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Reports

Los Alamos
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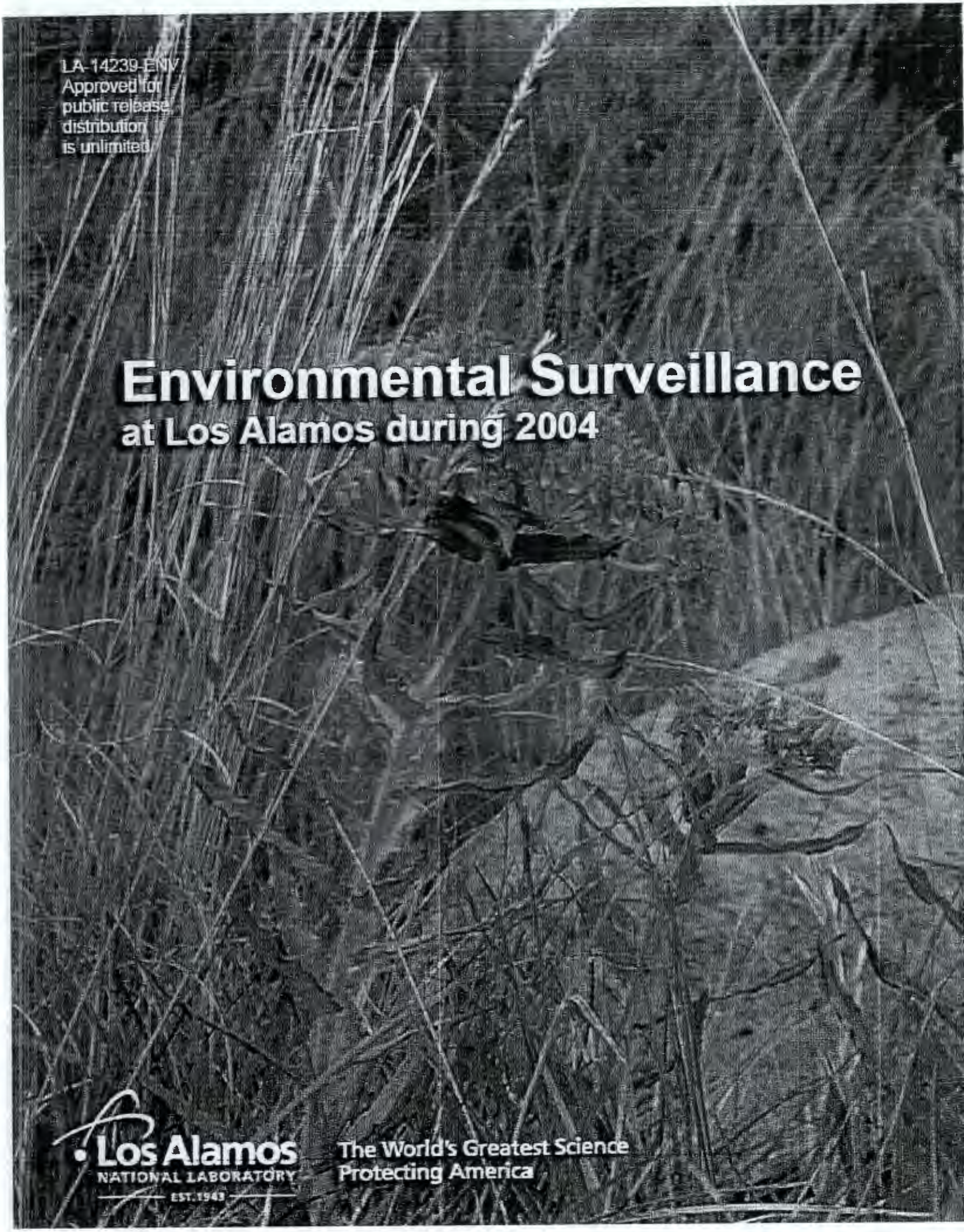
Environmental Surveillance
at Los Alamos during 2004



Los Alamos
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The World's Greatest Science
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Los Alamos National Laboratory's Governing Policy on Environment

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.

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Issued: September 2005

Environmental Surveillance at Los Alamos during 2004

Environmental Surveillance Program:

Meteorology and Air Quality (Group ENV-MAQ)
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Water Quality and Hydrology (Group ENV-WQH)
505-665-0453

Solid Waste Regulatory Compliance (Group ENV-SWRC)
505-665-9527

Ecology (Group ENV-ECO)
505-665-8961

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Los Alamos NM 87545

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Abstract

Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory) Environmental Stewardship Division, 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 2004. Chapter 3 provides a summary of the maximum radiological dose a member of 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; Chapter 7, soils; and Chapter 8, foodstuffs and biota) in a format to meet the needs of a general and scientific audience. 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, and Appendix C describes the Laboratory's technical areas and their associated programs.

In printed copies of this report or Executive Summary, we've also enclosed a disk with a copy of the full report in Adobe Acrobat (PDF) form and detailed supplemental tables of data from 2004 in Microsoft Excel format.

Inquiries or comments regarding these annual reports may be directed to

US Department of Energy
Office of Facility Operations
528 35th Street
Los Alamos, NM 87544

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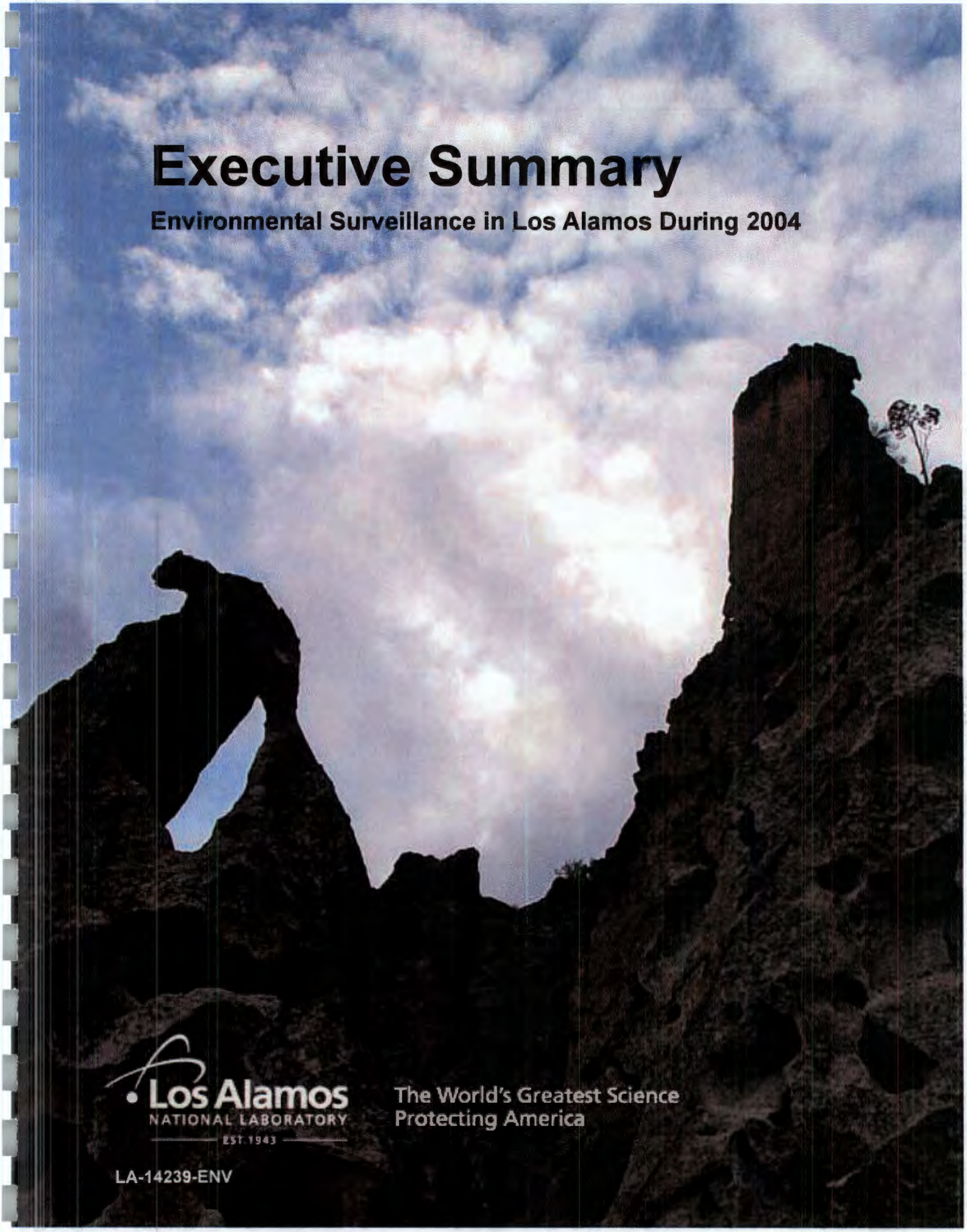
Abstract

Executive Summary

Environmental Surveillance in Los Alamos During 2004



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LA-14239-ENV

Executive Summary

Executive Summary – 2004

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; 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. 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 environmental performance of the Laboratory. This report

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

One of the Laboratory's strategic goals is to improve efficiency with which we achieve regulatory compliance and manage risk to support operational excellence.

Environmental Management System

LANL is implementing an Environmental Management System (EMS) pursuant to Department of Energy (DOE) Order 450.1. This order 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.

In April 2004, the Laboratory Director approved a new environmental policy for the Laboratory. The Laboratory developed a sitewide approach and framework for the EMS. In addition, each division is implementing the system within its organization and ensuring internal systems are appropriate and tailored to its specific functions. The EMS Core team is supporting divisions by facilitating meetings, providing standard procedures, tools, environmental subject matter expertise, and training as needed. The divisions are conducting initial evaluations of products, activities, and processes to determine if they have significant potential environmental impacts. This evaluation is being used to guide development of objectives, targets, action plans, and continuous improvement plans.

Federal Facility Compliance Agreement

During 2004, the Laboratory entered into an agreement with the Environmental Protection Agency (EPA) and the NM Environment Department (NMED) on the requirements of a Federal Facility Compliance Agreement. The agreement establishes a compliance plan for the regulation of storm water discharges from specific types of point sources at the Laboratory until such time as those sources are regulated by an individual storm water permit issued by EPA. In good faith, the Laboratory began implementing the intent of the Federal Facility Compliance Agreement in 2004 before the completion of negotiations.

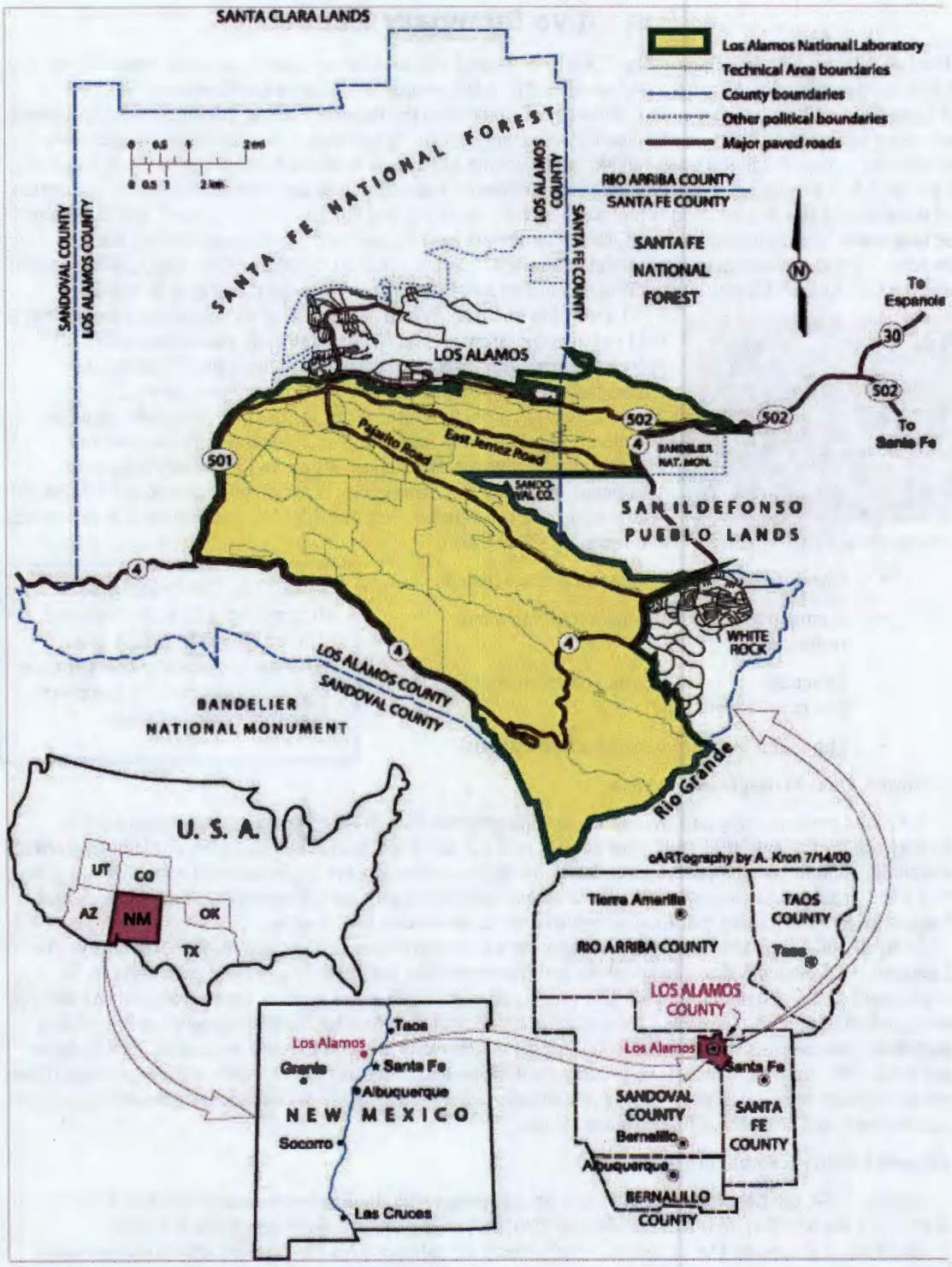


Figure ES-1. Regional location of Los Alamos National Laboratory.

Compliance Order on Consent (Consent Order)

A draft Compliance Order on Consent (Consent Order) was issued through the NMED in September 2004. The Laboratory continued to operate voluntarily in accordance with the November 26, 2002 Order and with the newly issued draft Consent Order. NMED, DOE, and University of California (UC) signed the final Consent Order on March 1, 2005. The Consent Order is the principal regulatory driver 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. In addition, several other plans and reports not required by the draft Consent Order schedules were submitted to NMED in calendar year 2004.

Improvement Targets

Improvement targets remain for the Laboratory and include continuing to improve Resource Conservation and Recovery Act (RCRA) compliance. While RCRA compliance improved in 2004, the NMED annual inspection identified four alleged violations in a Notice of Violation issued April 20, 2005. The Laboratory is improving processes, systems, and training to continue to reduce the number of possible violations in the future. The Laboratory made substantial progress in implementing an Environmental Management System that will require the identification and minimization of environmental impacts and waste sources. The Pollution Prevention Program continues to produce savings of several million dollars through recycling efforts, waste reduction, and support for sustainable design for the construction of new buildings. Though perchlorate is no longer discharged, the movement of perchlorate from past effluent discharges is being monitored to determine if it could pose a threat to water sources.

Design of Surveillance System and Sample Locations

LANL use 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, water discharges, and waste. These releases have the potential to affect many different receptors or components of the environment including humans, air quality, water quality, plants, and animals by one or many pathways such as by breathing in contaminants or coming into close proximity or contact with hazardous materials.

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 and to identify actions to protect or improve the environment while accomplishing the mission effectively. Monitoring also contributes data needed to ensure and demonstrate compliance with regulations.

The Laboratory employs a tiered approach to monitor the environment and identify impacts from LANL operation. 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 monitoring of the environment is at the LANL perimeter. This information helps determine if operations are impacting the general LANL property and neighboring property (e.g., pueblo and county lands). Perimeter monitoring can measure the highest potential impact to the public. The third level of monitoring is at specific project sites on LANL

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 also provides the data used to demonstrate compliance with applicable environmental laws and regulations.

Compliance

Laboratory compliance continues to improve. In addition, the Laboratory continues to reduce releases to the environment, waste generated, and water discharges.

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. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations.

Environmental Radiological Dose Assessment (see Chapter 3)

Humans, plants, and animals potentially receive radiation doses from various Laboratory operations (Table ES-2). The DOE dose limits are the mandated criteria that are used to determine whether a measurement represents a hazard. Figure ES-2 shows trends of doses to the maximally exposed individual (MEI) over the last 12 years at an off-site location. We calculated potential radiological doses to members of the public that resulted from LANL emissions and discharges. During 2004, the population within 80 km of LANL received a collective dose of 0.90 person-rem. The total off-site MEI dose was approximately 1.68 mrem. The dose received by an average Los Alamos residence from Laboratory operations totaled about 0.04 mrem. Similarly, the total dose to an average White Rock residence from Laboratory operations totaled about 0.03 mrem.

Biota Dose

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

(1) population within 80 km of LANL

(2) the on-site MEI (on LANL property)

(3) residents of Los Alamos and White Rock

Biota dose was estimated for sites where contaminants are present from past and current activities. The Material Disposal Areas (MDAs) are of particular interest because deep-rooted plants can penetrate pockets of contamination and transport it to the surface. MDAs A, B, C, T, and G all show signs that some plants have penetrated the radioactive material. The preliminary assessment indicates that the biota doses for plants and animals at LANL are below the DOE limits. The locations with the highest radionuclide concentrations resulted in doses less than 20% of the 100 mrad/day limit for terrestrial animals and less than 10% of the 100 mrad/day limit for terrestrial plants and aquatic animals.

Table ES-1. Environmental Statutes under which LANL Operates and Compliance Status in 2004

Federal Statute	What it Covers	Status
Resource Conservation and Recovery Act (RCRA)	Generation, management, and disposal of hazardous waste and cleanup of inactive, historical waste sites.	NMED conducted one 'wall-to-wall' RCRA hazardous waste compliance inspection in 2004. NMED identified 4 alleged violations, a 64% reduction from the 11 violations identified in 2003. The Laboratory completed 1,095 self-assessments that resulted in a nonconformance finding rate of less than 3.5%. The Laboratory (under the Environmental Remediation and Surveillance Program) continued to operate in accordance with requirements. Additionally, the Laboratory voluntarily operated in accordance with the November 26, 2002 Order containing corrective action requirements and later replaced by the September 1, 2004 draft Compliance Order on Consent (Consent Order), both issued through the NMED. The Laboratory is in compliance with groundwater monitoring requirements. Five groundwater characterization wells were completed in 2004.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public's right to know about chemicals released into the community.	The Laboratory reported releases, waste disposal, and waste transfers totaling 58,516 lb of lead, 665 lb of nitric acid, and 37,553 lb of nitrate compounds.
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. In addition, use of refrigerants continued to decline. The dose to the Maximum Exposed Individual (MEI) from LANL air emissions was 1.68 mrem, much less than the annual limit of 10 mrem. The Los Alamos Neutron Science Center (LANSCE) was the principal contributor to the dose. The Laboratory self-reported the removal of asbestos by a contractor without appropriate advance notification, resulting in NMED issuing a Notice of Violation.
Clean Water Act (CWA)	Water quality and effluent discharges from facility operations	Two of the 1283 samples collected from industrial outfalls exceeded effluent limits; we implemented additional analytical procedures when matrix interference is suspected. None of the 145 samples collected from the Sanitary Wastewater Systems Plant's outfall exceeded effluent limits. Changes in analytical procedures were made to prevent future exceedances. About 70% of the Laboratory's permitted construction sites were compliant with National Pollutant Discharge Elimination System (NPDES) requirements. Corrective actions for the noncompliant sites are scheduled for 2005. Additionally, the LANL engineering standards were updated to ensure compliance. The Laboratory is in compliance with groundwater monitoring requirements. Five groundwater characterization wells were completed in 2004. The new regional well R-33 in Mortandad Canyon shows no contamination from nitrate, perchlorate, and tritium based on initial analytical results. However, the intermediate wells show impacts of perchlorate and nitrate.
Toxic Substances Control Act (TSCA)	Chemicals such as PCBs	The Laboratory disposed of 1,964 kg of capacitors and 4,792 kg of fluorescent light ballasts in 171 containers at EPA-permitted treatment and disposal facility.

Table ES-1. Environmental Statutes under which LANL Operates and Compliance Status in 2004 (Cont.)

Federal Statute	What it Covers	Status
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.
Endangered Species Act (ESA) & Migratory Bird Treaty Act (MBTA)	Rare species of plants and animals	The Laboratory maintained compliance with the ESA and MBTA. The Laboratory continued to monitor endangered species status.
National Historic Preservation Act (NHPA) and others	Cultural resources	The Laboratory maintained compliance with the NHPA. The laboratory continued to survey sites and buildings and consult with the pueblos.
National Environmental Policy Act (NEPA)	Projects evaluated for environmental impacts	The NEPA team completed 9 large environmental evaluations. No non-compliances were reported.

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

Pathway	Dose	Location	Trends
Air	1.52 mrem/yr	East Gate	None; remains well below regulatory limits
Direct irradiation	1.75 mrem/yr	TA-18 – onsite	None
	0.88 mrem/yr	San Ildefonso – offsite	
Food	<0.1 mrem/yr	All sites	None
Drinking water	<0.1 mrem/yr	All sites	None
Background	300 to 500 mrem/yr	All sites	N/A
Dose to terrestrial animals	<20 mrad/day	TA-15 EF site, TA-21 MDA B	None
Dose to aquatic animals	<85 mrad/day	TA-50 Effluent Canyon	None
Dose to terrestrial plants	<50 mrad/day	TA-21 MDA B	None

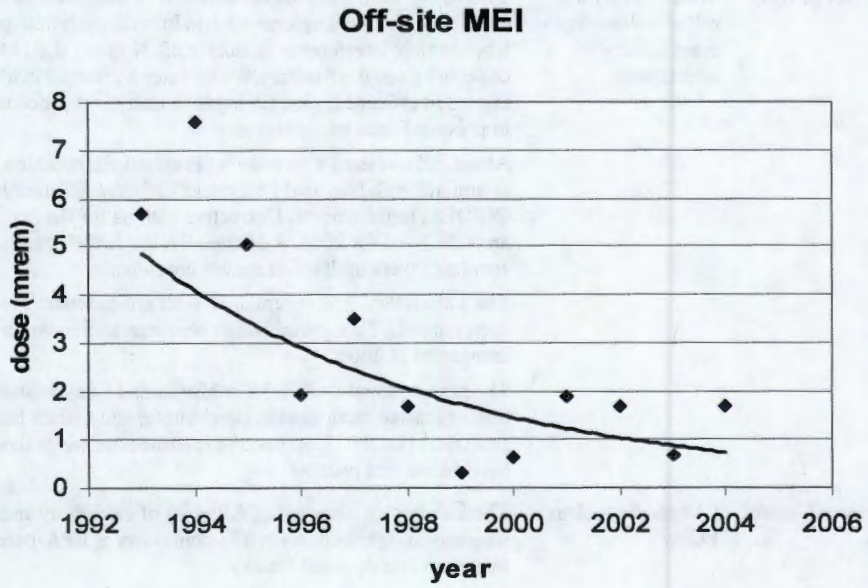


Figure ES-2. Trend of dose (mrem) to the maximally exposed individual off-site. Most years, this location is at East Gate, located along Highway 502 near the east end of the Los Alamos airport.

Air Emissions and Air Quality (see Chapter 4)

The Laboratory measures the emissions of radionuclides at the emission sources (building stacks). 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). Similarly, the Laboratory takes air samples at general locations at LANL, at the 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 were comparable with previous years.*
- *About 85% of radioactive air emissions were from LANSCE operations.*

Stack emissions were comparable to previous years and in most cases lower than previous years. LANL stack emissions during 2004 totaled approximately 5,230 Ci. Of this total, tritium emissions composed about 790 Ci, and air activation products from LANSCE stacks contributed nearly 4,440 Ci (85% of total emission). Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 0.0001 Ci. Emissions of particulate/vapor activation products also were less than 1 Ci. Because of the close proximity of the LANSCE facility with the LANL site boundary, GMAP emissions from LANSCE remain the greatest source of off-site dose from the airborne pathway.

Radionuclide concentrations in 2004 from ambient air samples were generally comparable with concentrations in past years. Measurable concentrations of radionuclides were not detected at regional sampling locations. The highest annual mean radionuclide concentrations from air samples within LANL boundaries and at perimeter locations were well below 1% of the applicable EPA and DOE standards. Measurable amounts of tritium were found at most on-site locations and at perimeter locations; the highest concentrations of tritium were at TA-54 from waste emissions and at TA-21 related to decommissioning operations at a former tritium facility. The highest plutonium-238 concentration of 2.4 aCi/m^3 was from an on-site sample location at TA-54. One off-site perimeter sample location (Los Alamos Inn-South) had plutonium-239 concentrations averaging 20 aCi/m^3. This concentration was a result of resuspension of plutonium deposited during historical activities. Am-241 concentrations were highest at Area G. 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.

- *Measurable concentrations of radionuclides were not detected at regional sampling locations.*
- *The highest air concentrations on LANL and at perimeter locations were well below 1% of the applicable EPA and DOE guidelines.*

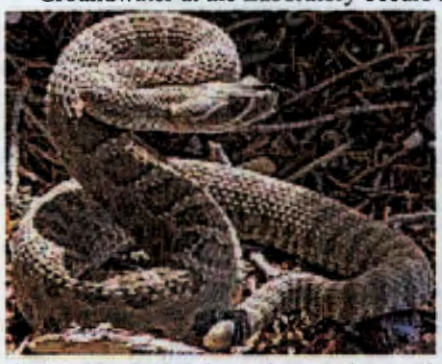
Air monitoring continued at one White Rock and two Los Alamos locations for particles with diameters of 10 micrometers (μm) or less (PM-10) and for particles with diameters of 2.5 μm or less (PM-2.5). The annual average for PM-10 was about 14 micrograms/m^3 and was 7 micrograms/m^3 for PM-2.5 at all locations. 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 samples from 22 sites for beryllium. These sites are located near potential beryllium sources at LANL or in nearby communities. Previous results indicated that the source of beryllium in our AIRNET samples was naturally occurring beryllium in resuspended dust. Beryllium air concentrations for 2004 were similar to those measured in recent years. All values are equal to or less than 2% of the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard.

- *PM-10 and PM-2.5 measures were well below EPA standards.*
- *Beryllium air concentrations for 2004 were similar to past years and were equal to or less than 2% of the NESHAP standard.*

Groundwater Monitoring (see Chapter 5)

Groundwater at the Laboratory occurs as a regional aquifer at depths ranging from 600 to 1,200 ft 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 sources.



Liquid effluent disposal is the primary means by which Laboratory contaminants have had a limited effect on the regional aquifer. Liquid effluent disposal at the Laboratory has significantly affected the quality of alluvial groundwater in some canyons. In some canyons, six decades of liquid effluent disposal by LANL have degraded groundwater quality in the alluvium. Because flow through the underlying approximately 900-ft-thick zone of unsaturated rock is slow, the impact of effluent disposal is seen to a lesser degree in intermediate-depth perched groundwater and is only seen in some wells within the regional aquifer. Table ES-3 summarizes contaminants found in portions of the groundwater system.

In general, groundwater quality is improving as
- *outfalls are eliminated,*
- *quantity of discharges are reduced, and*
- *water quality of the discharges improves.*

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 such effluent.

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 numerous sanitary treatment plants.

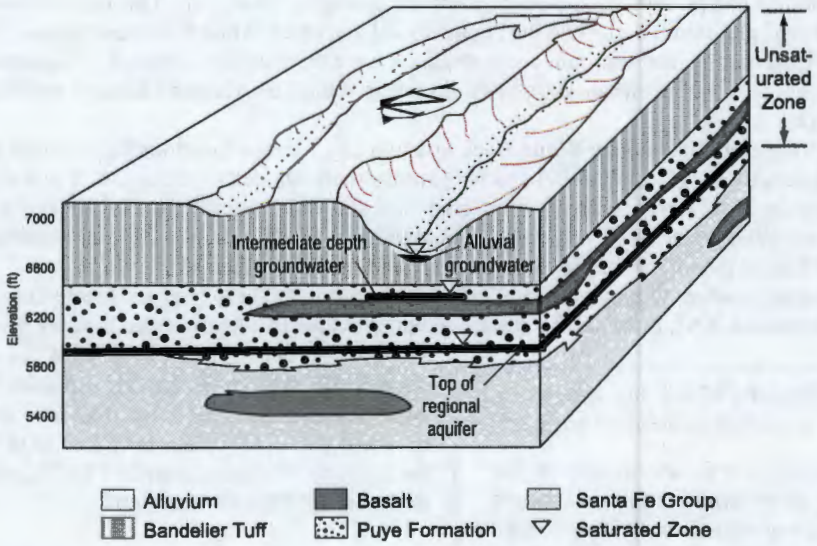


Figure ES-3. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

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
Tritium	Alluvial and intermediate groundwater in Mortandad Canyon	No	Not used as a drinking water supply	Activity decreasing as effluent quality improves
Other radionuclides	Alluvial groundwater in Mortandad Canyon	No	Not used as a drinking water supply; radionuclides have not penetrated to deeper groundwater	Some constituents are fixed in location; some are decreasing as effluent quality increases
Perchlorate	All groundwater zones in Mortandad Canyon, regional aquifer in Pueblo Canyon, alluvial groundwater in Cañon de Valle	Yes, in Pueblo Canyon	No established regulatory standard; values exceed EPA provisional risk level in all Mortandad Canyon groundwater zones; supply well with values below risk level is permanently off line	Decreasing in Mortandad Canyon alluvial groundwater as effluent quality improves; insufficient data for other groundwater
Nitrate	Intermediate groundwater in Mortandad Canyon, alluvial and intermediate groundwater in Pueblo Canyon	Yes, in Pueblo Canyon	Potential effect on drinking water, some above NM groundwater standards. In Pueblo Canyon, may be due to LA County's Bayo Sewage Treatment Plant	Insufficient data in Mortandad, values in Pueblo are variable
Molybdenum	Alluvial groundwater in Los Alamos Canyon	No	Not used as drinking water, limited in extent	Near NM GW limit for 10 years
Barium	Alluvial groundwater in Cañon de Valle	No	Not used as drinking water, limited in area	Insufficient data
High explosives	Alluvial and intermediate groundwater in Cañon de Valle	No	Limited in area, presence in regional aquifer uncertain	Insufficient data

[a] Shallow groundwater includes alluvial and intermediate groundwaters.

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. Potassium-40 is also a source of natural radioactivity.

We compared radionuclide levels in all groundwater with drinking water and human health standards even though these standards only apply to drinking water sources. None of the radionuclide activities in perched alluvial groundwater were above the 100-mrem/yr DOE standard used to protect the public. For nonnatural radioactivity, only strontium-90 concentrations in alluvial groundwater from Mortandad and DP/Los Alamos canyons were near or exceeded the 4-mrem DOE derived concentration guide (which we use as a screening level) applicable to drinking water (Figure ES-4). The maximum strontium-90 values in

Mortandad and DP/Los Alamos Canyon alluvial groundwater were 7.6 and 4.6 times, respectively, the EPA drinking water standard. Total LANL-derived radioactivity exceeded the 4 mrem derived concentration guide in Mortandad Canyon alluvial groundwater samples.

During the last decade, the EPA has recognized the potential for perchlorate toxicity at concentrations in the ppb (µg/L) range. No EPA regulatory limit exists for perchlorate in drinking water, though several states have set limits in the range of 10 to 20 ppb, and California has a public health goal of 6 ppb. EPA Region VI has established a risk level of 3.7 ppb.

The Radioactive Liquid Waste Treatment Facility, which discharges into Mortandad Canyon, has met all DOE radiological discharge standards for five consecutive years; has met all NPDES requirements for five consecutive years; and has met NM groundwater standards for fluoride, nitrate, and total dissolved solids for all but two weeks of the past five years.

LANL and the NMED DOE Oversight Bureau have detected perchlorate in most groundwater samples analyzed from across northern New Mexico. The perchlorate concentrations in samples not affected by known contaminant sources range from about nondetect (<0.05 ppb) to 0.85 ppb. Water samples from most LANL locations show low perchlorate concentrations in this range, but samples taken downstream from inactive perchlorate release sites show higher values, that is above about 0.6 ppb. Figure ES-5 illustrates the perchlorate values found in alluvial groundwater downstream of the RLWTF discharge in Mortandad Canyon. Discharge of perchlorate from the plant effectively ceased in 2002 with installation of equipment designed to remove perchlorate from the effluent. As shown in Figure ES-5, the concentrations of perchlorate in groundwater and surface water have dropped since that time.

Watershed Monitoring (see Chapter 6)

Watersheds that drain the Laboratory are dry for most of the year. Of the 85 miles of watercourse, approximately 2 miles are naturally perennial, and approximately 3 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.

- *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 far 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 protective guideline limits (Table ES-5).

Sediment radioactivity levels are above fallout background but substantially lower than screening action levels (SALs) in Los Alamos and Pueblo Canyons. Cesium-137 in Mortandad Canyon sediments is at elevated levels in an approximately 1.5-mile-long reach on-site and some samples exceed industrial site soil screening levels. Plutonium-239,240 in sediments extends off-site down Los Alamos Canyon into the Rio Grande, but levels remain well below the screening levels for unrestricted use of the land. Polychlorinated biphenyls (PCBs) are present in sediments in most watercourses that drain the Laboratory and are at concentrations below EPA industrial soil screening levels in Sandia Canyon sediments, where the highest levels occur. Channel sediments in Pueblo, Los Alamos, Sandia, and Mortandad Canyons contain polycyclic aromatic hydrocarbons (PAHs) of uncertain origin with maximum concentrations near or above applicable EPA soil screening levels. The overall pattern of radioactivity in channel sediments, such as along lower Los Alamos Canyon, has not greatly changed in 2004.

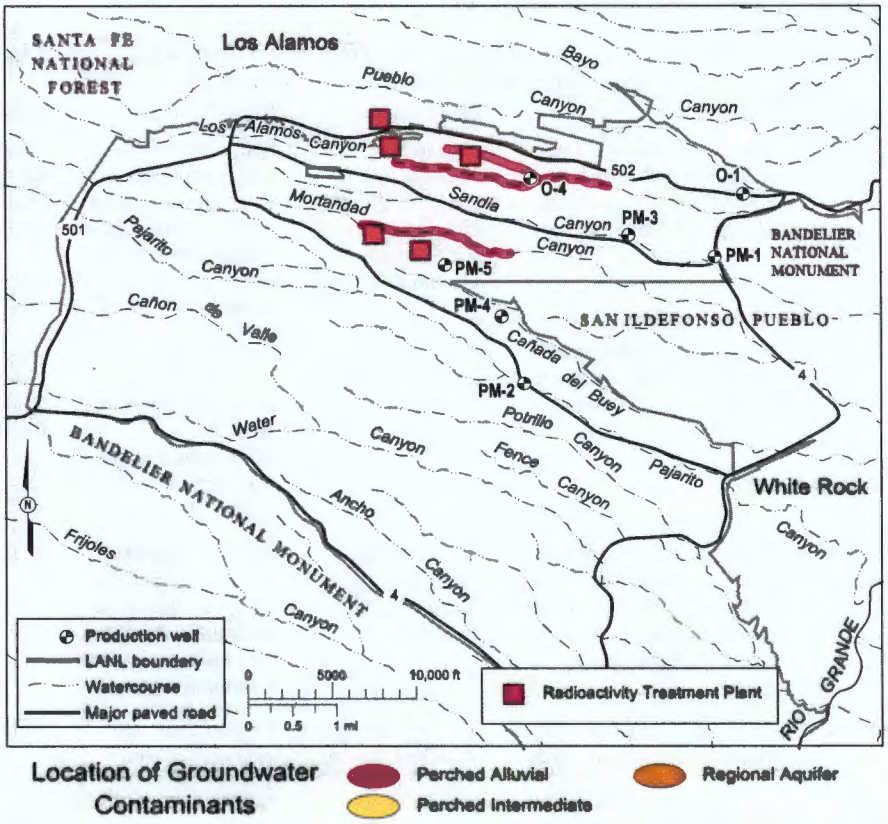


Figure ES-4. Location of groundwater contamination by strontium-90 above the 8 pCi/L EPA drinking water maximum contaminant limit. The extent of alluvial groundwater contamination lateral to the canyon is not to scale: contamination is confined to the alluvium within the canyon bottom and is narrow at the map scale.

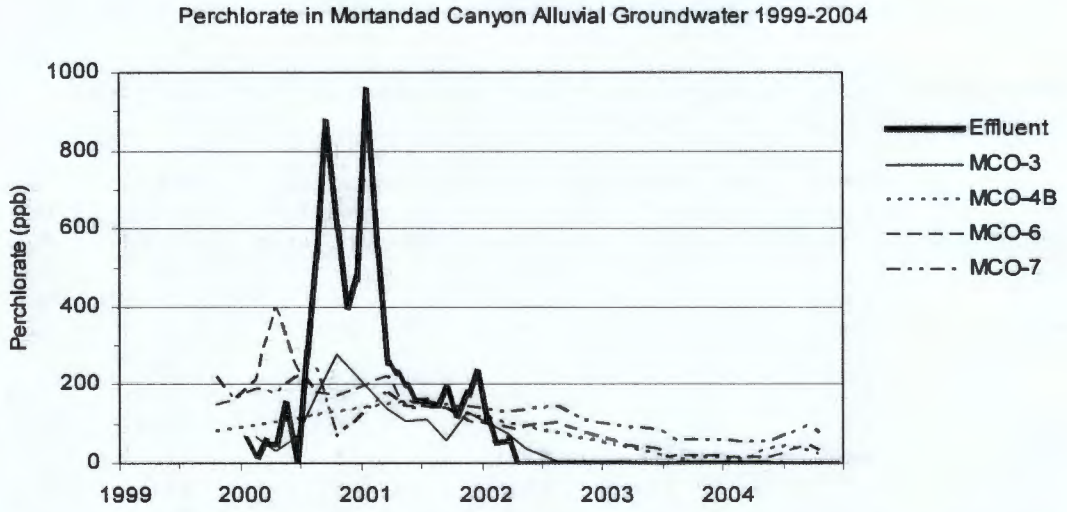


Figure ES-5. Perchlorate in Mortandad Canyon Alluvial Groundwater and RLWTF effluent, 1999–2004. Ion-exchange treatment was started in March 2002 to remove perchlorate to below 1 ppb.

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 in Pueblo, DP, Los Alamos, Pajarito, and Mortandad canyons	Yes, in Los Alamos/ Pueblo canyons; slightly elevated in the Rio Grande and Cochiti Reservoir	Sediments below health concern except on-site along a short distance in Mortandad Canyon but exposure potential is limited	Increased transport in Pueblo Canyon in response to postfire flooding and increased urbanization
	Higher than background in runoff in Pueblo, DP, Los Alamos, and Mortandad canyons	Yes, in Los Alamos/ Pueblo Canyons	Minimal exposure potential because events are typically sporadic. Mortandad Canyon surface water 60% of DCG for year	Flows in Pueblo Canyon occurring more often after fire; flows in other LANL canyons recovered to near prefire levels
Polychlorinated biphenyls (PCBs)	Detected in sediment in nearly every canyon. Detected in Sandia Canyon runoff and base flow above NM stream standards	Yes, particularly in the Los Alamos/ Pueblo Canyons	Wildlife exposure potential in Sandia Canyon. Elsewhere findings include non-Laboratory and Laboratory sources	None
Dissolved copper	Detected in many canyons above NM acute standards	Yes, in Los Alamos Canyon	Origins uncertain, probably several sources	None
High-explosive residues and barium	Detections near or above screening values in Cañon de Valle base flow and runoff	No	Minimal potential for exposure	None
Benzo(a)pyrene	Detections near or above industrial screening levels in Los Alamos Canyon	Yes, in Los Alamos/Pueblo Canyons	Origins uncertain; probably multiple sources	None

Table ES-5. Estimated Annual Average Surface Water Concentrations of Radionuclides in Selected Canyons Compared with the DCGs[a] and BCGs[b].

	Estimated 2004 Average Concentration (pCi/L)					
Radionuclide	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon between DP and SR-4	Mortandad Canyon below Effluent Canyon	Max Percent of DCG[a]	Max Percent of BCG[b]
H-3	0.7	64	14	12600	0.6	0.004
Sr-90	0.6	23	0.4	4	2	8
Cs-137	0.02	1	0.4	42	1	0.2
U-234	0.1	0.8	0.1	3	0.6	1
U-235,236	0.01	0.05	0.01	0.2	0.03	0.08
U-238	0.1	0.1	0.1	0.3	0.04	0.1
Pu-238	0.001	0.02	0.005	5	13	3
Pu-239,240	0.3	0.1	0.05	5	16	2
Am-241	0.01	0.2	0.07	8	27	2

[a] DCGs = 100-mrem Derived Concentration Guides for Public Exposures
[b] BCGs = Biota Concentration Guides

Radioactivity in surface water below current radioactive effluent discharges in Mortandad Canyon would result in only 60% of the 100-mrem/yr DOE limit for public exposure, but the water is not used as a drinking source and flows do not extend off-site (Figure ES-6). Samples of base flow (persistent surface waters) collected near the Laboratory or from the Rio Grande in 2004 met the New Mexico stream standards for livestock watering or wildlife habitat except for a PCB result from Sandia Canyon, which was greater than the wildlife habitat standard. A small number of the short-lived storm runoff events contained concentrations of some metals, gross alpha, and PCBs above the state stream standards or above background levels.

Soil Monitoring (see Chapter 7)

Soil acts as an integrating medium that can account for contaminants released to the environment. This year, we collected soil surface samples from two areas on Pueblo de San Ildefonso lands and additional samples at Area G and at DARHT. We had samples analyzed from these areas for radionuclides and heavy metals and then compared them with samples collected off-site from regional (background) areas located away from the Laboratory.

Radionuclide concentrations in soils from Pueblo de San Ildefonso were well below the concentration level that would result in exceeding the DOE dose limit of 100 mrem/yr. Radionuclide concentrations in most samples were either at a nondetect level or below the regional statistical reference level (RSRL). Non-radionuclide contaminant levels in most samples from Pueblo de San Ildefonso were at nondetect levels or below the RSRL. All samples were well below the screening level.

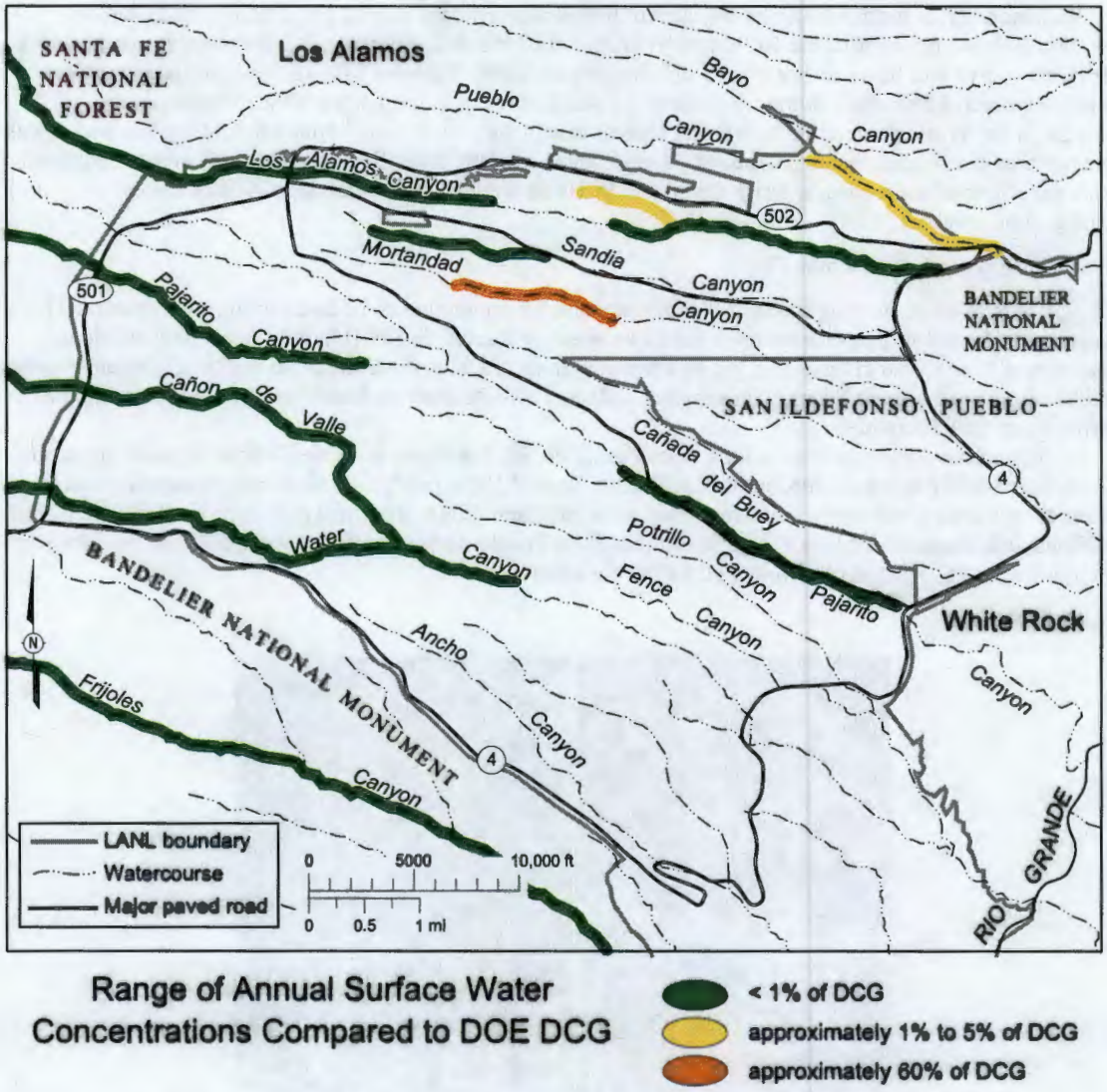


Figure ES-6. Annual average radioactivity in persistent surface waters compared with the DOE Derived Concentrations Guides (DGCs). The extent of contamination lateral to the canyon is not to scale: contamination is confined to the canyon bottom and is narrow at the map scale.

