GROUNDWATER SAMPLING RESULTS BY WATERSHED

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. The Guaje well field, located northeast of the Laboratory, contains five water supply wells. No tritium was detected in low-detection-limit (1 pCi/L) analysis of samples from these wells (Table S5-3). Groundwater with such a tritium activity below approximately 1.6 pCi/L is probably old and isolated from surface recharge. The age of such groundwater is more than 3,000 years, but large dating uncertainties may be associated with small tritium activities (Blake et al., 1995).

G-1A and G-2A both had arsenic at about 12 percent of the EPA MCL of 50 µg/L. For the new MCL of 10 µg/L, which will be effective in 2006, this value would be 60 percent of the MCL. This naturally occurring arsenic has been found in this well field at such levels during its entire history. Perchlorate was found in each of the five wells at concentrations ranging from 0.25 to 0.44 µg/L, which is consistent with background levels and prior findings for these wells. We attribute the presence of two volatile organic compounds (acetone and methylene chloride) at low levels in one sample from G-1A to inadvertent contamination during sampling or analysis rather than to their presence in groundwater.

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

a. Pueblo Canyon

Pueblo Canyon receives effluent from Los Alamos County's Bayo Sewage Treatment Plant. Acid Canyon, a tributary, received radioactive industrial effluent from 1943 to 1964. Little radioactivity shows up in groundwater at this time. Tritium and perchlorate results from regional aquifer groundwater in this canyon, though below standards, may indicate the lingering influence of past discharges from radioactive wastewater outfalls in Acid Canyon. High nitrate concentrations found in alluvial and intermediate groundwater may be due to sanitary effluent from the Los Alamos County Bayo Sewage Treatment Plant.

A low-detection-limit tritium result for supply well O-1 was 33 pCi/L, indicating a subdued effect of past tritium-bearing surface water recharge on tritium activity at the regional aquifer (this well was out of service much of the year). Three O-1 samples showed perchlorate at an average of 2.3 µg/L, and O-1 also has above-background nitrate (1.2 mg/L nitrate as nitrogen, compared to an MCL of 10 mg/L).

Low-detection-limit tritium values in Pueblo Canyon regional aquifer monitoring wells increased downstream, from nondetection at Test Well 4 above the former outfall, to 117 pCi/L at Test Well 1 (near O-1).

Regional aquifer nitrate and perchlorate values also increased downstream, with nitrate nondetect at Test Well 4 and near background (0.3 mg/L) at R-2. Test Well 1 (near O-1) showed nitrate (as nitrogen) at up to 53 percent of the 10-mg/L EPA MCL in the regional aquifer. Perchlorate was nondetect at Test Well 4, at background in R-2, and at the highest concentration for these wells in R-4 at 4 µg/L. Downstream, R-5 had 1.5 µg/L and Test Well 1 had 1.9 µg/L to 2.2 µg/L of perchlorate.

For years, samples from the older wells have shown levels of iron, lead, and manganese in the range of the EPA MCLs. These levels were related to aging steel and galvanized well components. Test Wells 4, 2, and 1 showed high levels of iron, manganese, and lead in 2005. New characterization well R-2 showed high levels of aluminum, iron, and manganese; these may be due to effects from drilling. Samples from R-2 and R-4 showed a large number of volatile and semivolatile organic compounds in field and equipment blanks, which may be the result of field or analytical laboratory contamination.

Pueblo Canyon intermediate well Test Well 2A showed 944 pCi/L of tritium, consistent with long-term trends in that well. Low-detection-limit tritium values in intermediate wells ranged from nondetection in R-5 to 24 pCi/L in POI-4 and 34 pCi/L in Test Well 1A. R-5 showed 1.1 mg/L of fluoride in the intermediate zone, 66 percent of the NM groundwater standard, which is similar to prior data. Perchlorate values from the intermediate zone were nondetection or background, except for a result of 1.5 µg/L from R-5. Older well Test Well 1A showed high

iron, manganese, lead, and zinc related to aging well components. Two pesticides (DDE[4,4'-] and DDT[4,4'-]) were found in Test Well 1A; this is the first time samples from this well have been analyzed for these substances. Several other volatile and semivolatile organic compounds were found in this well, which may be the result of field or analytical laboratory contamination.

All four alluvial wells in Pueblo Canyon had strontium-90 at values ranging from 6 percent to 14 percent of the 8-pCi/L EPA MCL. Three wells had detectable plutonium-239,240 as in prior years. Perchlorate concentrations ranged from nondetect to 1.9 μg/L in well PAO-1, the farthest upstream well, located just upstream from the mouth of Acid Canyon. The wells show the effects of high turbidity by high aluminum, manganese, and iron, much of these apparently colloidal. Well APCO-1 also has high nitrate, phosphate, fluoride, turbidity, and total suspended solids; the solutes indicate the influence of sanitary effluent from the Bayo Sewage Treatment Plant, which discharges just upstream. Higher organic content of the effluent or the well's location in marshland may result in anoxic groundwater conditions, leading to higher concentrations of dissolved or colloidal manganese.

b. Los Alamos Canyon

Los Alamos Canyon received releases of radioactive effluents during the earliest Manhattan Project operations at 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 over the years.

Low values of tritium were found in a few regional aquifer wells in Los Alamos Canyon, indicating a small contribution from recent recharge. Values in Test Well 3 and R-9 were 5.7 pCi/L and 14.9 pCi/L, respectively, while results from other wells were nondetections. Values in R-8 and supply well O-4 were nondetect, based on reanalyses of samples. Perchlorate in R-9 was 0.98 μg/L, while other regional aquifer and supply wells in Los Alamos Canyon were at background, that is, below 0.6 μg/L.

Several of the newer regional aquifer wells had high levels in samples of aluminum, iron, and manganese due to drilling fluid or turbidity effects. Older Test Well 3 also had significant lead (near the EPA screening level) and other metals, related to aging casing. Because of a leaking fuel tank found at TA-21 during 2002, supply well O-4 was sampled four times during 2005 for Diesel Range Organics. The compound was found in one sample near the detection limit but not in other samples, suggesting a false positive. The PCB compound Aroclor-1254 was found in one sample from R-8. The compound was not found in any of the four samples collected the previous year, so is likely an analytical artifact.

A filtered sample from Basalt Spring in lower Los Alamos Canyon, which is fed by intermediate groundwater, contained plutonium-238 just above the detection limit, as in some prior years. No plutonium-238 was detected in the unfiltered sample so the result may be a false positive. Otherwise, the plutonium may have come from surface sediments near the spring which discharges close to the streambed. Samples from intermediate wells R-6i and LAOI-3.2 contained 4300 pCi/L and 890 pCi/L of tritium, respectively. These wells both lie downstream from the former radioactive liquid waste discharge in DP Canyon. R-6i and LAOI-3.2 samples also had 8.1 μg/L and 2.5 μg/L of perchlorate.

Alluvial groundwater in DP and Los Alamos Canyons continues to show strontium-90 above the 8-pCi/L EPA MCL (Figure 5-9). The strontium-90 values in DP Spring and well LAUZ-1 were also above the 4-mrem DOE DCG screening level for drinking water dose. Several other LANL-derived radionuclides were found in alluvial groundwater, but at values well below the 4-mrem DCG screening level. Tritium levels in alluvial groundwater in these two canyons have fallen sharply since the cessation of discharges. Tritium is now present at values between 80 pCi/L to 200 pCi/L. In lower Los Alamos Canyon, a filtered sample in LLAO-4 showed plutonium-238 just above the detection limit.

Metals concentrations in alluvial wells in Los Alamos Canyon showed the effect of turbidity, with relatively high values of aluminum and iron. In Los Alamos Canyon, molybdenum in LAO-2 was 72 percent of the NM groundwater limit (Figures 5-11 and 5-12). 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, perhaps because of large variation in stream flow caused by drought conditions.

Aroclor-1260 was detected in LAO-B, a background well upstream from Laboratory contaminant sources. This is one of only two Aroclor detections in Los Alamos Canyon alluvial groundwater over more than six years, suggesting the result is a false positive.

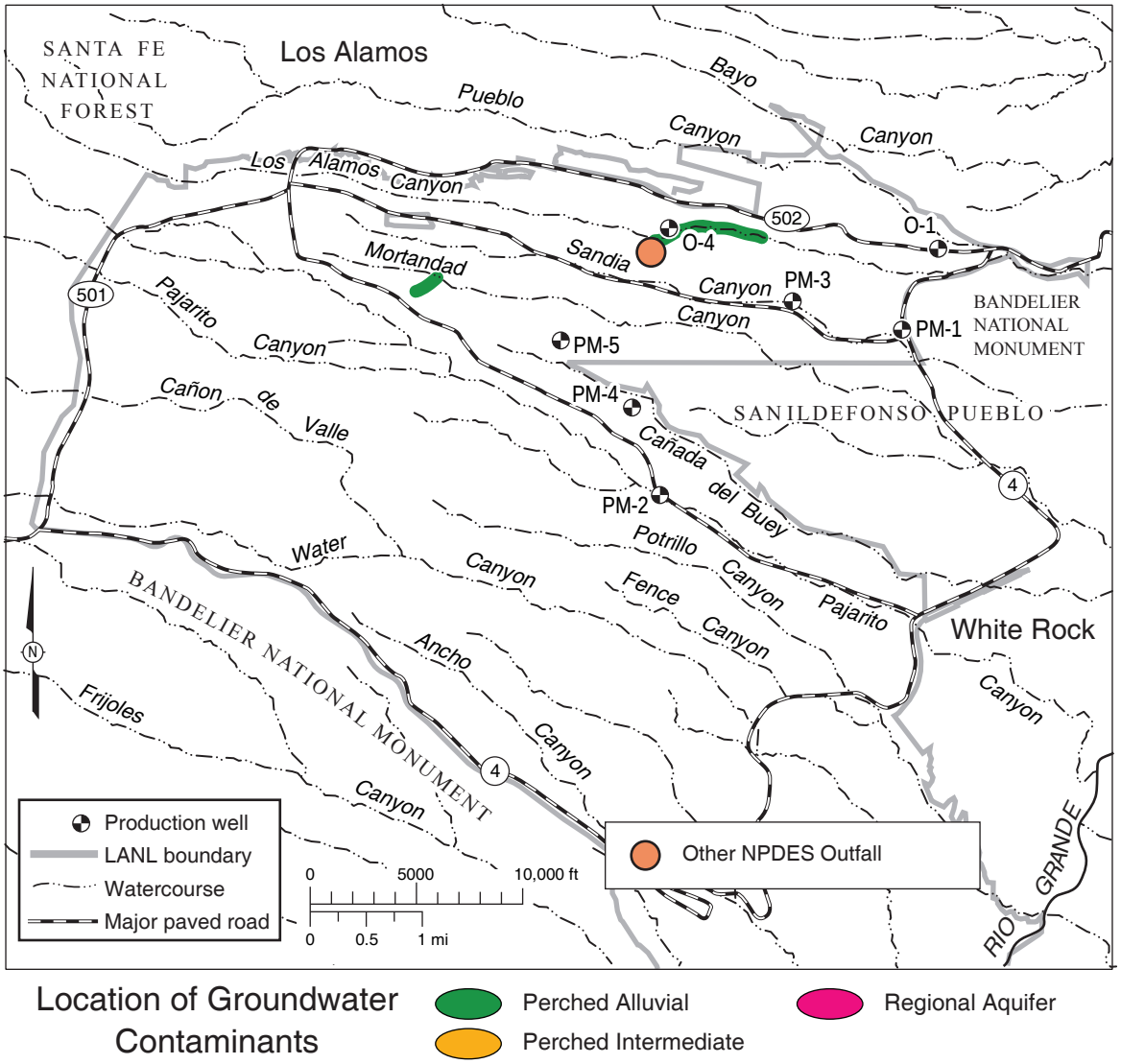

Figure 5-11. Location of molybdenum above the 1 mg/L New Mexico groundwater standard for irrigation use. The maximum 2005 value in Los Alamos Canyon alluvial groundwater was 72 percent of the groundwater standard. Different colors indicate the affected groundwater zones.

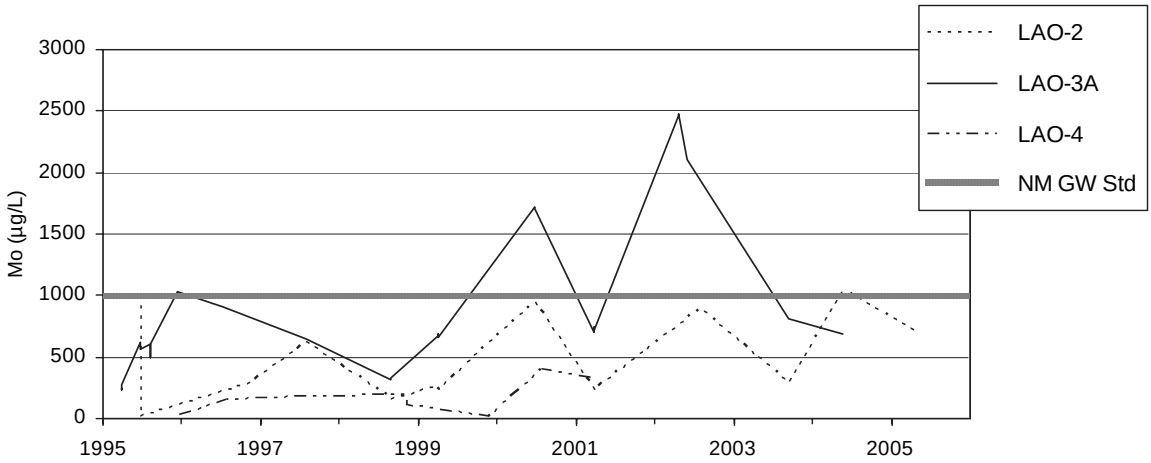

Figure 5-12. Molybdenum concentration histories in Los Alamos Canyon alluvial groundwater compared with the New Mexico groundwater standard.

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 and from treated effluents from the TA-46 SWWS Plant that have been routed to Sandia Canyon since 1992. The use of chromate for treatment of cooling water at the power plant was discontinued in 1972 (ESP 1973). These discharges are tentatively identified as the source for hexavalent chromium concentrations discovered in the regional aquifer beneath Mortandad Canyon that exceed New Mexico groundwater and EPA drinking water standards by factors of 8 and 4, respectively. Sandia and Mortandad Canyons lie close together, and water infiltrating beneath Sandia Canyon may have been diverted to the south by southwesterly-dipping basalts prior to reaching the regional aquifer (ERSP 2006). Chromium concentrations in samples from regional aquifer well R-11 in Sandia Canyon averaged 20 µg/L in both filtered and unfiltered samples; later analyses show the chromium is in the hexavalent form. These concentrations are above the range for hexavalent chromium found in off-site water supply wells (up to 6 µg/L), which are remote from any LANL contaminant sources.

Samples from supply well PM-3 showed no tritium using the 1 pCi/L detection limit analytical method. Analyses of one sample from PM-1 detected tritium, whereas reanalysis of that sample and results from other samples were nondetections; these latter results indicate the detection is an analytical error.

In Sandia Canyon, perchlorate values at R-12 in intermediate groundwater and the regional aquifer were nondetects. Regional wells R-11 and R-10a had values in the range of 0.77 µg/L and 0.62 µg/L, respectively, or slightly above background. Values in supply wells PM-1 and PM-3 were about 0.42 µg/L, similar to prior results and within background.

Several intermediate and regional R-12 samples had high iron or manganese (in the range of EPA MCLs), a result of well construction and use of drilling fluids (Longmire 2002, ERSP 2005). Samples from R-10a and R-11 contained aluminum and iron above or near standards, resulting from turbidity or drilling fluids. Organic compounds detected in well samples appear to result from inadvertent low-level contamination during analysis or sampling.

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. Past discharges into tributary Ten Site Canyon included a previous radioactive effluent treatment plant at TA-35.

Cañada del Buey, a tributary to Mortandad Canyon, contains a shallow perched alluvial groundwater system of limited extent, and only two observation 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 the early summer of 1992 within the upper and middle reaches of the drainage. Past discharges included accidental releases from experimental reactors and laboratories at TA-46.

a. 2005 Radioactive Liquid Waste Treatment Facility Discharges

Data on the RLWTF's yearly radionuclide discharge into Mortandad Canyon from 2002 through 2005 appear in Table S5-13 in the Data Supplement. Table S5-13 also shows mean annual levels in effluent for each radionuclide and the ratio of this to the 100-mrem DOE DCG for public dose. Figures 5-13 and 5-14 show the relationship of RLWTF average annual radionuclide activities and mineral concentrations in discharges to DOE DCGs or New Mexico groundwater standards since 1996. The 2005 discharges from the RLWTF met all DOE and New Mexico requirements. Beginning in 1999, LANL made significant upgrades to the RLWTF treatment system. As a result, for the last six years the RLWTF has met all DOE radiological discharge standards, all NPDES requirements, and for all but two weeks has voluntarily met NM groundwater standards for fluoride, nitrate, and total dissolved solids (TDS). Two weekly composite samples exceeded the fluoride standard in 2003.

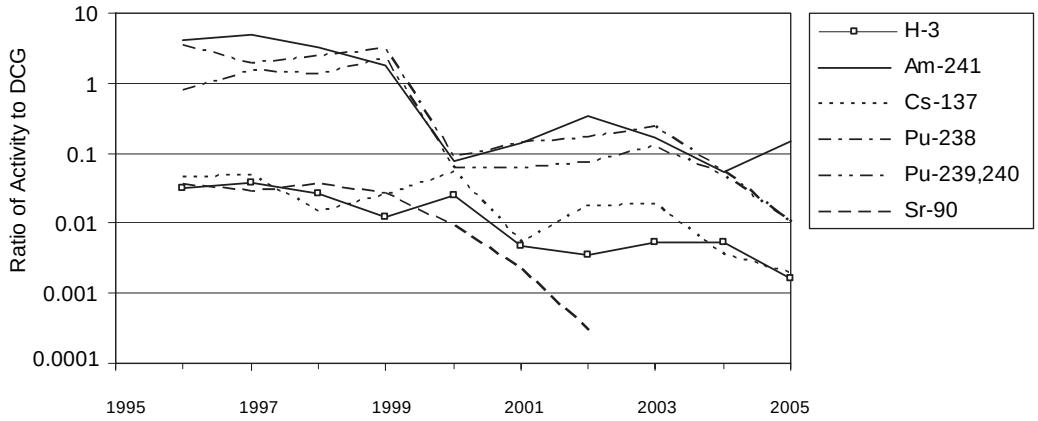

Figure 5-13. Ratio of 1996–2005 average annual radionuclide activity in RLWTF discharges to the 100-mrem public dose DOE DCGs

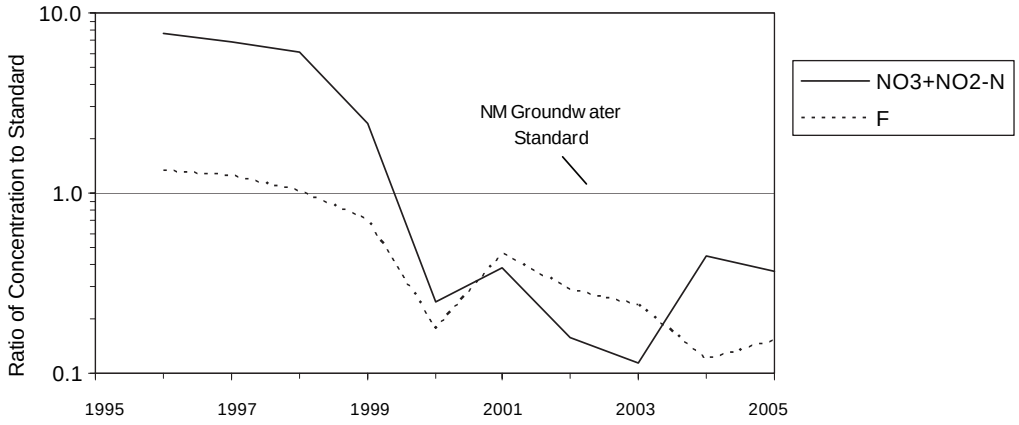

Figure 5-14. Ratio of 1996–2005 average annual mineral concentration in RLWTF discharges to the New Mexico groundwater standards.

During 2005, the nitrate + nitrite (as nitrogen) concentrations of all effluent discharges from the RLWTF were less than the New Mexico groundwater standard for nitrate (as nitrogen) of 10 mg/L (Figure 5-15). The average 2005 effluent total nitrate + nitrite (as nitrogen) concentration was 3.7 mg/L. In 2005, the highest nitrate concentration in a Mortandad Canyon base flow grab sample taken below the Effluent Canyon outfall was 1.6 mg/L.

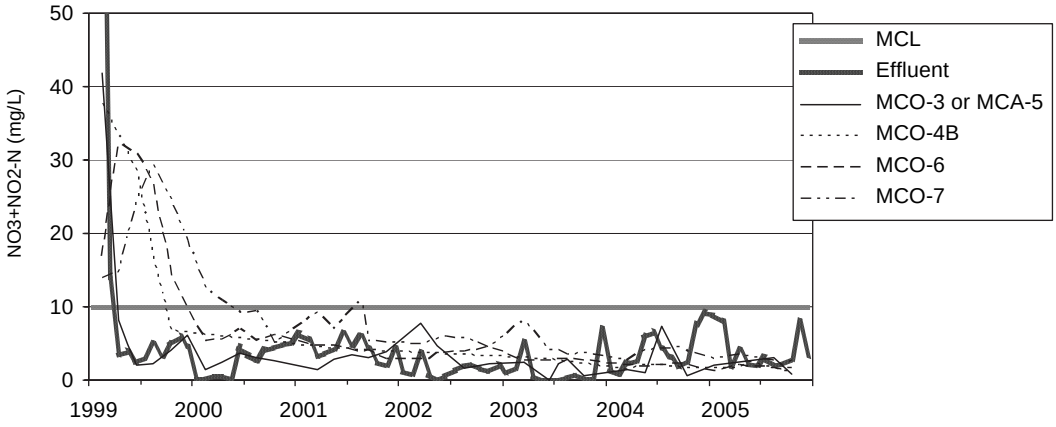

Figure 5-15. Nitrate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2005.

The fluoride concentration in the discharge has also declined over the last few years (Figure 5-16). The 2005 effluent fluoride concentration (average value of 0.24 mg/L) was below the New Mexico groundwater standard of 1.6 mg/L. In 2005, the fluoride concentration in Mortandad Canyon at the surface water station Mortandad below Effluent Canyon was 0.44 mg/L.

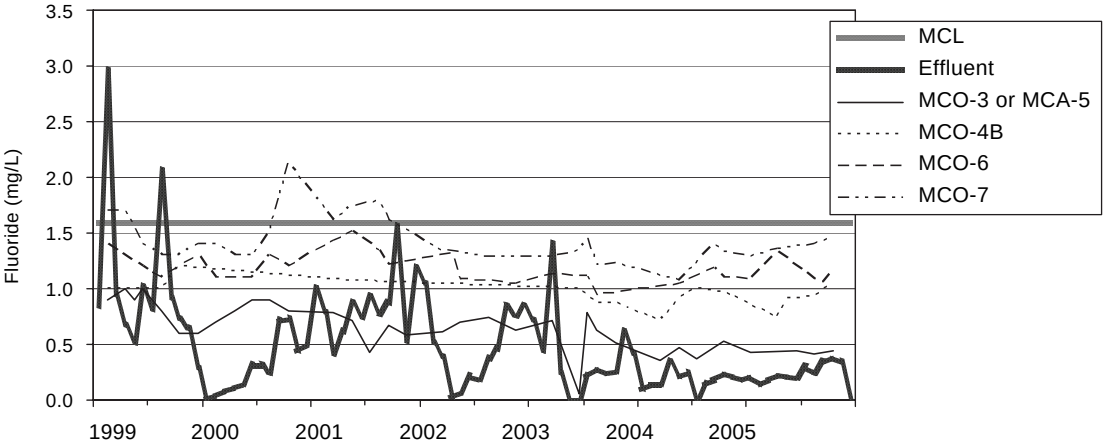

Figure 5-16. Fluoride in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2005.

A system for removing perchlorate from the RLWTF effluent became operational on March 26, 2002; no perchlorate has been detected in the effluent after this date (Figure 5-17). For 2005, the annual perchlorate discharge was effectively zero.

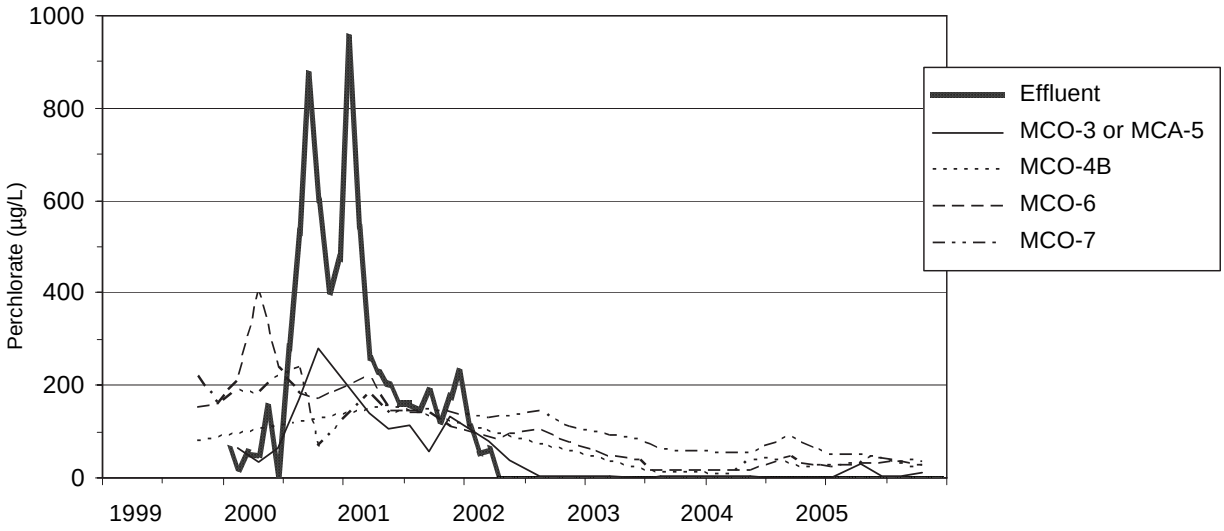

Figure 5-17. Perchlorate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 to 2005.

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer

The regional aquifer beneath Mortandad Canyon shows some impact from past LANL discharges; intermediate groundwater shows a larger effect. In 2005, sampling at regional aquifer monitoring well R-28 in Mortandad Canyon found contamination by hexavalent chromium at four times the EPA MCL of 100 µg/L (Figure 5-18) and eight times the NM groundwater standard. The Laboratory has begun investigation of this issue in cooperation with NMED, with past cooling tower discharges in Sandia Canyon identified as the likely source (ERSP 2006). MCOI-6, an intermediate groundwater well in Mortandad Canyon, consistently showed filtered chromium above the NM groundwater standard of 50 µg/L. Other intermediate wells had much higher unfiltered chromium values, which we attribute to aquifer or drilling-related materials present in the sample.

A sample from regional well R-34 had technetium-99 at 5.24 pCi/L, well below the 4-mrem DCG of 4,000 pCi/L; this result was just above the MDA; three other samples from the well and reanalysis of this sample were nondetect. Since 2000, R-15 tritium has shown an increase from 2 pCi/L to recent values of 31 pCi/L (Figure 5-19). The latest values indicate some contribution of recent recharge to the regional aquifer at R-15. A corresponding increase has occurred for perchlorate (from less than 5 µg/L to 7 µg/L), but not nitrate (Figure 5-20). The earlier perchlorate data have a MDL of 4 µg/L giving lower precision for that period. Possible explanations for the increase in tritium and perchlorate levels include lingering effects of well installation with a delay in return to predrilling values (perhaps caused by addition of water during drilling or well development), or some change of concentration within the surrounding groundwater during this time. R-28 has tritium values up to 181 pCi/L and perchlorate concentrations in the range of 1 µg/L; these results along with the chromium levels indicate impact of LANL effluents. No other regional aquifer well in Mortandad Canyon had repeatable low-detection limit tritium detections, and other perchlorate values were below 0.5 µg/L.

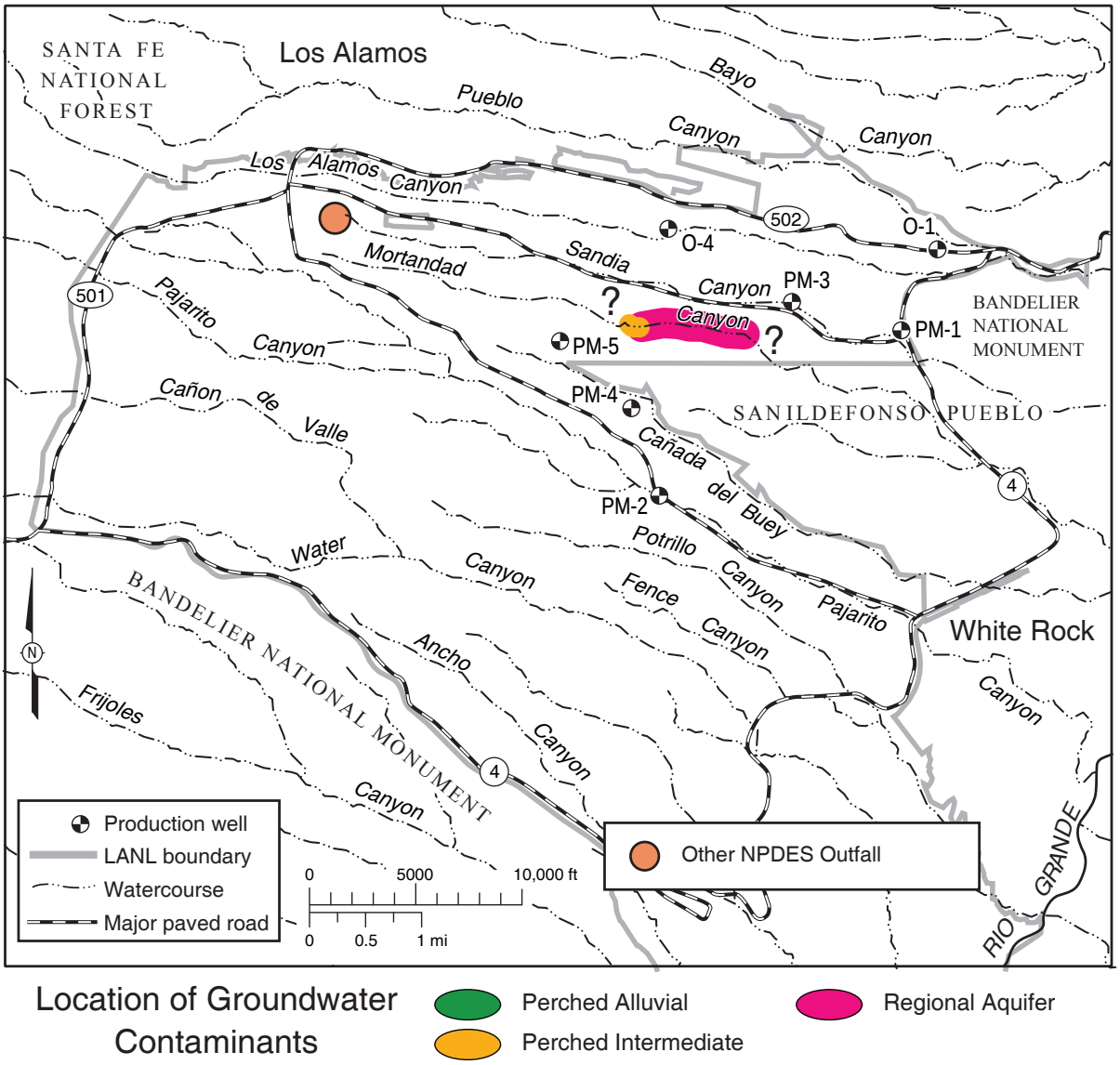

Figure 5-18. Location of hexavalent chromium above the 50 µg/L New Mexico Groundwater Standard. The maximum 2005 value in the regional aquifer was over eight times the groundwater standard. Different colors indicate the affected groundwater zones. The extent of intermediate groundwater and regional aquifer contamination is based on a limited number of wells: question marks on the maps indicate where contaminant extent is inferred, not necessarily substantiated.

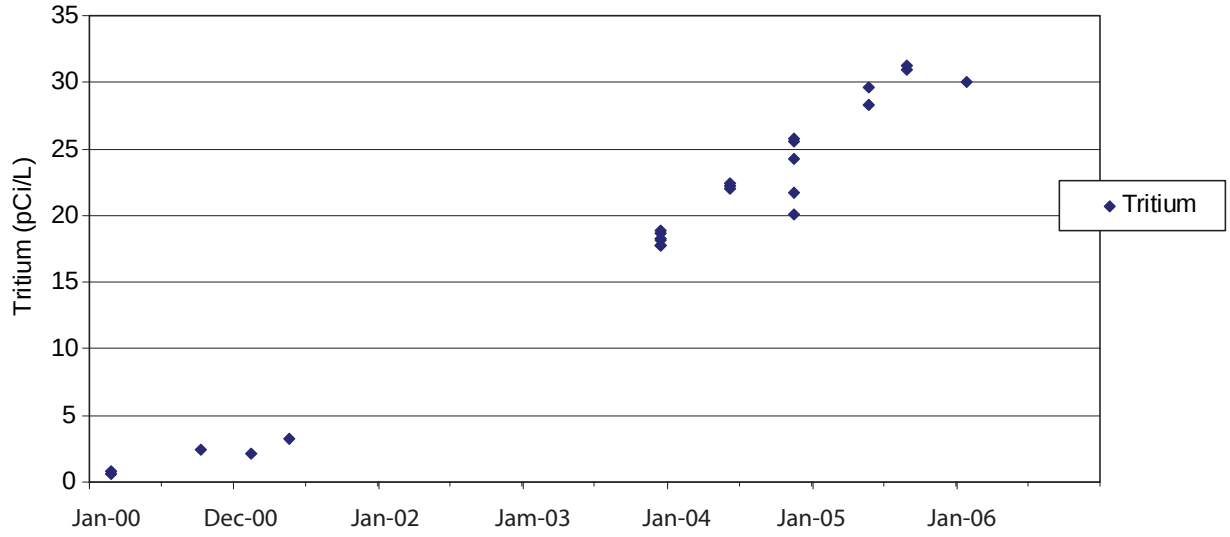

Figure 5-19. Tritium history in Mortandad Canyon regional aquifer well R-15.

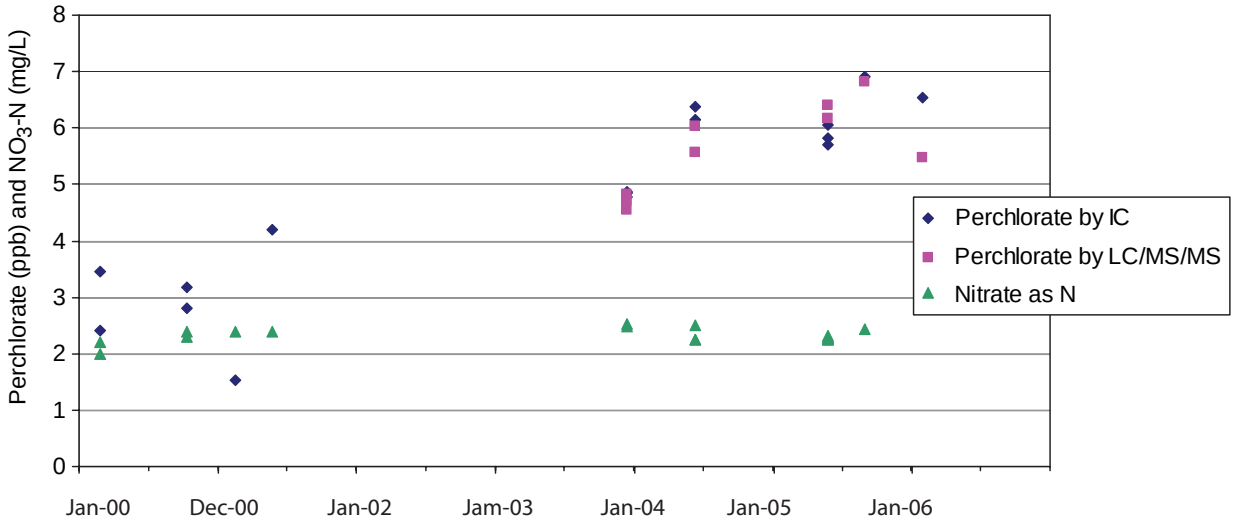

Figure 5-20. Perchlorate and nitrate histories in Mortandad Canyon regional aquifer well R-15.

Several regional wells in Mortandad Canyon had other metals present at concentrations near or above groundwater standards. Aluminum, iron, and manganese are related to turbidity or drilling fluid effects. Arsenic was found in a few samples, but not consistently. Filtered and total chromium results in R-28 have been above 400 µg/L and have been confirmed as hexavalent chromium by separate analysis. R-33 had one filtered nickel result in June 2005 at 1124 ft of 168 µg/L; the unfiltered value was 25 µg/L. Two turbidity measurements were 0.97 NTU and 24 NTU; this wide range suggests a large change in water quality during sampling which may be the source of the high nickel result. Subsequent nickel values from two sampling events for R-33 at this depth average 30 µg/L for filtered and 15 µg/L for unfiltered samples. Iron concentrations were near the EPA secondary drinking water standard of 300 µg/L, but no other metal concentrations were elevated.

Several PAH compounds were found in reanalysis of a sample from R-14 at 1,204 ft, but not in the original analysis or in three prior or one subsequent samples. This suggests that, rather than the compounds being present in the groundwater sample, the results are analytical artifacts.

Contaminants found in Mortandad Canyon intermediate groundwater indicate an impact by LANL effluents, with several compounds above regulatory standards. In intermediate perched groundwater from four wells, tritium was found at activities ranging from 4,300 pCi/L to 23,500 pCi/L; the latter value is just above the MCL of 20,000 pCi/L (Figure 5-21). At MCOI-8, the well farthest upstream toward the effluent discharge location, the tritium value was 136 pCi/L. Technetium-99 was detected in three wells at values from 2.6 pCi/L to 7.9 pCi/L; the values are near the detection limit and well below the 4-mrem DCG of 4,000 pCi/L. Nitrate (as nitrogen) in three of the wells ranged from 13 mg/L to 16.8 mg/L, all above the NM groundwater standard of 10 mg/L (Figure 5-21). Perchlorate was not detected in the well farthest upstream (MCOI-8) but in four other wells ranged from 81 µg/L to 256 µg/L; the EPA's Drinking Water Equivalent Level is 24.5 µg/L (Figure 5-22).

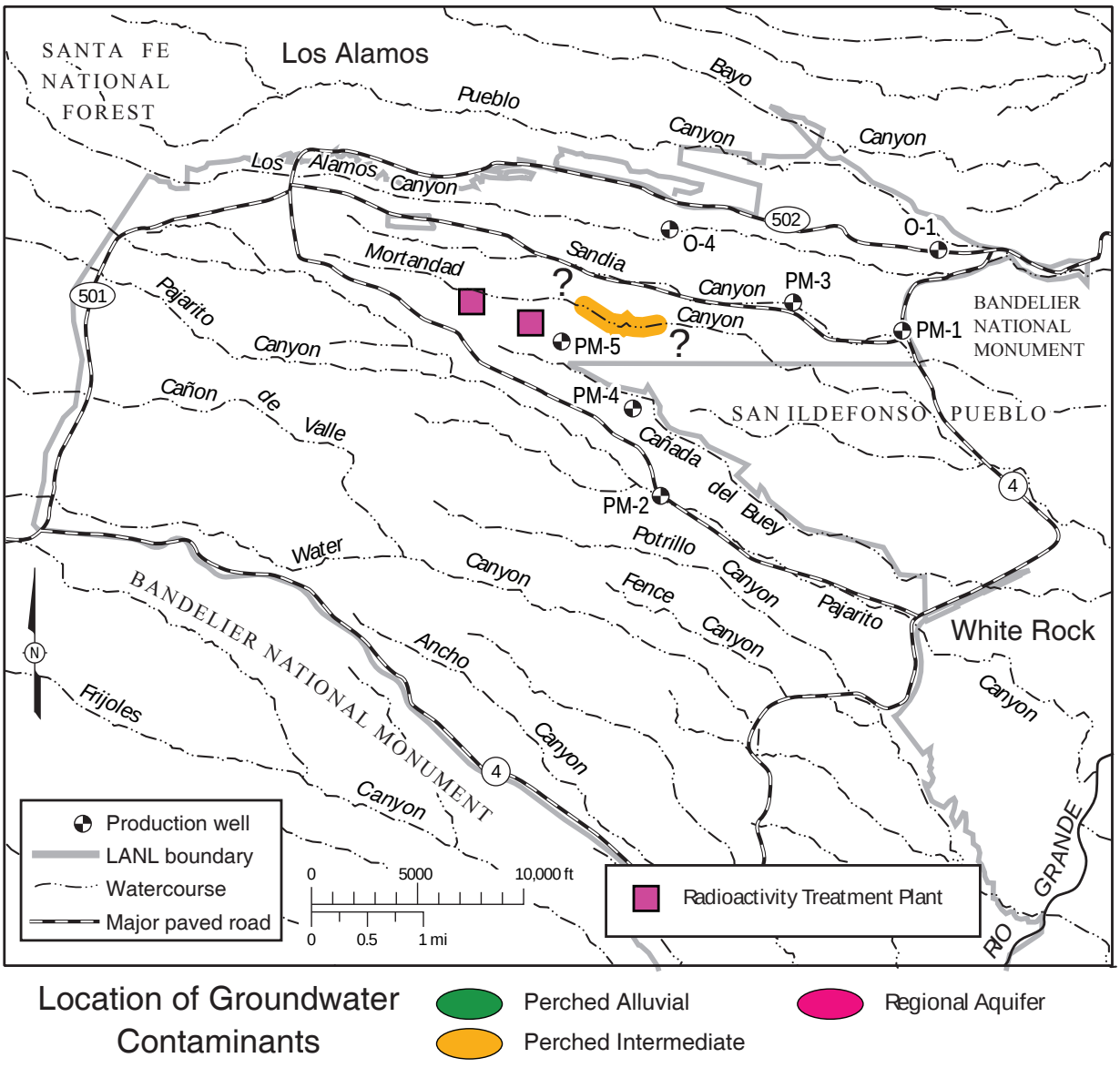

Figure 5-21. Location of nitrate (as nitrogen) above the 10 mg/L EPA MCL and tritium above the 20,000 pCi/L EPA MCL. Different colors indicate the affected groundwater zones.

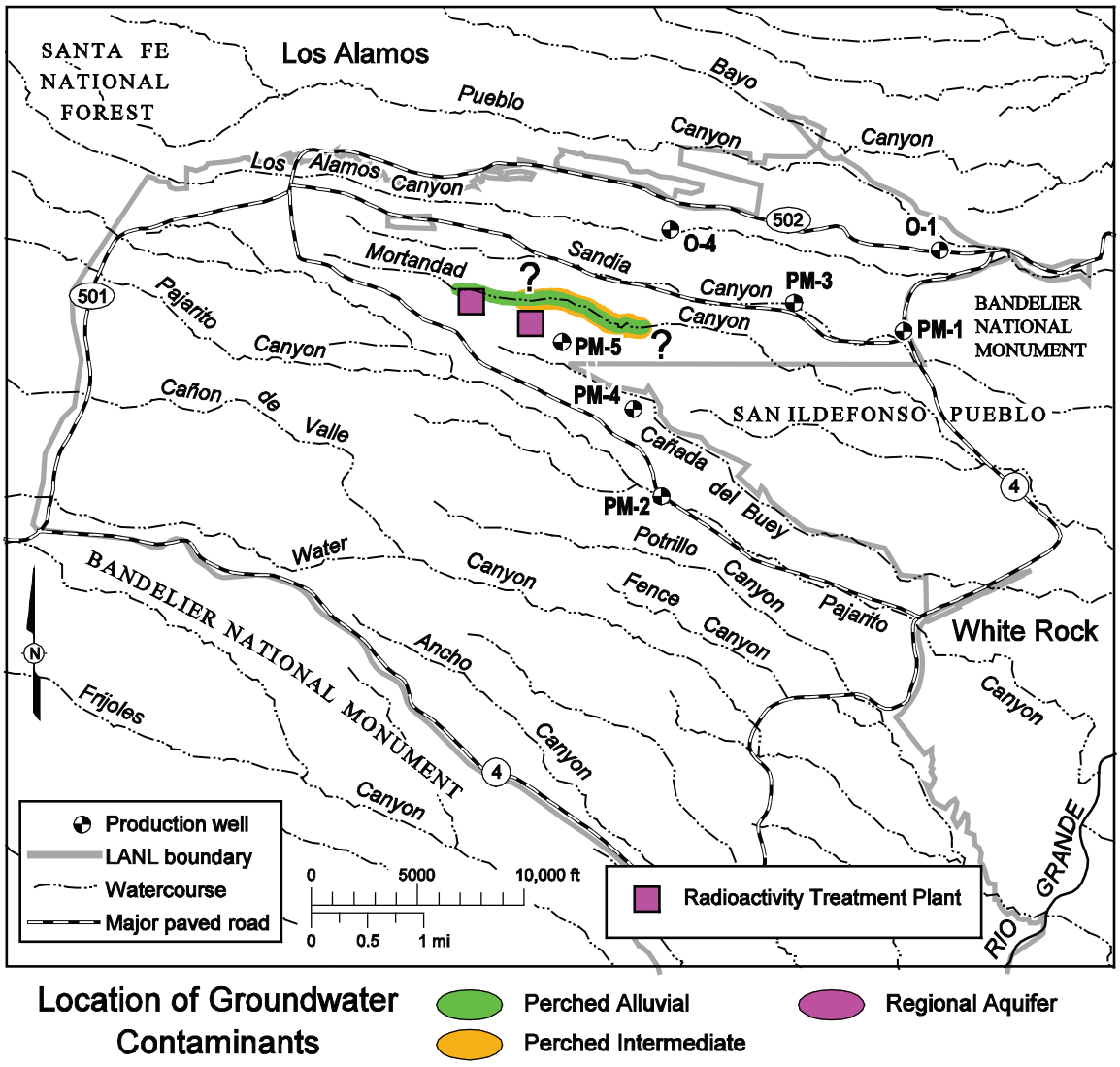

Figure 5-22. Location of perchlorate above the 24.5 µg/L EPA Drinking Water Equivalent Level. Maximum values in Mortandad Canyon were 50 µg/L in alluvial groundwater and 256 µg/L in intermediate groundwater during 2005. Different colors indicate the affected groundwater zones.

Chromium was detected in three of the newest intermediate-depth wells: MCOI-4, -5, and -6. In MCOI-4 and MCOI-5 the filtered values are much lower than the unfiltered values, leading to the conclusion that the chromium comes from aquifer or well materials, rather than the groundwater. Elevated nickel concentrations in MCOI-5 support a conclusion of metal corrosion as a chromium source in this well. Because these wells have little water, they must be sampled with a bailer, which produces very turbid samples (turbidities of 16 NTU to 83 NTU). MCOI-6 has sufficient water to allow use of a pump, producing lower turbidity samples (4.9 NTU to 6.4 NTU). Both filtered and unfiltered chromium values in this well are slightly above 50 µg/L (the NM GW Standard) and analysis in 2006 confirms that this chromium is predominantly in the form of hexavalent chromium. MCOI-5 also had values near or above standards of nickel, lead, and antimony. Most of these results were in unfiltered samples suggesting a relationship to drilling or casing materials; the unfiltered nickel values were much lower but still about 60 percent of EPA MCL.

In June of 2005 the volatile organic compound dioxane[1,4-] was detected in two intermediate wells in Mortandad Canyon. The compound was found in several sampling events and in field duplicates and results were confirmed by reanalyzing samples. All detected analytical results were below or slightly above the practical quantitation limit (PQL) of 50 μg/L (the MDL is 20 μg/L) and qualified as estimated values. There is no federal or New Mexico standard for dioxane[1,4-]. The Consent Order requires LANL to evaluate risk for contaminants with no regulatory standard at a 10^{-5} excess cancer risk level, using the EPA Region VI risk calculations. The EPA Region VI dioxane[1,4-] 10^{-5} risk value is 61 μg/L; the recent dioxane (estimated) results range up to 56 μg/L. A principal use of dioxane is as a solvent stabilizer in commercial formulations of chlorinated solvents such as trichloroethane, and it has many other uses in manufactured products and analytical processes. The Laboratory is working with NMED on a strategy to determine the extent and impact of dioxane[1,4-] as a groundwater contaminant in Mortandad Canyon. Dioxane[1,4-] has not been detected in any other water samples at the Laboratory; one 2005 detection in a City of Santa Fe supply well was not confirmed by reanalysis of the sample.

c. Alluvial Groundwater

Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest nearest to the TA-50 RLWTF outfall at well MCA-5 (which replaces MCO-3) and decrease down the canyon. Most radionuclides are adsorbed to sediment closer to the outfall. The levels of strontium-90 and gross beta are usually above EPA drinking water criteria, which we use as screening levels, in many of the wells. In past years, the levels of strontium-90, plutonium-238, plutonium-239,240, and americium-241 exceeded the 4-mrem DOE drinking water DCGs (which are not applicable to the alluvial groundwater, as it is not a source of drinking water). Since the early 1990s, those radionuclide levels have not exceeded the 100-mrem DOE DCGs for public dose for ingestion of environmental water. In 2005, total LANL-derived radioactivity was above 4 mrem in Mortandad Canyon alluvial groundwater samples from wells MCA-5, MCO-4B, MCO-5, MCO-6 and MCO-7 (Figure 5-10). For radioactivity from a DOE source, results for the following constituents were near or above the 4-mrem DOE DCG screening level: strontium-90 in MCA-5, MCO-4B, MCO-5, and MCO-6; total uranium in MCO-7 (not supported by lab replicate, likely an outlier); and unfiltered americium-241, plutonium-238, and plutonium-239 -240 in MCA-5. The levels of strontium-90 are also above the EPA MCL by a factor of up to 5.4 times. Gross beta values in samples from most alluvial wells were near or exceeded the EPA 50 pCi/L drinking water screening level. While cesium-137 is not usually detected in groundwater due to its strong adsorption to aquifer material, it was detected at MCA-5 in 2005 at 6 percent of the 4-mrem DCG screening level. Cesium-137 was found in both filtered and unfiltered samples.