Foodstuffs and Nonfoodstuffs Biota Monitoring (see Chapter 8)

A wide variety of wild and domestic edible plant, fruit, and fish and animal products are harvested in the area surrounding the Laboratory. We collected foodstuff and nonfoodstuff biota within and near LANL property to determine whether they were impacted by Laboratory operations. Also, we collected nonfoodstuff biota at Area G, the Laboratory's principal low-level waste disposal area, and at the Laboratory's principal explosive test facility (DARHT). Concentrations, trends, and doses were assessed.

All 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 collected were within or similar to the regional background levels and showed no increasing trends in concentrations.

Wild edible plants (oak acorns, wild spinach, and purslane) were sampled 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 0.1 mrem for each pound of each consumed, which is 0.1% of the DOE dose limit of 100 mrem/yr.

All nonradionuclide contaminant concentrations, with the exception of barium, in these wild edible plants were either undetected or within the regional background levels. Barium concentrations were about three times higher than regional background concentrations reported for common produce plants. Bioaccumulation of barium by purslane plants is suspected to cause this elevated level.

No vegetation or small mammal samples were collected in 2004 from the overall site or the region. However, vegetation and small mammal samples were collected at TA-54 (Area G) and from TA-15 (DARHT). All radionuclide concentrations in vegetation were below a level that would result in 0.1 rad/day, which is 10% of the DOE dose limit of 1 rad/day for the protection of terrestrial plants. Radionuclide concentrations in small mammals varied; however, all concentrations would result in doses well below 10% of the DOE identified levels for biota.

- *All radionuclides in all crop plant samples were indistinguishable from natural or fallout levels.*
- *All radionuclide concentrations in wild edible plants were below levels that would result in a dose of 0.1 mrem per year per pound consumed (0.1% of the DOE dose limit of 100 mrem).*

PCB congener concentrations were measured in stationary semi-permeable membrane devices from the Rio Grande at two locations above LANL and three locations below LANL in 2002 and 2003. Semi-permeable membrane devices consist of a polyethylene membrane and triolein lipid, both of which mimic the accumulation of PCBs and other dissolved organic contaminants by fish. Results showed only a small amount of similarity between the type of aroclors indicated in the Rio Grande below LANL and aroclors known to exist at LANL. For the particular time periods studied, it was concluded that LANL was not likely contributing PCBs to the Rio Grande as indicated by the statistically similar total PCBs between the two stations above LANL and the station immediately below LANL.

1. Introduction

1. Introduction

contributing author:
Ted Doerr

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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. The Laboratory is managed by the Regents of the University of California (UC) under a contract that is 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.

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 (LANL 2005).

The Los Alamos National Laboratory's vision is to be "The trusted, competitive scientific solution for today's and tomorrow's national security challenges." Seven national security goals have been identified to implement the 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 their 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 the commitment to completing all work in a safe and secure manner. The Laboratory uses Integrated Safety Management (ISM) to set, implement, and sustain safety performance and meet environmental expectations. In addition, the Laboratory initiated an Environmental Management System (EMS) as part of

ISM to focus on environmental performance, protection, and stewardship (see Section C of this chapter for additional information). The foundation of the EMS and demonstration of the Laboratory's commitment is the April 2004 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

A part of the Laboratory's commitment to the policy is to monitor and report how Laboratory activities are affecting the environment. The objectives of this report, as directed by DOE Order 231.1 (DOE 2003a, DOE 2004), are

- 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. Include environmental performance indicators and/or performance measures programs.

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.

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. Recent studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al., 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-2) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains' volcanic center 1.2–1.6 million years ago, the tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft eastward above the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. The Cerros del Rio Basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

Surface water in the Los Alamos area 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

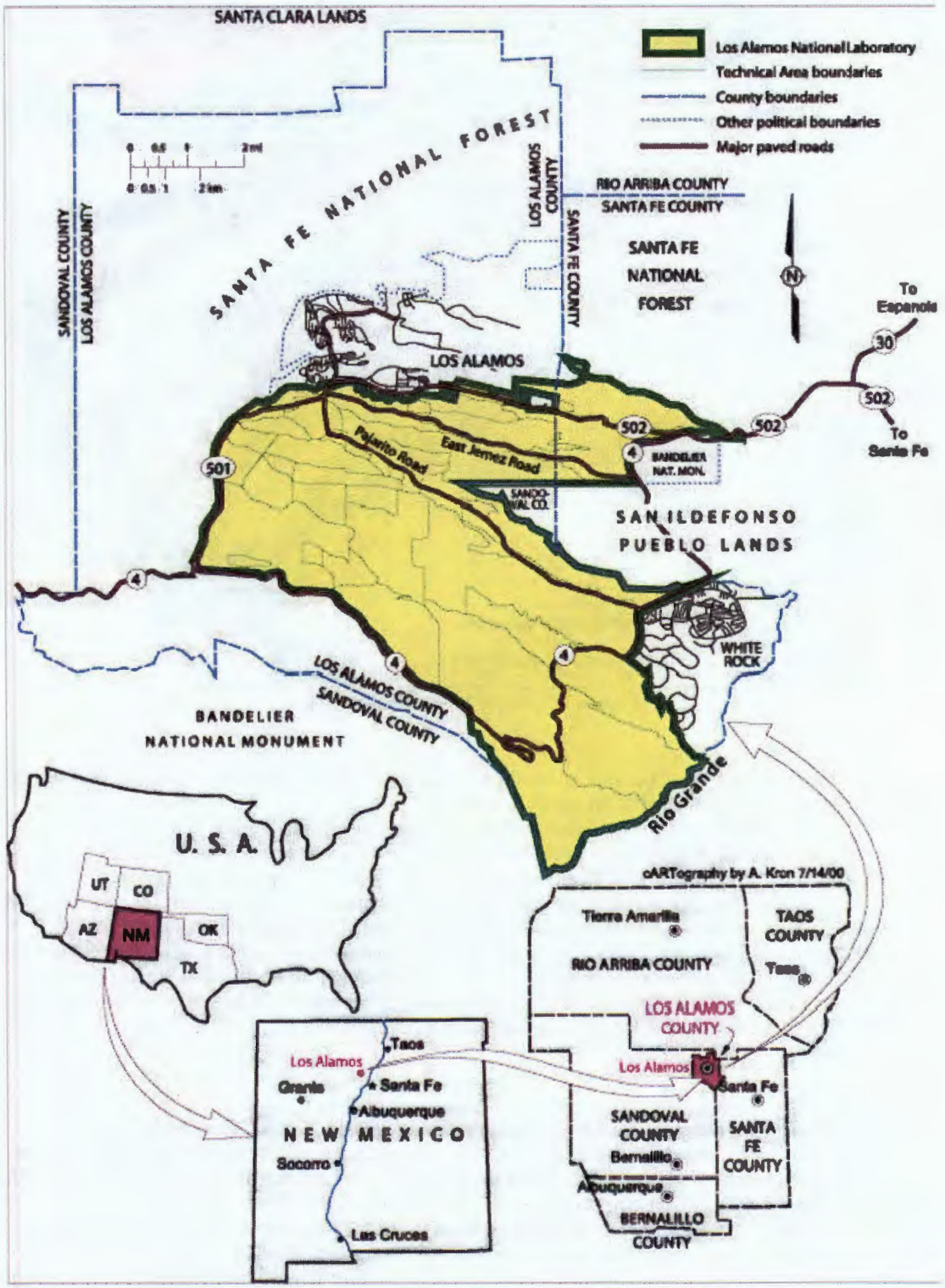

Figure 1-1. Regional location of Los Alamos National Laboratory.

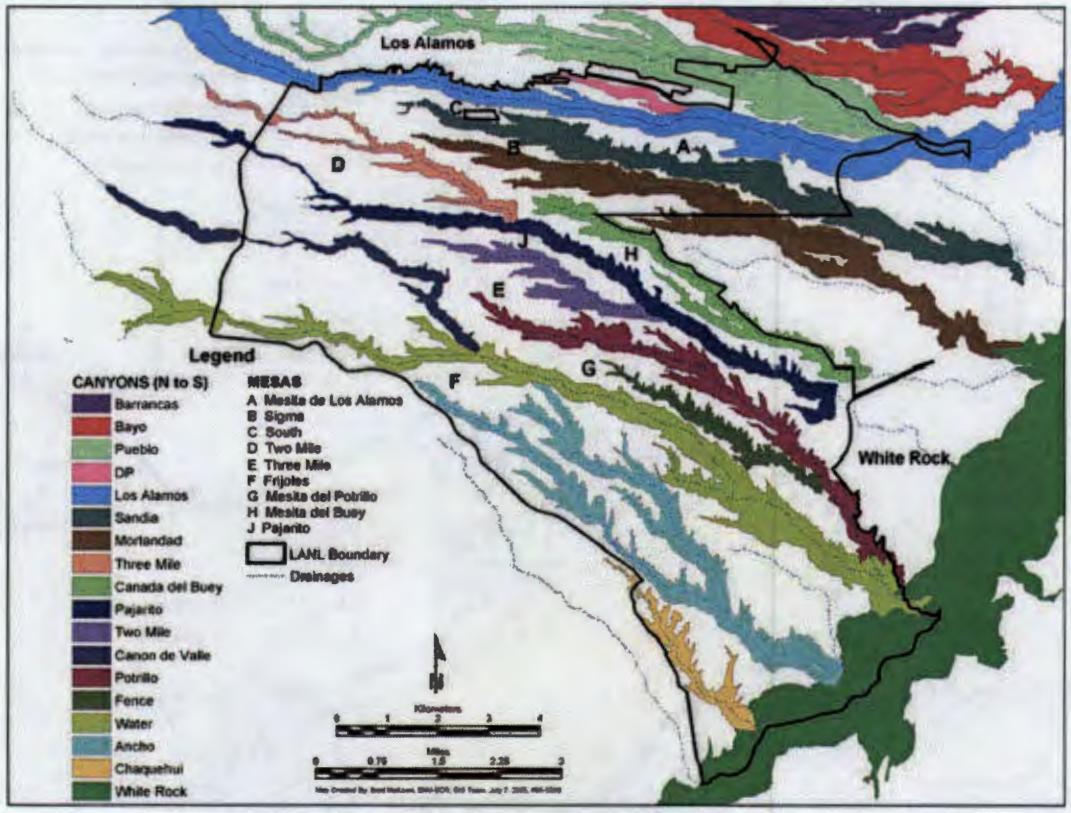

Figure 1-2. Major canyons and mesas.

canyons, but the volume is insufficient to maintain surface flows across the Laboratory site 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 of the Los Alamos area, 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 acre feet of water from the 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 1,500-m (5,000-ft) elevation gradient from the Rio Grande on the east to the Jemez Mountains 20 km (12 mi) 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 1,700 to 1,900 m (5,600 to 6,200 ft). The piñon (*Pinus edulis* Engelm.)-juniper cover type, generally in the 1,900- to 2,100-m (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 2,100- to 2,300-m (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 2,300 to 2,900 m (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 2,900 to 3,200 m (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 17,200 ha (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 3,110 ha (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 between 1998 and 2003 have resulted directly and indirectly in the mortality of many trees. To date, over 90% of the piñon trees greater than 3.0 m (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 85% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and more than 1800 sites have been recorded. More than 85% of the ruins date from the 14th and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 5,800 and 7,100 ft. Almost three-quarters of all ruins 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 275 buildings have been evaluated to date.

5. Climate

Los Alamos 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. 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.

Daily temperatures are highly variable (a 23°F range 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. Summer temperatures range from 70°F to 88°F during the daytime and from 50°F to 59°F during the nighttime.

The average annual precipitation (which includes both rain and the water equivalent for frozen precipitation) from 1971 to 2000 is 18.95 in., and the average annual snowfall amount is 58.7 in. July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in 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 USA, is estimated at 15 strikes per square mile per year. Lightning is most commonly observed between May and September (about 97% of the lightning activity).

The complex topography of Los Alamos 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 ranged 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 land provides buffer areas for security and safety and is held in reserve for future use.

The Laboratory has about 2,000 structures with approximately eight million square feet under roof, spread over an area of approximately 40 square miles. Facilities were identified as Key or Non-Key Facilities in the annual Site-Wide Environmental Impact Statement (SWEIS) Yearbook (LANL 2004). The Annual Yearbook makes comparisons between projects reported in the SWEIS for Continued Operation of Los Alamos National Laboratory (DOE 1999) projections and actual operations data.

Key facilities are defined as being critical to meeting mission assignments and house operations that have potential to cause significant environmental impacts, were of most interest or concern to the public (based on comments in the Site-Wide Environmental Impact Statement public hearings), or would be more subject to change because of DOE programmatic decisions.

The remainder of LANL was identified in the SWEIS Yearbook (2004) as "Non-Key," not to imply that these facilities were any less important to accomplishment of critical research and development, but because they did not meet the above criteria.

Fifteen facilities were identified as Key Facilities in the annual SWEIS Yearbook (LANL 2004) (Table 1-1). The Key Facilities (as presented in the SWEIS) comprised 42 of the 48 Category 2 and Category 3 Nuclear Structures at LANL. These facilities represent the great majority of environmental risks associated with current LANL operations. Specifically, the Key Facilities contribute

- more than 99 percent of all radiation doses to the public,
- more than 90 percent of all radioactive liquid waste generated at LANL,
- more than 90 percent of all radioactive solid waste generated at LANL,
- more than 99 percent of all radiation doses to the LANL workforce, and
- approximately 30 percent of all chemical waste generated by LANL.

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 two-thirds of the LANL workforce. The Non-Key Facilities include such important buildings and operations as the Central Computing Facility, the TA-46 sewage treatment facility, and the main Administration Building.

D. Management of Environment, Safety, and Health

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 environment, safety, and health (ES&H) laws and regulations are how the Laboratory does business. ISM is the way that we meet the moral commitment to avoid injury to people or the environment and the business imperative to meet the safety and environmental requirements of the UC-DOE contract for managing and operating the Laboratory.

ISM is integral to accomplishing our 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, 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 levels, and 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, 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.

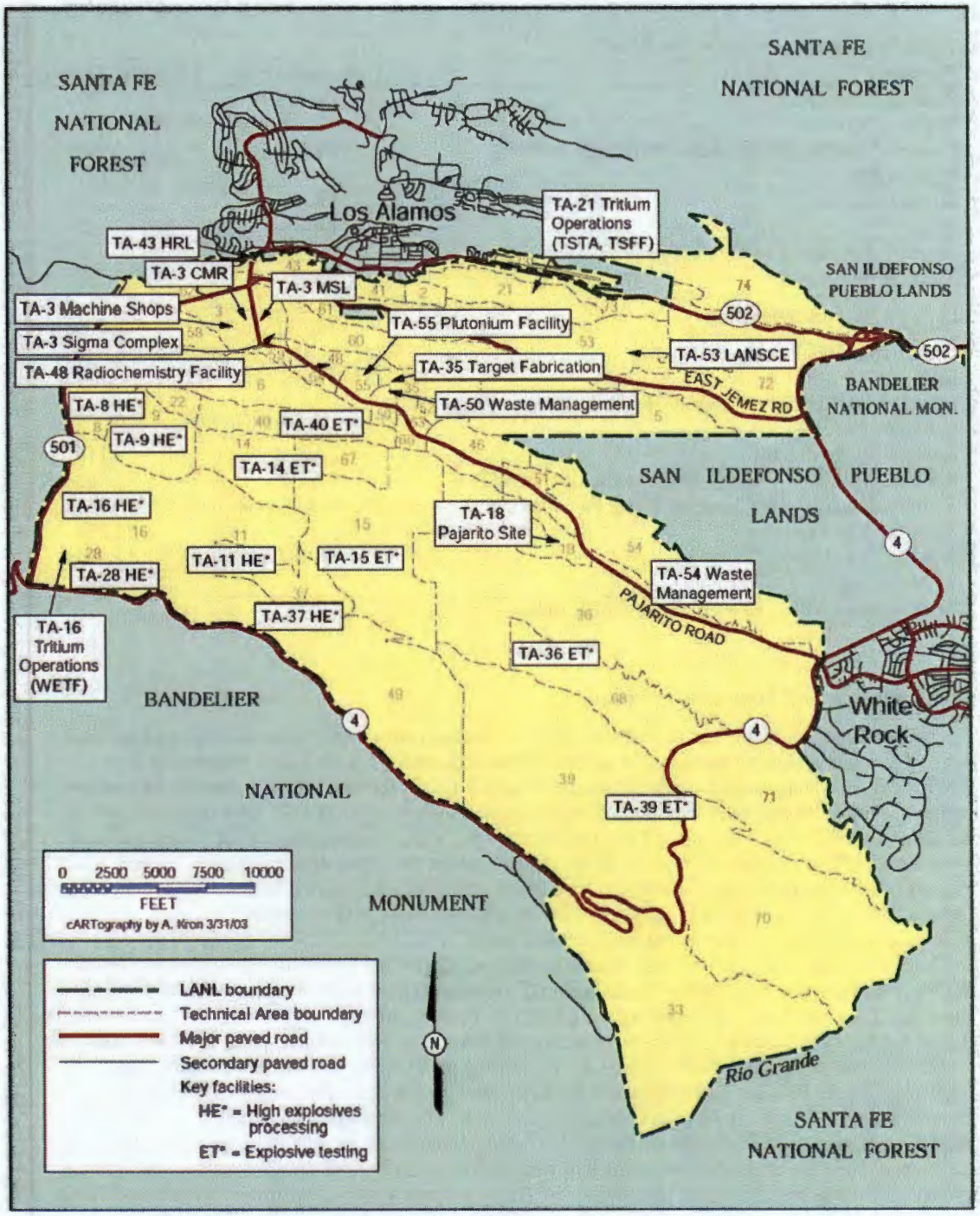

Figure 1-3. Technical Areas and key facilities of Los Alamos National Laboratory in relation to surrounding landholdings.

Table 1-1. Key and Non-Key Facilities[a].

Facility	Technical Areas	~Size (Acres)
Plutonium Complex	TA-55	93
Tritium Facilities	TA-16 & TA-2	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

[a]Table is from SWEIS Yearbook – 2003 (LANL 2004).

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 is implementing an Environmental Management System (EMS) pursuant to DOE Order 450.1, Environmental Protection Program. This order mandates that the EMS be integrated with an existing IMS already established pursuant to DOE Policy 450.4 using ISO (International Standards Organization) 14001 standards as a model. 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."

The EMS program met several milestones in 2004. An EMS Core Team and EMS Element Teams (Policy, Planning, Implementation Checking and Corrective Action, and Management Review) were chartered. The Core Team developed an EMS Program Plan, an institutional process, and procedures. The current LANL ISM Description Document was revised to reflect EMS requirements. In March 2004, the LANL Director issued an ISO-compliant LANL Environmental Policy that has been incorporated into LANL Governing Policies. Element Teams have completed work describing environmental aspects and impacts and are completing the prioritization process. A communications plan detailing internal and external communication pathways was drafted. A Memorandum of Agreement was approved between LANL and major subcontractors to assure site-wide coordination of EMS development. LANL groups, divisions, management units, and the NNSA Site Office are receiving regular progress briefings. Tools have been developed and implemented to integrate EMS with ISM at the job level. Future work approval requires evaluation of environmental hazards, controls, and pollution prevention opportunities to meet many DOE Order 450.1 requirements.

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 to support the Laboratory's mission generate waste contaminated with material that must receive proper management to avoid a risk 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 operations in a manner that minimizes hazardous and non-hazardous waste generation as much as is technically and economically feasible and maintains excellence in matters related to 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 pollution prevention 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 achievement;
- 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 two national NNSA Pollution Prevention awards for Laboratory projects in fiscal year 2004. Projects in fiscal years 2003 and 2004 yielded over $7,000,000 in savings to the Laboratory. The P2 Program was instrumental in incorporating preventive measures and compliance into the Integrated Work Management process. The Pollution Prevention performance index for the 2005 DOE Pollution Prevention goals is 94%.

c. Environmental Remediation and Surveillance Program. The Laboratory's Environmental Restoration Project (renamed in 2005 to Environmental Remediation and Surveillance Program) is part of a national DOE effort to reduce risk to human health and the environment at its facilities. 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 program 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 2004. Ongoing fieldwork included sampling of groundwater monitoring wells and monitoring of water levels.

A major characterization activity reported on in calendar year 2004 was the Los Alamos and Pueblo Canyons investigation. This multiyear investigation addressed sediment, surface water (including springs), alluvial groundwater, and biota potentially impacted by Laboratory solid waste management units and areas of concern located within the Los Alamos and Pueblo Canyons watershed. The objectives included defining

the nature and extent of contamination in sediment, surface water, and alluvial groundwater and assessing potential risks to human health and the environment from the contaminants. The results of the investigation indicated that contaminants released from solid waste management units and areas of concern are below New Mexico Environment Department (NMED) and DOE human-health risk/dose target levels for present day and foreseeable future land use (i.e., recreational activities) and indicated no adverse effects to terrestrial and aquatic biota in the watershed.

Another major remediation activity reported on in 2004 was the removal of three surface impoundments at TA-53. The remediation activities included the excavation of the sludge, liner, and contaminated soil/tuff, as well as excavation of radioactively contaminated soil and sediment from the drainage leading from the mesa top impoundments to the canyons. Environmental samples were collected following the remediation from within and around the impoundments, including from boreholes drilled to characterize potential releases beneath the site and the drainage. The analytical results showed that the nature and extent of residual contamination is defined. The analysis detected inorganic chemicals, organic chemicals, and radionuclides in the soil, sediment, and tuff and found that they decreased with distance (vertically and laterally) from the impoundments. The contaminant concentrations are below NMED and DOE human health risk/dose target levels for present day and foreseeable future land uses (i.e., industrial activities). An ecological screening assessment also indicated no potential for adverse effects to biota.

d. Compliance and Surveillance Programs

i. 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 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 on the World Wide Web at www.airquality.lanl.gov. 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 assure that air quality and ambient radiation doses meet EPA and DOE standards. These data are published in this report and on the Web at www.airquality.lanl.gov.

The Laboratory also participates with and assists neighboring communities and pueblos in performing ambient air and meteorological monitoring.

ii. Water Resources. The LANL Groundwater Protection Program and Water Quality and Hydrology monitoring program manage and protect groundwater and surface water resources. 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 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.

iii. 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 Laboratory began initial planning for a comprehensive biological resources management plan in 1997. The Mitigation Action

Plan for the Site-Wide Environmental Impact Statement 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 the development of an institutional biological resources management plan and on-the-ground resource management activities (e.g., forest thinning and fuels treatment). The plan is currently being developed to address the need 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 biocontaminants. 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.

iv. 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 resource protection. Cultural resources include archeological 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 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 is developing a Cultural Resources Management Plan as an institutional comprehensive plan that defines the responsibilities, requirements, and methods for managing its cultural properties. The plan will provide an overview of the cultural resources program, establish a set of procedures for effective compliance with applicable historic preservation laws, address land-use conflicts and opportunities, ensure public awareness of DOE's cultural heritage stewardship actions at LANL, and provide 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 an integral part of the way the Laboratory does business. The Laboratory uses ISM to create a worker-based safety culture, where people are committed to safety in their daily work. Environmental protection, like safety, is an underlying value, not a priority that can be ignored when other priorities seem more important.

Each Laboratory organization is responsible for its own environmental management and performance. Line management provides leadership and ensures ES&H performance 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. These line organizations are supported by ES&H specialists in the Technical Services Directorate.

The Laboratory established the Technical Services Directorate in 2004 to improve the Laboratory's performance in the areas of environmental stewardship, general health and safety, project management, internal security, facility engineering standards, quality assurance, and nuclear and hazardous operations. The Environmental Stewardship Division (ENV) was established under the Technical Services Directorate. The restructure enhances the visibility and effectiveness of all functions.

ENV Division represents the Laboratory on environmental issues with regulators and external stakeholders. ENV Division provides a broad range of technical expertise and assistance to internal customers. This expertise and assistance is 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 is 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.

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). ENV Division has 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, Environmental Protection Agency, and the US Defense Nuclear Facilities Safety Board.

ENV Division develops and manages the Laboratory programs for environmental regulatory compliance. This work is conducted in four ENV Division groups: Meteorology and Air Quality (MAQ), Water Quality and Hydrology (WQH), Solid Waste Regulatory Compliance (SWRC), and Ecology (ECO). With assistance from Laboratory legal counsel, ENV Division works to define and recommend Laboratory policies for applicable federal and state environmental regulations and laws and DOE orders and directives. ENV Division is responsible for communicating environmental policies to Laboratory employees and makes appropriate environmental training programs available. The ENV groups work with line managers to prepare and review required environmental documentation. The four groups also initiate and manage Laboratory programs for environmental assessment and are responsible for executing environmental surveillance work under the auspices of the division's Environmental Protection Program.

ENV Division uses approximately 600 sampling locations for routine environmental monitoring. The maps in this report present the general location of monitoring stations. For 2004, Laboratory personnel performed more than 250,000 routine analyses for chemical and radiochemical constituents on more than 12,000 routine environmental samples. Laboratory personnel also collected many additional samples in continuing efforts to monitor the effects of the Cerro Grande fire that occurred in 2000, which burned more than 7,500 acres of Laboratory property. Samples of air particles and gases, water, soils, sediments, foodstuffs, and associated biota are routinely collected at monitoring stations and then analyzed. These analyses help identify whether impacts occurred from LANL operations. Trained personnel collect and analyze additional samples to obtain information about particular events, such as major surface-water runoff events, nonroutine radiation releases, or special studies.

E. References

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2. Compliance Summary

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 qualities. 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 these organizations issued that the Laboratory operated under in 2004 and the specific operations and/or sites affected. Table 2-2 lists the various environmental inspections and audits conducted at the Laboratory during 2004. The following sections summarize the Laboratory's regulatory compliance performance during calendar year 2004.

B. Compliance Status

Laboratory compliance with environmental regulations continues to improve. Similarly, the Laboratory continued to comply with all applicable biological and cultural requirements.

The Laboratory completed 1,095 Resource Conservation and Recovery Act (RCRA) self-assessment that resulted in a nonconformance finding rate of less than 3.5%. Similarly, Laboratory performance on NMED inspections continue to improve. Only seven violations were identified which was a 67% reduction in violations compared to 2003. The Laboratory continued to address cleanup and legacy waste issued in accordance with NMED requirements. The Laboratory met all permit limits for emissions to the air. In addition, use of refrigerants continued to decline.

The Laboratory continues to meet requirements under the Clean Water Act. None of the 145 samples collected from the Sanitary Waste System Plant's outfall exceeded Clean Water Act effluent limits; however, 2 of 1283 samples collected from industrial outfalls exceeded effluent limits. The majority of the Laboratory's permitted construction sites were compliant with National Pollutant Discharge Elimination System (NPDES) requirements. Corrective actions for the noncompliant sites are scheduled for 2005 and the LANL engineering standards were updated to ensure compliance.

The Laboratory is in full compliance with RCRA groundwater monitoring requirements. However, the Laboratory increased its monitoring program in response to perchlorate and nitrate concerns.

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. The RCRA, as amended by the Hazardous and Solid

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 2004

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	August 2002	---	NMED
	General Part B Permit Renewal Application, Revision 2.0	August 2003	---	NMED
	TA-54 Part B Permit Renewal Application, Revision 3.0	June 2003	---	NMED
	TA-16 Part B Permit Renewal Application, Revision 4.0	June 2003	---	NMED
	TA-55 Part B Permit Application, Revision 2.0	September 2003	---	NMED
	General Part A Permit Application, Revision 4.0	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 storm water from industrial activities	October 30, 2000	October 30, 2005*	EPA
	Construction General Permits (21) for the discharge of storm water 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[l]	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 approval pending	---	NMED
Air Quality Operating Permit (20.2.70 NMAC[m])	LANL air emissions	April 30, 2004	April 29, 2009	NMED

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 2004 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Air Quality (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	TA-3 Power Plant	September 27, 2000	None	NMED
			Revised, November 26, 2003	
			Modified, July 30, 2004	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
Air Quality (NESHAP)[n]	Beryllium machining at TA-3-102	March 19, 1986	Closed, February 20, 2004	NMED
	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
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]New Mexico Oil Conservation Division
[l]Sanitary Wastewater Systems Plant
[m]New Mexico Administrative Code
[n]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 2004

Date	Purpose	Performing Agency
03/23/04	Asbestos inspection at TA-48, Bldg. 1	NMED[a]
03/23/04	Asbestos inspection at TA-3, Trench	NMED
05/26/04	Asbestos inspection at TA-16-370	NMED
11/01/04	Asbestos inspection at TA-15, Hollow complex	NMED
12/29/04	Asbestos inspection at TA-3-246, -247, -379	NMED
03/22/04–04/13/04	Hazardous waste compliance inspection (NMED Closeout 4/22/2004)	NMED
4/15/04	Aboveground storage tank inspection	NMED-PSTB[b]
5/20/04	Aboveground storage tank inspection	NMED-PSTB[b]
5/26/04	Aboveground storage tank inspection	NMED-PSTB[b]

(No PCB[c], NPDES[d], FIFRA[e], Section 401/404, or Groundwater Discharge Plan inspections were conducted in 2004.)
[a]New Mexico Environment Department
[b]New Mexico Environment Department-Petroleum Storage Tank Bureau
[c]Polychlorinated biphenyls
[d]National Pollutant Discharge Elimination System
[e]Federal Insecticide, Fungicide, and Rodenticide Act

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 the NMED, the Laboratory submitted preliminary permit renewal applications for NMED review starting in 1996. The final set of Part B permit applications was submitted in 2003 for final NMED review.

b. Resource Conservation and Recovery Act Permitting Activities. To reflect consolidations in hazardous waste management units in accordance with the annual unit audit, the Laboratory's General Part A RCRA Permit Application was revised in December 2004. The motivation for this submittal was proposed fee regulation changes that NMED presented for comment in October 2004.

The Laboratory submitted a version of the LANL hazardous waste facility permit containing all previously submitted permit modifications in September 2004 in an attempt to begin to bring the permit up to date with current operations. In October and November of 2004, an additional twenty Class 1 modifications were submitted to further update this version.

Closure activities for several waste management units were completed, and NMED approved them in 2004. These closures included the interim status container storage units at Technical Area (TA) -50-1, Room 59 and TA-50-37; the Exhaust System at TA-50-37; the container storage unit at TA-50-114; and the container storage unit at TA-50-37, Room 117. The Laboratory received approval for these closures in November 2004. Closure activities began for the sand filters at TA-16-401 and -406 and were completed for the container storage unit at TA-55-PF 4-B38 in 2004. The Laboratory will draft final closure certification reports and submit them to NMED for final approval.

c. Other Resource Conservation and Recovery Act Activities. The compliance assurance program, managed by the Environmental Stewardship Division's Solid Waste Regulatory Compliance Group (ENV-SWRC), performs Laboratory self-assessments to determine that hazardous and mixed waste is managed to meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. ENV-SWRC communicates 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 2004, the Laboratory completed 1,095 self-assessments that resulted in a nonconformance finding rate of less than 3.5%.

d. Resource Conservation and Recovery Act Compliance Inspection. From March 22 to April 13, 2004, the 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 2004 Site Treatment Plan deadlines and milestones by treating and disposing of more than 7 cubic meters (m^3) of Site Treatment Plan low-level mixed waste.

f. Solid-Waste Disposal. The Laboratory closed an on-site landfill that had been used to dispose of solid waste and New Mexico special waste. Material Disposal Area J, located at TA-54, was subject to New Mexico Solid Waste Management Regulations. Area J is now under long-term post-closure care and monitoring.

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 2004 included 1,560 tons of trash and 607 tons of construction and demolition debris. Through LANL recycling efforts, 3,831 tons of material did not go to the landfill in 2004.

g. Compliance Order on Consent (Consent Order). For calendar year 2004, the Laboratory (under the Environmental Remediation and Surveillance Program) continued to operate in accordance with the 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 the Resource Conservation and Recovery Act. Additionally, while negotiating a compliance order on consent, the Laboratory voluntarily operated in accordance with the November 2002 Order issued by NMED containing corrective action requirements. After September 1, 2004, the Laboratory voluntarily complied with a draft schedule of deliverables negotiated by NMED, DOE, and LANL.

NMED, DOE, and UC signed the final Compliance Order on Consent (Consent Order) for corrective action on March 1, 2005. The Consent Order is the principal regulatory driver for the Environmental Stewardship – 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 (SWMUs) and areas of concern (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.

Table 2-3. Investigation Work Plans and Investigation Reports Submitted for Review and/or Approved in 2004

Plan Title	Date Submitted	Date Approved
Investigation Work Plans		
Mortandad Canyon Groundwater Work Plan, Revision 1	1/16/2004	2/11/2004
MDA T [SWMU 21-016(a)-99] Investigation Work Plan	2/27/2004	
SWMU 16-003(o) Investigation Work Plan	3/31/2004	6/28/2004
Addendum to the Sampling and Analysis Plan for Middle Mortandad/Ten Site Canyon Aggregate	3/31/2004	6/25/2004
Remedy Design Work Plan for the Airport Landfill [SWMUs 73-001(a-d), 73-004(d)]	4/30/2004	9/2/2004
MDA G [SWMU 54-013(b)-99] Investigation Work Plan, Revision 1	6/14/2004	11/5/2004
MDA V [SWMU 21-018(a)-99] Investigation Work Plan	6/30/2004	11/5/2004
MDA B (SWMU 21-015) Investigation Work Plan	6/30/2004	12/24/2004
DP Site Aggregate Area Investigation Work Plan	8/31/2004	
MDA U [SWMU 21-017(a)-99] Investigation Work Plan	11/30/2004	
Groundwater Investigation Work Plan for SWMU 03-010(a)		3/30/2004
Accelerated Corrective Action Work Plan for Former TA-19	1/28/04	6/23/2004
MDA L Investigation Work Plan, Revision 1		9/28/2004
Investigation Reports		
TA-53 Surface Impoundments [SWMU 53-002(a)-99 and AOC 53-008] Investigation Report	1/31/2004	
Interim Measures Completion Report for the Airport Drainages	3/1/2004	
Los Alamos and Pueblo Canyons Investigation Report	4/30/2004	
Phase III Resource Conservation and Recovery Act Facility Investigation Report for SWMU 16-021(c)-99		6/23/2004
Voluntary Corrective Action Completion Report for SWMU 21-024(f) and AOCs 21-030 and C-21-015		6/21/2004
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)		6/21/2004

All of the Laboratory deliverables (plans and reports) scheduled in 2004 under the November 2002 Order and the September 2004 negotiated draft schedule were submitted on time to NMED (Table 2-3). In addition, the Laboratory submitted several other plans and reports not specifically required by the November 2002 Order to NMED during 2004.

2. Comprehensive Environmental Response, Compensation, and Liability Act

As part of the Conveyance and Transfer project, the Laboratory prepared environmental baseline survey documents for three subparcels of land during 2004. 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 (LASO) 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 (EPCRA)

a. Introduction. The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act of 1986 and Executive Order 12856.

b. Compliance Activities. In 2004, the Laboratory submitted two annual reports to fulfill its requirements under Emergency Planning and Community Right-to-Know Act, as shown on Table 2-4 and described here.

Table 2-4. Compliance with Emergency Planning and Community Right-to-Know Act during 2004

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 has 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 2004.
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 50 hazardous materials stored at LANL over specified quantities in 2004 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 Releases	Requires all federal facilities to report total annual releases of listed toxic chemicals used in quantities above reportable thresholds.	Use of lead compounds, nitric acid, and nitrate compounds exceeded the reporting thresholds in 2004, 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 2004.

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 2004.

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 50 chemicals and explosives at the Laboratory that were stored on-site in quantities that exceeded threshold limits during 2004.

Toxic Release Inventory Reporting. Executive Order 12856 requires all federal facilities to comply with Title III, Section 313, of 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 three thresholds in 2004 and, therefore, was required to report the uses and releases of these chemicals. The reported materials were lead compounds, nitric acid, and nitrate compounds. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. The largest use of nitric acid is at the plutonium processing facility. In 2004, the facility continued operation of a process called mixed oxides fuels. The goal of the project is to demonstrate that surplus plutonium can be used in the form of mixed-oxide fuel to generate electricity in existing commercial reactors. The Laboratory has a nitric acid recycle system in place; however, the mixed oxides fuels project cannot use the recycled nitric acid because it has not been demonstrated to meet quality specifications. Therefore, spent nitric acid from the mixed oxides fuels project is sent to the Radiological Liquid Waste Treatment Facility (RLWTF) for treatment and disposal. The waste nitric acid stream is neutralized with sodium hydroxide, forming sodium nitrate. The sodium nitrate created during this treatment step is part of the listed nitrate compound category and must be reported under Emergency Planning and Community Right-to-Know Act Section 313 if quantities exceed 25,000 lb. Table 2-5 summarizes the reported releases for the three Emergency Planning and Community Right-to-Know Act Section 313 reportable chemicals for 2004.

Table 2-5. Summary of 2004 Reported Releases under EPCRA Section 313

	Lead Compounds (lb)	Nitric Acid (lb)	Nitrate Compounds (lb)
Air Emissions	5.0	248	0
Water Discharges	422	0	12,571
On-Site Land Disposal	5,536	0	11,524[b]
Off-Site Waste Transfers	52,518[a]	417	13,478[b]

[a]Off-site waste disposal of lead includes 45,008 lb lead from the Dynamic Experimentation Division (DX) firing site cleanup project.

[b]Nitrate bottoms from RLWTF are transferred off-site for dewatering, then returned to LANL for on-site disposal. Per EPA guidance, this activity must be reported as both waste transfer when shipped out and as on-site land release when disposed on-site.

4. Toxic Substances Control Act

Because the Laboratory's activities are research and development (R&D) and do not involve commercial manufacturing of chemicals to sell, the polychlorinated biphenyls (PCB) regulations and import/export of R&D chemical substances have been the Laboratory's main concern under the Toxic Substances Control Act (TSCA). 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 2004, the Laboratory shipped 171 containers of PCB waste off-site for disposal. The quantities of waste disposed of include 1,964 kg of capacitors and 4,792 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 the 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 the EPA granted an administrative extension to LANL for continued use of Area G during the review process. Approval of a renewal request is expected to occur in 2005. During 2004, the EPA did not perform any PCB inspections, and approximately 26 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 the manufacturing of pesticides and the protection of workers who use these chemicals. Sections of this act that are applicable to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture has the primary responsibility to enforce pesticide use under the act. The New Mexico Pesticide Control Act applies to the Laboratory's licensing and certifying of pesticide workers, record keeping, applying of pesticides, inspecting of equipment, storing of pesticides, and disposing of pesticides.

The NM Department of Agriculture did not conduct assessments or inspections of the Laboratory's pesticide application program in 2004. The Laboratory conducted four quarterly inspections of the pesticide storage area in 2004 and found that the storage area was being maintained in accordance with RCRA regulations.

Amounts of pesticides used during 2004 included the following:

Herbicides		Insecticides	
VELPAR L (Liquid)	44 gal.	TEMPO (Powder)	50 oz
TELAR (Granule)	14 g	STINGER WASP (aerosol)	50 oz
2-4-D Amine (Liquid)	11 gal.		

6. Clean Air Act

In April 2004, the Air Quality Bureau of the NMED issued Operating Permit No P100 to the Regents of the University of California for LANL pursuant to the federal Clean Air Act Amendments and Title 20 of the New Mexico Administrative Code, Chapter 2, Part 70 – Operating Permits (20.2.70 NMAC). The operating permit conditions mirror existing source specific permit conditions applicable to operating requirements, record keeping, monitoring, and reporting. Implementing the Title V Operating permit requires increased record keeping, increased frequency of reporting, and an annual compliance certification. Complying with the conditions of the Title V Operating permit is deemed to be compliance with all applicable requirements existing at the date of permit issuance.

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

LANL staff calculates air emissions using emission factors source tests, manufacturer's data, and EPA documentation. Calculated emissions are based on actual or maximum production rates, fuel and fuel usage, and/or material throughput. To satisfy requirements set forth in the Title V Operating Permit, LANL completed and submitted to NMED its first semiannual emissions report in 2004.

LANL is a major source under the Title V Operating Permit program based on the potential to emit nitrogen oxides (NO_X), carbon monoxide (CO), and volatile organic compounds. In 2004, small boilers and heaters were the major contributors of NO_X and CO, whereas R&D activities were responsible for most of the VOC emissions. Another significant contributor of NO_X and CO is the TA-3 power plant (Table 2-6 and Figure 2-1).

Hazardous air pollutant emissions reported from R&D activities generally reflect the quantities procured during the calendar year. Reporting procured quantities assures a conservative estimate of hazardous air pollutant emissions. In a few cases, LANL evaluated procurement values and operational processes in more

Table 2-6. Calculated Actual Emissions for Regulated Pollutants (tons) Reported to NMED

	Pollutants					
Emission Units	**NO_x**	**SO_x**	**PM**	**CO**	**VOC**	**HAPs**
Asphalt Plant[a]	0	0	0	0	0	0
TA-21 Steam Plant	1.58	0.012	0.12	1.33	0.09	0.03
TA-3 Steam Plant	16.34	0.29	2.16	11.26	1.54	0.51
Regulated Boilers	6.55	0.041	0.61	4.5	0.38	0.13
R&D Chemical Use	NA	NA	NA	NA	7.95	5.71
Air Curtain Destructors[b]	0	0	0	0	0	0
Degreaser	NA	NA	NA	NA	0.011	0.011
Paper Shredder	NA	NA	0.055	NA	NA	NA
Rock Crusher	0	0	0	0	0	0
Carpenter Shop (TA-3-38)	NA	NA	0.023	NA	NA	NA
Storage Tanks	NA	NA	NA	NA	0.047	NA
Stationary Standby Generators[c]	5.9	1.1	0.3	1.4	0.3	0.003
Miscellaneous Small Boilers[c]	20.17	0.147	1.578	16.97	1.13	0.34
TOTAL	**50.5**	**1.6**	**4.8**	**35.5**	**11.4**	**6.7**

[a]The old asphalt plant was shut down in 2003. A new asphalt plant is under construction but did not operate in 2004.

[b]The air curtain destructors were taken out of service in October 2003.

[c]Emissions from these source categories reported for the first time in 2004 as the Title V Operating Permit requires. Emissions units in these categories are exempt from construction permitting and annual emission inventory reporting requirements.

detail to report actual emission in place of the procured values. See Table 2-6 for reported values of hazardous air pollutant emissions for 2004.

Two sources listed in the Title V Operating Permit saw changes in the permit status as described in the Title V Operating Permit Application. These sources were the asphalt plant and the paper shredder.

Construction of a BDM Engineering asphalt plant, Model Number TM 2000, permitted under Air Quality Permit No GCP-3-2195G, started in 2004. The BDM Engineering asphalt plant construction was started to replace the Barber-Greene plant that was dismantled in 2003. Construction delays caused by the Mexican Spotted Owl nesting season and the asphalt plant's proximity to a mating area prevented completion and start-up in 2004. LANL produces asphalt only when outside asphalt contractors are unavailable to provide support. Production is solely for use in minor road patching and paving.

The data disintegrator was installed at TA-52-11 in July of 2004. This building had previously housed a paper shredder that had operated there since 1991. The paper shredder was taken offline and removed in July 2004 to make room for the data disintegrator. The data disintegrator was permitted for installation under New Source Review Air Quality Permit No. 2195-H issued by NMED in October 2003. Data disintegrator operations began in August 2004 and is capable of data destruction of paper, microfiche, film, plastic magnetic tape, and compact discs.

As part of the Operating Permit Program, the NMED collects annual fees (20.2.71 NMAC) from facilities. For LANL, the fees are based on the allowable emissions from activities and operations as reported in the 1995 operating permit application. LANL's fees for 2004 were approximately $12,800.

a. New Mexico Air Quality Control Act.

i. Construction Permits. The Laboratory operates under several permits issued by NMED (Table 2-1). During 2004, the Laboratory submitted a Notice of Intent for a soil vapor extraction system, and received 1 permit modification for a 24.6-MW output turbine. Also, five sources were exempt from construction permitting but required written notification to the NMED (20.2.72 NMAC).

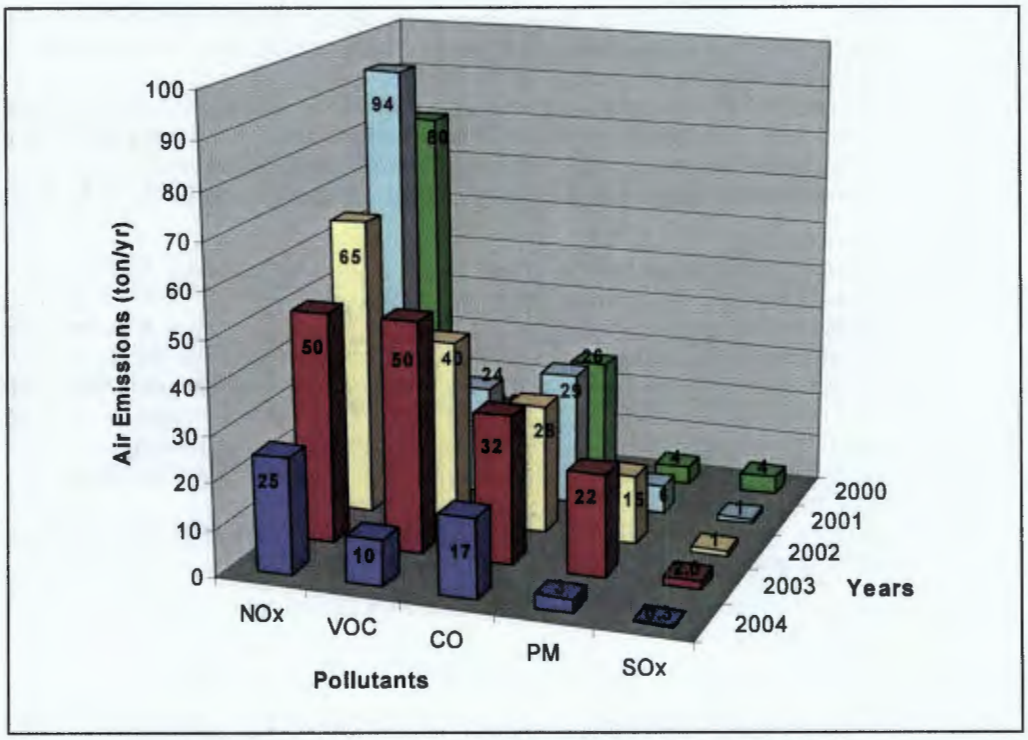

Figure 2-1. Criteria pollutant emissions from LANL 2000–2004.

In July, NMED issued a permit modification to add a combustion turbine at the TA-3 power plant. The power plant intends to operate the 24.6-MW output turbine as a standby or peaking unit. The turbine will augment, not replace, the existing boilers' electric generation capacity. Construction is expected to start in 2005.

LANL submitted a Notice of Intent for a soil vapor extraction system for use at TA-54 Material Disposal Area L. NMED determined no permit was required for installation and operation of the unit.

ii. Open Burning. 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. All operational burns for 2004 were conducted within the terms specified in the permits. The Laboratory reports the results of these operations annually to the NMED to document compliance with permit requirements.

As required by the revised open burn regulation, 20.2.60 NMAC, LANL prepared and submitted to NMED applications under 20.2.72 NMAC, Construction Permits, for open burn activities at the DX TA-36 sled track, the ESA TA-16 flash pad, and the ESA TA-11 wood and fuel fire test site. As part of the application process, LANL made public notice through certified letters to local municipalities and pueblos, a radio announcement, and newspaper advertisements in the Los Alamos Monitor. In addition, NMED decided that notice to owners of property within 100 feet of the LANL boundary was appropriate. In response, LANL sent certified letters to approximately 450 property owners. LANL continues to operate under existing open burn permits until new permits are issued under 20.2.72 NMAC.

iii. Asbestos. The National Emission Standard for Hazardous Air Pollutants (NESHAP) for Asbestos requires that LANL provide advance notice to the 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 2004 included 27 large renovation jobs and demolition projects

for which the NMED received advance notice. These projects, combined with other smaller activities, generated approximately 645 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 five inspections during the year and identified no violations. The Quality Assurance Project Plans for for the Asbestos Report Project and the Rad NESHAP Compliance Project are available at http://www.airquality.lanl.gov/QA.shtml on the World Wide Web.

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. These goals include the following:

retrofit or replace, by the year 2005, all chillers with greater than 150 tons of cooling capacity and manufactured before 1984 and

eliminate the use of the remaining equipment by 2010.

Figure 2-2 shows the decrease in total refrigerants used from 2001 to 2004 for all equipment. In 2004, LANL replaced the remaining four chillers subject to the 2005 phaseout goal. In addition, over 4000 lb of refrigerant in eighteen units subject to the 2010 goal were replaced.

ii. Radionuclides. Under the National Emission Standard for Hazardous Air Pollutants for Radionuclides (Rad-NESHAP), the EPA 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 2004 TEDE (as calculated using EPA-approved methods) was 1.68 mrem. The location of the highest dose was at East Gate. Operations at the Los Alamos Neutron Science Center made the principal contribution to that highest dose. The QA Project Plan for the Rad NESHAP Compliance Project is available at http://www.airquality.lanl.gov/QADocs/RadN-QAPP-R3.pdf on the World Wide Web.

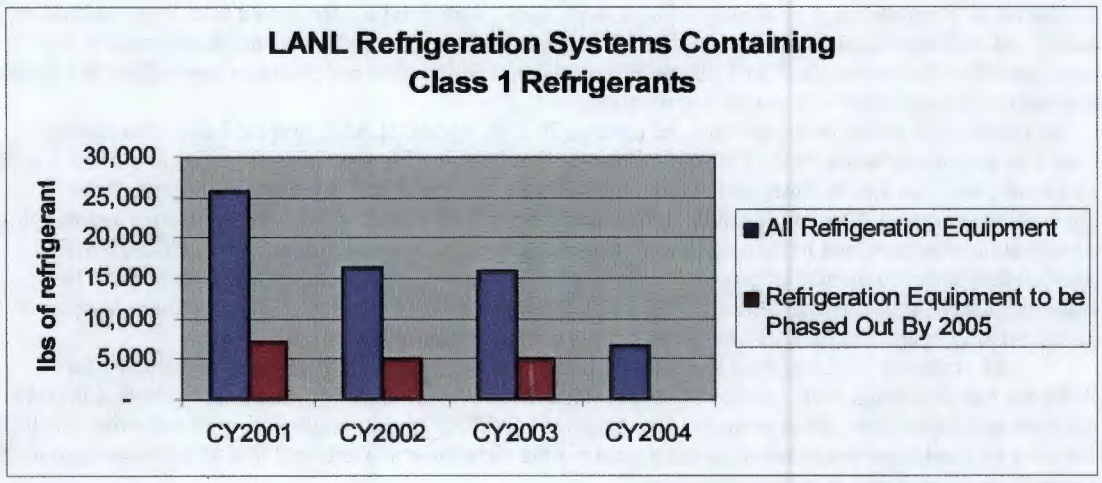

Figure 2-2. LANL refrigeration systems containing class 1 refrigerants.

LANL reviews plans for new and modified projects, activities, and operations to identify the need for emissions monitoring and prior approval from the EPA. During 2004, more than 60 reviews involved the evaluation of air-quality requirements associated with the use of radioactive materials. No projects reviewed in 2004 met the criteria requiring EPA pre-approval. However, one new project did meet the criteria for notification to EPA because the requirement for approval was waived under Section 61.96 of the regulation. The project involves research on very-low-energy ("ultra-cold") neutrons, and a byproduct of the experiments is the low-level production of tritium. The project started in April 2004 and is expected to continue into 2005.

7. Clean Water Act

a. National Pollutant Discharge Elimination System 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 National Pollutant Discharge Elimination System (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.

UC and the DOE/National Nuclear Security Administration (NNSA) are co-permittees of the NPDES permit covering Laboratory operations. The EPA Region 6 in Dallas, Texas, issues and enforces the permit. The 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 1 sanitary outfall and 20 industrial outfalls. To view the Laboratory's NPDES permit link to http://eweb.lanl.gov/Downloads/npdes_permit2001.pdf on the World Wide Web.

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. No NPDES outfalls were deleted in 2004; however, four outfalls were 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 2005 and will include one sanitary outfall and 16 industrial outfalls for a total of 17 permitted outfalls.

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. Analytical results are reported to the EPA and the NMED at the end of the monitoring period for each respective outfall category. During 2004, none of the 145 samples collected from the Sanitary Wastewater Systems (SWWS) Plant's outfall exceeded effluent limits; however, two of the 1283 samples collected from industrial outfalls exceeded effluent limits. Monitoring data obtained from sampling at NPDES permitted outfalls is available online at: http://wqdbworld.lanl.gov/.

The following is a summary of the corrective actions taken by the Laboratory during 2004 to address the NPDES outfall permit noncompliances cited above.

TA-3 Sigma Cooling Tower. On November 15, 2004, a total residual chlorine concentration of 0.28 mg/L exceeded the NPDES monthly average and daily maximum permit limit of 0.011 mg/L (counts as two instances of exceedance). The noncompliance was attributed to the following possible causes: (1) matrix interferences in the field analysis of total residual chlorine and (2) an adjacent, leaking pipe that resulted in steam condensate infiltrating into the clay outfall pipe. A chlorine-based biocide is not used at this cooling tower, and the dechlorinator (to neutralize any chlorine in the supply water) was working properly. Investigations could not confirm that the steam condensate was entering the outfall pipe. The current analytical procedure will be revised to include additional procedures to follow when matrix interference is suspected.

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 first 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://wqdbworld.lanl.gov/. During 2004, the SWWS Plant

generated approximately 33.3 dry tons (66,642 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 Permit Compliance Evaluation Inspection. The NMED Surface Water Quality Bureau did not conduct any NPDES Outfall Compliance Evaluation Inspections in calendar year 2004.

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

At most construction sites, LANL and the General Contractor apply individually for NPDES CGP coverage and are co-permittees for the site. 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 been initiated. A SWPP Plan describes the project activities, site conditions, and best management practices required to reduce pollution in storm water discharges and protect endangered or threaten species and critical habitat. Compliance with the NPDES CGP is demonstrated through inspections and reports that document the condition of the site.

During 2004, the Laboratory implemented and maintained 67 SWPP Plans and addendums to SWPP Plans and performed 616 storm water inspections. At the end of 2004, 70% of the Laboratory's permitted sites were compliant with NPDES CGP requirements. The noncompliant sites were primarily those where all soil disturbing activities had ceased, but final vegetative stabilization and/or the removal or maintenance of temporary best management practices were not satisfactorily completed. Corrective actions for the noncompliant sites are scheduled for 2005. Additionally, to reduce future noncompliances, during late 2004 the LANL engineering standards were updated to more accurately reflect storm water requirements, and additional protocols were established to enhance communication with project site owners.

The NPDES CGP Program has also developed a Geographic Information System-based system to manage project information and generate status reports that facilitate Appendix F reporting.

e. National Pollutant Discharge Elimination System Industrial Storm-Water Program. The NPDES Industrial Storm Water Permit Program regulates storm-water discharges from identified industrial activities (including Solid Waste Management Units). UC and the DOE are co-permittees under the NPDES Multi-Sector General Permit 2000 (MSGP-2000) for LANL. The permit requires the development and implementation of SWPP Plans and the monitoring of storm water discharges from permitted sites. In 2004, LANL maintained and implemented 15 SWPP plans for its industrial activities. LANL is currently conducting stream monitoring and storm water monitoring (1) at the confluence of the major canyons, (2) in certain segments of these canyons, and (3) at a number of site-specific facilities. In addition, LANL conducts voluntary monitoring in the major canyons that enter and leave LANL property. The flow-discharge information for the preceding period is reported in Shaull (2004) and in Discharge Monitoring Reports submitted to the EPA and to the NMED.

Compliance with the permit may be achieved primarily in two ways:

First, by identifying potential pollutants that may impact surface water quality and providing controls to limit the impact of those pollutants.

Second, by monitoring storm water runoff which encompasses (1) Laboratory surface waters that receive storm-water runoff should meet state surface-water-quality standards; (2) certain types of industrial sectors found at LANL that require "benchmark parameter monitoring" or "sector-specific monitoring" under the storm water permit; and (3) visually inspecting storm water runoff to assess odor, floating solids, foam, oil sheen, and other indicators of storm water pollution.

The current strategy for implementing the MSGP-2000 at LANL includes developing and implementing the following elements: (1) SWPP plans at 23 industrial activity locations; (2) a Storm-Water Monitoring Plan that provides detail on collecting storm water runoff at watershed-based and site-specific facility gauging stations; and (3) a best management practice installation, inspection, and maintenance program. See also Section C (Current Issues and Actions) regarding the Federal Facilities Compliance Agreement and Administration.

f. National Pollutant Discharge Elimination System Storm-Water Program Inspection. Neither the NMED nor the EPA conducted inspections at MSGP-regulated facilities during 2004.

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 the EPA (CWA, 40 CFR, Part 112) and the NMED Petroleum Storage Tank Bureau (PSTB) Regulations (20.5 NMAC). During 2004, 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.

On August 15, 2004, the EPA extended deadlines for new regulatory requirements under the federal Clean Water Act (40 CFR, Part 112). New regulations require the Laboratory to modify its SPCC Plans by February 17, 2006. The Laboratory must implement the modifications to the SPCC Plans before August 18, 2006. The primary modifications address AST storage capacity, inspection frequency, and integrity testing requirements. In 2004, the Laboratory developed or modified 14 SPCC Plans to comply with the new regulations. The Laboratory has completed all modifications to existing and new SPCC Plans and has begun to implement those modifications.

On August 15, 2003, the NMED-PSTB implemented new regulations that combined requirements for underground storage tanks and ASTs (20.5 NMAC). The new regulations require the development of Corrosion Prevention Plans and upgrades for AST systems before August 15, 2004. The Laboratory completed these requirements for AST systems before the compliance deadline. In July 2004, the Laboratory paid annual AST registration fees ($100 per AST) to NMED-PSTB.

During 2004, four AST systems were removed from the Laboratory's SPCC Plan list and/or NMED-PSTB registration list. ASTs that were removed are under temporary closure status with NMED-PSTB because they are no longer in service. The Laboratory is in the process of removing and decommissioning these ASTs. Additionally, five new AST systems were added to the Laboratory SPCC Plan list, and of those five, one was added to the NMED-PSTB registration list.

NMED-PSTB conducted AST inspections on April 15, 2004; May 20, 2004; and May 26, 2004, at various facilities at the Laboratory. The NMED cited no violations during these inspections.

On February 21, 2002, the Laboratory notified the EPA, the NMED, and the National Response Center of a discharge of approximately 48,000 gallons of diesel fuel into the environment from the TA-21-57 AST. 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.

On April 3, 2003, the Laboratory notified the 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 mitigation efforts.

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. The 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 2004, one Section 404/401 permit was issued to the Laboratory for the Hillside 137 Erosion Control Project in Los Alamos Canyon. Nationwide Permit No. 43 authorized work conducted by this storm water management and erosion control project. The Laboratory also conducted work under a 2003 Section 404/401 permit, Nationwide Permit No. 33, for the remediation of a drilling fluid release in Two Mile Canyon. In addition, LANL reviewed 582 excavation permits and 135 project profiles (through the

Permits and Requirements Identification System]) for potential impacts to floodplains or wetlands. One Floodplain/Wetland Assessment was prepared in support of NNSA/DOE for publication in the Federal Register.

No violations of the DOE Floodplains/Wetlands Environmental Review Requirements were recorded. The NMED and the Corps of Engineers did not inspect active sites permitted under the Section 404/401 regulations during 2004.

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, Bandelier National Monument, and from the water-supply wellheads to demonstrate compliance with SDWA maximum contaminant levels (MCLs). The 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. The EPA has authorized the NMED to administer and enforce federal drinking-water regulations and standards in New Mexico. In 2004, the Laboratory conducted additional, confirmation monitoring of the Los Alamos Water Supply System for Quality Assurance purposes. Chapter 5 presents these data.

In 2004, the county and the NMED conducted sampling for microbiological organisms, nitrate+nitrite (as N), radiochemical, total trihalomethanes, and total haloacetic acids in drinking water for SDWA compliance purposes. Results showed no exceedences of SDWA MCLs. More information on the quality of the drinking water from the Los Alamos Water Supply System is in Los Alamos County's annual Consumer Confidence Report, available online at: http://www.lac-nm.us/.

The NMED did not conduct an inspection of the drinking-water system in 2004.

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. Task III of Module VIII of the RCRA Hazardous Waste Facility Permit, the HSWA Module, requires the Laboratory to collect information about the environmental setting at the facility and to collect data on groundwater contamination.

During 2004, the Laboratory was in compliance with all applicable RCRA groundwater monitoring requirements. Groundwater-monitoring waiver applications for the Laboratory's regulated units were submitted to NMED with the Laboratory's Hazardous Waste Facility permit application in the 1980s and early 1990s. In May 1995, the NMED issued a letter to the Laboratory that indicated that there is insufficient information on the hydrogeologic setting upon which to base approval of the groundwater monitoring waiver demonstrations, and the waiver demonstrations were denied. By letter dated August 17, 1995, NMED required that a site-wide hydrogeologic characterization be completed that would satisfy both the RCRA operating permit and the HSWA module requirements (Section III. A. 1 of the HSWA portion of the RCRA permit requires that the hydrogeologic setting be characterized). Thus, groundwater monitoring requirements for RCRA-regulated units at Los Alamos National Laboratory are held in abeyance until the completion of the site-wide hydrogeologic characterization (NMED letter, August 17, 1995) described in the Hydrogeologic Workplan approved by NMED on May 22, 1998.

The Hydrogeologic Workplan (LANL 1998) was completed in 1997—describing a multiyear drilling and hydrogeologic analysis program to characterize the hydrogeologic setting of the Pajarito Plateau (Figure 2-3). The information from the program will be used to design an adequate monitoring system that could detect releases of groundwater contaminants from waste management operations. The goal of the project is to develop greater understanding of the geology, groundwater flow, and geochemistry beneath the 40-square-mile Laboratory area for monitoring system design and to assess any impacts that Laboratory activities may have had on groundwater quality. A report describing the findings and conclusions of the hydrogeologic characterization program is anticipated to be published in September 2005.

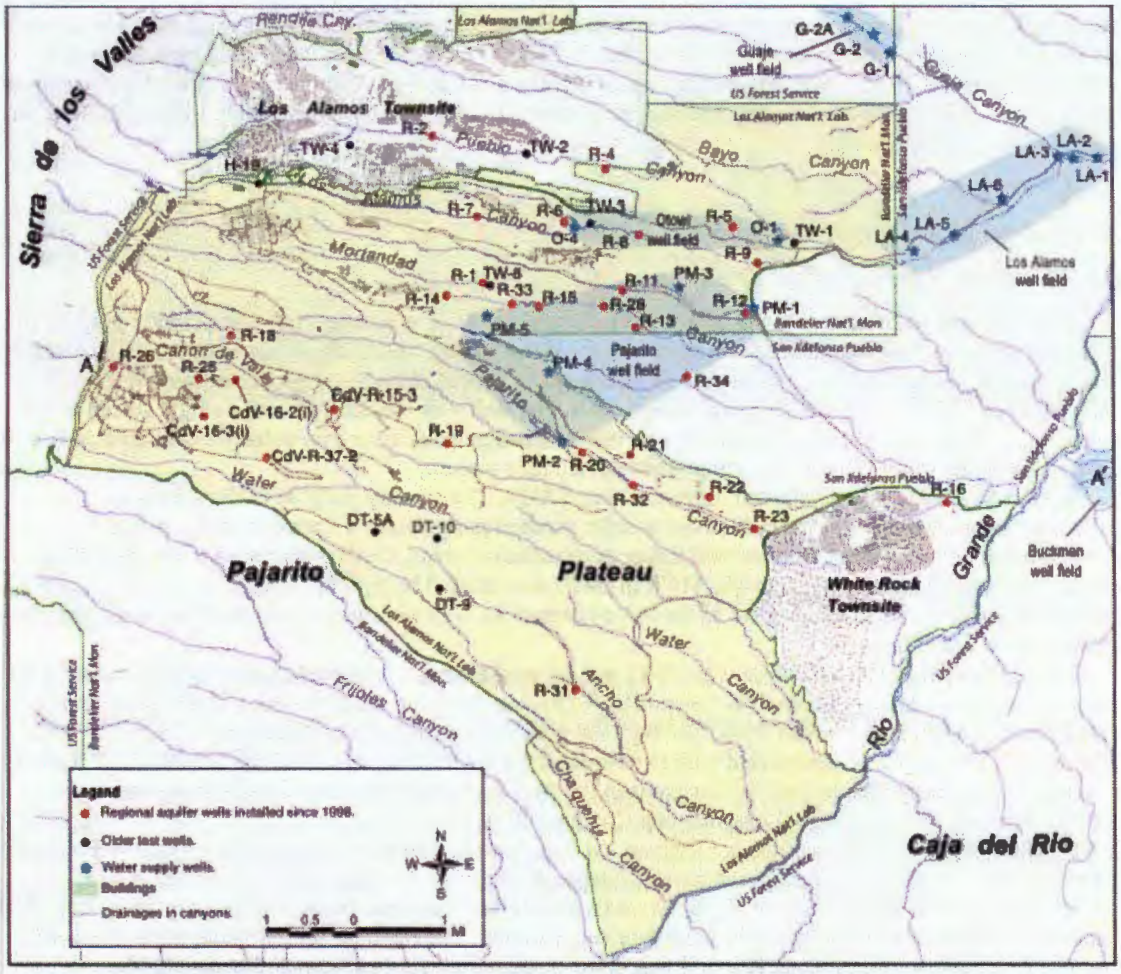

Figure 2-3. Map of hydrogeologic workplan regional aquifer characterization wells. Note that this map shows the LANL boundary from 2003, which is larger only in the northeast corner.

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 the 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 2004, the Laboratory had one approved groundwater discharge plan to meet NMWQCC regulations (Table 2-1) for the TA-46 SWWS Plant. On August 27, 2003, the Laboratory submitted a renewal application for the SWWS Plant groundwater discharge plan. Approval was pending by the NMED at the end of 2004. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the RLWTF at TA-50. As of December 31, 2004, NMED approval of the plan was still pending.

b. Compliance Activities. As part of the Hydrogeologic Characterization Program, and described in the Hydrogeologic Workplan, 29 hydrogeologic characterization wells have been installed in the regional aquifer and 6 characterization wells in intermediate saturated zones over the past six years, and each of the wells has been sampled. Data collected from these wells have provided new information on the regional aquifer and details of the hydrogeologic conditions. Five characterization wells were completed in 2004.

The characterization wells were drilled using air rotary in the vadose zone and rotary with water, foam 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 conducted in each well will enhance the understanding of the stratigraphy and rock characteristics. The five characterization wells completed in 2004 include the following:

R-6 and R-6i in DP Canyon,

R-18 in Pajarito Canyon, and

R-33 and R-34 in Mortandad Canyon

R-6 is located in DP Canyon, a tributary in the Los Alamos Canyon watershed. The primary purpose of the well is to serve as an upgradient sentinel well for water supply well Otowi-4. Drilling started in October 2004 and was completed at a total depth of 1,303 ft in November 2004. The regional aquifer water table is

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 the identification and protection of Traditional Cultural Properties, human remains, and sacred objects in compliance with the National Historic Preservation Act of 1966 (as amended) 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 development 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, TA-3 University House Traditional Cultural Properties, and Cerro Grande Rehabilitation project.

C. Current Issues and Actions

1. Federal Facilities Compliance Agreement and Administration

During 2004, the Laboratory entered into negotiations with the EPA and the NMED on the requirements of a Federal Facility Compliance Agreement. The intent of the agreement was to establish a compliance plan for the regulation of storm water discharges from SWMU and AOC point sources at the Laboratory until such time as those sources are regulated by an individual storm water permit issued by EPA pursuant to the NPDES program. The purpose of the compliance program is to provide a schedule to ensure compliance with the NPDES storm water permitting program. The scope of the agreement is limited to providing a compliance program for the regulation of storm water discharges from SWMUs and AOCs at the Laboratory in lieu of the Laboratory's Storm Water Multi-Sector General Permit.

In good faith, the Laboratory began implementing the intent of the Federal Facility Compliance Agreement in 2004 before the completion of negotiations. In 2004, the Laboratory completed the following tasks:

(1) Developed a draft Storm Water Monitoring Plan that describes how the telemetry based network of monitoring stations would be used to implement watershed scale monitoring at the Laboratory;

(2) Developed a draft Storm Water Pollution Prevention Plan for SWMU/AOCs that describes site-specific monitoring and erosion control program at SWMU/AOCs;

(3) Collected 146 storm water samples at (43) monitoring stations and 168 samples at (38) site-specific locations; and

(4) Submitted the first half of the Individual Permit Application for Storm Water Discharges From SWMUs/AOCs to the EPA. The complete permit application is scheduled for submittal in March 2005.

2. New Mexico Hazardous Waste Management Compliance Orders

the NMED. The original project allowed for the piecemeal removal of walls/floor/ceiling to remove rodent infestation. As the work proceeded, the scope of the job increased and exceeded the regulatory requirements for notification. This change in scope resulted in a failure to make a timely notification to the NMED in writing of the Laboratory's intention to abate asbestos as required by 40 CFR 61 Subpart M. The incident was self reported by project personnel, and LANL and KSL Services took the appropriate action.

D. References

ESP 2004: Environmental Surveillance Program, "Environmental surveillance at Los Alamos during 2002," Los Alamos National Laboratory report LA-14085-ENV (January 2004).

LANL 1995: Dual-Axis Radiographic Hydrodynamic Test Facility Mitigation Plan

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

LANL 2003: Water Quality & Hydrology Group, "Mortandad Canyon groundwater work plan," Los Alamos National Laboratory document LA-UR-03-6221 (August 2003)

Longmire and Counce 2005: P. Longmire and D. Counce, "Water chemistry results for wells R-1, R-2, R-4, R-11, R-26, and R-28," presentation at Groundwater Protection Program Quarterly Meeting, April 12, 2004, in Pojoaque, NM [Los Alamos National Laboratory document LA-UR-04-2387 (2005)].

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

Shaull 2004: D. A. Shaull, "Surface water data at Los Alamos National Laboratory: 2003 water year," Los Alamos National Laboratory report LA-14131-PR (March 2004).

2. Compliance Summary

3. Environmental Radiological Dose Assessment

3. Environmental 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 in Department of Energy (DOE) orders. 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 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 at one location. Animals range over a wider area, which usually dilutes their dose. Humans receive the lowest dose because they limit their time in areas with residual radioactivity, and they do not eat the vegetation or drink the water in these areas. Therefore, locations with no significant human dose may become significant from the perspective of potential biota dose.

B. Human Dose Assessment

1. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented here are calculated using standard methods. The "effective dose equivalent" referred to here as "dose," is calculated using radiation weighting factors and tissue weighting factors to adjust for the various types of radiation and the various tissues in the body. The final result, measured in mrem, is a measure of the overall risk to an individual, whether from external radiation or contact with radioactive material. For example, 1 mrem of 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 dose standard of the Environmental Protection Agency (EPA) of 10 mrem/year, which is codified in the Code of Federal Regulations (40 CFR 61, EPA 1986). These doses are in addition to exposures from natural background, consumer products, and medical sources. Doses from public water supplies are also limited according to the Clean Water Act, either by established maximum contaminant levels for some radionuclides or by dose (4 mrem/year for man-made radionuclides, beta/photon emitters) (EPA 2000). (See Appendix A.)

2. Public Dose Calculations

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

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

(1) the entire population within 80 km of the Laboratory;

(2) the maximally exposed individual (MEI) who is not on LANL/DOE property (referred to as the off-site MEI);

(3) the on-site MEI, defined as a member of the public who is on LANL/DOE property, such as Pajarito Road;

(4) residents in Los Alamos and White Rock.

b. General Considerations. We use the standard methods recommended by federal agencies to determine radiation doses (DOE 1988a, 1988b, 1991; EPA 1988, 1993, 1997; and NRC 1977). We begin with measurements and extend these with calculations using the standard methods that are used worldwide.

As we discuss in Section B.4, the dose rate from naturally occurring radioactivity is about 400 mrem/year. It is extremely difficult to measure doses from LANL that are less than 0.1% 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). Doses above natural background were observed near Technical Area (TA) -54 and TA-18.

To receive a measurable dose, a member of the public must be within a few hundred meters of the source, e.g., on Pajarito Road. At distances more than 1 km, the 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. In practice, this means the only significant doses from direct radiation are near TA-54 (Section B.3.b of this chapter) and near TA-18 (Section B.3.c).

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 the 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 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 source-term information with meteorological data to estimate where the released radioactive material went.

Some of the nuclide emissions from the Los Alamos Neutron Science Center (LANSCE) are not measured by AIRNET. These are measured at the stacks (Chapter 4, Section B), and the resulting doses are calculated by CAP88 (Chapter 3, Section B.3.b). Because the radioactive half-lives are short, these doses decrease steeply with distance; e.g., the annual dose is approximately 1.52 mrem at East Gate from LANSCE, 1 km to the north of LANSCE, and is 0.007 mrem at a location in Los Alamos 5 km to the west-northwest.

iii. Water (Ingestion Pathway). The majority of radionuclides detected in ground water samples collected from potential drinking water sources (e.g., Los Alamos County water supply wells, the regional aquifer, and springs) during 2004 resulted from the presence of natural radioactivity in ground water sources. These radionuclides include natural uranium and its decay products such as Ra-226. The only radionuclide detected in ground water samples that could possibly be attributed to Laboratory operations was tritium. The highest concentration of tritium (303 pCi/L) was measured in a sample from a regional aquifer test well which is not used for drinking water supply. This concentration is far below the federal community drinking water standard of 20,000 pCi/L and would thus result in a dose less than 0.1 mrem/year. Certain springs in White Rock Canyon that are supplied by the regional aquifer showed tritium concentrations approaching 10 pCi/L which is less than levels of tritium in rain water (about 30 pCi/L; Holloway 1993). The dose received from using these springs as the sole source of drinking water would be much less than 0.01 mrem per year.

In 2004, stream flow was intermittent and there were no realistic means for members of the public to regularly ingest surface waters containing radionuclides associated with Laboratory operations. Those surface waters that contained concentrations of radionuclides above applicable standards resulted from

storm runoff and contained levels of sediment that would make these waters unsuitable for drinking water purposes. These surface waters would have only been available anywhere from 1% to 11% of the time during calendar year 2004, were generally present only on Laboratory property, and would have required ingesting at least 70 liters of this turbid and sediment-ladened water to receive a dose greater than 0.1 mrem.

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 downwind of Area G. Some samples had radionuclide concentrations above the RSRLs (Regional Statistical Reference Levels), specifically U-234, U-235, and U-238 at the Tsankawi/PM-1 sample location and Pu-238 and Pu-239,240 at the Pueblo de San Ildefonso sample site. (RSRLs represent background 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.) However, the resulting dose from soil (from external gamma exposure, dust inhalation, and soil ingestion) at either sample location would be much less than 0.1 mrem/year. As the Sr-90 and Cs-137 soil concentrations at both sample locations are much less than the RSRLs for both radionuclides, it is reasonable to state that all or almost all are from global fallout and not from LANL. The tritium is mainly from three sources: cosmic rays, nuclear weapons testing, and LANL; however, the dose from tritium in soil is virtually nonexistent at both sample sites. Similarly, the transuranics may include a small contribution from LANL, but the dose is much less than 0.01 mrem/year. Finally, the isotopic mixture of uranium is consistent with natural uranium. In summary, we conclude that the LANL contribution to dose from soil is too small to measure and is much less than 0.1 mrem/year.

v. Food (Ingestion Pathway). We report measurements of the radioactive content of foods in Chapter 8. For the most part, the results are similar to those reported in previous years. Of those radionuclide concentrations that were detected in fruits, vegetables, and grains collected, almost all were below the RSRLs. With the exception described below, the concentrations are consistent with global fallout and the presence of naturally occurring uranium in soil or are insignificant when compared with counting uncertainties.

Of those radionuclide concentrations that were found to be above the RSRLs, three samples (two of purslane and one of wild spinach) collected from Pueblo de San Ildefonso lands in Mortandad Canyon were higher compared with historical levels. Refer to Supplemental Table S8-3 for specific radionuclide concentration values. Taking into account these radionuclide concentrations and other radionuclides measured in these samples and those radionuclides measured in a third sample of acorns that were below the RSRLs, the total dose received from consuming a pound each of purslane, spinach, and acorns would be much less than 0.1 mrem. Further study of wild foodstuffs in this particular area will be pursued as stated in Section A.6.b. of Chapter 8.

We conclude that the LANL contribution to the dose from consuming foodstuffs is too small to measure and much less than 0.1 mrem/year.

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 Laboratory Implementation Requirement LIR-402-700-01.2, "Occupational Radiation Protection Requirements, Chapter 14, Part 3. Releasing Items." In keeping with the principle of maintaining radiation dose levels to "As Low as Reasonably Achievable," it is a Laboratory goal to not knowingly release any items with residual radioactivity. According to the best of our knowledge, there is no 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 Laboratory operations during 2004 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 2004 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 0.90 person-rem, which compares with 0.88 person-rem reported for 2003. Tritium contributed about 45% of the dose, and short-lived air activation products such as C-11, N-13, and O-15 from LANSCE contributed about 53%.

No observable health effect is expected from these doses.

Population doses for the past 12 years have declined from a high of about 4 person-rem in 1994 to less than 1 person-rem in 2004 (Figure 3-1). LANSCE is the major contributor to the population 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.

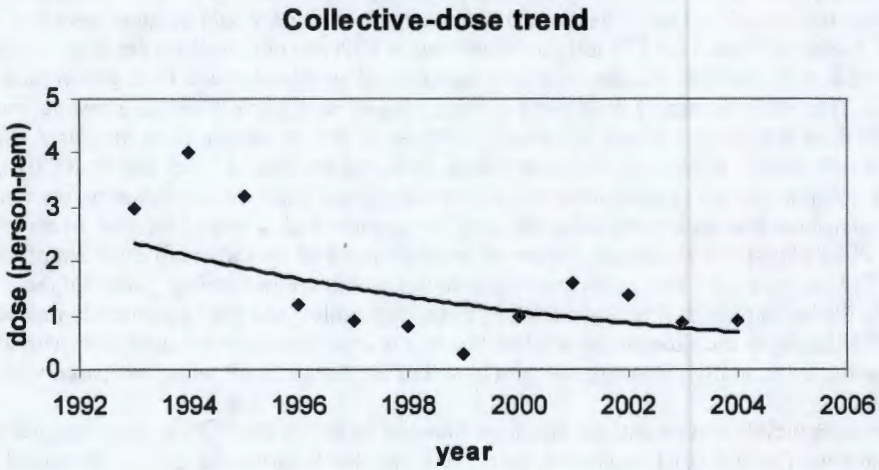

Figure 3-1. Trend of collective dose (person-rem) to the population within 80 km of LANL.

b. Off-Site Maximally Exposed Individual. The off-site MEI is a hypothetical member of the public who, while not on DOE/LANL property, received the greatest dose from LANL operations. During 2004, 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. During LANSCE operations, short-lived positron emitters, such as C-11, N-13, and O-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, an atmospheric dispersion and dose calculation computer code. The CAP88-modeled doses (Jacobson 2005) were approximately 1.52 mrem from LANSCE and 0.12 mrem from other LANL stacks and diffuse emissions sources. We added 0.04 mrem from the radionuclides measured at the AIRNET station, though this dose is primarily from tritium, most of which was in the CAP-88 modeled doses. Thus, the total dose at East Gate was approximately 1.68 mrem.

The second location 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 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 is 14/16 = 0.875 mrem. (A gamma photon dose is 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 calculated the dose from the LANL stacks: 0.040 mrem/16 = 0.003 mrem. We then added the maximum dose

measured by 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 that the MEI dose at this location was 0.89 mrem, which is less than the MEI dose at East Gate.

The off-site MEI dose, 1.68 mrem, is far below the currently applicable standards; based on previous studies, we conclude it causes no observable health effects.

The off-site MEI dose for the past 12 years has 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 300–500 mrem.

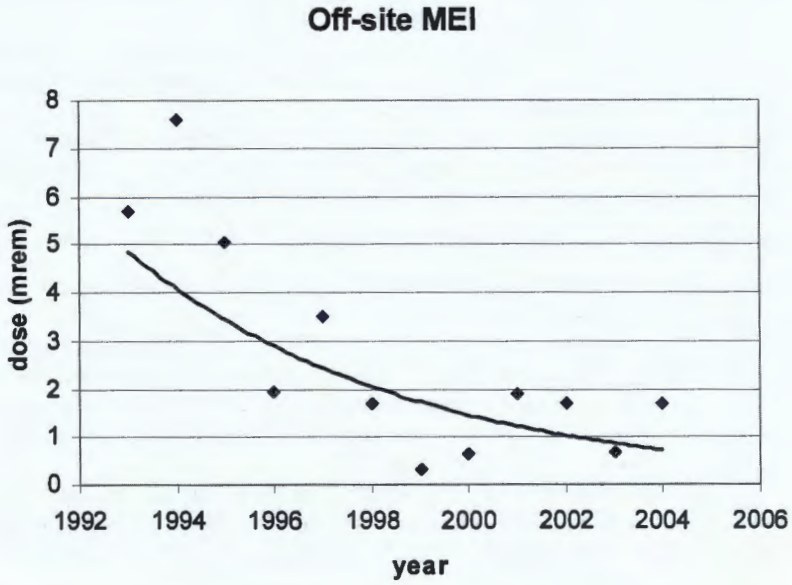

Figure 3-2. Trend of dose (mrem) to the maximally exposed individual off-site.

c. On-Site Maximally Exposed Individual. The on-site MEI is a member of the public on Pajarito Road who passes LANL TA-18.

Dosimeters that are sensitive to neutron and gamma photon radiation are located on Pajarito Road. We collected data continuously throughout 2004 (Chapter 4, Section C), and these data allow us to calculate doses that might have been received by members of the public. The measured neutron dose was 21 mrem (during 24 hours a day and 365 days a year). A 2-mrem neutron background value is subtracted from the measured value to provide the background-corrected neutron dose of 19 mrem. We then apply a gamma photon correction factor of 1.05 to provide a neutron plus gamma dose of 20 mrem. Following the guidance of the NCRP (NCRP 1976), we multiplied this total by1/16 to account for occupancy. This calculation indicates a dose of 1.25 mrem to a member of the public on Pajarito Road during 2004 derived from the dosimeter measurements.

In addition, we calculate a single event dose from operation of one of the critical assemblies within TA-18. This calculation indicates a neutron plus gamma dose of 1.75 mrem to a member of the public on Pajarito Road who would be present during the single event operation of the assembly.

We then select the higher of the two doses to represent the on-site MEI dose attributable to direct radiation, which would be 1.75 mrem. All other pathways at the Pajarito Road Location, including CAP88 calculations for the air pathway, add less than 0.1 mrem to the calculated direct radiation dose, taking intermittent occupancy into account. Because we assume that the member of the public is a resident of Los

Alamos, we also add the Los Alamos resident dose of 0.04 mrem (refer to section 3.d.i below) to the 1.75 mrem on-site MEI direct radiation dose, resulting in a total dose of 1.79 mrem. This dose is approximately 1.8% of the DOE public all-pathway dose limit of 100 mrem.

d. Doses in Los Alamos and White Rock. We used background-corrected AIRNET data (reported in Chapter 4, Section A) to calculate an annual dose at each of the AIRNET stations for the two collections of perimeter stations that represent the Los Alamos resident and the White Rock resident. The measured AIRNET concentrations were converted to doses using the factors in EPA 1986. To these doses, we added the dose contributions from LANSCE, calculated using CAP88 for these Los Alamos and White Rock perimeter AIRNET station locations. The summed AIRNET and CAP88 doses for the Los Alamos stations and the White Rock stations were then averaged to provide the representative Los Alamos resident and the White Rock resident air pathway doses.

i. Los Alamos. During 2004, the measurable contributions to the dose at an average Los Alamos residence were 0.02 mrem from tritium and 0.01 mrem from LANSCE. Other radionuclides each contribute less than 0.01 mrem, amounting to a total of 0.04 mrem.

ii. White Rock. During 2004, the measurable contributions to the dose at an average White Rock residence were 0.01 mrem from tritium and 0.01 mrem from LANSCE. Other radionuclides each contribute less than 0.01 mrem, amounting to a total of 0.03 mrem.

The contributions from direct radiation, food, water, and soil are discussed in Chapter 3, Section B.2; each was too small to measure. In summary, the total annual dose to an average resident from all pathways was less than 0.1 mrem. No observable health effect is expected from these doses.

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 radionuclides naturally in the environment. Doses from cosmic radiation range from 50 mrem/year at lower elevations near the Rio Grande to about 90 mrem/year in the mountains. 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 K-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 300–500 mrem. The estimated LANL-attributable 2004 dose to the MEI (on-site), 1.79 mrem, is less than 1% 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 are not expected to cause observable health effects.

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). Because the calculations apply to all types of biota and all types of ecosystems, the DOE methods are general in nature and allow specific parameters to be adjusted according to local conditions. The site-specific methods used at LANL are discussed in detail in the Biota Dose Assessment Quality Assurance

Project Plan, ENV-MAQ-BIOTA, 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, following the guidance of the DOE Standard (DOE 2002) and the ENV-ECR group (LANL 2004, LA-UR-04-8246), we calculate the dose to selected plants and animals. 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 as 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: 3 ha (30,000 m2) (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, it begins 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 BCGs are only the first step. 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.

We have applied the initial screening to every location affected by radionuclides from present or past LANL operations, including the Material Disposal Areas (MDAs). However, following the guidance of the DOE Standard (DOE 2002), we have not included external-radiation dose from experimental facilities such as the Dual Axis Radiographic HydroTest facility and LANSCE.

For the MDAs, the biota dose cannot easily be calculated from the soil concentrations for three reasons: the radioactive material is unevenly distributed, it is packaged, and it is buried. It is unevenly distributed because of the variety of items. It is packaged, usually in a form that is relatively inaccessible to biota, in order to protect the health of the workers transporting the waste to the burial site. And most of the waste is buried below the depths usually accessed by biota. In some cases, the pits or shafts are protected by a biological barrier such as concrete. Therefore, at some of the MDAs, the biota doses are essentially zero.

According to the best available data, 14 locations failed the initial screening. Therefore, as required by the DOE Standard, each of these locations was subjected to a site-specific assessment using RESRAD-BIOTA (http://web.ead.anl.gov/resrad/home2/biota.cfm).

The bioaccumulation factor for Cs-137 in terrestrial biota is between 0.01 and 0.1 (Bennett 1996; Fresquez 1997a and b, 1998, 2000a, b, and c; Hakonson 1973, 1975, and 1976; and White 1981). Thus, the Cs-137 dose is almost entirely external dose, which is calculated using the DOE external dose conversion factor.

For Sr-90, the bioaccumulation factor in terrestrial biota is between 0.1 and 1 (Fresquez 1997a, 1998, 2000a, b, and c). We assume it is equal to 1, which implies the internal and external doses are the same. Therefore, the Sr-90 dose is obtained from the dose conversion factor in the DOE Standard (DOE 2002, Module 3, Table 2.3 or Table 2.4) multiplied by the concentration in the soil or the concentration in the plant, whichever is greater.