Under the Laboratory's groundwater discharge plan application for the RLWTF, we collected additional quarterly samples for nitrate, fluoride, perchlorate, and total dissolved solids during 2005 from four alluvial monitoring wells in Mortandad Canyon: MCA-5 (or MCO-3), MCO-4B, MCO-6, and MCO-7. Nitrate (as nitrogen) concentrations in Mortandad Canyon alluvial groundwater were below the NMWQCC groundwater nitrate standard of 10 mg/L (Figure 5-15), and fluoride (Figure 5-16) concentrations were below the NMWQCC groundwater standard of 1.6 mg/L. MCO-7 had nitrate (as nitrogen) at about 34 percent of the NMWQCC groundwater standard. Five results from three wells (MCA-5, MCO-3, and MCO-4B) were unusually high due to field preservation errors. All of the Mortandad Canyon alluvial groundwater samples had fluoride concentrations ranging from 60 percent to 90 percent of the New Mexico groundwater standard. Two downstream wells (MT-1 and MCO-7.5) had fluoride values above the standard, a result of past effluent discharge. As shown in Figures 5-15 and 5-16, the nitrate (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 have been below the New Mexico groundwater standards.

Mortandad Canyon alluvial groundwater samples had some of the highest perchlorate concentrations found at LANL (Figures 5-17 and 5-22). Alluvial groundwater concentrations of perchlorate have dropped following the reduction of perchlorate in RLWTF effluent in March 2002, especially near the outfall. The 2005 concentrations at upstream wells MCA-5 and MCO-3 were up to 28 μg/L, above the EPA's Drinking Water Equivalent Level of 24.5 μg/L. Perchlorate concentration generally increased downstream, with 21 μg/L to 44 μg/L at MCO-4B, and 35 μg/L to 50 μg/L at MCO-7. As with nitrate and fluoride, the decrease over time of perchlorate near the outfall and downstream indicates that the concentrations in alluvial groundwater are decreasing in response to improved effluent quality.

Several PAH compounds were found in the April 20 sample from MT-3, all near the detection limit and at estimated concentrations. One of the compounds, chrysene, was above the EPA MCL screening level. This is the only time chrysene has been detected in this well. The compound has only been detected seven times in groundwater samples at the Laboratory, but not more than once at a particular location. PAH compounds are subject to carryover between analytical laboratory samples and are readily transferred as field contamination from sources such as used motor oil, diesel fuel, and combustion products.

d. Long-Term Radioactivity Trends

Figures 5-23 through 5-27 depict long-term trends of radionuclide concentrations in surface water and shallow perched alluvial groundwater in Mortandad Canyon downstream from the RLWTF outfall at TA-50. The figures show only radionuclide detections. If more than one sample was collected in a year, the average value for the year is plotted. The surface water samples are from the station Mortandad below Effluent Canyon (formerly GS-1), a short distance downstream from the outfall. Radioactivity levels at this station vary daily depending on the concentration of a release from the RLWTF. These samples also vary in response to changing amounts of runoff from other sources in the drainage.

The alluvial groundwater samples are from observation well MCO-5 in the middle reach of the canyon. Groundwater radioactivity at MCO-5 is more stable than surface water sampled at station Mortandad below Effluent Canyon because groundwater responds more slowly to variations in runoff water quality. Because of its strong adsorption to sediments, cesium-137 is not usually detected in groundwater samples, though it was detected in 2005 at alluvial well MCA-5, which is nearest the outfall.

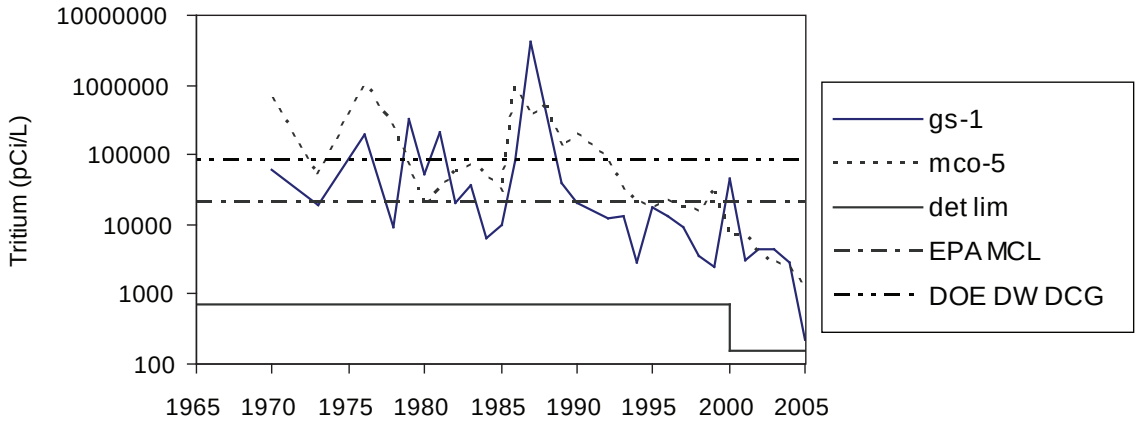

Figure 5-23. Average annual tritium activity in Mortandad Canyon surface water and alluvial groundwater.

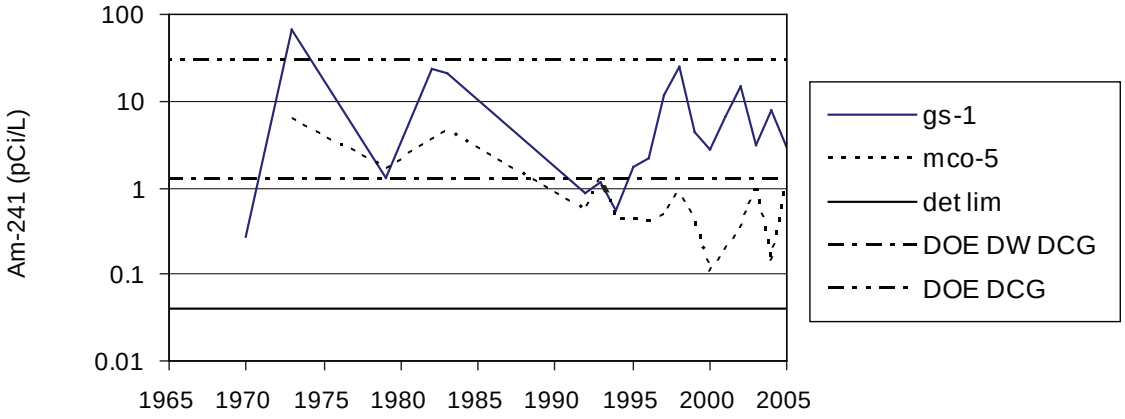

Figure 5-24. Average annual americium-241 activity in Mortandad Canyon surface water and alluvial groundwater.

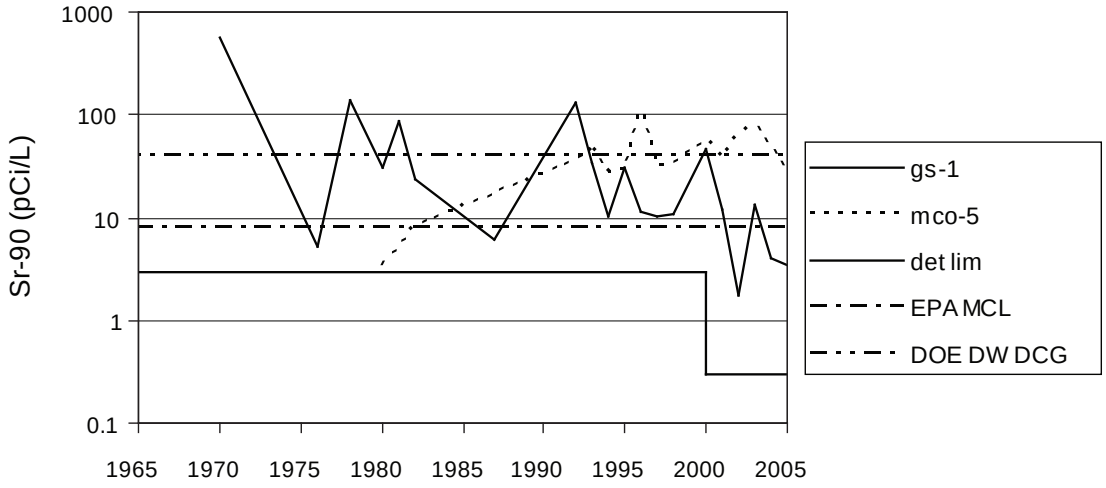

Figure 5-25. Average annual strontium-90 activity in Mortandad Canyon surface water and alluvial groundwater.

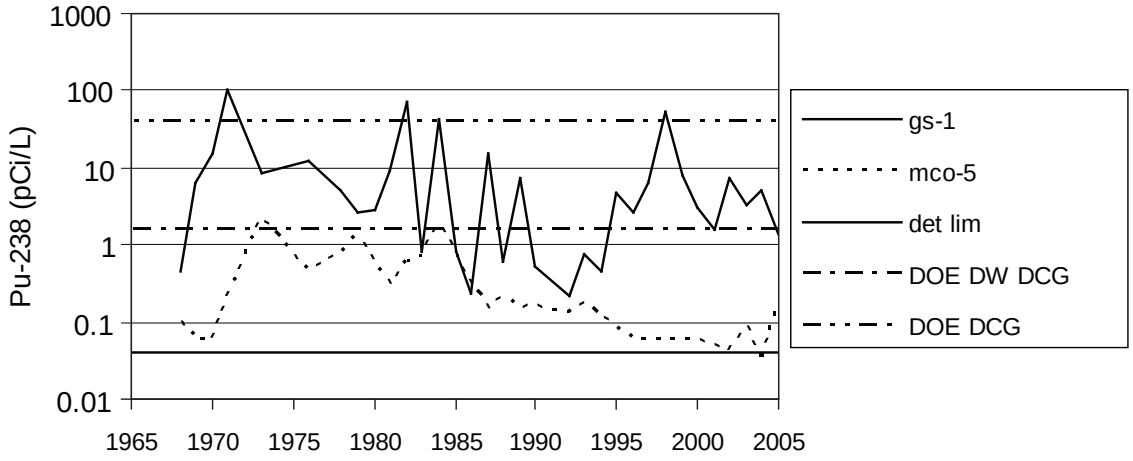

Figure 5-26. Average annual plutonium-238 activity in Mortandad Canyon surface water and alluvial groundwater.

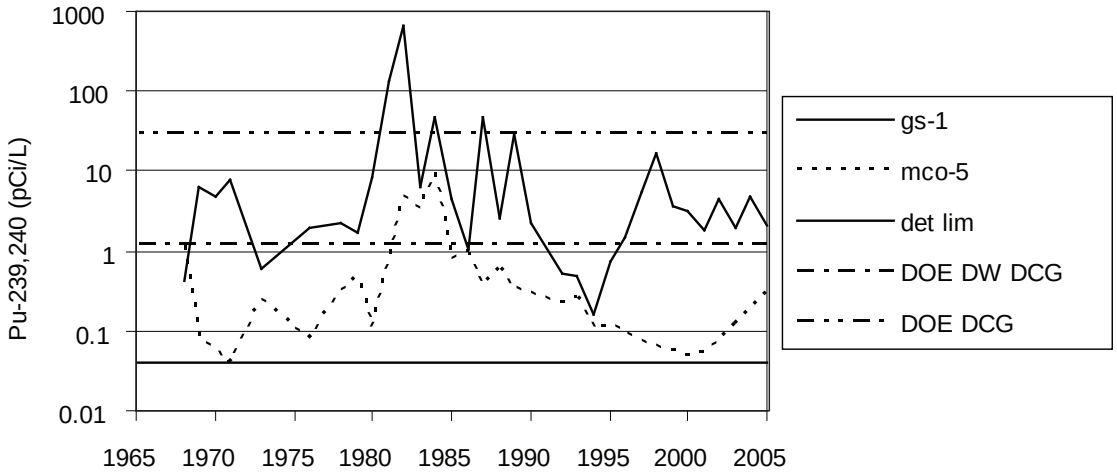

Figure 5-27. Average annual plutonium-239, 240 activity in Mortandad Canyon surface water and alluvial groundwater.

Chemical reactions such as adsorption do not delay tritium transport, so tritium activity is relatively uniform throughout the alluvial groundwater. Tritium activities within the Mortandad Canyon alluvial groundwater have been below the EPA MCL since 2001 (Figure 5-23). Average annual tritium activity in the RLWTF effluent dropped below 20,000 pCi/L in 2001, and tritium activity has dropped in surface water and alluvial groundwater since then.

Before 1990, americium-241 activity was not measured regularly at monitoring stations in Mortandad Canyon. For most years up to 1999, the americium-241 activity of RLWTF discharges was above the 100-mrem DOE DCG for public dose of 30 pCi/L. In the last few years, americium-241 in surface water nearest the outfall has been just below the 100-mrem DOE DCG, whereas in the groundwater nearest the outfall it is closer to the 4-mrem DCG screening level (Figure 5-24). Americium-241 in alluvial groundwater downstream at MCO-5 has been below the 4-mrem DOE DCG since the early 1990s.

In 2005, strontium-90 was detected in surface water at Mortandad below Effluent Canyon and in all alluvial groundwater observation wells down to MCO-7.5 (Figure 5-25). The strontium-90 activities in the upstream wells remain at values in the range of the 4-mrem DOE DCG screening level for drinking water (40 pCi/L) and the EPA MCL (8 pCi/L). It appears that strontium-90 has been retained by cation exchange 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 mass of the radionuclide is moving slowly downstream.

Both plutonium isotopes were detected in surface water at Mortandad below Effluent Canyon and at nearly all alluvial wells in 2005 (Figures 5-26 and 5-27). Both isotopes have been historically detected at Mortandad below Effluent Canyon and at MCO-3 (now MCA-5) at levels near the 100-mrem DOE public dose DCGs (30 pCi/L for plutonium-239,240 and 40 pCi/L for plutonium-238), but the levels have decreased during the past few years. Values at other alluvial observation wells, except for MCO-4 and MCO-7.5, were near the detection limit in the 1990s. Plutonium has, in general, been detected in all alluvial observation wells in Mortandad Canyon but appears to be decreasing in activity at downstream locations.

e. Cañada del Buey

Water supply wells PM-4 and PM-5 are on the mesa top just south of Cañada del Buey. PM-4 operates as a backup well and during 2005 had one sample event. Analysis of one sample from PM-5 detected tritium, although reanalysis of that sample and results from other samples were nondetections. Analyses for perchlorate in samples from PM-4 and PM-5 had an average concentration of 0.34 μg/L, similar to earlier results and to other supply wells in northern New Mexico. No HE compounds were detected in samples from these wells.

No alluvial wells were sampled in Cañada del Buey in 2005 because of lack of water in the alluvium.

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. In lower Pajarito Canyon near the eastern Laboratory boundary, saturated alluvium occurs but does not extend beyond that boundary. In the past, the Laboratory released wastewater into tributaries of Pajarito Canyon from several HE-processing sites at TA-9. Some firing sites border portions of tributaries Twomile and Threemile canyons. A nuclear materials experimental facility occupies the floor of Pajarito Canyon at TA-18. Waste management areas, used for disposal of organic solvents and low-level radioactive waste, occupy the mesa north of the lower part of the canyon.

In 2005, samples from supply well PM-2 did not have tritium detectable by the low-detection-limit method (MDA about 1 pCi/L). Six perchlorate analyses had an average concentration of 0.31 μg/L, similar to prior data. The HE compound 2,4-diamino-6-nitrotoluene was detected at a value just above the detection limit in PM-2 on May 18, but not in a sample taken November 16 or in earlier samples, suggesting the result is an analytical artifact. Two apparent detections of DOE-derived radionuclides were found in Pajarito Canyon regional aquifer well samples, but both are inconsistent with other data. A detection of cobalt-60 in R-18 is at odds with nondetections in a field duplicate sample taken at the same time and from another sampling event in 2005. In R-19 at 1190 ft plutonium-239,240 was found in a filtered sample but not the corresponding unfiltered sample, and two reanalyses of the filtered sample produced nondetections.

Regional aquifer well R-22 lies just east of MDA G, the low-level radioactive waste management facility. In 2005, R-22 showed tritium at 2–3 pCi/L in the uppermost of five regional aquifer ports. This result is consistent with previous sampling observations. Tritium was also found at 11 pCi/L in the deepest port, consistent with earlier results. Otherwise, tritium was not detected and perchlorate was at background values in regional aquifer samples from Pajarito Canyon.

High concentrations of iron and manganese (in the range of EPA MCLs) in R-20, R-22, and R-32 are a result of materials used in well drilling and construction (ERSP 2005). Other metals (arsenic, beryllium, chromium, mercury, antimony, and selenium) appeared sporadically in samples. Chromium was found at 31.4 μg/L in an unfiltered sample from 907 ft in R-22, but was 1.8 μg/L in the filtered sample. Prior unfiltered chromium analyses were nondetect or up to 3.2 μg/L; thus this latest unfiltered chromium result does not yet lend itself to a pattern that can be evaluated. Selenium results are just above the MDL of 2.5 μg/L (SW 846:6020). The values in samples from three wells ranged from 2.6 μg/L to 5.3 μg/L (this largest value in R-20 at 907 ft), and a result of 3 μg/L was found in a field blank (also in R-20 at 907 ft). One of the well results occurred in a field duplicate but not the companion sample.

Organic results from these wells do not indicate any consistent presence of organics with one exception: In R-22, sampling for volatile organic compounds and semivolatile organic compounds again found isopropylbenzene at 907 ft. This compound has been detected at this port in five prior sampling events (concentrations are between 0.54 μg/L and 1.0 μg/L and all but one are estimated values), and also in a deeper port at 1448 ft in a 2002 sample. Isopropylbenzene may be a temporary result of drilling fluids used (Longmire and Goff 2002). Xylene was found in a sample from R-23 but not in a field duplicate. Fluorophenol[2-] and phenol-d6 were found in one sample at R-18 but not in the field duplicate sample.

Tritium was found in intermediate borehole R-23i, near the eastern LANL boundary, at 60 pCi/L. Water in borehole screening samples is of indeterminate origin, making interpretation difficult. Personnel sampled five springs in the Upper Pajarito Canyon drainage. PC, Homestead, Starmer, Keiling, and Bulldog Springs are fed by intermediate-depth groundwater from within adjacent mesas. PC Spring lies west of LANL in the Sierra de los Valles, so likely reflects background conditions. These intermediate springs mainly issue along canyon sides above adjacent streams. No LANL-derived radioactivity was found in these spring samples. High nitrate values reported for three springs in June were due to a field preservation error. Except for a perchlorate result from Bulldog Spring of 0.6 μg/L, results from intermediate springs and wells were within a background range. These perchlorate results are about half the values found in 2004. Aluminum and iron reflecting turbidity and selenium near the detection limit of 2.5 μg/L were the metals detected in these spring and well samples. The Bulldog Spring sample also contained HE compounds HMX and RDX, the latter at 17 percent of the of the EPA tap water screening level of 6.1 μg/L (corresponding to 10^{-5} excess cancer risk). In 2004, RDX was present in this spring at 83 percent of the EPA tap water screening level.

Cesium-137 was detected in a filtered sample from alluvial well PCO-2 at 8 percent of the 120 pCi/L 4-mrem DCG screening level, but was not detected in the filtered sample. Comparison data are sparse for this well during the last decade due to lack of water in the alluvium. Strontium-90 was found in PCO-3 at 6 percent of the 8 pCi/L MCL. This result is near the detection limit; a similar value was found in a filtered sample in 2001 but at that time no strontium-90 was detected in the unfiltered sample. Perchlorate was either not detected or within background ranges for alluvial springs and wells. A small amount of the HE compound HMX was found in the sample from Threemile Spring.

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. In 1997, the Laboratory consolidated these individual NPDES outfalls into one outfall, the High Explosives Wastewater Treatment Facility. Alluvial groundwater in Cañon de Valle shows barium above 1 mg/L, the New Mexico groundwater standard (Figure 5-28), and RDX above 6.1 μg/L, an EPA risk-based tap water screening level that corresponds to a 10^{-5} excess cancer risk.

Intermediate perched groundwater in this area also shows RDX above 6.1 μg/L (Figure 5-29). The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for open-air testing of weapons systems. These three small canyons have surface water only in response to precipitation events, and no known shallow groundwater.

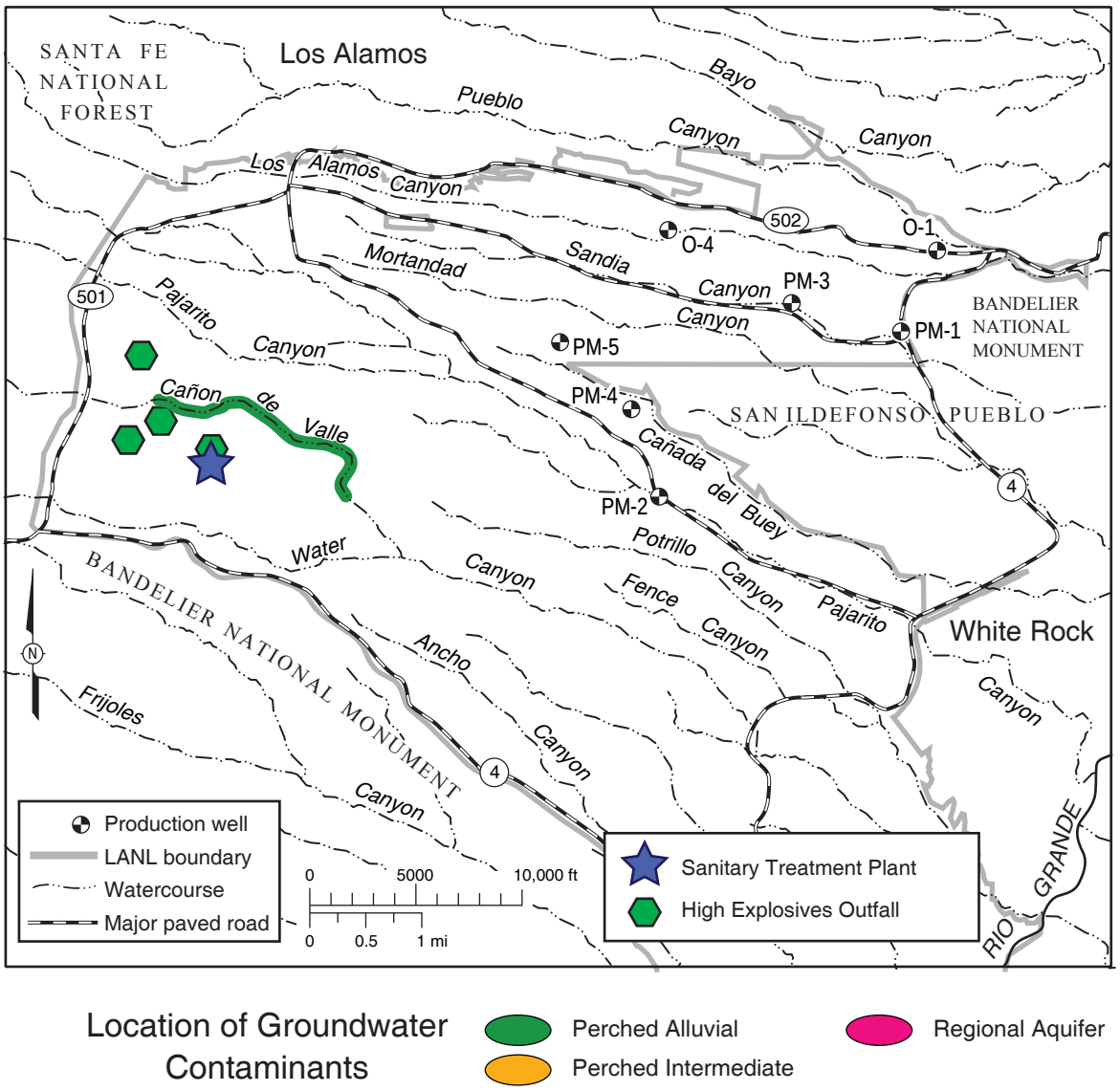

Figure 5-28. Location of RDX above the EPA Region VI tap water screening level of 6.1 µg/L, and barium above the New Mexico groundwater standard of 1 mg/L in perched alluvial groundwater. Different colors indicate the affected groundwater zones.

No tritium was detected in any regional aquifer samples within this watershed. Perchlorate was either not detected or values were below 0.31 µg/L and thus within the background range. The main metals found in well samples were iron and manganese, the result of drilling fluid impact (ERSP 2005). Arsenic was found in CdV-R-37-2 at 1,200 ft at 64 percent of the new MCL of 10 µg/L, which will be effective in 2006; the result is just above the detection limit.

At CdV-R-15-3 and CdV-R-37-2 (regional wells near Cañon de Valle), trichlorotrifluoroethane (freon 113), which may show up as a false positive when running a mass spectrometer, was found in most field trip blanks and samples, suggesting some source of sample contamination or analyte misidentification. Isopropylbenzene was detected three times in CdV-R-37-2 at 1,200 ft. This compound may be a temporary result of drilling fluids used.

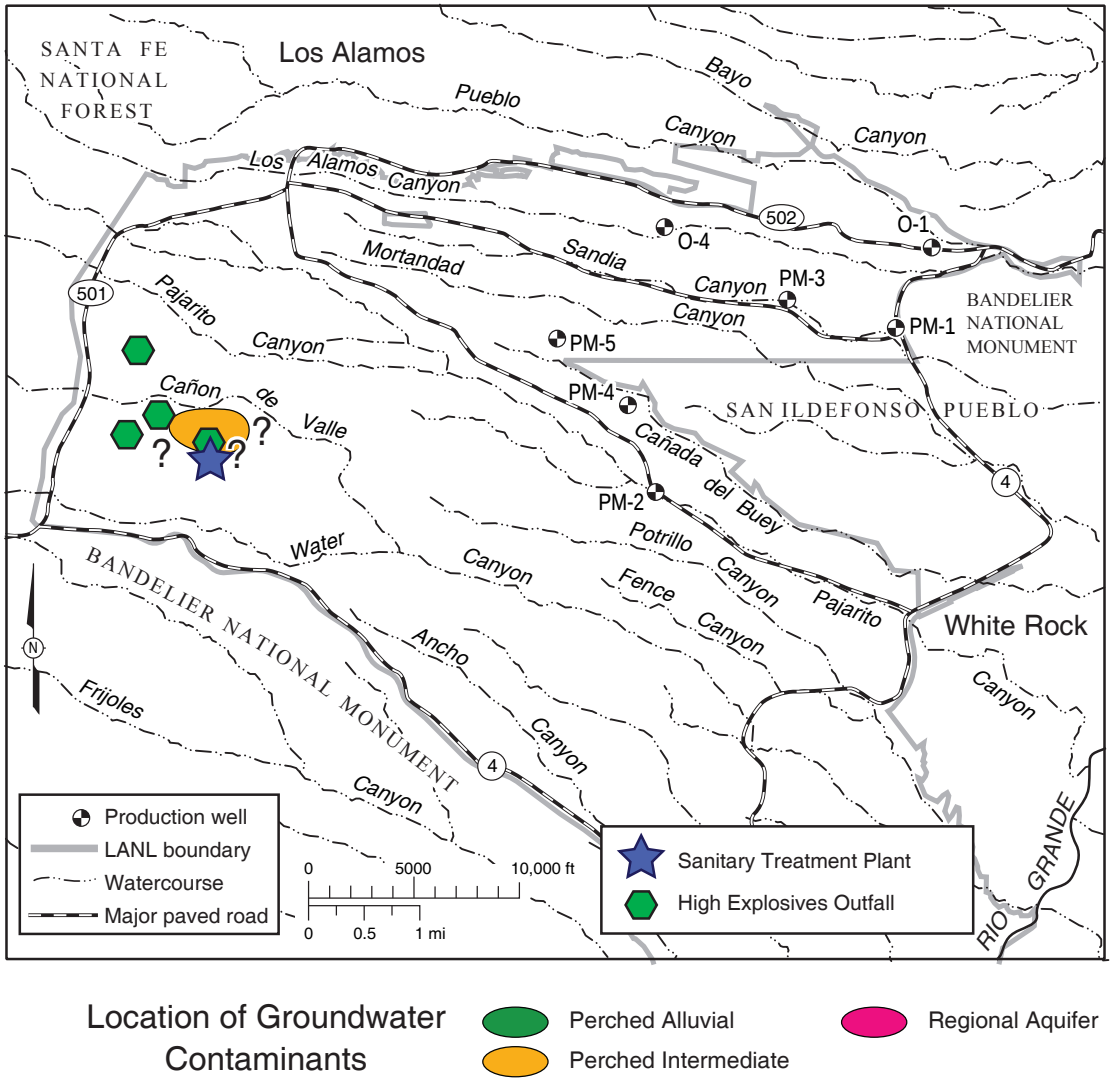

Figure 5-29. **Location of RDX above the EPA Region VI tap water screening level of 6.1 mg/L in perched intermediate groundwater. Maximum 2005 values for RDX in intermediate groundwater were up to 19 times the screening level in springs and 8.5 times that value in wells. Different colors indicate the affected groundwater zones.**

Plutonium-239,240 was found just above the MDA in one unfiltered sample from R-25 at 891 ft in an intermediate perched zone, but not in the filtered sample. Tritium was detected in three ports in R-25, two other wells, and several springs that sample intermediate perched zones. The tritium activities ranged from 7 pCi/L to 68 pCi/L for wells and 70 pCi/L to 195 pCi/L for springs, and are consistent with earlier sampling results. Perchlorate in intermediate-depth wells was either not detected or within background, with the highest value of 0.58 µg/L. For springs flowing from intermediate perched zones, perchlorate values ranged up to 0.74 µg/L, slightly above background.

High metals results (that is, near or above standards) in intermediate-depth wells and springs were found for aluminum, iron, and manganese. These results are related to sample turbidity for springs and to drilling fluids for wells. High unfiltered lead was found in June samples from CdV-16-1(i), but lead concentrations were lower on two subsequent sample dates, which suggests a temporary effect of well installation. Boron was found in Martin Spring and other nearby springs at concentrations up to 175 percent of the NM groundwater standard, a reflection of past effluents. Barium was found in Peter and Martin Springs at 50 percent to 80 percent of the NM groundwater standard.

Chromium (unfiltered) and nickel (filtered and unfiltered) were high in samples from two intermediate ports in R-25. The unfiltered concentrations for both metals, and filtered for nickel, show substantial increases over time in both ports (Figures 5-30 and 5-31). If chromium was in the hexavalent form, the filtered and unfiltered concentrations would be similar, which is not the case. The presence of both metals, and lower filtered chromium, suggests that the metals come from drilling or perhaps corrosion of well casing materials rather than groundwater. At 758 ft, unfiltered chromium has ranged from 17 µg/L to 45 µg/L with the latest value of 153 µg/L, while filtered values (not shown) have been between 0.8 µg/L and 6.2 µg/L. However, the NM groundwater standard for chromium, 50 µg/L, applies to dissolved (filtered) concentrations and the filtered sample results are much below the standard. Chromium values in the 892 ft port show a similar pattern: unfiltered chromium has ranged from 6.7 µg/L to 35 µg/L with the latest value of 70 µg/L, while filtered values (not shown) have been between 0.7 µg/L and 1.9 µg/L. For nickel the EPA MCL is 100 µg/L; recent filtered values at 758 ft and 892 ft were 720 µg/L and 520 µg/L, respectively.

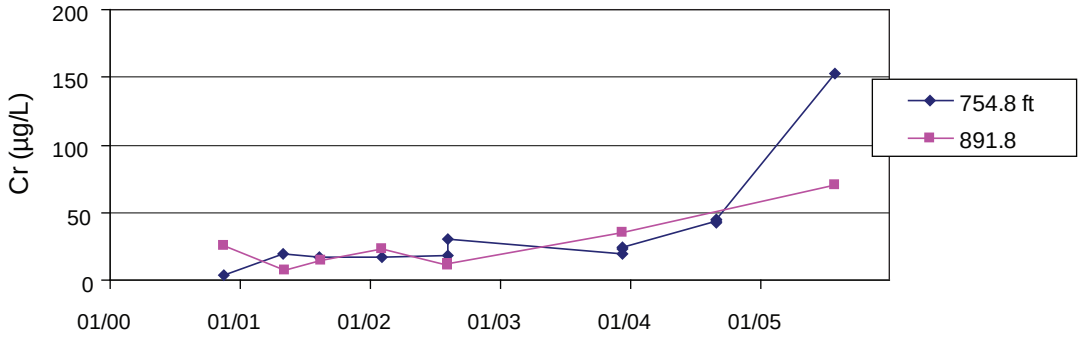

Figure 5-30. Chromium concentration histories in the shallowest two R-25 ports.

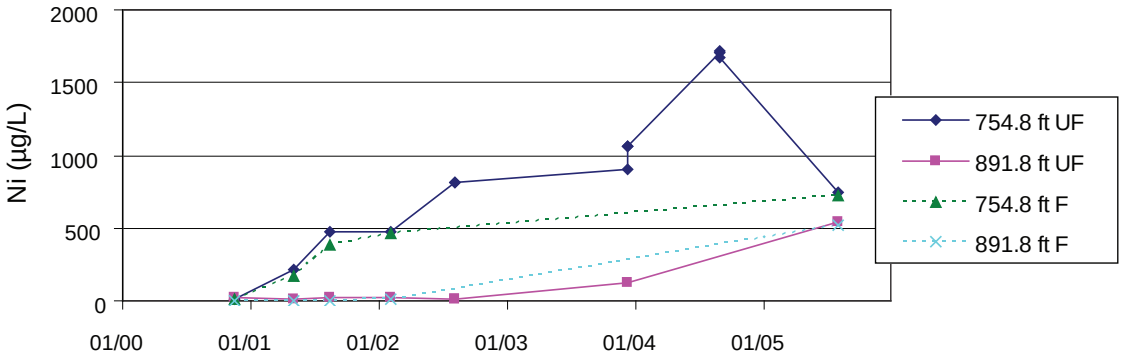

Figure 5-31. Nickel concentration histories in the shallowest two R-25 ports.

Intermediate perched zone well and spring samples contained several HE compounds. Of these compounds, RDX (Figure 5-29) was above the 6.1 µg/L EPA tap water screening level in springs and in wells. The chlorinated solvents tetrachloroethene (also known as tetrachloroethylene, perchloroethylene, or PERC) and trichloroethene (or trichloroethylene or TCE) continue to be found in SWSC, Burning Ground, and Martin Springs. The highest values were in Burning Ground Spring at 37 percent and 40 percent, respectively, of the EPA MCL which is 5 µg/L for both compounds. These compounds were also found in two wells, with the highest values in the shallowest port of R-25 at about 30 percent of the MCL.

Cañon de Valle alluvial well CDV-16-02657 had uranium at up to 55 percent of the 30 µg/L NM Groundwater Standard, as previously seen in that well. Tritium was found in many alluvial wells in Cañon de Valle and Martin Spring Canyon at activities ranging from 70 pCi/L to 190 pCi/L. In previous years, CDV-16-02655 has shown nitrate (as nitrogen) up to 90 percent of the NM Groundwater Standard; in 2005 one value was 67 percent of that

standard. That well also showed the highest perchlorate value for this area, just above background at 0.9 µg/L. A large number of other perchlorate results for alluvial wells were nondetections.

In addition to aluminum, iron, and manganese related to sample turbidity, many other metals were above standards in alluvial groundwater samples in Cañon de Valle. Among these metals were arsenic, barium, beryllium, cadmium, nickel, lead, and vanadium. High values for these metals frequently correlate with high sample turbidity as well. Selenium also was above the NMWQCC Wildlife Habitat Standard in CDV-16-02655 and CDV-16-02657 (values were by SW-846:6010B but not estimated). (The surface water standard would apply if the ground water flowed to the surface.) Most of the high metal values occurred in two wells: CDV-16-02655, located in a swampy area on the mesa top west of building 260; and CDV-16-02657, located just below the 260 outfall. Barium, present due to past high explosives wastewater discharges, was above the NM groundwater standard in numerous wells, often by a factor of 10 or more (Figure 5-28).

Alluvial well samples contained several HE compounds. As with intermediate perched groundwater, RDX (Figure 5-28) was present at concentrations comparable to risk levels: up to two to six (and in one case, 43) times the 6.1 µg/L EPA 10^{-5} excess cancer risk level. Numerous PAH compounds, including benzo(a)pyrene were found in one well sample and one field blank from a different well. PAH compounds are subject to carryover between analytical laboratory samples and are readily transferred as field contamination from sources such as used motor oil, diesel fuel, and combustion products. In the first example, benzo(a)pyrene was found in Canon de Valle alluvial well CDV-2655 above the EPA MCL in January 2005 but not in five other sample rounds since 1997. The results for every detected semivolatile compound from that sample (including the PAH compounds) were rejected in secondary validation, as the validator identified quality deficiencies in the reported data. Tetrachloroethene was found in CDV-2655 at 10 percent of the EPA MCL; the compound is commonly found in groundwater in Cañon de Valle.

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 HEs and fissionable material insufficient to produce a nuclear reaction. In 1960, the US Geological Survey drilled three deep wells (named DT-5A, DT-9, and DT-10) to monitor regional aquifer water quality. Another well, R-31, lies downstream from firing sites at TA-39. In 2005, strontium-90 was detected slightly above the detection limit in one field blank and one sample from 670 ft in regional well R-31. The detection was in an unfiltered sample and the filtered sample was nondetect for strontium-90. Perchlorate values were either in the range for background or nondetections. Aluminum, iron, and manganese (related to aging well casings or to turbidity) were above or standards in the three DT wells. Iron and manganese are high in R-31 due to persistent effects of drilling fluids.

8. White Rock Canyon Springs

The springs that issue along the Rio Grande in White Rock Canyon represent the principal discharge of regional aquifer groundwater that flows underneath the Laboratory (Purtymun et al., 1980). A few springs such as Spring 2B appear to represent discharge of perched groundwater; that spring is supplied by municipal sanitary effluent discharge near White Rock. The springs serve as boundary monitoring points for evaluating the Laboratory's impact on the regional aquifer and the Rio Grande.

Other than tritium, the only radionuclide detection in White Rock Canyon springs was uranium in La Mesita Spring. Naturally occurring uranium is commonly detected in this and a few other springs. Few low-detection-limit tritium samples were collected from springs in 2005; results for the remaining springs are summarized in prior reports in this series. For the majority of White Rock Springs, tritium activities lie within a range for regional aquifer background; for a few springs, the tritium activity might reflect recent infiltration of precipitation or possibly LANL influence. Except where impacted by effluent discharge, activities of tritium in the regional aquifer in other parts of the Laboratory range from nondetection to between 1 and 3 pCi/L. Tritium concentrations in northern New Mexico surface water and precipitation range from 30 to 50 pCi/L; tritium activity in precipitation is higher near LANL (Adams et al. 1995). Most of the springs had tritium values ranging between nondetection (less than about 1 pCi/L) and 2 pCi/L, in the background range.

Three springs (4, 4B, and 4C) issue within a few hundred feet of each other near the Rio Grande. Springs 4 and 4C have tritium activities of about 10 pCi/L; Spring 4B has an activity of 45 pCi/L; these values are in the range of results for precipitation. These three springs issue along the river just below an extensive flat area, which is the top of an ancient landslide block. The topography creates a likely location for infiltration of local precipitation. The springs (particularly Spring 4B, which has the highest activity) show considerable seasonal variation in flow related to rainfall and snowmelt.

Results for perchlorate from spring samples were similar to prior results. Most were within the range determined by NMED to represent background (unpublished results). A few springs have higher values: one spring, La Mesita Spring, east of the river, had the highest value of 0.89 µg/L. Springs 4 and 4C have values slightly above 0.6 µg/L. In addition, the perchlorate values found in the springs appear to relate to the geologic setting where they discharge. Most of the springs discharge from one of two geologic units: the Tesuque Formation and the Totavi Lentil (the lower part of the Puye Formation) (Purtymun et al., 1980). The northern group of springs that discharge from the Totavi Lentil has slightly higher average perchlorate concentrations than the southern group that discharges from the Tesuque Formation. For example, in 2004, perchlorate concentrations for the Totavi Lentil springs (Sandia Spring, Spring 3 series, 4 series, Spring 5) averaged 0.47 µg/L. For the Tesuque Formation springs (Springs 5A, 6, 6A, 8A, 9, 9A, Doe Spring), perchlorate concentrations averaged 0.27 µg/L. Perchlorate results for 2005 fit this pattern.

Spring 2 contained arsenic at new 2006 EPA MCL of 10 µg/L. The arsenic occurs naturally in springs and wells in the area and has been at even higher concentrations in Spring 2 in prior years. Several springs had high selenium values compared with the New Mexico wildlife habitat surface water standard; most results were near detection limits, and in some cases were not detected in analyses of the sample using other analytical methods with lower detection limits.

A detection of the PCB Aroclor-1262 occurred in the Spring 1 sample. This only the second time in many years that an Aroclor has been found in a spring sample.

9. Pueblo de San Ildefonso

The groundwater data for Pueblo de San Ildefonso indicate the widespread presence of naturally occurring uranium at levels approaching the EPA MCL of 30 µg/L. These measurements are consistent with previous samples. Naturally occurring uranium concentrations near or exceeding the EPA MCL are prevalent in well water throughout the Pojoaque area and San Ildefonso Pueblo. The high gross alpha readings for these wells are related to uranium occurrence.

The U-234 value in Westside Artesian well was below half the 4-mrem DOE DCG for drinking water. The gross alpha values in these wells (except Westside Artesian well, at 18 pCi/L) were below the EPA primary drinking water standard of 15 pCi/L.

Low-detection-limit tritium measurements were nondetect in LA-5, Westside Artesian, Eastside Artesian, and Pajarito Well (Pump 1) suggesting older-age water with little contribution from recent recharge. Tritium values for J. Martinez House and Black Mesa wells were in the range of 2 pCi/L to 4 pCi/L, suggesting they are a mixture of some young water with older water.

Several of the Pueblo de San Ildefonso wells have levels of sodium, chloride, fluoride, and total dissolved solids near or above New Mexico groundwater standards or EPA health advisory levels. Perchlorate concentrations in these wells ranged from nondetect to 0.5 µg/L.

The boron value in the Westside Artesian well was 220 percent of the groundwater standard of 750 µg/L, similar to the values of past years. Boron in Pajarito Well Pump 1 was 150 percent of the NM standard. The J. Martinez House well and Pajarito Well Pump 1 had arsenic above the new 2006 EPA MCL of 10 µg/L. Organic samples from Westside Artesian and Black Mesa wells contained benzene, toluene, and xylene, suggesting contamination by gasoline, perhaps during sampling. Other than sample issues mentioned in the introduction, no further organic compounds were found in Pueblo de San Ildefonso well samples.

10. Buckman Well Field

In 2005, we sampled three wells in the City of Santa Fe's Buckman Field. As in past samples, these wells, particularly Buckman well No. 2, contain high uranium relative to drinking water standards. The gross alpha levels in these wells are attributable to the presence of uranium and were near or above the EPA primary drinking-water standard of 15 pCi/L. The EPA MCL for gross alpha, however, does not include the contribution to gross alpha by radon or uranium. The U-234 value in Buckman well No. 2 was about 134 percent of the 4-mrem drinking water DCG; for Buckman wells No. 1 and 8 this value was about 28 percent of the DCG.

Generally, no tritium is detected in these wells at a detection limit of about 1 pCi/L, and this was the case with 2005 samples. Perchlorate concentrations in the Buckman wells ranged from 0.30 µg/L to 0.36 µg/L, within the apparent range of naturally occurring values. One organic sample produced a result of 643 µg/L for dioxane[1,4-]; however, on reanalysis the sample was a nondetect and we attribute the first result to analytical error or perhaps analytical laboratory cross-contamination. Other than sample issues mentioned in the introduction, no additional organic compounds were found in the Buckman well samples. No HE compounds were detected in these well samples.

G. QUALITY ASSURANCE OF GROUNDWATER, SURFACE WATER, AND SEDIMENT SAMPLE ANALYSES

1. Introduction

Environmental sampling personnel conducted quality assurance (QA) activities in 2005 in accordance with DOE Order 414.1A, which prescribes a risk-based, graded approach to QA. This process promotes the selective application of QA and management controls based on the risk associated with each activity to maximize effective resource use.

The water quality database (http://www.lanl.gov/community/environment/h2o/) contains all the surface water, groundwater, and sediment analytical data received from our analytical laboratories. None of the data are censored or removed. If analytical results are inconsistent with prior data, we investigate 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 are 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.

All sampling was conducted using standard operating procedures. 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, the list of analytes to be measured, and the bottle sizes and preservatives for each analysis required.

See Supplemental Tables S5-14, S5-15, S5-16 for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples during 2005.

2. Quality Assurance Program Development

During 2005, we revised one quality plan that affects collection and use of water quality compliance data. We also issued one new implementing procedure and revised approximately 21 procedures to reflect the constant improvements in the processes. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that processes perform satisfactorily.

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 Statement of Work (Model SOW). The SOW provides contract analytical laboratories the general QA guidelines specified in the Model SOW and also includes specific requirements and guidelines for analyzing surface water, groundwater, and sediment samples.

3. QA of Field Sampling Activities

We submit quality control samples along with environmental samples so that we can detect possible field or analytical laboratory contamination and track analytical laboratory performance. 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 analytes in deionized water field blanks could indicate contamination of our deionized water source or sample bottles or contamination from the analytical laboratory. We evaluate the results from QC samples along with the environmental sample results in order to understand whether the results truly represent environmental measurements.

The required analytical laboratory batch QC is defined by the analytical method, the analytical SOW, and generally accepted laboratory practices. The laboratory batch QC is used in the data-validation process to evaluate the quality of individual analytical results, to evaluate the appropriateness of the analytical methodologies, and to measure the routine performance of the analytical laboratory.

In addition to batch QC performed by laboratories, we submitted field QC samples to test the overall sampling and analytical laboratory process and to spot-check for analytical problems. These samples included equipment blanks, field blanks (deionized water), performance evaluation blanks (deionized water), and field trip blanks. Duplicate analyses of select samples were also conducted at the laboratory.

a. Equipment and Field Blanks

Equipment and field blanks were submitted for metals, organic, general inorganic, and radiochemistry analyses to monitor for contamination during sampling and decontamination of equipment.

b. Performance Evaluation Blanks

Performance evaluation blanks are deionized water (DI) blanks submitted as regular samples, without any indication that they are QC samples. They go through the same analytical process as the regular field samples. The DI blanks are measured with the same background contributions from reagents and biases as the regular samples and give an estimate of background and systematic analytical errors, and aid in the determination of false detections in associated environmental samples.

c. 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 at the analytical laboratory.

d. 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.

The nitrate results for 10 samples at 9 groundwater and surface water locations (MCA-5, DP Spring, MCO-3, field duplicate at MCO-3, PC Spring, Bulldog Spring, Keiling Spring, Starmers above Pajarito, Pajarito 1.0 mile above Twomile, and La Delfe above Pajarito) sampled between May 6, 2005 and June 22, 2005 were reported at levels over 500 mg/L. Review of these samples found that the nitrate values were not supported by the total dissolved solids determination or the historical data for the sites, where these data were available. Additional testing at the laboratory indicated that the high levels of nitrate were not found in unpreserved samples, for those affected samples with containers still available for additional testing. The high nitrate values in these samples is likely from the incorrect use of nitric acid preservative in the field in place of the method-specified sulfuric acid preservative.

In some cases, sample results for filtered and unfiltered sample results are compared to see if the results for each are consistent with historical results, as well as with each other. There were several instances where the filtered and unfiltered results indicated that there might have been a problem with how the sample containers were labeled in the field. In these cases, results for inorganic analytes were higher in the filtered sample when compared to the

unfiltered sample collected at the same time from the same location. In each case, the samples were examined at the laboratory to determine if it was possible to tell if the samples were filtered or unfiltered. In those cases where it appeared that an error was made, the data were rejected during data validation due to the possibility of a field sampling error.