2. Biota Dose Results

A site-specific assessment was performed on each of the locations that failed the initial screening. The assessments are described in detail in McNaughton 2005 and are summarized in each section below and in Table 3-1.

The background dose from naturally occurring radioactive material is 2 to 10 mrad/day and has not been included. Doses less than 0.5 mrad/day are listed as zero.

TA-5, Mortandad Canyon. Mortandad Canyon received radioactive liquid waste from several technical areas, beginning in the 1950s with waste from TA-35 and continuing today with waste from TA-50. Mortandad Canyon tributaries include Pratt Canyon and Effluent Canyon. Pratt Canyon is included in the TA-35 section of this report, and the aquatic environment of Effluent Canyon is in the TA-50 section.

Mortandad Canyon has been studied extensively (Hakonson 1973, 1975, and 1976; Miera 1977; White 1981; Nyhan 1978 and 1982; Bennett 1996; LANL 1997; and Reneau 2003). The part of Mortandad Canyon that fails the initial screening extends about 3 km from the TA-50 outfall to Mortandad Canyon Observation Well MCO-8.2 in TA-5. Near the TA-50 outfall (reach M2), the radionuclide concentrations are higher and the canyon is narrower. In the middle reaches (M3 and M4), the concentrations are lower and the canyon is wider. When the concentrations are averaged over the standard population area of 3 ha, the resulting population doses for M2, M3, and M4 are all similar and amount to less than 10 mrad/day for both plants and animals (Table 3-1).

The predominant radionuclide in Mortandad Canyon is Cs-137, which contributes about 5 mrad/day. Sr-90, tritium, and the transuranics each contribute about 1 mrad/day, and uranium contributes much less than 1 mrad/day.

In 2005, Mortandad Canyon biota will be studied further. Meanwhile, the biota dose in Mortandad Canyon is estimated to be below the DOE limits for plant and animal populations (Table 3-1).

TA-10, Bayo Canyon. Bayo Canyon was the site of TA-10, which was contaminated during the radioactive lanthanum project during the 1940s and 1950s. TA-10 was decommissioned in 1963, and the land was transferred to Los Alamos County in 1967.

From the perspective of biota dose, the only significant contamination is in an area of about 0.1 ha that is part of solid waste management unit (SWMU) 10-002(a)-99. In this location, residual Sr-90 is being brought to the surface through plant roots (Fresquez 1995; LANL 1997). Averaged over 3 ha, the biota concentrations are less than 10 pCi/g, and population doses to animals and plants are essentially zero (Table 3-1).

TA-15, EF Site. U-238 is widespread at LANL; it is present at most firing sites and buried in most disposal pits. The aerial surveys (EGG 1989; DOE 1998) demonstrate that the firing site with the highest concentration is EF Site (SWMU 15-004(f)-99). It contains about half the U-238 dispersed in explosive tests at LANL (Becker 1992; LANL 1998). Therefore, EF Site represents the worst case for U-238.

The U-238 concentration at the firing point is 1,000 to 2,000 pCi/g and decreases to about 200 pCi/g at 50 m from the firing point (Hanson 1976, 1977, and 1978; White 1979 and 1980). The average concentration over 3 ha is 300 pCi/g, which results in a population dose of about 20 mrad/day to both plants and animals. Thus, the biota dose from uranium at EF Site is 20% of the limit for animals and 2% of the limit for plants (Table 3-1). Because EF Site is the worst case, this assessment indicates the biota doses do not exceed the DOE limits at other LANL locations with uranium.

TA-21, Material Disposal Area, MDA A. MDA A was established in 1945 to collect plutonium that could not be recovered with the technology of the time. The plutonium is in sealed steel tanks that are isolated from biota, so the biota dose from the tanks is zero. The surrounding soil contains about 30 pCi/g of transuranics (Rogers 1977; LANL 1991), which causes a population dose of about 1 mrad/day to plants and less to animals. Therefore, we conclude the doses to plants and animals at MDA A are less than 1% of the DOE limits (Table 3-1).

TA-21, Material Disposal Area, MDA B. MDA B, established in 1944, is a 2.4-ha area south of and parallel to DP Road. The contents are not well known (Rogers 1977; LANL 1991), but based on existing measurements in biota (Wenzel 1987), we estimate the population doses are about 50 mrad/day to plants and 20 mrad/day to animals, mostly from transuranics brought to the surface by deep-rooted plants.

TA-21, Material Disposal Area, MDA T. MDA T was established in 1945 to receive liquid effluent from the liquid-waste-treatment facilities located in buildings TA-21-35 and TA-21-257. The earliest disposal method used absorption beds, 1.2 m deep, that are now covered with 1.8 m of crushed tuff. Later,

the effluent was disposed of in shafts covered with 0.6 m of concrete and 1.2 m of tuff (Rogers 1977; Nyhan 1984 and 1985; LANL 1991). Thus, the radioactive material is partly but not completely isolated from biota.

Based on biota measurements (LANL 1991), we estimate the population dose is about 10 mrad/day to both plants and animals, mostly from Am-241, with small contributions from Pu-239, Cs-137, and Sr-90.

TA-21, DP Canyon. DP Canyon, north of TA-21, is a tributary of Los Alamos Canyon. It was contaminated more than 20 years ago, primarily by the outfall from TA-21-257 at SWMU 21-011(k) (Hakonson 1973; Miera 1977 and 1978; Rogers 1977; LANL 1991, 1995, and 2003). Since that time, the location was remediated in 1996 and again in 2003 (LANL 2003). The data demonstrate that the population dose to both plants and animals is about 2 mrad/day, mostly from Cs-137. These amounts are 2% or less of the DOE limits.

TA-35, Material Disposal Area, MDA W. MDA W is the burial site of two stainless-steel tubes from the LAMPRE-1 reactor (LANL 1990). The steel tubes are encased in a vault of 0.2-m-thick concrete. The area will be investigated in 2005 to ensure that the vault is secure. Meanwhile, pending these results, we conclude the radioactive material is isolated from biota, and therefore the biota dose is zero.

TA-35, Pratt Canyon. Pratt Canyon was contaminated between 1951 and 1963, primarily with 0.2 Ci of Sr-90 from a liquid-waste treatment facility east of building TA-21-2 (LANL 1992 and 1997a; Jarmer 1997). A douglas fir and a clump of gambel oaks contain about 3,000 pCi/g of Sr-90, which causes about 350 mrad/day to these trees. The area of contamination is small, however. Averaging over 3 ha, the population dose is about 1 mrad/day to both animals and plants (Table 3-1).

TA-49, Material Disposal Area, MDA AB. MDA AB was used for a series of underground weapon safety tests in 1962. Almost all the radioactive material is 30 m below the surface and is not accessible to biota (LANL 1990). At the surface, there is some Pu-239 with concentrations up to 5 pCi/g, which is the result of human actions such as drilling (Purtymun 1987; Hansen 1980; Soholt 1990). The resulting individual doses are less than 1 mrad/day, and the population doses are essentially zero.

TA-50, Aquatic Environment and Effluent Canyon. The Radioactive Liquid Waste Treatment Facility at TA-50 discharges treated liquid waste through a permitted outfall into Effluent Canyon, north of building TA-50-1. Table 6-2 in Chapter 6 lists the concentrations of radionuclides in the water.

The stream is less than a meter wide and flows for about 1–2 km before the streambed dries up. Animals such as deer and elk drink the water and insect larvae live in the water, but terrestrial animals do not obtain a significant fraction of their diet from aquatic animals in the stream.

At LANL, the bioaccumulation factor for Cs-137 in soil is between 0.01 and 0.1 (Hakonson 1973; Fresquez 1997a and b, 1998, 2000a, b, and c), but it has not been measured in water. For this preliminary site-specific assessment, we used the Cs-137 bioaccumulation factor of 100, which is the value for daphnia, a surrogate for aquatic animals on-site (Baker 1992). Using this value, the dose is 5 mrad/day to terrestrial animals and 85 mrad/day to aquatic animals. These values are less than 10% of the DOE limit.

TA-50, Terrestrial Environment and MDA C. The contamination at the head of Ten-Site Canyon resulted from a 1974 radioactive-liquid-waste spill that spread a few hundred meters east of TA-50-1 (Emility 1996). The environmental restoration database shows one soil sample with a decay-corrected Sr-90 concentration of 45 pCi/g. The maximum dose at this location to an individual plant is 1 mrad/day, and the maximum to an individual animal is less than 1 mrad/day.

The TA-50 population area includes MDA C, which is a 5-ha area containing disposal pits and shafts dating from 1948 (Rogers 1977). Gross-alpha data (Neptune 2003) indicate that two pine trees penetrated radioactive material, but the specific radionuclide was not identified, and the trees have been removed. Assuming the radionuclide was Pu-239, the population dose was about 40 mrad/day to the trees and 10 mrad/day to animals (Table 3-1). These doses are less than 10% of the DOE limits.

TA-54, Material Disposal Area, MDA G. MDA G is the largest material disposal area at LANL and the only one still in use for radioactive material. Most of the radioactive material is stored in sealed drums that exclude contact with plants or animals.

The underground radioactive material available to biota can be deduced from the biota measurements (Gonzales 2000; Bennett 2002; Nyhan 2002 and 2004; Soholt 2003; Budd 2004; and Fresquez 2003, 2004a, 2004b, 2005). For example, Gonzales and Budd (Gonzales 2000 and Budd 2004) measured a tritium concentration of 522,000 pCi/mL in plants above the tritium shafts near the south fence of MDA G. This measurement implies a similar concentration of tritium underground. Also, Fresquez (LA-14181-PR,

2004b) measured 83,000 pCi/mL in trees adjacent to the shafts. Averaging over 3 ha, we estimate the population dose from tritium is 3 mrad/day to plants and 1 mrad/day to animals.

In another location, Fresquez (LA-14193-MS, 2005) measured 15 pCi/g of Pu-239 and 5 pCi/g of Pu-238 in and on a single sample of mice. Using the worst-case assumption that all of this was in the carcass rather than on the pelt, this result indicates an individual dose of 86 mrad/day. The population dose based on the average concentrations in mice is 4 mrad/day. These population doses are about 1% of the DOE limits.

TA-54, Material Disposal Area, MDA H. MDA H is a 0.1-ha inactive area with 9 shafts, 18 m deep, capped with 1 m of tuff plus 1 m of concrete (LANL 1990; LANL 1998). Thus, the radioactive material in the shafts is partially isolated from biota. In 1969, moisture samples from a depth of 12 m were reported to be 2 million pCi/mL of tritium (LANL 1998). After correcting for decay, this concentration is approximately equal to the BCG. However, biota do not penetrate to a depth of 12 m. At the surface, the only radioactivity above background is tritium at a concentration of 2,500 pCi/g, which results in a dose of 1 mrad/day to the maximally exposed plant and animal. Averaging over 3 ha, the population dose is 1/30 mrad/day, which is essentially zero.

Table 3-1. Biota population dose (mrad/day) and predominant radionuclide at LANL locations that fail the initial screening.

Location	Biota Population Dose (mrad/day) Terrestrial Plant	Aquatic Animal	Terrestrial Animal	Predominant Radionuclide
DOE limit	**1,000**	**1,000**	**100**	
TA-5, Mortandad Canyon	9		7	Cs-137
TA-10, Bayo Canyon	0		0	Sr-90
TA-15, EF Site	20		20	U-238
TA-21, MDA A	1		1	Pu-239
TA-21, MDA B	50		20	Pu-239
TA-21, MDA T	13		8	Am-241
TA-21, DP Canyon	2		2	Cs-137
TA-35, MDA W	0		0	Pu-239
TA-35, Pratt Canyon	1		1	Sr-90
TA-49, MDA AB	0		0	Pu-239
TA-50, Effluent Canyon		85	5	Pu-239
TA-50, MDA C	40		10	Gross alpha
TA-54, MDA G	3		1	H-3
TA-54, MDA H	0		0	H-3

3. Biota Dose Summary

Fourteen locations at LANL have maximum radionuclide concentrations above the DOE default BCGs and so trigger a site-specific assessment. Table 3-1 summarizes the results of preliminary site-specific assessments.

The MDAs are a particular concern because deep-rooted plants can penetrate pockets of contamination and transport it to the surface, as noted by Foxx and Tierney (Foxx 1984a and b; Tierney 1987). MDAs A, B, C, T, and G all show signs that plants have penetrated the radioactive material. At these locations, the doses from Am-241, Pu-239, and U-238 are probably high by a factor of 2–4, because we have used an alpha radiation-weighting factor of 20, which is appropriate for humans, whereas for biota the best estimate "appears to lie in the range of about 5–10" (DOE 2002, page M2-77).

In summary, although the present data are incomplete, the preliminary assessments indicate that the biota doses for plants and animals at LANL are below the DOE limits.

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3. Environmental Radiological Dose Assessment

4. Air Surveillance

4. Air Surveillance

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A. Ambient Air Sampling *(Andrew Green and Craig Eberhart)*

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 come 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 (for example, 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 (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: during 2000, the Cerro Grande fire dramatically increased short-term ambient concentrations of particulate matter (ESP 2001).

In the Environmental Stewardship Division, Meteorology and Air Quality Group (ENV-MAQ) personnel compare 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. The group usually compares 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.

2. Air-Monitoring Network

During 2004, LANL operated 46 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 follows: regional, pueblo, perimeter, waste site [Technical Area (TA) -54], or other on-site locations.

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

	Units	EPA Concentration Limit[b]	Annual Averages[c] 2000	2001	2002	2003	2004
Alpha	fCi/m^3	NA[d]	1.0	0.8	0.8	0.8	1.1
Beta	fCi/m^3	NA	13.0	13.9	13.3	13.7	18.3
Tritium[e]	pCi/m^3	1500	0.8	0.0	–0.1	–0.1	0.1
Pu-238	aCi/m^3	2100	0.0	0.0	0.0	–0.1	1.2
Pu-239	aCi/m^3	2000	0.0	0.1	0.3	–0.1	–0.1
Am-241	aCi/m^3	1900	0.4	–0.2	0.3	–0.7	–0.4
U-234	aCi/m^3	7700	17.1	17.9	21.7	20.9	14.9
U-235	aCi/m^3	7100	0.9	1.3	2.4	1.8	0.9
U-238	aCi/m^3	8300	15.9	17.7	21.8	20.1	14.1

[a] Data from LANL-operated regional air-sampling stations during the last 5 years. (Locations can vary by year.)
[b] Each EPA concentration limit is from 10 CFR 40 Part 61, Appendix E and corresponds to 10 mrem.
[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.

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 2 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. This silica gel is dried in a drying oven to remove most residual water before being used 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 then analyzed for the presence of tritium. The AIRNET quality assurance project plan (MAQ-AIRNET) 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, MAQ personnel recorded on a palm-held microcomputer the sampling data, 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.

c. Analytical Chemistry. A commercial laboratory analyzed each particulate-matter filter for gross alpha and gross beta activities. These filters were also grouped across sites, designated as "clumps," and analyzed for gamma-emitting radionuclides. For 2004, clumps usually ranged from six to nine filters. To prepare a quarterly composite for isotopic analyses for each AIRNET station, half-filters from the six or seven sampling periods at each site are 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. Every two weeks, 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 meet the requirements of Code of Federal Regulations 40 (CFR) 61, Appendix B. The AIRNET quality assurance project plan provides a summary of the target minimum detectable activity for the biweekly and quarterly samples.

d. Laboratory Quality Control Samples. For 2004, the MAQ Group and the contractor 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 chemistry laboratories. The chemistry met the quality assurance requirements for the AIRNET program.

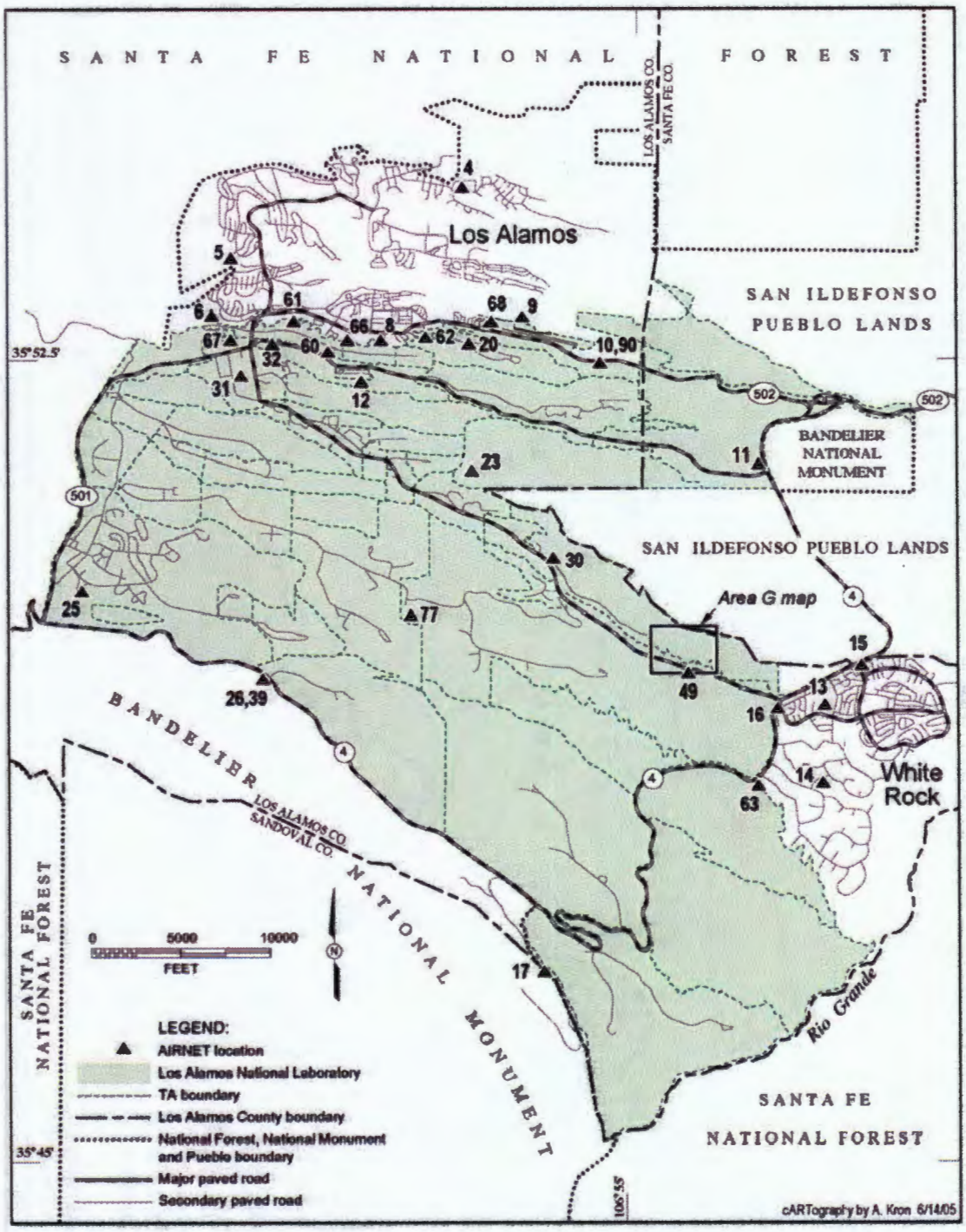

Figure 4-1. Off-site perimeter and on-site LANL AIRNET locations.

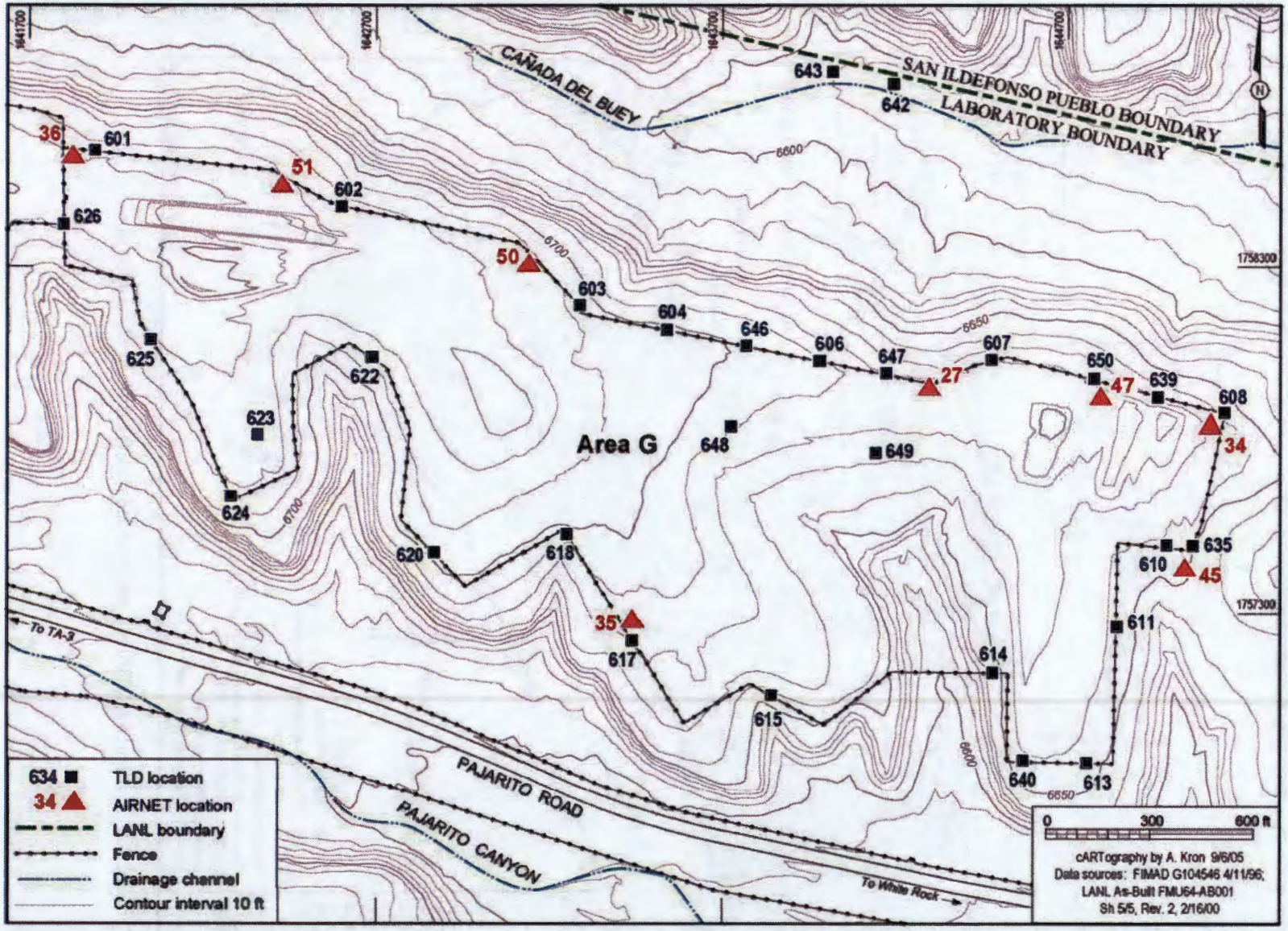

Figure 4-2. AIRNET and thermoluminescent dosimeter locations at TA-54, Area G.

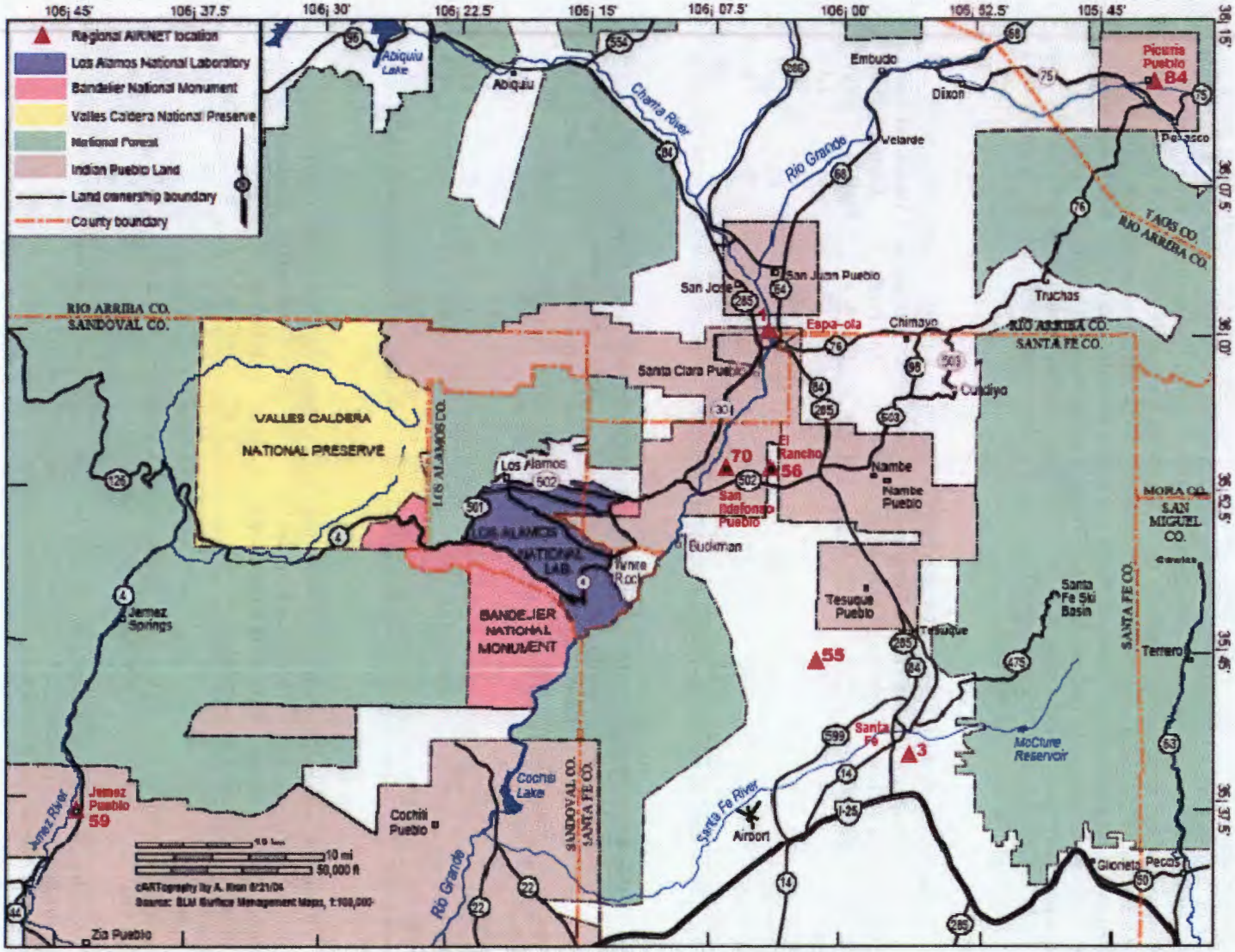

Figure 4-3. Regional and pueblo AIRNET locations.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations. Tables 4-2 through 4-12 summarize the 2004 ambient air concentrations calculated from the field and analytical data. In the Data Supplement, Tables S4-1 though 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 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 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (fCi/m^3)	95% Confidence Interval[a] (fCi/m^3)	Maximum Annual Concentration Station	(fCi/m^3)
Regional	103	103	103	1.10	± 0.08	01	1.19
Pueblo	77	77	77	1.12	± 0.10	70	1.13
Perimeter	622	620	619	0.97	± 0.03	62	1.12
Waste Site	207	206	206	0.94	± 0.04	50	1.01
On-Site	188	176	176	0.94	± 0.04	53	1.06

[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 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (fCi/m^3)	95% Confidence Interval[a] (fCi/m^3)	Maximum Annual Concentration Station	(fCi/m^3)
Regional	103	103	103	18.3	± 0.9	01	19.3
Pueblo	77	77	77	17.5	± 1.0	70	19.1
Perimeter	622	619	619	16.4	± 0.3	62	18.1
Waste Site	207	206	206	16.4	± 0.5	35	16.9
On-Site	188	176	176	16.6	± 0.5	53	17.6

[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 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (pCi/m^3)	95% Confidence Interval[a] (pCi/m^3)	Maximum Annual Concentration Station	(pCi/m^3)
Regional[b]	104	7	1	0.10	± 0.17	55	0.28
Pueblo[b]	76	6	0	0.03	± 0.19	70	0.24
Perimeter[b]	619	306	191	2.09	± 0.22	09	6.47
Waste Site[c]	207	199	183	105	± 59	35	792
On-Site[c]	188	112	86	3.92	± 0.77	25	13.35

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 1,500 pCi/m3.
[c] DOE DAC Guide for workplace exposure is 20,000,000 pCi/m3.

Table 4-5. Airborne Pu-238 Concentrations for 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (aCi/m³)	95% Confidence Interval[a] (aCi/m³)	Maximum Annual Concentration Station	(aCi/m³)
Regional	15	0	0	0.09	± 0.28	01	0.43
Pueblo	12	0	0	0.14	± 0.32	84	0.33
Perimeter	88	0	0	–0.12	± 0.15	39	0.36
Waste Site	32	1	0	0.20	± 0.30	36	0.70
On-Site	17	0	0	0.20	± 0.34	53	1.29

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 2,100 aCi/m3.
[c] DOE DAC Guide for workplace exposure is 3,000,000 aCi/m3.

Table 4-6. Airborne Pu-239, 240 Concentrations for 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (aCi/m³)	95% Confidence Interval[a] (aCi/m³)	Maximum Annual Concentration Station	(aCi/m³)
Regional	15	0	0	–0.07	± 0.42	03	0.23
Pueblo	12	1	0	0.47	± 0.53	84	0.73
Perimeter	88	7	3	0.91	± 1.15	66	19.37
Waste Site	32	6	3	1.09	± 0.81	45	3.62
On-Site	17	1	0	–0.02	± 0.39	53	0.97

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 2,000 aCi/m3.
[c] DOE DAC Guide for workplace exposure is 2,000,000 aCi/m3.

Table 4-7. Airborne Am-241 Concentrations for 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (aCi/m³)	95% Confidence Interval[a] (aCi/m³)	Maximum Annual Concentration Station	(aCi/m³)
Regional	15	1	0	-0.47	± 0.46	03	-0.24
Pueblo	12	0	0	-0.54	± 0.48	70	-0.28
Perimeter	88	5	0	-0.18	± 0.15	68	0.59
Waste Site	32	7	1	0.33	± 0.41	27	1.77
On-Site	17	3	0	-0.17	± 0.50	53	1.13

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 1,900 aCi/m3.
[c] DOE DAC Guide for workplace exposure is 2,000,000 aCi/m3.

Table 4-8. Airborne U-234 Concentrations for 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (aCi/m³)	95% Confidence Interval[a] (aCi/m³)	Maximum Annual Concentration Station	(aCi/m³)
Regional	15	15	14	17.4	± 4.7	03	24.3
Pueblo	12	12	12	16.4	± 6.3	59	23.8
Perimeter	88	86	74	8.0	± 1.6	32	32.0
Waste Site	32	31	28	11.4	± 4.6	50	30.5
On-Site	17	17	15	6.2	± 1.7	53	10.2

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 7,700 aCi/m3.
[c] DOE DAC Guide for workplace exposure is 20,000,000 aCi/m3.

Table 4-9. Airborne U-235 Concentrations for 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (aCi/m³)	95% Confidence Interval[a] (aCi/m³)	Maximum Annual Concentration Station	(aCi/m³)
Regional	15	5	0	1.17	± 0.64	03	1.93
Pueblo	12	3	0	1.12	± 0.73	59	1.49
Perimeter	88	12	1	0.67	± 0.24	67	2.78
Waste Site	32	5	0	0.91	± 0.33	45	1.52
On-Site	17	5	0	0.58	± 0.58	77	1.07

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 7,100 aCi/m3.
[c] DOE DAC Guide for workplace exposure is 20,000,000 aCi/m3.

Table 4-10. Airborne U-238 Concentrations for 2004 — Group Summaries

Station Grouping	Number of Biweekly Samples	Number of Samples Exceeding Uncertainty >2s	>3s	Mean (aCi/m³)	95% Confidence Interval[a] (aCi/m³)	Maximum Annual Concentration Station	(aCi/m³)
Regional	15	15	14	17.0	± 5.2	03	23.8
Pueblo	12	12	12	16.4	± 6.8	59	25.0
Perimeter	88	82	74	8.6	± 1.7	32	33.3
Waste Site	32	30	29	12.0	± 4.5	50	28.8
On-Site	17	17	15	8.3	± 3.3	77	16.1

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b] EPA 40 CFR Part 61, Appendix E, Table 2. Concentration Limit is 8,300 aCi/m3.
[c] DOE DAC Guide for workplace exposure is 20,000,000 aCi/m3.

Table 4-11. Airborne Gamma-Emitting Radionuclides Potentially Released by Laboratory Operations

Nuclide	Number of Biweekly Samples	Number of Samples > MDA[a]	Mean Concentration (fCi/m³)	Measured MDA as % of Required MDA[b]
As-73	182	0	1.11	0.20
As-74	182	0	–0.02	0
Cd-109	182	0	0.10	0.35
Co-57	182	0	0.002	0.00
Co-60	182	0	–0.02	0
Cs-134	182	0	–0.03	0
Cs-137	182	0	–0.02	0
Mn-54	182	0	–0.01	0
Na-22	182	0	0.002	0.15
Rb-83	182	0	–0.01	0
Rb-86	182	0	0.05	0.16
Ru-103	182	0	–0.006	0
Se-75	182	0	0.001	0.01
Zn-65	182	0	–0.04	0

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

Table 4-12. Airborne Concentrations of Gamma-Emitting Radionuclides that Naturally Occur in Measurable Quantities.

Nuclide	Number of Biweekly Samples	Number of Samples > MDA[a]	Mean[b] Concentration (fCi/m^3)
Be-7	182	182	88
Pb-210	182	1	26

[a] Minimum detectable amount.
[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% 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% confidence intervals are overestimated for the average concentrations and probably represent confidence intervals that approach 100%. 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. [Where s represents standard deviation, or sigma]. 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% of the time at 2s, but less than 0.3% of the time at 3s.

b. Gross Alpha and Gross Beta Radioactivity. We use gross alpha and gross beta analyses primarily (1) to evaluate general radiological air quality, (2) to identify potential trends, and (3) to 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 2 femtocuries (fCi)/m^3. The primary alpha activity is caused by polonium-210 (a decay product of radon) and other naturally occurring radionuclides (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 is the primary cause of this activity.

In 2004, we collected and analyzed close to 1200 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 seemingly lower concentrations: the use of actual sampled air volumes instead of standard temperature and pressure volumes and 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. Variability among sites within AIRNET is usually much less than variability over time. A good example of seasonal variation is the observation in winter during atmospheric inversions of higher levels of radon, and therefore higher gross alpha and beta count rates, at lower elevations around LANL. The radon is trapped below the inversion layer.

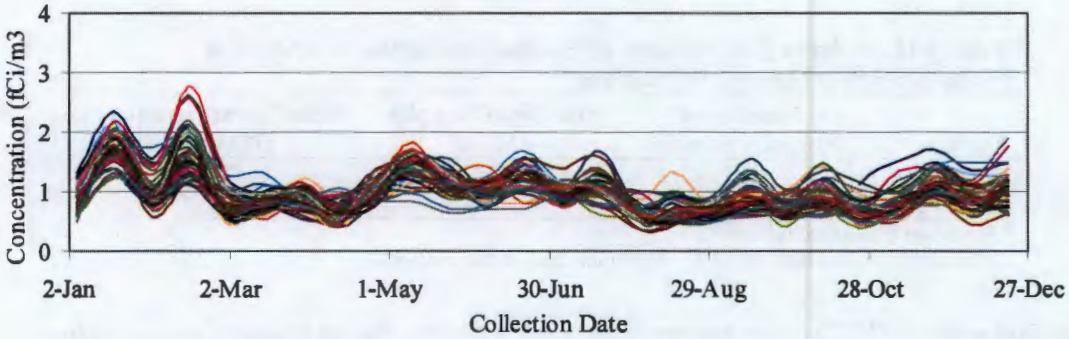

Figure 4-4. Gross alpha measurements (fCi/m^3) by sampling site.

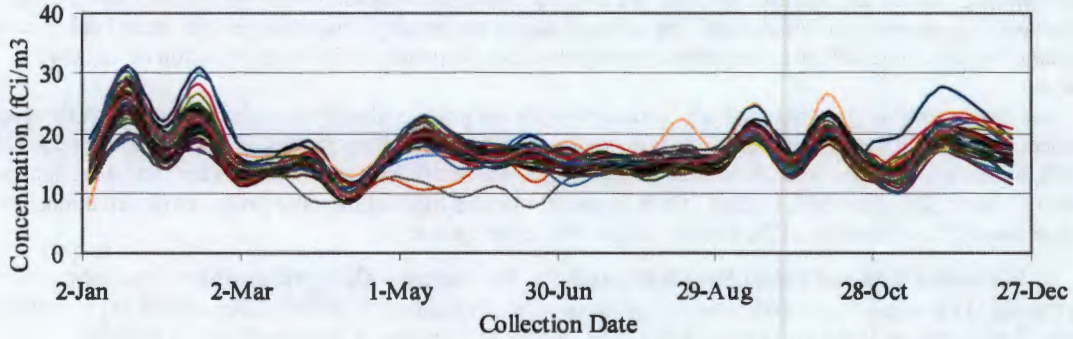

Figure 4-5. Gross beta measurements (fCi/m^3) by sampling site.

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 2004 at the regional and pueblo stations were not significantly different from 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 TA-54, Area G. These data indicate that LANL does produce 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 a strong coherence between measured stack emissions at TA-21 and off-site AIRNET measurements nearby in east Los Alamos and generally downwind of the TA-21 stacks. This coherence gives us confidence that AIRNET tritium measurements do reflect tritium releases from LANL.

The highest off-site annual tritium concentration in 2004, 6.5 picocuries (pCi)/m^3, was at the Los Alamos Airport, which is close to TA-21. This concentration is equivalent to about 0.5 % of the EPA public dose limit. Emissions from TA-21 averaged 2 Ci per day in 2004 and seldom caused concentrations to exceed investigation levels as described in section A.5 of this chapter [Investigation levels are set at values of 5 year averages plus 3s.]. We measured elevated concentrations at a number of on-site stations, with the highest annual concentration at TA-54, Area G. This annual mean concentration, 800 pCi/m^3, is only about 0.004% of the DOE DAC for worker exposure and is measured at a location near shafts containing tritium-contaminated waste.

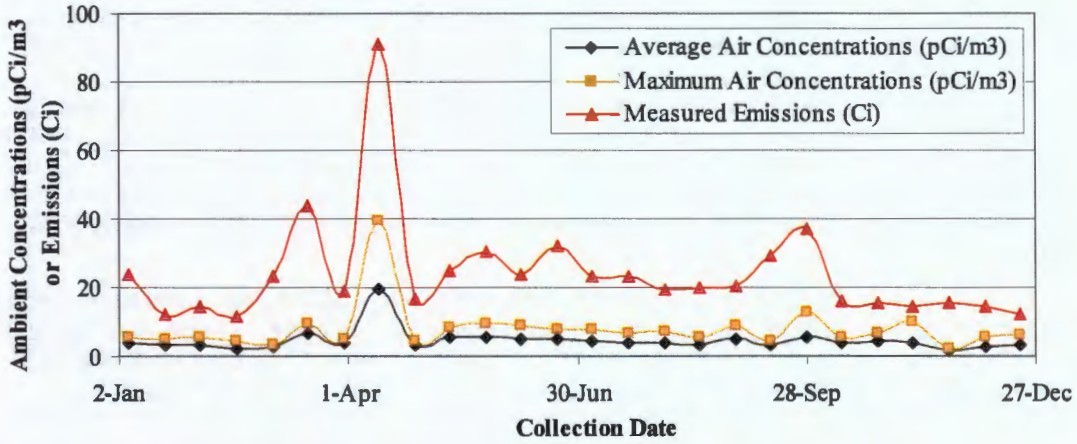

Figure 4-6. Tritium oxide stack emissions at TA-21 and ambient concentrations in east Los Alamos.

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 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 2004. No concentrations of plutonium-238 more than 3s from zero were measured at any station in any quarter. The highest quarterly concentration was on-site and had a value of 2.4 aCi/m^3, which corresponds to much less than 1% of the DOE DAC for worker exposure.

No detectable concentrations of plutonium-239,240 greater than 3s were found at any of the regional or pueblo samplers (Table 4-6). Three perimeter quarterly concentrations were above their 3s uncertainties; all of them were collected at site 66 (Los Alamos Inn-South). The annual mean concentration at this location was 20 aCi/m3, or about 1% 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 Inn. Three on-site quarterly concentrations were above their 3s uncertainties; all of them at Area G and substantially below 1% 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, pueblo, or perimeter sampling stations (Table 4-7).

One on-site quarterly sample with a concentration of americium-241 greater than 3s was measured at Area G. This on-site concentration was significantly less than 1% of the DOE DAC for worker exposure.

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). Because known LANL emissions are not of natural uranium but of enriched (EU—has excess uranium-234 and -235) or depleted (DU—has excess uranium-238) uranium, comparisons of isotopic concentrations are used to estimate LANL contributions. Using excess uranium-234 to detect the presence of EU may not seem suitable because the enrichment process is usually designed to increase uranium-235 concentrations. However, the enrichment process normally increases uranium-234 at a faster rate than uranium-235.

All annual mean concentrations of the three uranium isotopes were well below 1% of the applicable EPA and DOE guidelines (Tables 4-8 through 4-10). The maximum 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-234 and uranium-238 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 2004, two samples at the same on-site location had DU, as shown in Figure 4-7. This restricted access location is known to have such surface contamination. This is the smallest number of DU detections in a year since 1995. These excess uranium-283 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 no EU during 2004.

g. Gamma Spectroscopy Measurements. In 2004, MAQ personnel conducted 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." Our practice is to investigate the measurement of any analyte (listed in Table 4.11) above its minimum detectable amount. We do 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 is highly unlikely unless an actual release occurs. Beryllium-7 was routinely detected, and lead-210 was measured on one occasion in 2004.

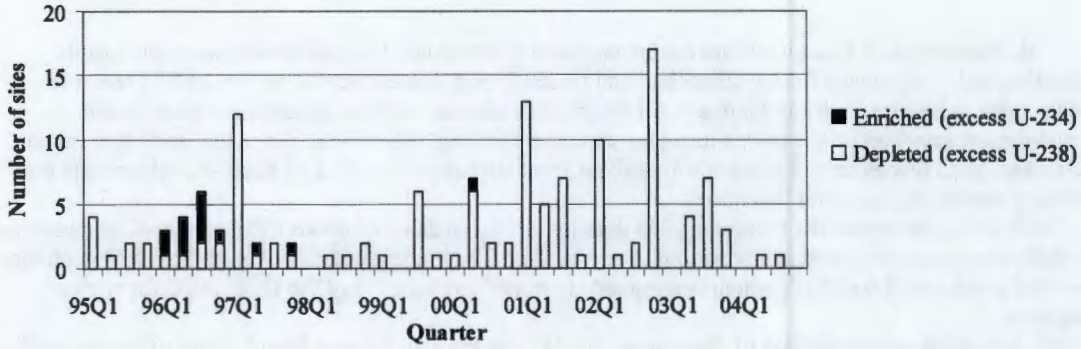

Figure 4-7. AIRNET sites with excess isotopic uranium.

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 year rolling average plus 3s. "Alert" levels are based on dose and require a more thorough, immediate follow-up.

In 2004, a few air sampling values exceeded action levels. When a measured air concentration exceeds an action level, the MAQ 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.

Some investigations were related to slightly elevated tritium concentrations being measured near TA-21, which is known to release both HTO and HT from decommissioning and decontamination activities. Some investigations were of elevated uranium levels caused by wind. And finally, we are conducting an ongoing investigation into an unexpected plutonium reading attributed to the El Rancho site in the final quarter.

a. El Rancho Plutionium-238 Investigation. An analytically rejected unexpected value was noted at the El Rancho station. At this early stage of the investigation, it appears to be due to analytical laboratory contamination or some other cause but not a real presence of the isotope at the station.

As part of the investigation into this occurrence, we revisited all plutonium measurements over the last two years. Previously (in 2003), an unexpected detection of plutonium at the same station had been rejected. We have decided to initiate a more thorough investigation. This investigation is under way at the time of writing and includes collecting swipe samples at the station and reanalyzing the remaining half-filters.

The rejected 2004 annual concentration of plutonium-238 at the El Rancho station was 13.3 aCi/m^3, which corresponds to less than 1% of the publicly permitted EPA 40 CFR Part 61, Appendix E, Table 2 (10 mrem/yr) concentration limit of 2100 aCi/m^3.