There was also a continuing issue with bottle breakage during shipping. In many cases the sample loss was due to the sample container lid coming off during shipping. After investigation, it was decided to discontinue the use of the containers with large lids that were causing the problem. Once the container issue was addressed, the loss of samples was reduced significantly. Since the samples were lost, there are no data reported for the sample containers that were broken. For most locations affected by this issue, the missing analyses were covered by samples collected during subsequent sampling events.

On the whole, the equipment and field blanks and field duplicates were satisfactory, indicating no significant handling issues from sampling and analyses.

4. QA of Analytical Laboratory Results

We verify that analytical data used to support monitoring activities are defensible and of known quality. Analytical data packages 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 in the Data Supplement list qualifier and validation flag codes that accompany 2004 sediment and water data.

Analytical Quality Associates, Inc. (AQA) validated all of the 2005 data packages. Individual validation memos were issued for each analytical fraction 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.

When documentation or contract-compliance problems are identified during data validation, the analytical services laboratory is contacted and attempts are made to resolve or clarify the problem. In 2005, this process required the largest analytical services provider, General Engineering Laboratories (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 data packages. GEL reissued corrected documents for all of the reports containing missing documentation or erroneous data. All NCRs were successfully closed.

In addition to routine review of data packages, analytical laboratory oversight includes audits, site visits, and conference calls to review general laboratory quality practices. Problems identified during these processes normally require the laboratory to take a formal corrective action. All requested corrective actions for 2005 were completed.

a. Radiological Data

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, we report them as they are received from the analytical laboratory as required by the "Environmental Regulation 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 that case, a detected result is reported when analytical results are greater than three times the reported (one sigma) uncertainty.

b. Nonradiological Data

For organic compounds and some general inorganic chemistry (that is, major anions, cations, and nutrients) parameters, 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. In some cases, nonradiological results are reported at levels down to the laboratory-derived MDL. Data between the MDL and PQL are qualified as estimated by the analytical laboratory. The analytical laboratory reports results below the MDL as nondetections.

c. Detection-Limit Issues

The SOW requires that analytical laboratories verify their calculated MDLs empirically. Federal regulations prescribe a process for determining analytical laboratory detection limits which uses standards based on deionized water. For analysis of environmental samples, these detection limits may not be achievable. The additional constituents present in natural water samples may lead to matrix interference in the analytical process, which decreases the method sensitivity. Comparison of results from these analyses to 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.

5. Field Data Results

The water sampling group developed a procedure to address the requirements for measurement of field parameters. This procedure was implemented on July 29, 2005.

6. Analytical Laboratory Assessment

A data package assessment was conducted at GEL on November 14 through 17, 2005. The assessment included data package completeness, documentation of the analytical work, instrument calibration and calibration checks, method quality control, secondary reviews and QA oversight, sample receiving and custody, holding times, use of appropriate methods, calculation review, and sample preparation. Ancillary records reviewed in support of the assessment include analyst proficiency training, standards preparation and traceability, calibrations not included in the data package, holding blanks, electronic files, laboratory performance evaluation samples, and any non-conformances and corrective actions associated with the report. Additionally, contractual compliance with the DOE-AL Model, LANL, Sandia National Laboratory, and Pantex site SOWs was reviewed.

This data package assessment included data packages for organic, radiochemical, and general inorganic analyses. All the files were retrieved quickly and contained all the required documentation except as noted in this report. There were nine items submitted for corrective action. GEL responded with corrective actions for all nine items on January 11, 2006.

a. Participation in Laboratory Intercomparison Studies

GEL is required by the SOW to participate in independent national performance evaluation programs. GEL participated in the EPA water supply and water pollution proficiency testing programs while those programs were in effect. GEL does continue to participate in the DOE Mixed Analyte Performance Evaluation Program (MAPEP) for radiochemistry, organic, and inorganic analyses. For 2005, GEL participated in 13 different performance evaluation studies that addressed a total of 2,110 parameters.

Results for the MAPEP are categorized as: (1) acceptable (result within the 2-sigma acceptance range), (2) acceptable with warning (result within the 3-sigma acceptance range), and (3) not acceptable (result outside the 3-sigma acceptance range). Participating analytical laboratories are required to initiate internal corrective actions when evaluation results are categorized as "not acceptable," and those corrective actions are spot-checked during various analytical laboratory oversight activities. A summary of performance evaluation program deficiencies is shown in Table 5-2 for the six parameters (three parameters in each of two evaluations) that were found deficient in the performance evaluation studies relevant to water and sediment analyses. All other water and sediment analytes not shown in the table were acceptable.

Table 5-2
Summary of Performance Evaluation Program Deficiencies for General Engineering Laboratories, LLC

	MAPEP-05-MaS13 (Soil Sample)	MAPEP-05-MaS14 (Soil Sample)
Antimony	Result not acceptable	Result not acceptable
Selenium	Result not acceptable	
Chromium	Acceptable with warning	Result not acceptable
Nickel-63		Acceptable with warning

MAPEP-05-MaS13: The evaluation report determined that GEL incorrectly detected selenium at 1.35 mg/kg. possibly due to enriched Kr in the sample. GEL received a letter of concern for the repeated failure of antimony in soil performance evaluation samples. The reported value was 8.68 mg/kg and reference value was 30.9 mg/kg. GEL is working to resolve the consistent low recoveries of antimony in soils.

MAPEP-05-MaS14: The report indicated that GEL has a high bias for chromium results. Reference value for chromium was 34.1 mg/kg and the reported value was 46.0 mg/kg. There was a low bias for antimony. Reference value for antimony was 51 mg/kg and the reported value was 16.4. Since GEL failed to meet both chromium and antimony acceptance criteria, they have digested the sample following 3050 section 7.5 and had acceptable results for chromium and antimony.

7. Program Audits and Assessments

The environmental division retained Time Solutions Corporation to perform an independent assessment of the Environmental Characterization and Remediation Group and the Water Quality and Hydrology Group that formerly managed environmental restoration and groundwater monitoring. The assessment was conducted in August and September of 2005. Time Solutions observed that pre-sampling (planning) activities were inconsistently implemented within the water group. The sampling planning process was formalized and will be documented in project requirement documents.

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6. WATERSHED MONITORING

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A. INTRODUCTION

The Laboratory monitors the quality of surface water and stream sediments throughout northern New Mexico to evaluate the potential environmental effects of Laboratory operations. The Laboratory analyzes samples for several parameters, including radionuclides, high explosives, metals, a wide range of organic compounds, and general chemistry of surface water. In this chapter, we assess effects of Laboratory operations and evaluate any trends over time. We also compare the monitoring results with criteria established to protect human health and the aquatic environment.

For decades, this monitoring was conducted primarily to assess the radiological impacts from the Laboratory. During this time, monitoring of the non-radiological impacts has increased. Much of the current non-radiological monitoring of surface water is determined by recent agreements with federal and state regulatory agencies. The result of these agreements is more widespread monitoring of both perennial and ephemeral stream flows for an extensive list of constituents. Increased sampling of base flow has resulted from the New Mexico Environment Department (NMED) Compliance Order on Consent, discussed in Chapter 2. Increased sampling of storm runoff and snowmelt has resulted from the Federal Facility Compliance Agreement (FFCA) and Administrative Order (AO) (EPA 2005 a, b). Sampling is conducted at dozens of new locations. The total surface water monitoring effort has yielded a substantial amount of water quality data. While data collected for the FFCA and AO are published elsewhere (LANL 2006), we summarize the results in this chapter for 2005.

B. HYDROLOGIC SETTING

Watersheds that drain Laboratory property are dry for most of the year. No perennial surface water extends completely across Laboratory land in any canyon. The canyons consist of over 85 miles of watercourses located within the Laboratory and immediately upstream of the Laboratory within Los Alamos Canyon. Of the 85 miles of watercourse, approximately two miles are naturally perennial, and approximately three miles are perennial waters created by effluent.

The remaining 80 or more miles of watercourse are dry for varying lengths of time. The driest segments may flow in response only to local precipitation or snowmelt, and the streambed is always above the water table. The flow in these streams is ephemeral. Other streams may sometimes have the water table higher than the streambed and/or extensive snowmelt in the watershed and are said to be intermittent. Intermittent streams may flow for several weeks to a year or longer. To aid in water quality interpretation, we divide stream flow into three types or matrices. Each of the three flow types might be collected at a single location within a time span of as little as a week, depending on weather conditions. At times, the flow might represent a combination of several of these flow types.

The three types are

- Base flow—persistent stream flow, but not necessarily perennial water. (This stream flow is present for periods of weeks or longer. The water source may be effluent discharge or shallow groundwater that discharges in canyons.)
- Snowmelt—flowing water present because of melting snow. (This type of water often may be present for a week or more and in some years may not be present at all.)
- Storm 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 is present for extended periods of time, it is available for potentially longer-term exposures, such as wildlife watering. While storm runoff or snowmelt may provide a short-term water source for wildlife, that water is a principal agent for moving Laboratory-derived constituents off-site and possibly into the Rio Grande.

None of the streams within Laboratory boundaries average more than one cubic ft 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. By comparison, flow in the Rio Grande commonly averages approximately 800 to 1,000 cfs. Although most of the watercourses at LANL are dry throughout the year, occasional floods can redistribute sediment in a streambed to locations downstream from where a release or spill occurs.

Runoff was slightly above normal in 2005, primarily because of a heavy snowpack that created a large snowmelt runoff from February through May. Summer precipitation in 2005, following six consecutive years of below average amounts, was similar to the average of pre-Cerro Grande fire years, 1995 through 1999. Snowmelt runoff extended across the Laboratory in all major canyons and totaled about 1175 ac-ft at the downstream stations. Total storm runoff volume in 2005, at downstream gages in the watersheds crossing LANL lands, was higher than the two previous years, primarily due to three large runoff events in August and September. Flow volumes in lower Pueblo Canyon were approximately equal to that of the other LANL canyons combined, similar to the pre-fire conditions (Gallaher and Koch 2005). The largest peak runoff event for the year was recorded in Pueblo Canyon on August 14, 2005, at 116 cfs (Shaull et al. 2006), significantly smaller than previous peak flows recorded since the Cerro Grande fire. Hydrologic conditions in all LANL canyons and in Pueblo Canyon have recovered to near pre-fire levels. However, recovery after the fire has been somewhat counteracted in upper Pueblo Canyon by urbanization. The increased pavement and roofs shed more local precipitation into the canyon.

The large snowmelt caused continuous stream flow in Los Alamos Canyon extending from the Jemez Mountains, across the Laboratory, and into the Rio Grande. Continuous flow fed by snowmelt was present for approximately four months, from February through May. The total quantity of snowmelt measured in Los Alamos Canyon at the Laboratory's eastern boundary was approximately 710 ac-ft and 680 ac-ft at the confluence with the Rio Grande.

C. SURFACE WATER AND SEDIMENT STANDARDS

Table 6-1 summarizes the standards used to evaluate the monitoring data. The suite of standards varies, depending on the stream flow conditions and established or potential uses. To evaluate Laboratory impacts, we compare analytical results for surface water and sediment samples with regulatory water quality criteria or with risk-based screening levels.

1. Applicable New Mexico Surface Water Standards

The New Mexico Water Quality Control Commission (NMWQCC) establishes surface water standards for waters of the state 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., livestock watering, aquatic life) for the surface water. Nonclassified surface waters are 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.

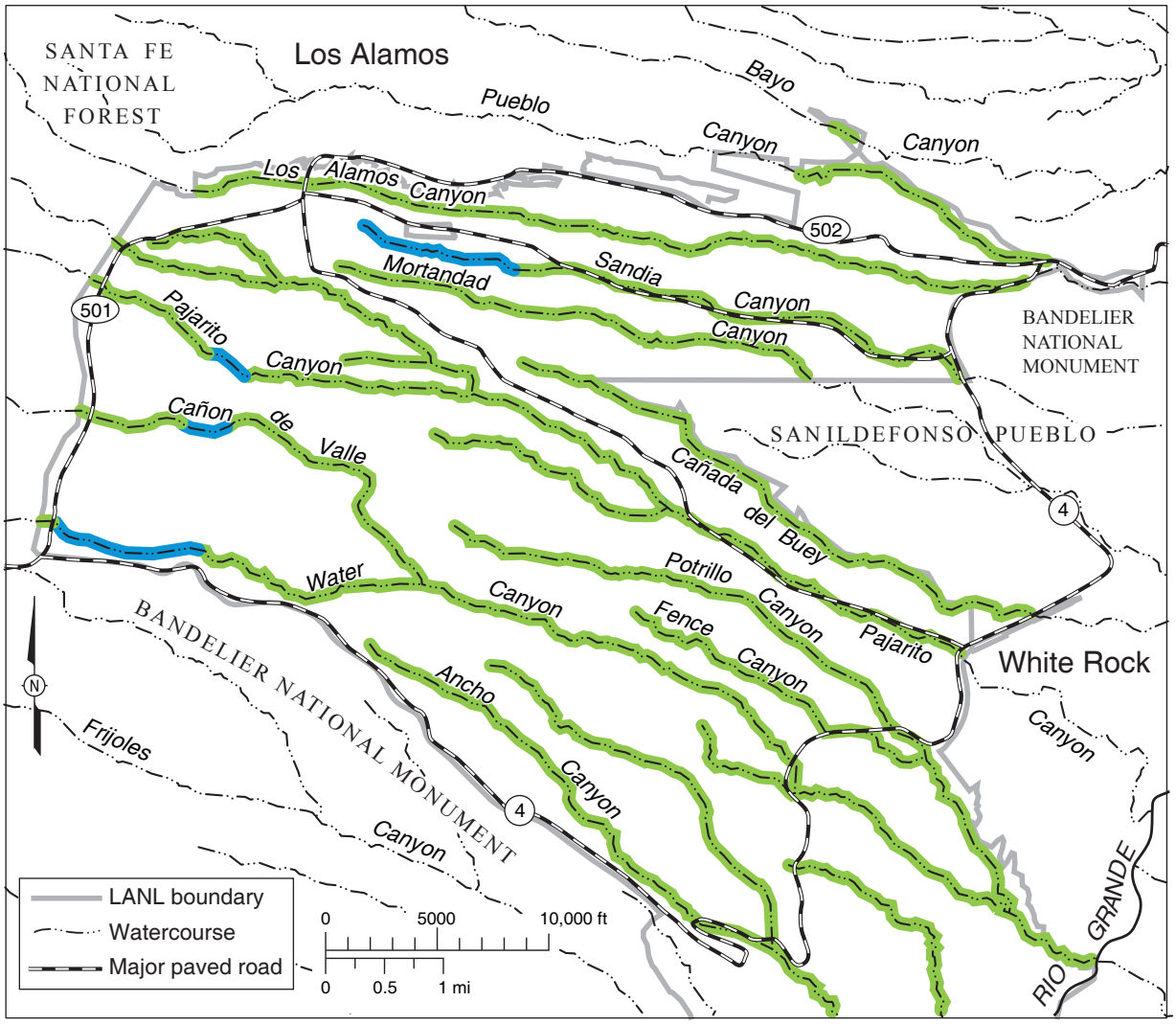
Table 6-1
Application of Surface Water Standards and Sediment Screening Values to Monitoring Data

Medium	Standard	Risk- or Dose-Based Screening Level	Reference	Location	Notes
Surface water					
Radionuclides		Biota Concentration Guides	DOE Technical Standard	On-site and off-site	Surface waters are present sporadically or are not available for long-term access and do not provide persistent drinking water. The actual exposure pathway is to plants/animals, and not to humans. BCGs 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 based on time-weighted average over the year per DOE Order 5400.5 and 20.3.4 NMAC.
		New Mexico Radiation Protection Regulations	20.3.4 NMAC		
	State water quality standards for surface water		20.6.4 NMAC	On-site and off-site	Based on the protection of livestock watering for Ra-226 + Ra-228, tritium, and gross alpha radiation. NMWQCC standards are not specific about exposure frequency or duration; for screening purposes, compare single sample results with numeric criteria.
Non-radionuclides	State water quality standards for surface water		20.6.4 NMAC	On-site ephemeral, intermittent streams	Single sample results are compared with numeric water quality criteria corresponding to livestock watering, wildlife habitat, and limited aquatic life standards (including acute aquatic life and human health criteria for persistent pollutants).
				On-site perennial streams	Single sample results are compared with numeric water quality criteria corresponding to livestock watering, Wildlife Habitat, and coldwater aquatic life standards (including chronic aquatic life and human health criteria). For screening purposes, single sample results are compared with 1.5 times the chronic aquatic life criteria (NMED 2006a).
				Off-site	Single sample results are compared with numeric water quality criteria corresponding to designated uses contained in NMWQCC water quality standards.
	State water quality standards for ground water		20.6.2 NMAC	On-site and off-site	Single sample result comparisons with groundwater quality criteria are used to determine potential for stream flows to impact underlying bodies.

Table 6-1 (continued)

Medium	Standard	Risk- or Dose-Based Screening Level	Reference	Location	Notes
Sediments					
	None	Human health screening levels	LANL	On-site and off-site	Screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public; comparisons are made for recreational or industrial exposure parameters; based on a dose rate limit 15 mrem/year (LANL 2005). Recreational levels are appropriate for Laboratory lands because of public access. There are no residential uses of LANL lands and residential use is impractical at most locations (e.g., many canyon bottoms)
Radionuclides		Biota concentration guides	DOE technical standard	On-site and off-site	Dose limit to biota same as for surface water. Individual results compared to BCGs.
		Background	LANL or McLin (2004)		We compare results from Pajarito Plateau stations to plateau-specific background levels (LANL 1998). Results from regional stations are compared to background levels specific to the major rivers within the Rio Grande drainage system (McLin 2004).
	None	Screening levels	NMED, EPA Region VI, or LANL	On-site and off-site	Recreational or industrial screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public.
Non-radionuclides		Background	LANL or McLin (2004)		We compare results from Pajarito Plateau stations to plateau-specific background levels (LANL 1998). Results from regional stations are compared to background levels specific to the major rivers within the Rio Grande drainage system (McLin 2004).

Significant changes were made in the NMWQCC stream standards that became effective July 17, 2005. The most significant change, with respect to surface water monitoring at the Laboratory, is the classification of all surface waters with segment-specific designated uses within the Laboratory boundary. Four segments, with designated uses of coldwater aquatic life, livestock watering, wildlife habitat, and secondary contact, are classified as perennial (Figure 6-1). The remaining segments, with designated uses of limited aquatic life, livestock watering, wildlife habitat, and secondary contact, are classified as ephemeral or intermittent.



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 6-1. Designated stream segments and uses at Los Alamos National Laboratory.

The 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 boundaries where the potential is greater for more direct use of the water. Stream flows may extend onto Pueblo de San Ildefonso tribal land. Spring water may be used traditionally and ceremonially by San Ildefonso tribal members, and uses may include ingestion or direct contact.

2. Radionuclides in Surface Water

There are no drinking water systems on the Pajarito Plateau that rely on surface water supplies because of the limited extent of stream flow. The emphasis of our radiological assessment of surface water is, therefore, on potential exposures to aquatic organisms and terrestrial plants and animals, rather than to humans. For protection of biota population, we compare concentrations of radionuclides in surface water with the DOE Biota Concentration Guides (BCGs; DOE 2002). Comparison of water quality results to BCGs is done based on annual flow-weighted radionuclide content of the water rather than on individual samples. We also compare surface water results with the NMWQCC water quality 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; for screening purposes, we compare single sample results with numeric criteria for Ra-226 + Ra-228 and tritium, as discussed in Section 3 below.

3. Gross Alpha in Surface Water

The NMWQCC livestock watering standard includes a numeric criterion for adjusted gross alpha. Adjusted gross alpha means the total alpha radioactivity, excluding that arising from radon-222, uranium, and (as defined by the Atomic Energy Act) source, special nuclear, and by-product material (NMWQCC 2005). Monitoring results of storm runoff after the Cerro Grande fire have shown widespread gross alpha activities greater than the 15 pCi/L livestock watering criterion. In response to these findings, the NMED designated several Los Alamos area drainages as water-quality impaired and added them to the federal Clean Water Act §303(d) list (NMWQCC 2004). The affected drainages with heightened gross alpha activities are Guaje Canyon, Pueblo Canyon, Los Alamos Canyon, Mortandad Canyon, Pajarito Canyon, and Water Canyon. In the 2002 and 2003 surveillance reports, we showed that the gross alpha activities generally correspond to the suspended sediment concentrations, and upstream gross alpha activities were comparable to on-site gross alpha activities and largely were due to the natural radioactivity in the surface sediments. This natural alpha radioactivity arises from the presence in the sediment material of naturally occurring uranium, thorium, and members of their decay chains. The 2005 gross alpha activities also correspond to sediment concentrations. The upstream gross alpha activities have declined substantially as stream flows are reduced with recovery in the burned areas, which has resulted in reduced concentrations of suspended solids. Although gross alpha activities have progressively declined since the Cerro Grande fire, about 60 percent of the surface water samples collected in 2005 contained adjusted gross alpha activities greater than the 15 pCi/L livestock watering criterion. 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, we do not discuss gross alpha results in detail in this report. Instead, we emphasize the concentrations measured for specific individual radionuclides identified in LANL waste streams (Watkins and Del Signore 2005) or known to be associated with the nuclear industry (Langmuir 1997). A listing of gross alpha concentrations measured in surface water is provided in Supplemental Table S6-1.

4. Nonradioactive Constituents in Surface Water

We compare surface water concentrations of nonradioactive constituents with the NMWQCC (2005) numeric water quality criteria that correspond to the designated uses for the stream. All surface waters within the Laboratory boundary have the designated uses of livestock watering and wildlife habitat. For classified ephemeral and intermittent watercourses, the limited aquatic life use applies, along with the acute (short-term) aquatic life criteria and the human health criteria for persistent pollutants. The NMWQCC human health criteria are based on the US Environmental Protection Agency (EPA) criteria for "consumption of organisms only." Within the classified perennial waters, the coldwater-designated use applies, together with both the acute and chronic (long-term) aquatic life criteria and the human health criteria for toxic pollutants, including persistent and carcinogenic pollutants. Hardness-dependent aquatic life numeric criteria are calculated using a water hardness value of 100 mg $CaCO_3$/L.

For evaluating the potential impact of chronic exposure to surface water constituents on aquatic life, we adopt the protocol employed by the NMED for assessing standards attainment in waters of the state (NMED 2006a). For designated perennial stream segments, single sample results are compared with the chronic screening level that is 1.5 times the chronic aquatic life criterion. Surface water quality results are lastly compared with the NMWQCC groundwater standards to evaluate the potential for stream flows to impact underlying groundwater bodies (NMWQCC 2002).

5. Sediments

We screen sediment results to screening levels to identify concentrations of a constituent that may require further assessment. The Laboratory's Environmental Remediation and Surveillance Program uses residential, industrial worker, or recreational screening action levels (SALs) to identify radionuclide activity levels of interest (LANL 2005). Comparisons with SALs are used to readily distinguish the areas with the most potential concern: concentrations below the SALs are not of concern to public health, whereas concentrations greater than the SALs would trigger more detailed investigations. Only industrial worker or recreational screening levels for radionuclides are applicable on Laboratory land. At present, industrial and recreational are the only uses of Laboratory land. Concentrations of nonradioactive compounds in sediments are compared with recreational or industrial soil-screening levels developed by NMED (2006), EPA Region 6 (EPA 2005), or LANL (2005). All of these screening levels are conservative (protective) because they are calculated based on the assumption that humans will be exposed to the chemicals or radionuclides for extended periods of time, which is not the case on LANL property. For sediment stations located on the Pajarito Plateau we also compare sediment data with established plateau-specific background levels of metals or background activities of radionuclides that are naturally occurring or result from atmospheric fallout (LANL 1998) and other sources than LANL. Data from regional sediment stations are compared to background levels established for the major drainages of the area, the Rio Grande, Rio Chama, and Jemez River (McLin 2004).

D. SAMPLING LOCATIONS AND DATA ANALYSIS METHODS

1. Regional Monitoring Locations

Regional base flow and sediment sampling stations (Figure 6-2) are located in northern New Mexico. Samples from regional stations reflect background concentrations and provide a basis for evaluating Laboratory impacts to the Rio Grande drainage system. We obtained regional sediment samples from stations on the Rio Grande and the Jemez River, 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 60 km upstream of the Laboratory.

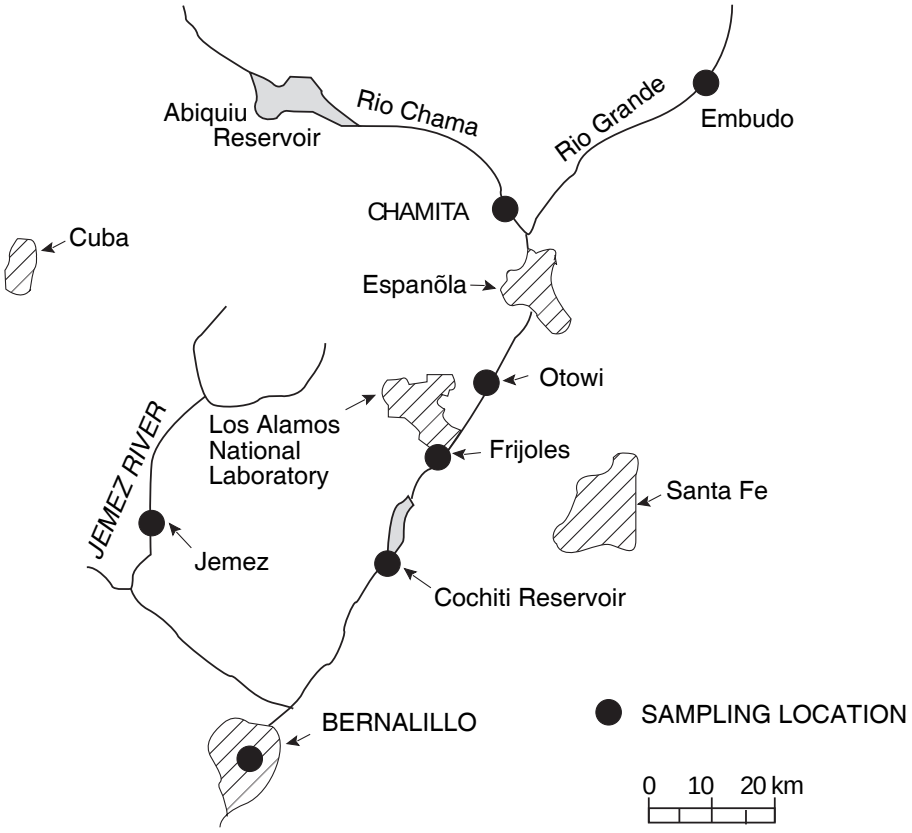


Figure 6-2. Regional base flow and sediment sampling locations.

2. On-Site and Perimeter Monitoring Locations

We sample surface water and sediments in all major canyons that cross current or former Laboratory lands. Stream sediments are sampled to evaluate any accumulation of undissolved contaminants in the aquatic environment (DOE 1991). Surface water samples are collected across the Pajarito Plateau within and near the Laboratory, with particular emphasis placed on monitoring at the Laboratory boundaries. We collect base-flow grab samples from locations where effluent discharges or natural springs maintain stream flow (Figure 6-3).

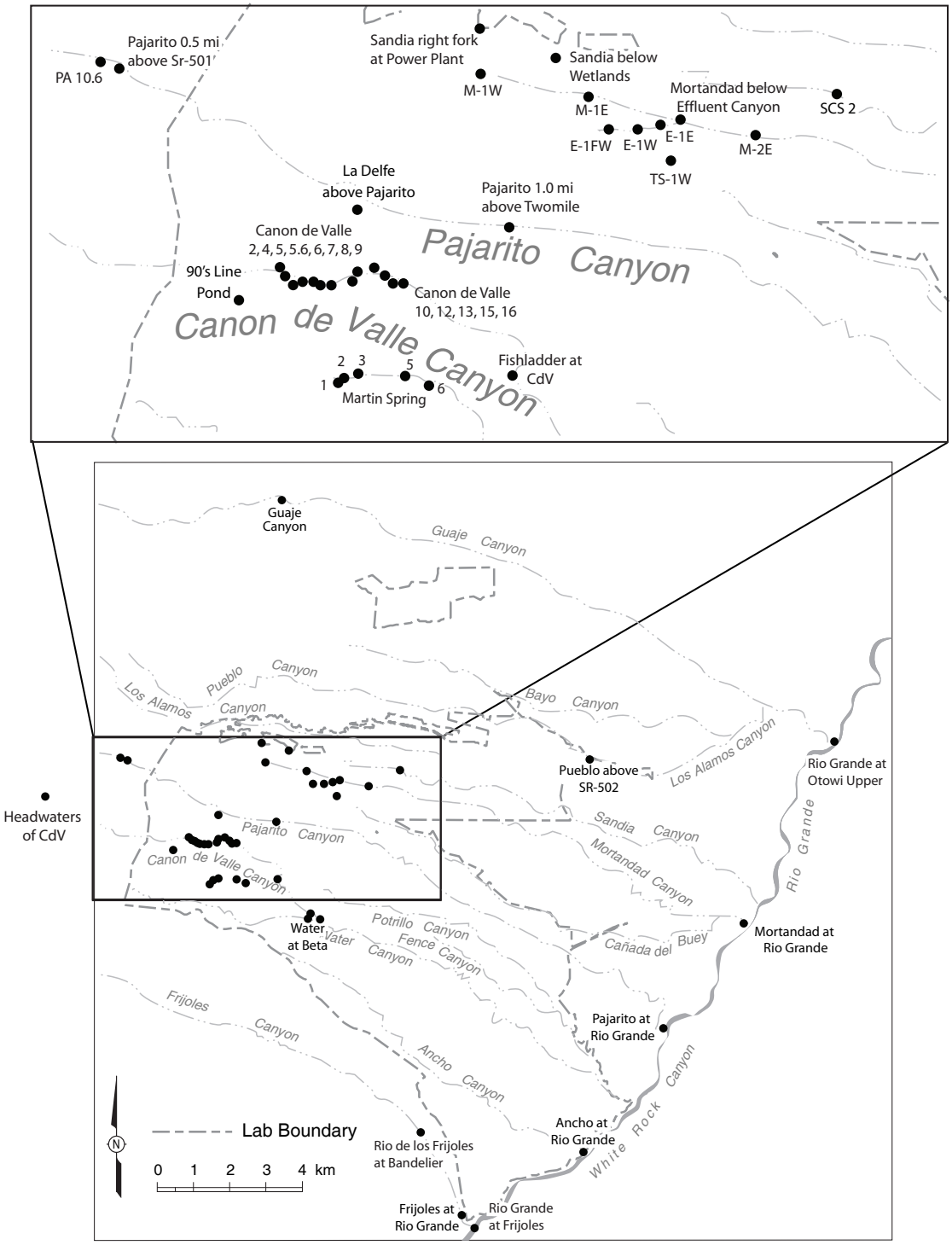


Figure 6-3. Base flow sampling locations in the vicinity of Los Alamos National Laboratory.

Storm runoff samples in watercourses are collected using stream-gaging stations with automated samplers (Figure 6-4). Many gaging stations are located where drainages cross the Laboratory's boundaries. We also sample storm runoff at many mesa-top sites that allow us to target specific Laboratory activities (Figure 6-5). These sites usually have negligible runoff from other sources.

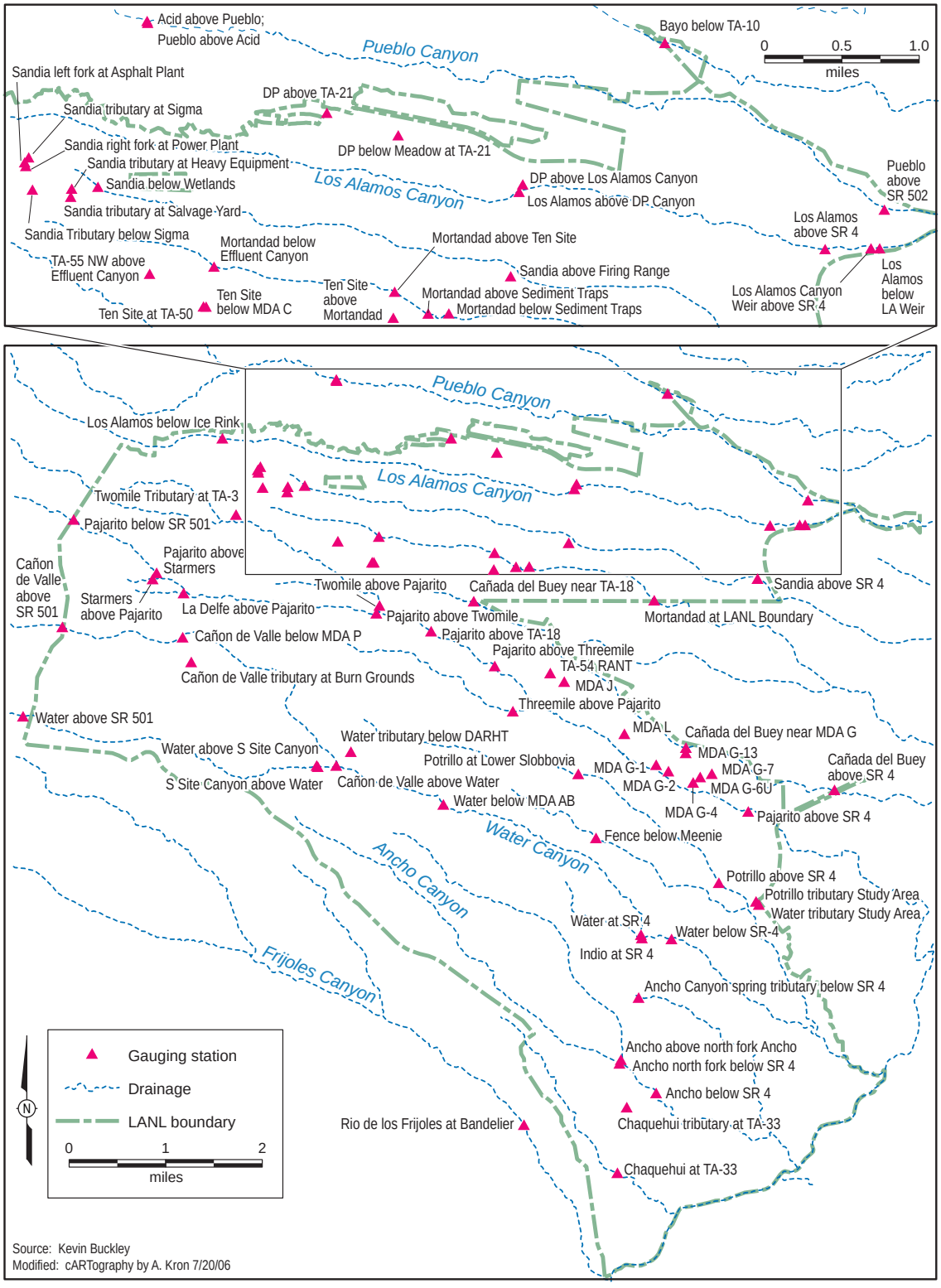


Figure 6-4. Storm runoff sampling (gage) stations in the vicinity of Los Alamos National Laboratory.

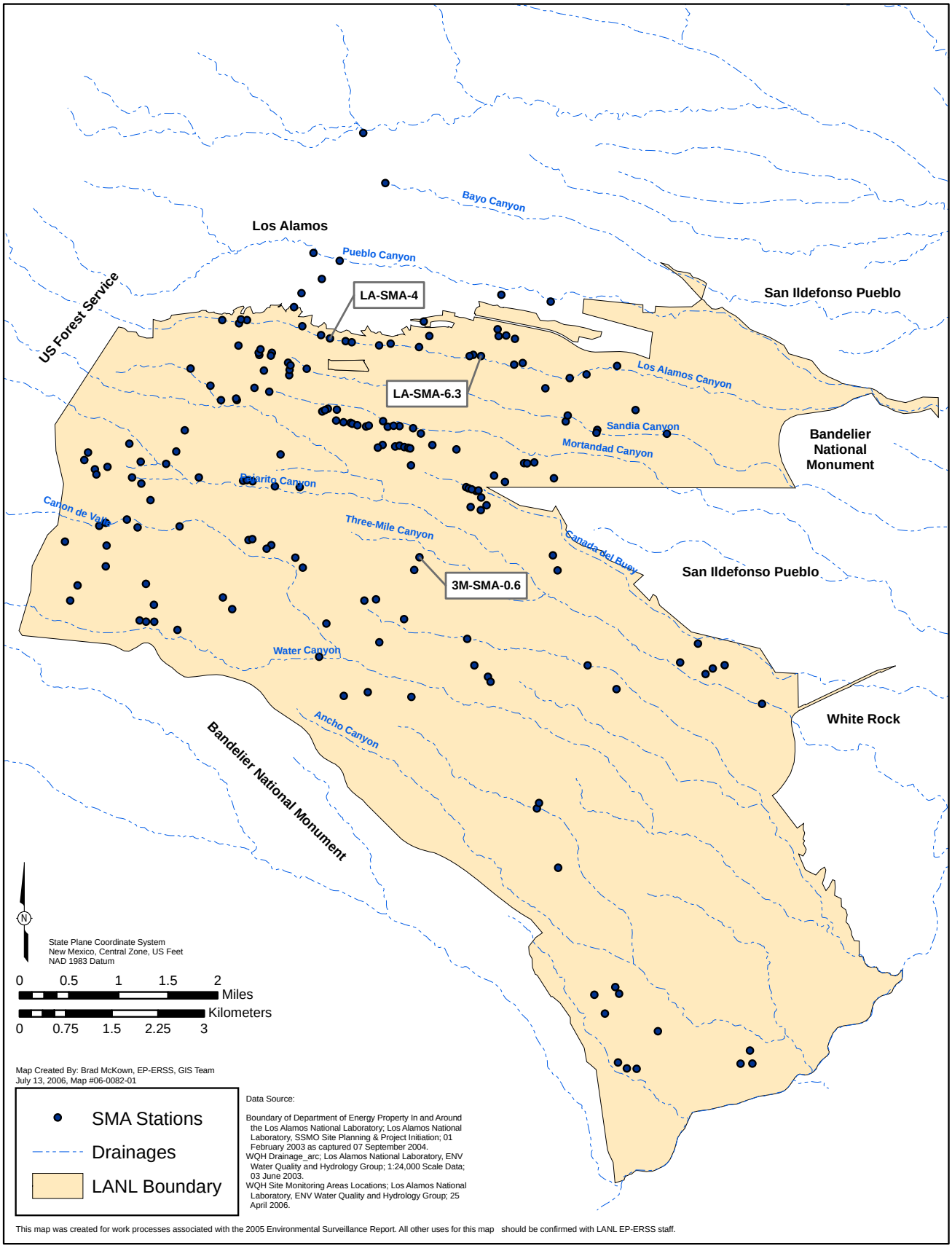


Figure 6-5. Site-specific storm runoff sampling stations in the vicinity of Los Alamos National Laboratory.

Sediment stations on the Pajarito Plateau (Figure 6-6) are located within approximately 4 km of Laboratory boundaries, with the majority located within Laboratory boundaries. Many of the sediment-sampling stations on the Pajarito Plateau are located within canyons to monitor sediment contamination in the active channel related to past and/or present effluent release sites. We sampled three major canyons in 2005 (Pueblo, Los Alamos, and Mortandad) that have experienced past or present liquid radioactive releases; samples are collected from upstream of the Laboratory to their confluence with the Rio Grande.

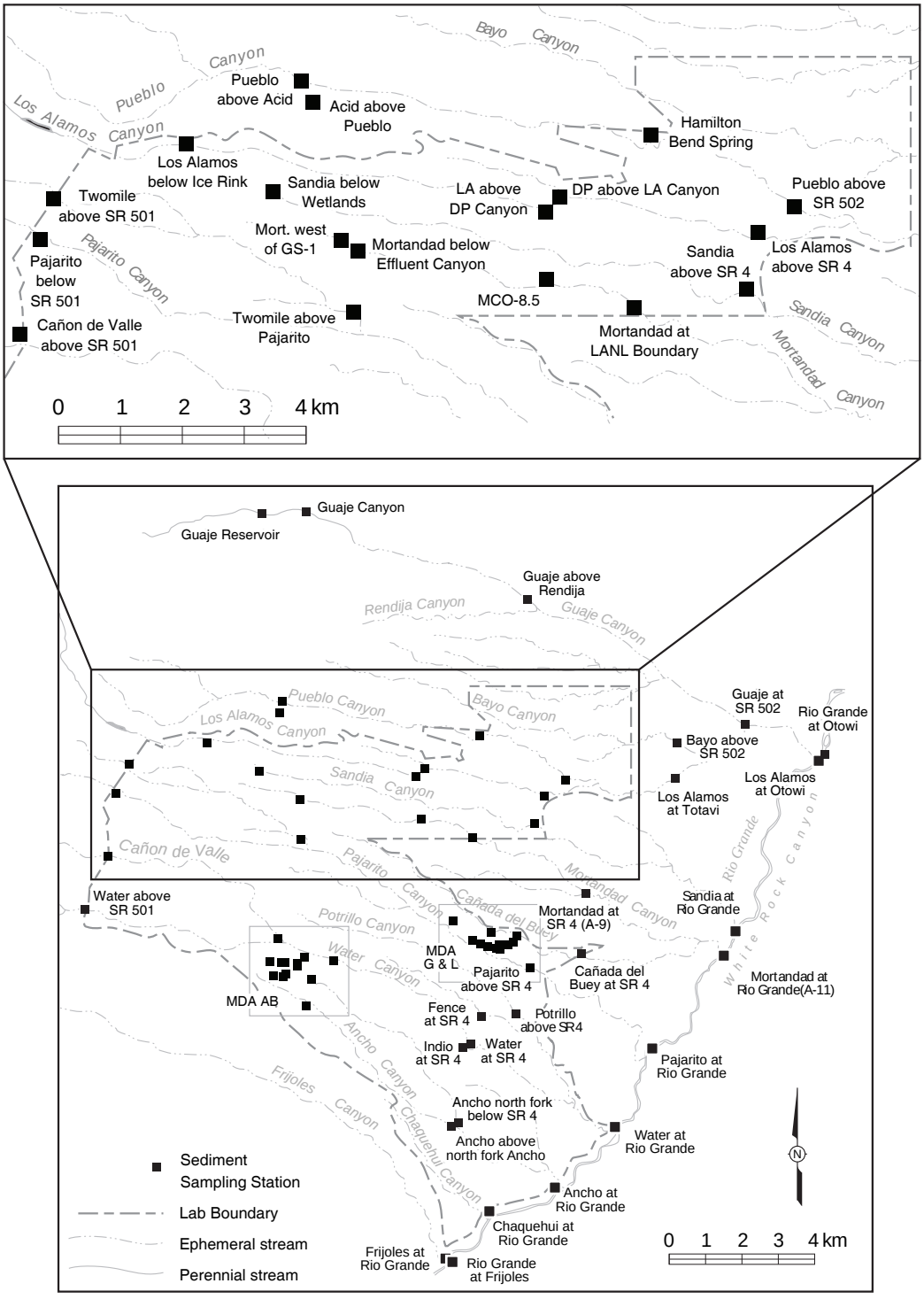


Figure 6-6. Sediment sampling locations in the vicinity of Los Alamos National Laboratory. Material disposal areas with multiple sampling locations are shown in Figures 6-7 and 6-8.

We collected sediments from drainages downstream of two material disposal areas (MDAs), MDA G and MDA AB. Material Disposal Area G at Technical Area (TA)-54 is an active waste storage and disposal area. Nine sampling stations were established outside its perimeter fence in 1982 (Figure 6-7) to monitor possible transport of radionuclides from the area. Material Disposal Area AB at TA-49 was the site of underground nuclear weapons testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). The tests involved high explosives (HEs) and fissionable material insufficient to produce a nuclear reaction. We established 11 stations in 1972 to monitor surface sediments in drainages adjacent to MDA AB (Figure 6-8).

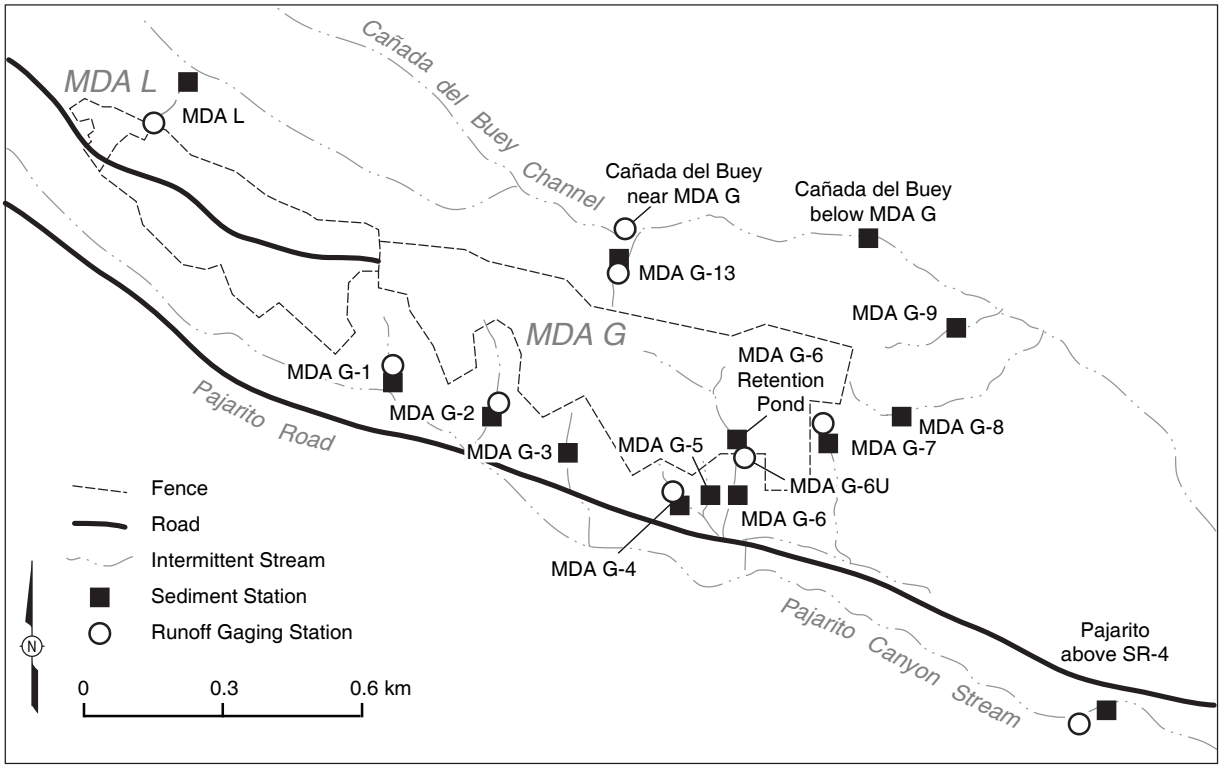


Figure 6-7. Sediment and storm runoff sampling stations at TA-54, MDA L, and MDA G.

We also sample surface water and sediments at several locations on San Ildefonso Pueblo lands. DOE entered into a Memorandum of Understanding with the Pueblo and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on pueblo land. The watershed drainages that pass through LANL onto Pueblo lands are Los Alamos/Pueblo, Sandia, Mortandad, and Canada del Buey Canyons.

3. Sampling and Analysis Procedures

Our procedures for sampling and analysis depend on the type of stream flow and location. We collect grab samples of base flow and snowmelt runoff from free-flowing streams near the bank. We filter and preserve grab samples in the field. The storm runoff (gage) stations, located mostly in canyon bottoms, are equipped with automated samplers that are activated at the start of significant flow events. Typically, the automated samplers collect water from the first 30 minutes of the runoff event to sample the first flush of storm water. This is the second year that we have sampled the first flush and it is a significant change from previous years. Previously, we sampled over a two-hour period. We expect higher concentrations in the first flush compared to the average concentration during a flow event, so the 2004 and 2005 data are not directly comparable to data from previous years.

Storm runoff samples from mesa tops are collected with buried single-stage runoff samplers. Individual storm runoff sample bottles are shipped to the commercial analytical laboratory as is, without compositing or splitting. The analytical laboratory filters and preserves runoff samples because filtering highly sediment-laden waters in the field is difficult.

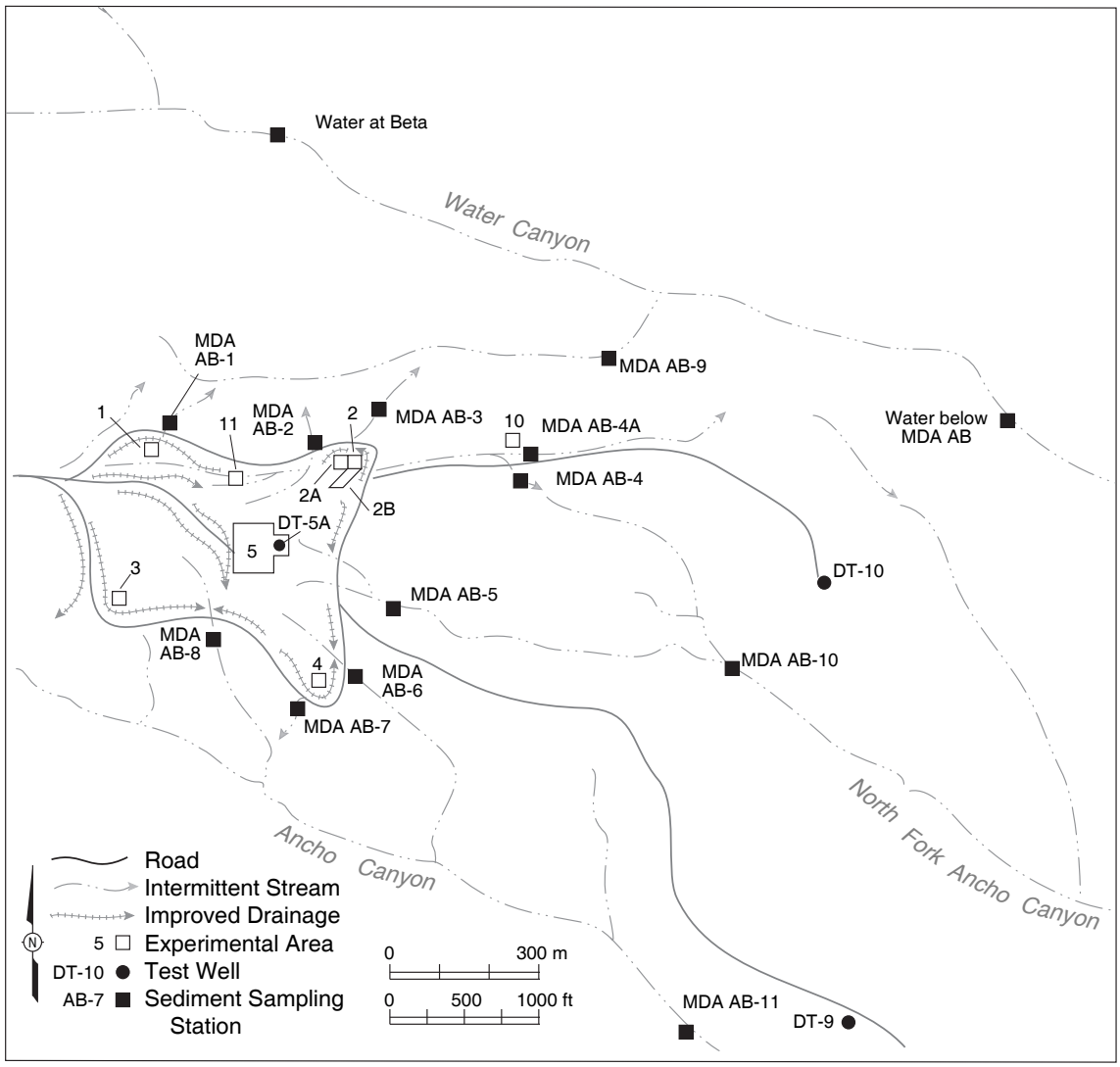


Figure 6-8. Sediment sampling stations at Area AB, TA-49.

We collect sediment samples from edge of the main channels of flowing streams. To collect samples from the beds of intermittently flowing streams, we use a disposable scoop to collect fine-textured sediment across the main channel to a depth of 20 mm.

4. Contaminant Maps

We reviewed recent watershed monitoring results to develop a broad picture of key analytes that reflect possible effects from Laboratory operations. Most of the above-background results for surface water were found in storm runoff samples. We prepared a series of maps to show general patterns of where potential contamination from Laboratory operations was measured in surface water or sediment during 2005. To add confidence to the 2005 results, we also considered previous sampling results in the development of the maps. When the same pattern showed up in several samples within part of a canyon, we highlighted that area on the maps.

We prepared separate maps for sediments and for storm runoff, although they often show similar distribution for a constituent. Because of the lack of flow, storm runoff data are sparse in some parts of the Laboratory. The maps show analytes that are widely distributed, possibly affecting an entire watershed, and may not show localized contamination. The maps are presented later in this chapter.

The maps show contaminant distributions extrapolated beyond the area covered by monitoring locations. This extrapolation takes into account the location of contaminant sources and direction of sediment and surface

water movement. Question marks on the maps indicate where contaminant extent is inferred, but not confirmed by monitoring coverage, or they indicate locations where analytical measurements indicate detections that are contradicted by other measurements. Along canyons, the extent of contamination lateral to the canyon is diagrammatic: contamination is quite narrow at the map scale.

E. 2005 WATERSHED MONITORING DATA TABLES

The supplemental data tables contain all the 2005 watershed-related surface water and sediment analytical results, with one general exception. Storm runoff results from the FFCA monitoring program were separately published (LANL 2006) and thus are not included in the supplemental data tables; this mainly includes trace metals and organic compounds in runoff. In the supplemental data tables, radiological results are presented in sequence for each of these media, followed by the results for major chemical quality analytes, trace metals and minor constituents, and organic compounds.

Surface water and sediment samples are analyzed for gross alpha, gross beta, and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, uranium isotopes, and tritium, cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22). Table S6-1 in the Data Supplement lists the results of radiochemical analyses of surface water for 2005. The tables also list the total propagated one-sigma analytical uncertainty and the analysis-specific minimum detectable activity, where available. Uranium was analyzed by isotopic methods. For most radionuclide measurements, a detection is an analytical result that does not include an analytical laboratory (or in some cases, secondary validation) qualifier codes of X or U (indicating nondetect). Trace-level tritium measurement results for base flow samples are presented in Table S6-2. The results of radiochemical analyses of sediments appear in Table S6-3. Table S6-4 lists radiological detections for results that are higher than river or reservoir sediment background levels and identifies values that are near or above SALs.

Concentrations of major chemical constituents in base flow are listed in Table S6-5. Table S6-6 and S6-7 present results of metals analyses for base flow and sediments, respectively.

The scope and results of organic analyses are presented in Table S6-9 through S6-12. Table S6-9 presents the number and type of organic analyses performed on base flow samples, and Table S6-10 presents results for any organic compound detected in base flow. Similarly, Tables S6-11 and S6-12 present summaries of organic analyses of stream sediments.

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).

F. 2005 WATERSHED MONITORING FINDINGS

The overall quality of most surface water in the Los Alamos area is good, containing low levels of dissolved solutes. Of the more than 200 analytes measured in sediment and surface water within the Laboratory, most are at concentrations far below regulatory standards or risk-based levels. However, nearly every major watershed indicates some effect from Laboratory operations, often for just a few analytes. This section first presents a Laboratory-wide overview on how surface water quality compares to DOE and New Mexico regulatory standards or guidelines, and then discusses in more detail the key findings on a watershed-by-watershed basis.

1. Comparison to DOE Radiological Guides

Table 6-2 compares the annual average concentrations of radioactivity in surface waters at Los Alamos against the DOE's BCGs. In order to compare surface water sample results with the DOE BCGs, we calculated the time-weighted average annual radioactivity in waters, focusing on the wetter stream segments. Time-weighted average concentrations were calculated for the individual radionuclides of primary concern on the landscape at Los Alamos: americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, tritium, and several uranium isotopes. Concentrations measured during base flow periods and during storm runoff periods were weighted proportionally after reviewing stream flow records (Shaull et al. 2006) to distinguish the flow regimes; periods with no flow were assigned concentrations of zero.

Table 6-2
Comparison of Estimated Annual Average Unfiltered Surface Water Concentrations of Radionuclides in Selected Canyons with the Biota Concentration Guides (pCi/L)

Radionuclide	BCGs[a]	Pueblo above Acid	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon at Skate Rink	LA Canyon between DP and SR-4	LA Canyon at Rio Grande	Mortandad Canyon below Effluent Canyon	Pajarito Canyon above SR-4	Max percent of BCG[a]
Am-241	400		0.4	0.02		3.3	0.1	5.1		1%
Cs-137[b]	20,000	3		2	11	24		20		0.1%
H-3	300,000,000	161			131			237		0.0%
Pu-238	200	0.08		0.06		0.17		2.1		1%
Pu-239,240	200	0.1	11	0.4	0.1	2.5	0.4	2.9		1%
Sr-90	300	0.5	0.4	3.5	0.3	1.7	2.0	3.4	0.4	1%
U-234	200	5.6	1.7	1.9	1.3	7.9	3.4	2.0	0.1	4%
U-235,236	200	0.6	0.1	0.1	0.1	7.1	0.3	1.1		4%
U-238	200	2.4	1.6	1.8	1.4	0.5	3.3	1.9	0.1	2%
Sum of ratios to BCGs		0.05	0.07	0.03	0.02	0.11	0.04	0.07	0.00	

[a] BCG = DOE Biota Concentration Guides (DOE 1992).
[b] The BCG for Cs is a site-specific modified BCG from McNaughton 2005.
Blank cells indicate no analytical laboratory detection in 2005.

This approach is consistent with DOE guidance (DOE 2003). For waters containing more than one radionuclide, a ratio for each radionuclide is calculated 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. Because the calculations are often based on limited sample sets and hydrologic interpretation, these results should be viewed as approximations.

The time weighted annualized concentrations and sum of ratios, for unfiltered surface water in the major canyons were well below the BCGs. Table 6-2 shows that concentrations of all of the individual isotopes were less than 5 percent of their respective BCGs. When the mixtures of isotopes are considered, the largest sum of the ratios was found in the Los Alamos Canyon stream segment between DP Canyon and SR-4, at 11 percent of the standard.

2. Comparison to New Mexico Surface Water Quality Standards

The New Mexico Surface Water Quality Standards (NMWQCC 2005) vary across the Laboratory depending on the designated uses for a particular stream segment, as discussed in Section C.1. To evaluate how 2005 monitoring results compare to the state standards, we matched the applicable standards to results for each specific location. During the year, 580 sampling events were conducted at 169 locations. The monitoring included 86 site-specific (mesa top or hillside) sites and 79 watercourse (canyon floor) sites on the Pajarito Plateau. The FFCA testing program varied by watershed but surface water samples typically were tested for more than 100 analytes. FFCA runoff results (mainly metals and organic compounds) are reported elsewhere (LANL 2006). All other sample results are given in the supplemental tables.

We identified 16 analytes that were present at concentrations greater than water quality standards. Storm runoff accounted for the largest proportion of high concentrations, consistent with previous years. Generally, these concentrations reflect the large sediment load carried by the storm runoff events. In contrast, high concentrations in base flow or snowmelt samples were infrequent for most analytes. Figure 6-9 compares the frequency at which storm runoff and base flow/snowmelt results were greater than standards for these 16 analytes. Data for base flow and snowmelt were combined for this analysis because of their similarity in water quality (low sediment load) and flow duration (several weeks or longer).

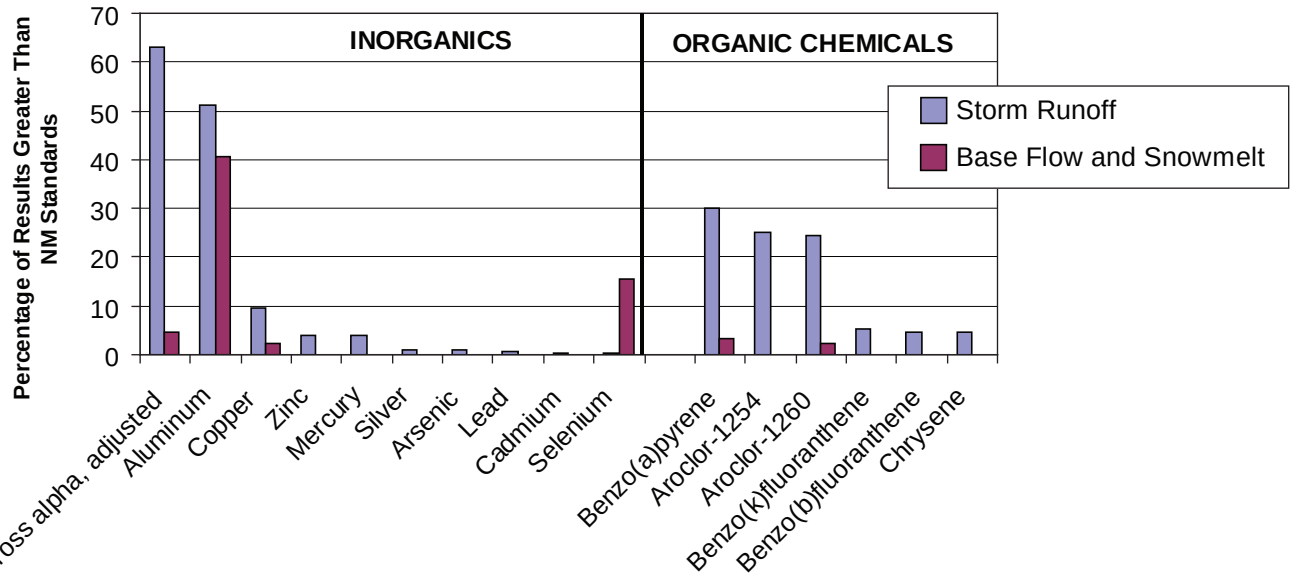


Figure 6-9. Frequency that storm runoff and base flow/snowmelt results were greater than New Mexico Water Quality Standards.

More than half of the storm runoff samples contained concentrations of adjusted gross alpha and aluminum that were higher than New Mexico standards for livestock watering (gross alpha) or aquatic life (dissolved aluminum). About 40 percent of base flow/snowmelt samples also contained concentrations of aluminum higher than aquatic life standards. Aluminum is a natural component of soil and not derived from Laboratory operations. The majority of the adjusted gross alpha activity is likely caused by suspended sediment made up of native soils and sediments, as activities from major Laboratory-associated radionuclides are not reflected in the adjusted gross alpha results (see discussion in Section C.3).

Approximately one-fourth of the storm runoff samples contained concentrations of PCBs (Aroclors 1254 and 1260) above human health and wildlife habitat standards. The PCBs are likely Laboratory-derived. These PCB concentrations reflect the large sediment load in a storm water runoff event and are due to their chemical affinity for the suspended sediment in the runoff. Frequent PCB concentrations above the standards were observed in Los Alamos and Sandia Canyons and at least one PCB detection was observed in nearly all sampled watersheds. Storm runoff concentrations of PCBs were higher than the effective human health standard by a maximum of approximately 4 times. Sampling by NMED (NMED 2006c) confirmed the presence of PCBs on LANL property.

It should be recognized that the New Mexico stream standards for PCBs are extremely low. The standards for aquatic life is 0.014 μg/L and for human health is 0.00064 μg/L (0.64 nanograms/L) (see discussion on PCBs in the Rio Grande in Section F.3 below).

The human health standards are levels where ingesting contamination through aquatic life consumption would harm peoples' health. Although there are no fish on Laboratory lands, a concern is the transport of PCBs into the Rio Grande by storm runoff events. In 2005, snowmelt sustained streamflow for four consecutive months in Los Alamos Canyon from the Laboratory to the confluence with the Rio Grande (see discussion in Section B, Hydrologic Setting).

Despite the detection of PCBs in runoff within the Laboratory, available data show no discernible impacts on PCB concentrations in the Rio Grande. Biological monitoring of reservoirs along the Rio Grande drainage does not indicate measurable increases in PCB concentrations due to Laboratory operations. Mean total PCB concentrations in fish from Abiquiu reservoir were statistically similar to mean total PCB concentrations in fish from Cochiti reservoir (see Chapter 8 for details). The statistical similarity in PCBs upstream and downstream of LANL has also been shown for dissolved water concentrations using samples taken with semi-permeable membranes. Additionally, sampling by NMED and LANL of the Rio Grande surface water shows whole water concentrations of PCBs are similar upstream and downstream of LANL (Mullen and Koch 2004). These results indicate there are other sources for PCBs in the Rio Grande.

Several polycyclic aromatic hydrocarbons (PAH), particularly benzo(a)pyrene, were detected in storm runoff samples at concentrations above the human health standards. PAHs are commonly associated with urban runoff and may also have been created through the Cerro Grande fire (Gallaher and Koch 2004).

Base flow and snowmelt contained concentrations of selenium slightly (1.1 to 2 times) above the wildlife habitat standard of 5 μg/L in approximately 10 percent of samples. However, most of the higher selenium concentrations appear to reflect analytical anomalies. All but one of the 11 exceedances were analyzed using SW-846:6010B, which has a nominal detection limit of 6 μg/L. Nearly all of the detections using this method were estimated by the analytical laboratory. We plan to revise methods used for analysis of selenium in surface and groundwater to obtain more sensitive results. Regardless, selenium is likely naturally occurring at these levels. Of the remaining constituents, only copper showed concentrations larger than standards in more than 5 percent of the samples.

Figure 6-10 shows a preliminary comparison of concentrations measured at site-specific monitoring stations and at watercourse stations. On this Laboratory-wide perspective, there appears to be minimal differences in the distribution of results for the two classes of monitoring stations. This is a somewhat surprising finding, as the site-specific FFCA monitoring is conducted close to potential contaminant sources under the assumption that site-specific stations would be more likely to detect a contaminant release than the watercourse stations. This preliminary analysis indicates that the watercourse stations appear to be just as effective in detecting elevated constituent concentrations as are the site-specific stations. More analysis is required to see if this initial finding holds on a watershed-by-watershed basis.

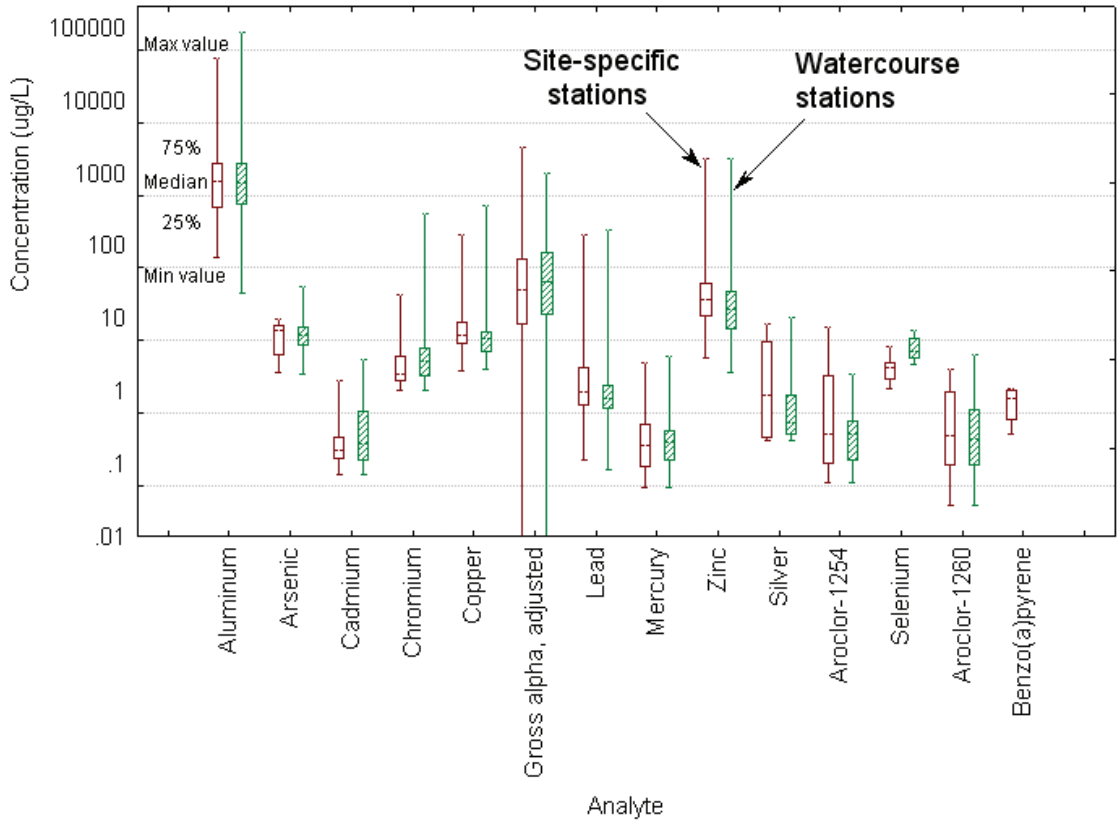


Figure 6-10. Comparison of concentrations measured in storm runoff at site-specific and watercourse stations. The vertical bars show the range of results and the middle 50 percent of the results occur within the boxes.

3. Impacts to the Rio Grande

Waters and sediments along the Rio Grande historically have shown relatively small impacts from Laboratory operations. Results for 2005 were consistent with those findings.

All base flow samples from the Rio Grande had concentrations below drinking water standards and standards for the protection of aquatic life, wildlife habitat, and irrigation. Radioactivity in these samples was low. None of the radionuclides commonly associated with LANL operations were detected, except for uranium. Uranium concentrations (0.5 to 2 μg/L) were well below the federal drinking water standard of 30 μg/L.

Radionuclide concentrations in bottom sediments from Cochiti Reservoir were lower than in other post-fire years. Plutonium-239,240 and cesium-137 concentrations showed increases for one to two years following the Cerro Grande fire (Gallaher and Koch 2005), but concentrations in 2005 have recovered to pre-fire levels. Plutonium-239,240 concentrations in 2005 were near or below analytical detection limits. Metals concentrations in the bottom sediments were unremarkable. The residual high-explosives organic compound 2-4-dinitrotoluene was detected in Cochiti Reservoir bottom sediments at an estimated concentration of 2.8 mg/kg, considerably below the EPA Region VI soil screening level of 120 mg/kg. This compound was not detected in earlier analyses (2003).

To further assess recent Laboratory impacts to the Rio Grande, we compared concentrations for key LANL analytes at locations along the Rio Grande upstream and downstream of LANL. Stations considered to be upstream of LANL surface water drainage are those located above the Rio Grande at Otowi bridge. Downstream stations along the segment from the Otowi bridge to the Cochiti Reservoir reflect any LANL influences. To focus on post-Cerro Grande fire conditions, with heightened drainage from the Los Alamos area to the Rio Grande, we limited the data to those for the years 2000 through 2005. We compared concentrations for metals (chromium, copper, lead, mercury) and radioactivity (cesium-137, plutonium-239,240, americium-241, total uranium) in sediments accumulated in the bottoms of reservoirs within the Rio Grande drainage system. Results are shown in Figures 6-11 and 6-12.

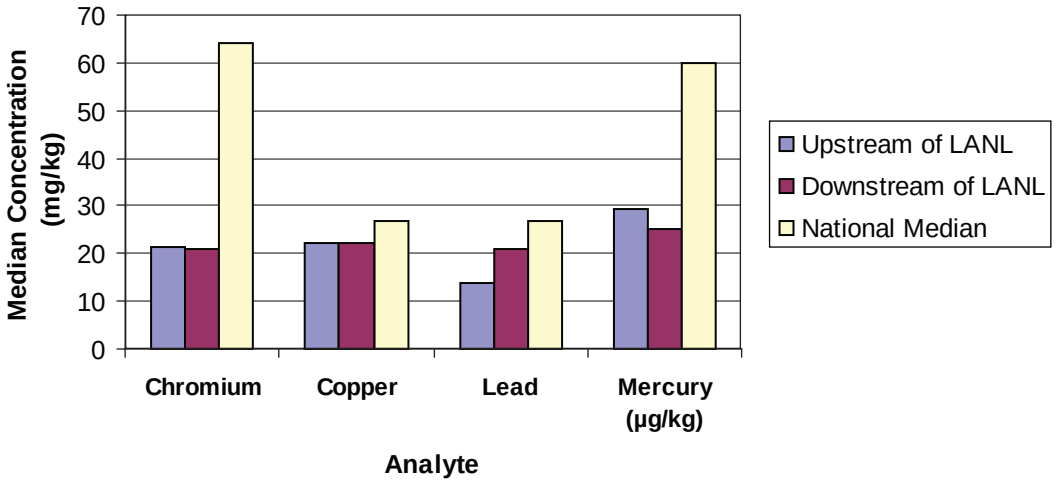


Figure 6-11. **Metals concentrations in bottom sediments from reservoirs within the Rio Grande drainage system. Reservoirs located upstream of LANL include Abiquiu, El Vado, Heron, and Rio Grande. The downstream reservoir is Cochiti. National median data are from the US Geological Survey (Gilliom et al. 1997).**

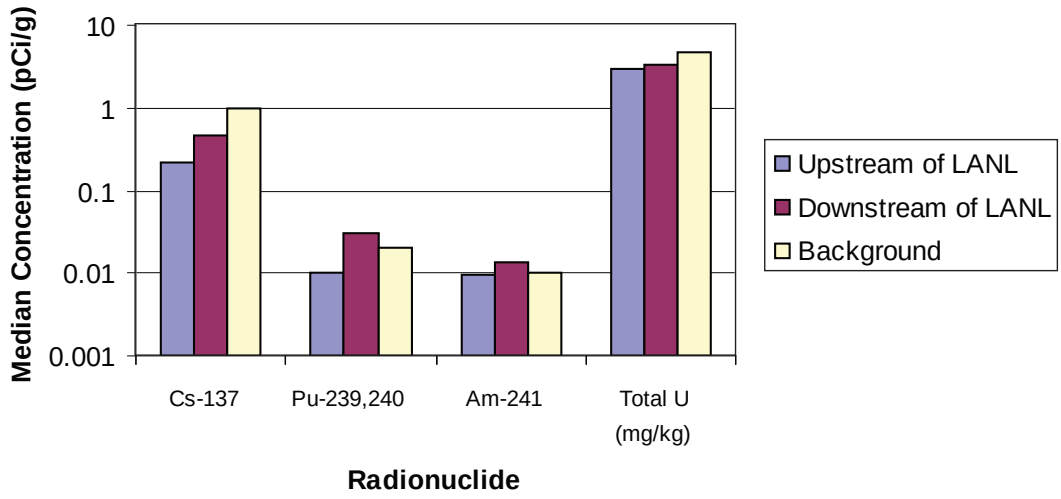


Figure 6-12. **Radionuclide concentrations in bottom sediments from reservoirs within the Rio Grande drainage system. Reservoirs located upstream of LANL include Abiquiu, El Vado, Heron, and Rio Grande. The downstream reservoir is Cochiti. Background upper limit radioactivity reference values are from McLin (2004).**

Of the four metals assessed, only lead shows a significant increase in downstream (Cochiti Reservoir) bottom sediment concentrations. The possible sources of lead are numerous, including urban and roadway runoff. Median concentrations for the four assessed metals are below US Geological Survey national median concentrations measured in reservoir studies across the country (Gilliom et al. 1997).

Concentrations of cesium-137 and plutonium-239,240 in reservoir bottom sediments show slight increases below LANL. However, the median concentration of cesium-137 remains within global fallout ranges for the region. Previous analysis concluded that the cesium-137 was primarily fallout-associated ash washed from the burned hillsides above Los Alamos (Gallaher and Koch 2005). The plutonium-239,240 was primarily attributed to Laboratory-contaminated sediments in Los Alamos Canyon watershed (see discussion in Section 4.B below).

Three independent types of measures show that PCB concentrations below LANL to Cochiti Reservoir are indistinguishable from above. We have measured PCB concentrations in fish tissue, in submerged synthetic membranes, and in the water column. All of the three measurement programs showed no significant difference in PCB concentrations between upstream and downstream locations. Fish tissue and membrane results are discussed in Chapter 8 of this report. Water column data are presented in Figure 6-13.

A preliminary analysis indicates that PCB concentrations greater than 0.1 ng/L can theoretically be ascribed to background fallout levels of PCBs. This is within the magnitude of some values measured in the Rio Grande water column (Figure 6-13). Around the world, PCB compounds are ubiquitous on the landscape. PCBs have been detected in soils from remote locations in the northern Rio Grande drainage system (Gonzales and Fresquez 2003).

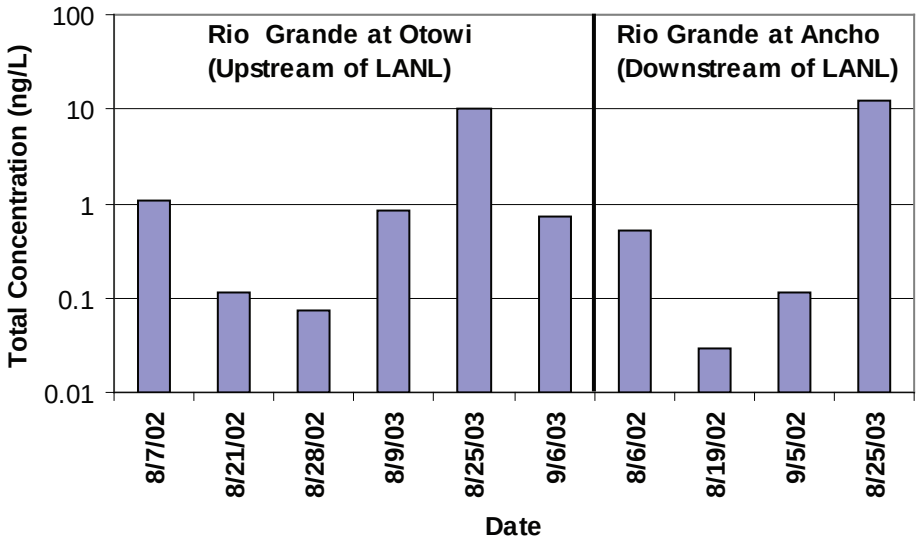


Figure 6-13. Total PCB concentrations in Rio Grande surface water in 2002 and 2003 (Mullen and Koch 2004).

4. Canyon-specific Results

a. 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. Concentrations of metals, organics, and radionuclides in Guaje Canyon base flow and sediments were below regulatory limits or screening levels. Active channel sediments contained background ranges of metals and radionuclides (LANL 1998).

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

Los Alamos Canyon has a large drainage that heads in the Sierra de los Valles. The Laboratory has used the land in the Los Alamos Canyon watershed continuously since the mid-1940s, with operations conducted at some time in all of the sub-drainages. Each of the canyons draining the watershed also receives urban runoff from the Los Alamos town site, and lower Pueblo Canyon receives treated sanitary municipal wastewater.

Past release of radioactive liquid effluents into Pueblo (via tributary Acid Canyon), DP, and Los Alamos Canyons has introduced americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, and tritium, among other radionuclides, into the canyon. Many of these radionuclides bind to stream sediments and persist at levels several orders of magnitude above worldwide fallout levels. Elevated levels of radioactivity can be found in those canyons in both surface waters and stream bottom sediments. Plutonium has moved down Pueblo Canyon, through Los Alamos Canyon, offsite across Pueblo de San Ildefonso lands, and reaches the Rio Grande near the Otowi Bridge (Graf 1997; Reneau et al., 1998). Plutonium-239,240 contamination from past Acid Canyon discharges has been traced in stream sediments more than 55 km to lower Cochiti Reservoir (Gallaher and Efurd 2002). Several contaminated sediment removal efforts have been conducted in Acid Canyon. In 2005, additional stabilization of sediment was performed in Pueblo Canyon to retard transport downstream. 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 plants to provide additional stream bank support, was completed in 2005 (PPWP 2005).

High concentrations of radionuclides were measured in several storm runoff samples collected near specific facilities within the watershed. These results indicate that additional erosion controls and water management structures likely are needed within the watershed. In Acid Canyon, large plutonium-239,240 concentrations were measured in three samples collected from a station located at South Fork of Acid Canyon and in one sample collected at Acid Canyon above Pueblo. The maximum plutonium-239,240 concentration in Acid Canyon was 235 pCi/L. Although stream sediment concentrations of plutonium-239,240 have progressively declined in past decades, these data indicate that downstream transport of the contaminant from the canyon is ongoing.

Hillside stations in middle Los Alamos Canyon contained elevated concentrations of plutonium-239,240 and americium-241. The highest concentrations were measured in storm runoff from channels below the Manhattan Project-era plutonium research building at TA-1 (station LA-SMA-4) and DP site at TA-21 (station LA-SMA-6.3). Two samples at LA-SMA-4 showed concentrations of plutonium-239,240 an average of 50 pCi/L. The maximum plutonium-239,240 concentration measured at LA-SMA-6.3 was 775 pCi/L, amongst the largest recorded at the Laboratory. Despite the high plutonium-239,240 concentrations measured in hillside runoff, concentrations measured in the canyon floor stream were considerably lower. The maximum plutonium-239,240 concentration in all of the Los Alamos Canyon watercourse stations was 7 pCi/L.

A stream gage in lower Los Alamos Canyon above the Rio Grande was installed in 2002 to monitor downstream runoff from Los Alamos and Pueblo Canyons. In 2005, snowmelt runoff samples were collected from this site, but no storm runoff samples were collected.

In 2005, we estimate that storm runoff carried approximately 5 mCi of Pu-239,240 across the Laboratory boundary, primarily from Los Alamos Canyon. This is significantly less than approximately 60 mCi estimated for the years 2001 through 2003 after the Cerro Grande fire, but larger than estimated pre-fire levels in the late 1990s of 1 mCi per year or less. This constitutes approximately five percent of the total inventory of residual plutonium-239,240 stored in stream sediments within the Los Alamos Canyon watershed in the late 1990s (LANL 2004).

The Los Alamos Canyon weir was constructed in the summer of 2000 after the Cerro Grande fire to slow runoff and catch sediment and associated contaminants before runoff flows downstream of LANL (Figure 6-14). During 2005, six snowmelt or storm runoff samples were collected immediately upstream and downstream of the weir. We estimate that approximately two-thirds of the suspended sediment load measured at the upstream station in 2005 was trapped in the weir.

This trapping efficiency is comparable to those calculated by Gallaher and Koch (2004) for the years 2000 through 2003, where efficiencies ranged from 23 to 80 percent and averaged 45 percent. Thus, the structure plays a significant role in limiting offsite movement of contaminated sediments from LANL. Time-weighted average concentrations of americium-241 in 2005 are estimated to drop at this location from about 3.3 pCi/L immediately upstream of the weir to 0.9 pCi/L downstream of the weir. Average plutonium-239,240 concentrations similarly declined in 2005 from 2.5 to 1.1 pCi/L. With proper maintenance, such structures may prove to be valuable in reducing off-site transport.

Figure 6-14. Low-head weir in Los Alamos Canyon retaining storm runoff and sediment. Notice deposition of stream sediments in basin of weir. Photographs courtesy of UDSA Forest Service.

At all locations evaluated with elevated radionuclide concentrations, substantial reductions in radioactivity would result if the suspended sediment concentrations were reduced. To illustrate, annualized radionuclide concentrations, as well as suspended sediment concentrations, were reduced by approximately two thirds after passing through the low-head weir.

Throughout the Los Alamos Canyon watershed, radionuclide concentrations in sediments remained below recreational and even residential SALs. Plutonium-239,240 concentrations in lower Los Alamos Canyon sediments were below analytical detection limits. Analysis of sediments from Pueblo and Los Alamos Canyons found no significant changes in radionuclide concentrations from the previous year. Plutonium-239,240 and cesium-137 concentrations temporarily increased after the Cerro Grande fire and have since fallen to near pre-fire levels (Figures 6-15 through 6-18).

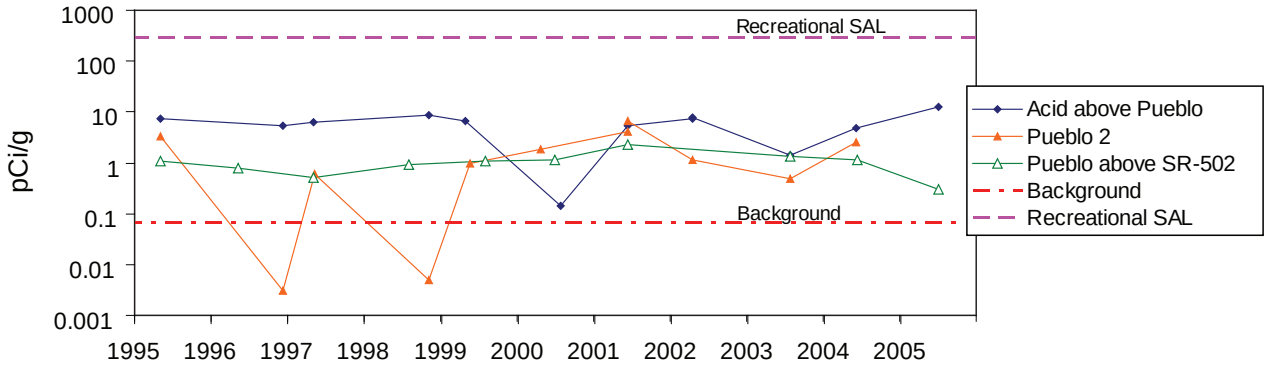


Figure 6-15. Long-term plutonium-239,240 trends in Pueblo Canyon sediments.

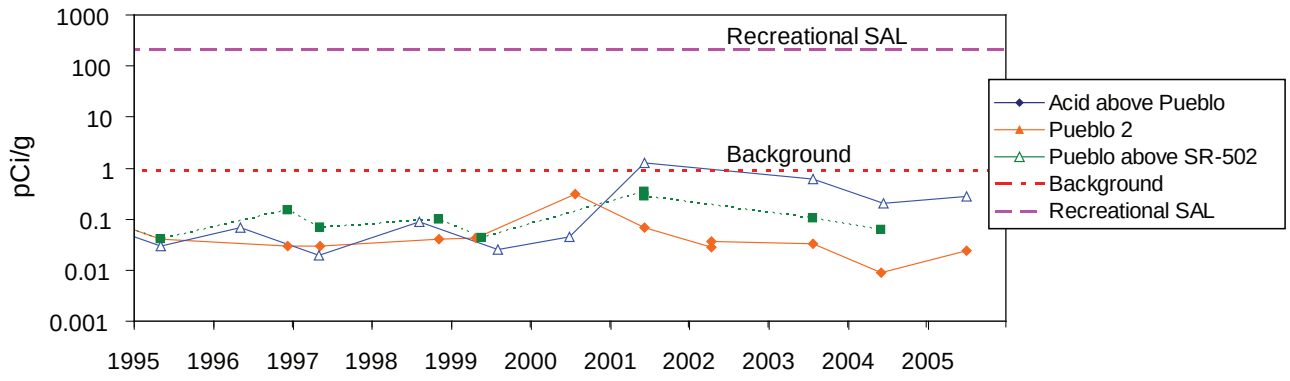


Figure 6-16. Long-term cesium-137 trends in Pueblo Canyon sediments.

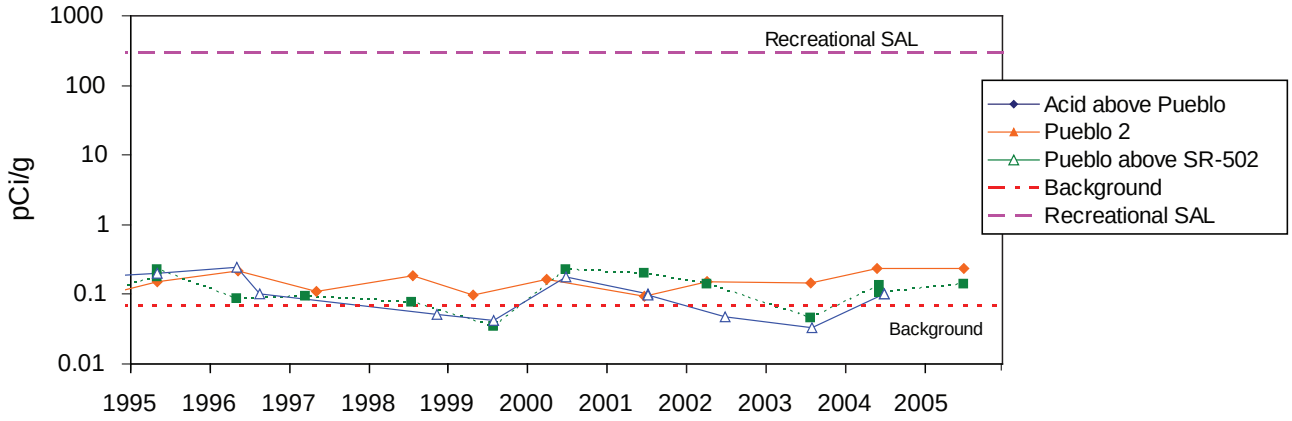


Figure 6-17. Long-term plutonium-239,240 trends in Los Alamos Canyon sediments.

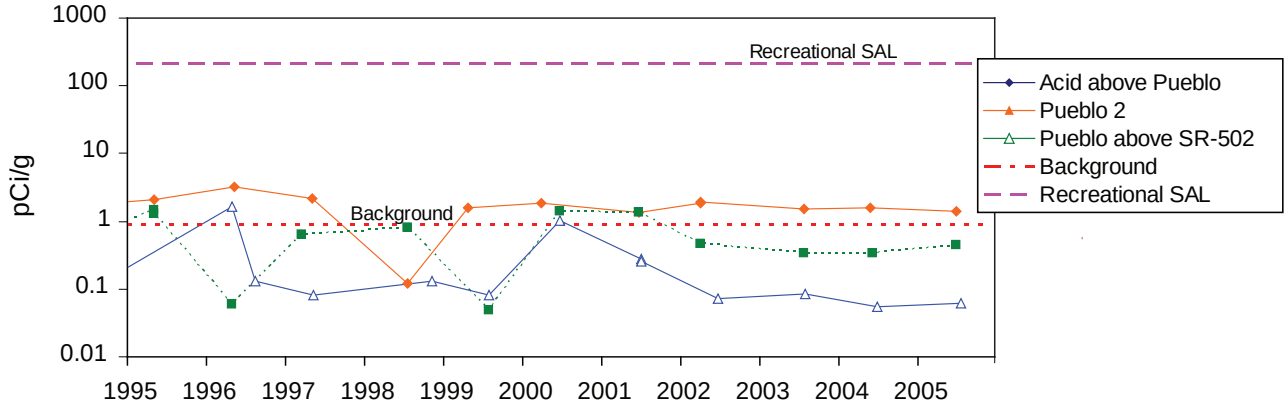


Figure 6-18 . Long-term cesium-137 trends in Los Alamos Canyon sediments.

Nonradiological constituents detected at significant concentrations in storm runoff and stream sediments in the Los Alamos Canyon watershed include PCBs, benzo(a)pyrene, mercury, copper, lead, and zinc. In Los Alamos Canyon (Figure 6-19), PCBs were detected in runoff above New Mexico water quality standards in multiple samples. The largest PCB concentrations in runoff were measured in middle Los Alamos Canyon from hillside channels that drain former TA-1 and TA-21. At one site immediately below LANL facilities at TA-21, concentrations were greater than standards in three of four PCB samples collected. Analysis in 2005 detected benzo(a)pyrene in sediment samples from station Acid Canyon above Pueblo at 94 percent of the draft recreational soil screening level (LANL 2005) and 1.2 times the industrial soil screening level (NMED 2006) (Figure 6-20). We previously concluded that the major source of benzo(a)pyrene in the Los Alamos Canyon drainage was urban runoff, rather than a Laboratory-related source (LANL 2004).

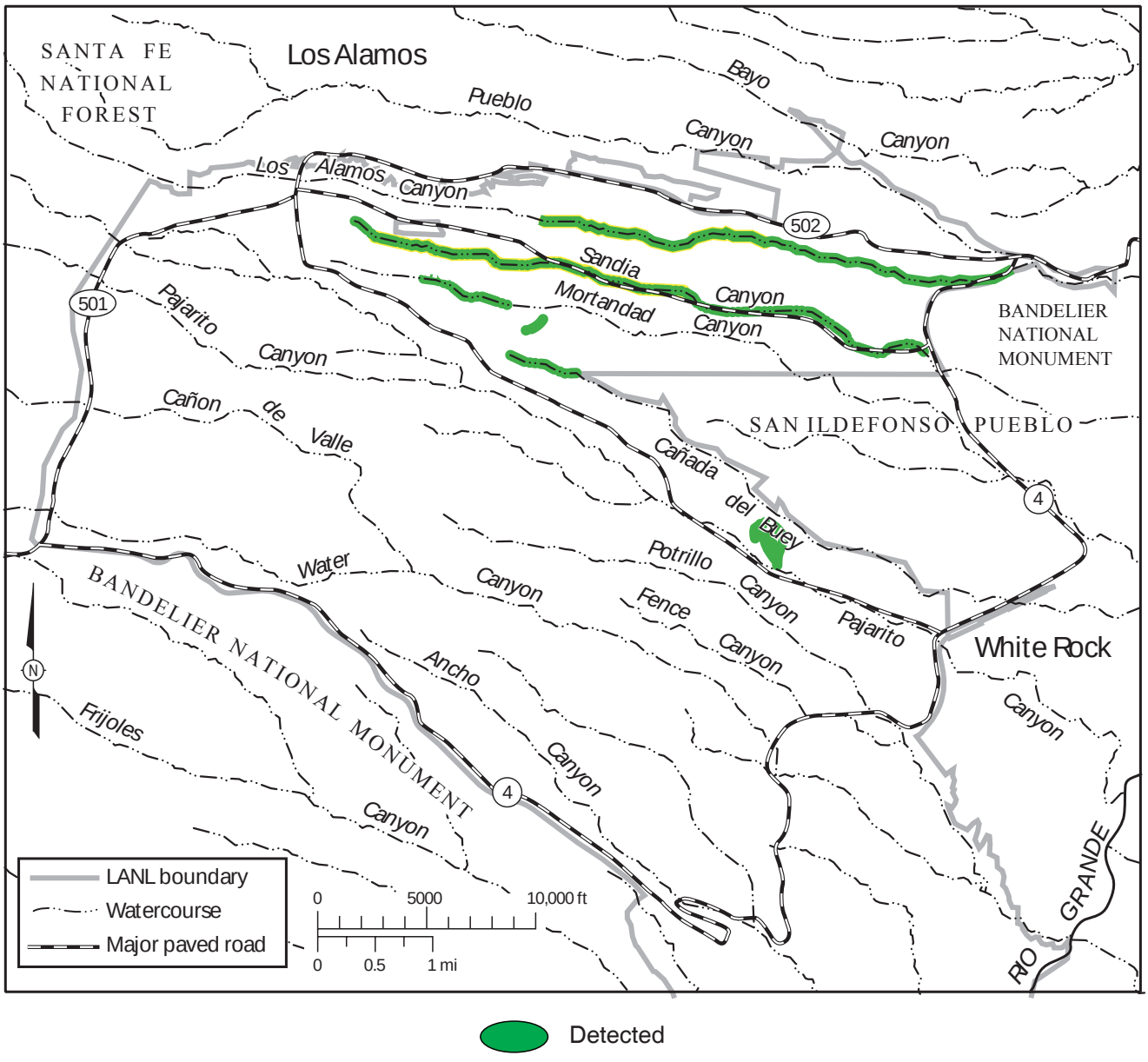


Figure 6-19. Location of surface water with detected PCBs.