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 now, the uranium-238 concentrations have been consistently higher than the uranium-234 concentrations, indicating the presence of DU. The station at TA-36 was not included in these averages because of the persistent and known presence of DU in the samples, as discussed below.

Figure 4-6 shows that DU has been detected regularly—most notably in the first quarters of 1997, 2001, and 2002 and the fourth quarter of 2002 when significant differences (3s) were detected in 25% or more of the samples. All of the samples with DU were collected on Laboratory property or within Los Alamos County. In the six years before 2001, 15 quarterly composite samples with DU were collected off-site. During 2001–2003, 23 off-site DU samples were collected—a notable increase since the Cerro Grande fire in 2000. The ongoing drought through the years following the fire has kept DU (and other) dust ready for resuspension. However, in 2004, rainfall was substantially above levels in preceding years, and no DU was detected off-site. Off-site concentrations of DU are comparable to or less than historical natural uranium concentrations.

The station at TA-36 is located in a posted radiation-control area where DU is present (Eberhart et al., 1999; ESP 1999; ESP 2000; and ESP 2001) as surface contamination from explosive tests (Figure 4-9). Over the last decade, of the 40 quarterly composites analyzed for isotopic uranium at this site, 32 have indicated DU. The 2004 uranium-234 and -238 concentrations at this site were respectively 7 and 16 aCi/m^3. Assuming about 15% of the activity in DU is uranium-234, the calculated contributions at this location were about 2 aCi/m^3 of uranium-234 and 11aCi/m^3 of uranium-238. Therefore, the combined estimated LANL contribution at this on-site controlled-access location is below 0.0001% of the DOE DAC for workplace exposure.

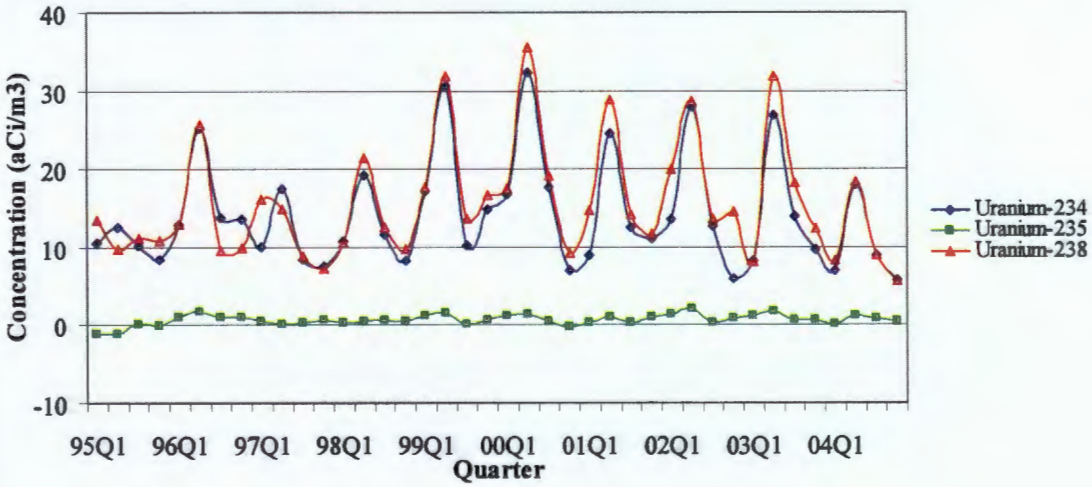

Figure 4-8. AIRNET quarterly uranium concentrations (network-wide excluding site 77).

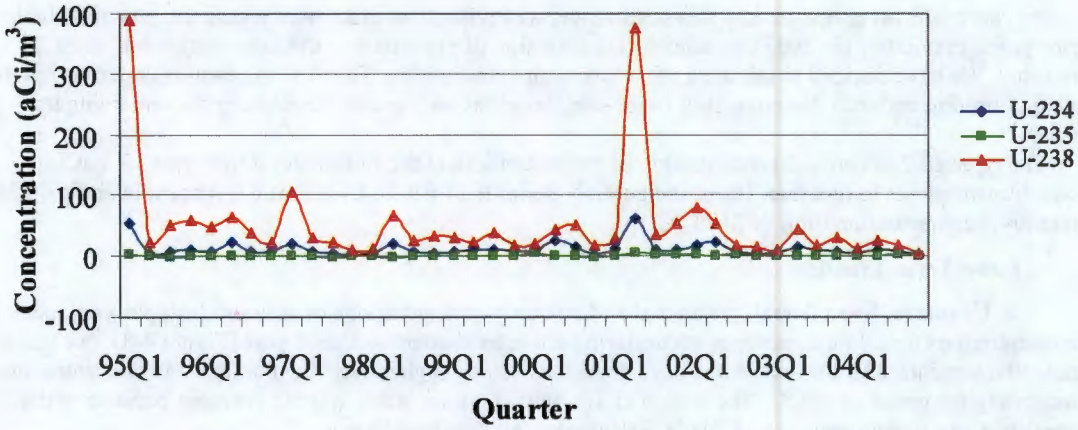

Figure 4-9. Uranium concentrations at site 77 at TA-36.

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 detectable concentrations of these radionuclides. Perimeter samplers are somewhere in between, with occasional samples having measurable concentrations. Figures 4-10, 4-11, and 4-12 are graphs of the annual concentrations by isotope and general station locations. 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 decreasing for several years except for the soil-screening operation in 2002 (Figure 4-13) (ESP 2002). The average concentrations for the other sample groupings vary but remain near zero, with occasional samples and/or locations having detectable concentrations.

c. Tritium. Unlike other contaminants, tritium concentrations are strongly influenced by current operations and emissions with no distinctive trends over this period (Figure 4-14). With fewer decommissioning and decontamination activities at TA-21 during 2004, we currently see lower ambient values nearby. However if such work increases in the future, we expect to see an increase in ambient levels.

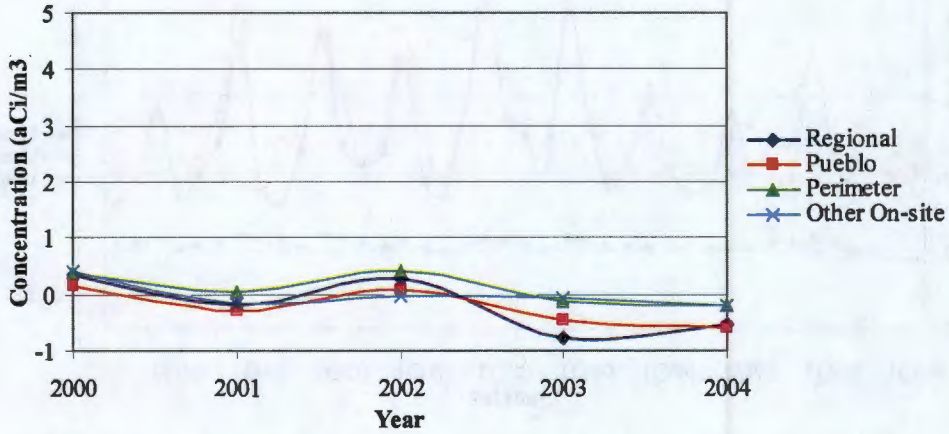

Figure 4-10. Am-241 concentration trends.

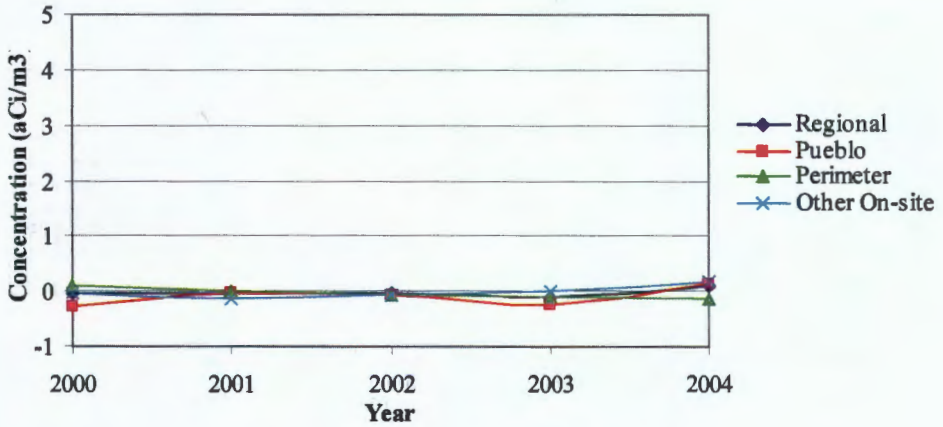

Figure 4-11. Pu-238 concentration trends.

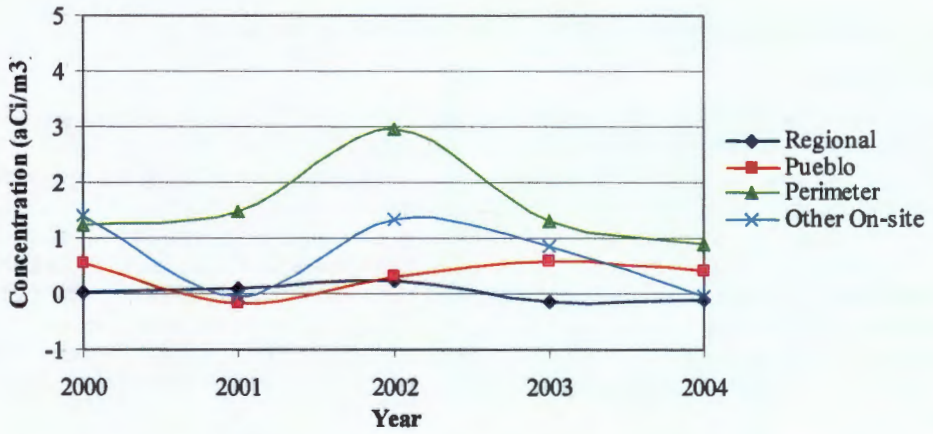

Figure 4-12. Pu-239,240 concentration trends.

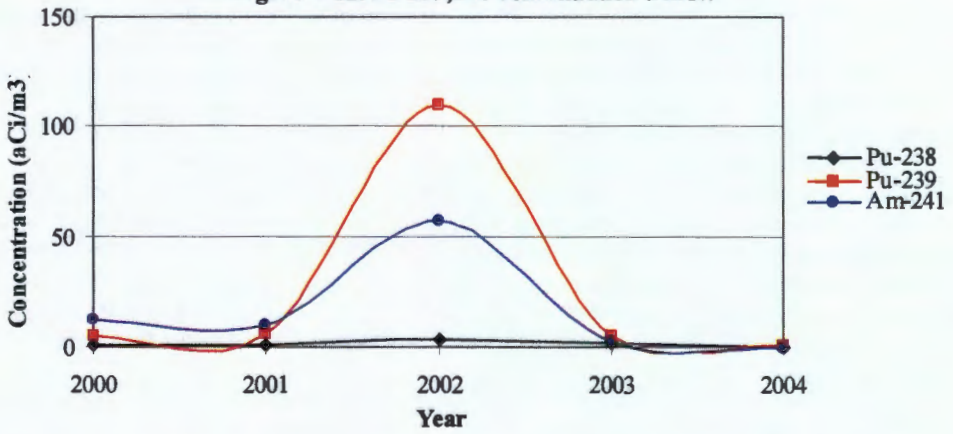

Figure 4-13. Americium and plutonium concentration trends for TA-54, Area G.

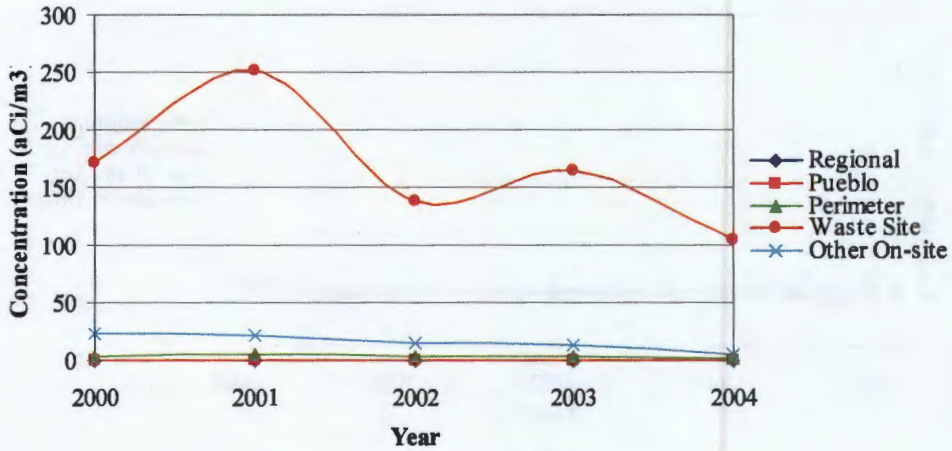

Figure 4-14. Tritium concentration trends.

B. Stack Sampling for Radionuclides *(Dave Fuehne and Andrew Green)*

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. ENV-MAQ personnel at LANL evaluate these 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 Code of Federal Regulations (CFR) 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989). During 2004, we identified 27 stacks as 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.

2. Sampling Methodology

In 2004, 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 an 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 the filter that captures small particles of radioactive material. These samples are collected weekly and shipped to an off-site analysis 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 these composite samples 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 then 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, that operations at the Los Alamos Neutron Science Center (LANSCE) and hot cell activities at the Chemistry and Metallurgy Research Building and TA-48 generate. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the filter.

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 sample containing the elemental tritium is then passed through a palladium catalyst that converts the elemental tritium to HTO. The sample is then 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 2004 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 to an off-site analytical laboratory. Before screening the samples for the presence of alpha and beta activity, the laboratory allowed approximately 72 hours for the short-lived progeny of radon to decay. These initial screening analyses ensure that potential emissions were within normal values. The laboratory performed final analyses after the sample had been allowed to decay for approximately one week, which allows for more accurate determinations of concentrations of longer-lived isotopes. In addition to alpha and beta analyses, the laboratory used gamma spectroscopy to identify specific isotopes in the sample. LANSCE glass-fiber filters were analyzed using only gamma spectroscopy.

Because gross alpha/beta counting cannot identify specific radionuclides, the glass-fiber filters were composited every six months for radiochemical analysis. We used the data from these composite analyses to quantify emissions of radionuclides such as the isotopes of uranium and plutonium. To ensure that the analyses requested (e.g., uranium-234, -235, and -238 and plutonium-238 and -239, 240, etc.) identified all significant activity in the composites, ENV-MAQ compared the results of the isotopic analysis with gross activity measurements.

c. Vaporous Activation Products Emissions. We generally removed and replaced the charcoal canisters that sample facilities with the potential for significant vaporous activation products emissions weekly, then shipped the samples 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 generally collected and transported to LANL's Health Physics Analytical Laboratory on a weekly basis. The Health Physics Analytical Laboratory added an aliquot of each sample to a liquid scintillation cocktail and determined the amount of tritium in each vial by liquid scintillation counting.

e. Gaseous Mixed Activation Products (GMAP) Emissions. Continuous monitoring was used, rather than 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 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, MAQ personnel 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 2004 totaled approximately 5,230 Ci. Of this total, tritium emissions composed approximately 790 Ci, and air activation products from LANSCE stacks contributed nearly 4,440 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 0.00001 Ci. Emissions of particulate/vapor activation products (P/VAP) also were less than 0.01 Ci.

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

Table 4-13. Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2004 (Ci)

TA-Bldg	H-3[a]	Am-241	Pu[b]	U[c]	Th[d]	P/VAP[e]	GMAP[f]	Sr-90
TA-03-029		2.06E-07	2.07E-06	2.78E-06	1.33E-06			
TA-03-102				1.99E-08	1.01E-09			
TA-16-205	1.40E+02							
TA-21-155	3.37E+02							
TA-21-209	2.99E+02							
TA-48-001						2.31E-04		
TA-50-001					6.99E-08			
TA-50-037								
TA-50-069				5.02E-11				
TA-53-003	6.30E-01						1.84E+00	
TA-53-007	2.68E+00					7.98E-03	4.44E+03	
TA-55-004	9.41E+00			9.52E-08				
Total[g]	7.89E+02	2.06E-07	2.07E-06	2.90E-06	1.40E-06	8.21E-03	4.52E+03[h]	0.00E+00

[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] Some differences may occur because of rounding.
[h] Total for GMAP includes 82 curies released from diffuse sources at TA-53.

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 2004, LANSCE facility (TA-53) nonpoint source emissions of activated air comprised approximately 79 Ci carbon-11 and 3.3 Ci argon-41, whereas TA-18 contributed 0.91 Ci argon-41.

Table 4-14. Detailed Listing of Activation Products Released from Sampled LANL Stacks in 2004 (Ci)

TA-Building	Nuclide	Emission
TA-48-001	Ga-68	1.09E-04
TA-48-001	Ge-68	1.09E-04
TA-48-001	Rb-86	4.55E-06
TA-48-001	Se-75	6.88E-06
TA-48-001	Se-75	5.30E-07
TA-53-003	C-11	1.84E+00
TA-53-007	Ar-41	8.48E+00
TA-53-007	As-72	2.21E-05
TA-53-007	As-73	1.34E-04
TA-53-007	Be-7	1.29E-06
TA-53-007	Br-76	1.84E-03
TA-53-007	Br-77	2.24E-05
TA-53-007	Br-82	1.51E-03
TA-53-007	C-10	8.10E-02
TA-53-007	C-11	3.46E+03
TA-53-007	Hg-197	2.18E-03
TA-53-007	Hg-197m	2.18E-03
TA-53-007	N-13	6.43E+01
TA-53-007	N-16	2.81E-01
TA-53-007	Na-24	8.61E-06
TA-53-007	O-14	4.75E+00
TA-53-007	O-15	8.99E+02
TA-53-007	Os-191	3.01E-05
TA-53-007	Se-75	3.44E-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-22	2.6 yr
Na-24	14.96 h
P-32	14.3 d
K-40	1,277,000,000 yr
41Ar	1.83 h
Mn-54	312.7 d
Co-56	78.8 d
Co-57	270.9 d
Co-58	70.8 d
Co-60	5.3 yr
As-72	26 h
As-73	80.3 d
As-74	17.78 d
Br-76	16 h
Br-77	2.4 d
Br-82	1.47 d
Se-75	119.8 d
Sr-85	64.8 d
Sr-89	50.6 d
Sr-90	28.6 yr
I-131	8 d
Cs-134	2.06 yr
Cs-137	30.2 yr
Os-183	13 h
Os-185	93.6 d
Os-191	15.4 d
Hg-193	3.8 h
Hg-195	9.5 h
Hg-195m	1.67 d
Hg-197	2.67 d
Hg-197m	23.8 h
U-234	244,500 yr
U-235	703,800,000 yr
U-238	4,468,000,000 yr
Pu-238	87.7 yr
Pu-239	24,131 yr
Pu-240	6,569 yr
Pu-241	14.4 yr
Am-241	432 yr

5. Long-Term Trends

Figures 4-15 through 4-18 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, tritium emissions were down slightly from 2003 and on a steady downward trend. GMAP emissions are elevated from 2003 levels, but fairly consistent with 2002. Emissions from plutonium and uranium isotopes stayed relatively steady since 2000. Note that with the suspension of work activity in July 2004, most operations ceased for long periods of time. One side effect of this work suspension is a reduction in air emissions from these operations, as noted by the tritium, uranium, and plutonium emissions plots. The exception to this is GMAP emissions from LANSCE, because the accelerator run cycle was completed in April 2004.

Tritium emissions are also down because of the completion of source removal activities at TA-21-155. Continued emissions from this facility result from off gassing of contaminated equipment remaining in the building. Monitoring will continue until it is felt that the potential emissions levels from TA-21-155 are fully characterized. At TA-21-209, operations are being prepared for transfer to TA-16, where LANL is consolidating most tritium operations, and the 21-209 building is being prepared for decontamination and decommissioning. 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 such 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. 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, are well below regulatory limits.

In 2004, LANSCE operated in the same configuration as 2001–2003, 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 in January 2004 (extending the end of the 2003 cycle) through the end of April 2004. The reductions in GMAP emissions from LANSCE in 2003 were not maintained in 2004, because of elevated beam operation and other parameters.

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 nonradioactive components. Because of the operating parameters in 2004, the delay line was not as effective as it was in the early 2003 run cycle, and the rate of emissions increased compared with 2003. The overall total emissions from 2004 remained well below any regulatory limits.

Figure 4-19 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. Bear in mind that 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 gaseous nuclides are not easily removed from an exhaust stack air stream by standard control techniques, such as filtration. These two emissions types continue to fluctuate as the major emissions type, changing as tritium cleanup operations, and LANSCE operations vary from year to year. Because of the close proximity of the LANSCE facility with the LANL site boundary, GMAP emissions remain the greatest source of off-site dose from the airborne pathway.

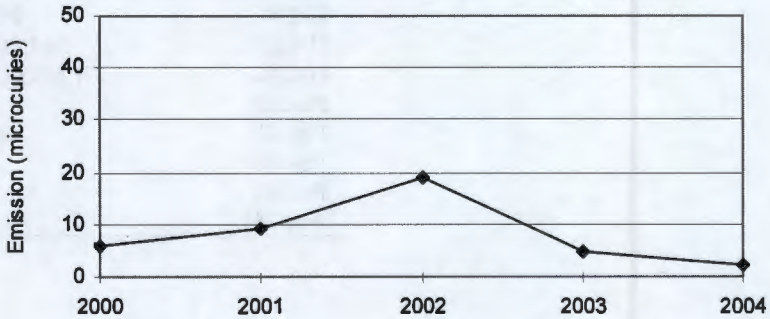

Figure 4-15. Plutonium emissions from sampled LANL stacks.

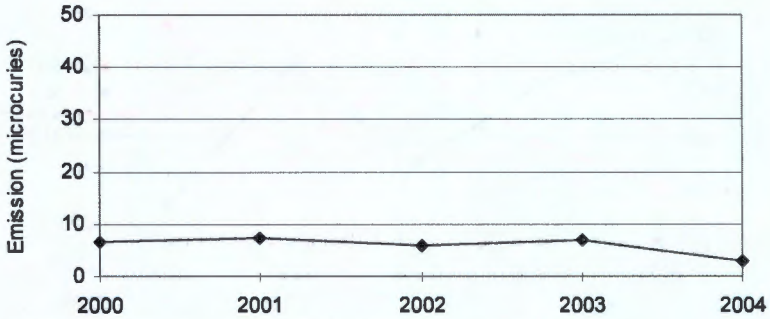

Figure 4-16. Uranium emissions from sampled LANL stacks.

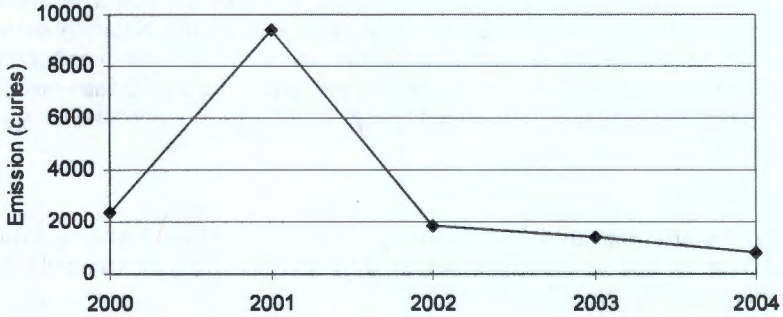

Figure 4-17. Tritium emissions from sampled LANL stacks.

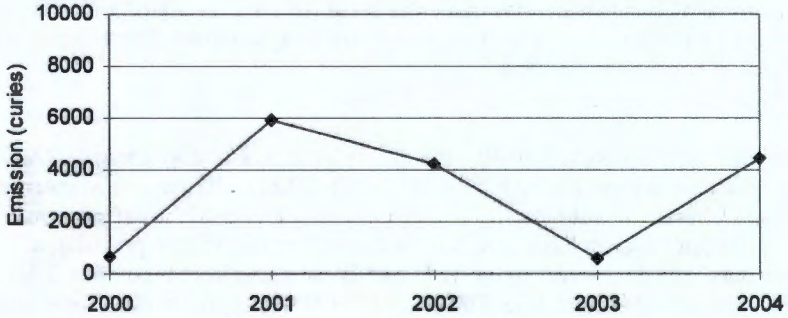

Figure 4-18. GMAP Emissions from sampled LANL stacks.

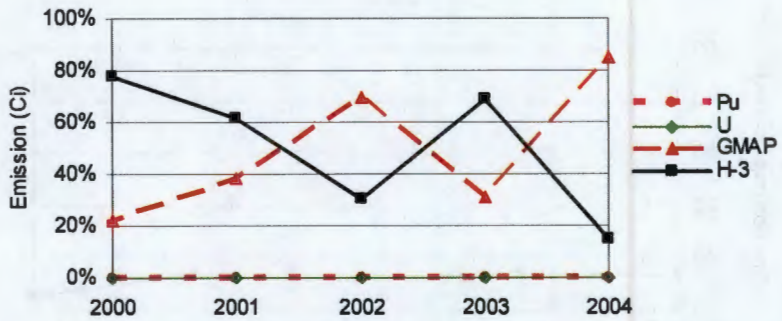

Figure 4-19. Fraction of total stack emissions resulting from plutonium, uranium, tritium, and GMAP.

C. Gamma and Neutron Radiation Monitoring Program *(Andrew Green and Michael McNaughton)*

1. Introduction

ENV-MAQ monitors 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. Because the natural radiation doses are generally much larger than those from man-made sources, it is extremely difficult to distinguish man-made sources from the natural background. The dose rate from natural terrestrial and cosmic sources varies approximately from 100 to 200 mrem/yr.

2. Monitoring Network

a. Dosimeter Locations. In an attempt to distinguish any impact from LANL operations on the public, ENV-MAQ has located 90 thermoluminescent dosimeter (TLD) stations around LANL and in surrounding communities (Figures 4-2 and 4-20).

b. Neutron Dosimeters. We monitor potential neutron doses with 52 albedo TLD stations. Albedo dosimeters are sensitive to neutrons and use a hydrogenous material to simulate the human body that causes neutron backscatter.

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

ENV Division operating procedures outline the quality assurance/quality control (QA/QC) protocols. In the MAQ group, guidance is provided by ENV-MAQ-QMP. 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%.

4. Results

The annual dose equivalents at almost all stations are consistent with natural background radiation and with previous measurements. Detailed results are listed in the Data Supplement Table S4-11 and at http://www.airquality.lanl.gov/DPRNET.htm.

The locations with a measurable contribution from LANL operations are at TA-18, LANSCE (TA-53), and TA-54, Area G.

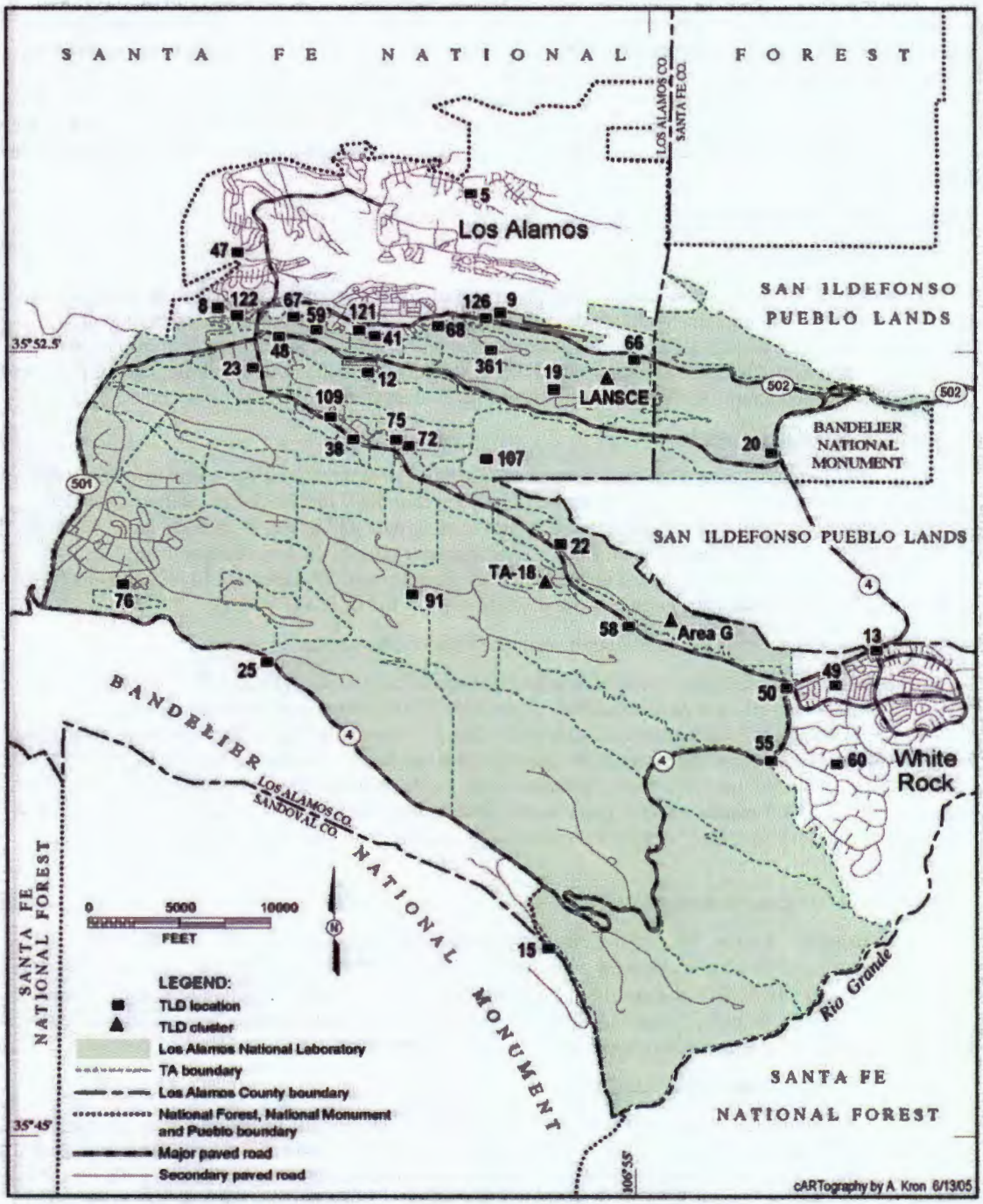

Figure 4-20. Off-site perimeter and on-site LANL TLD locations.

At TA-18, most of the dose is from neutrons; the gamma dose is too small to distinguish from the natural background radiation. The largest measured public neutron dose was 21 mrem on Pajarito Road outside the TA-18 parking lot (Station 187). Pajarito Road had restricted public access throughout 2004.

The TA-53 lagoons, which previously contained activated material, have been remediated, and current doses at stations 114 and 115 are close to background levels. Access by the public to TA-53 is restricted.

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 most Area G data are not representative of a potential public dose.

In conclusion, the maximum public dose from year-round exposure to direct penetrating radiation during 2004 was 1.25 mrem near TA-18. It is unlikely any member of the public received this dose because of the restricted public access to this location. This dose falls well below the 100-mrem/year maximum allowable limit set by EPA.

D. Nonradioactive Ambient Air Monitoring *(Andrew Green and Craig Eberhart)*

1. Introduction

During 2004, ENV-MAQ continued a reduced version of the nonradiological monitoring (NonRadNet) air-monitoring program 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 2004, 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. One Los Alamos station is at the Los Alamos Medical Center; the other near 48th Street. Both these latter locations lie between the main LANL technical area 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; an associated mass of accumulated particulate matter is recorded and saved. The data are later downloaded to a MAQ-maintained database. MAQ 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

a. Particulate Matter. We achieved an overall data collection efficiency exceeding 90% for 2004. 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 14 $\mu g/m^3$ at all locations; for PM-2.5 it is half this value. These averages are well below the 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 the EPA standards.

5. Detonation and Burning of Explosives

LANL tests explosives by detonating them at firing sites operated by the Dynamic Experimentation Division. LANL maintains records that include the type of explosives used and other material expended at each site. Table S4-12 (in the Data Supplement) summarizes the amounts of expended materials for the last four years. LANL also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2004, LANL burned 5 tons of high explosives.

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 2004 were less than the amounts for which impacts are analyzed in the DOE (1999) report.

Table 4-16. PM-2.5 and PM-10 Concentration Data Summary for 2004

Station Location	Constituent	Maximum 24-Hour ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
48th Street, Los Alamos	PM-10	53	12
	PM-2.5	17	7
Los Alamos Medical Center	PM-10	54	16
	PM-2.5	16	7
White Rock Fire Station	PM-10	43	13
	PM-2.5	15	7
EPA Standard	PM-10	<150	<50[a]
	PM-2.5	<65	<15[a]

[a]EPA 40 CFR Part 50

6. Beryllium Sampling

The state of New Mexico has no ambient-air-quality standard for beryllium. For comparison purposes, we use the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard of 10 ng/m^3 (40 CFR Part 61). Beryllium air concentrations for 2004 are very similar to those measured in recent years. All values are 2% of, or less than, the NESHAP standard.

During 2004, we analyzed quarterly composite samples from 22 sites for beryllium, aluminum, and calcium (see Table S4-11 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 4-21 (correlation coefficient = 0.906). Nonnatural occurrences of beryllium would appear far from the straight line. We believe all the measured beryllium concentrations are of a natural origin—resuspended soil and dust.

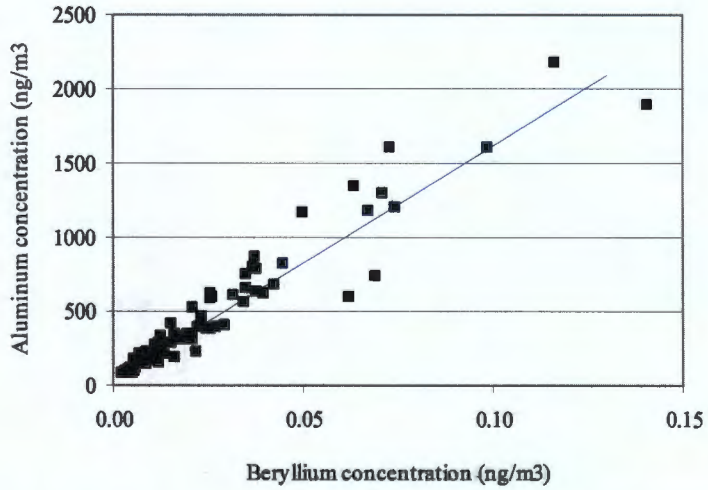

Figure 4-21. Correlation between aluminum and beryllium concentrations in AIRNET samples.

E. Meteorological Monitoring *(Scot Johnson)*

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 of the ENV-MAQ Group 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 on the Internet 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. 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.

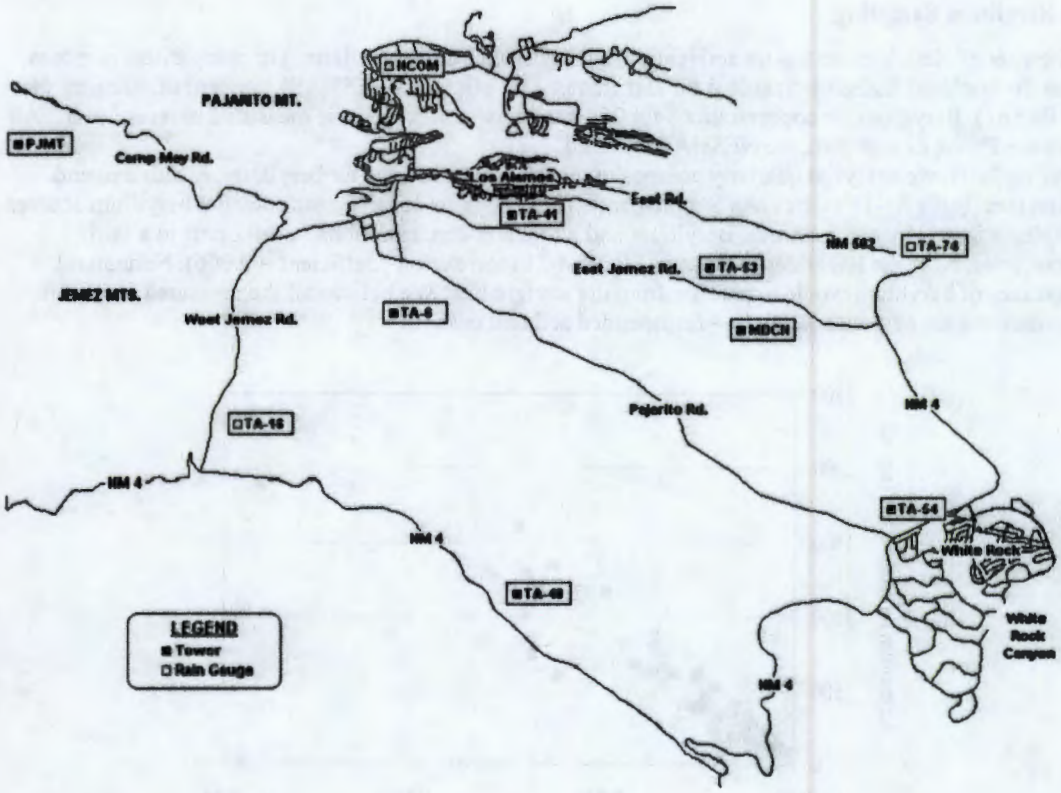

Figure 4-22. Meteorological network.

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 at 0.33 hertz (Hz), 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 (i.e., daily minimum and maximum temperatures, daily total precipitation, maximum wind gust, etc.) are also generated and checked for quality. During the past 45 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) during 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 of the ENV-MAQ Group.

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% of the time. These conditions lead to high solar heating during the day and strong long-wave radiative cooling of the earth 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.

By convention, the 30-yr period of 1971 to 2000 is used to determine climatological averages. The average annual precipitation (which includes both rain and the water equivalent for frozen precipitation) from 1971 to 2000 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 11am on January 15th, 1987 and 11 am the next day. The record single-season snowfall is 153 in. set in 1986–87.

The 2 months of July and August account for 36% of the annual precipitation and encompass the bulk of the rainy season, which typically begins in early July and ends in early September. Afternoon thunderstorms form as moist air from the 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. 2004 in Perspective

Figure 4-23 presents a graphical summary of Los Alamos weather for 2004. 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 1971–2000 time period).

Following a 6-year trend of warmer-than-normal temperatures and a dryer-than-normal climate, 2004 weather returned to normal in Los Alamos County. The average annual temperature in 2004 of 48.1°F slightly exceeded the normal annual average of 47.9°F. The total precipitation in 2004 of 18.78 in. was 99% of normal (18.95 in.). February was considerably colder than normal while March and May were much warmer than normal. Cold (warm) and wet (dry) usually go together and not surprisingly, February was much wetter than normal while March and May were drier than normal. February and April experienced surprisingly abundant precipitation, exceeding twice the normal amount during both months. The February precipitation came as snow during three storm events and totaled 38 inches, more than four times the normal February snow amount of 9 inches. The annual snowfall total of 82.4 in. was 140% of normal (58.7 in.).

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-24 shows the historical record of temperatures in Los Alamos from 1924 through 2004. The data before 1924 are sparse and are therefore omitted. The annual average temperature is not the average temperature per se, but rather the midpoint between daily high and low temperatures, averaged over the year. One-year averages are shown in green in Figure 4-24 To aid in showing longer-term trends, the 5-year running mean is also shown. It can be seen, for example, that the warm spell during the past few years is not as severe as warm spells during the early-to-mid 1950s.

Figure 4-25 shows the historical record of the annually summed total precipitation. As with the historical temperature profile, the 5-year running mean is also shown. The precipitation in 2004 was close to average. The previous year, 2003, was the second driest year during the 80-year record; only 1956 was drier. The 5-year average shows that the recent drought appears to be the most severe drought on record in Los Alamos. But note that only Los Alamos measurements are shown. It may be that droughts of the late 1930s and early-to-mid 1950s were more widespread and more severe in measurements elsewhere, if not in Los Alamos.

Daytime winds (sunrise to sunset), based on 15-minute-averaged wind observations for 2004 at the four Pajarito Plateau towers and the Pajarito Mountain tower, are shown in the form of wind roses (Figures 4-26 and 4-27). 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. Wind roses from different years are almost identical.

Daytime winds measured by the four Pajarito Plateau towers are predominately from the south (Figure 4-26), 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 4-27). 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 *(Terrance Morgan)*

1. Quality Assurance Program Development

During 2004, ENV-MAQ revised two quality plans that affect collection and use of air-quality-compliance data. We also issued three new implementing procedures and revised approximately 36 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 MAQ processes perform satisfactorily. All current quality-related documents are available on the MAQ public (Green) Web site (www.airquality.lanl.gov).

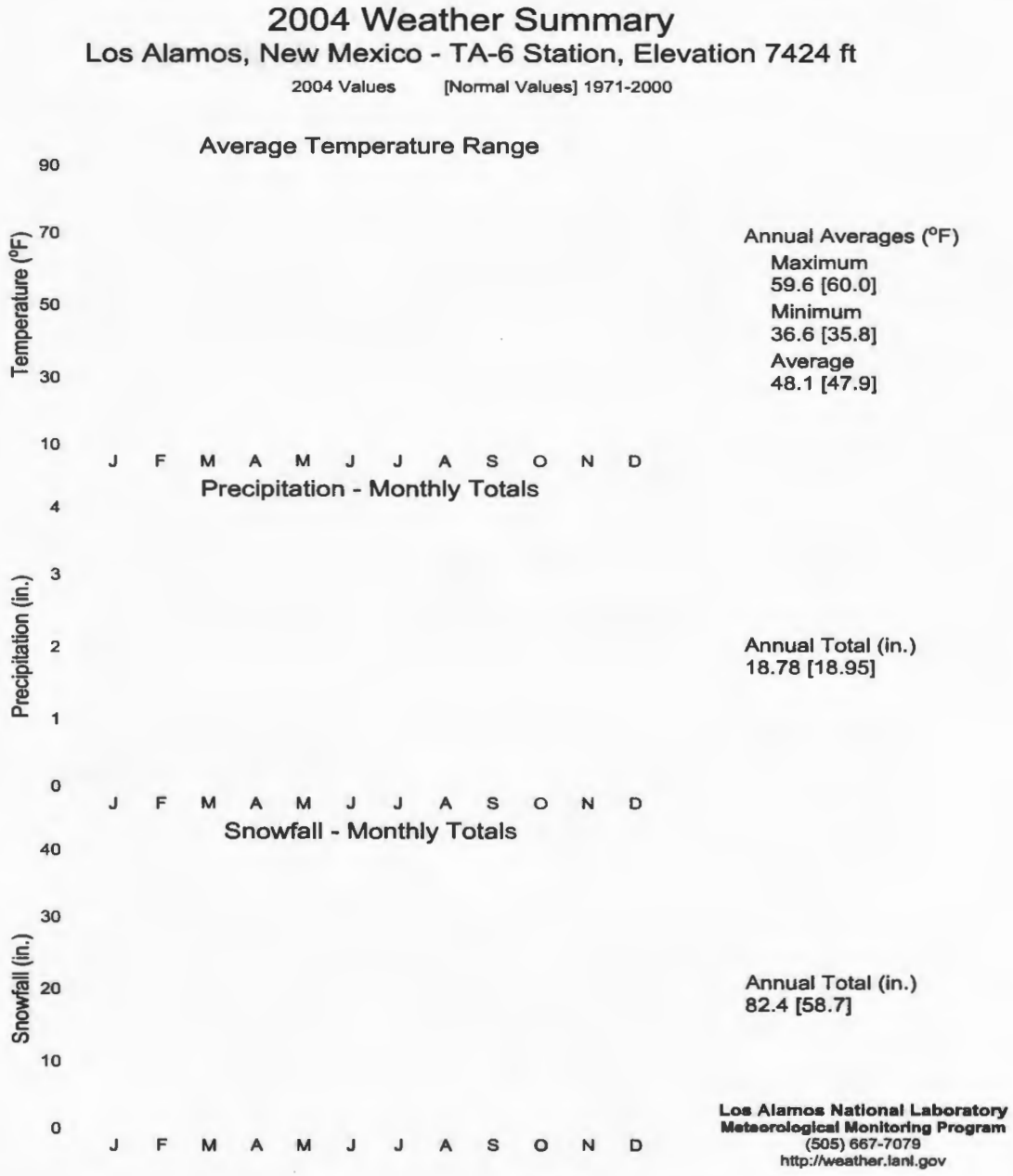

Figure 4-23. Weather summary for Los Alamos in 2004 at TA-6 station, elevation 7,424 ft. (Numbers in brackets are 30-year averages, and nonbracketed numbers are 2004 figures.)

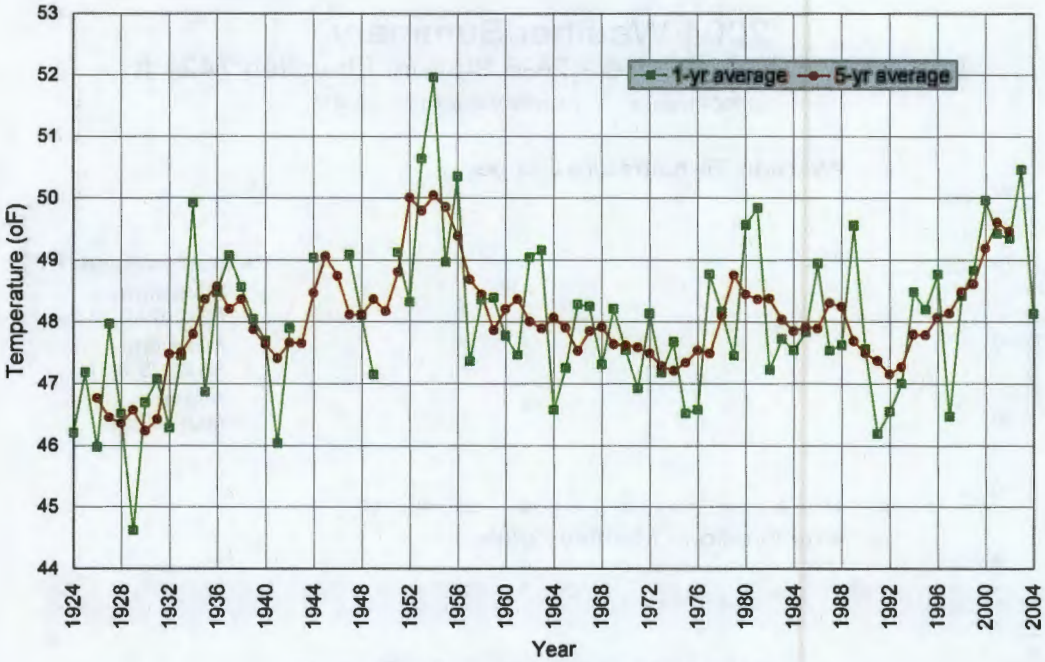

Figure 4-24. Temperature history for Los Alamos.

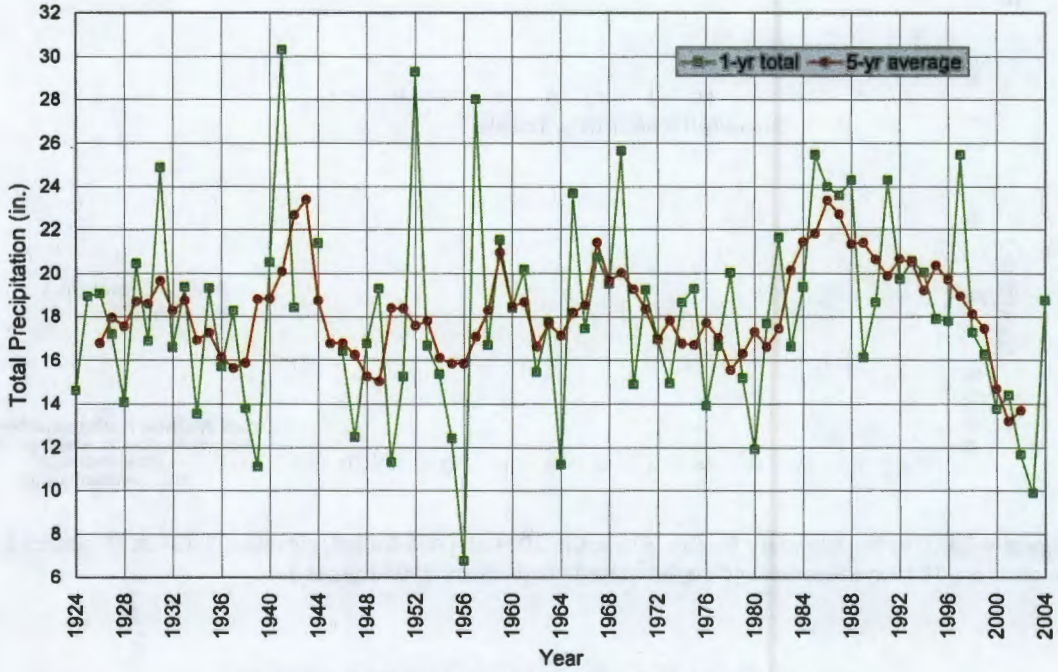

Figure 4-25. Total precipitation history for Los Alamos.

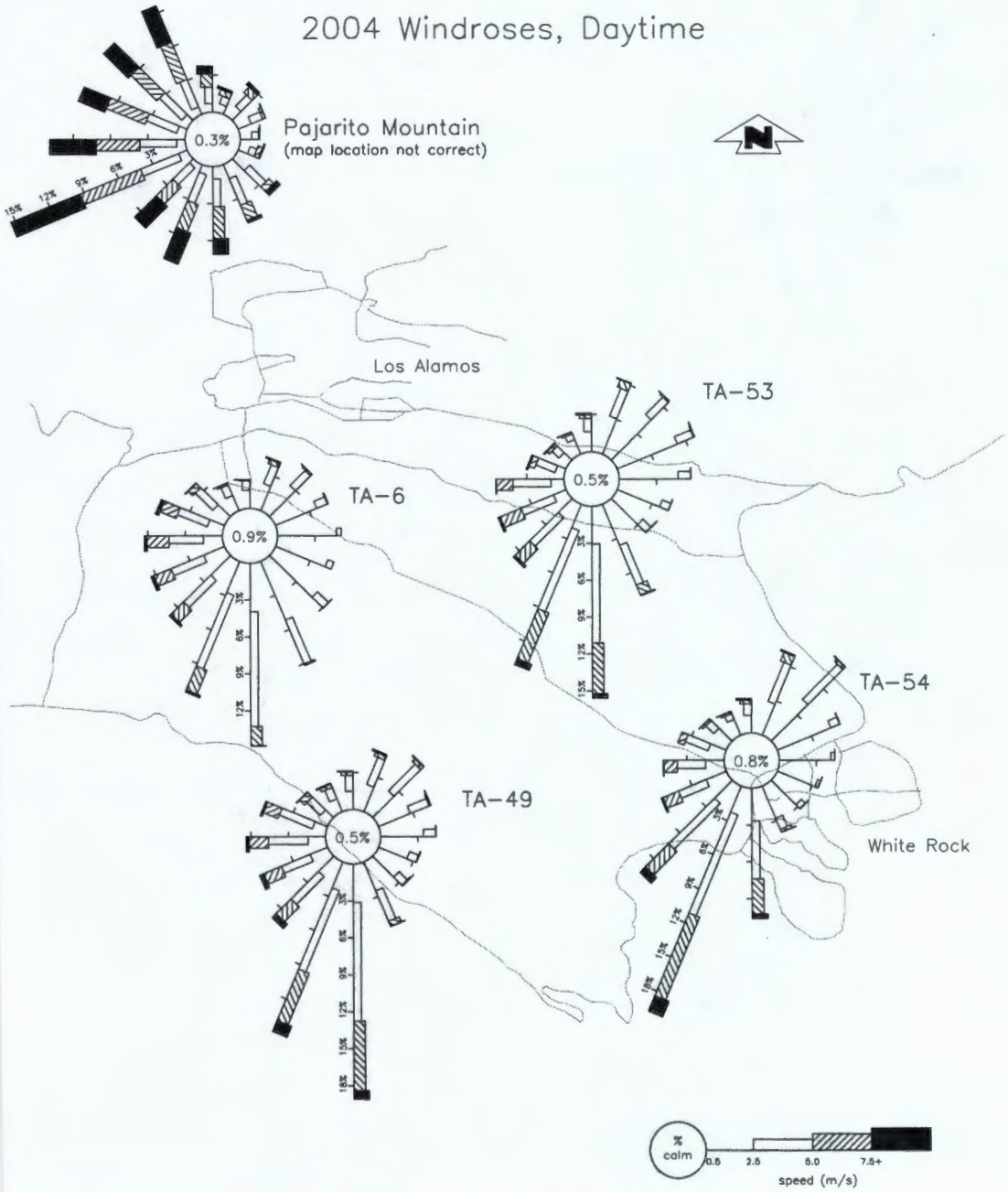

Figure 4-26. Daytime wind roses, 2004.

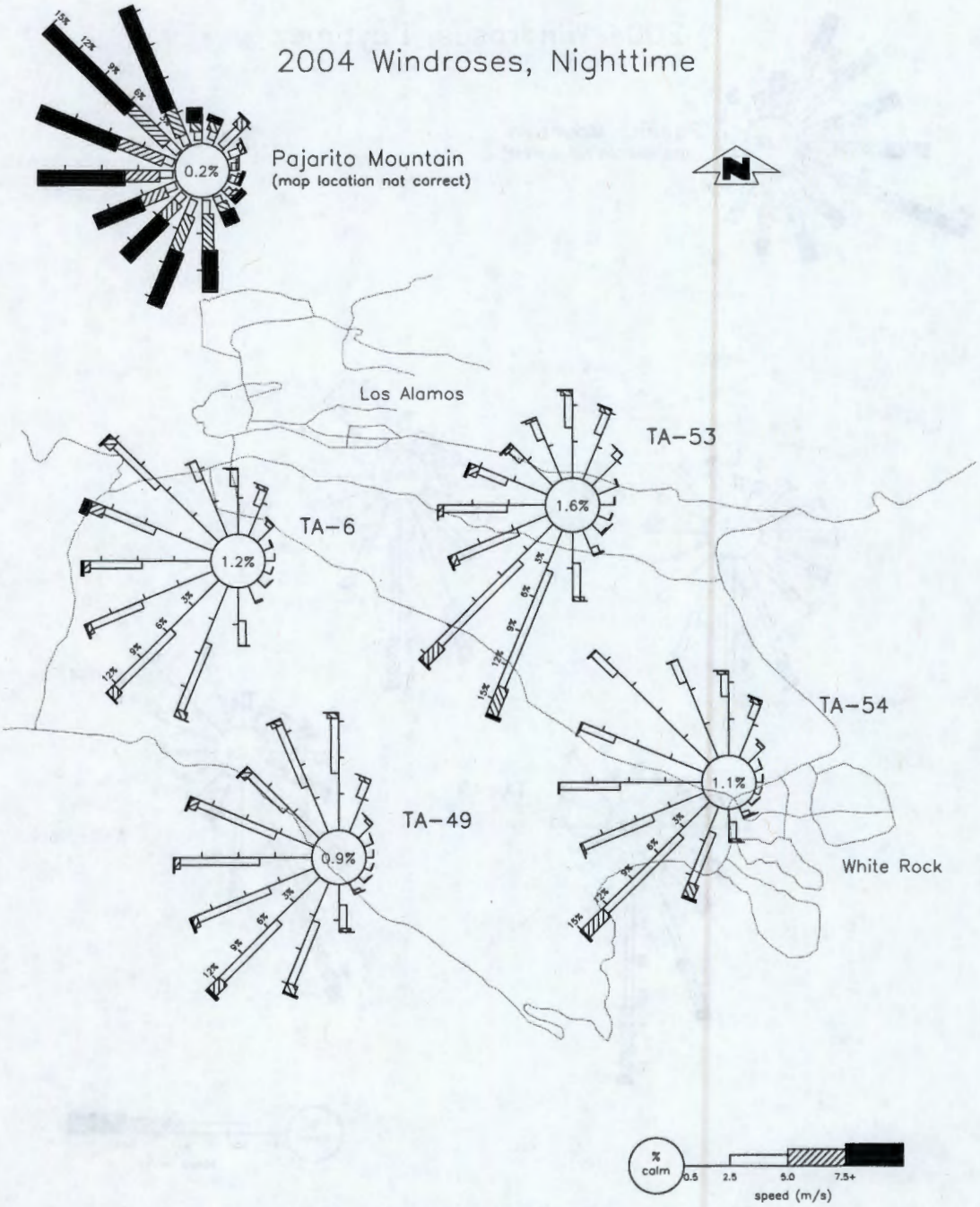

Figure 4-27. Nighttime wind roses, 2004.

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 MAQ 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 MAQ 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. ENV-MAQ submits independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned to MAQ 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 included 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%. Sample run time was greater than 95% for the compliance stations in each network.

5. Analytical Data Quality Assessment Results

Analytical data completeness for both sampling programs was >90% for all compliance stations. The Clean Air Act requires an EPA-compliant program of QC samples be included as an integral part of the sampling and analysis process. MAQ 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 2004 program of quality monitoring indicate that all analytical laboratories maintained the same high level of control that MAQ has observed in the past several years.

6. Analytical Laboratory Assessments

During 2004, 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 the Health Physics Measurements Group (HSR-4) performed instrumental analyses of tritium in stack emissions.

MAQ personnel performed an assessment of Paragon Analytics during 2004. The laboratory participated in national performance-evaluation studies during 2004. 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 December 2004, ENV-MAQ hosted an audit to evaluate areas of the Laboratory's Rad-NESHAP compliance program. The auditors were an external QA professional and stack monitoring experts who run the same type of programs at other DOE sites. The audit looked at engineering, data handling, and a general program review. While the program was pronounced in good health overall, several observations were made to improve processes. These observations include keeping procedures up to date, following through on formal close-out of deficiencies, meeting internal commitments made in our QA plans, and improved system inspection methods.

G. Unplanned Releases

There were no unplanned airborne releases from LANL during 2004.

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5. Groundwater Monitoring

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 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 environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations (LANL 1996, 1998).

Groundwater resource management and 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. The Los Alamos County public water supply comes from supply wells that draw water from the regional aquifer, which lies at a depth of 600 to 1,200 feet.

Since the 1940s, liquid effluent disposal by the Laboratory has degraded water quality in the shallow perched groundwater that lies beneath the floor of a few canyons. These water quality impacts extend in a few cases to perched groundwater at depths of a few hundred feet beneath these canyons. The contaminated perched groundwater bodies are separated from the regional aquifer by hundreds of feet of dry rock, so recharge from the shallow perched groundwater occurs slowly. As a result, little contamination reaches the regional aquifer from the shallow perched groundwater bodies, and water quality impacts on the regional aquifer, though present, are low. With one exception (perchlorate in well O-1 in Pueblo Canyon), drinking water in the Los Alamos area has not been adversely impacted by Laboratory actions. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water requirements.

The Environmental Stewardship Division Environmental Remediation and Surveillance Program and Water Quality and Hydrology Group (ENV-WQH) implement the Laboratory's groundwater monitoring program. The ENV-WQH Group collects groundwater samples from wells and springs within or adjacent to the Laboratory and from the nearby San Ildefonso Pueblo.

B. Hydrogeologic Setting

Additional information on groundwater studies at Los Alamos and a more detailed discussion of the Laboratory's hydrogeologic conceptual model appear in the Laboratory's annual groundwater status report (Nylander et al., 2003).

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).

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

Groundwater beneath the Pajarito Plateau occurs in three modes, two of which are perched (Figure 5-2). Perched groundwater is retained above a less permeable layer and 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.

Streams have filled some parts of canyon bottoms with alluvium up to 100 ft thick. Many relatively dry canyons have little surface water flow and little or no alluvial groundwater. In wet canyons, stream runoff percolates through the alluvium until downward flow is impeded by less permeable layers of tuff, 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, and Sandia 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 within the Laboratory border 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 intermediate groundwater in various locations shows localized radioactive (tritium), organic (high explosives [HEs] cyclonite [RDX], trinitrotoluene [2,4,6-TNT], and HE degradation products), and inorganic (perchlorate and nitrate) contamination from Laboratory operations.

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.

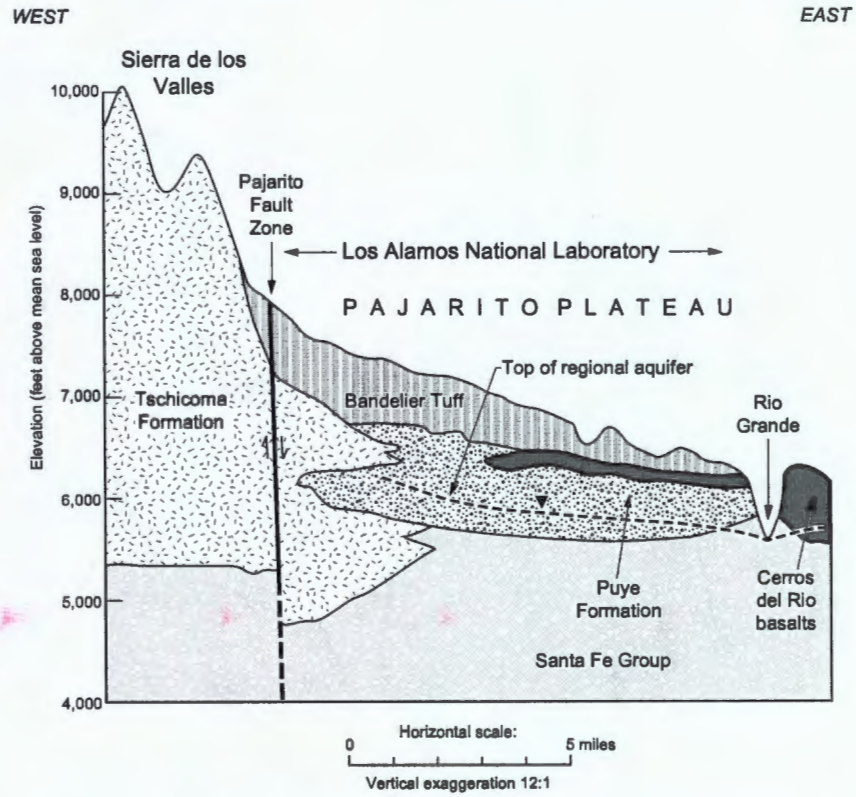


Figure 5-1. Generalized geologic cross section of the Pajarito Plateau.

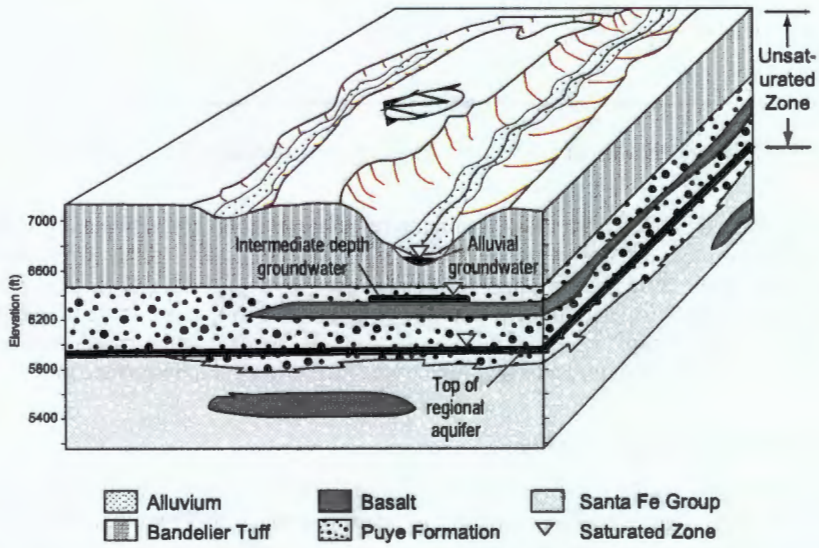


Figure 5-2. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

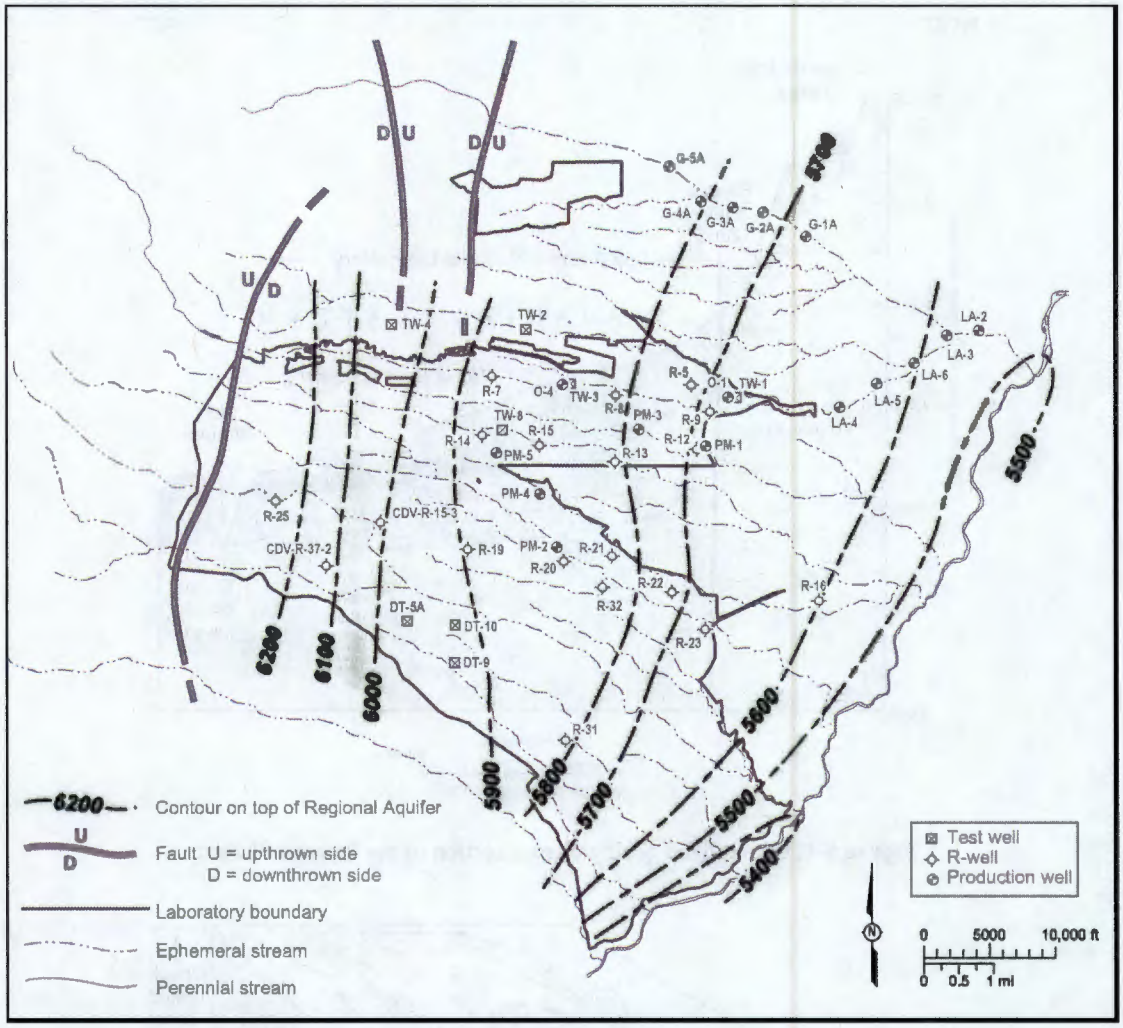


Figure 5-3. Generalized water level contours for the regional aquifer (Nylander et al., 2003).

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%) 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.

3. Overview of Groundwater Quality

Liquid effluent disposal is the primary means by which Laboratory contaminants have had a limited effect on the regional aquifer. In most cases 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 significantly affected the quality of alluvial groundwater in some canyons (Figure 5-4). These effluents have to a lesser degree affected deeper intermediate perched groundwater and the regional aquifer. 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.

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 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 the plan shown in 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 Environmental Protection Agency (EPA) maximum contaminant levels (MCLs). For groundwater sources other than water supply wells, DCGs based on the DOE's 100-mrem/yr public dose limit for water ingestion apply. For risk-based 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. 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 noncancer 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), apply to this water.

D. Monitoring Network

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 San Ildefonso Pueblo land, the DOE entered into 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 San Ildefonso Pueblo mainly sample the regional aquifer and are shown in Figure 5-8. Basalt Spring is an intermediate groundwater sampling point, and wells LLAO-1B and LLAO-4 sample alluvial groundwater.

1. Regional Aquifer and Intermediate Groundwater Monitoring

Sampling locations for the regional aquifer and intermediate perched groundwater include monitoring (test) wells, supply wells, and springs. Wells recently constructed under the Hydrogeologic Workplan 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.

Table 5-1. Application of Groundwater Standards to LANL 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	Other groundwater samples	DOE 100-mrem Derived Concentration Guides	4-mrem Derived Concentration Guides, EPA MCLs	DOE Order 5400.5, 40 CFR 141-143	On-site and off-site	DOE Public Dose Limit is 100 mrem/yr. 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

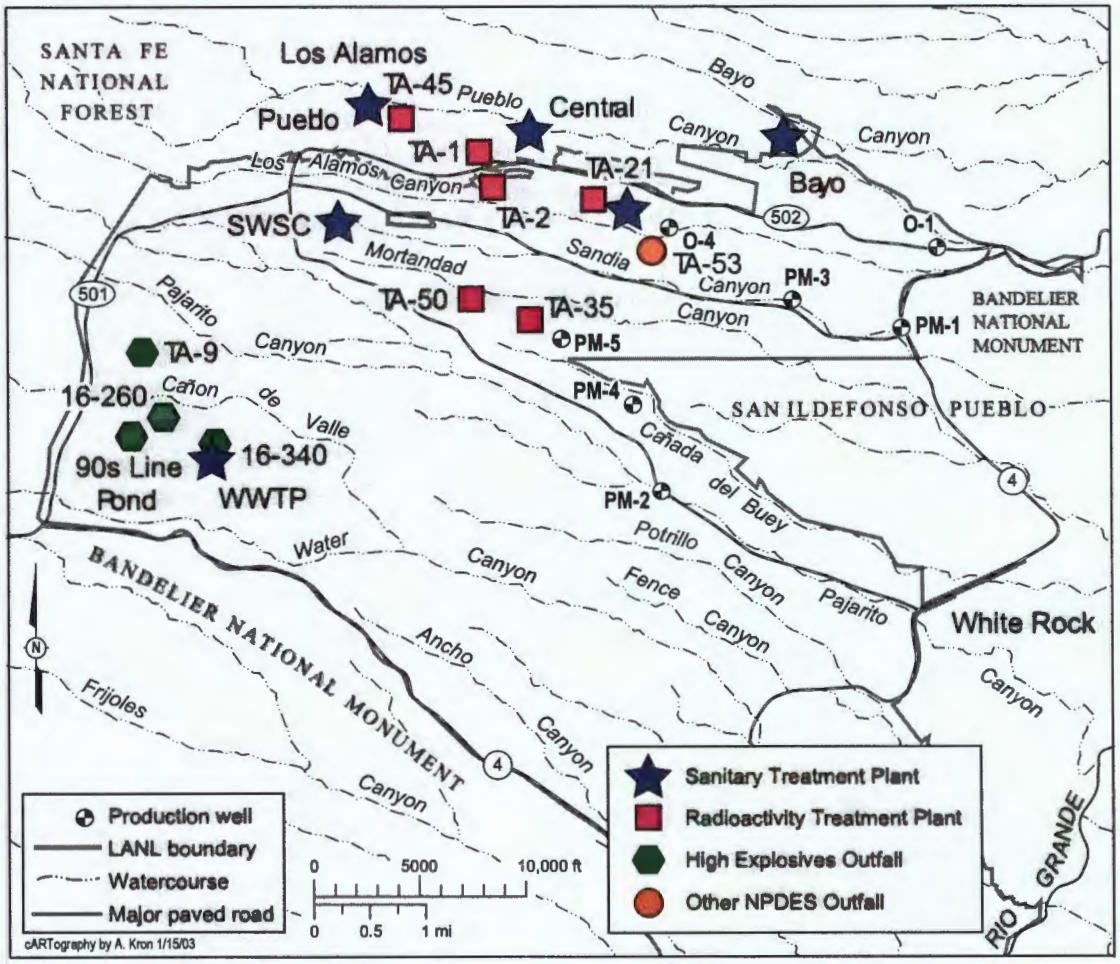


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. Most sources shown are inactive.

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 are 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 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.

ENV-WQH collects samples from 12 deep water supply wells in 3 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. The County of Los Alamos 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 that ENV-WQH has carried out. Koch and Rogers (2003) summarized operation of the water supply system for the years 1998–2001.

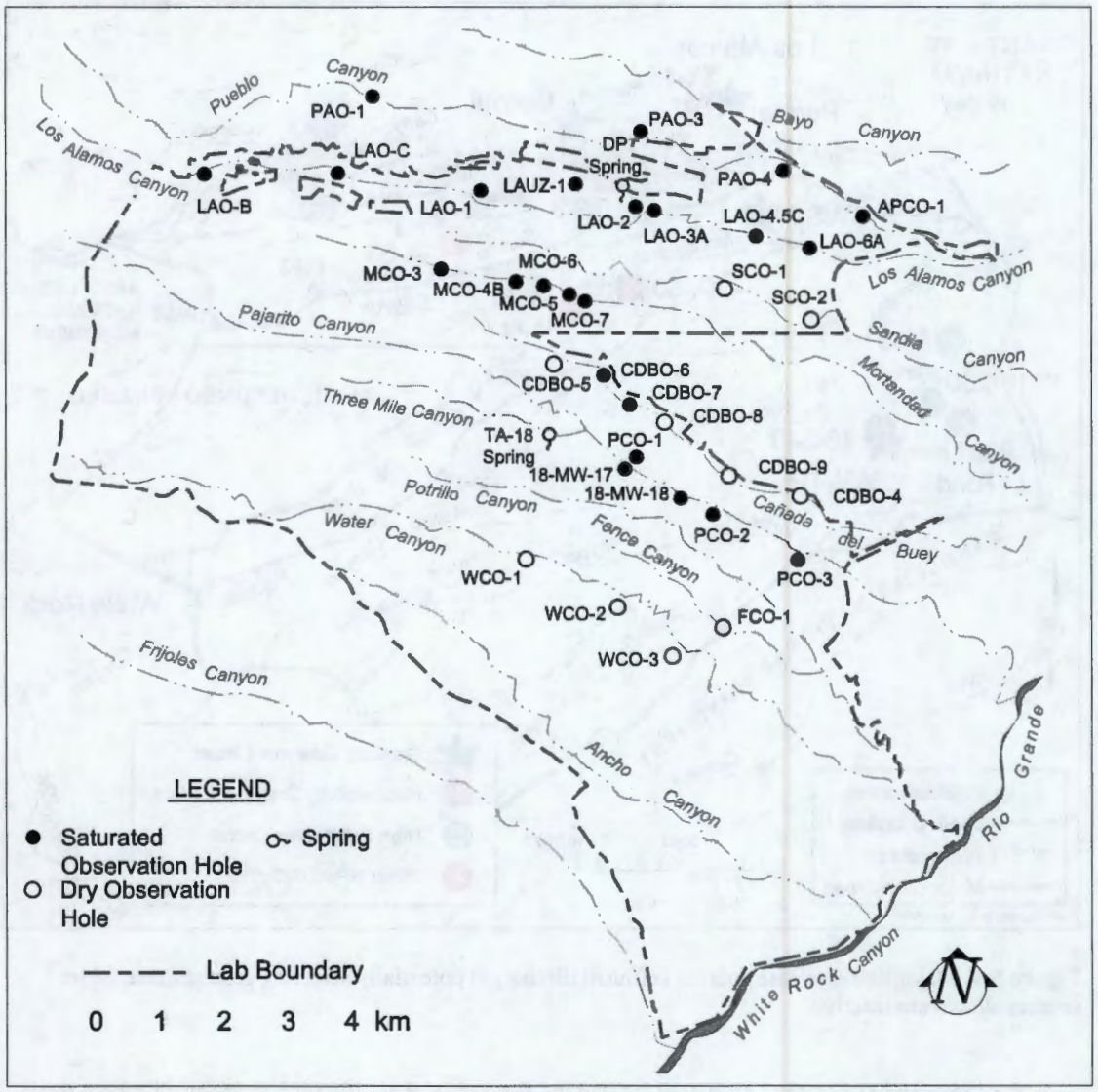


Figure 5-5. Springs and wells used for alluvial groundwater monitoring.

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

We sample numerous springs near the Rio Grande because they 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.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, ENV-WQH uses shallow wells to sample the perched alluvial groundwater in five canyons (Pueblo, Los Alamos, Mortandad, and Pajarito Canyons and Cañada del Buey). In any given year, some of these alluvial observation wells may be dry, and water samples cannot be obtained. Observation wells in Water, Fence, and Sandia canyons have been dry since their installation in 1989. All but one of the wells in Cañada del Buey are generally dry.

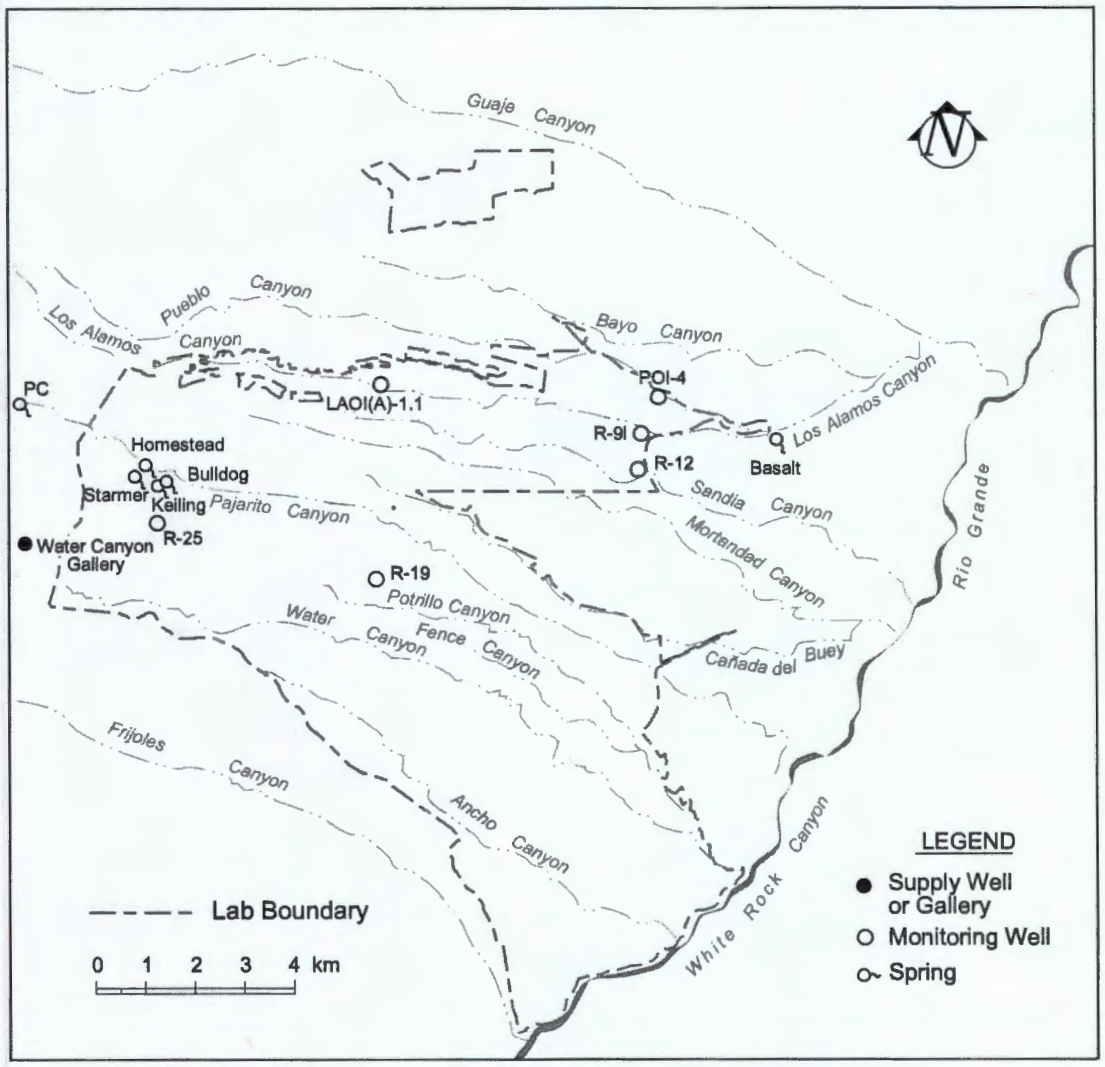


Figure 5-6. Springs and wells used for intermediate perched zone monitoring.

E. Groundwater Sampling Results by Constituents

Tables in the Data Supplement present groundwater monitoring data for 2004. 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 saturated zone sampled and the port depth appear in the table. The depth of screen top is given for other wells, with a value of –1 if depth is unknown. Table S5-1 in the Data Supplement provides definitions for sample description codes used in the data tables.

Table S5-2 in the Data Supplement lists the results of radiochemical analyses of groundwater samples for 2004. 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; total uranium is also calculated in the table from the isotopic values using specific activities for each isotope. Table S5-3 shows low-detection-limit tritium results from analyses done by the University of Miami. To emphasize analytical results that are detections, Table S5-4 in the Data Supplement lists radionuclides detected in groundwater samples.

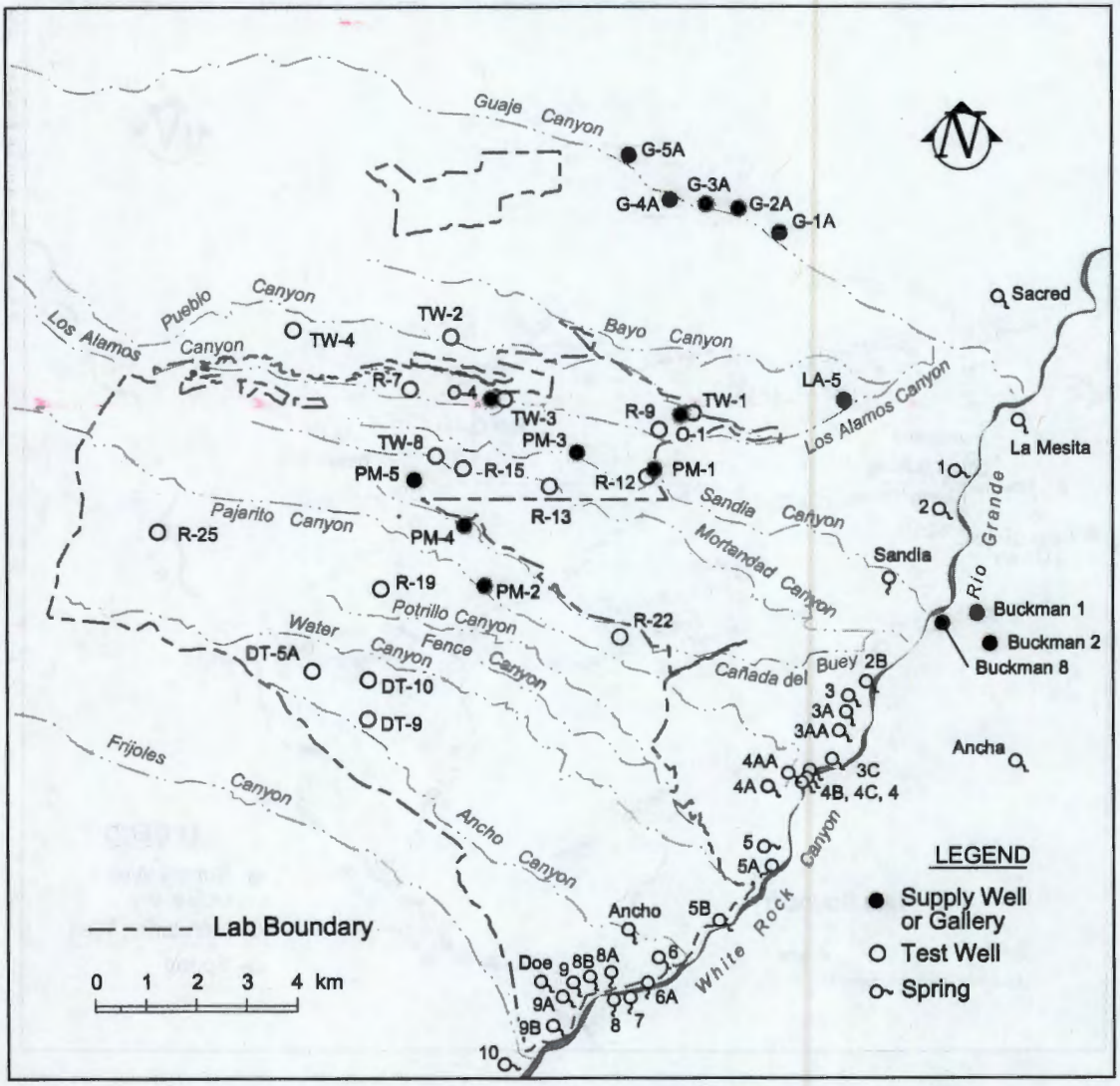


Figure 5-7. Springs and wells used for regional aquifer monitoring.

We define detections as values that exceed both the analytical method measurement-specific detection limit (where available) and three times the individual measurement uncertainty.

Qualifier codes are shown in Table S5-4 to provide additional information on analytical results that meet the detection criteria but 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 ENV-WQH staff receive the analytical laboratory data packages, they receive secondary validation by an independent contractor, Analytical Quality Associates (AQA). The reviews by AQA include verifying, for example, 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.

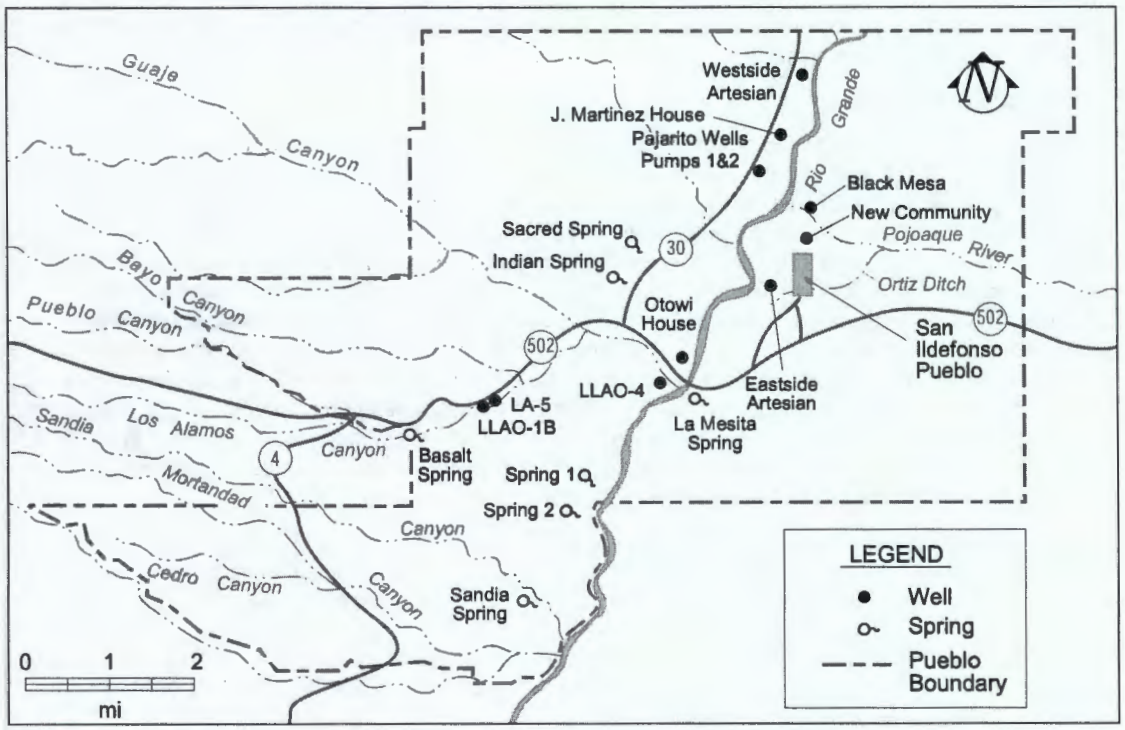


Figure 5-8. Springs and wells used for groundwater monitoring on San Ildefonso Pueblo.

Because gross alpha and gross beta are usually detected in water samples, Table S5-4 indicates occurrences of these measurements only above threshold values. The specific levels are 5 pCi/L for gross alpha and 20 pCi/L for gross beta and are lower than the EPA MCLs or screening levels. The right-hand columns of Table S5-4 indicate radiochemical detections that are greater than one-half of either the 100-mrem DOE DCGs for public dose for ingestion of environmental water or the other standards shown on the table. For gross alpha, the DCG assumes that the radioactivity comes solely from americium241 and plutonium-239,240; for gross beta, from strontium-90; thus, these values are for screening purposes and are conservative.