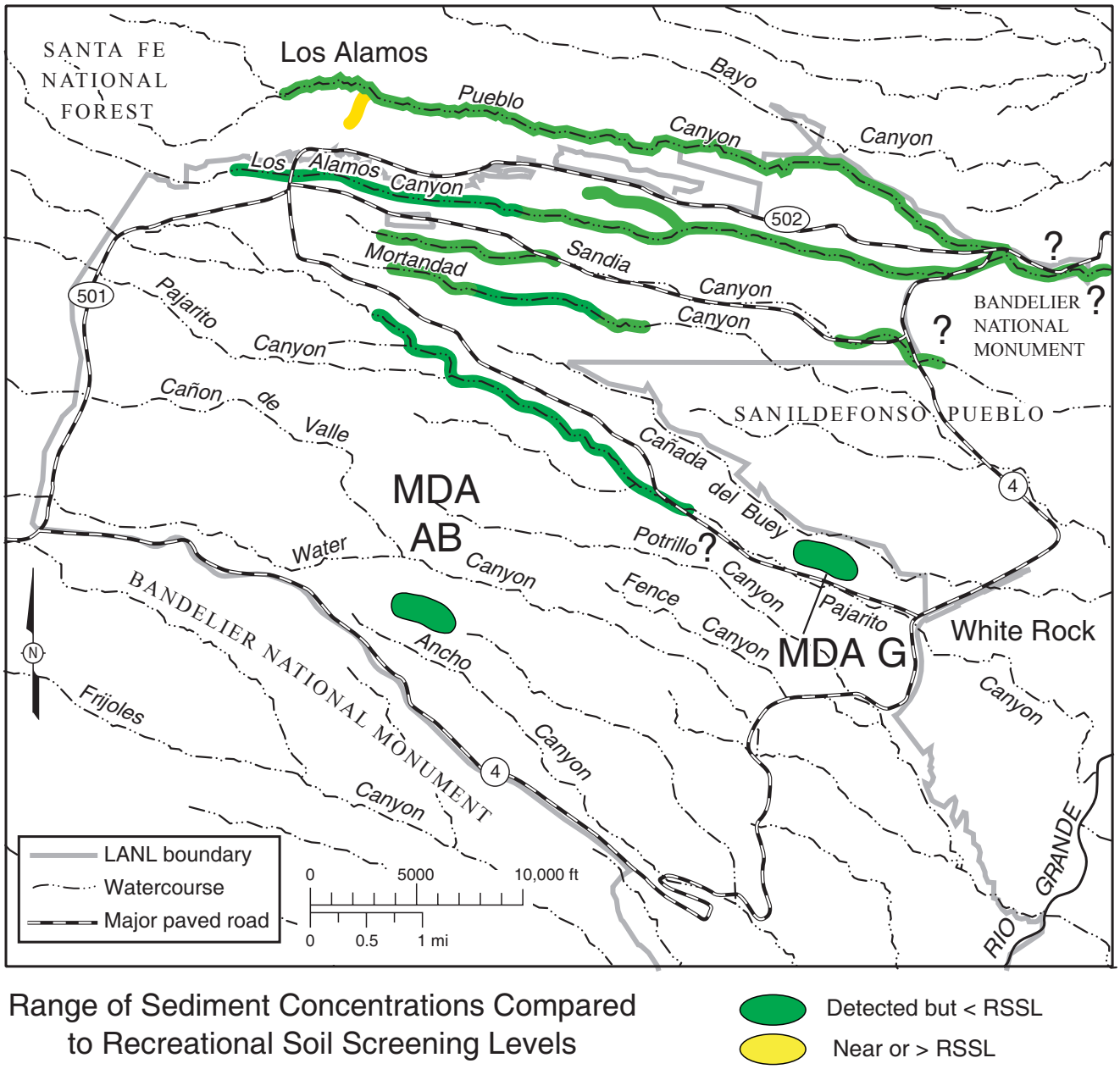


Figure 6-20. **Location of sediment with benzo(a)pyrene, a polycyclic aromatic hydrocarbon, detected or above screening levels. Different colors indicate where polycyclic aromatic hydrocarbons are detected or are above the LANL draft recreational soil screening level. The highest concentration in 2005 was in Acid Canyon, at 95 percent of the recreational soil screening level and 1.2 times the industrial soil screening level.**

Mercury was detected in runoff samples at several hillside locations in Pueblo and Los Alamos Canyons at concentrations two to three times above the wildlife habitat standard. In the canyon floors of these drainages, however, mercury concentrations were below the standard in Pueblo Canyon and only slightly (1.1 times) above the standard in Los Alamos Canyon. LANL mercury sources are known to exist in the drainage system, and erosion control features have been installed near the sources to minimize downstream movement. Concentrations of copper (Figure 6-21), lead, and zinc were detected above the NM acute aquatic life standards. Elevated concentrations of these elements were found in DP Canyon above LANL facilities at TA-21 and are likely derived from urban runoff sources rather than Laboratory operations.

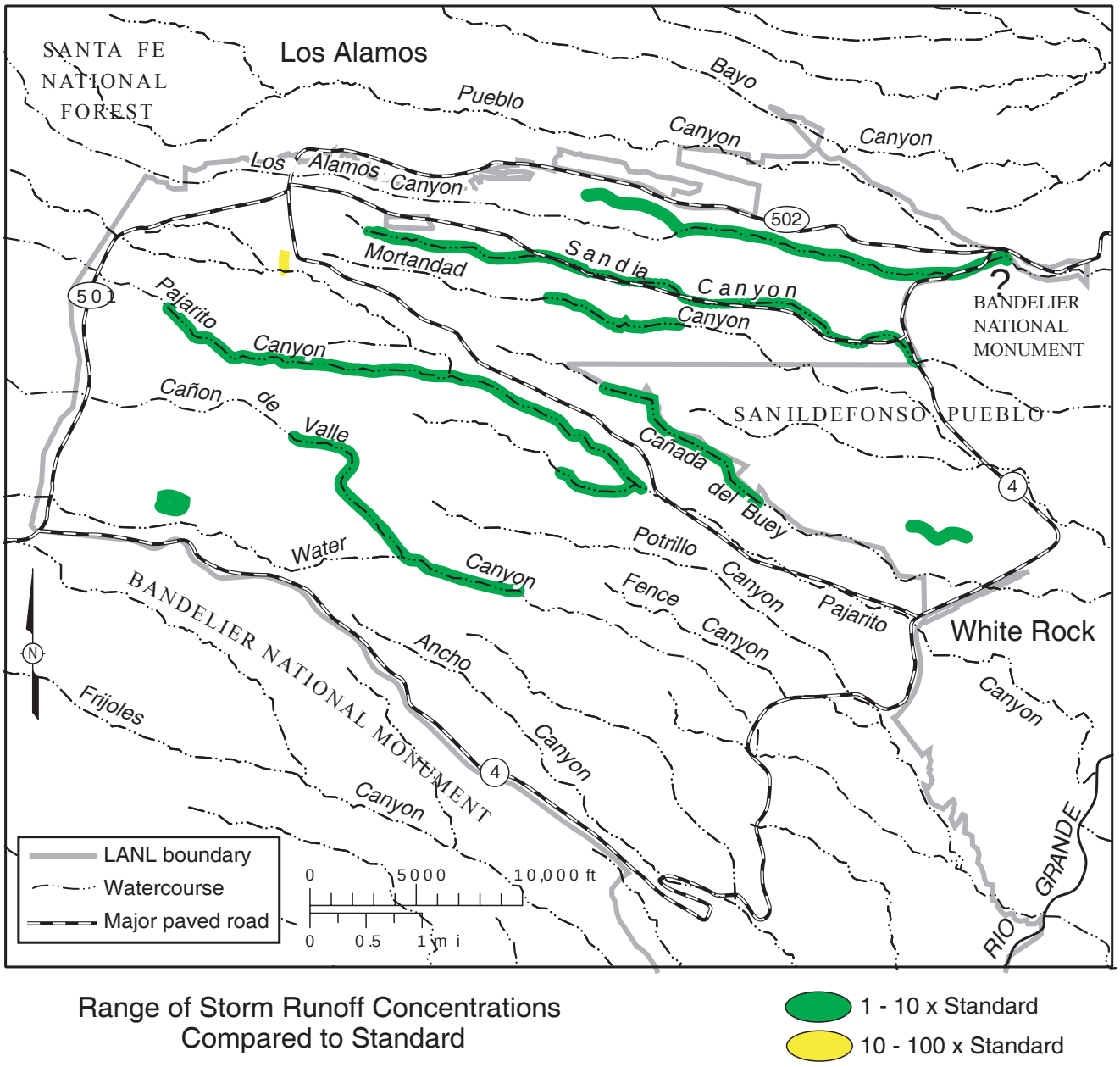


Figure 6-21. Location of surface water with levels of dissolved copper greater than stream standards.

c. Sandia Canyon

Sandia Canyon heads on the Pajarito Plateau within the Laboratory's TA-3 area and has a total drainage area of about 5.5 mi^2. This relatively small drainage extends eastward across the central part of the Laboratory and crosses Pueblo de San Ildefonso land before joining the Rio Grande. Effluent discharges primarily from power plant blowdown create perennial flow conditions along a 2-mi reach below TA-3. Only one day of runoff was recorded at the Laboratory boundary in 2005 (Shaull et al. 2006). Monitoring results have consistently shown minimal off-site contamination from the Laboratory in Sandia Canyon.

PCB concentrations above water quality standards were detected throughout the watershed from near the Laboratory's main technical area at TA-3 to the LANL downstream boundary at SR-4. Unlike the Los Alamos Canyon watershed, however, there is minimal off-site stream flow in Sandia Canyon. Four of four storm runoff

samples collected above the Sandia Canyon firing range contained PCB Aroclors 1254 and 1260 at concentrations greater than the New Mexico stream standards. The Aroclor 1260 was also detected in a runoff sample collected at the Laboratory's eastern boundary. The human health standards protect people from ingesting contamination through fish consumption, but there are no fish in Sandia Canyon. Further, flows from the canyon have little probability of reaching the Rio Grande. In addition, PCB concentrations above standards were detected at four site-specific monitoring stations in upper Sandia Canyon. Sediment samples collected in Sandia Canyon contained PCB concentrations well below (16 percent of) the LANL draft recreational soil screening level. Downstream sediment concentrations of PCBs decline quickly and are near background (fallout) ranges at the LANL downstream boundary. PCB concentrations in sediments at station Sandia below the Wetlands in 2005 are variable with no clear trend evident (Figure 6-22). PCB concentrations at the other canyon stream sediment stations were consistent with previous years.

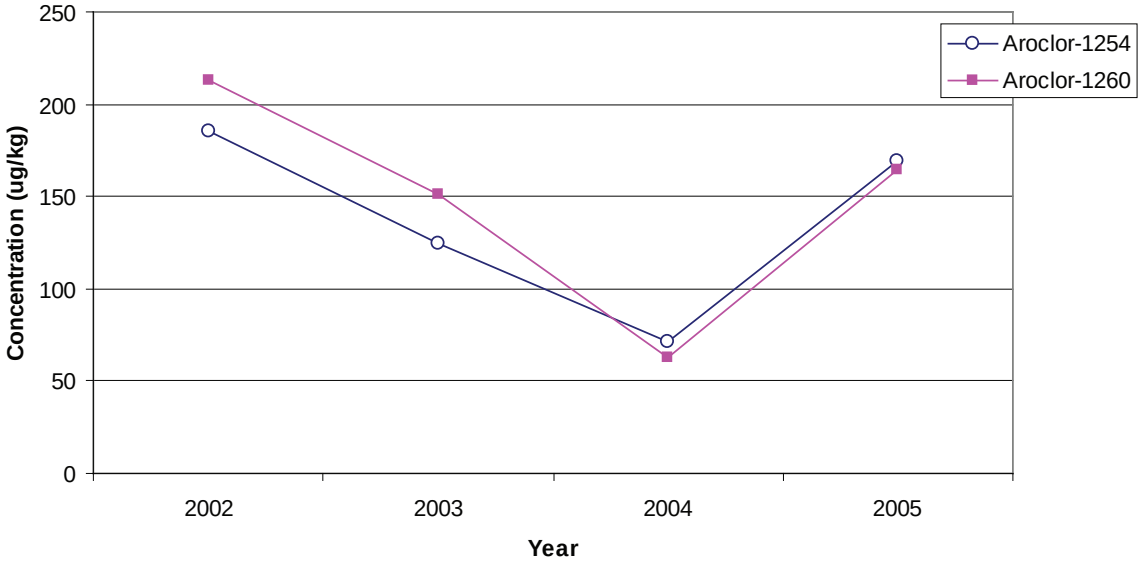


Figure 6-22. Recent trends of PCB concentrations in stream sediments at the Sandia below Wetlands station.

Above-background concentrations of chromium, copper, lead, mercury, silver, and zinc in surface water and sediments are found along an approximately two-mile segment of Sandia Canyon below TA-3. Storm runoff occasionally contains concentrations above regulatory standards. Measurements in 2005 found dissolved concentrations of copper (Figure 6-21) and lead above the acute and chronic aquatic life standards by two to six times, and total mercury concentrations were above the wildlife habitat standard by four times.

Perchlorate was detected in a base-flow sample collected in January 2003 from below the power plant at a concentration of 18.5 µg/L. We collected subsequent samples in March 2003 of outfalls 001 (power plant) and 03A027 (cooling tower) discharging to Sandia Canyon that did not detect perchlorate using EPA Method 314 at a detection limit of 4 µg/L. Analyses of Sandia Canyon base flow in 2005 did not detect perchlorate.

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

Mortandad Canyon heads on the Pajarito Plateau near the main Laboratory complex at TA-3. The canyon crosses Pueblo de San Ildefonso land before joining the Rio Grande.

The annual time-weighted average concentrations of americium-241, plutonium-238, and plutonim-239,240 are well below the BCG in unfiltered surface water collected below Effluent Canyon (Table 6-2). When the mixture of radionuclides is considered (see discussion in Section F.1), the surface waters in Mortandad Canyon below Effluent Canyon were seven percent of the BCG.

Figures 6-23 through 6-26 show activities of plutonium-238, plutonium-239,240, americium-241, and cesium-137 at four sediment stations in Mortandad Canyon. All of the stations are located below the RLWTF discharge. The stations MCO-8.5, MCO-9.5, and the LANL boundary are located below sediment traps, installed in the 1970s.

Stream sediments in Mortandad Canyon downstream of Effluent Canyon as far as the sediment traps, and downstream to near MCO-9.5, contain above background concentrations of americium-241, plutonium-238, plutonium-239,240, and cesium-137 (Figures 6-23 through 6-26). Radionuclide concentrations in active channel sediment upstream of the sediment traps were 5 percent or less of the recreational SAL (LANL 2005) (Figure 6-24). The sediment traps are located approximately two miles upstream of the Laboratory's eastern boundary. Despite the history of releases into the Mortandad Canyon watershed, radioactivity in sediments at the Laboratory's eastern boundary is within background levels or is only slightly elevated above background levels. Americium-241, cesium-137, and plutonium-239,240 concentrations in sediments at the boundary are orders of magnitude lower than at upstream stations closer to the Radioactive Liquid Waste Treatment Facility (RLWTF) discharge. The rarity of stream flow within Mortandad for two miles upstream of the Laboratory boundary is the main reason for the lower sediment radioactivity downstream.

Radioactivity concentrations in sediments just below the RLWTF have not changed appreciably in the past decade. Concentrations in Mortandad Canyon at the LANL boundary are near or below the sediment background levels. However, recent monitoring results show that concentrations near the Laboratory boundary are higher than previously recognized before 2001. The increase in plutonium and cesium activities at MCO-8.5 and –9.5 was due to relocating the sampling stations to the active channel.

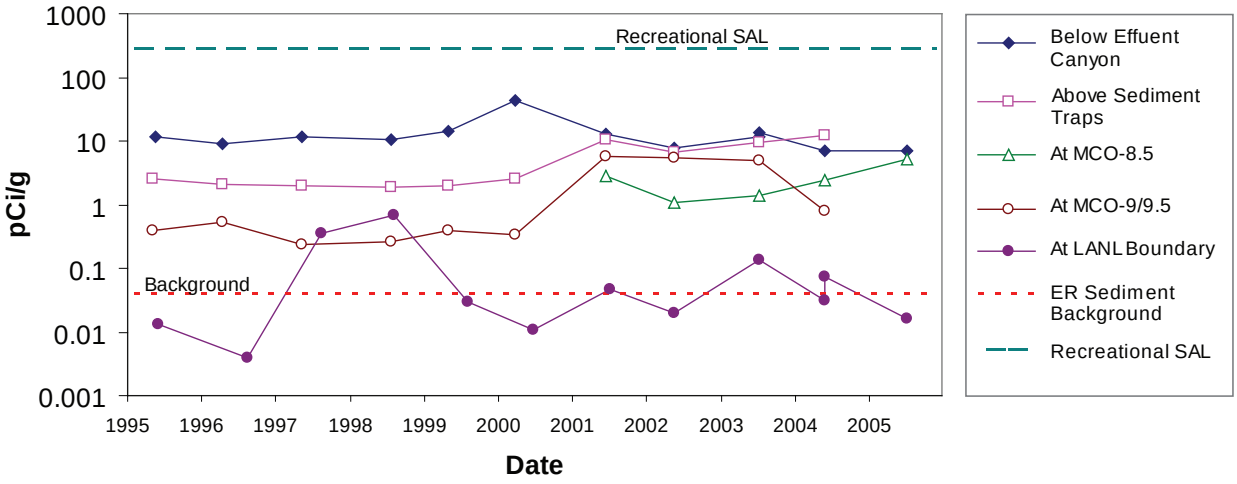


Figure 6-23. Long-term americium-241 trends in Mortandad Canyon sediments.

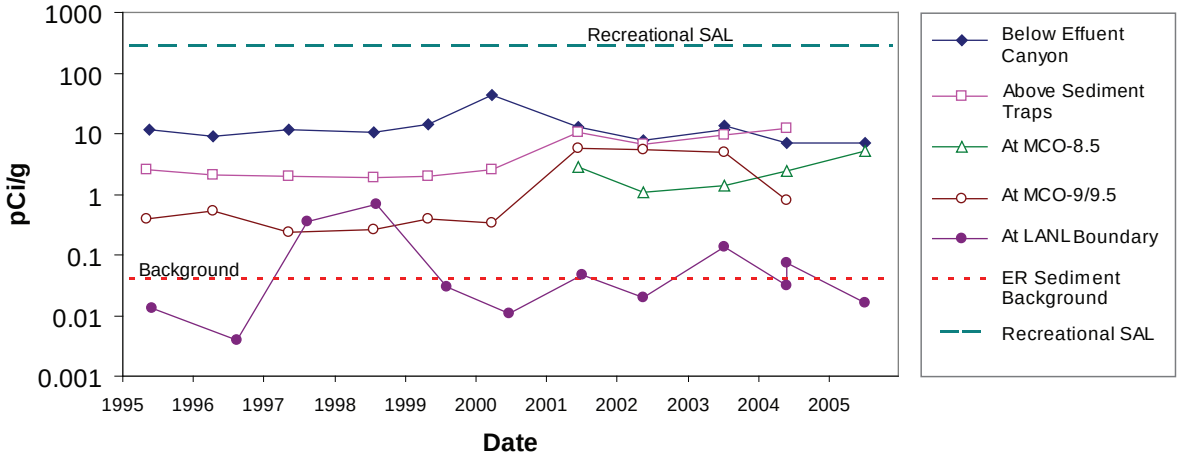


Figure 6-24. Long-term cesium-137 trends in Mortandad Canyon sediments.

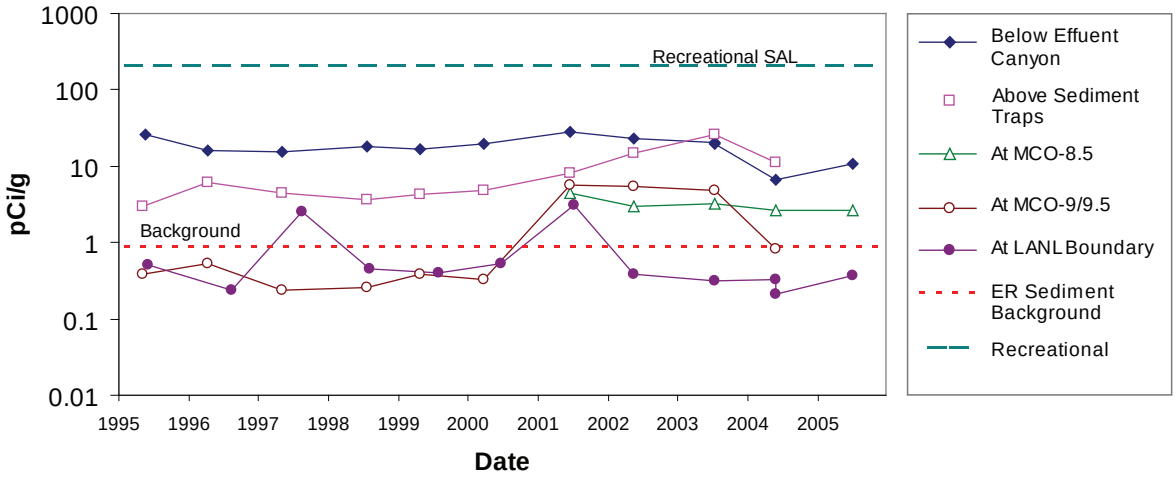


Figure 6-25. Long-term plutonium-238 trends in Mortandad Canyon sediments.

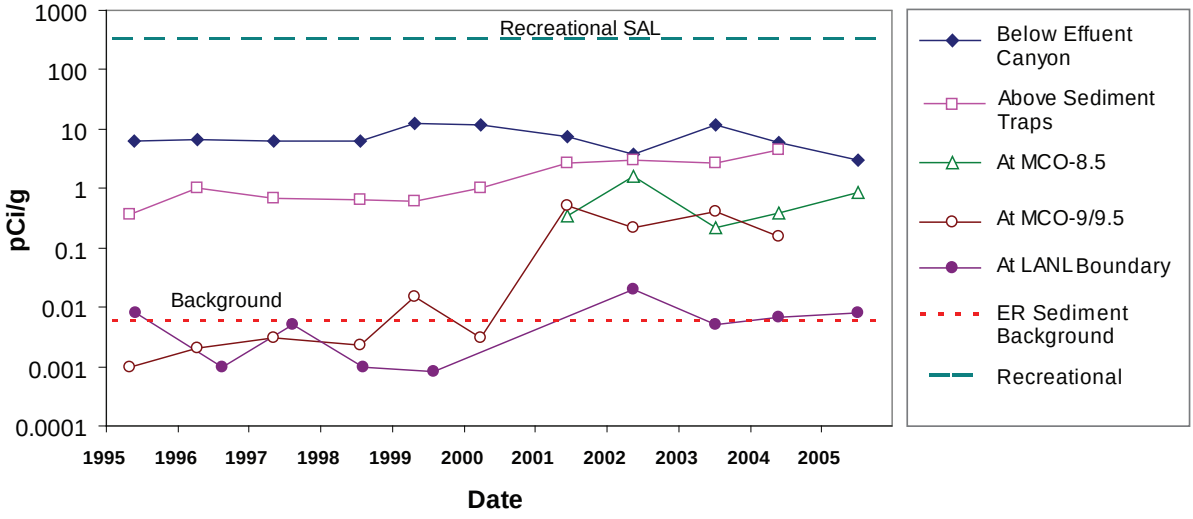


Figure 6-26. Long-term plutonium-239,240 trends in Mortandad Canyon sediments.

PCBs above water quality standards were detected in storm runoff samples from Mortandad and Ten Site Canyons, and from Cañada del Buey. In Mortandad Canyon and in Cañada del Buey the detections were for Aroclor-1254, while in Ten Site Canyon two detections for Aroclor-1260 were recorded—these results suggest different sources of PCBs in the canyons. Dissolved copper concentrations were detected above the New Mexico Acute Aquatic Life stream standard by three times in base flow and runoff samples collected at the station Mortandad below Effluent Canyon station.

Radioactivity in sediment around MDA G and in Cañada del Buey was generally consistent in 2005 with previous years, with the following exceptions. Starting in 2002, plutonium-239,240 concentrations have gradually increased at sediment sampling stations MDA G-7 and G-8, which are both located on the eastern portion of Area G (Figure 6-27). MDA G-7 station samples a tributary of Cañada del Buey and MDA G-8 is in a tributary that drains to Pajarito Canyon. While the 2005 results were approximately 10 times above background fallout levels, they were far below (0.1 percent) the recreational SAL (LANL 2005).

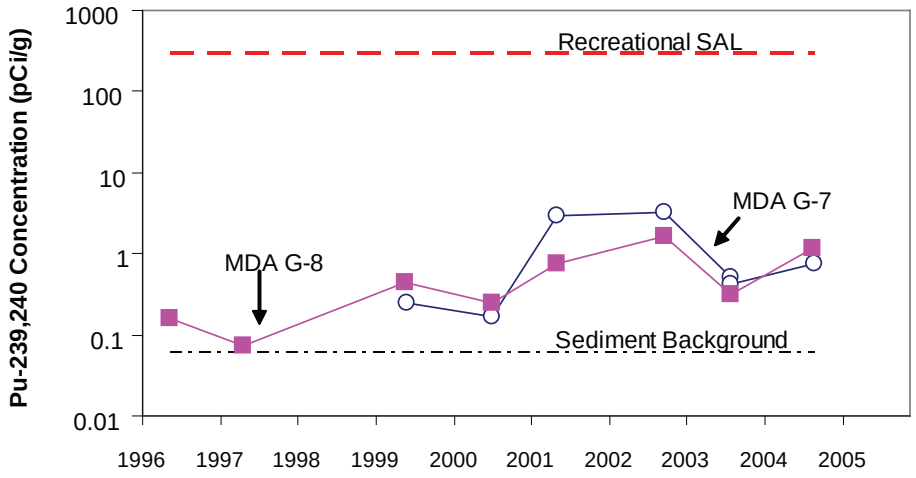


Figure 6-27. Recent trends of plutonium-239,240 activities at Material Disposal Area G sediment stations G-7 and G-8.

Plutonium-239,240 was not detected in Cañada del Buey sediments beyond the immediate vicinity of MDA G in 2005. One storm runoff sample collected from the hillside north of Area G (Station G-13) contained detectable PCB Aroclor-1254. The Laboratory's PCB disposal area is located within Area G but surface drainage is to the south, and in the opposite direction. The detection of PCBs in that sample likely reflects the large suspended sediment concentration in the sample (22,000 mg/L).

e. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads on the flanks of the Sierra de los Valles on US Forest Service lands. The canyon crosses the central part of the Laboratory before entering Los Alamos County lands in White Rock.

Consistent with past years, we found americium-241, plutonium-238, and plutonium-239,240 at concentrations greater than background in sediment samples from channels draining MDA G. Concentrations of these radionuclides were commonly 5 to 10 times background. Since 1997, station MDA G-8 shows a statistically significant ($p<0.05$, Kendall Tau nonparametric test) upward trend in Pu-239,240 concentrations. All of the radionuclides were at concentrations below recreational and even residential SALs.

In runoff samples collected in 2004, we detected dissolved copper concentrations greater than the New Mexico Acute Aquatic Life standard in channels throughout the Pajarito Canyon watershed, including Twomile, Threemile, and Starmers Canyons (Figure 6-21). Results for 2005 do not support that finding, as dissolved copper concentrations along Pajarito stream were below standards. Dissolved copper concentrations greater than standards were limited to three sites on hillsides. Concentrations of copper and zinc larger than standards have consistently occurred at the Twomile tributary at TA-3 station. That site monitors drainage from a large paved area and the Laboratory's main machine shop.

In Threemile Canyon, high concentrations of uranium-238 were detected in three runoff samples collected below a high-explosive firing site (station 3M-SMA-0.6) (Figure 6-5). The samples indicate the presence of depleted uranium, as activity ratios of uranium-238 to uranium-234 were in excess of seven.

A sediment sample from Pajarito Canyon above SR 4 contained 15 metals and several radionuclides elevated two to five times above sediment background (LANL 1998). Cesium-137 concentrations were 6.5 times above background. The 2005 results are similar to the 2004 results and indicate a source(s) other than MDA G because cesium-137 is not substantially elevated in sediments around Area G. The sample station was relocated in 2002. Previously, the station was downstream of SR-4, where flow is rapid and little sediment accumulates; the relocated station is in a depositional area upstream of the berm formed by SR-4. The elevated analyte levels may be related to the finer texture of sediment that accumulates above the highway. Some of the elevated constituents, for example, cesium-137, barium, and manganese, were also found at high concentrations in post–Cerro Grande fire runoff samples (Gallaher and Koch 2005). Because the station is now located where sediment accumulates, both Cerro Grande fire-related and Laboratory-derived constituents are probably present. A sediment sample collected from Pajarito Canyon below SR-501 (upstream of LANL operations) contained barium in a concentration 1.4 times the sediment background level and selenium in a concentration 5.3 times the background level (LANL 1998).

PCBs were detected in one of four runoff samples collected at the MDA G-6U station located on the southeastern corner of Area G. This station monitors drainage from the central portion of MDA G, including the Laboratory's PCB disposal facility. This is the first detection of PCBs in waters in years of monitoring several drainage channels along the southern perimeter of MDA G.

f. Water Canyon (includes Cañon de Valle, Potrillo, Fence, and Indio Canyons)

Water Canyon heads on the flanks of the Sierra de los Valles on US Forest Service land and extends across the Laboratory to the Rio Grande. Water Canyon and its tributary Cañon de Valle pass through the southern portion of the Laboratory where explosives development and testing take place. Elevated concentrations of barium, HMX, and RDX have previously been measured in sediment and surface water and are consistent with previous results. Average concentrations for dissolved barium and RDX for 2005 exceed these risk levels by about three and seven times, respectively. This area is being investigated under a RCRA Corrective Measures Study.

Base flow and storm runoff within Cañon de Valle and Water Canyons contain concentrations of dissolved copper, dissolved zinc, and dissolved silver larger (by two to three times) than the New Mexico Acute Aquatic Life standards. Past discharges from photography laboratories are probably the source of the silver.

G. SPECIAL STUDY OF RADIOLOGICAL CONCENTRATIONS IN THE JEMEZ RIVER DRAINAGE

The Pueblo of Jemez and the Laboratory collaborated in a joint reconnaissance evaluation of plutonium origins and radionuclide concentrations in the Jemez River drainage. Stream sediments were collected at three locations and analyzed for isotopic composition and radionuclide concentrations. Two of the sites were located on the East Fork of the Jemez River within the Valles Caldera National Preserve, and a third was located near the village of Canon, which is located approximately seven miles south of the town of Jemez Springs (Figure 6-28).

The origin of the plutonium was determined through Thermal Ionization Mass Spectrometry (TIMS) analyses. The TIMS procedure establishes the isotopic signature of the plutonium in the sample by precisely measuring the number of atoms of the isotopes plutonium-240 and plutonium-239. Plutonium derived from worldwide fallout has an isotopic signature (plutonium-240/plutonium-239 atom ratio) much different than plutonium used by LANL in its research activities. This technique has been successfully used in many studies around the world to identify the origin of plutonium. LANL and NMED have used this technique to assess stream sediments in the Rio Grande (for example, Gallaher and Efurd 2002). Split samples of the stream sediments were also submitted to the General Engineering Laboratories for conventional radionuclide concentration determinations.

Figure 6-28. Cooperative sampling of stream sediments in Jemez River drainage conducted with Pueblo of Jemez scientists. Sampling was conducted of the Jemez River near Jemez Springs (left picture) and two ponds along the East Fork of the Jemez River within the Valles Caldera National Preserve (right). Some samples were sieved (right) to determine how the size of the sediment affects the concentrations of radionuclides.

The TIMS results indicated that the plutonium was dominantly derived from fallout. All three isotopic signatures were consistent with those of regional background soils and sediments. The radionuclide concentrations were also within background ranges. Plutonium-238 and -239,240 concentrations were below analytical detection levels for conventional alpha spectrometry methods.

H. QUALITY ASSURANCE

To process watershed samples, we used the same quality assurance (QA) protocols and analytical laboratories described in Chapter 5. QA performance for the year is also described in Chapter 5.

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7. SOIL MONITORING

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A. INTRODUCTION

A soil sampling and analysis program provides the most direct means of determining the concentration, distribution, and long-term trends of radionuclides and other chemicals around nuclear facilities (DOE 1991). The soil characterization program provides information about potential pathways (such as soil ingestion, food ingestion, resuspension into the air, and groundwater contamination) that may deliver radioactive materials or chemicals to humans.

The overall soil surveillance program at Los Alamos National Laboratory (LANL or the Laboratory) consists of

- An institutional component that monitors soils within and around the perimeter of LANL in accordance with Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993); and
- A facility component that monitors soils within and around the perimeter of the Laboratory's
  - principal radioactive waste disposal area (Area G) in accordance with DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and
  - principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) in accordance with the Mitigation Action Plan (DOE 1996).

The objectives of LANL's soil surveillance program are to determine the following:

- Radionuclide and nonradionuclide (heavy metal and organic chemical) concentrations and distributions in soils collected from potentially impacted areas (Lab-wide and facility-specific);
- Trends over time (i.e., whether radionuclides and nonradionuclides are increasing or decreasing over time); and
- The committed effective dose equivalent potentially received by surrounding area residents (see Chapter 3 for the potential radiation doses that individuals may receive from exposure to soils).

B. SOIL STANDARDS

To evaluate Laboratory impacts from radionuclides and nonradionuclides, the soil-sampling team first compares the analytical results of soil samples collected from the Laboratory's on-site and perimeter areas to regional or baseline statistical reference levels (RSRLs or BSRLs). Where the results exceed these levels, we then compare the concentrations to the soil screening levels (SLs); and, finally, if needed, to the standard. Table 7-1 summarizes the levels and/or the standard used to evaluate the soil sample results.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations = 99 percent confidence level) for radionuclides and nonradionuclides calculated from soil data collected from regional locations away from the influence of the Laboratory over at least the last five sampling periods. (Note: For a list of regional locations, see Fresquez 2004a.) RSRLs, which represent natural and fallout sources, are calculated annually and can be found in the annual issues of the Laboratory's Environmental Surveillance Report.
- On-site baseline levels: The Mitigation Action Plan for LANL's DARHT facility, the Laboratory's principal explosive test facility, mandated the establishment of baseline (pre-operational) concentrations for potential environmental contaminants that might result from DARHT operations (DOE 1996). BSRLs are the concentrations of radionuclides and nonradionuclides in soils and sediments around the DARHT facility during the years 1996 through 1999, before the operational phase (as of the year 2000). The BSRL concentrations of radionuclides and trace elements are calculated from the mean DARHT facility sample concentration plus two standard deviations, 95 percent confidence level (Fresquez et al. 2001a). (Note: Prior evaluations of BSRLs with RSRLs [at two sigma] show no statistical differences between the two. The soil-sampling team uses BSRLs at DARHT to meet Mitigation Action Plan requirements.)
- Soil Screening levels: SLs for radionuclides are set below the federal dose level of 100 mrem so that potential concerns may be identified in advance of major problems, i.e, a "yellow flag." If a constituent exceeds an SL, then we investigate the reason for that increase more thoroughly. LANL's Environmental Remediation and Surveillance Program developed screening action levels to identify potential contaminants of concern on the basis of a 15-mrem protective dose limit (this is 15 percent of the standard) (LANL 2005) using the RESRAD computer model version 6.21 (Yu et al. 1995). We compared nonradionuclides to the New Mexico Environmental Department (NMED) soil screening levels that are set at a 10^{-5} risk for carcinogens or a hazard quotient (HQ) of 1 for non-carcinogens (NMED 2005).
- Standard: If screening levels for radionuclides are exceeded, then a dose to a person would be calculated using RESRAD. The calculated dose would be based on a residential scenario with soil ingestion, inhalation of suspended dust, and ingestion of homegrown fruits and vegetables as the primary exposure pathways for one or more radionuclides taken from supplemental Table S7-1. Unit conversions, input parameters, model and parameter assumptions, and the uncertainty analysis that we used can be found in Fresquez et al. 1996. This calculated dose would be compared to the 100-mrem/yr DOE 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	100 mrem	15 mrem	RSRL
	DARHT	100 mrem	15 mrem	BSRL
Nonradionuclides	Perimeter		10^{-5} risk (resident) or HQ = 1	RSRL
	On-site		10^{-5} risk (industrial) or HQ = 1	RSRL
	Area G		10^{-5} risk (industrial) or HQ = 1	RSRL
	DARHT		10^{-5} risk (industrial) or HQ = 1	BSRL

C. INSTITUTIONAL MONITORING

1. Monitoring Network

For a complete description of the soil-sampling monitoring network, see Fresquez 2004a. In the past, the soil-sampling team collected samples from 12 on-site, 10 perimeter, and four regional locations on an annual basis (Figure 7-1). Because a review of past analytical data has shown that levels of radionuclides (Fresquez et al. 1998) and nonradionuclides (Fresquez et al. 2000, Fresquez et al. 2001b) in soils collected within and around the LANL perimeter have been very low and, for the most part, have not increased over time, soils are now sampled once every three years. Our last survey was in 2003 (Fresquez 2004a) and the next planned full-scale soil assessment will occur in 2006.

Although the soil-sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we annually collect two perimeter soil samples on their lands that are downwind of Area G, the Laboratory's principal radioactive waste disposal site. Area G, approximately 63 ac in size, is located in the Laboratory's Waste Disposal Site (Technical Area [TA] 54) at the Laboratory's eastern boundary. Soil samples at these locations were collected at the 0- to 2-in. depth from relatively level, open (unsheltered by trees or buildings), rock-free, and undisturbed areas on Pueblo de San Ildefonso lands.

One sample, identified as "San Ildefonso," was collected across Mortandad Canyon from Area G, and the other sample, identified as "Tsankawi/PM-1," was collected about 2.5 miles from Area G. These samples were analyzed for tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; and uranium-238. Also, the soils were analyzed for 23 trace and abundant elements, including barium, beryllium, chromium, mercury, cadmium, lead, and other metal elements. Results for tritium are reported on a pCi/mL basis; results for the other radionuclides are reported on a pCi/g dry weight basis; and, the results for the elements are reported on a mg/kg (parts per million) and µg/kg (parts per billion) dry weight basis. The results from these two samples are in supplemental Table S7-1.

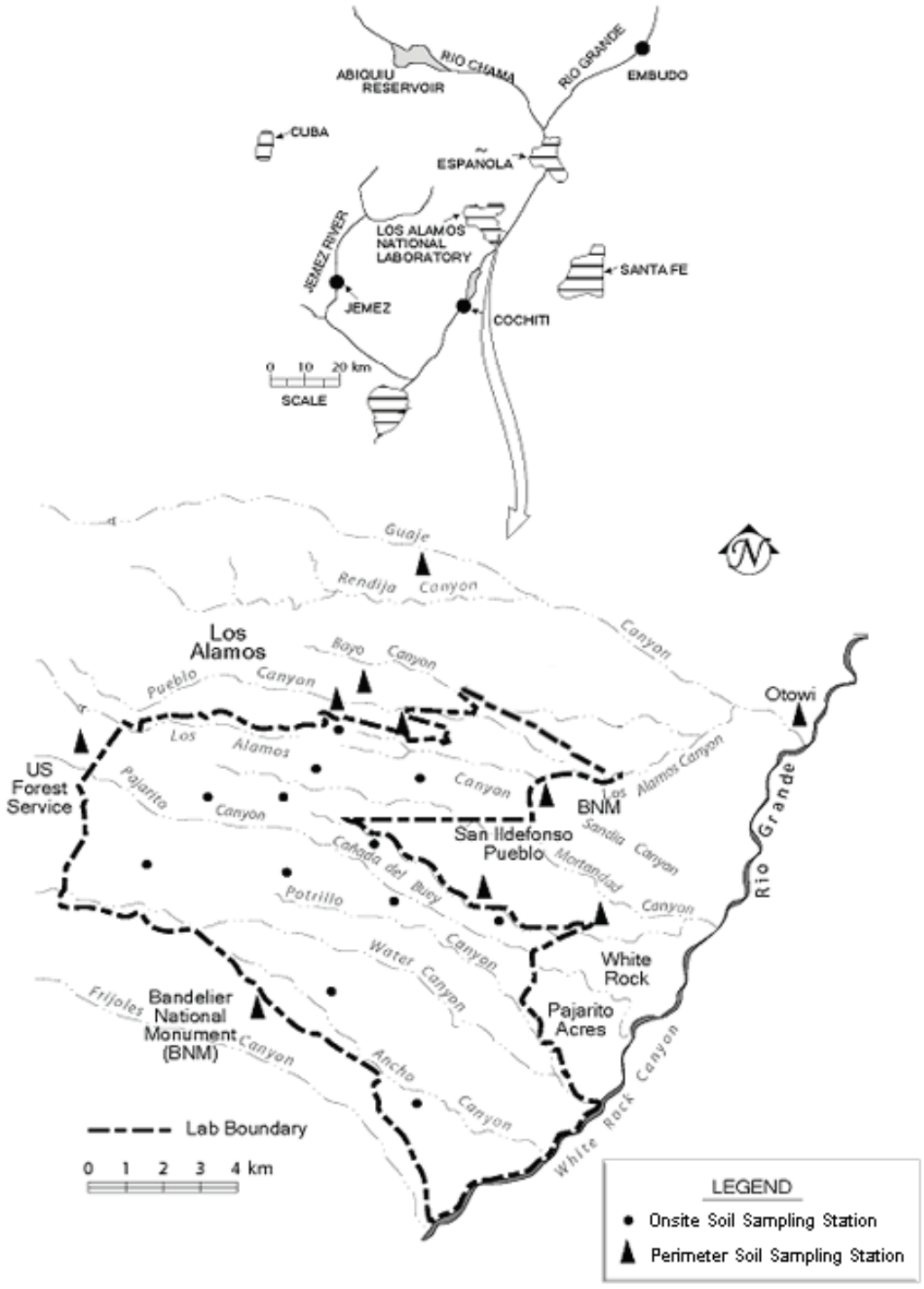

Figure 7-1. On-site Laboratory, perimeter, and off-site regional soil sampling locations.

2. Radionuclide Analytical Results

When we compared the radionuclide concentrations with regional background concentrations on both Pueblo de San Ildefonso sites, we found that all radionuclides (with the exception of uranium-234 and uranium-238 isotopes in the Tsankawi/PM-1 sample) were either nondetectable or below RSRLs (Table S7-1). A nondetectable value is one in which the result is lower than three times the total propagated analytical uncertainty and is not significantly different from zero (Keith 1991; Corely et al. 1981).

In 2004, the concentration of plutonium-239,240 in San Ildefonso soil (0.038 pCi/g dry) was just above the RSRL value of 0.032 pCi/g (Fresquez 2005a). This year, the concentrations of plutonium-239,240 are below the RSRL, and a comparison of concentrations detected since 1996 from this same general location show that, for the most part, levels are below the upper-level regional background concentration (Figure 7-2). Those concentrations that were above the RSRL (two out of 10 measurements) were still far below the residential screening level of 33 pCi/g dry and do not pose any significant human health hazards.

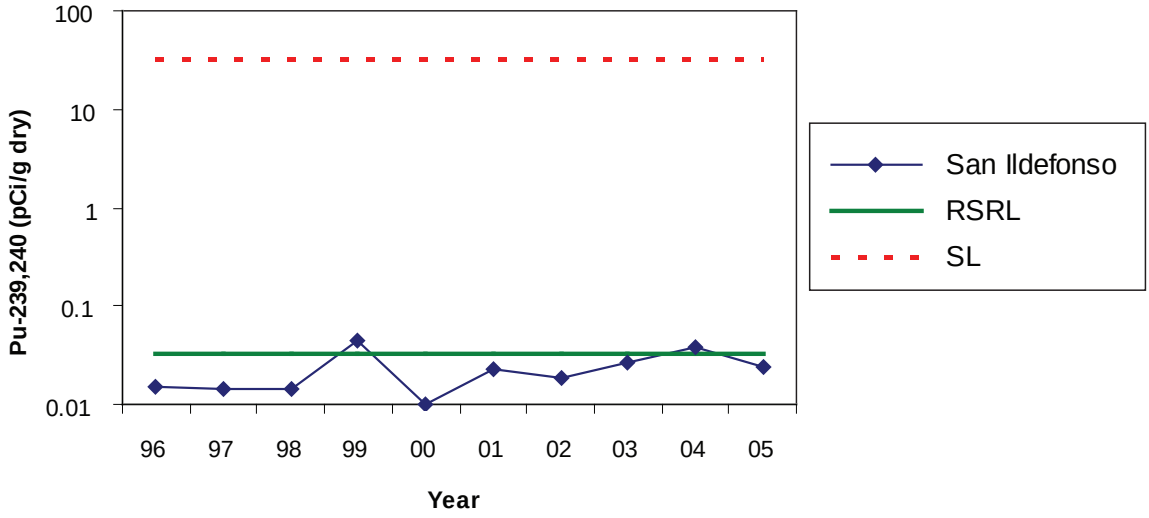

Figure 7-2. Plutonium-239,240 concentrations in soil samples collected from Pueblo de San Ildefonso lands over time, approximately one-half mile northeast of Area G, as compared with the regional statistical reference level (RSRL) and the screening level (SL).

Like 2004, the levels of uranium-234 and uranium-238 isotopes in the soil sample collected from the Tsankawi/PM-1 site show only slightly higher levels than RSRLs. A comparison of the isotopic distribution of uranium-234 and uranium-238 in the Tsankawi/PM-1 sample implies that the uranium is of natural origin and probably not a Laboratory contribution.

3. Nonradionuclide (Trace and Abundant Elements) Analytical Results

Table S7-2 shows the results of the elemental analysis, including many heavy metals, in surface soils collected from Pueblo de San Ildefonso lands. All elemental concentrations, including barium, beryllium, chromium, cadmium, lead, nickel, and mercury, in soils from Pueblo de San Ildefonso lands were below RSRLs.

D. FACILITY MONITORING

1. Monitoring Network

The Laboratory conducts facility-specific soil monitoring on an annual basis at Area G (Lopez 2002) and at DARHT (Nyhan et al. 2001). Area G is a 63-ac (25.5-hectare) radioactive waste processing area located on the east end of Mesa del Buey at TA-54 (Figure 7-3). Area G was established in 1957 and is the Laboratory's primary 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 deposited at Area G (DOE 1979). Monitoring at Area G includes the collection and analysis of air, sediments, surface water runoff, soil, vegetation, and small mammals for possible contaminants. Section D.2, below, reports on soil surface samples (15) collected at designated places within and around the perimeter of Area G for tritium; plutonium-238; plutonium-239,240; americium-241; uranium-234; uranium-235; and uranium-238. We report on the analysis of vegetation collected at Area G in Chapter 8, Section 4.b. Paragon Analytics, Inc., analyzed the samples.

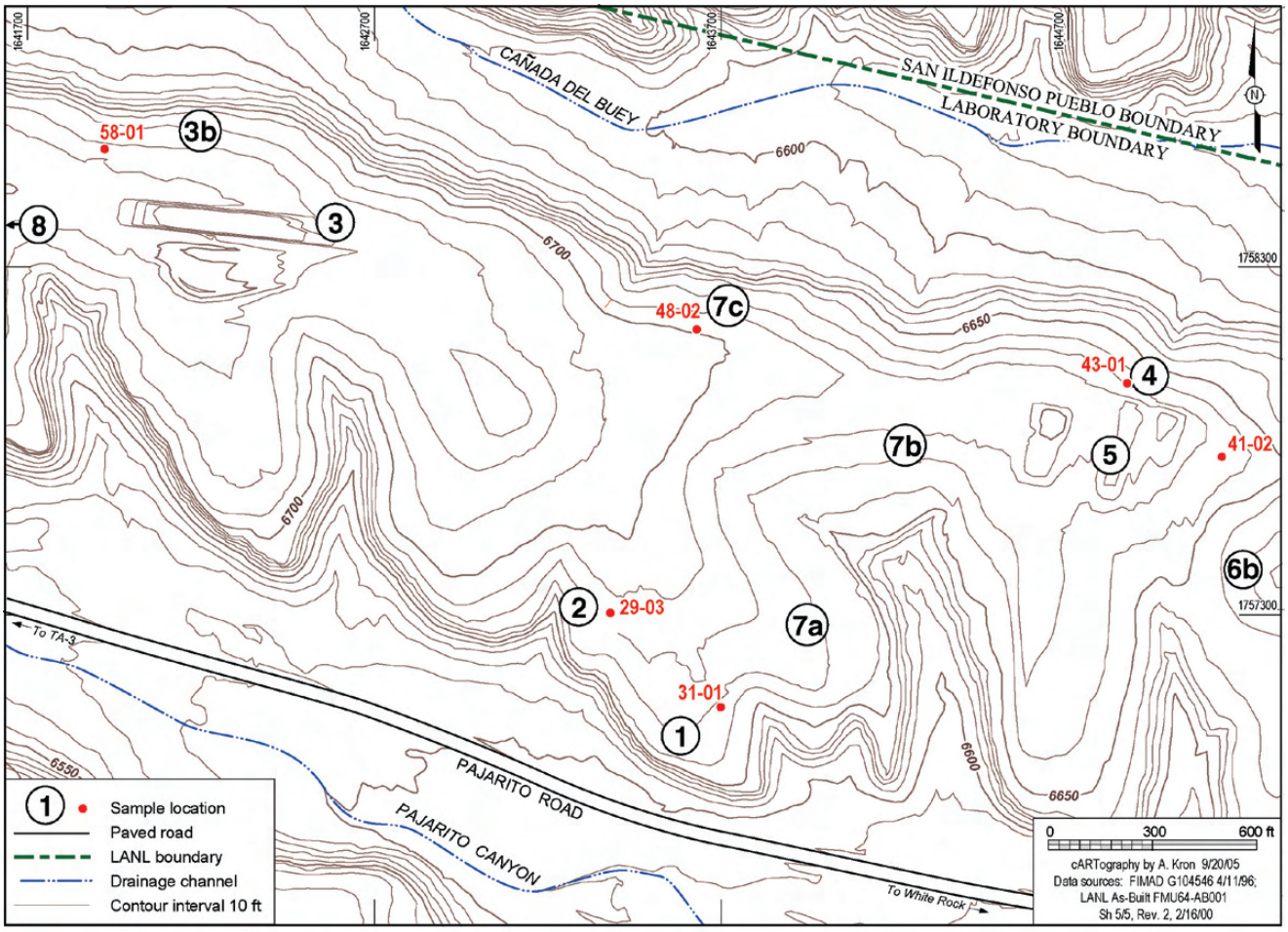

Figure 7-3. Sample locations of soils and vegetation at Area G.

DARHT, approximately 20 ac (eight hectares) in size, is located at R-Site (TA-15) at the Laboratory's southwestern end. Activities at DARHT include the utilization of very intense X-ray sources 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). Possible contaminants include various radionuclides and heavy metals. Similar to Area G, the monitoring includes an assessment of various media to determine impacts, if any.

Section D.3, below, reports on four surface soil and four sediment samples collected at designated locations less than 200 feet away on all four sides of the facility within the DARHT grounds. Paragon Analytics, Inc., analyzed all samples for concentrations of tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; uranium-238; and for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium. We report on the analysis of vegetation collected at DARHT in Chapter 8, Section 4.c.

We compared Area G's results for radionuclides in soils with the RSRLs, whereas we compared DARHT results for radionuclides and nonradionuclides in soils and sediments with the BSRLs.