Table S5-8 in the Data Supplement lists the results of general chemical analyses of groundwater samples for 2004. Table S5-9 lists groundwater perchlorate results. We analyzed samples for perchlorate by two methods. This table includes all perchlorate results determined by liquid chromatography/mass spectrometry (LC/MS/MS) method [SW-846:8321A(M)] and all detections by ion chromatography perchlorate MDL (EPA:314.0). The value for the ion chromatography perchlorate MDL (EPA:314.0) is 4 ppb according to our independent analytical laboratory. The LC/MS/MS method [SW-846:8321A(M)] detection limit is 0.05 ppb, or larger if the sample had higher concentrations and was analyzed using sample dilution. In the latter case, the MDL is the dilution factor times 0.05 ppb. 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 groundwater contaminant distribution maps depict contaminants that exceed regulatory or risk levels. Rather than showing data for 2004 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. Within alluvial groundwater in canyons, the extent of contamination

lateral to the canyon is not to scale: contamination is confined to the alluvium within the canyon bottom and is quite narrow at the map scale.

1. Organic Sample Analysis

In 2004, ENV-WQH personnel analyzed samples from selected springs and monitoring wells for organic constituents. Table S5-11 in the Data Supplement summarizes stations sampled and organic suites for which samples were analyzed. These samples were analyzed for some or all of the following organic suites: volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls (PCBs), pesticides, diesel-range organics (DROs), and HEs. The Quality Assurance section of this chapter covers analytes and analytical methods. We rejected many of the possible organic detections 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 go along during sampling to determine if organic constituents come from sample transportation and shipment. Table S5-12 in the Data Supplement shows organic compounds detected above the analytical laboratory's reporting level in 2004, as well as results from field QC samples.

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.

Most analytical methods require the analysis of laboratory-prepared method blanks or instrument blanks with each batch of samples. Organic target analytes 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 WQH collected during this reporting period contained toluene, acetone, butanone[2-], and hexanone[2-], which suggests inadvertent sample contamination in either the field or analytical laboratory.

b. Pesticide Sample Contamination. In August 2004, ENV-WQH personnel identified several positive pesticide results, notably results for 4,4'-DDT and 4,4'-DDE, in LANL samples. These results were supported by neither previous data nor process knowledge at the sample locations. Subsequent examination of the analytical laboratory's (General Engineering Laboratory or GEL) data revealed that some glassware used in the process was only rinsed, with no further cleaning, between uses. This finding meant that pesticide contamination could be transferred from one sample to another during the sample preparation. As a result, all pesticide results for 2004 are considered unusable. See Section H.3 for more details about this issue.

2. Radioactivity in Groundwater

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 isotope decay chains, including isotopes of thorium and radium. Potassium-40 is also a source of natural radioactivity. In 2004, the only radioactivity values that exceeded half the 100-mrem DOE public dose DCG values in groundwater samples were results for gross alpha from two City of Santa Fe water supply wells. The gross alpha is from decay of natural uranium, and the DOE DCG does not apply because the radioactivity is not from a DOE source. The EPA MCL for gross alpha also does not apply, because that

standard does not include contribution of uranium to gross alpha; uranium is covered by a separate EPA MCL.

None of the radionuclide activities in perched alluvial groundwater were above the 100-mrem DOE DCG for public dose for ingestion of environmental water. For non-natural radioactivity, only results for strontium-90 from alluvial groundwater in Mortandad and DP/Los Alamos canyons were near or exceeded the 4-mrem DOE DCGs applicable to drinking water (but are not applicable to the alluvial groundwater itself, which is not a source of drinking water). The maximum 2004 strontium-90 values in Mortandad and DP/Los Alamos Canyon alluvial groundwater were also respectively 7.6 and 4.6 times the EPA MCL (Figure 5-9). Total LANL-derived radioactivity exceeded 4 mrem in Mortandad Canyon alluvial groundwater samples from MCO-3 (the highest at 2.14 times the 4-mrem DCGs), MCO-4B, MCO-5, and MCO-6 (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 screening level. Natural U-234 and U-238 values in Buckman well No. 2 exceeded the 4-mrem DOE DCGs applicable to drinking water.

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 2004, using this analytical method, about 16 groundwater results between 145 and 875 pCi/L are indicated as detections. Parallel analyses at a detection limit of 1 pCi/L provided results of nondetect for many of these samples, suggesting that the GEL MDAs are optimistic.

Seven samples (including a deionized water blank QC sample) produced high values of cesium-137 during 2004. After review, the analytical laboratory qualified these as nondetections.

3. Perchlorate in Groundwater

During the last decade, the EPA has recognized the potential for perchlorate toxicity at concentrations in the ppb range. The California Department of Public Health was instrumental in developing a new analytical method to measure perchlorate concentrations in this range for the first time, using ion chromatography. No EPA regulatory limit exists for perchlorate in drinking water, though several states have set limits in the range of 10 to 20 ppb, and California has a public health goal of 6 ppb. EPA Region VI has established a risk level of 3.7 ppb.

LANL and the New Mexico Environment Department (NMED) DOE Oversight Bureau (DOB) have found perchlorate in most groundwater samples analyzed from across northern New Mexico. The perchlorate concentrations in samples not affected by known contaminant sources range from about nondetect (<0.05 ppb) to 0.85 ppb. This result suggests that perchlorate has widespread occurrence in groundwater at concentrations below 1 ppb. A study reported in *Environmental Science and Technology* (EST 2003) found that perchlorate was present in 73% of 217 public water supply wells across a large portion of northwest Texas, with 35% at levels near or above 4 ppb. The presence of perchlorate did not appear to be related to any known anthropogenic perchlorate sources.

The NMED DOE Oversight Bureau's recent study concluded that a value of 0.6 ppb constituted an upper limit for background for naturally occurring perchlorate in local groundwater samples. Regardless of the merits of this study, the value of 0.6 ppb has some interesting ramifications. Water samples from most LANL locations show low perchlorate concentrations, but samples taken downstream from inactive perchlorate release sites show distinctly higher values. These two groups appear to be separated at about 0.6 ppb.

4. Metals in Groundwater

The occurrence in groundwater samples of most high metals values (compared with regulatory standards) are due to ubiquitous well-sampling-related issues rather than to LANL contamination. In some new LANL characterization wells, the use of fluids to assist well drilling led to temporary effects on chemistry of groundwater samples (Bitner 2004). With varying success, new wells undergo extensive well development to reduce the turbidity of water samples and to remove drilling fluids from the rock formations. Drilling fluid effects on water quality appear to linger longer in multiple completion wells than in single completion wells, as the latter can be developed more vigorously.

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

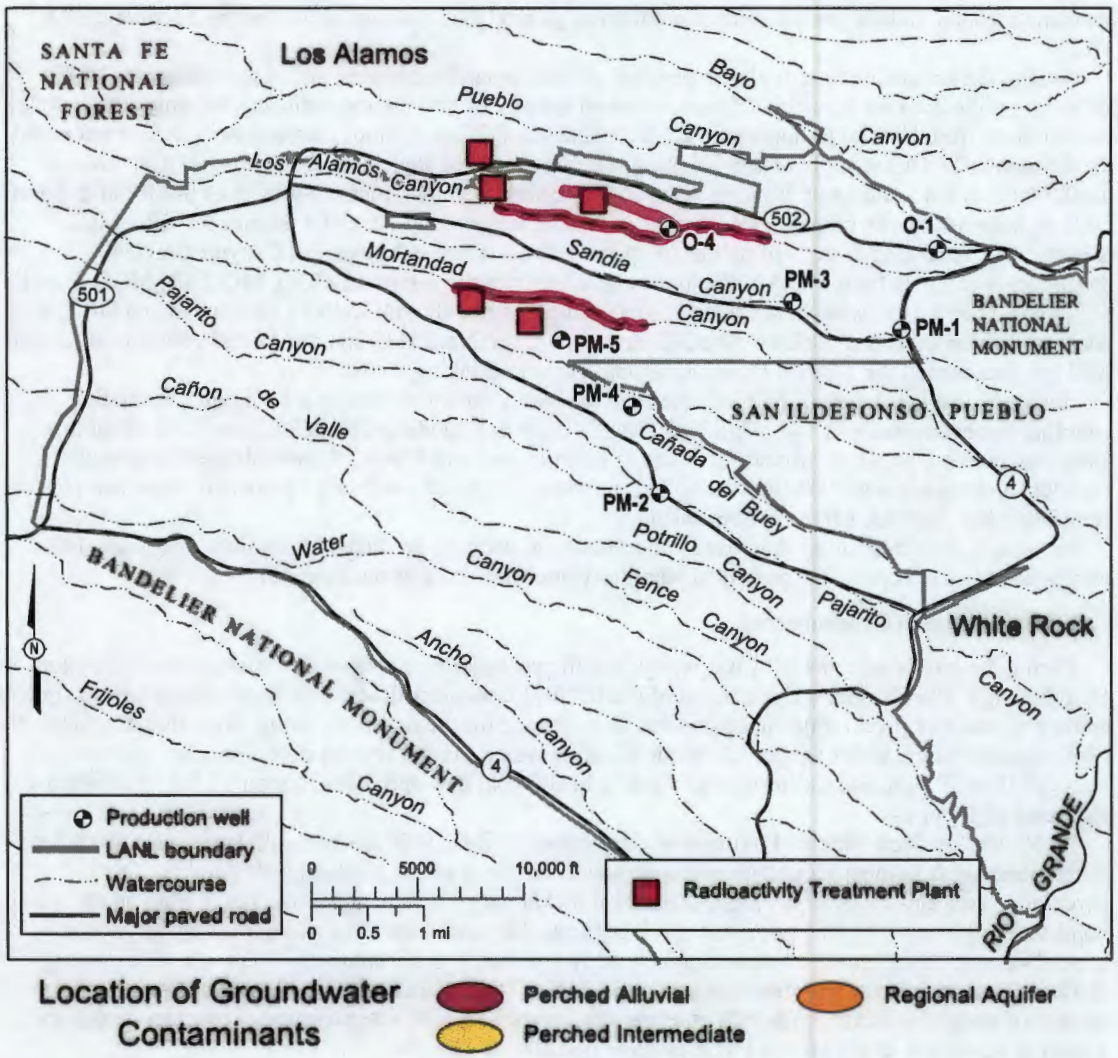


Figure 5-9. Location of groundwater contamination by Sr-90 above the 8 pCi/L EPA MCL. The maximum 2004 values in Mortandad and DP/Los Alamos Canyon alluvial groundwater were 7.6 and 4.6 times the MCL, respectively. Different colors indicate the affected groundwater zones. Along canyons, the extent of 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.

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 temporary effect of the drilling fluids on the region near the well (Bitner 2004). The unusual presence of nickel, chromium, and other trace metals in samples from new characterization wells is also attributed to the low oxidation state.

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 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 of soil material).

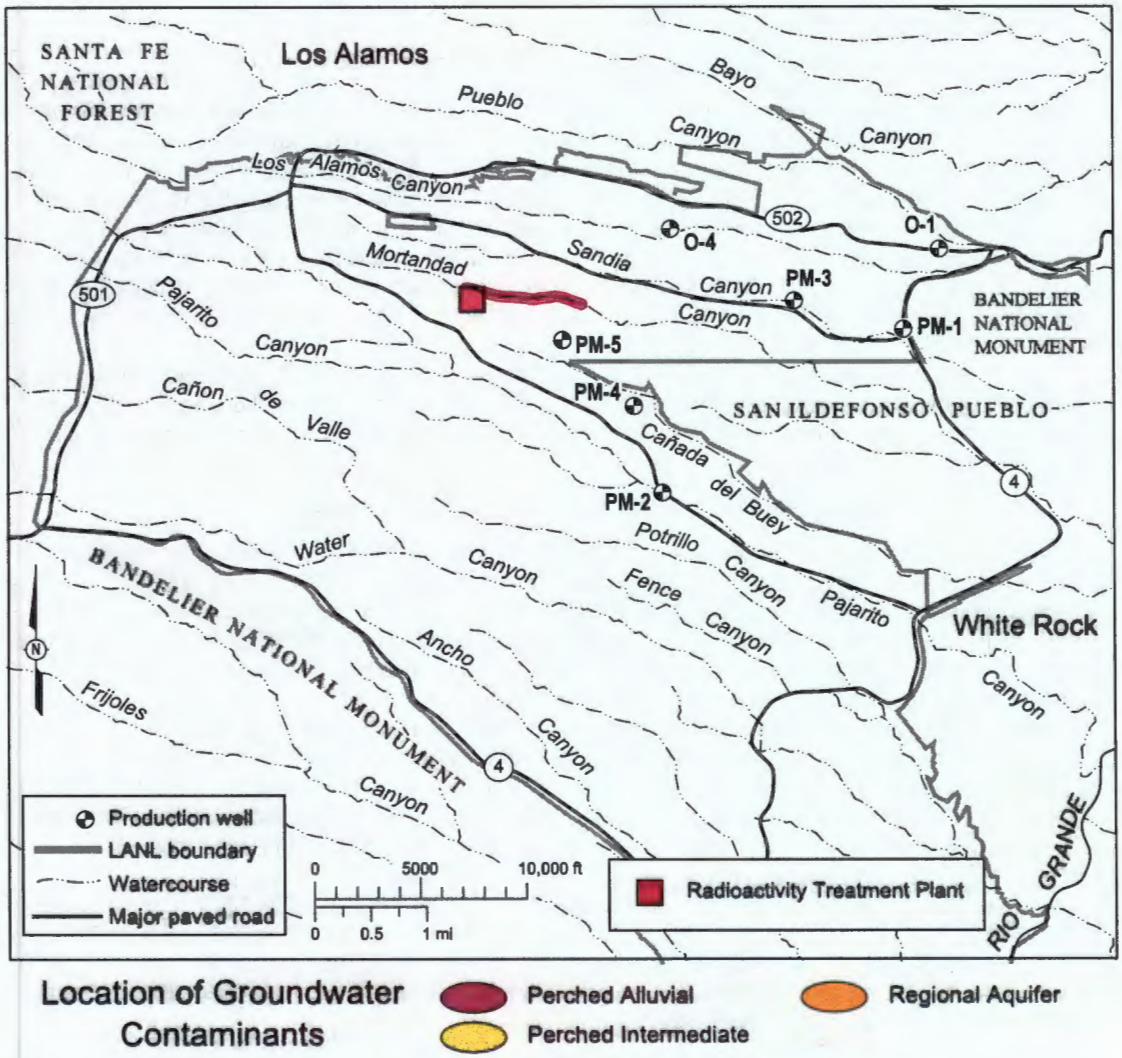


Figure 5-10. Location of groundwater contamination by the sum of Sr-90, Pu-238, Pu-239,240, and Am-241 above the 4-mrem DOE DCG for drinking water. The 2004 maximum values in Mortandad Canyon alluvial groundwater for Sr-90, Pu-238, Pu-239,240, and Am-241 were 1.53, 0.35, 0.35, and 0.47 times the 4-mrem limit, respectively. Different colors indicate the affected groundwater zones.

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. The highest values were in Ancho Spring (9.3 µg/L) and several other regional aquifer wells and springs. The selenium is apparently of natural origin. Selenium concentrations in surface water, for example, increased substantially after the Cerro Grande fire as a result of ash content in the water, but have fallen in recent years.

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). Tritium was detected in analyses of the same samples using liquid scintillation (with an MDA of about 200 pCi/L), indicating a lack of precision for that method near the MDA. Groundwater with 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-2A had arsenic at about 20% of the EPA MCL of 50 ppb. For the new MCL of 10 ppb which will be effective in 2006, this value would be 99% of the MCL. Using the LC/MS/MS method, perchlorate was found in each well at concentrations ranging from 0.27 to 0.43 ppb, which is consistent with background levels.

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 may show small but lingering influence of discharges from radioactive wastewater outfalls in Acid Canyon. High nitrate found in groundwater may be due to sanitary effluent from the Los Alamos County Bayo Sewage Treatment Plant.

Eight low-detection-limit tritium results for supply well O-1 averaged 43.9 pCi/L, indicating a subdued effect of past tritium-bearing surface water recharge on tritium activity at the regional aquifer. Eight O-1 samples showed perchlorate at an average of 2.6 ppb using the LC/MS/MS method (Figure 5-11), and O-1 also has above-background nitrate (Figure 5-12). Because of a leaking fuel tank found at Technical Area (TA) -21 during 2002, well O-1 was tested three times for DROs; the DRO compound was found at a low level only in January 2004 but not in other samples, suggesting a false positive.

Test Well 1 (near O-1) showed nitrate (as nitrogen) at 48% of the 10-mg/L EPA MCL in the regional aquifer (Figure 5-12). Past Test Well 1 samples have shown tritium at 277 pCi/L to 360 pCi/L. In 2004, a Test Well 1 sample showed 118 pCi/L, in line with earlier data (and confirming a sample mix-up in 2003). Test Well 1 also had 1.6 ppb of perchlorate. Other low-detection-limit tritium values in Pueblo Canyon included 23 pCi/L in intermediate well POI-4.

Test Well 1 has 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 Well 1 showed high levels of aluminum, iron, manganese, and lead in 2004.

Alluvial well APCO-1 had strontium-90 at 8% of the 8-pCi/L EPA MCL as well as detectable plutonium-239,240 as in prior years. Nitrate (as nitrogen) in this well was 110% of the NM groundwater limit, likely because of sanitary effluent from the Bayo Sewage Treatment Plant. APCO-1 shows the effects of high turbidity by high aluminum and iron, much of these apparently colloidal. This well also has high manganese as well as nitrate, phosphate, fluoride, turbidity, and total suspended solids; the solutes indicating the influence of sanitary effluent from the Bayo Sewage Treatment Plant. Higher organic content of the effluent or the well's location in marshland may result in anoxic groundwater conditions, resulting in higher concentrations of dissolved or colloidal manganese. A sample from Pueblo Canyon alluvial groundwater (APCO-1) had a perchlorate value below 0.6 ppb.

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.

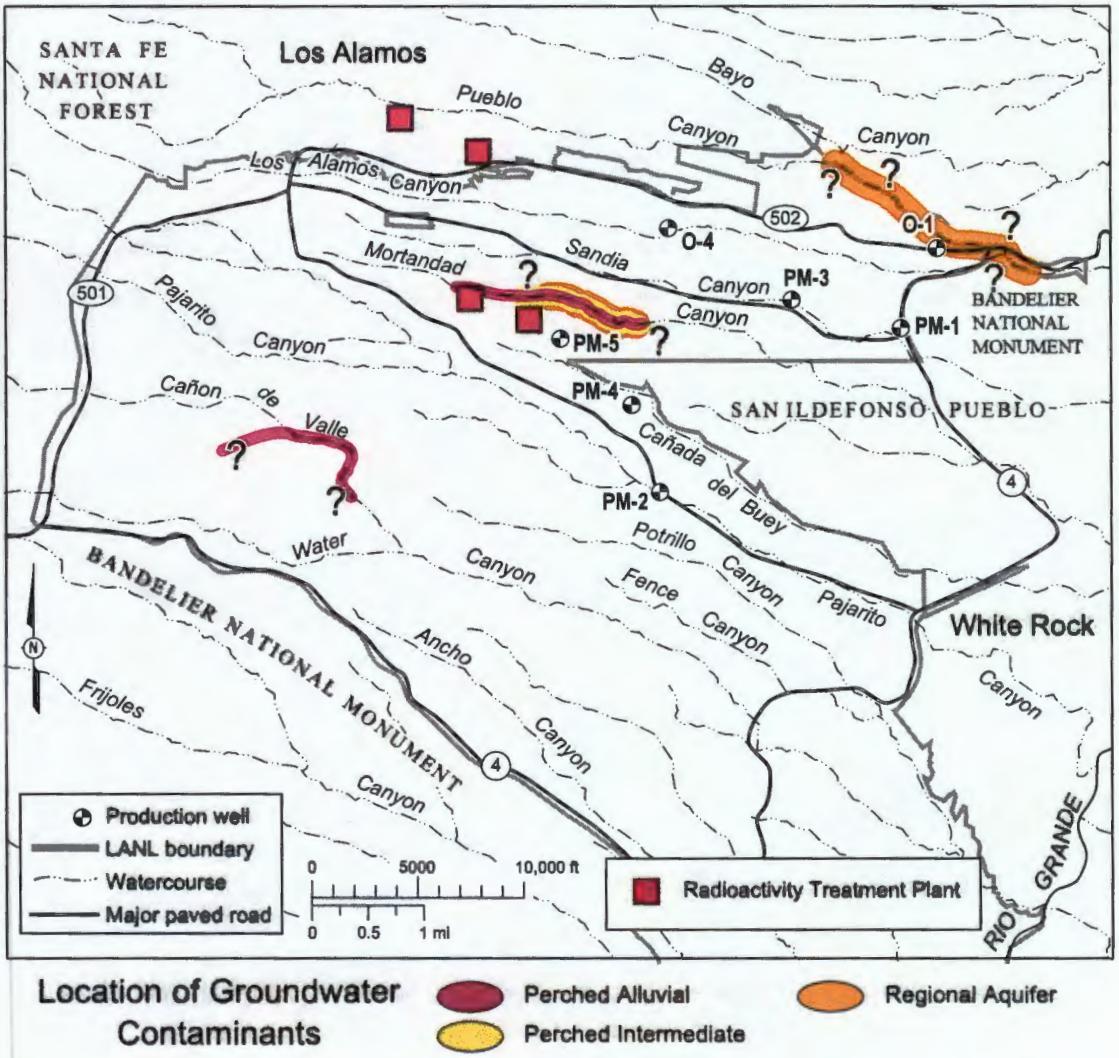


Figure 5-11. Location of groundwater contamination by perchlorate above the 3.7 ppb EPA Region VI risk level. Maximum values in Mortandad Canyon were 99 ppb in alluvial groundwater during 2004 and 142 ppb in intermediate groundwater during 2002. In Pueblo Canyon, regional groundwater the maximum was 3.0 ppb using the LC/MS/MS method. 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.

Alluvial groundwater in DP and Los Alamos canyons continues to show strontium-90 at up to 4.6 times the 8-pCi/L EPA MCL (Figure 5-9). The strontium-90 value in LAO-3A was also 90% of the 4-mrem DOE DCG for drinking water dose. A few other LANL-derived radionuclides were found in alluvial groundwater at values well below the 4-mrem DCGs. Tritium levels in alluvial groundwater in these two canyons have fallen sharply since the cessation of discharges. In Los Alamos Canyon alluvial groundwater, 1 pCi/L upstream of the former Omega West Reactor to 208 pCi/L downstream of DP Canyon. Intermediate groundwater values were 8 pCi/L at LAOI(A)-1.1, 250 pCi/L at R-9i, and 48 pCi/L at Basalt Spring. R-9 in the regional aquifer showed 16 pCi/L and O-4 showed 1.5 pCi/L, whereas results from other regional wells (R-7, TW-3, and LA-5) were nondetections. Duplicates, reanalyses, and other samples from O-4 were nondetections.

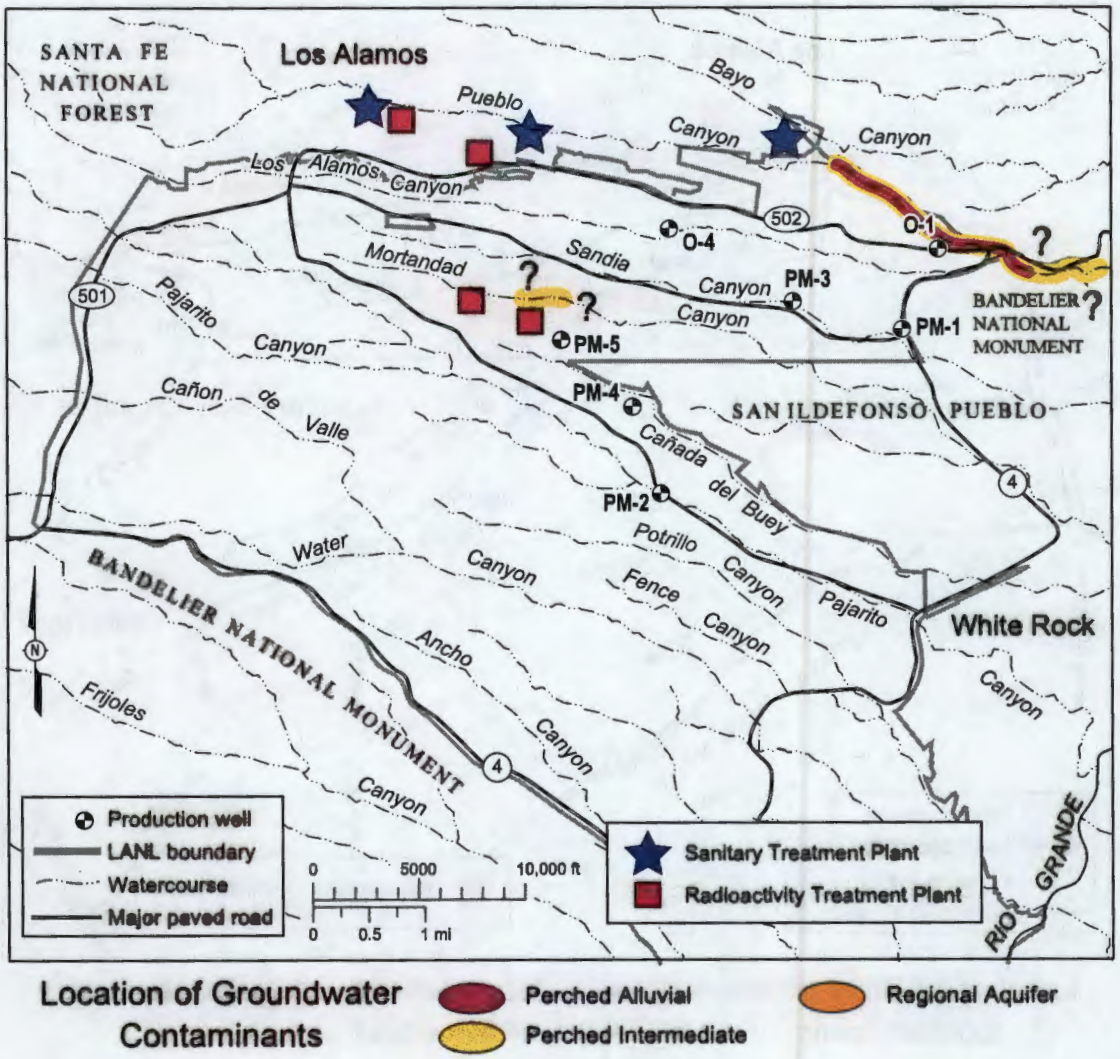


Figure 5-12. Location of groundwater contamination by nitrate (as nitrogen) above the 10 mg/L EPA MCL. Maximum values in Mortandad Canyon were 74% of the MCL in alluvial groundwater during 2004 and 132% of the MCL in intermediate groundwater during 2002. In Pueblo Canyon, maximum values in alluvial and intermediate groundwater and the regional aquifer were 116%, 79%, and 48% of the MCL. Pueblo Canyon values have ranged to 100% of the MCL in recent years. 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.

In Lower Los Alamos Canyon, the maximum nitrate (as nitrogen) value in intermediate groundwater was 79% (Basalt Spring) of the EPA MCL, likely because of sanitary effluent from the Los Alamos County Bayo Sewage Treatment Plant.

In Los Alamos Canyon alluvial groundwater, the perchlorate concentration in LAO-C, which is upstream from most LANL sources, was 0.1 ppb. Values from LAO-2 and LAO-3A range from 0.64 to 0.72 ppb, and may show a residual effect from past discharges that entered DP Canyon from TA-21. A little farther downstream, LAO-4.5C shows 0.25 ppb of perchlorate. Intermediate groundwater values were 0.15

ppb at LAOI(A)-1.1, not detected at R-9i, and 0.7 ppb at Basalt Spring. In the regional aquifer, perchlorate was not detected at R-7 or TW-3, was 0.98 ppb at R-9, and was about 0.37 ppb at O-4 and LA-5.

Metals concentrations in alluvial wells and some intermediate and regional wells in Los Alamos Canyon showed the effect of turbidity, with relatively high values of aluminum and iron. Wells R-7, R-9, and R-9i showed high levels of iron and manganese reflecting lingering influence of drilling fluid on quality of water samples. As with other older monitoring wells, Test Well 3 has high iron, lead, and manganese because of aging steel and galvanized well components. In Los Alamos Canyon, molybdenum in LAO-2 was 105% of the NM Groundwater Limit and in LAO-3A was at 70% of the Limit (Figures 5-13 and 5-14). The molybdenum comes 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.

No organic compounds other than those related to sampling or analysis artifacts were found in Los Alamos Canyon groundwater samples.

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives water from the cooling tower at the TA-3 power plant. Treated effluents from the TA-46 Sanitary Wastewater Systems (SWWS) Plant are rerouted to Sandia Canyon.

Well R-12 at the eastern Laboratory boundary had low levels of tritium in two intermediate zones (2 to 5 pCi/L) and the regional aquifer (1.6 pCi/L), indicating a slight effect on these horizons by recent recharge. Samples from supply well PM-1 showed no tritium using the 1 pCi/L detection limit. Analyses for some samples from PM-3 detected tritium, whereas reanalyses of those samples and results from other samples were nondetections.

In Sandia Canyon, perchlorate values at R-12 in the regional aquifer were nondetects or just above the MDL. Values in supply wells PM-1 and PM-3 were about 0.42 ppb, similar to prior results.

Several R-12 samples had high iron or manganese (in the range of EPA MCLs), a temporary result of well construction (Longmire 2002b). The supply wells were tested for DROs and for HE; none of these compounds were detected.

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. 2004 Radioactive Liquid Waste Treatment Facility Discharges. RLWTF's yearly radionuclide discharge data into Mortandad Canyon from 2002 through 2004 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. Figure 5-15 shows the relationship of RLWTF average annual radionuclide activities and mineral concentrations in discharges to DOE DCGs or New Mexico groundwater standards since 1996. The 2004 discharges from the RLWTF met all DOE and New Mexico requirements. The RLWTF has met all DOE radiological discharge standards for five consecutive years; has met all NPDES requirements for five consecutive years; and has met NM groundwater standards for fluoride, nitrate, and total dissolved solids (TDS) for all but two weeks of the past five years. Two weekly composite samples exceeded the fluoride standard in 2003. A new reverse osmosis and ultrafiltration system began operating at the RLWTF in April 1999. This system removes additional radionuclides from the effluent so that the discharges meet the DOE DCGs for public dose. Americium-241; plutonium-238; and plutonium-239,240 in the discharge have not exceeded the public dose DCGs since December 1999. At

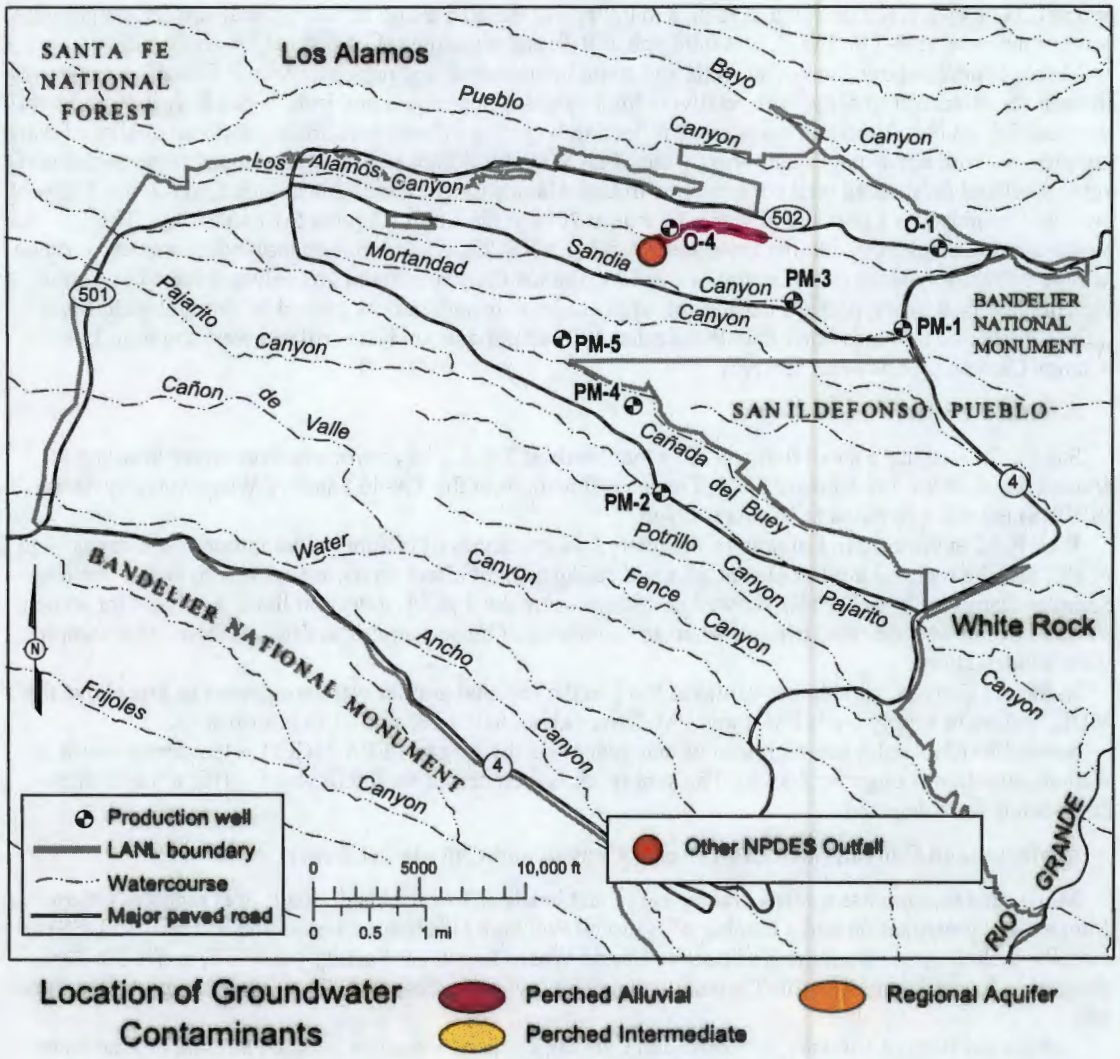


Figure 5-13. Location of groundwater contamination by molybdenum above the 1 mg/L New Mexico Groundwater Standard for Irrigation Use. The maximum 2004 value in Los Alamos Canyon alluvial groundwater was 105% of the groundwater standard. Different colors indicate the affected groundwater zones.

the end of 2000, the RLWTF adopted a voluntary goal to keep tritium activity in its effluent below 20,000 pCi/L. This limit is the EPA MCL and is also 1% of the public dose DCG. Whenever possible, effluent with tritium above 20,000 pCi/L is segregated and trucked to the TA-53 RLWTF evaporation basins for evaporation. Since 2000, tritium activity in the effluent has been below 20,000 pCi/L.

During 2004, 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 5-16). The average 2004 effluent total nitrate + nitrite (as nitrogen) concentration was 4.5 mg/L. In 2004, the nitrate concentration in Mortandad Canyon base-flow grab sample from the surface water station Mortandad below Effluent Canyon was 13.5 mg/L.

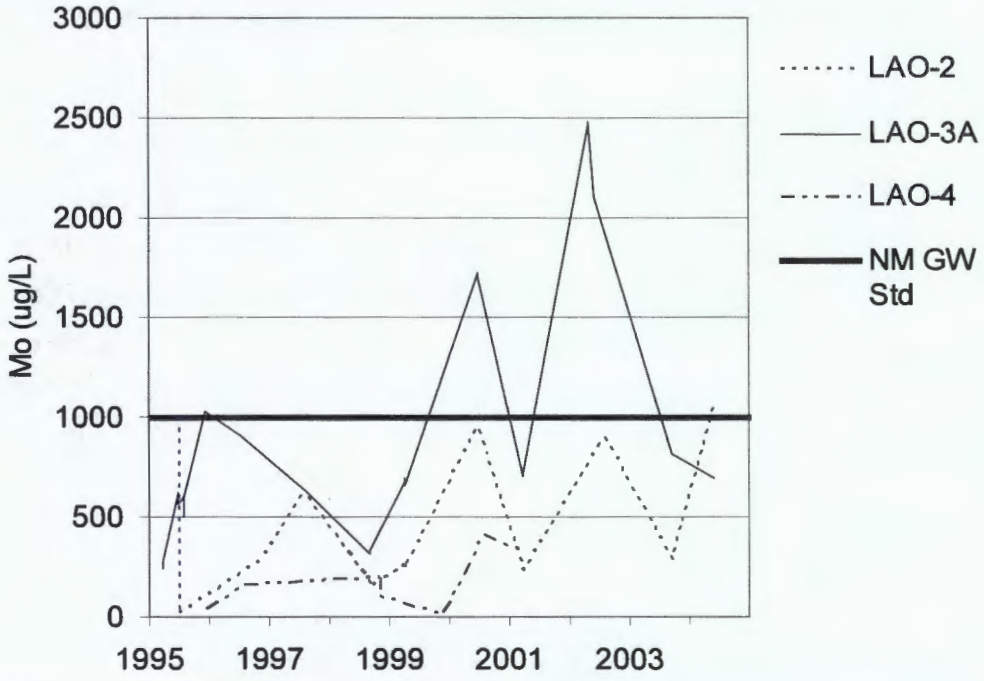


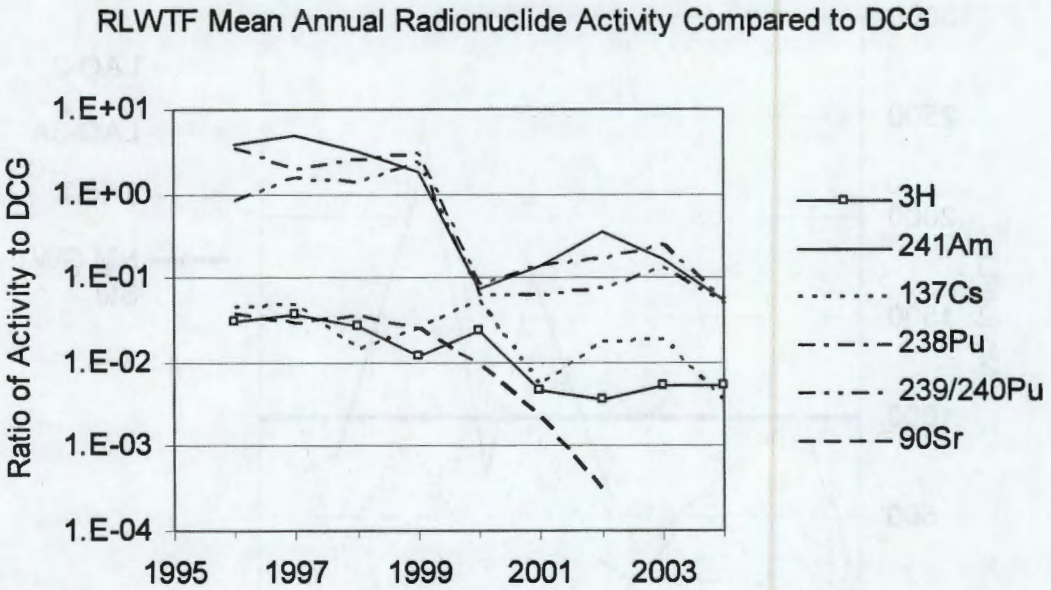
Figure 5-14. Molybdenum histories in Los Alamos Canyon alluvial groundwater compared with the New Mexico groundwater standard.

The fluoride concentration in the discharge has also declined over the last few years. The 2004 effluent fluoride concentration (average value of 0.19 mg/L) was below the New Mexico groundwater standard of 1.6 mg/L. In 2004, the fluoride concentration in Mortandad Canyon at the surface water station Mortandad below Effluent Canyon was 0.44 mg/L.

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. RLWTF annual perchlorate discharges in 2000, 2001, and 2002 were 4.74 kg, 2.29 kg, and 0.175 kg, respectively. For 2003 and 2004, the annual perchlorate discharge was effectively zero. The resulting annual average effluent concentrations in 2000, 2001, and 2002 were 254 µg/L, 169 µg/L, and 16 µg/L, respectively, with none detected in 2003 or 2004. This low value in TW-8 confirms the long trend for that well and a sample mix-up in 2003. No tritium was detected in R-13.

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer. The regional aquifer beneath Mortandad Canyon shows a slight impact of past LANL discharges; intermediate groundwater shows a larger effect. Regional aquifer wells TW-8 had 6 pCi/L of tritium, and R-15 averaged 23 pCi/L. Regional aquifer perchlorate values in Test Well 8 and R-13 were 0.35 ppb and 0.40 ppb. Perchlorate in R-15 was around 6 ppb (Figure 5-11), indicating an impact of recharge from shallow groundwater on the regional aquifer (no MCL, EPA Region VI risk level of 3.7 µg/L, which corresponds to HI = 1).

In 2002, initial results from new well MCOBT-4.4, drilled to an intermediate perched zone, showed several contaminants at concentrations of concern (Broxton et al., 2002a). No additional data were collected in 2003 or 2004 because of mechanical problems with the well. Because of well design problems, the well is under evaluation for plugging and abandonment and replacement. In 2002, the 500-ft-deep intermediate perched zone sample found about 13,000 pCi/L of tritium (MCL of 20,000 pCi/L), 13.2 mg/L of nitrate (as nitrogen, MCL 10 mg/L, Figure 5-12), and 142 µg/L of perchlorate (Figure 5-11).



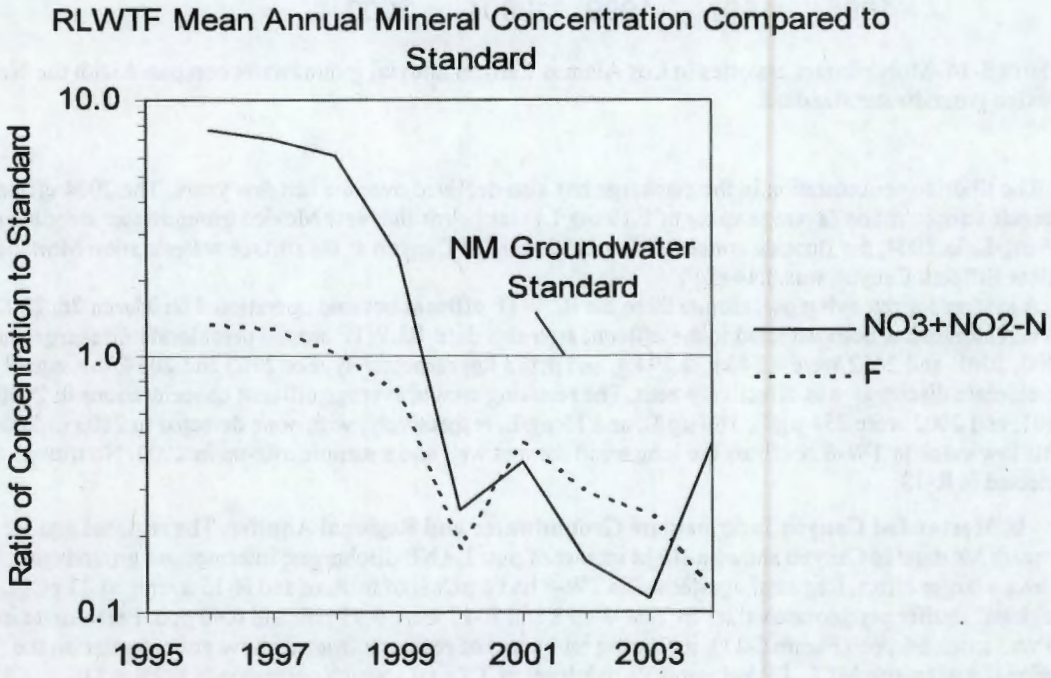


Figure 5-15. Ratio of 1996–2004 average annual radionuclide activity and mineral concentration in RLWTF discharges to the 100-mrem public dose DOE DCGs or New Mexico groundwater standards.