2. Radionuclide Analytical Results for Area G at TA-54

Many surface soil samples collected at Area G contained concentrations of tritium, plutonium-238, plutonium-239,240, and americium-241 above RSRLs (Table S7-3) (Fresquez et al. 2005). Concentrations of tritium in soils were detected above the RSRL in four of the 15 soil samples collected. Of these four samples, the highest levels were measured at 297 and 274 pCi/mL from soil samples (location #2 and 29-03) collected near the southern portion of Area G where the tritium waste disposal shafts are located (see Figure 7-3 for locations). Our

results are similar to concentrations detected in past years at these locations (Fresquez et al. 2004a, Fresquez and Lopez 2004) and match up well with the vegetation data collected at Area G on the southern side (see Chapter 8, Section 4.b). Although tritium is consistently detected above the RSRL in soil samples in the southern portion of Area G year after year, the concentrations are far below the SL of 5,400 pCi/mL (converted from the SL of 750 pCi/g and assuming 12 percent moisture content), and the migration of tritium from the Area G boundary, at least at surface and subsurface depths, is not extensive. In a recent study at Area G, tree samples were collected along a transect starting from the southern portion at various distances (approximately 10, 50, 100, 150, and 200 m) from the perimeter fence line (Fresquez et al. 2003). Results showed that the concentrations of tritium in trees collected nearest the perimeter boundary (10 to 16 m) were higher than the RSRL for vegetation. From there, the concentrations of tritium in trees significantly decreased with distance, and at about 90 m (295 ft) away, the concentrations were similar to the RSRL.

Some soil samples collected at Area G, particularly around the perimeter of the north and northeastern sections, contained americium-241 (eight out of 15), plutonium-238 (seven out of 15), and plutonium-239,240 (nine out of 15) above RSRLs. The highest concentrations of americium-241 (0.41 pCi/g dry), plutonium-238 (3.1 pCi/g dry), and plutonium-239,240 (1.1 pCi/g dry) were detected in a soil grab sample (site 41-02) located at the perimeter of the northeastern corner of Area G. All concentrations were below SLs, however. Out of 45 values, only one uranium isotope, uranium-234, was higher than the RSRL (1.4 vs. 1.3 pCi/g dry) and the distribution of uranium-234 to uranium-238 in all of the soil samples collected indicated natural sources. These data are very similar to last year's results (Fresquez and Lopez 2004). Overall, concentrations of radionuclides in surface soils at Area G are still very low (pCi/g range) and far below SLs and regulatory standards.

With reference to trends over time (1996–2005), Figures 7-4 and 7-5 show the concentrations of tritium and plutonium-239,240 in soils collected from areas that consistently have had the highest amounts detected year after year. The results for tritium at the "worst case" locations (sites #1, 2, 29-03, and 31-01) show that, with the exception of an increase in tritium concentrations that peak in 2002, all levels appear to decrease to those commonly observed in past years (Figure 7-4). We do not know completely why the concentrations of tritium in soils at these locations at Area G increased so dramatically during the period of time around 2002, but many factors associated with tritium movement at Area G—such as the different waste forms and containment systems, variabilities in the physical properties of the tuff (ash flows, open joints, and porosity), precipitation, temperature, and barometric pressure—all play roles in the fluctuating soil vapor levels observed from year to year (Purtymun 1973, Abeele and Nyhan 1987). As for the plutonium-239,240 concentrations in the "worst case" areas at Area G, which are located on the northern side (sites #4, 41-02, and 7c), they do not appear to be increasing over time (Figure 7-5).

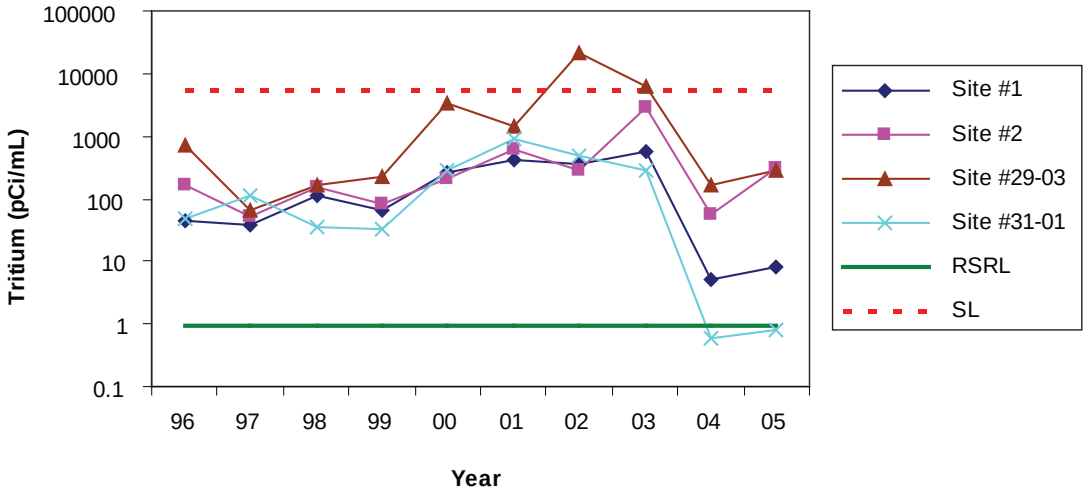

Figure 7-4. Tritium in surface soils collected from the worst case locations (southern portions) at Area G at TA-54 from 1996 to 2005 as compared with the regional statistical reference level (RSRL) and screening level (SL).

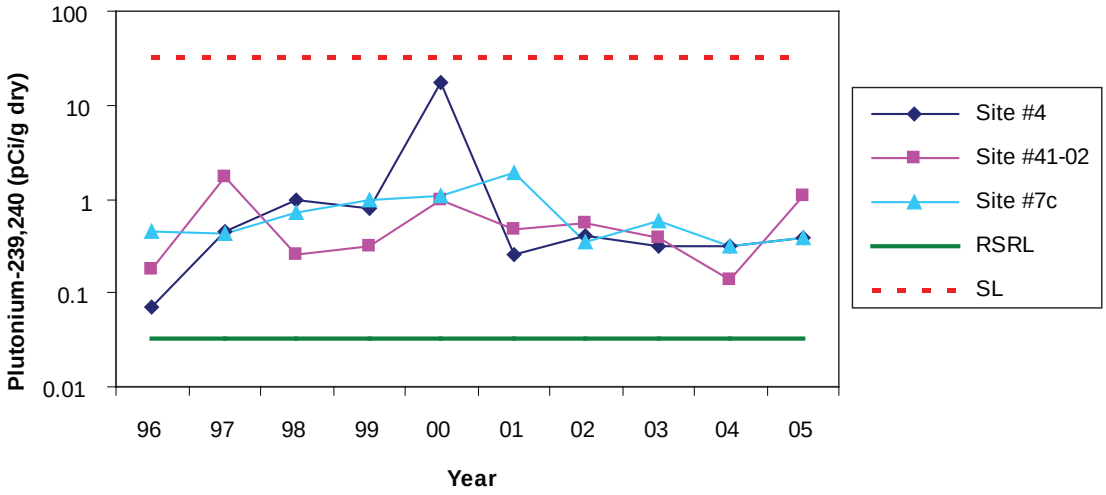

Figure 7-5. Plutonium-239,240 in surface soils collected from the worst case locations (northern portions) at Area G at TA-54 from 1996 to 2005 as compared with the regional statistical reference level (RSRL) and screening level (SL).

More chemical data associated with sediment transport within canyon reaches in Pajarito Canyon and Canada del Buey located downgradient of the tributary drainages from Area G, and deep boreholes drilled alongside Area G pits and shafts can be found in Chapter 9, Section E.2.

3. Radionuclide and Nonradionuclide Analytical Results for TA-15, DARHT

In general, all of the radionuclides in soils and sediments collected from around the DARHT facility are low, and most samples, especially the sediment samples, contained radionuclide concentrations that were either nondetectable or below BSRL values (Table S7-4) (Fresquez 2006).

Radionuclides that were above the BSRLs included concentrations of cesium-137 in three out of the four soil samples and one out of the four sediment samples, plutonium-239,240 in one out of the four soil samples and one out of the four sediment samples, and most of the uranium isotopes in the soil samples. All of the radionuclides in the soil and sediment samples were far below SLs and the distributions of uranium-234 to uranium-238 were consistent with natural uranium. These data, in terms of the concentration levels, exhibited similar results in past years (Nyhan et al., 2003, Fresquez et al., 2004b and Fresquez 2004b). We have, however, measured uranium consistent with depleted uranium in some soil samples in past years. Nevertheless, the concentrations and distributions of all observed radionuclides in soils and sediments from all locations collected in 2005 at DARHT are of no significant health concern. Similarly, all trace metal elements in soil and sediment samples collected at the DARHT facility were similar to BSRLs (Supplemental Table S7-5).

E. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND NONFOODSTUFFS BIOTA PROGRAM

1. Quality Assurance Program Development

The sampling team conducts soil, foodstuffs, and nonfoodstuffs biota (SFB) sampling according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Quality Assurance Project Plan for the Soils, Foodstuffs, and Biota Monitoring Project and in the following procedures:

- "Produce Sampling,"
- "Fish Sampling,"
- "Game Animal Sampling,"
- "Processing and Submitting Samples,"

- "Soil Sampling,"
- "Chain-of-Custody Data for Soil, Foodstuffs, and Biota Samples,"
- "Sampling Soil and Vegetation at Facility Sites," and
- "Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota."

These procedures, which are available at http://www.lanl.gov/community/environment/air/, ensure that the collection, processing, and chemical analysis of samples, the validation and verification of data, and the tabulation of analytical results are conducted in a consistent manner from year to year. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analyzing and reporting.

2. Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of carefully documented procedures, described above, that govern all aspects of the sample-collection program.

The team collects all samples under strict chain-of-custody procedures, which minimize the chances of data transcription errors. We hand-deliver soil samples to the sample management office where they are directly shipped to an external analytical laboratory under full chain-of-custody. Foodstuffs and nonfoodstuffs biota samples are brought back in locked ice chests to the TA-21 laboratory and processed in a secure and radiologically clean laboratory. After processing, the sample management office ships the samples to an external analytical laboratory under full chain-of-custody. The project leader tracks all samples, and upon return of data from the supplier via electronic and hard copy means, the validation and verification staff chemist assesses the completeness of the field sample process along with other variables. A quality assessment document is created and 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-chemistry services after the Data Quality Objective process has identified and quantified the program objectives. These statements of work are sent to potentially qualified suppliers who then 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 lab (including recent past performance on nationally conducted performance-evaluation programs) are primarily used to award contracts for specific types of radiochemical and inorganic analyses.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. Each laboratory returns data by e-mail 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 samples contains all the internal quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the 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 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 in each database and prepare periodic reports to management.

4. Field Data Quality Assessment Results

Field data completeness for SFB in 2005 was 100 percent.

5. Analytical Data Quality Assessment Results

Analytical data completeness for all SFB sampling programs was >95 percent. We track, trend, and report all quality control data in specific quality evaluation memos that we submit to project staff along with each set of analytical data received from our chemistry laboratories. The overall results of the 2005 program of quality monitoring indicate that all analytical laboratories maintained the same high level of control that has been observed in the past several years.

6. Analytical Laboratory Assessments

During 2005, two external laboratories performed all chemical analyses reported for SFB samples:

- Paragon Analytics, Inc., Fort Collins, Colorado, provided radiological and trace element analysis in soils, vegetation, fish, and small mammals.
- Alta Laboratory, El Dorado Hills, California, provided PCB analyses in fish tissue.

We performed an assessment of Paragon Analytics during 2004. The laboratory participated in national performance-evaluation studies during 2004 and 2005. The detailed results of these performance evaluations are included in the assessment report. Overall, the study sponsors judged the analytical lab 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 are being implemented as written. The auditors (Time Solutions 2) were external QA professional experts (ISO 9000 and 14001:2004 certified) and examined all aspects of the SFB program as it relates to procedures. While it was noted that improvements have been made to the SFB program since the last audit by auditors external to the group but internal to LANL, several observations were made to improve processes. These observations include keeping procedures up to date and meeting internal commitments made in our group quality assurance plans. Since that quality assessment, we have implemented all observations.

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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 edible vegetables, fruit, grain, and animal products are harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes an important exposure pathway by which radionuclides (Whicker and Schultz 1982) and nonradionuclides (heavy metals and organics) (Gough et al. 1979) can be transferred to humans. Over the years, we have collected a variety of foodstuff samples (e.g., fruits, vegetables, grains, fish, milk, eggs, honey, herbal teas, mushrooms, piñon nuts, domestic animals, and large and small game animals) from the surrounding area and communities to determine the impacts of Laboratory operations on human health via the human food chain. Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate this monitoring program, and the guidance for assessing these impacts to foodstuffs are presented in DOE (1991).

The objectives of the program are as follows:

- Measure radioactive and nonradioactive concentrations in foodstuffs from on-site (the Los Alamos National Laboratory [LANL]) and perimeter areas, and compare these results to regional (background) areas;
- Determine trends over time; and
- Provide data used to estimate dose from the consumption of the foodstuffs (see Chapter 3 for dose estimates to individuals from the ingestion of foodstuffs).

This year, we focused on the collection and analysis of radionuclides, metals, and polychlorinated biphenyls (PCBs) in predator and bottom-feeding fish from Cochiti Reservoir—an impoundment downstream of LANL. For the second year, we also collected, analyzed, and assessed common purslane, a wild edible plant, collected from within Mortandad Canyon on Pueblo de San Ildefonso lands.

2. Foodstuffs Standards

To evaluate Laboratory impacts to foodstuffs from radionuclides and nonradionuclides, we first compared analytical results of foodstuffs samples to regional statistical reference levels (RSRLs). Where the levels exceed RSRLs, we then compared the concentrations to screening levels (SLs) and standards, if available. Table 8-1 summarizes the levels and/or the standards used to evaluate the foodstuffs monitoring program.

Table 8-1
Standards and Other Reference Levels Applied to Foodstuffs

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	All foodstuffs	100 mrem	1.0 mrem	RSRLs
Nonradionuclides					
Trace elements	On-site and perimeter	All foodstuffs			RSRLs
Mercury	Perimeter	Fish	1 µg/g (wet) in edible portion	0.3 µg/g (wet) in edible portion	RSRLs
Polychlorinated Biphenyls	Perimeter	Fish	2 µg/g (wet)	1.5 ng/g (wet) (limited consumption restrictions)	RSRLs

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations = 99 percent confidence level) calculated from foodstuffs data collected from regional locations away from the influence of the Laboratory (>9 miles away) (DOE 1991) over at least the last five sampling dates. (For a list of regional locations see Section A.3.a, "Monitoring Network.") RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of this report.
- Screening Levels: SLs are set below federal regulations so that potential concerns may be identified in advance of major problems—i.e., a "yellow flag." If a constituent exceeds an SL, then the reason for that increase is thoroughly investigated. For radionuclides, the dose assessment team developed screening levels to identify the potential contaminants of concern on the basis of a conservative 1 mrem protective annual dose limit (this is 1 percent of the 100 mrem/yr DOE standard presented in Order 450.1) (see the QA plan for dose assessment at http://www.lanl.gov/community/environment/air/). Nonradionuclides, like mercury and PCBs in fish, are compared with the Environmental Protection Agency (EPA) water quality criterion (EPA 2001).
- Standard: Based on the concentrations of radionuclides in foodstuffs, we calculated a dose to a person (see Chapter 3). We compared this dose with the 100-mrem/yr DOE all pathway dose standard. Nonradionuclides, like mercury and PCBs in fish, are compared to Food and Drug Administration (FDA) (FDA 2000) or EPA (EPA 2000) levels.

3. Fish

a. Monitoring Network

There are 19 canyons that, depending on the season and amount of precipitation, may carry water through LANL lands to the Rio Grande. We sampled Cochiti Reservoir, a recreational fishery on the Rio Grande located approximately five miles downstream of LANL, to determine if fish are affected by Laboratory operations (Figure 8-1). We compared fish collected from Cochiti Reservoir to background fish collected upstream of the Laboratory—principally from Abiquiu Reservoir or Heron Reservoir, depending on the availability of water.

Figure 8-1. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations.

Abiquiu and Heron Reservoirs are located on the Chama River and are upstream from the confluences of the Rio Grande and the intermittent streams that cross Laboratory lands (Fresquez et al. 1994). Radionuclides, metals, and PCBs in fish from background areas are from worldwide fallout, natural sources, or other sources not associated with the Laboratory.

Samples that were collected from Cochiti and Abiquiu Reservoirs in 2005 included the predator fish northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides salmoides*), smallmouth bass (*Micropterus dolomieui*), white crappie (*Pomoxis annularis*), brown trout (*Salmo trutta*), white bass (*Morone chrysops*), and walleye (*Stizostedion vitreum*). Bottom-feeding fish collected included the white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*). We analyzed these fish for tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235 and uranium-238. Results for radionuclides in fish are reported on a per gram dry weight basis, with the exception of tritium, which is reported on a per mL basis (Table S8-1 and S8-2). In addition to radionuclides, 23 trace inorganic elements were analyzed (Table S8-3 and S8-4). Results for these elements are reported on a wet weight basis. Finally, PCB analysis included the full 209 congener list (Gonzales and Fresquez 2006) and are reported on a ng/g (ppb) wet weight basis (Table S8-5).

b. Radionuclide Analytical Results

The complete set of results for fish is found in the data supplement, Tables S8-1 and S8-2. All radionuclides in predator fish from Cochiti Reservoir were either not detected (the result is less than three times the analytical uncertainty) (Keith 1991, Corely et al. 1981) or detected at concentrations similar to radionuclide concentrations in fish collected upstream of LANL (<RSRLs). Similarly, all radionuclides in bottom-feeding fish collected from Cochiti Reservoir were nondetectable or below RSRLs, except for one sample that contained uranium-234 and uranium-238 just above the RSRLs. However, the isotopic uranium concentrations were far below SLs and the isotopic distribution indicates that the uranium was of natural origin. These results, with particular reference to total uranium, are similar to past years (Figure 8-2) (Fresquez and Armstrong 1996) and to other reservoir studies in Colorado (Whicker et al. 1972; Nelson and Whicker 1969) and New Mexico (Fresquez et al. 1996, Fresquez et al. 1998). In addition, the results are similar to radionuclide levels in fish collected along the length of the Rio Grande from Colorado to Texas (Booher et al. 1998) and directly downstream of LANL in 1998 (Fresquez et al. 1999a).

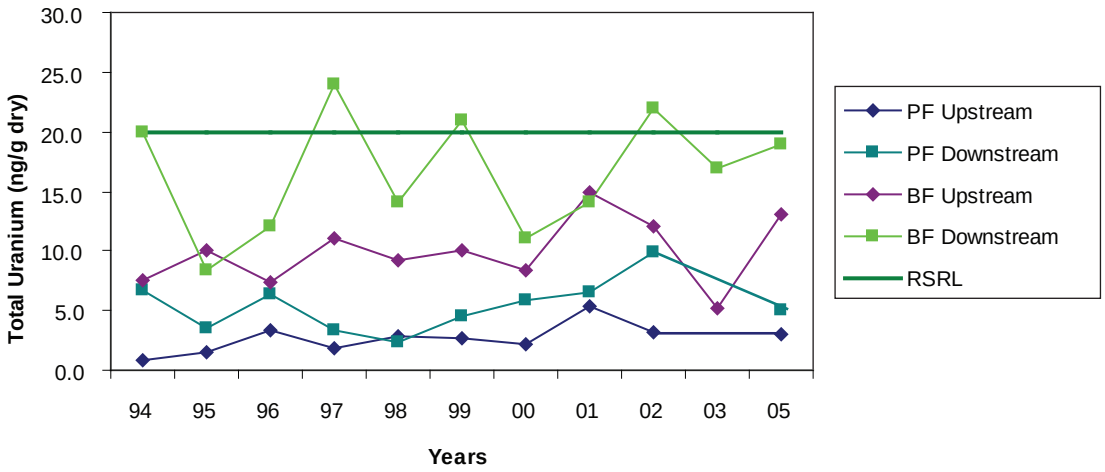


Figure 8-2. Mean total uranium in predator fish (PF) and bottom-feeding fish (BF) collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1994 through 2005 as compared to the regional statistical reference level (RSRL).

c. Nonradionuclide (Trace and Abundant Elements) Analytical Results

Total inorganic elemental concentrations in muscle fillets of predator and bottom-feeding fish collected upstream (Abiquiu Reservoir) and downstream (Cochiti Reservoir) of LANL are presented in Tables S8-3 and S8-4. Of the 23 inorganic elements analyzed in fish samples from Cochiti Reservoir, most were either below the reporting limits (e.g., not detected) or below the RSRLs. Only manganese in most samples was detected above the RSRL in predator fish samples from Cochiti Reservoir. The levels (maximum of 2.3 mg/kg), however, were far below the levels considered toxic to fish (>2,420 mg/kg) (Schroeder et al. 1966) and are at the same levels as the bottom-feeding fish from both locations (averages were 0.54 and 0.62 mg/kg). Manganese is an essential nutrient for enzyme function in living organisms and has a low order of toxicity (Schroeder et al. 1966).

Although mercury concentrations in both fish types downstream of LANL were similar in concentrations to fish collected upstream of the Laboratory and agree with past results (Figures 8-3 and 8-4) (Fresquez 2004a, Fresquez et al. 1999b), the levels in many predator fish samples collected from both reservoirs are above the SL of 0.30 mg/kg wet. Because mercury normally biomagnifies up the food chain, the predator (carnivorous) fish would be expected to contain more mercury than the bottom-feeding (omnivorous) fish (Ochiai 1995). Also, these levels are not atypical as there are currently 26 fish consumption advisories in New Mexico, including the Rio Grande, for mercury (NMDH 1993, Bousek 1996, Torres 1998). The main sources of mercury into the water systems in New Mexico is from natural degassing of the earth's crust, the burning of fossil fuels, and the microbial conversion of mercury using carbon as an energy source from flooded vegetation (NMED 1999).

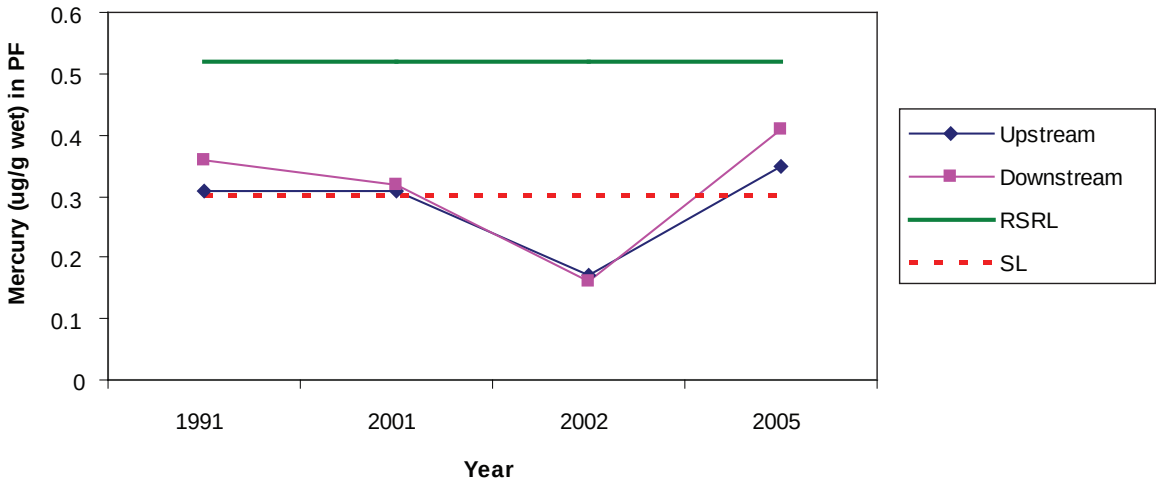


Figure 8-3. Mean mercury concentrations in predator fish (PF) collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1991 through 2005 as compared to the regional statistical reference level (RSRL) and screening level (SL).

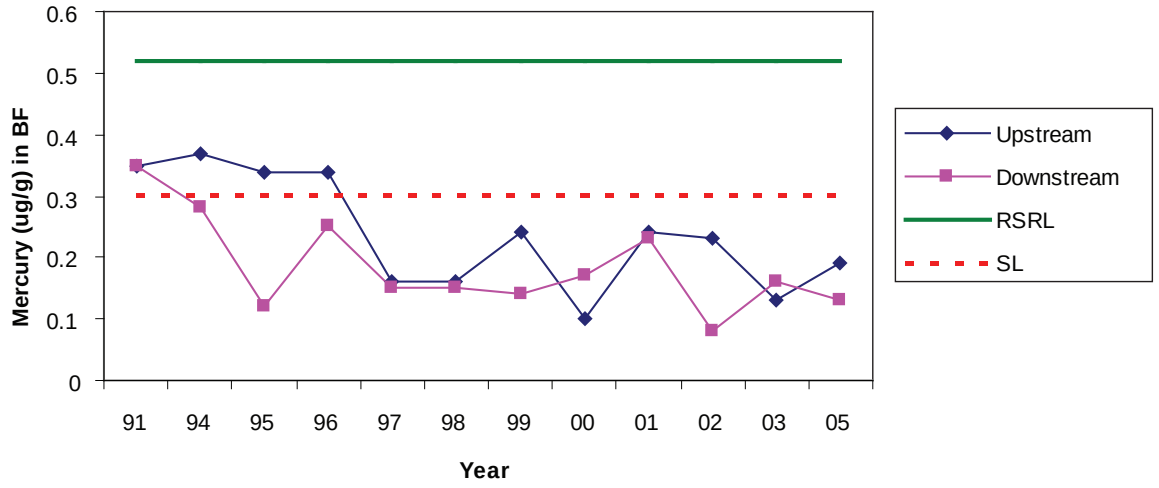


Figure 8-4. Mean mercury concentrations in bottom-feeding fish (BF) collected from reservoirs upstream (Abiquiu) and downstream (Cochiti) of LANL from 1991 through 2005 as compared to the regional statistical reference level (RSRL) and screening level (SL).

d. PCB Analytical Results

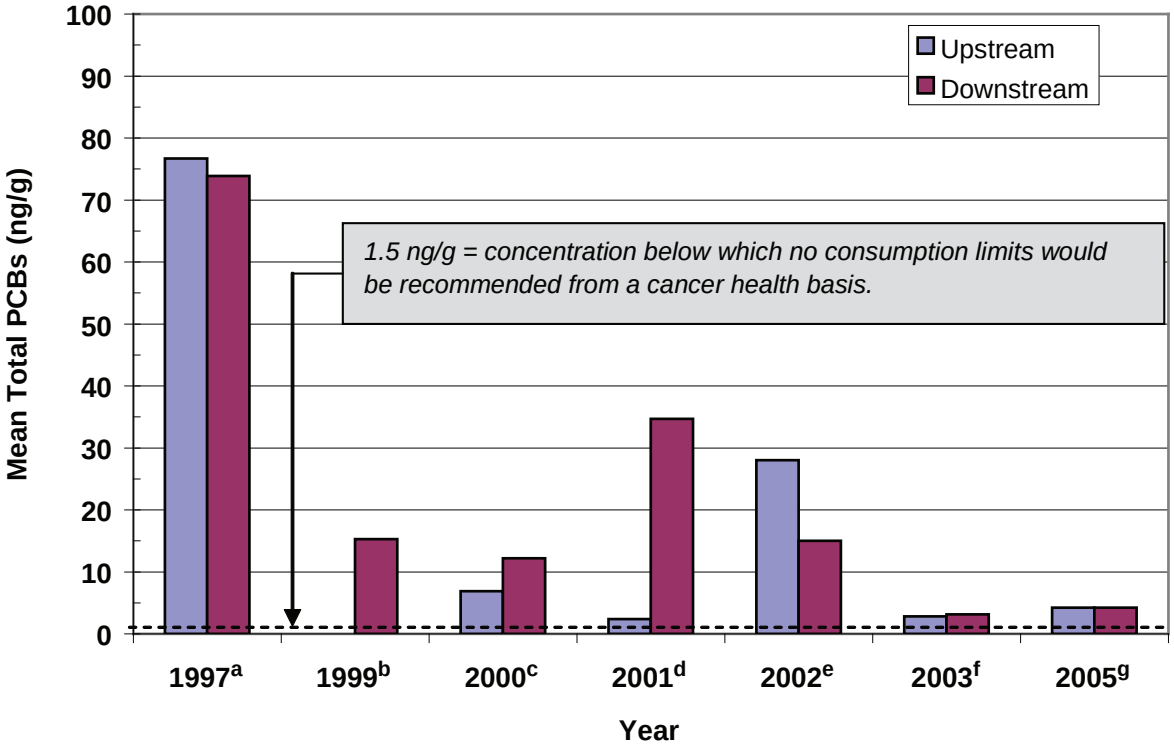
We collected six species of fish from Abiquiu (upstream of LANL) and Cochiti (downstream of LANL) Reservoirs and analyzed the edible portion (fillets) for 209 possible PCB congeners (Gonzales and Fresquez 2006). Mean total PCB concentrations in fish from Abiquiu Reservoir (μ=2.4 ng/g) were statistically similar (α=0.01) to mean total PCB concentrations in fish from Cochiti Reservoir (μ=2.7 ng/g) implying that LANL may not be the only or major source of PCBs in fish in Cochiti Reservoir (Table S8-5). The levels of PCBs in fish from Cochiti Reservoir generally appear to be declining over the years, at least since 2001 when PCB levels appeared to have peaked following the Cerro Grande Fire (Figure 8-5). Although a PCB "fingerprinting" method can be used to relate PCB "signatures" in one area to signatures in another area, this method of implicating the source of PCBs

cannot be effectively used for biota because metabolic processes alter the PCB signature. Regardless of the source of the PCBs, certain species of fish (catfish and carpsuckers) at both Abiquiu and Cochiti Reservoirs continue to harbor levels of PCBs that could be harmful to human health if they are the primary part of the diet over a long period of time. Bottom-feeding fish (carpsucker and catfish) from Cochiti Reservoir contained statistically higher levels of total PCBs (μ=4.25 ng/g-fillet-wet) than predator fish (walleye, northern pike, bass) (μ=1.67 ng/g) and the bottom-feeding fish had levels of PCBs that fall into a restricted consumption category according to EPA guidelines (Table S8-6). Similarly, bottom-feeding fish from Abiquiu Reservoir contained statistically higher levels of total PCBs (μ=4.25 ng/g-wet) than predator fish (walleye, bass) (μ=0.68 ng/g-wet) and only the bottom-feeding fish had levels of PCBs that fall into a restricted consumption category. These results are similar to previous studies showing that fish or artificial fish fat (fat bags) from downstream sources (Rio Grande and Cochiti Reservoir) contain similar PCB levels to fish collected from upstream sources (Gonzales et al. 1999, Fresquez et al. 2001, Fresquez et al. 2002, Gonzales and Fresquez 2003, Gonzales and Montoya 2005). However, like total PCBs, levels of the particular congeners (dioxin-like) that tend to dominate the risk from consuming the fish generally are decreasing over time.

4. Wild Edible Plants

a. Monitoring Network

In 2004, we collected three types of wild edible plants (common purslane [*Portulaca sp.*], wild spinach [*Spinacia sp*], and acorns [*Quercus sp.*]) from within Mortandad Canyon on Pueblo de San Ildefonso lands (Fresquez et al. 2005a). The composite samples (two of purslane and one of spinach) were collected approximately 5 to 50 m (16 to 160 ft) from the LANL boundary fence line. Also, acorns from oak trees (*Quercus sp.*) were collected about 200 m (650 ft) from the LANL boundary fence line. The analysis of these wild edible foods, particularly purslane, showed higher amounts of strontium-90, plutonium-239,240, and barium than RSRLs. (Note: Purslane was compared to RSRLs, which were determined from common produce plants and not directly from purslane plants, per se.) Although all radionuclide concentrations in purslane samples collected from within Mortandad Canyon were below SLs, we wanted to better define the reasons for these slightly higher amounts of radionuclides in these 2004 plant samples. To this end, in 2005 we collected more purslane samples (three composite samples) from the same locations as last year in Mortandad Canyon and also some purslane samples (two composite samples) from background sites in northern New Mexico. In addition, we collected soil samples from the same locations where we collected the purslane samples in Mortandad Canyon so that a source could be identified. All samples were analyzed for tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, uranium-234, uranium-235 and uranium-238. Also, in addition to barium, 22 other trace and abundant elements were analyzed.



Upstream: Above LANL confluences (e.g., Abiquiu Reservoir, Rio Grande above Otowi bridge).

Downstream: Below LANL confluences (e.g., Cochiti Reservoir, Rio Grande below Otowi bridge).

[a] Total PCBs from summation of Aroclors from catfish collected from the Rio Grande. (Data source: Gonzales et al. 1999).

[b] Mean total PCBs in fillets was estimated from whole-body concentrations in one catfish and one carp collected from Cochiti Reservoir. (Data source: NMED 2006).

[c] Carp collected from Abiquiu (upstream of LANL) and Cochiti (downstream of LANL) Reservoirs; Mean total PCBs from summation of 209 congener analysis; Fillet concentrations estimated from ratio of fillet concentration: whole body concentration established by LANL (2002). (Data source: LANL 2001).

[d] Abiquiu and Cochiti Reservoirs; Cochiti mean total PCBs estimated for 209 total from dioxin-like total PCBs measured in catfish fillets. Abiquiu mean total PCBs estimated for catfish fillets from whole-body and estimated for 209 total from dioxin-like total. (Data source: LANL 2002).

[e] Rio Grande; Catfish; Mean total PCBs from summation of 209 congener analysis of catfish fillets from the Rio Grande. Ten catfish from four confluences downstream of LANL and five catfish upstream of LANL along San Idelfonso Pueblo. (Data source: Gonzales and Fresquez 2003).

[f] Semipermeable membrane devices (SPMDs), also referred to as "fat bags," consist of triolein-containing polyethylene membrane tube housed in perforated stainless steel canisters. SPMDs were placed in the Rio Grande above Otowi bridge (upstream of LANL) and at the confluence of Ancho Canyon (downstream of LANL) for 28-day sampling periods. SPMDs sample dissolved PCBs similar to fish. SPMDs were analyzed for 209-congener suite. (Data source: Gonzales and Montoya 2005).

[g] Catfish and carpsuckers taken from Abiquiu (upstream of LANL) and Cochiti (downstream of LANL) Reservoirs. Mean total PCBs from summation of 209 congener analysis of fillets. (Data source: Gonzales and Fresquez 2006).

Figure 8-5. Mean total PCB concentrations (from 209 congeners possible) in fillets of bottom-feeding fish from the Rio Grande and Abiquiu and Cochiti Reservoirs over time. The dotted line is equal to 1.5 ng/g and represents the lower limit of consumption restrictions.

b. Radionuclide Analytical Results

The analyses of the nine radionuclides in purslane plants collected from Mortandad Canyon on Pueblo de San Ildefonso lands show that strontium-90 was the only radionuclide that was detected in concentrations above the RSRLs (Table S8-7). These data confirm the uptake of strontium-90 by purslane plants detected in 2004 (Figure 8-6) (Fresquez et al 2005a). Although the concentrations of strontium-90 in purslane plants from Mortandad Canyon are higher than the concentrations found in purslane plants collected from background

locations, the soil samples collected from the same locations as the purslane plants in Mortandad Canyon do not directly support the plant data (Table S8-8). That is, strontium-90 in soils collected from the same locations as the purslane samples in Mortandad Canyon (0.13 and 0.19 pCi/g dry) are not elevated above background concentrations (the RSRL is 0.41 pCi/g dry). A probable reason for this lack of correlation between the higher levels of strontium-90 in purslane plants and the lower levels of strontium-90 in soils from Mortandad Canyon as compared to background may be due to the levels of calcium in the soils. Since plants do not discriminate between strontium and calcium, the tendency of strontium-90 to accumulate in biota is increased if there is a reduction of the calcium in the environment (Whicker and Schultz 1982). A study conducted in the United Kingdom showed that the amount of strontium-90 in plants increased as the amount of exchangeable calcium diminished from 3,000 or 4,000 mg/kg in the soil to less than 2,000 mg/kg (UKARC 1961). Our data shows this general relationship. Tables S8-9 (plant chemical properties) and S8-10 (soil chemical properties) show that the levels of calcium in purslane plants (7,167 mg/kg dry) and soils (1,345 mg/kg dry) from Mortandad Canyon is less than half the amounts in purslane plants (19,500 mg/kg dry) and soils (2,689 mg/kg dry) from background locations. Thus, the lower levels of soil calcium in Mortandad Canyon, compared with background levels, may be a reason we found higher levels of strontium-90 in the purslane plants. Nevertheless, the highest level of strontium-90 in purslane plants from Mortandad Canyon are still below the screening level of 1 pCi/g dry (e.g., <1 mrem).

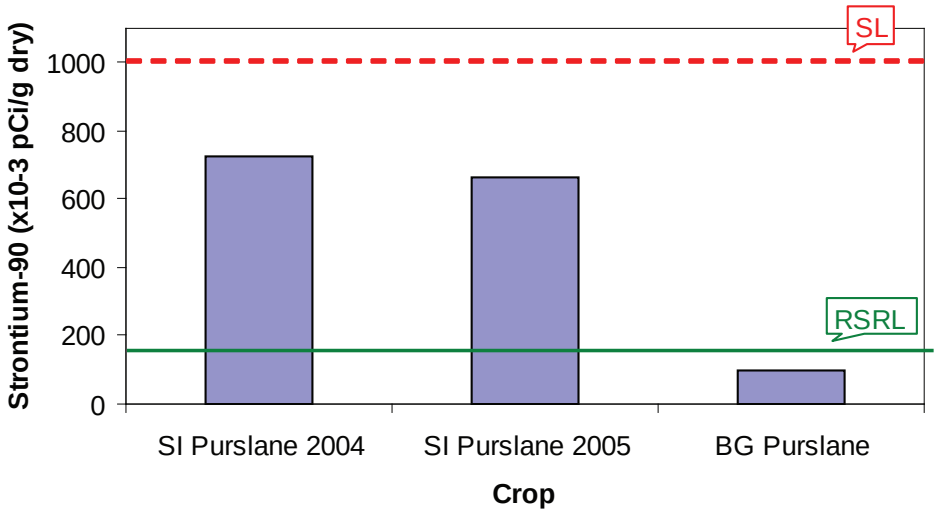


Figure 8-6. Mean strontium-90 concentrations in purslane collected from within Mortandad Canyon on Pueblo de San Ildefonso (SI) lands in 2004 and 2005 compared with background (BG), the regional statistical reference level (RSRL), and the screening level (SL).

c. Nonradionuclide (Trace and Abundant Elements) Analytical Results

All inorganic elemental concentrations, including barium, in purslane samples collected from within Mortandad Canyon on Pueblo de San Ildefonso lands were either below the reporting limits or below RSRLs (Table S8-9). Last year (2004), we reported that barium in the purslane samples collected from within Mortandad Canyon was about three times higher than the RSRLs calculated from common produce plants (e.g., apples, squash, tomatoes, etc.) and hypothesized that purslane plants were probably bio-accumulators of barium (Fresquez et al. 2005a). This year, in addition to the purslane samples collected from Mortandad Canyon, we also collected samples of purslane from background regional areas, specifically with the intention of comparing purslane to purslane (i.e., developing an RSRL from purslane plants). We also collected soil samples from the location of the purslane samples and analyzed them for a host of inorganic elements, including barium (Table S8-10). Results show that barium concentrations in purslane plants collected from background areas contained the same amount of barium as purslane plants collected from Mortandad Canyon in 2004 and 2005 (Figure 8-7). Similarly, we found normal concentrations of barium and all other elements in soil samples collected from the same location as the purslane samples.

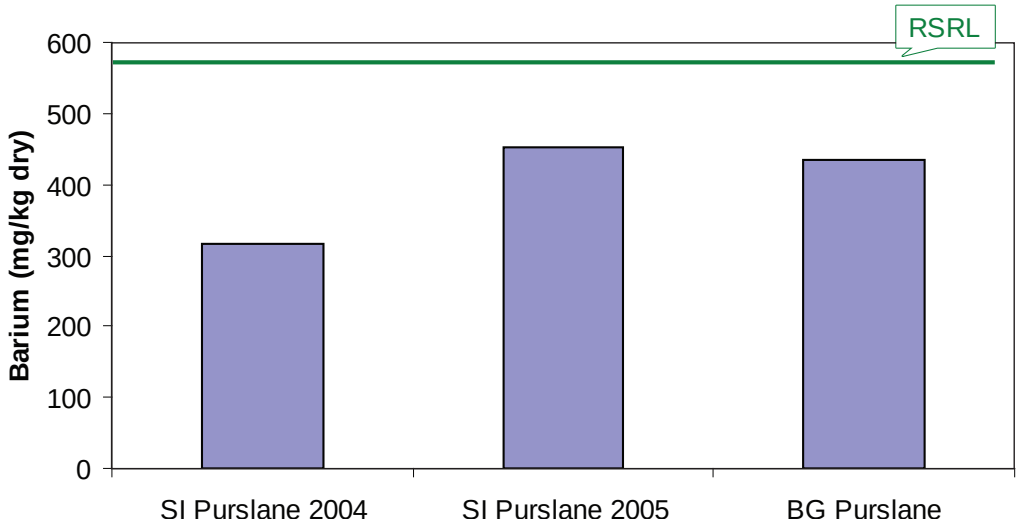


Figure 8-7. Mean barium concentrations in purslane plants collected from within Mortandad Canyon on Pueblo de San Ildefonso (SI) lands in 2004 and 2005 as compared to background (BG) and the regional statistical reference level (RSRL).

B. NONFOODSTUFFS BIOTA MONITORING

1. Introduction

DOE Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993) mandate the monitoring of nonfoodstuffs biota for the protection of ecosystems. Although monitoring of biota, mostly in the form of facility-specific or site-specific studies, began in the 1970s with the Environmental Surveillance Program, site-wide vegetation monitoring started in 1994. Laboratory personnel monitor small mammals, amphibians, reptiles, birds, and vegetation within and around LANL on a systematic basis or for special studies of radiological and nonradiological constituents.

The three objectives of the nonfoodstuffs biota program are to determine the following:

- Radionuclide and nonradionuclide concentrations in biota from on-site and perimeter areas and compare them with regional background concentrations,
- Trends over time, and
- Dose to plants and animals.

Chapter 3 includes the results of the 2005 biota dose assessments at LANL.

2. Nonfoodstuffs Biota Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides in nonfoodstuffs biota, we first compared the analytical results of biota samples collected from on-site and perimeter areas with regional or with baseline statistical reference levels (RSRLs or BSRLs, respectively). If the levels exceed RSRLs (or BSRLs), then we compare the concentrations with SLs, if available, and then to standards, if available. Table 8-2 summarizes the standards used to evaluate the biota-monitoring program. A discussion of these comparison levels is as follows:

- Regional background levels: RSRLs are the upper-level background concentrations (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from nonfoodstuffs biota data collected from regional locations away from the influence of the Laboratory (>9 miles away) (DOE 1991) over the past five years. RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of this report.

Table 8-2
Standards and Other Reference Levels Applied to Nonfoodstuffs Biota

Constituent	Sample Location	Media	Standard	Screening Level	Background Level
Radionuclides	On-site and perimeter	Terrestrial plants and aquatic biota	1.0 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1.0 rad/d	0.1 rad/d	BSRLs
	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
Nonradionuclides	On-site and perimeter	Biota		TVs	RSRLs
	DARHT	Biota		TVs	BSRLs

- Baseline levels: BSRLs are the concentrations of radionuclides and nonradionuclides in biota within and around the DARHT facility (1996–1999) before the operation phase (as of the year 2000). The Mitigation Action Plan for the DARHT facility at LANL mandated the establishment of baseline (preoperational) concentrations for potential environmental contaminants that might result from DARHT operations (DOE 1996). These concentrations of radionuclides and trace elements are calculated from the mean DARHT facility sample concentration plus three standard deviations. (Note: Although prior evaluations of BSRLs with RSRLs show no statistical differences between the two, the use of BSRLs at DARHT is required by the Mitigation Action Plan.)
- Screening Levels: SLs are set below federal regulation standards so that potential concerns may be identified in advance of potential ecological health problems—a "yellow flag." If a constituent exceeds an SL, then the reason for that exceedance is thoroughly investigated. For radionuclides in nonfoodstuffs biota, SLs were set at 10 percent of the standard by the dose assessment team at the Laboratory to identify the potential contaminants of concern. Nonradionuclides are compared with Toxicity Values (TV) gained from the literature.
- Standards: Based on the concentrations of radionuclides in biota, we calculated a dose and compared it with the 1.0 rad/d DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/d for terrestrial animals (DOE 2002).

3. Institutional Monitoring

No institutional monitoring of vegetation was performed in 2005—samples are collected every third year in conjunction with the soil monitoring program. The next sampling period for native vegetation collections is in 2006. For a discussion of results reported in past years, see Gonzales et al. (2000) for 1998 sampling results and see Fresquez and Gonzales (2004) for 2002 and 2003 sampling results. In general, all radionuclide concentrations in vegetation sampled from perimeter and Laboratory areas are low, and most were either nondetectable or below RSRLs. Only plutonium-239,240 was detected above RSRLs in both overstory (trees) and understory (grasses/forbs) vegetation from Laboratory areas. An on-site area where plutonium-239,240 was noted to be at higher concentrations in/on native vegetation as compared with the RSRL was at TA-21 (DP Site). The values, however, were still very low (pCi range), and the difference between on-site concentrations and regional background concentrations was small. Although uranium concentrations in vegetation from all on-site areas were below RSRLs, some plants had uranium isotopic distributions indicative of depleted uranium. Depleted uranium, a less-radioactive version of the metal used as a substitute for the enriched uranium in weapons components tested at LANL, is probably a result of airborne deposition from LANL firing sites (Hansen 1974). However, since depleted uranium is about 40 percent less radioactive than natural uranium and the total uranium concentrations in plants collected from some on-site areas are still below regional background levels, no significant impacts to plants or to animals that ingest the forage are anticipated. In fact, a recent biota dose assessment of the most uranium-contaminated firing site, EF site at TA-15 (Becker 1992, LANL 1998), showed that the dose to plants and animals was 2 percent and 20 percent of the DOE limits, respectively (McNaughton 2006).

4. Facility Monitoring

a. Monitoring Network

We conduct facility-specific biota monitoring on an annual basis at the Laboratory's principal low-level radioactive waste disposal site (Area G) (Lopez 2002) and the Laboratory's principal explosive test facility (DARHT) (Nyhan et al. 2001). See Chapter 7, Section D.1, for a more complete description of Area G and DARHT and Fresquez and Lopez (2004) and Fresquez (2004b), respectively, for a description of sampling methodology. We compared radionuclide levels in biota collected at Area G with RSRLs and compared results for radionuclide and nonradionuclide levels in biota collected at DARHT with BSRLs. Samples at Area G and DARHT were analyzed for tritium, cesium-137, strontium-90, americium-241, and plutonium and uranium isotopes. In addition, DARHT samples were analyzed for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium.

b. Radionuclide Analytical Results for Area G (TA-54)

i. Vegetation. We collected unwashed overstory (trees) and understory (grass and forb) vegetation samples at up to nine locations within and around the perimeter of Area G (Figure 7-3) (Fresquez et al. 2005b). All concentrations of radionuclides in overstory (Table S8-11) and understory (Table S8-12) vegetation are very low and most were not detected or were less than the RSRLs. The exceptions were tritium in some overstory and understory vegetation collected from the south portion of Area G adjacent to the tritium shafts (Sites 1 and 2) and plutonium-238 and plutonium-239,240 in vegetation samples collected from the north (Site 7c) and northeastern (Site 4) areas of Area G. These data correlate very well with the soils data (Chapter 7, section D.2) and are similar to past years (Figures 8-8 and 8-9) (Nyhan et al. 2004, Fresquez et al. 2004a, Fresquez and Lopez 2004). All radionuclide concentrations that were detected above RSRLs were below the SL of 0.1 rad/day for terrestrial plants (e.g., <345,000 pCi/mL for tritium and <822 pCi/g ash for Pu isotopes).

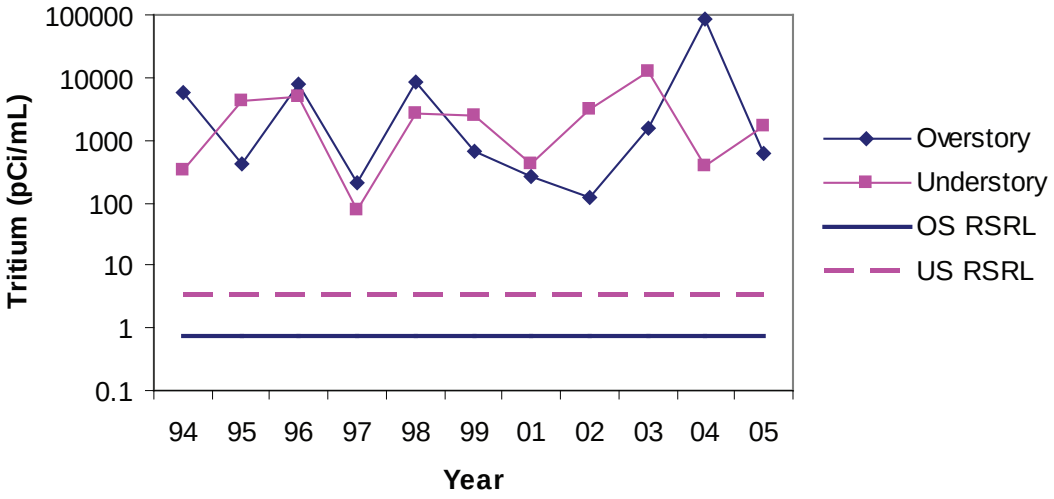


Figure 8-8. Tritium in overstory (OS) and understory (US) vegetation collected from a selected (worst case) location (site 2; see Figure 7-3 for location information) outside of Area G at TA-54 from 1994 through 2005 compared with the regional statistical reference levels (RSRLs).

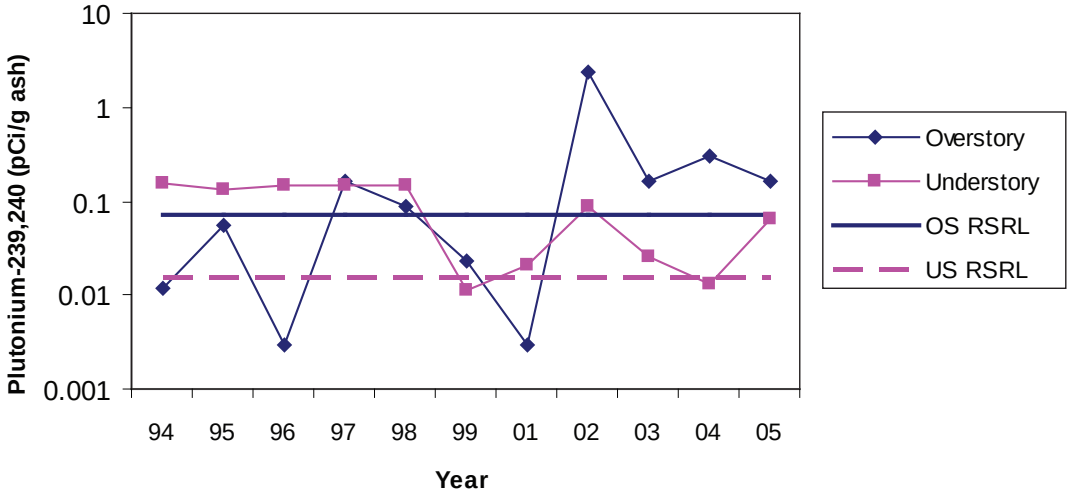


Figure 8-9. Plutonium-239,240 in overstory (OS) and understory (US) vegetation collected from a selected (worst case) location (site 4; see Figure 7-3 for location information) outside of Area G at TA-54 from 1994 through 2005 compared with the regional statistical reference levels (RSRLs).

c. Radionuclide and Nonradionuclide Analytical Results for DARHT (TA-15)

i. Vegetation. We collected unwashed overstory and understory vegetation from four locations around the DARHT facility (Fresquez 2006b) and compared the analytical results with BSRL data established for a four-year preoperational period (Fresquez et al. 2001). All radionuclides, with the exception of uranium-238 in overstory and understory vegetation, were either not detected or below BSRLs (Table S8-13). Although uranium-238 concentrations were detected above the BSRL in all of the overstory vegetation samples collected around the DARHT facility, the concentrations were below the SL (<987 pCi/g ash). The uranium in all of the overstory (and one understory) plants had uranium-234 and uranium-238 isotope distributions consistent with that of depleted uranium and the distribution correlates well to last year's results (Fresquez 2004b). Depleted uranium has also been detected in soils (Fresquez 2004a), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) at DARHT in past years.

For the nonradionuclides, the concentrations of silver, beryllium, cadmium, chromium, mercury, antimony, selenium, and thallium, for the most part, were below the reporting limits (i.e., they were undetected) (Table S8-14). The nonradionuclides that we detected above the reporting limits included arsenic, barium, copper, nickel and lead; and of these, only arsenic in overstory and understory plants and copper in overstory plants were above the BSRLs. These two elements have been detected in higher concentrations than the BSRLs in the past (Nyhan et al., 2003). Although the concentrations of arsenic and copper in plant tissues collected around the DARHT facility were above the BSRLs, they are below concentrations considered to be toxic to plant growth. Concentrations of arsenic in plant tissues collected at DARHT (0.68 to 0.84 μg/g), for example, are below the range of 2.1 to 8.2 μg/g considered toxic to plants (NRC 1977). Similarly, copper, an essential plant micronutrient, in plant tissues from DARHT (7.5 to 12 μg/g) is within the recommended concentrations for adequate plant growth of 4 to 15 μg/g (Stout 1961) and below the levels considered to be excessive (>22 μg/g) (Figure 8-6) (Embleton et al. 1976, Stout 1961).

ii. Bees. During 2005, honey bees were collected from five hives located just northeast of the DARHT at LANL, analyzed for the same radionuclides and trace elements as those for soils and vegetation samples (Hathcock et al. 2006), and compared to BSRL for bees (Haarmann 2001). Most concentrations of radionuclides (Table S8-15) and all nonradionuclides (Table S8-16) were below the BSRLs. The only radionuclides that were above the BSRLs were those associated with uranium, particularly uranium-238, and the ratios showed that the uranium was of depleted grade. All concentrations of uranium isotopes, however, were still very low and below terrestrial animal dose screening levels (<0.01 rad/d) and, therefore, not a significant hazard.

C. SPECIAL NONFOODSTUFFS BIOTA MONITORING STUDIES

1. Characterization of Biotic and Abiotic Media Upgradient and Downgradient of the Los Alamos Canyon Weir

In May 2000, a prescribed burn at Bandelier National Monument went out of control and burned nearly 50,000 acres of federal and Pueblo lands, 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 a low-head weir in Los Alamos Canyon to prevent sediment transport past the northeastern boundary of LANL. Investigations of sediment and surface water within the Los Alamos Canyon watershed indicate that some inorganic, organic, and radionuclides are present in these media at concentrations above SLs (LANL 2004). The weir consists of a rock-filled gabion that lies across the stream bed in Los Alamos Canyon near the junction of N.M. 4 and N.M. 502.

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 Mitigation Action Plan Section 2.1.7, "Mitigation Action for Soil, Surface and Ground Water, and Biota," mandates the monitoring of soil, surface and groundwater, and biota at areas of silt or water retention behind 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. We conducted this study to determine the contaminant concentrations of sediment (0- to 15-cm depth), native grasses and forbs (unwashed), and deer mice (Peromyscus sp.) (whole body) in the areas behind the Los Alamos Canyon weir. To this end, the Laboratory measured radionuclides and 23 other inorganic elements (Fresquez 2005b.)

Overall, concentrations of radionuclides and metals in sediments (Tables S7-6 and S7-7), vegetation (Tables S7-8 and S7-9), and small mammals (Table S7-10) collected behind the Los Alamos Canyon weir were very low and mostly below background concentrations (RSRLs) and do not pose significant human health or environmental hazards. These conclusions are consistent with the human health risk assessment and the baseline ecological risk assessment conducted as part of the Los Alamos Canyon Investigation (LANL 2004).

2. Determining Uptake and Distribution of Uranium Isotopes in Pinus Ponderosa at LANL Using Dendrochronogical Analysis

LANL has been conducting open-air, dynamic explosive tests since the early 1940s. We collected samples to determine whether open-air explosives tests have significantly increased uranium concentrations in ponderosa pine (Pinus ponderosa) wood pulp at an isolated site at LANL (see Vigil 2005 for all data). Most of these explosive tests involve the use of uranium and it has been estimated that nearly 100 metric tons of depleted and natural uranium have been expended by LANL since operations began (Becker 1992). We compared composites of wood pulp from pre- and post-LANL operations to determine if variations in environmental uranium concentrations from open-air dynamic explosive tests were reflected in uranium concentrations in trees. Results were that 1) on-site samples collected near a firing site where depleted uranium was expended into the environment showed slightly higher mean activity and total uranium concentrations than off-site samples, however the differences were statistically insignificant, 2) mean total uranium concentrations in post-LANL pulp (0.855 μg/g) were about two times higher than in pre-LANL pulp (0.423 μg/g) in on-site samples; however, the difference was statistically insignificant, and 3) mean total uranium concentrations in on-site post-LANL pulp (0.855 μg/g) were greater than off-site post-LANL pulp (0.257 μg/g), however the difference was statistically insignificant (Table S8-17). On-site samples tended to have lower uranium-234/uranium-238 ratios and higher total uranium concentrations, which was expected in samples containing some depleted uranium. Although the statistical analyses indicate that dynamic tests have not significantly impacted uranium concentrations in ponderosa pine pulp, the robustness of the statistical tests were low as the result of the low number of samples.

3. Cesium-137 in Moss Collected from Background Springs in Northern New Mexico

We collected moss (Bryophyte sp.) growing on the top of rocks from background springs in northern New Mexico to evaluate cesium-137 as an indicator of contamination in aquifers. The moss samples were rinsed in the field. Cesium-137 concentrations varied from -180 pCi/kg dry in the more sheltered sites to 276 pCi/kg dry in the more exposed sites (Table S8-18). The sheltered sites, as compared to the more exposed sites, contained more overstory and understory vegetation so the potential for soil contamination from wind and rain splash to the moss would be less. The weighted mean was 40 ±15 pCi/kg dry.

Results from a moss sample collected from Hemingway Spring in 2003 (24 pCi/kg dry), located approximately 78 miles north of LANL, compares well with readings from the NMED (2004) (13 pCi/kg dry) and the RadioActivist (2004) (59 pCi/kg dry). In addition, our analysis of moss collected from Big Spring, a sheltered site located approximately 44 miles north of LANL, in 2004 (-4.0 pCi/kg dry) and 2005 (-20 pCi/kg dry) showed similar concentrations to those collected by the NMED (2004) (-17 pCi/kg dry) (see Appendix B for an explanation of negative values).

Cesium-137 in the soil from global fallout in the northern hemisphere is around 400 pCi/kg (UNSCEAR 2000). Therefore, the differences in cesium-137 concentrations in moss from different background sites may result from the degree of exposure from the surrounding environment. Environmental factors that may influence the amount of cesium-137 in moss may include the distance the sample was collected downstream from the spring source, the amount of bare ground surrounding the collection points, elevational differences between the spring and higher possible wind blown contamination sources (e.g., a mesa overlooking the spring), and the amount and type of understory and overstory vegetation surrounding the sampling site. These all influence rain splash, which is a major source of contamination to plants in exposed locations (White et al. 1981, Dreicer et al. 1984, Foster et al. 1985).

In summary, cesium-137 is present in moss near several springs in northern New Mexico and the likely source is global fallout.

D. QUALITY ASSURANCE FOR THE SOIL, FOODSTUFFS, AND NONFOODSTUFFS BIOTA PROGRAM

See Chapter 7, Section E.

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9. ENVIRONMENTAL RESTORATION

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A. INTRODUCTION

This chapter summarizes the work accomplished during 2005, and in some cases in previous years, to investigate and clean up sites and facilities formerly involved in weapons research and development. This work was conducted by the former Environmental Remediation and Surveillance Program and the former Environmental Restoration Project. Starting in mid-2006, this work was managed under the new Environment and Remediation Support Services Division. The goal of the cleanup and investigation efforts is to ensure that past operations do not threaten human or environmental health and safety in and around Los Alamos County. The sites under investigation are designated as solid waste management units (SWMUs) or areas of concern (AOCs). Individual SWMUs and AOCs may be grouped into consolidated units. More information about the environmental restoration work may be found at http://www.lanl.gov/community/environment/cleanup/.

The New Mexico Environment Department (NMED) has authority under the New Mexico Hazardous Waste Act over cleanup of hazardous wastes and hazardous constituents. The US Department of Energy (DOE) has authority over cleanup of radioactive contamination. Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and DOE Order 435.1, "Radioactive Waste Management." Corrective actions for the releases of hazardous waste and hazardous constituents at the Laboratory are subject to the Compliance Order on Consent (the Consent Order) signed by the NMED, the DOE, the Regents of the University of California, and the State of New Mexico Attorney General on March 1, 2005. The Consent Order was issued pursuant to the New Mexico Hazardous Waste Act (New Mexico Statutes Annotated 1978, § 74-4-10) and the New Mexico Solid Waste Act (NMSA 1978, §74-9-36[D]). DOE is implementing corrective actions pursuant to the Atomic Energy Act for releases of radionuclides in conjunction with the activities required under the Consent Order.

1. 2005 Projects

The program was organized in 2005 into projects that encompassed groupings or types of sites (SWMUs and AOCs) slated for investigation and/or remediation. These projects include Watershed Integration, Townsites, Delta Prime (DP) Site, Technical Area (TA) 54 Material Disposal Areas (MDAs), and Corrective Actions. Each of these projects is briefly described below.

a. Watershed Integration

The Watershed Integration Project includes the activities in the Canyons Investigations, the required Groundwater Monitoring Project (through the Interim Facility-Wide Groundwater Monitoring Plan), and storm water monitoring and minimization of erosion and the transport of contaminants from sites by storm water runoff. The project collects, manages, and reports environmental data, and utilizes the combined data to support site decisions.

b. Townsites

The Townsites Project includes the investigation of and, as appropriate, the corrective actions for sites associated with Laboratory operations during the Manhattan Project and early Cold War era. The SWMUs or AOCs are located within the Los Alamos townsite (on property currently owned by private citizens, businesses, or Los Alamos County) and on property administered by the US Forest Service, the National Park Service, and the DOE. In addition, the Townsites Project includes the remediation and investigation of all land transfer parcels prior to transfer under Public Law 105-119.

c. DP Site

This project includes implementation of investigation work plans and evaluation and implementation of corrective measures for MDAs A, B, T, U, and V, the former process waste lines, and a broad category of environmental sites, referred to as the DP Site Aggregate (TA-21). The TA-21 site includes sanitary septic systems, pipes, drains and outfalls, a drywell sump, surface drainage and disposal areas, a polychlorinated biphenyl (PCB) container storage area, drum storage areas, the footprint of a historic waste treatment laboratory, and a sewage treatment plant, all of which served all or parts of the process facilities at DP West and DP East. Potential remedies include maintenance, excavation, engineered cover, and stabilization.

d. TA-54 MDAs

This project includes implementation of investigation work plans and evaluation and implementation of corrective measures for MDAs G, H, and L. The corrective measure evaluations will assess the potential remedies for each MDA and recommend a preferred remedy for implementation. Potential remedies include maintenance, excavation, engineered cover, stabilization, and soil vapor extraction. In addition, long-term monitoring will be conducted at each of the MDAs.

e. Corrective Actions

This project includes all investigations and subsequent remediation of SWMUs and AOCs intermixed with active Laboratory operations. The investigation and cleanup activities for these SWMUs and AOCs will be coordinated with managers for active mission projects to ensure operations are not disrupted. Soil removal, geodetic surveys, and debris pickup are a few of the activities taking place at aggregates where a corrective action is anticipated.

2. Work Plans and Reports

During calendar year 2005, a number of work plans and reports were written, reviewed, and/or approved by NMED. The work plans are proposed investigation activities designed to characterize SWMUs, AOCs, consolidated units, aggregates, and watersheds. The data are used to determine if the sites are characterized to define the nature and extent of contamination and the presence of potential unacceptable risks to human health and the environment. Depending on the data and the assessment results, sites may require additional investigation, remediation, monitoring, or no further action.

Tables 9-1 and 9-2 summarize the work plans and reports submitted and approved in 2005, the work plans and reports submitted prior to 2005 but approved in 2005, and the work plans and reports submitted in 2005 but not yet approved. The remainder of this section presents summaries of the investigations reported on in 2005.

Table 9-1
Work Plans Submitted and/or Approved in 2005

Document Title	Date Submitted	Date Approved	Status of Investigation
Work Plan for Pajarito Canyon	7/17/1998	10/17/2005[a]	Investigation activities started
Work Plan for Sandia Canyon and Canada del Buey	9/1/1999	9/23/2005	Scheduled to start in 2007
Work Plan for North Canyons	9/21/2001	7/21/2005[a]	Scheduled to start in 2006
MDA T [SWMU 21-016(a)-99] Investigation Work Plan	2/27/2004	5/23/2005[a]	Investigation activities started
DP Site Aggregate Area Investigation Work Plan	8/31/2004	4/15/2005[a]	Scheduled to start in 2006
Revisions to DP Site Aggregate Area Investigation Work Plan	7/29/2005	—[b]	Under review
MDA U [SWMU 21-017(a)-99] Investigation Work Plan	11/30/2004	3/28/2005[a]	Work plan activities completed
MDA L Investigation Work Plan, Revision 2	1/13/2005	N/A[c]	Work plan activities completed
MDA A Investigation Work Plan	1/31/2005	7/28/2005[a]	Scheduled to start in 2006
MDA A Historical Investigation Report	1/31/2005	N/A	N/A
Accelerated Corrective Action Work Plan for SWMU 33-013	3/22/2005	5/2/2005[a]	Work plan activities completed
Accelerated Corrective Action Work Plan for AOC 03-001(i) and SWMUs 03-029 and 61-002	12/2/2004	3/17/2005[a]	Work plan activities completed
Investigation Work Plan for 16-008(a)-99 [90s Line], 16-007(a)-99 [30s Line] the Ponds	3/31/2005	8/24/2005	Scheduled to start in 2006
MDA C Investigation Work Plan, Revision 1 and Supplemental Information	5/12/2005	4/13/2005[a]	N/A
MDA C Investigation Work Plan, Revision 2	10/21/2005	N/A	Investigation activities started
Investigation Work Plan for TA-16-340 Complex, Revision 1	5/13/2005	N/A	Work plan activities completed
Investigation Work Plan for Pueblo Canyon Aggregate Area	5/27/2005	9/23/2005[a]	Scheduled to start in 2006
Mortandad Canyon Biota Work Plan	5/27/2005	12/16/2005[a]	Work plan activities completed
Investigation Work Plan for Guaje, Barrancas, Rendija Canyons Aggregate Areas	7/22/2005	—	Scheduled to start in 2006
Investigation Work Plan Bayo Canyon Aggregate Area	7/29/2005	12/21/2005	Scheduled to start in 2006
Bayo Canyon Historical Investigation Report	7/29/2005	N/A	N/A
Investigation Work Plan for Middle Los Alamos Canyon Aggregate Area	12/22/2005	—	Under review

[a] Work plans approved with modifications.
[b] "—" = approval not received in 2005.
[c] N/A = not applicable.

Table 9-2
Reports Submitted and/or Approved in 2005

Document Title	Date Submitted	Date Approved	Status of Investigation
Los Alamos and Pueblo Canyons Investigation Report	4/30/2004	5/16/2005[a]	Supplemental report submitted
Los Alamos and Pueblo Canyons Supplemental Investigation Report (revised risk assessment)	12/15/2005	—[b]	Under review
VCA Completion Report using Soil Vapor Extraction System (AOC 00-027)	6/3/2005	—	Under review
Corrective Measure Study Report for SWMU 16-021(c)-99, Revision 1	6/15/2005	—	Under review
MDA H Corrective Measure Study Report, Revision 1	6/30/2005	—	Under review
Completion Report for the Voluntary Corrective Action at SWMUs 0-030(l), 0-033(a), and 0-030(a), and AOCs 0-004, 0-010(b), 0-033(b), and 0-029 (a,b,c) Supplemental Responses	7/15/2005 and 11/10/2005	12/27/2005	Completed
Remedy Completion Report for former TA-19	7/29/2005	—	Additional sampling warranted
MDA P Site Closure Certification Report, Revision 1	9/2/2005	11/10/2005	Completed
TA-53 Surface Impoundments [SWMU 53-002(a)-99 and AOC 53-008] Investigation Report, Revision 1	9/8/2005	—	Under review
MDA G Investigation Report	9/8/2005	—	Under review
MDA L Investigation Report	9/13/2005	—	Under review
VCA Completion Report for Consolidated Unit 21-013(d)-99	9/30/2003	1/22/2005	Completed
Investigation Report for Mortandad/Ten Site Canyons Aggregate Area	9/30/2005	—	Under review
VCM Completion Report for SWMU 21-011(k)	10/31/2003	8/9/2005	Completed
SWMU Assessment Report for 03-013(i)	10/26/2005	11/16/2005[a]	Completed
Remedy Completion Report for AOC 03-001(i) and SWMUs 03-029 and 61-002	12/15/2005	—	Under review

[a] Reports approved with modifications.
[b] "—"= approval not received in 2005.

B. WATERSHED INTEGRATION PROJECT

The Laboratory took the following actions in this project in 2005:

- Investigations in Pajarito Canyon were started with sediment sampling along the main channels and adjacent floodplains.
- The investigation of sediment, surface water, groundwater, and biota in Mortandad Canyon was completed.
- The work plans for investigations in Pajarito Canyon, Sandia Canyon and Cañada del Buey, and the North Canyons (Guaje, Barrancas, Rendija, and Bayo Canyons) were approved.
- A revised risk assessment for the Los Alamos and Pueblo Canyons Investigation Report was submitted in a supplemental investigation report.

The following are brief summaries of the investigation activities started or completed in 2005.

1. Pajarito Canyon

a. Site Description and History

Pajarito Canyon is located in the central part of the Laboratory (see Figure 1-2). 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 Canyon and Threemile Canyon 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 TAs -3, -12, -15, -18, -23, -27, -59, -64, -48, -55, -54, -8, -9, and -69.

b. Remediation and Sampling Activities

We conducted the first phase of the sediment investigation in 2005 according to the approved work plan for Pajarito Canyon (LANL 1998), as modified by agreements with the NMED (LANL 2005e). Field investigations included detailed geomorphic mapping, associated geomorphic characterization, and sediment sampling in the 14 reaches specified as priority reaches in the work plan (LANL 1998). The Laboratory previously conducted sediment sampling in 2000 as part of post-Cerro Grande fire sediment characterization activities in three reaches that were identified as "contingency reaches" in the work plan, in addition to five priority reaches.

In addition to the sediment investigations, surface water, springs, and groundwater will also be characterized. The Laboratory installed one regional monitoring well and one perched intermediate monitoring well in 2005. The regional well is located immediately below the flood retention structure, which is below the confluence of Pajarito and Twomile Canyons. The intermediate well is located in lower Pajarito Canyon just west of State Road 4.

c. Investigation Summary

The investigation activities in Pajarito Canyon will continue in 2006.

2. Mortandad Canyon

a. Site Description and History

Mortandad Canyon is located in the north-central part of the Laboratory and extends for 9.8 miles from Diamond Drive in TA-3 east-southeast to the Rio Grande. Mortandad Canyon has a total watershed area (excluding Cañada del Buey) of about 6.0 mi^2. Primary tributary drainages on Laboratory land are Effluent Canyon, which heads in TA-48, and Ten Site Canyon, which heads in TA-50. In addition, Cañada del Buey, a major tributary, joins with Mortandad Canyon upstream of the Rio Grande and has a watershed area of 4.3 mi^2. Technical areas in the watershed include TAs-3, -4, -5, -35, -42, -48, -50, -52, -55, -60, and -63.

b. Remediation and Sampling Activities

The third phase of sediment investigations in the Mortandad Canyon watershed were conducted in 2005 according to the approved work plan for Mortandad Canyon (LANL 1997). This phase of the sediment investigation addressed remaining uncertainties in the sources, nature, and extent of contaminants in sediment deposits in the watershed. We collected a total of 132 samples from 16 reaches in Mortandad, Effluent, and Ten Site Canyons and an unnamed tributary to Mortandad Canyon that heads in TA-5. This work completed the planned sediment investigations under the approved work plan (LANL 1997).

We conducted surface water and groundwater-related activities in Mortandad Canyon in late 2004 into 2005. The activities included drilling and monitoring of groundwater monitoring wells and piezometers, sampling of persistent surface water, drilling of characterization boreholes, an infiltration investigation, and conducting geophysical surveys (LANL 2004b). A total of eight alluvial wells, two piezometer nests, four intermediate wells, and two regional aquifer wells were drilled. Twelve characterization boreholes were drilled to assess contamination in the vadose zone beneath the canyon floor. Three additional boreholes were drilled to investigate geophysical anomalies identified in the geophysical surveys. We selected the surface water sample locations from areas where persistent surface water is present (LANL 2004b).

Our studies evaluated the potential ecological effects of contaminants through multiple lines of evidence (LANL 2005b). The studies included field surveys of small mammals (primarily mice and shrews), birds, and plants and laboratory toxicity tests of plant seedlings, earthworms, and aquatic invertebrates (chironomids). Habitat assessments and aquatic macroinvertebrate sampling were conducted at locations where surface water flow volume and persistence could support aquatic invertebrate communities. Concentrations of contaminants within insects, eggs, and small mammals were also measured. In addition, bird nestbox monitoring was conducted to measure parameters of effect (nest success, eggshell thickness, and sex ratio) and exposure (egg concentrations and insect concentrations) for avian ground invertevores (western bluebird) and for avian insectivores (southwestern willow flycatcher). Spatial modeling across the watershed will further assess the potential risk across larger areas for representative bird and mammal receptors.

c. Investigation Summary

Results of the investigation will be presented in the Mortandad Canyon investigation report in 2006.

C. TOWNSITES PROJECT

Investigations conducted on townsite SWMUs and AOCs in 2005 included the following:

- Remediation and sampling at TA-19 and the soil vapor extraction project at AOC 00-027, i.e., the Knights of Columbus.
- Work plans were submitted to NMED for investigations of the Pueblo Canyon Aggregate Area; Bayo Canyon Aggregate Area; Guaje, Barrancas, and Rendija Canyons Aggregate Areas; and the Middle Los Alamos Canyon Aggregate Area.
- The Pueblo and Bayo Canyons Aggregate Areas work plans were approved by NMED and the others were under review. No investigation activities were conducted for these aggregate areas.
- Supplemental information and assessments were submitted for the voluntary corrective action at SWMUs 0-030(l), 0-033(a), and 0-030(a), and AOCs 0-004, 0-010(b), 0-033(b), and 0-029 (a, b, c) (no field activities occurred), which was subsequently approved and the sites approved for no further action by NMED.

The following sections briefly summarize the investigations completed in 2005 and those investigations for which reports were submitted in 2005.

1. TA-19

An accelerated corrective action (ACA) was conducted for Consolidated Unit 19-001-99 in what was TA-19 (formerly known as the East Gate Laboratory) (LANL 2004a). A complete description of the field activities, data review, and risk assessments for this site are presented in the Remedy Completion Report for the Investigation and Remediation of Consolidated Unit 19-001-99 (LANL 2005d).

a. Site Description and History

The former East Gate Laboratory was used to conduct spontaneous-fission experiments and to store radioactive source material. Site operations potentially released inorganic chemicals and radionuclides to the surface and subsurface soil and tuff. Consolidated Unit 19-001-99 (comprised of septic system [SWMU 19-001]), surface disposal area [SWMU 19-002], sewer drainline and outfall [SWMU 19-003], and potential soil contamination beneath buildings [AOC C-19-001]) is located on Los Alamos Mesa east of the Los Alamos County airport and the East Gate industrial park. The consolidated unit is bounded by Pueblo Canyon on the north and by a small side canyon to Pueblo Canyon on the south/southeast. TA-19 currently includes access to, and a portion of, "Camp Hamilton Trail," a public recreational hiking trail.

b. Remediation and Sampling Activities

Soil was removed from two areas in 2004 and samples collected to confirm the effectiveness of the soil removal. Two surface soil samples from two locations were collected from the perimeter of the excavated area at one of the

soil removal locations, and four samples from two locations were collected from the perimeter of the excavated area at the other soil removal location. The soil removal locations were stabilized using straw bales and wattles around and downslope of the removal areas. Samples were also collected from the surface and subsurface soil and/or tuff.

c. Investigation Summary

The characterization sampling did not define the extent of inorganic chemical contamination for this consolidated unit.

The human health risk assessment determined that exposure point concentrations of all noncarcinogenic and carcinogenic chemicals of potential concern (COPCs) were less than their respective residential soil screening levels (SSLs). The radionuclide COPC (uranium-235) was less than the residential screening action level (SAL). The total excess cancer risk and the hazard index (HI) were below the NMED target levels (NMED 2004). The total dose was below DOE's target dose limit (DOE 2000).

The ecological risk assessment was conducted by comparing soil concentrations to ecological screening levels for terrestrial receptors. The assessment eliminated all COPCs as chemicals of potential ecological concern (COPECs) at the site.

d. Conclusions and Recommendations

Cobalt and chromium concentrations above background at depth (between 4 and 6.5 feet) on the mesa top and the south slope indicated that the vertical extent of these COPCs was not determined. To address this issue, additional samples were proposed to be collected from the mesa-top locations where the elevated chromium and cobalt concentrations were reported.

The human health screening risk assessment concluded that there is no potential unacceptable risk or dose to residential receptors. The ecological screening risk assessment concluded that the concentrations of COPECs do not pose a potential unacceptable risk to ecological receptors. However, we will re-evaluate potential risk after we receive the additional data collected at the site.

The sampling recommended in the report has been conducted and results submitted to NMED in 2006.

2. AOC 0-027

A complete description of the field activities, data review, and risk assessments for this site are presented in the Addendum to the Completion Report for the Voluntary Corrective Action Using a Soil Vapor Extraction System at Area of Concern 0-027 (LANL 2005c).

a. Site Description and History

AOC 0-027 is located in Los Alamos at the intersection of Trinity Drive and DP Road, the current site of the Knights of Columbus Hall. The Laboratory used the site as a fuel-tank farm from approximately 1946 to mid-1948. Then in 1948, the Laboratory converted the site to a drum storage area and stored 55-gal. metal drums of lubricants there for distribution to various Laboratory sites and craft shops. The Laboratory used the drum storage area until the early 1960s, when the storage area was decommissioned.

In June 1996, a soil vapor survey was conducted in the vicinity of the former fuel-tank farm and drum storage area to determine whether vapor-phase contamination existed in the subsurface soils and tuff. Soil vapor samples were analyzed for benzene, toluene, ethylbenzene, and xylene (BTEX). The survey detected elevated levels of BTEX contaminants. Subsurface core samples were collected from 20 borehole locations selected based on the locations of the former fuel-storage cells and areas of contaminated soil identified by the soil vapor survey.

b. Remediation and Sampling Activities

In 2002, the restoration program implemented a soil vapor extraction (SVE) system at the site (LANL 2005c). Eight shallow boreholes were drilled in the parking area of the Knights of Columbus property and used as

monitoring and extraction wells for the SVE system. After the SVE operation was completed, eight new shallow boreholes were drilled, each within 8 ft to the northeast of one of the boreholes drilled in 2002, as confirmatory sampling locations for the SVE process.

The SVE system operated 24 hours a day, seven days a week. After approximately 14 months of operation, the system had largely removed the highly volatile components of the contamination in the areas affected by the system air flow. When the contaminant removal rate had reached an overall asymptotic level, the SVE system operation was terminated. It is estimated that 15,877 lb of gasoline-range organics were removed by the SVE system at AOC 0-027 over the 20-month period of operation. Based on the weight ratio of benzene to gasoline-range organics in the 2002 borehole samples, the system removed an estimated 95 lb of benzene from the subsurface (LANL 2005c).

c. Investigation Summary

As a result of the removal of organic vapors, the human health risk (based on an industrial scenario) was reduced by an order of magnitude for carcinogenic contaminants and by nearly half for noncarcinogenic contaminants. The carcinogenic risk is less than the NMED target level, while the HI for noncarcinogens is slightly greater than the NMED target (NMED 2004).

Although an industrial scenario was used to calculate risk for the site, the actual use of the site is much more limited. Currently the Knights of Columbus Hall is used much less frequently than an average business or office, such that users of the building would receive less exposure than a worker who would be there 8 hr/day for 225 day/yr). The majority of the residual contamination and the highest concentrations are located beneath the concrete parking lot rather than beneath the building itself, so that users of the building are not exposed to potential contamination for extended periods of time. Land use for the site is expected to continue without significant change for the reasonably foreseeable future. For these reasons, the industrial scenario is protective and overestimates the actual risk at the site.

No complete pathways for ecological receptors occur at the site because all the contamination is in the subsurface at depth and the affected area is paved with concrete.

d. Conclusions and Recommendations

The results of confirmation sampling indicated no potential unacceptable risk to human or ecological receptors. Therefore, the corrective action at AOC 0-027 is complete and further investigation or remediation is not warranted (LANL 2005c).

These conclusions and recommendations are pending NMED approval.

D. DP SITE PROJECT

The Laboratory took the following actions in this project during 2005:

- The investigation of soil, tuff, pore gas, and groundwater at MDA U was completed.
- The investigation at MDA T started.
- The investigation and remediation of MDA V started.
- Work plan for DP Site Aggregate Area was approved and revisions to the work plan were submitted.
- The work plan for MDA A was submitted and approved.
- The voluntary corrective measure at the outfall from the industrial waste treatment plant at TA-21 (SWMU 21-011[k]) (report submitted in 2003) was approved.

The following sections summarize the investigations started or completed in 2005.

1. MDA U

NMED approved the MDA U investigation work plan with modifications (LANL 2004i) to finalize the subsurface characterization of the site. Field investigations were completed in 2005 based on the approved work plan.

a. Site Description and History

MDA U (Consolidated Unit 21-017[a]-99) is located on the northeastern section of the DP Mesa within TA-21. The site is inactive and consists of four individual SWMUs consolidated into a single unit (Consolidated Unit 21-017[a]-99). The four SWMUs are the western absorption bed (21-017[a]); the eastern absorption bed (21-017[b]); former distribution box (21-017[c]); and a sump (21-022[f]). This investigation did not address the sump. MDA U operated from 1948 to 1968 as a subsurface disposal site for radioactively contaminated liquid wastes. MDA U also received process cooling water effluent until sometime after 1976. In addition, oil from precipitrons (air filters used to remove dust, dirt, smoke, soot, and other solids from ventilating air) was disposed of at MDA U. Disposal of liquid effluent ceased in 1968, but the western absorption bed continued to receive water from a cooling tower until approximately 1976.

b. Remediation and Sampling Activities

During our investigation, we drilled a total of nine boreholes at MDA U. Eight boreholes were placed around the perimeter of MDA U to define the lateral and vertical extent of site contamination and were advanced to a depth of approximately 120 feet below ground surface (bgs). The ninth borehole, located in the center of MDA U between the absorption beds, was drilled to a depth of 360 ft bgs to define the vertical extent of contamination, the nature and depth of fracture zones, and the existence of any possible perched saturation zones.

Surface samples were collected at each of the nine borehole locations. Subsurface samples were collected from each borehole where elevated field-screening levels, fracture zones, or zones of elevated soil-moisture content were present. Subsurface pore-gas samples were collected from each of the nine boreholes after characterization drilling and geophysical logging activities were completed.

c. Investigation Summary

The Laboratory will report the results of the MDA U investigation in an investigation report and submit it to NMED in 2006.

2. MDA T

NMED approved the MDA T investigation work plan with modifications (LANL 2004c) to finalize the characterization of the site. Investigation activities at MDA T commenced in late 2005.

a. Site Description and History

MDA T (Consolidated Unit 21-016[a]-99), an area of approximately 2.2-ac located within TA-21 on DP Mesa, has both hazardous and radiological components. The SWMUs and AOCs associated with Consolidated Unit 21-016(a)-99 were operational from 1945-1986. The consolidated unit includes SWMUs and AOCs associated with the decommissioned waste treatment facilities and various disposal and storage areas adjacent to or within the boundary of MDA T. The SWMUs include inactive absorption beds, a retrievable waste storage area, asphalt-lined disposal shafts, sumps, acid holding tanks, acid sumps, effluent holding tanks, sodium hydroxide storage tank, an americium raffinate storage tank, acid valve pit manholes, underground steel tanks, a septic tank, grit chamber or settling tank, and airborne releases from incinerators used to burn waste oils and organics after testing (oil spills from the incinerators are known to have occurred). In addition, several AOCs are associated with MDA T and include an outdoor storage area used to hold containerized radioactive sludge, an acid storage tank, a former satellite accumulation action, a raffinate holding tank, aboveground acid holding tanks, and spills and other unintentional releases.

b. Remediation and Sampling Activities

The investigation at MDA T will consist of the following:

- Three deep vertical boreholes about 385 ft bgs into the Cerro Toledo interval and five deep vertical boreholes to 280 ft bgs within the boundaries of the MDA T area.
- Three contingent deep boreholes to 280 ft bgs to the north and south of MDA T if contamination is detected with field screening instruments in adjacent boreholes.
- Seven shallower vertical boreholes to 100 ft bgs around Building 257 and its associated structures.
- Three contingent 100-ft boreholes to further characterize contamination associated with Building 257 if contamination is detected with field screening instruments in adjacent boreholes.
- One 100-ft borehole and six 40-ft boreholes around the location of former Building 35.
- Three shallow boreholes to 40 ft bgs within the drainage at the north end of MDA T.
- A row of four boreholes to 30 ft bgs at each end and outside of the fenced area of MDA T to locate the paleochannel beneath MDA T.
- Up to four former surface sample locations across the site based on field surveys and screening (more surface samples will be collected as needed).
- Surface (0–0.5 ft) and shallow subsurface (1.5 ft–2.0 ft) samples from 14 locations along the top of the DP Canyon slope to the DP Canyon stream channel.

Surface samples will be collected on the canyon slope and within the MDA T boundary to characterize areas of elevated activities based on the survey. Subsurface samples will be collected from all boreholes. Subsurface pore gas samples will also be collected from the three deep vertical boreholes (385 ft bgs).

c. Investigation Summary

The Laboratory plans to report the results of the MDA T investigation in an investigation report and submit the report to NMED in 2006.

3. MDA V

NMED approved the MDA V investigation work plan (LANL 2004f) with modifications to finalize the characterization of the site. Investigation activities at MDA V began in 2005.

a. Site Description and History

MDA V, which is part of Consolidated Unit 21-018(a)-99, includes three SWMUs and one AOC in a 0.88-ac fenced area located on the south side of DP Road just west of the TA-21 main gate. These SWMUs and AOC comprise three wastewater absorption beds, a former laundry facility, a waste treatment laboratory septic system and outfall, and two surface disposal areas.

b. Remediation and Sampling Activities

Fourteen boreholes will be drilled to between 40 ft and 80 ft bgs and one borehole will be drilled near the center of MDA V to 380 ft bgs into the Cerro Toledo interval. Subsurface pore gas samples will be collected from the boreholes.

Remediation of MDA V will involve the excavation and removal of distribution pipes and absorption bed materials (soil, sand, gravel, and cobbles). Remediation activities will include the removal of buried pipes and contaminated soil beneath the lines and from the outfall area. The surface disposal areas will also be remediated and will involve the removal of debris from the slope area. Contaminated soil beneath the debris may also be removed. Following the remediation activities, confirmation samples will be collected.

c. Investigation Summary

The Laboratory will report the results of the MDA V investigation in an investigation report and submit it to NMED in 2006.

E. TA-54 MDAs PROJECT

The following actions occurred in this project:

- NMED approved the investigation work plan for MDA L with modifications to finalize the environmental characterization of the site.
- The Laboratory issued a second revision to the MDA L work plan (LANL 2005h).
- NMED approved the MDA G investigation work plan with modifications to finalize the environmental characterization of the site.
- The Laboratory issued a revised MDA G work plan (LANL 2004j).
- The investigation reports for both MDAs were submitted in 2005.
- Revision 1 of the corrective measure study report for MDA H was submitted (no investigation activities occurred in 2005) and is under review.

The following sections summarize the overall investigations that were started, continued, and completed as well as those investigations for which reports were submitted in 2005.

1. MDA L

A complete description of the field activities, data review, and risk assessments for this site are presented in the Investigation Report for Material Disposal Area L, Solid Waste Management Unit 54-006, Technical Area 54 (LANL 2005f).

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-ac) fenced area known as Area L. MDA L operated from the late 1950s until it was decommissioned in 1985. MDA L is a decommissioned area established for disposing of nonradiological liquid chemical waste, including containerized and noncontainerized 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 L investigation reported data from 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. Upon decommissioning, the pit and impoundments were filled and covered with clean, crushed, consolidated tuff. When the shafts were filled to within approximately 3 ft of the surface, they were capped with a 3-ft concrete plug.

b. Remediation and Sampling Activities

One sediment sample was collected in 2005 to complete the characterization of the channel that drained storm water from the surface of MDA L before the asphalt surface was emplaced. Eight boreholes were drilled alongside the pit, impoundments, and shafts in 2004 and 2005 (LANL 2005f). Five boreholes were drilled to 150 ft bgs and another was drilled at an angle of 85º from horizontal to a vertical depth of 300 ft bgs. One borehole was drilled to 660 ft bgs with an air-rotary rig to determine whether perched groundwater is present and to collect hydrogeologic property data.

Samples of core, fracture samples, and subsurface pore-gas samples were collected from some or all of the boreholes (LANL 2005f). To supplement the current pore-gas monitoring program, boreholes were completed as vapor-monitoring boreholes by installing a FLUTe soil-gas sampling sand-filled membrane.

Tritium measurements in air were collected during two biweekly sampling events in the breathing zone for an on-site worker at the MDA L fence line. Ambient air in eight selected structures at MDA L was sampled for volatile organic compounds (VOCs) over an 8-hr period.

c. Investigation Summary

Concentrations of inorganic chemicals detected in core from beneath MDA L were indicative of natural variability within the various stratigraphic layers. Inorganic chemicals identified as COPCs in the previous investigation were detected in subsurface rock samples collected during the 2005 investigation; in addition, other inorganic chemicals were detected above background values.

Only one radionuclide (uranium-235) was reported slightly above its background level. No other radionuclides were detected or detected above background in core samples beneath MDA L.

Consistent with previous results, core samples confirmed the presence of a number of organic chemicals at trace levels (i.e., at μg/kg) beneath the former disposal units. The organic chemicals appear to be the result of multiphase partitioning from the vapor plumes. Other VOCs, semivolatile organic compounds (SVOCs), and PCBs detected beneath MDA L were at trace concentrations and appear to be isolated occurrences and not the result of a release.

Analytical results from pore-gas samples collected from the eight boreholes confirmed the presence of a vapor-phase plume. Analytical results from these boreholes and ongoing quarterly vapor-plume monitoring data confirm the eastern and western shaft fields as the sources of the plume. The data also confirm that the VOC plume is in a near steady state, and the vapor-phase concentrations do not indicate the presence of a free liquid source in the subsurface beneath MDA L. The plume is limited at depth by the Cerros del Rio basalt layer.

The collected samples confirmed tritium in all eight boreholes. The highest tritium readings were beneath the eastern portion of the facility. In addition, tritium was detected in the Cerros del Rio basalts at a depth interval of 550 to 608 ft.

Subsurface samples were collected from the deep borehole to evaluate moisture properties and to determine if perched water zones are present beneath MDA L. Perched water was not encountered in this borehole.

Ambient air was sampled in eight selected structures at MDA L. We compared the concentrations of the individual analytes and analyte mixtures with the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs) or Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs), and we found that the concentrations were below the published exposure limits.

The screening assessment for tritium in air was based on two biweekly sampling events in the breathing zone for a site worker at the MDA L fence line. The activities measured during the events were several orders of magnitude less than 1500 pCi/m^3, which US Environmental Protection Agency (EPA) has determined is equivalent to an annual radiation dose of 10 mrem/yr from inhalation, assuming the receptor is on site 24 hr/day, unshielded.

The results of the human health risk assessment indicated that noncarcinogenic and carcinogenic risks for an industrial worker were less than the NMED target levels (NMED 2004). Potential dose for an industrial worker was below the DOE's target dose limit (DOE 2000).

Contamination in channel sediment and tuff does not pose a potential risk to ecological receptors. Pore-gas VOCs may potentially impact burrowing animals based on the inhalation HI (38). No burrows are present within the fence at MDA L because the surface is paved with asphalt. The presence of active burrows outside of the fenced source area to the west of MDA L, however, indicates that pore-gas VOCs may not be a factor limiting or preventing gopher burrows.

d. Conclusions and Recommendations

Data gathered during the previous investigation, ongoing quarterly monitoring, and the recent investigation have characterized the nature and extent of contamination in the drainage and subsurface media (LANL 2005f). Subsurface samples collected to evaluate moisture properties did not identify any perched groundwater zones to a depth of 660 ft beneath MDA L. In addition, the results from human health and ecological risk assessments indicated that MDA L poses no potential unacceptable risk or dose to human and ecological receptors (LANL 2005f).

Therefore, based on the results of our field investigations, we recommended the following actions:

- Complete a corrective measure evaluation to recommend a remedy to ensure potential future releases from MDA L do not pose a potential unacceptable risk or dose to human and ecological receptors.
- Monitor the subsurface vapor plumes in accordance with a long-term monitoring plan approved by NMED.

These conclusions and recommendations are pending NMED approval.

2. MDA G

A complete description of the field activities, data review, and risk assessments for this site are presented in the Investigation Report for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99, Technical Area 54 (LANL 2005g).

a. Site Description and History

MDA G (Consolidated Unit 54-013[b]-99) is located within TA-54, Area G, in the east-central portion of the Laboratory on Mesita del Buey. Portions of MDA G started general operations, such as burning of combustibles in 1957, while other portions of MDA G started receiving low-level waste (LLW) in 1959. MDA G ceased operations in 2003. 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).

MDA G is a decommissioned (removed from service) subsurface site at TA-54 established for disposition of LLW, certain radioactively contaminated infectious waste, asbestos-contaminated material, and PCBs. The site was also used for the retrievable storage of transuranic (TRU) waste. The site 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, closed them, and capped the disposal shafts with a concrete plug.

b. Remediation and Sampling Activities

Sediment samples were collected from canyon reaches in Pajarito Canyon and Cañada del Buey located immediately downgradient of the easternmost tributary drainages from Area G. Sediment deposits in these reaches potentially contain contaminants transported from Area G, including MDA G, and from other upstream locations.

Thirty-nine boreholes were drilled alongside MDA G pits and shafts. Thirty-seven boreholes were proposed to be drilled to 200–300 ft bgs; actual drilling depths were approximately 68 ft to 250 ft due to refusal at some locations. Most boreholes were vertical in orientation but three boreholes were drilled at an angle of 45º from horizontal to a vertical depth of approximately 176 ft (2) to 200 ft (1) bgs. One borehole was drilled to 700 ft bgs (after a first attempt reached only 556 feet) to determine whether perched groundwater is present and to collect data on hydrogeologic properties.

Core was collected from 37 boreholes. Paired samples of fracture fill and surrounding intact tuff were collected when large fractures, or fracture zones, were encountered. Paired fracture samples were collected when sufficient, intact, nonfractured core material was available.

Subsurface pore gas samples were collected beneath MDA G from each borehole. The boreholes will be incorporated into the Laboratory's pore-gas monitoring network.

c. Investigation Summary

Inorganic chemicals, organic chemicals, and radionuclides were detected above sediment background or fallout values or were detected in samples collected from reaches in Canada del Buey and Pajarito Canyon. Many of the detected concentrations do not differ from relevant background or baseline data sets. SWMUs or AOCs up canyon from Area G in the Cañada del Buey or Pajarito Canyon watersheds may be sources for the contaminants. Possible sources for these contaminants will be further evaluated as part of canyon investigations in these watersheds.

Concentrations of inorganic chemicals detected beneath MDA G were indicative of natural variability within the various stratigraphic layers. All inorganic chemicals detected above background in the units adjacent to the base of the disposal pits, trenches, and shafts were generally less than five times the background. In addition, all inorganic chemicals detected at levels greater than background were in samples taken from intervals containing clay-filled fractures and were less than the soil background, a more representative comparison.

Several naturally occurring radionuclides and fallout radionuclides were detected or detected above background in samples collected from beneath MDA G. Naturally occurring radionuclides were detected at concentrations within the natural variability in the subsurface. Fallout radionuclides detected in subsurface samples generally occurred sporadically across the site, with detections occurring in less than one third of the boreholes.

VOCs (consisting primarily of chlorinated hydrocarbons) were detected beneath MDA G. The highest VOC concentrations are beneath the eastern, central, and western portion of the site. Tritium was detected in pore-gas samples mostly in the eastern and south-central portion of Area G. The results of quarterly monitoring show VOCs and tritium concentrations to be stable over time and do not indicate that the plume is expanding.

Results of the human health risk assessment indicated that noncarcinogenic and carcinogenic risks for an industrial worker were less than NMED's target levels (NMED 2004). Potential dose for an industrial worker at MDA G is below the DOE's target dose limit (DOE 2000).

Contamination in channel sediment does not pose a potential risk to ecological receptors. The inhalation ecological screening level comparison to pore-gas VOCs indicates no potential present-day risk to burrowing animals.

d. Conclusions and Recommendations

Data gathered during the previous investigation, data obtained from ongoing quarterly pore-gas monitoring, and data collected during the 2005 investigation have characterized the nature and extent of contamination in surface and subsurface media at MDA G (LANL 2005g). Subsurface samples collected to evaluate moisture properties did not identify any perched groundwater zones to a depth of 700 ft beneath MDA G. The results from the human health and ecological risk assessments indicated that the site poses no potential unacceptable risk/dose to human and ecological receptors (LANL 2005g).

Therefore, based on the results of the field investigations, we recommend the following actions:

- Complete an evaluation to recommend a remedy to ensure that future releases from the site pose no unacceptable risks to human and ecological receptors.
- Monitor the subsurface vapor plume in accordance with a long-term monitoring plan as approved by NMED.

These conclusions and recommendations are pending NMED approval.

F. CORRECTIVE ACTIONS PROJECT

The Laboratory took the following actions in this project in 2005:

- Initial investigation at SWMU 03-013(i) completed and reported on.
- ACA work plan for the Security Perimeter Road (SWMUs 03-029 and 61-002 and AOC 03-001[i]) was approved, the investigation and remediation completed, and the report was submitted.

- Revised work plan for the TA-16-340 Complex submitted in 2004 and the investigation completed in 2005.
- The investigation of Mortandad/Ten Site Canyons Aggregate Area was completed and the investigation report submitted.
- ACA work plan for SWMU 33-013 submitted and approved and the investigation activities completed.
- Work plan for MDA C approved and revisions 1 and 2 along with supplemental information submitted and investigation activities implemented at MDA C.
- Revisions to the closure certification report for MDA P and the investigation report for the TA-53 surface impoundments were submitted; the closure certification report for MDA P was approved.
- Work plan for the Ponds at TA-16 (Consolidated Units 16-008[a]-99 [90s Line] and 16-007[a]-99 [30s Line]) submitted and approved.

The following sections summarize the investigations started, continued, and/or completed in 2005 as well as those investigations for which reports were submitted in 2005.

1. Pull Test Facility (SWMU 03-013[i])

The Laboratory submitted an assessment plan for SWMU 03-013(i) (LANL 2004g) and NMED approved it. A complete description of the field activities, data review, and risk assessments for this site are presented in the SWMU Assessment Report for SWMU 03-013(i) (LANL 2005j).

a. Site Description and History

SWMU 03-013(i), located in TA-3, consists of soil and gravel contaminated by historical releases of hydraulic oil at the Cable Control Building (03-246) and the Cable Stress Building (03-247), collectively referred to as the Pull Test Facility. The Pull Test Facility was constructed prior to 1967 and operated until the mid-1980s when a replacement facility was constructed on Sigma Mesa. This facility was used to test the tensile strength of various steel cables used in conjunction with underground nuclear test assemblies.

In 2005, the Laboratory demolished and removed two metal buildings containing controls for the pull-test equipment, a hydraulic oil compressor and storage tank, and two hydraulic rams used to perform the tensile strength testing.

b. Remediation and Sampling Activities

Eight samples from four locations were collected following the excavation of the footprint of Building 03-246, four samples were collected from two locations downgradient of the former Building 03-246 location, and four samples were collected from two locations within the footprint of Building 03-247. A trench was also excavated into the area between the building locations and samples collected. No debris, pipelines, or staining were observed.

c. Investigation Summary

The potential present-day risk to a site worker at the former pull test facility is below NMED target levels (NMED 2004). Therefore, the screening assessment indicates that there is no potential unacceptable risk to human health.

Based on the ecological screening assessment for SWMU 03-013(i), all COPECs were eliminated. The ecological screening assessment indicates that SWMU 03-013(i) does not pose a potential ecological risk to receptors.

d. Conclusions and Recommendations

The risk assessments indicated that there are no potential unacceptable risks to human and ecological receptors at this site. However, the extent of contamination for inorganic chemicals and organic chemicals has not been determined. As part of the Upper Sandia Canyon Aggregate Area investigation, the Laboratory will conduct additional sampling to determine the extent of contamination.

These conclusions and recommendations are pending NMED approval.

2. AOC 03-001(i) and SWMUs 03-029 and 61-002

The Laboratory conducted an accelerated cleanup at AOC 03-001(i) and SWMUs 03-029 and 61-002 because these sites lie in the path of the planned TA-3 security perimeter road and may be inaccessible during and after the road's construction. A complete description of the field activities, data review, and risk assessments for this site are presented in the Remedy Completion Report for the Investigation and Remediation of Area of Concern 03-001(i) and Solid Waste Management Units 03-029 and 61-002 (LANL 2005k).

a. Site Description and History

AOC 03-001(i) in TA-3 consists of two separate, inactive material and equipment storage areas. Storage Area #1 is a 30-ft –by 30-ft, unpaved area approximately 100 yards west of Building 03-70 used to stage and dispense petroleum products from two small, aboveground storage tanks located on a small hill above a large sand-and-gravel staging area. Storage Area #2 consists of a 50-ft by 150-ft, unpaved area located behind Building 03-70 used as a staging area for old transformers and containers of roofing compound, tars, and adhesives. Dumpsters staged in the area were used for the storage of bagged and labeled asbestos before their disposal at the Los Alamos County Landfill. The area was also used as an unpaved parking area for the Laboratory's Roads and Grounds Division.

SWMU 03-029 is an inactive, 30-ft by 70-ft landfill near the rim of Sandia Canyon, approximately 300 feet south of Building 03-271. While active, the landfill was used as an asphalt cleanout area. The landfill reportedly contains small pieces of asphalt and possibly residue from asphalt emulsion.

SWMU 61-002 is a former storage area east of the Radio Repair Shop (Building 61-23) on the south side of Jemez Road. An 81-ft by 91-ft portion of the SWMU lies within a fenced area and the remainder of the SWMU extends south onto the Los Alamos County Landfill. The fenced portion was historically used as a storage area for capacitors, transformers, unmarked containers, and may also have been used to store petroleum products. Before 1985, oil contaminated with PCBs was stored in containers on the soil surface within the fenced area. The area was also used by Radio Repair Shop personnel to store large spools of wire and cable.

b. Remediation and Sampling Activities

AOC 03-001(i), Storage Area #1: During the initial characterization 18 soil samples were collected from AOC 03-001(i) Storage Area #1. Soil samples from Storage Area #1 showed elevated concentrations of petroleum hydrocarbons in the soil, indicating that additional remediation activities were necessary. Cleanup resulted in the excavation and removal of approximately 540 yd^3 of petroleum contaminated soils from an area 40 ft by 40 ft by 10 ft deep.

AOC 03-001(i), Storage Area #2: The characterization sampling included 26 samples collected from Storage Area #2. After the completion of the ACA characterization sampling, the site was excavated to the grade planned for the TA-3 security perimeter road. Twelve soil samples were collected from the base of the excavation. Approximately 1,000 yd^3 of soil was excavated from a 100-ft long by 50-ft wide by 4-ft deep area.

SWMU 03-029, Asphalt Landfill: A geophysical survey was conducted using ground-penetrating radar (GPR) and an electromagnetic (EM)-31 and EM-61 detector. The survey results identified two possible locations for the buried waste and these areas were further investigated by trenching. Subsequently, the security perimeter road construction plans were changed and it was no longer necessary to excavate SWMU 03-029. As a result, all additional accelerated cleanup activities for this site were not implemented, and the investigation of SWMU 03-029 will be completed as part of the Upper Sandia Canyon Aggregate Area investigation.

SWMU 61-002, Former Equipment and Materials Storage Area: Remediation activities included excavation; field screening; the collection of surface and subsurface confirmation samples (a total of 61 samples); and the characterization, removal, and disposal of contaminated soil. Approximately 60 yd^3 of petroleum-contaminated soil was excavated from this area. A total of 424 yd^3 of material was removed from SWMU 61-002. During the excavation of the northwestern portion of the SWMU, an area containing high levels of petroleum hydrocarbons was discovered adjacent to Building 61-23. The source of this petroleum contamination is unknown but may be

associated with the past storage of petroleum products at the site. The efforts to define the extent of the petroleum hydrocarbon contamination were unsuccessful. After collecting four confirmation samples at two locations, a second stage of drilling and characterization sampling was initiated in the northwestern area of SWMU 61-002.

c. Investigation Summary

AOC 03-001(i), Storage Areas #1 and #2: No carcinogens were detected, and the HI for the construction worker was less than the NMED target level (NMED 2004) at Storage Area #1. There is no cancer risk estimate or HI calculated for an industrial worker at Storage Area #1 because all surface and shallow-subsurface material, down to a depth of approximately 10 ft bgs, was removed and the site was backfilled with clean soil.

The risk assessment results for Storage Area #2 indicated that the total excess cancer risks and the HIs for an industrial worker and a construction worker are below the NMED target risk levels (NMED 2004).

An ecological evaluation was not performed on AOC 03-001(i) Storage Area #1 because all surface and shallow-subsurface material, down to a depth of approximately 10 ft bgs, was removed. An ecological evaluation was not performed on AOC 03-001(i) Storage Area #2 because material was excavated, and the area is disturbed and will be covered by the security perimeter road.

SWMU 61-002, Former Equipment and Materials Storage Area: The risk assessment results indicated that the total excess cancer risk for an industrial worker and a construction worker are below the NMED target risk level (NMED 2004).

The noncarcinogenic risk for an industrial worker is less than the NMED target level (NMED 2004). The HI for a construction worker is slightly above the NMED target level (NMED 2004). SWMU 61-002 will be further investigated and the risk re-evaluated for the construction worker.

The ecological screening assessment for SWMU 61-002 eliminated all of the COPECs. The ecological screening assessment indicated that this SWMU does not pose a potential ecological risk to receptors.

d. Conclusions and Recommendations

The results of the investigation indicated that the nature and extent of contamination at AOC 03-003(i) are characterized. In addition, the risk assessments found that the site does not pose a potential unacceptable risk to an industrial worker and a construction worker. Ecological receptors are also not affected because material was excavated, and the area is disturbed and will be covered by the road. Therefore, the Laboratory has completed corrective actions to the levels required for NMED to issue a Certificate of Completion (complete with controls). The Laboratory will assume responsibility for the controls specified for the site by NMED in accordance with the level of remediation performed. The Laboratory expects that such controls will be limited to institutional or administrative controls to ensure that the land use remains consistent with the residual contamination at the site.

For SWMU 61-002, the results of the human health risk assessment for an industrial worker and the ecological risk assessment indicated that the site does not pose a potential unacceptable risk to human health or the environment. However, the results of the human health risk assessment for a construction worker indicated that the levels of noncarcinogenic chemicals may pose a potential unacceptable risk. The extent of petroleum contamination in the northwestern sector of the site was not characterized with the existing site data. The Laboratory will complete the characterization to define the vertical and lateral extent of the identified petroleum contamination following the demolition and removal of the building overlying part of this SWMU.

These conclusions and recommendations are pending NMED approval.

3. TA-16-340 Complex

The investigation work plan has been approved with modifications (LANL 2004e) to characterize the site. This work plan also describes interim cleanup activities completed prior to the characterization activities. Field investigations were completed in 2005 based on the approved work plan.

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 a small canyon known as Fishladder Canyon, and contains Consolidated Unit 13-003(a)-99, the septic system associated with the western area of the P-Site Firing Site (at former TA-13); the sump and drainline for former Building 16-342 (Consolidated Unit 16-003[n]-99); the sumps and drainlines for former Building 16-340 (SWMU 16-003[o]); and the sump and drainline for former Building 16-345 (SWMUs 16-029[f] and 16-026[j2], respectively).

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 high explosives (HE) and solvents together with inert binders. HE and solvent-contaminated wash water were routed to six sumps associated with Building 16-340 and to a single sump and outfall associated with Building 16-342. Historically, discharges from the Building 16-340 and 16-342 sumps were routed to the Building 16-340 and 16-342 outfalls, respectively.

b. Remediation and Sampling Activities

Overall, during the decontamination and decommissioning operations and/or the investigation/remediation activities, the Laboratory removed and disposed of all existing fixtures and structures (Buildings 16-340, 16-342, and 16-345, sumps, drainlines, manholes, fishladder/air stripper) associated with the TA-16-340 Complex. Contaminated soil (approximately 100 yd^3) was also removed from the TA-16-340 Complex.

A total of 239 soil, fill, tuff, and sediment samples were collected from the TA-16-340 Complex.

Two intermediate-depth boreholes (200 ft bgs) were drilled near the top and bottom of the historical fishladder structure; one borehole was drilled upgradient of the fishladder, near the TA-16-340 outfall and the second borehole was drilled downgradient from the fishladder. Two shallow boreholes (approximately 12 ft bgs) were also drilled in Consolidated Unit 13-003(a)-99.

Three shallow alluvial groundwater monitoring wells (wells 16-25278, 16-25279, and 16-25280) were installed in Fishladder Canyon. Well development activities were conducted and alluvial groundwater sampling was conducted.

Flowing water was observed and sampled (as part of monitoring activities) at the confluence of Fishladder Canyon and Cañon de Valle.

Subsurface pore-gas samples were collected from the two 200-ft intermediate boreholes. Both the upgradient and downgradient boreholes were sampled at three depth intervals during two rounds of sampling.

c. Investigation Summary

The Laboratory will describe the results of this investigation in an investigation report and submit the report during early 2006.

4. Mortandad/Ten Site Canyons Aggregate Area

We conducted characterization activities to investigate an aggregate of SWMUs and AOCs in TAs-4, -5, -35, -52, -60, and -63 (LANL 2002; LANL 2004d). The SWMUs and AOCs addressed constitute the Middle Mortandad/Ten Site Canyons Aggregate Area within the Mortandad Canyon watershed. The SWMUs and AOCs occupy a narrow mesa (Ten Site Mesa) and adjacent slopes between Mortandad and Ten Site Canyons, the floor of a small tributary canyon to Ten Site Canyon (named Pratt Canyon) and adjacent Mesita del Buey and Sigma Mesa as well as part of the floor of Ten Site Canyon. For the purposes of the investigation and the report, the SWMUs and AOCs were organized into seven subareas: Mesa Top, Ten Site Slope, Mortandad Slope, Pratt Canyon, Ten Site Canyon, East Ten Site Slope, and Sigma Mesa.

The Investigation Report for the Mortandad/Ten Site Aggregate (LANL 2005h) presents a complete description of the field activities, data review, and risk assessments for this site.

a. Site Description and History

Mesa Top Subarea. The Mesa Top Subarea consists of 21 SWMUs and five AOCs. The SWMUs and AOCs in this subarea include components of the former wastewater treatment plant (WWTP), former container storage areas, an area of surface deposition from stack emissions, oil spills, septic tanks, and former oil-handling facilities. Operational histories indicate that the Mesa Top Subarea may contain a variety of inorganic, organic, and radiological contaminants.

Ten Site Slope Subarea. Ten Site Slope is the south-facing slope of Ten Site Canyon. The slope has a very steep middle section with flatter bench sections above and below, and it is marked by several distinct drainage channels. The Ten Site Slope Subarea consists of nine SWMUs and seven AOCs. The SWMUs and AOCs are outfalls, former container storage areas, inactive septic systems, and areas of stained asphalt/oil spills. The SWMUs/AOCs are either located on, or adjacent to, the north slope of Ten Site Canyon or are outfalls that discharge onto that slope. Operational histories indicate that the Ten Site Slope Subarea may contain a variety of inorganic, organic, and radiological contaminants.

Mortandad Slope Subarea. Mortandad Slope is the north-facing slope of Mortandad Canyon. The slope drops steeply from the mesa edge to a broad terrace, followed by a near-vertical drop into the incised main channel of Mortandad Canyon. The Mortandad Slope Subarea is made up of seven SWMUs and three AOCs. The SWMUs and AOCs are outfalls, former container storage areas, an inactive septic system, a canyon-side disposal area, and oil spills. Operational histories indicate that the Mortandad Slope Subarea may contain a variety of inorganic, organic, and radiological contaminants as a result of past Laboratory operations.

Pratt Canyon Subarea. Pratt Canyon is a tributary of Ten Site Canyon and is located at the east end of Ten Site Mesa. Pratt Canyon heads at the east end of the mesa at the location of the former TA-35 WWTP, several components of which were located within the upper portion of the canyon. The Pratt Canyon Subarea consists of six SWMUs and two AOCs, all within TA-35. These are cooling water and storm water outfalls, former WWTP components, an inactive septic system and leach field, and Pratt Canyon itself, which received planned and unplanned discharges from the WWTP that operated from 1951 to 1963. The potential contaminants in the Pratt Canyon Subarea are primarily related to the former WWTP operations.

Ten Site Canyon Subarea. The Ten Site Canyon Subarea includes much of the Ten Site Canyon floor extending from the west end of TA-35 to east of the confluence with Pratt Canyon. The Ten Site Canyon Subarea is made up of four SWMUs and two AOCs. In addition to receiving potential releases from hill-slope SWMUs/AOCs (e.g., Ten Site Slope Subarea) and the Pratt Canyon Subarea, the Ten Site Canyon Subarea is directly associated with components of an inactive sanitary wastewater treatment facility including three lagoons, a sand filter treatment unit, and an effluent outfall and its discharges. In addition to sanitary waste, the lagoons reportedly received small quantities of radionuclides and other chemicals as well as photographic processing wastes from TAs-35, -48, -50, and -55. The facility ceased operations in 1992, when sanitary waste was redirected to the Laboratory's sanitary wastewater treatment facility at TA-46.

East Ten Site Slope Subarea. East Ten Site Slope is the south slope of Ten Site Canyon, which extends south and east of Ten Site Mesa. The East Ten Site Slope Subarea includes 13 SWMUs and three AOCs in TAs-4, -5, -52, and- 63, including surface and canyon-side disposal areas, an outfall, former firing sites, a former wastewater treatment facility, a former French drain, inactive septic systems, and industrial waste lines. The SWMUs and AOCs are primarily related to (1) operations and processes at former Alpha (TA-4) and Beta (TA-5) firing sites, and their associated support structures, and (2) the historical UHTREX (Ultra High Temperature Reactor Experiment) facility (housed in Building 52-01) and related wastewater neutralization and septic systems. Operational history indicates that SWMUs and AOCs in the East Ten Site Slope Subarea contained inorganic and radiological contaminants.

Sigma Mesa Subarea. Sigma Mesa lies east of TA-3, between Sandia Canyon to the north and Mortandad Canyon to the south. The Sigma Mesa Subarea contains one SWMU and two AOCs. The SWMU and the AOCs (a former surface impoundment and two former storage areas) are located on the south side of Sigma Mesa, toward the eastern end. The subarea uses included outdoor storage for materials to be recycled, Laboratory maintenance

contractor utility equipment/materials storage, and minor experiments (solar pond evaporation and mud drilling). The contaminants potentially present come from residual oil from transformers and salvaged underground storage tanks and from a solar evaporation experiment with low-level radioactive liquid.

b. Remediation and Sampling Activities

Mesa Top Subarea. A total of 350 soil, tuff, sediment, and fill samples, including 24 field duplicate samples, were collected from 137 locations within the Mesa Top Subarea from 1993 to 2005.

Ten Site Slope Subarea. A total of 312 soil, fill, tuff, and sediment samples, including 19 field duplicate samples, were collected from 129 locations within the Ten Site Slope Subarea between 1993 and 2004.

Mortandad Slope Subarea. A total of 242 soil, fill, tuff, and sediment samples, including 12 field duplicate samples, were collected from 103 locations within the Mortandad Slope Subarea between 1994 and 2004.

Pratt Canyon Subarea. A total of 230 soil, fill, tuff, and sediment samples, including 20 field duplicate samples, were collected from 72 locations in the Pratt Canyon Subarea between 1994 and 2005.

Ten Site Canyon Subarea. A total of 129 soil, fill, tuff, and sediment samples, including nine field duplicate samples, were collected from 82 locations in the Ten Site Canyon Subarea between 1994 and 2004.

East Ten Site Slope Subarea. A total of 346 soil, fill, tuff, and sediment samples, including 24 field duplicate samples, were collected from 116 locations in the East Ten Site Slope Subarea in 1995 and 2004.

Sigma Mesa Subarea. Seventy-six soil, fill, and tuff samples, including four field duplicate samples, were collected from 38 locations in the Sigma Mesa Subarea in 1994, 2004, and 2005.

c. Investigation Summary

Mesa Top Subarea. The noncarcinogenic COPCs were less than their respective industrial SSLs and less than the NMED target level (NMED 2004). The total excess cancer risk under an industrial scenario is slightly above the NMED target level (NMED 2004). Much of the total excess cancer risk is due to concentrations of polyaromatic hydrocarbons (PAHs) under asphalt pavement, where no complete exposure pathway exists. These contaminants are not operational releases but are related to the asphalt. The radionuclide contaminants were below their respective industrial SALs and below the DOE target dose limit (DOE 2000).

Based on the ecological screening assessment for the Mesa Top Subarea, all of the COPCs were eliminated. Therefore, no potential unacceptable ecological risk exists in the Mesa Top Subarea.

Mortandad Slope Subarea. The noncarcinogenic COPCs were less than their respective recreational SSLs and less than the NMED target level (NMED 2004). The carcinogenic COPCs were less than their respective recreational SSLs but slightly above the NMED target level (NMED 2004). The radionuclide COPCs were less than their respective recreational SALs and below the DOE target dose limit (DOE 2000).

Because the carcinogenic risk was slightly higher than the NMED target level, the dose, risk, and HI for each individual SWMU or AOC in the subarea were calculated using the maximum detected concentrations, to further refine the assessment.

The carcinogenic risk above the NMED target level is the result of PAHs detected at SWMU 35-016(p) and SWMU 35-016(o). At SWMU 35-016(p), 45 percent of the risk is from benzo(a)pyrene and 99 percent of the total is from PAHs. The PAHs that are driving the cancer risk at this SWMU are located on a steep slope. They are inaccessible to recreational users. However, to reduce the potential cancer risk and to prevent transport of contaminants to more accessible areas on the slope, we recommended that the PAH-contaminated soil from the three locations at SWMU 35-016(p) be removed.

At SWMU 35-016(o), 68 percent of the risk is from benzo(a)pyrene and 86 percent of the total is from PAHs. The PAHs that are driving the cancer risk at these SWMUs are located on a steep slope. They are inaccessible to recreational users. However, to reduce the potential cancer risk and prevent transport of contaminants to more accessible areas on the lower slope, we recommended that the PAH-contaminated soil from the five locations at SWMU 35-016(o) be removed.

The ecological screening assessment will be re-evaluated following the removal activities and the collection of confirmatory samples as described previously for human health.

Ten Site Slope, Pratt Canyon, Ten Site Canyon, East Ten Site Slope, and Sigma Mesa Subareas. All carcinogenic and noncarcinogenic COPCs were less than their respective recreational or industrial SSLs and less than the NMED target level and the total potential excess cancer risk is less than or equivalent to the NMED target level (NMED 2004). The radionuclide COPCs were less than their respective recreational or industrial SALs and below the DOE target dose limit (DOE 2000).

Based on the ecological screening assessment for the Pratt Canyon Subarea, most or all of the COPECs were eliminated. Any remaining COPECs do not present a potential unacceptable ecological risk to receptors.

d. Conclusions and Recommendations

The Laboratory has determined the vertical extent of contamination for all SWMUs and AOCs, with the exception of SWMUs 35-016(o and p) in the Mortandad Slope Subarea (PAHs only), Consolidated Unit 35-016(k)-00 in the Pratt Canyon Subarea (PAHs only), and AOC 05-001(c) in the East Ten Site Slope Subarea (uranium isotopes only). In several of the subareas (Ten Site Slope, Mortandad Slope, Pratt Canyon, Ten Site Canyon, and East Ten Site Slope), measurable concentrations of a few contaminants, primarily radionuclides, persist downslope. In these cases, the Laboratory will determine the lateral extent of contamination during our Mortandad Canyon investigations.

The risk assessment results indicated that no potential unacceptable human or ecological risks exist in any of the seven subareas, with the following exceptions:

- Slight excess potential cancer risk above the NMED target level exists due to elevated concentrations of PAHs in SWMUs 35-016(o) and 35-016(p) within the Mortandad Slope Subarea.
- Slight excess potential cancer risk above the NMED target level exists due to elevated concentrations of PAHs underneath asphalt at SWMU 35-018(a) within the Mesa Top Subarea; however, the PAHs are not due to an operational release, and there is no complete exposure pathway to site workers.

We recommended the following actions to address the remaining issues and potential excess cancer risk:

- To determine the vertical extent of PAHs within the Mortandad Slope and Pratt Canyon Subareas, we recommended that additional sampling be conducted at SWMUs 35-016(o and p) (Mortandad Slope Subarea) and Consolidated Unit 35-016(k)-00 (Pratt Canyon Subarea).
- To reduce the potential for excess cancer risk in the Mortandad Slope Subarea and prevent the migration of PAHs down-canyon, we recommended that surface material be excavated from the locations with the highest concentrations of PAHs in SWMUs 35-016(o) and 35-016(p). Screening assessments for the Mortandad Slope Subarea will be re-evaluated, incorporating the results of confirmation sampling, following excavation.
- To determine the extent of radionuclide contamination in the East Ten Site Slope Subarea, we recommended that additional sampling be conducted at SWMU 05-001(c).

The Laboratory requested that NMED issue a Certificate of Completion (complete with control) for the SWMUs and AOCs for which the Laboratory has completed corrective actions. The control for the SWMUs and AOCs identified will be the maintenance of the land use (industrial or recreational), which was the basis for the completion of activity. The Laboratory will assume responsibility for the controls specified for the site by NMED in accordance with the level of remediation performed. The Laboratory requested that this Certificate of Completion state that "Corrective Action is Complete with Controls."

These conclusions and recommendations are pending NMED approval.

5. SWMU 33-013

NMED approved the accelerated cleanup work plan (LANL 2005a) with modifications. The investigation and remediation activities were conducted in accordance with the approved work plan.

a. Site Description and History

SWMU 33-013 is situated in an area of proposed construction of the Laboratory's High Bay Complex within the northern portion of TA-33. SWMU 33-013 was an uncovered surface storage area for items such as vacuum pumps, drums containing oil contaminated with tritium and possibly with metals and solvents, and dumpsters of miscellaneous materials awaiting disposal. The exact date that storage operations began is not known, but Building 33-86 began operation in June 1955. Storage activities were moved to a fenced site at the southeast end of Building 33-86 in the spring of 1989. The storage area was approximately 50 ft by 50 ft and was located on the asphalt surface inside the northeast corner of the fence surrounding the former TA-33 tritium facility (Building 33-86).

b. Remediation and Sampling Activities

The investigation of SWMU 33-013 included geodetic surveys, field screening, removal of asphalt and contaminated soil, collection of confirmation samples, and site restoration. The base course covering the site, the asphalt pad, and the first 6 in. of soil beneath the asphalt pad were excavated and removed. Confirmation samples were collected after remediation was completed. Following completion of field activities, the excavation was backfilled with clean fill and base course brought in from an off-site source.

c. Investigation Summary

The Laboratory will report the results of the ACA investigation in a remedy completion report and submit the report to NMED early in 2006.

6. MDA C

NMED has approved the MDA C investigation work plan with modifications to finalize the characterization of the site. The Laboratory issued a second revision to the MDA C work plan (LANL 2005i) and began investigation activities at MDA C in 2005.

a. Site Description and History

MDA C (SWMU 50-009) is located in the east-central portion of the Laboratory near the west end of Mesita del Buey at the head of Ten Site Canyon. 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. MDA C was established in May 1948 to replace MDA B (SWMU 21-015). The landfill was used until April 1974 but received waste only intermittently from 1968 to 1974. These wastes included uncontaminated classified materials, metals, hazardous materials, and radioactively contaminated materials. MDA C is an 11.8-ac fenced, radiologically controlled area containing seven subsurface disposal pits and 108 shafts of various dimensions. The pits and shafts were excavated into the overlying soil and unit 3 of the Tshirege Member of the Bandelier Tuff and were unlined, except for 10 shafts in Shaft Group 3 that were lined with concrete.

b. Remediation and Sampling Activities

Forty-two vertical boreholes will be installed surrounding the disposal pits and shafts. Four perimeter boreholes will be drilled to the south and east of MDA C to assist in determining the lateral extent of potential contamination from MDA C and will be located approximately 250 ft away from the nearest disposal pit. A single, vertical borehole will be drilled to a depth of approximately 800 ft bgs through the Cerro Toledo interval in the area north of Pit 5 near the head of Ten Site Canyon to determine whether perched groundwater is present beneath MDA C. A minimum of five tuff samples will be collected from each borehole.

Subsurface pore-gas samples will be collected during two rounds of sampling from each borehole. The second round of pore-gas sampling will be conducted approximately one month after drilling activities are completed at each borehole. In addition, two rounds of pore-gas sampling will be conducted at previous boreholes.

A gamma survey will be performed to determine the extent of radionuclide contamination in surface soil along the eastern boundary of MDA C. Based on the results of the survey, surface soil samples will be collected. The locations of these samples will be biased towards both the highest radionuclide concentration and from bounding locations on the grid perimeter.

c. Investigation Summary

The Laboratory will report the results of the MDA C investigation in an investigation report and submit the report to NMED in 2006.

G. QUALITY ASSURANCE PROGRAM

1. Quality Assurance Program Development

The program's quality assurance objectives are to perform work in a quality manner while minimizing potential hazards to the environment, public, or facility workers. All program 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 (QMP) for the environmental program establishes the principles, requirements, and practices necessary to implement an effective quality assurance program. The QMP defines the "what" of the quality management system (i.e., quality program). The "how" is detailed in one or more implementing procedures.

Each program participant is responsible for the quality of his or her own work. Quality specialists are available to help program participants determine the applicability of requirements to program activities. However, it is the responsibility of each person to be aware of the program's quality requirements and to perform all activities in accordance with current and approved procedures. All personnel are encouraged, expected, and required to identify and report opportunities for improvement as well as any deficiencies or conditions that do not conform to the requirements of the QMP. The improvement process has the objective of preventing problems and improving the quality of products and services.

The scope, depth, and rigor of implementing the quality assurance criteria for a specific activity are determined by the use of a graded approach. Activities are managed through systems that are adequate and commensurate with the quality requirements, risk, and hazards involved in the activity. Such a selective approach allows for the application of extensive controls to certain elements of activities and limited controls to others. The control measures applied to any particular activity (e.g., the procurement of items or services, conducting a field sampling campaign, or training), 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 of this portion of the program is maintained through the rigorous use of carefully documented procedures that govern all aspects of the sample-collection program.

Soil, water, sub-atmospheric 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-clean sampling containers in a secure and clean area for shipment. They are delivered to internal and external 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 through the program's relational database.

Field-sampling quality assurance is performed and assessed by trained staff for constraints of the database and completeness.

3. Analytical Laboratory Quality Assessment

Specific statements of work are written to govern the acquisition and delivery of analytical chemistry services after the project needs are defined through the Data Quality Objective process. 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 paper set of records that serves as the legally binding copy of the data. Each set of samples contains all the internal quality assurance and quality control data the analytical laboratory generates during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). The electronic data are uploaded into the database and are then verified and validated according to its corresponding variety of quality and consistency checks. All parts of the data-management process are tracked electronically in each database, and periodic reports to management are prepared.

4. Analytical Laboratory Assessments

The environmental restoration program has 14 contracts with outside analytical laboratories. The laboratories are on a three-year rotating audit schedule as long as they keep their NELAC and DOE laboratory certifications. During 2005, four external laboratory audits were performed for all chemical analyses reported for most samples; Paragon Analytics, Inc., General Engineering Laboratories, Pacific Ecorisk, and American Radiation Services. All laboratories participated in national performance-evaluation studies during 2005 and the results are included in the assessment report. Overall, the study sponsors judged the analytical laboratories to have acceptable performance for almost all analytes attempted in all matrices.

5. Program Audits and Assessments

No assessments of the overall program were conducted in 2005.

H. REFERENCES

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LANL 2002: "Sampling and Analysis Plan for the Middle Mortandad/Ten Site Aggregate," Los Alamos National Laboratory document LA-UR-02-0244, Los Alamos, New Mexico. (March 2002)

LANL 2004a: "Accelerated Corrective Action Work Plan for the Investigation and Remediation of Consolidated Solid Waste Management Unit 19-001-99," Los Alamos National Laboratory document LA-UR-04-0199, Los Alamos, New Mexico. (January 2004)

LANL 2004b: "Mortandad Canyon Groundwater Work Plan, Revision 1," Los Alamos National Laboratory document LA-UR-04-0165, Los Alamos, New Mexico. (January 2004)

LANL 2004c: "Investigation Work Plan for Material Disposal Area T, Solid Waste Management Unit 21-016(a)-99," Los Alamos National Laboratory document LA-UR-04-0559, Los Alamos, New Mexico. (February 2004)

LANL 2004d: "Addendum to Sampling and Analysis Plan for the Middle Mortandad/Ten Site Aggregate," Los Alamos National Laboratory document LA-UR-04-1714, Los Alamos, New Mexico. (March 2004)

LANL 2004e: "Investigation Work Plan For: The TA-16-340 Complex: SWMUs 13-003(a)-99, 16-003(n)-99, 16-003(o), 16-026(j2), and 16-029(f) at TA-16," Los Alamos National Laboratory document LA-UR-04-1466, Los Alamos, New Mexico. (March 2004)

LANL 2004f: "Investigation Work Plan for Solid Waste Management Unit 21-018(a)-99, Material Disposal Area V, at Technical Area 21," Los Alamos National Laboratory document LA-UR-04-3699, Los Alamos, New Mexico. (June 2004)

LANL 2004g: "Solid Waste Management Unit (SWMU) Assessment Plan for SWMU 03-013(i)," Los Alamos National Laboratory document LA-UR-04-6783, Los Alamos, New Mexico. (September 2004)

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LANL 2004i: "Investigation Work Plan for MDA U, SWMU 21-017(a)-99, Technical Area 21," Los Alamos National Laboratory document LA-UR-04-7268, Los Alamos, New Mexico. (November 2004)

LANL 2004j: "Investigation Work Plan for Material Disposal Area G, Solid Waste Management Unit 54-013(b)-99 at Technical Area 54, Revision 1," Los Alamos National Laboratory document LA-UR-04-3742, Los Alamos, New Mexico. (December 2004)

LANL 2005a: "Accelerated Corrective Action Work Plan for Solid Waste Management Unit 33-013, a Former Storage Area at Technical Area 33 (TA-33)," Los Alamos National Laboratory document LA-UR-05-1104, Los Alamos, New Mexico. (March 2005)

LANL 2005b: "Mortandad Canyon Biota Investigation Work Plan," Los Alamos National Laboratory document LA-UR-05-2231, Los Alamos, New Mexico. (May 2005)

LANL 2005c: "Addendum to the Completion Report for the Voluntary Corrective Action using a Soil Vapor Extraction System at Area of Concern 00-027," Los Alamos National Laboratory document LA-UR-05-0583, Los Alamos, New Mexico. (June 2005)

LANL 2005d: "Remedy Completion Report for the Investigation and Remediation of Consolidated Unit 19-001-99," Los Alamos National Laboratory document LA-UR-05-0975, Los Alamos, New Mexico. (July 2005)

LANL 2005e: "Response to the Notice of Disapproval for the Work Plan for Pajarito Canyon, Los Alamos National Laboratory, EPA ID No. NM0890010515 HWB-LANL-03-007," Los Alamos National Laboratory document LA-UR-05-5600, Los Alamos, New Mexico. (July 2005)

LANL 2005f: "Investigation Report for Material Disposal Area L, Solid Waste Management Unit 54-006 at Technical Area 54," Los Alamos National Laboratory document LA-UR-05-5777, Los Alamos, New Mexico. (September 2005)

LANL 2005g: "Investigation Report for Material Disposal Area G, Consolidated Unit 54-013(b)-99 at Technical Area 54," Los Alamos National Laboratory document LA-UR-05-6398, Los Alamos, New Mexico. (September 2005)

LANL 2005h: "Investigation Report for the Middle Mortandad/Ten Site Aggregate," Los Alamos National Laboratory document LA-UR-05-6135, Los Alamos, New Mexico. (September LANL 2005)

LANL 2005i: "Investigation Work Plan for Material Disposal Area C, Solid Waste Management Unit 50-009, at Technical Area 50, Revision 2," Los Alamos National Laboratory document LA-UR-05-7363, Los Alamos, New Mexico. (October 2005)

LANL 2005j: "Solid Waste Management Unit (SWMU) Assessment Report for SWMU 03-013(i)," Los Alamos National Laboratory document LA-UR-05-7420, Los Alamos, New Mexico. (October 2005)

LANL 2005k: "Remedy Completion Report for the Investigation and Remediation of Area of Concern 03-001(i) and Solid Waste Management Units 03-029 and 61-002," Los Alamos National Laboratory document LA-UR-05-8863, Los Alamos, New Mexico. (December 2005)

NMED 2004: "NMED HWB Ground Water Quality Bureau and Voluntary Remediation Program, Technical Background Document for Development of Soil Screening Levels, Revision 2.0, "Volume 1, Tier 1: Soil Screening Guidance Technical Background Document, Santa Fe, New Mexico. (February 2004)

APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with the 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 450.1, "Environmental Protection Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1A, "Environmental Safety and Health Reporting."

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 EPA 1988. 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. 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.

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]
Air Pathway Only[d]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem/yr (TEDE)[e]
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] This level is from EPA's regulations issued under the Clean Air Act, (40 CFR 61, Subpart H) (EPA 1989a).

[e] Refer to Glossary for definition.

Table A-2
DOE's Derived Concentration Guides for Water[a]

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.

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	µg/m3	60		
	30 days	µg/m3	90		
	7 days	µg/m3	110		
	24 hours	µg/m3	150		
PM10a	Annual	µg/m3		50	50
	24 hours	µg/m3		150	150
PM2.5b	Annual	µg/m3		15	15
	24 hours	µg/m3		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	µg/m3		1.5	1.5

[a] Particles ≤10 µm in diameter.
[b] Particles ≤2.5 µm in diameter.

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/community/environment/h2o/.

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 Water Regulations go to http://www.nmenv.state.nm.us/Common/regs_idx.html#DrinkH2O. 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.

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/swqb/index.html). 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.

REFERENCES

DOE 2003a: US Department of Energy, "Environmental Protection Program," US Department of Energy Order 450.1 (January 15, 2003).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

DOE 2003b: US Department of Energy, "Environment, Safety, and Health Reporting," US Department of Energy Order 231.1A (August 19, 2003).

EPA 1988: US Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors For Inhalation, Submersion And Ingestion, Federal Guidance Report No. 11," EPA-520/1-88-020 (September 1988).

EPA 1989a: US Environmental Protection Agency, "40CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," Federal Register 54, 51 653-51 715 (December 15, 1989).

EPA 1989b: US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," Code of Federal Regulations, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

ICRP 1988: International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, and 3, and their supplements, Annals of the ICRP 2(3/4) -8(4) (1979-1982), and Publication 30, Part 4, 19(4) (1988).

NCRP 1987: National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

NMEIB 1995: New Mexico Environmental Improvement Board, "New Mexico Drinking Water Regulations," (as amended through January 1995).

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 International System of Units (SI) or metric system of measurements has been used, with some exceptions. 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 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-1
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-2 presents conversion factors for converting SI units into US Customary Units. Table B-3 presents abbreviations for common measurements.

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.

Table B-2
Approximate Conversion Factors for Selected SI (Metric) Units

Multiply SI (Metric) Unit	by	to Obtain US Customary Unit
Celsius (°C)	9/5 + 32	Fahrenheit (°F)
centimeters (cm)	0.39	inches (in.)
cubic meters (m^3)	35.3	cubic feet (ft^3)
hectares (ha)	2.47	acres
grams (g)	0.035	ounces (oz)
kilograms (kg)	2.2	pounds (lb)
kilometers (km)	0.62	miles (mi)
liters (L)	0.26	gallons (gal.)
meters (m)	3.28	feet (ft)
micrograms per gram (μg/g)	1	parts per million (ppm)
milligrams per liter (mg/L)	1	parts per million (ppm)
square kilometers (km^2)	0.386	square miles (mi^2)

Table B-3
Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie	mrem	millirem
Bq	becquerel	mSv	millisievert
Btu/yr	British thermal unit per year	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	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
lb/h	pound per hour	pg/m^3	picogram per cubic meter
lin ft	linear feet	PM_{10}	small particulate matter (less than 10 μm diameter)
m^3/s	cubic meter per second		
μCi/L	microcurie per liter	$PM_{2.5}$	small particulate matter (less than 2.5 μm diameter)
μCi/mL	microcurie per milliliter		
μg/g	microgram per gram		
$\mu g/m^3$	microgram per cubic meter	R	roentgen
mL	milliliter	s, SD, or σ	standard deviation
mm	millimeter	s.u.	standard unit
μm	micrometer	sq ft (ft^2)	square feet
μmho/cm	micro mho per centimeter	TU	tritium unit
mCi	millicurie	>	greater than
mg	milligram	<	less than
mR	milliroentgen	≥	greater than or equal to
m/s	meters per second	≤	less than or equal to
mrad	millirad	±	plus or minus
		~	approximately

Standard deviations for the station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the standard equation:

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

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation (1s) 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.

TA-0: The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos townsite and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos townsite.

TA-2, Omega Site: 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: The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50 percent of the Laboratory's employees and floor space.

TA-5, Beta Site: This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Twomile Mesa Site: The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

TA-8, GT Site (or Anchor Site West): This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (X-ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site: Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site: This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

TA-15, R Site: This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x-rays), a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for weapons development testing. It is also the site where DARHT (the dual-axis radiographic hydrotest facility) is located. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.

TA-16, S Site: Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. TA-16 is the site of the Weapons Engineering Tritium Facility for tritium handled in gloveboxes. Development and testing of high explosives, plastics, and adhesives and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: This is a nuclear facility that studied both static and dynamic behavior of multiplying assemblies of nuclear materials. Near-critical experiments were conducted by remote control using low-power reactors called critical assemblies. The special nuclear materials at this site have been relocated to the Nevada Test Site.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West has been in the D&D program since 1992, and six buildings have been demolished. The programs conducted at DP West, primarily in inorganic and biochemistry, were relocated during 1997, and the remainder of the site was scheduled for D&D in future years. DP East is a tritium research site.

TA-22, TD Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-28, Magazine Area A: This is an explosives storage area.

TA-33, HP Site: An old, high-pressure, tritium-handling facility located here is being phased out. An intelligence technology group and the National Radio Astronomy Observatory's Very Large Baseline Array Telescope are located at this site.

TA-35, Ten Site: Work here includes nuclear safeguards research and development that are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy physics, tritium fabrication, metallurgy, ceramic technology, and chemical plating.

TA-36, Kappa Site: Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C: This is an explosives storage area.

TA-39, Ancho Canyon Site: The behavior of nonnuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation state measurements, and pulsed-power systems design.

TA-40, DF Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.

TA-41, W Site: Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: This site is adjacent to the Los Alamos Medical Center in the townsite. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics. The Department of Energy Los Alamos Area Office is also located within TA-43.

TA-46, WA Site: Activities include applied photochemistry research including the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater System Facility is located at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site: Laboratory scientists and technicians perform research and development activities at this site on a wide range of chemical processes including nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

TA-49, Frijoles Mesa Site: This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility is located here.

TA-50, Waste Management Site: This site is divided into two facility management units, which include managing the industrial liquid and radioactive liquid waste received from Laboratory technical areas and activities that are part of the waste treatment technology effort.

TA-51, Environmental Research Site: Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are performed at this site.

TA-52, Reactor Development Site: A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.

TA-53, Los Alamos Neutron Science Center: The Los Alamos Neutron Science Center, including the linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility, is located at this TA. Also located at TA-53 are the Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator, and research and development activities in accelerator technology and high-power microwaves.

TA-54, Waste Disposal Site: This site is divided into two facility management units for the radioactive solid and hazardous chemical waste management and disposal operations and activities that are part of the waste treatment technology effort; includes Area G.

TA-55, Plutonium Facility Site: Processing of plutonium and research on plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site: This site is located about 28 miles west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains and was the location of the Laboratory's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. The high elevation and remoteness of the site make Fenton Hill a choice location for astrophysics experiments. A gamma ray observatory is located at the site.

TA-58: This site is reserved for multiuse experimental sciences requiring close functional ties to programs currently located at TA-3.

TA-59, Occupational Health Site: Occupational health and safety and environmental management activities are conducted at this site. Emergency management offices are also located here.

TA-60, Sigma Mesa: This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.

TA-61, East Jemez Road: This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.

TA-62: This site is reserved for multiuse experimental science, public and corporate interface, and environmental research and buffer zones.

TA-63: This is a major growth area at the Laboratory with expanding environmental and waste management functions and facilities. This area contains physical support facilities operated by KSL Services.

TA-64: This is the site of the Central Guard Facility and headquarters for the Laboratory Hazardous Materials Response Team.

TA-66: This site is used for industrial partnership activities.

TA-67: This is a dynamic testing area that contains significant archeological sites.

TA-68: This is a dynamic testing area that contains archeological and environmental study areas.

TA-69: This undeveloped TA serves as an environmental buffer for the dynamic testing area.

TA-70: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-71: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-72: This is the site of the Protective Forces Training Facility.

TA-73: This area is the Los Alamos Airport.

TA-74, Otowi Tract: This large area, bordering the Pueblo de San Ildefonso on the east, is isolated from most of the Laboratory and contains significant concentrations of archeological sites and an endangered species breeding area. This site also contains Laboratory water wells and future well fields.

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/community/environment/docs/reports/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
University of California-managed laboratories	http://labs.ucop.edu
LANL's air quality pages	http://www.lanl.gov/community/environment/air/
LANL's water quality pages	http://www.lanl.gov/community/environment/h2o/
LANL's waste pages	http://www.lanl.gov/community/environment/waste/
LANL's ecology pages	http://www.lanl.gov/community/environment/eco/
LANL's risk reduction pages	http://www.lanl.gov/community/environment/risk/
LANL's clean-up pages	http://www.lanl.gov/community/environment/cleanup/

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.
albedo dosimeters	Albedo dosimeters are used to measure neutrons around TA 18. They use a neutron-sensitive polyethylene phantom to capture neutron backscatter to simulate the human body.
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.
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.

BOD	Biochemical (biological) oxygen demand. A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.
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.
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).

EDE	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).
EA	Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.
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 (1/2 × 1/2), after three half-lives, one-eighth (1/2 × 1/2 × 1/2), 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
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 with 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).
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.
RESRAD	A computer modeling code designed to model radionuclide transport in the environment.
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)
SAL	Screening Action Limit. A defined contaminant level that if exceeded in a sample requires further action.
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 percent 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)
DOB	DOE Oversight Bureau
DOE	Department of Energy
DRO	diesel-range organic compound
DU	depleted uranium
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
ENV	Environmental Stewardship Division
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ES&H	environment, safety, & health
EU	enriched uranium
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
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
P2	Pollution Prevention Program
PCB	polychlorinated biphenyls
PERC	perchloroethylene
PM	particulate matter
ppb	parts per billion
PSTB	Petroleum Storage Tank Bureau (NMED)
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)
RLWT	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SA	supplement analysis
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

SWPP	Storm Water Prevention Plan
SWMU	solid waste management unit
TA	Technical Area
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act

ELEMENTAL AND CHEMICAL NOMENCLATURE

Actinium	Ac
Aluminum	Al
Americium	Am
Argon	Ar
Antimony	Sb
Arsenic	As
Astatine	At
Barium	Ba
Berkelium	Bk
Beryllium	Be
Bicarbonate	HCO_3
Bismuth	Bi
Boron	B
Bromine	Br
Cadmium	Cd
Calcium	Ca
Californium	Cf
Carbon	C
Cerium	Ce
Cesium	Cs
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Curium	Cm
Cyanide	CN
Carbonate	CO_3
Dysprosium	Dy
Einsteinium	Es
Erbium	Er
Europium	Eu
Fermium	Fm
Fluorine	F
Francium	Fr
Gadolinium	Gd
Gallium	Ga
Germanium	Ge
Gold	Au
Hafnium	Hf
Helium	He
Holmium	Ho
Hydrogen	H
Hydrogen oxide	H_2O
Indium	In
Iodine	I
Iridium	Ir
Iron	Fe
Krypton	Kr
Lanthanum	La
Lawrencium	Lr (Lw)
Lead	Pb
Lithium	Li
Lithium fluoride	LiF
Lutetium	Lu
Magnesium	Mg
Manganese	Mn
Mendelevium	Md
Mercury	Hg
Molybdenum	Mo
Neodymium	Nd
Neon	Ne
Neptunium	Np
Nickel	Ni
Niobium	Nb
Nitrate (as Nitrogen)	NO_3-N
Nitrite (as Nitrogen)	NO_2-N
Nitrogen	N
Nitrogen dioxide	NO_2
Nobelium	No
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphorus	P
Phosphate (as Phosphorus)	PO_4-P
Platinum	Pt
Plutonium	Pu
Polonium	Po
Potassium	K
Praseodymium	Pr
Promethium	Pm
Protactinium	Pa
Radium	Ra
Radon	Rn
Rhenium	Re
Rhodium	Rh
Rubidium	Rb
Ruthenium	Ru
Samarium	Sm
Scandium	Sc
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Strontium	Sr
Sulfate	SO_4
Sulfite	SO_3
Sulfur	S
Tantalum	Ta
Technetium	Tc
Tellurium	Te
Terbium	Tb
Thallium	Tl
Thorium	Th
Thulium	Tm
Tin	Sn
Titanium	Ti
Tritiated water	HTO
Tritium	^3H
Tungsten	W
Uranium	U
Vanadium	V
Xenon	Xe
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

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