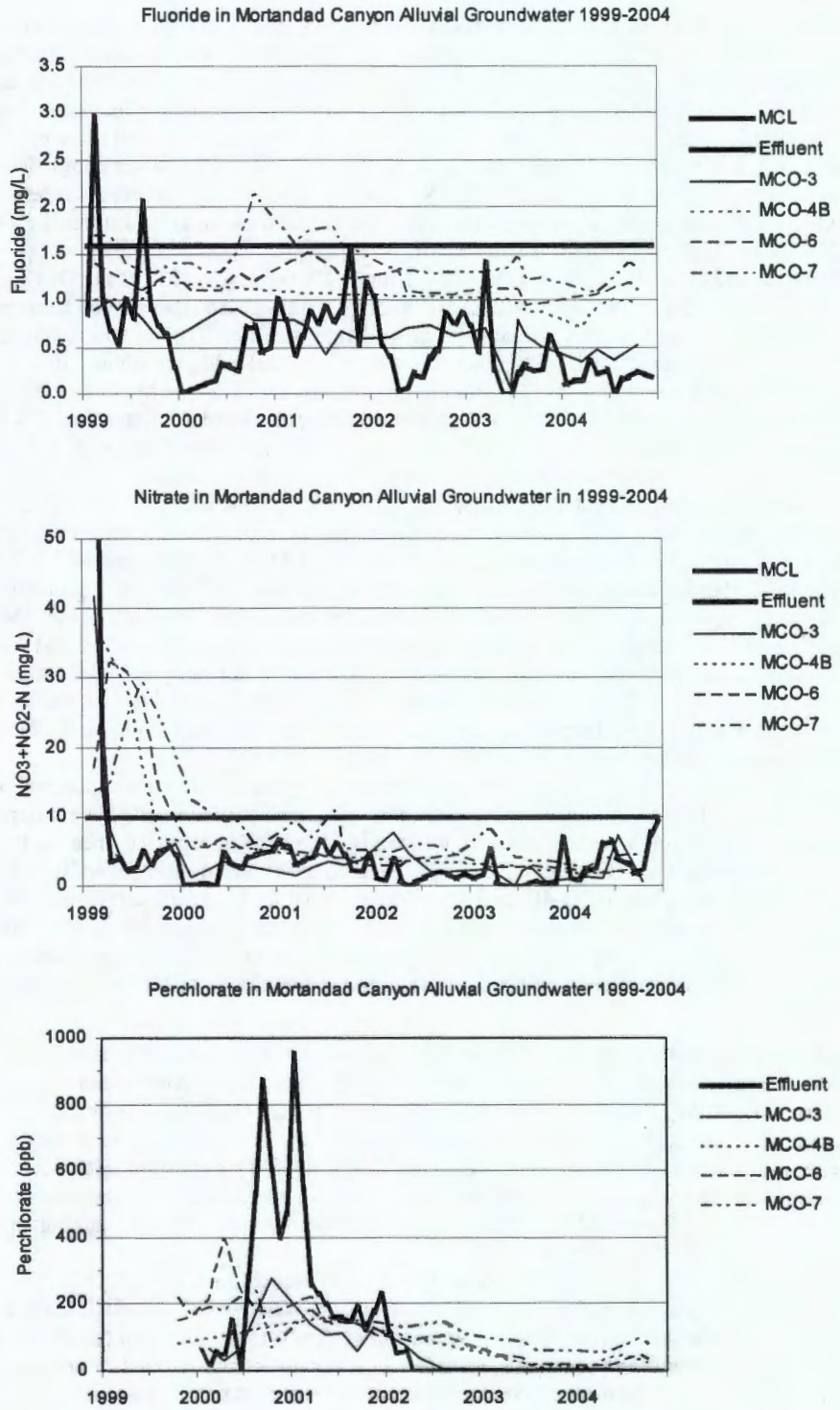


Figure 5-16. Fluoride, nitrate, and perchlorate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2004.

c. Alluvial Groundwater. Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest nearest to the TA-50 RLWTF outfall at well 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 usually exceed EPA drinking water criteria in many of the wells. In past years, the individual levels of strontium-90, plutonium-238, plutonium-239,240, and americium241 have exceeded the 4-mrem DOE drinking water DCGs, but have not recently exceeded the 100-mrem DOE DCGs for public dose for ingestion of environmental water. In 2004, total LANL-derived radioactivity exceeded 4 mrem in Mortandad Canyon alluvial groundwater samples from MCO-3 (the highest, at 2.14 times the 4-mrem DCGs), MCO-4B, MCO-5, and MCO-6 (Figure 5-10).

In 2004, americium241 at MCO-3 was 47% of the 4-mrem DCG but was 13% of the DCG at MCO-4B and 13% to 20% of the DCG at MCO-5, MCO-6, and MCO-7. Gross beta values ranged from more than 90% to 300% of the EPA screening level in alluvial groundwater samples. Tritium was found at activities ranging from 12% to 20% of the MCL of 20,000 pCi/L. Plutonium-238 and plutonium-239,240 at MCO-3 were each at 35% of the 4-mrem DOE DCGs. Plutonium-238 was also found at MCO-5 at 2% of the 4-mrem DCGs. Strontium-90 at MCO-4B was 1.5 times the DOE DCG and 7.6 times the EPA MCL (Figure 5-9). strontium-90 activity at MCO-3, MCO-5, and MCO-6 also exceeded the DOE DCG and the EPA MCL.

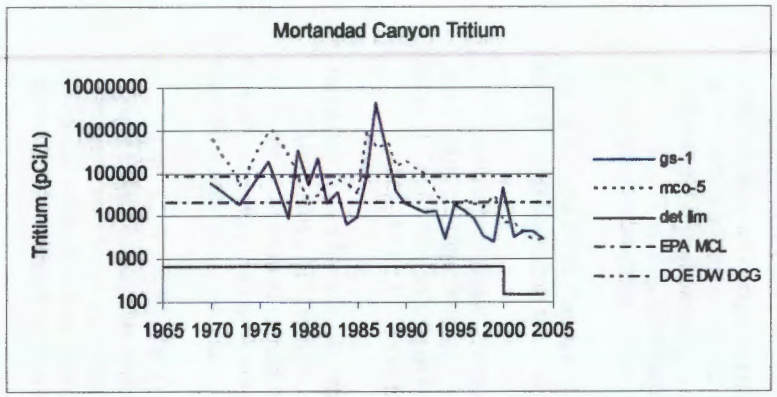
Under the Laboratory's groundwater discharge plan application for the RLWTF, ENV-WQH collected separate quarterly samples for nitrate, fluoride, perchlorate, and total dissolved solids during 2004 from four alluvial monitoring wells in Mortandad Canyon: MCO-3, MCO-4B, MCO-6, and MCO-7. Nitrate concentrations in Mortandad Canyon alluvial groundwater were below the NMWQCC groundwater nitrate standard of 10 mg/L (as nitrogen; Figure 5-16), and fluoride concentrations were below the NMWQCC groundwater standard of 1.6 mg/L. MCO-3 had nitrate (as nitrogen) at about 74% of the NMWQCC groundwater standard. All of the Mortandad Canyon alluvial groundwater samples had fluoride concentrations ranging from 60% to 90% of the New Mexico groundwater standard. As shown in Figure 5-16, the nitrate (as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 have been less than the New Mexico groundwater standards.

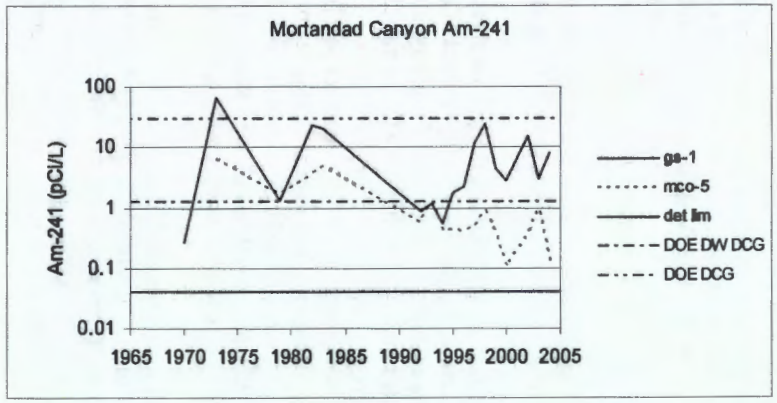
Mortandad Canyon alluvial groundwater samples had the highest perchlorate concentrations found at LANL (Figures 5-11 and 5-16). Alluvial groundwater concentrations of perchlorate have dropped following the reduction of perchlorate in RLWTF effluent in March 2002, especially nearest the outfall. The recent concentrations at MCO-3 were up to 5 ppb. Perchlorate concentration generally increased downstream, from 8 to 43 ppb at MCO-4B, and 52 to 99 ppb 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. For organic analyses, only dichlorobenzene[1,4-] and dichlorobenzene[1,3-] were found in samples from MCO-3 at values less than 1% of EPA MCLs.

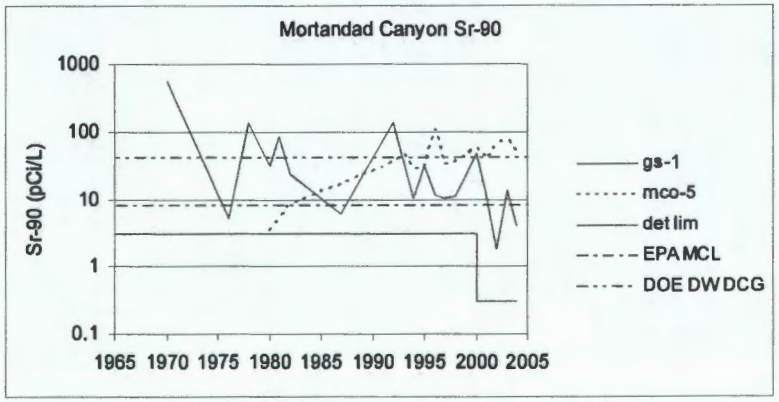
d. Long-Term Radioactivity Trends. Figure 5-17 depicts long-term trends of radionuclide concentrations in surface water and shallow perched alluvial groundwater in Mortandad Canyon downstream from the RLWTF outfall at TA-50. The figure shows only radionuclide detections. If more than one sample was collected in a year, the average value for the year is plotted. The surface water samples are from the station Mortandad Below Effluent Canyon (GS-1), a short distance downstream from the outfall. Radioactivity levels at this station vary daily depending on how soon individual samples are collected after a release from the RLWTF. These samples also vary in response to changing amounts of runoff from other sources in the drainage.

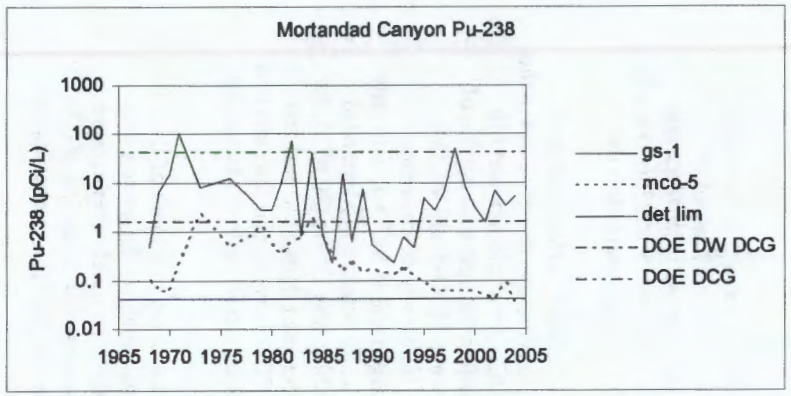
The groundwater samples are from observation well MCO-5 in the middle reach of the canyon. Groundwater radioactivity at MCO-5 is more stable than surface water sampled at station Mortandad Below Effluent Canyon because groundwater responds more slowly to variations in runoff water quality. Because of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

Chemical reactions such as adsorption do not delay tritium transport, so tritium activity is usually relatively uniform throughout the alluvial groundwater. Tritium activities within the Mortandad Canyon alluvial groundwater have been below the EPA MCL since 2001 (Figure 5-17). 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.









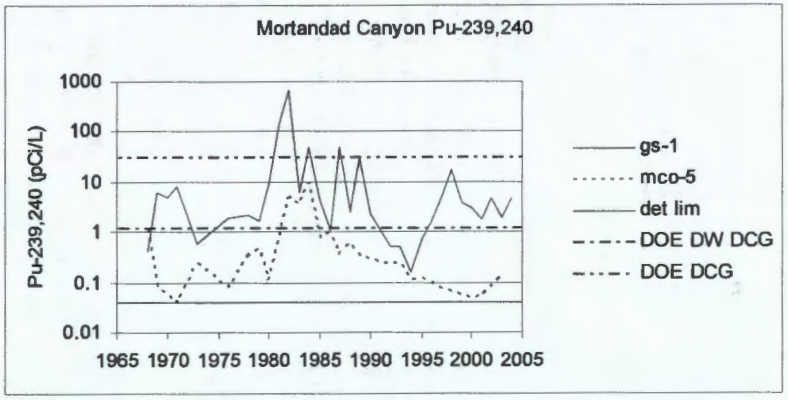


Figure 5-17. Average annual radioactivity in Mortandad Canyon surface water and alluvial groundwater.

Before 1990, americium241 activity was not measured regularly at monitoring stations in Mortandad Canyon. For most years up to 1999, the americium241 activity of RLWTF discharges exceeded the 100-mrem DOE DCG for public dose of 30 pCi/L. In the last few years, americium241 in surface water nearest the outfall has been just below the 100-mrem DOE DCG, whereas in the groundwater it is closer to the 4-mrem DCG. americium241 in alluvial groundwater downstream at MCO-5 has been below the 4-mrem DOE DCG.

In 2004, strontium-90 was detected in surface water at Mortandad below Effluent Canyon and in all alluvial groundwater observation wells down to MCO-7. The strontium-90 activities remain at values in the range of the EPA drinking water standard (8 pCi/L) and the 4-mrem DOE DCG for drinking water (40 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 at Mortandad below Effluent Canyon and at MCO-3, with only plutonium-238 detected at MCO-5 in 2004. Both isotopes have been historically detected at Mortandad below Effluent Canyon and at MCO-3 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 did not operate much during 2004 and had no sample events. Analyses for some samples from PM-5 detected tritium, although reanalyses of those samples and results from other samples were nondetections. Six analyses for perchlorate in samples from PM-5 had an average concentration of 0.34 ppb, 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 2004 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 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 2004, 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 0.29 ppb, similar to prior data. No HE compounds were detected in the well.

Regional aquifer well R-22 lies just east of MDA G, the low-level radioactive waste management facility. In 2004, R-22 showed tritium at 2–3 pCi/L in the uppermost of five regional aquifer ports. These results are consistent with previous sampling observations. Prior sampling found tritium at 13 pCi/L in the deepest port, which was not sampled in 2004. Perchlorate was not detected in ports 1 and 4, and concentrations in ports 2 and 3 were 0.32 ppb and 0.21 ppb.

Of the seven sampled ports of monitoring well R-19, the upper port is dry, the second port is within an intermediate perched zone, and the remaining five ports are in the regional aquifer. The perchlorate concentration in the intermediate port was 0.30 ppb. Concentrations of perchlorate in the upper two regional aquifer ports were about 0.25 ppb, and 0.06 ppb were detected in the deepest regional aquifer port. These values indicate no influence of recent groundwater recharge on water samples, consistent with other R-19 data.

High concentrations of iron and manganese (in the range of EPA MCLs) in R-19 and R-22 are a temporary effect of well construction (Longmire 2002c, 2002d). Samples from two ports in R-19 found bromoform and phthalate compounds at low concentrations; the latter are common contaminants from sampling and analysis processes. In R-22, sampling for volatile organic compounds and semivolatile organic compounds again found isopropyl benzene, in port 1. This compound was found in port 1 during

the third and fourth characterization sampling rounds and in port 5 on the fourth round. Isopropyl benzene may be a temporary result of drilling fluids used (Longmire and Goff 2002). Phthalate compounds were also found in some samples.

ENV-WQH personnel sampled six springs in the Upper Pajarito Canyon drainage. TA-18 Spring is an alluvial spring, and 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. Four of the springs had perchlorate concentrations between 0.15 ppb and 0.25 ppb, but Keiling and Bulldog Springs had perchlorate concentrations of 0.86 ppb and 1.09 ppb. All of the springs showed some of the metals (aluminum, iron, manganese) reflecting high turbidity, and several had background selenium above the NM Wildlife Habitat standard. Three springs showed traces of acetone (no regulatory standard). Bulldog Spring samples contained HMX and RDX, the latter at 83% of the EPA tap water screening level of 6.1 µg/L (corresponding to 10^{-5} excess cancer risk).

No alluvial wells were sampled in Pajarito Canyon in 2004 because of lack of water in the alluvium.

6. Water Canyon (Includes Cañon de Valle, Potrillo and Fence, 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 5-18), and RDX above 6.1 ppb, 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 ppb (Figure 5-19). The Potrillo, Fence, and Indio canyon watersheds contain several open-burning/open-detonation and firing sites used for open-air testing of weapons systems.

R-25, located down-gradient from a former HE wastewater outfall, has four ports in a large intermediate perched zone and four in the regional aquifer (Broxton et al., 2002b). Port 5 at a depth of 1,309 ft is the uppermost regional aquifer port. The intermediate port at 1,063 ft only yielded water during the first of 4 characterization sampling events. The Laboratory completed installation of the well casing in May 1999, and installed the Westbay packer system in October 2000. During the intervening 17 months, the well casing stayed open, allowing commingling of water between the eight screens. This mixing of water from different groundwater zones temporarily obscured the original water quality differences between the zones. Several key constituents (tritium, chlorinated solvents, and HE compounds) apparently were introduced into regional aquifer screens during the 17 months before packer installation. Concentration histories now available for six or seven sampling episodes from the ports indicate that concentrations for these analytes have decreased or stabilized over time. These sampling results indicate that several of these constituents are present in the regional aquifer only at very low levels, if at all.

Four main constituents of concern were found in intermediate and regional aquifer samples at some time during sampling of R-25 (ESP 2002; Longmire 2005). Two constituents were the HE compounds RDX and TNT, and two were the organic chlorinated solvents tetrachloroethene (tetrachloroethylene, perchloroethylene or PERC) and trichloroethene (or trichloroethylene or TCE). Samples collected in 2004 from the uppermost intermediate port showed several of these constituents at concentrations near EPA MCLs or EPA Region VI tap water screening levels. None of the four compounds was detected in samples from the uppermost regional aquifer port in 2004.

Tritium histories for the ports indicate that tritium activities in the intermediate perched zone (ports at depths 754 ft to 1,192 ft) have stabilized at values ranging from 30 pCi/L to 55 pCi/L (ESP 2004). This result suggests that groundwater mixing during well construction no longer affects tritium activity in the groundwater surrounding these ports. The tritium activity in the uppermost regional port at 1,309 ft has stabilized at approximately 15 pCi/L, and activities in the deepest three regional aquifer ports have continued to fall toward background values. The tritium activity in the intermediate and uppermost regional ports show the effect of past recharge from surface water and the overlying intermediate perched groundwater, whereas deeper regional ports appear to be isolated from surface recharge originating near

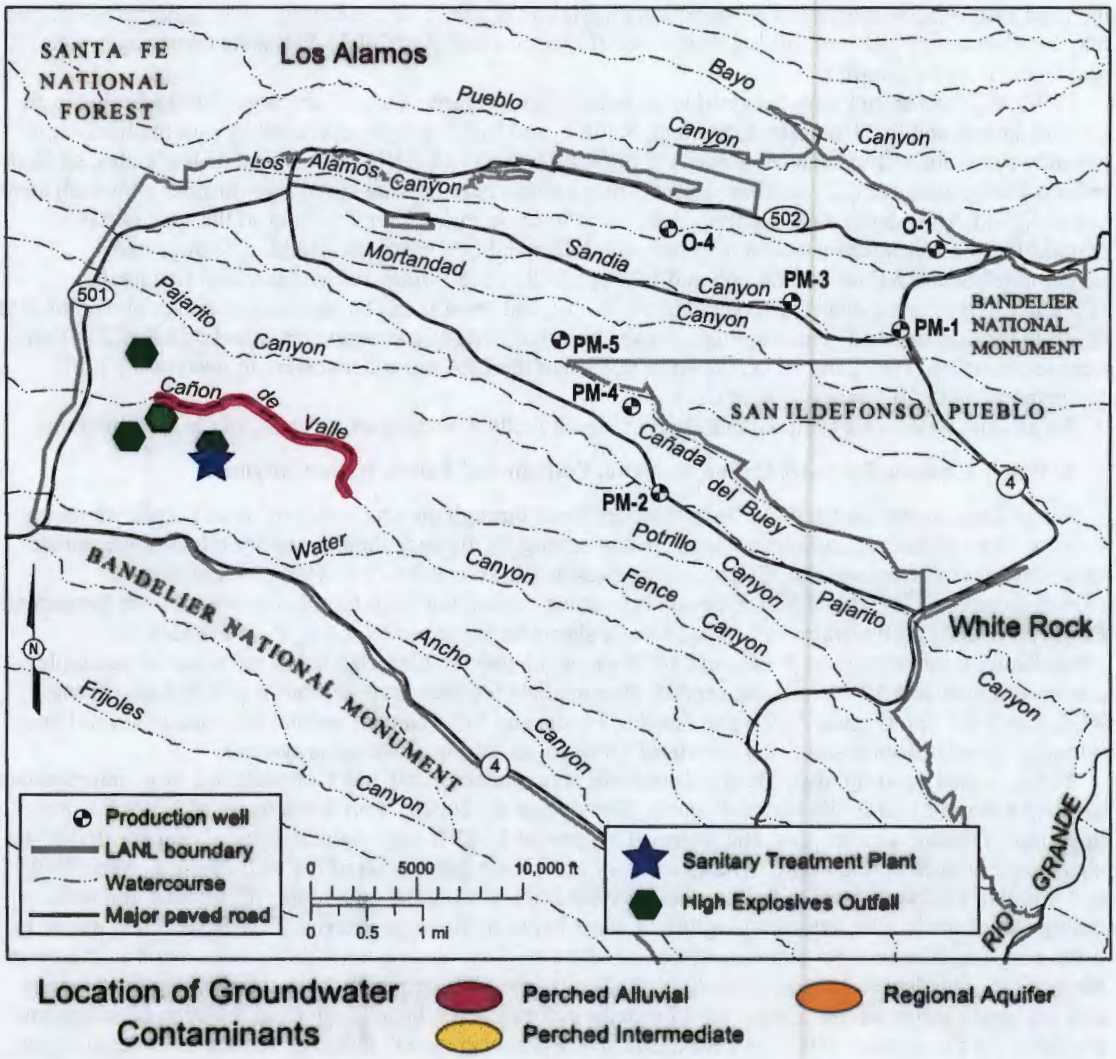


Figure 5-18. Location of groundwater contamination by RDX above the EPA Region VI screening level of 6.1 ppb and barium above the New Mexico groundwater standard of 1 mg/L in perched alluvial groundwater. This map is based on data obtained by the Environmental Restoration Project. Different colors indicate the affected groundwater zones.

this location. In 2004, R-25 samples showed 42 pCi/L of tritium at the uppermost intermediate port at 754 ft and about 16 pCi/L at 1303 ft in the uppermost regional aquifer port, in line with recent values.

RDX occurs in the upper port of the intermediate perched zone at an average concentration of 50 µg/L (44 µg/L in 2004), compared with an EPA tap water screening level of 6.1 µg/L. Concentrations of RDX at other ports have declined to about 1 µg/L or are nondetectable. The concentration histories suggest that RDX is present in large amounts only in perched intermediate groundwater near the upper port and was introduced into the other ports by groundwater mixing during well construction. No HE compounds were detected in the uppermost regional port in 2004. TNT concentration histories lead to a similar conclusion: TNT is present in the upper intermediate perched zone port at an average concentration of about 3 µg/L, compared with an EPA tap water screening level of 22.4 µg/L. Concentrations (where detected) in regional

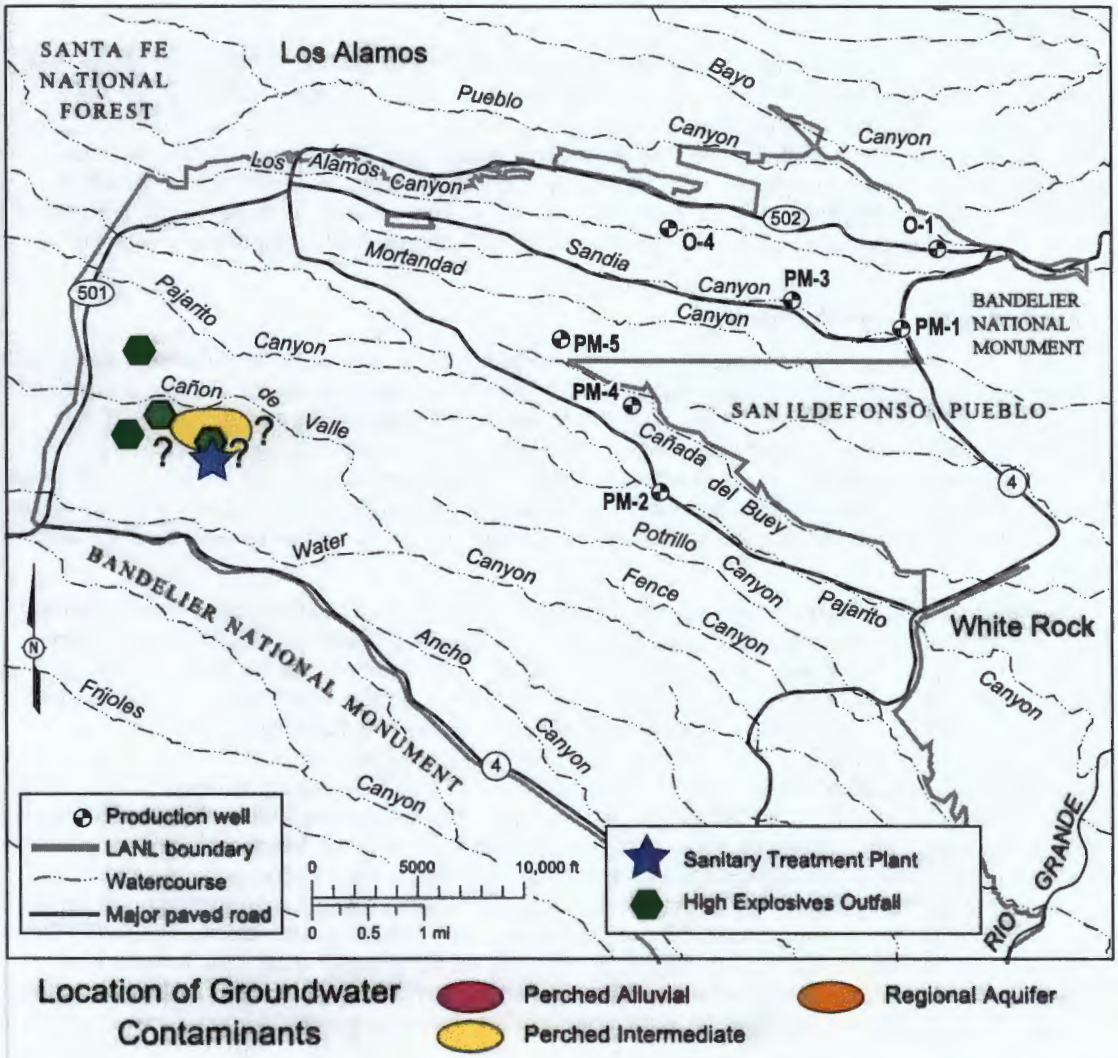


Figure 5-19. Location of groundwater contamination by RDX above the EPA Region VI screening level of 6.1 ppb in perched intermediate groundwater. Maximum 2004 values for RDX in intermediate groundwater at well R-25 were seven times the 6.1 ppb EPA Region VI 10-5 excess cancer risk screening level. Different colors indicate the affected groundwater zones.

aquifer ports are steadily decreasing. HMX was also detected in the uppermost intermediate port, but at concentrations far below screening levels.

Two chlorinated solvents, PERC and TCE, were found in samples from several ports at R-25 throughout their sampling history. PERC and TCE were only found in the uppermost intermediate port in 2004, and not in the uppermost regional aquifer port. The analytical results for PERC and TCE indicate that the chlorinated solvents are present near or above screening levels and at 30% to 40% of the MCL. Both solvents have EPA MCLs of 5 µg/L.

The upper intermediate port at R-25 had perchlorate at about 0.6 ppb; none was detected at the top of the regional aquifer. Several R-25 ports have showed high levels of iron and manganese (relative to EPA MCLs), a temporary effect of well construction found in other recently drilled wells (Longmire 2002d). Nickel and chromium have occurred at levels above EPA MCLs, possibly another temporary effect of well construction.

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 to monitor regional aquifer water quality. Perchlorate levels in the three wells ranged from 0.17 ppb to 0.25 ppb. Aluminum, iron, and manganese (related to aging well casings or to turbidity) often exceed regulatory standards in these wells. In 2004, only iron in DT-5A and manganese in DT-10 were at such levels. One PCB detection and several phthalate detections occurred in these wells in 2004 and are likely sampling or analytical artifacts.

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; in the case of Spring 2B, it 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 near background or precipitation levels, the only radionuclide detection in White Rock Canyon springs was uranium in La Mesita Spring. Naturally occurring uranium is commonly detected in La Mesita Spring.

We were unable to sample a number of springs in 2004 because they lacked sufficient flow. Samples from several springs were analyzed using the low-detection-limit tritium method. 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 rainwater range from 30 to 50 pCi/L. Rainfall around the Laboratory may have higher tritium activity because of atmospheric tritium releases (Adams et al., 1995). Most of the springs had tritium values ranging between nondetection (less than about 1 pCi/L) and 2 pCi/L. Three springs (Springs 2, 5A, and 6) had detections in some analyses or samples but not in duplicate samples or reanalyses: these values are near the detection limit. Three springs (4, 4B, and 4C) issue within a few hundred feet of each other near the Rio Grande. In 2002, Spring 4B had tritium values near 45 pCi/L, whereas the other two springs had tritium values near 10 pCi/L. Spring 4B has a low flow rate, and all the spring samples may be affected to some degree by rainfall. The largest spring in the area, Spring 4A, had a nondetect for tritium during 2002. The 2003 low-detection-limit tritium results for the springs were similar to earlier data; only Spring 4 was analyzed in 2004, and the result of near 10 pCi/L was similar to prior data.

Many of the springs were sampled for perchlorate in 2004. The results ranged from nondetection (<0.05 ppb) to 0.85 ppb. Of 41 analyses for 23 sampled springs, the average and standard deviation of the results (including detection limit for nondetections) were 0.39 ppb and 0.19 ppb. 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 Tesuque Formation consists of sandstones, siltstones, and interbedded basalts. The Totavi Lentil is a channel fill deposit made up of grain sizes ranging from gravel to boulders.

Purtymun (1980) divided the springs into four groups based on geologic unit and chemistry. Most of the sampled springs are in groups I and II. Group I springs discharge from the Totavi Lentil on the west side of the river. These springs follow the outcrop of the Totavi Lentil, increasing their elevation above the river in a downstream direction. In 2004, perchlorate concentrations for the group I springs (Sandia Spring, Spring 3 series, 4 series, Spring 5) averaged 0.47 ppb. Group II springs discharge from coarse-grained Tesuque Formation sediments on both sides of the river. For the group II springs (Springs 5A, 6, 6A, 8A, 9, 9A, Doe Spring), perchlorate concentrations averaged 0.27 ppb. Group III Springs 1 and 2 had 0.29 ppb and a nondetect, respectively. Other springs were quite variable, with group IV springs east of the river having a nondetect (Ancha Spring) and the highest value of 0.85 ppb (La Mesita Spring). Sacred Spring, north of Los Alamos Canyon, had 0.15 ppb.

Spring 2 contained fluoride at 74% of the New Mexico groundwater standard and arsenic at 50% of the EPA MCL of 50 ppb. The fluoride and arsenic occur naturally in springs and wells in the area. Spring 4A

had a high selenium value (compared with the New Mexico wildlife habitat surface water standard), but a duplicate filtered analysis and several unfiltered analyses did not find selenium at a detection limit of half that result value. A similar case applied to a selenium value at La Mesita Spring.

No organic compounds detections other than in QC samples or of common analytical or sampling-related contaminants were found in spring samples, supporting the conclusion that detections in prior years resulted from inadvertent sample or analytical contamination.

9. San Ildefonso Pueblo

The groundwater data for San Ildefonso Pueblo indicate the widespread presence of naturally occurring uranium at levels approaching the EPA MCL of 30 µg/L (effective 12/08/03). Naturally occurring uranium concentrations near 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. In 2004, Westside Artesian well had the highest total uranium of 24 µg/L, and New Community well and Black Mesa well had 13.5 µg/L. These measurements are consistent with previous samples.

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

Strontium-90 seemed to be detected in Westside Artesian Well, Pajarito Well Pump 1, and New Community Well, but was not found in a sample duplicate or a reanalysis, indicating the results were false positives.

Several of the San Ildefonso Pueblo 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 not detected to 0.6 ppb.

The boron value in the Westside Artesian well was 220% of the NMWQCC groundwater standard of 750 µg/L. This value was similar to the values of past years. Boron in Pajarito Well Pump 1 was 140% of the NM standard. The J. Martinez House well had arsenic at about 22% of the EPA MCL of 50 ppb. Other than sample issues mentioned in the introduction, no organic compounds were found in San Ildefonso Pueblo well samples.

10. Buckman Well Field

In 2004, ENV-WQH sampled three wells in the City of Santa Fe's Buckman Field for radionuclides and general inorganic chemistry constituents, with two rounds of samples for strontium-90, perchlorate, tritium, and HEs.

One sample from Buckman well No. 2 contained about 18 µg/L of uranium compared with a prior value in 2003 of 111 µg/L and compared with the EPA MCL of 30 µg/L. Earlier values were in the range of the 2003 result (and much less than the 2002 value of 248 µg/L) obtained for that well. Buckman No. 1 had 6 µg/L of uranium and Buckman No. 8 had 16 µg/L.

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 values in Buckman well No. 2 and Buckman well No. 8 were about 40% to 50% of the 4-mrem drinking water DCG.

Generally, no tritium is detected in these wells at a detection limit of about 1 pCi/L. In 2004, one sample produced a detection, but a duplicate sample did not detect tritium, casting doubt on the detected result. Perchlorate concentrations in the Buckman wells ranged from 0.27 ppb to 0.43 ppb. Other than sample issues mentioned in the introduction, no organic compounds were found in the Buckman well samples. No HE compounds were detected in these well samples.

G. Unplanned Releases

1. Radioactive Liquid Materials

No unplanned radioactive liquid releases occurred in 2004.

2. Nonradioactive Liquid Materials

Seven unplanned releases of nonradioactive liquid took place in 2004. The following is a summary of these releases.

- One bentonite drilling fluid release into Two Mile Canyon and Pajarito Canyon.
- Three unplanned petroleum product releases:
  1. TA-3-38
  2. TA-3-4100
  3. TA-60-1
- One unplanned mineral-oil-contaminated storm water release at TA-60-5 (Materials Recycling Facility).
- One unplanned release of untreated sanitary sewage from the TA-46 SWWS plant's collection system at TA-3-43 Manhole #616.
- One unplanned release of untreated sanitary sewage from a septic system at TA-40.

ENV-WQH investigated all unplanned releases of liquids as the NMWQCC Regulations 20.6.2.1204 New Mexico Administrative Code require. Upon cleanup, personnel from NMED and NMED DOB inspected the unplanned release sites to ensure adequate cleanup. The Laboratory is in the process of administratively closing out all releases for 2004 with NMED DOB. The Laboratory anticipates these unplanned release investigations will be closed out when NMED DOB personnel become available for final inspections.

H. Quality Assurance of Groundwater Sample Analyses at ENV-WQH

1. Introduction

ENV-WQH personnel conducted quality assurance (QA) activities in 2004 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 ENV-WQH Water Quality Database (http://wqdbworld.lanl.gov) contains all the water and sediment analytical data received from the analytical laboratory. None of the data are censored or removed. If analytical results are inconsistent with historic 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 or 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 ENV-WQH 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 Table S5-14 for the analytes, analytical methods, and detection limits used for analysis of surface water, sediment, and groundwater samples during 2004.

2. Analytical Laboratories

ENV-WQH is responsible for acquiring analytical services that support monitoring activities. The ENV-WQH Group Statement of Work (SOW) follows the National Nuclear Security Administration Service Center's Analytical Management Program's Model Statement of Work (Model SOW) for analytical services. The ENV-WQH 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. Analytical Quality Assurance Activities

ENV-WQH is responsible for verifying 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 2004 data packages. Individual validation memos were issued for each analytical fraction for each data report. The average report had about five data validation memos. AQA issued a number of nonconformance reports (NCRs) for Data Validation Memos that had to be reissued (Table 5-2). 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.

Table 5-2. Nonconformance Reports Issued by GEL Analytical Laboratory

NCR Issue	No. of Associated NCRs	Analyte	Corrective Action	Samples affected
Analytical Laboratory Cross-Contamination	1	All 2004 pesticide detections in water data	Commenced use of disposable glassware	all pesticide results unusable
Target analyte not in analytical laboratory spiking solution	1	Nitroglycerin	Analyte added to spiking solution	0
Data packages - unreadable pages, missing pages, etc.	108		Data packages corrected and re-issued	0

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 2004, this process required ENV-WQH's largest analytical services provider, General Engineering Laboratories, to issue about 110 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.

Two NCRs involved analytical issues. In the first case, LANL discovered that due to pervasive analytical laboratory contamination, many 2004 LANL samples produced false positive results for pesticides. As a result, we view every 2004 detection of pesticides in LANL water and sediment samples as a false positive. As described in more detail below, the analytical laboratory has taken steps to address the issue.

In August 2004, several positive pesticide results, notably results for 4,4'-DDT and 4,4'-DDE, were identified in ENV-WQH samples. These results were supported by neither previous data nor process knowledge at LANL. Subsequent examination of the GEL's data revealed some glassware used in the process was only rinsed, with no further cleaning between uses, which meant that pesticide contamination could be transferred from one sample to another during the sample preparation.

In late September 2004, GEL initiated corrective action to address the identified process deficiency. GEL also made specific recommendations for disqualifying sample results that had clearly shown cross contamination. AQA reviewed GEL's findings and recommendations, concurred, and rejected the data in question as unusable.

AQA subsequently reviewed all the positive pesticide results for all pesticide analytes reported to all of GEL's clients during 2004 for samples extracted before they implemented the corrective action. In cases for which positive pesticide hits were clearly the result of cross contamination, additional data were qualified as unusable (approximately two-thirds of the pesticides originally reported as detected). Pesticides that were qualified as unusable included alpha-BHC, delta-BHC, Heptachlor, Heptachlor epoxide, Endrin, Endrin aldehyde, Dieldrin, Endosulfan II, Endosulfan sulfate, 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE. However, numerous positive hits remain for which no unequivocal evidence of contamination exists. These data remain unqualified, but are considered unusable because of the known process deficiency that existed at the time GEL performed the analyses.

With four exceptions, groundwater pesticide samples were collected from late May through mid September of 2004. GEL initiated corrective actions in late September 2004 so the bulk of pesticide sample analyses are potentially affected. Apparently spurious pesticide detections occurred only in samples collected from late May through late June of 2004 and no pesticides were detected in any other samples.

The other NCR involved the use of an explosive spiking solution that included GEL's standard list of compounds. This solution did not include nitroglycerin, which was a requested groundwater analyte. GEL's corrective action was to add nitroglycerin to the standard spike solution to prevent future errors.

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 2004 were completed.

4. Radiological Data

Negative values are sometimes reported in radiological measurements. Negative numbers occur because radiochemistry counting instrument backgrounds must be subtracted 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).

The precision of radiological analytical results is reported as the one standard deviation (one sigma) total propagated uncertainty. ENV-WQH reports radiochemical detections as analytical results that are greater than both the sample-specific minimum detected activity and three times the reported uncertainty.

5. Nonradiological Data

Nonradiological results are reported at levels down to the laboratory-derived MDL. Data between the MDL and practical quantitation limit are qualified as estimated by the analytical laboratory. The analytical laboratory reports results below the MDL as nondetections.

A perennial issue is differing results of perchlorate by ion chromatography (EPA 314.0) and LC/MS/MS [SW-846 8321(M)]. Studies of chromatographs associated with low-level hits by ion chromatography are often ambiguous as to the definitive identification of perchlorate peaks in those chromatographs. LC/MS/MS has shown to be less sensitive to matrix effects and more reliable for low-level perchlorate analysis.

6. Detection-Limit Issues

The ENV-WQH Group 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.

7. Participation in Laboratory Intercomparison Studies

General Engineering Laboratories is required by the ENV-WQH SOW to participate in independent national performance evaluation programs. GEL participated in the EPA water supply and water pollution proficiency testing programs prior to their elimination. GEL does continue to participate in the DOE Mixed Analyte Performance Evaluation Program (MAPEP) for radiochemistry, organic, and inorganic analyses.

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 5-3. All other analytes not shown in the table were acceptable.

Table 5-3. Summary of Performance Evaluation Program Deficiencies for GEL Analytical Laboratory

	MAPEP-03-W11 (May 2004 Water Sample)	MAPEP-04-MaW12 (November 2004 Water sample)	MAPEP-04-MaS12 (November 2004 Soil sample)
diethylphthalate	Acceptable with warning		
benzo(a)anthracene	Acceptable with warning		
Chrysene	Acceptable with warning		
Fe-55		Result not acceptable	
Tc-99			Acceptable with warning
U-238			Acceptable with warning
Pu-239,240			Result not acceptable
U-234/235			Result not acceptable
antimony			Result not acceptable

8. Quality Control Samples

ENV-WQH submits 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 aid in the determination of false detections in associated environmental samples.

c. Field Trip Blanks. Trip blanks are helpful in identifying cross contamination 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.

e. Laboratory Duplicate Analyses. Laboratory duplicate samples are splits of samples processed and analyzed by the laboratory that provide information about the precision of the measurement system, including sample homogeneity, preparation, and analysis. Laboratory duplicates can indicate analytical techniques with poor reproducibility. Comparing laboratory duplicates can be used to evaluate the sampling

system and general environmental homogeneity at the time of sampling. Duplicates are required as routine batch QC for general inorganic, metals, and radiochemistry.

On the whole, the equipment and field blanks and laboratory duplicates were satisfactory, indicating no significant handling issues from sampling and analyses. For results (organized by analytical suite) for equipment, field, and performance evaluation blanks, see Tables S5-15, S5-16, S5-17, and S5-18 in the Data Supplement, as well as earlier tables along with sample data. Detections in the blanks are highlighted in Tables S5-4, S5-9, S5-19, S5-20, S5-21, and S5-22. Table S5-1 lists the definitions of sample description codes used in the data tables.

I. References

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5. Groundwater Monitoring

6. Watershed Monitoring

6. Watershed Monitoring

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A. Introduction

The Laboratory monitors surface water and stream sediments in northern New Mexico and southern Colorado 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 (for surface water) general chemistry. 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.

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 Los Alamos Canyon upstream of the Laboratory. Of the 85 miles of watercourse, approximately 2 miles are naturally perennial, and approximately 3 miles are perennial waters created by effluent.

The remaining 80 or more miles of watercourse dry out for varying lengths of time. The driest segments may flow in response only to local precipitation or snowmelt, and the bed is always above the water table. The flow in these streams is considered "ephemeral." Other streams may sometimes have the water table higher than the streambed and/or extensive snow melt in the watershed and are said to be "intermittent." Intermittent streams may flow for several weeks to a year or longer. The distinction between intermittent and ephemeral streams is important because intermittent streams may flow long enough to develop relatively complex biological communities similar to perennial streams.

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 that is 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 that is 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 snowmelt and base flow are present for extended periods of time, they pose similar potentially longer-term exposures, such as wildlife watering. While runoff 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 averages more than 1 cubic foot per second (cfs) of flow annually. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs. By comparison, flows in the Rio Grande commonly average approximately 800 to 1,000 cfs. Although most of the watercourses are dry throughout the year, occasional floods can redistribute sediment in a streambed to locations far downstream from where a release or spill occurs.

Precipitation was normal in 2004, following six consecutive years of below-average amounts. Total runoff volume at downstream gauges in 2004 was within pre Cerro Grande fire averages for the watersheds crossing current LANL lands. However, flow volumes in Pueblo Canyon remain more than 5 times higher than the pre Cerro Grande fire average (Gallaher and Koch 2005). Upper Pueblo Canyon has undergone significant urbanization since the Cerro Grande fire, and that may be a factor in the delayed recovery along with the post-fire effects. The largest peak runoff event for the year was recorded in Pueblo Canyon on July 24, 2004, at 504 cfs (Shaull et al., 2005).

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 standards or with risk-based screening levels.

1. Radionuclides in Surface Water

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 San Ildefonso tribal land. Spring water is used traditionally and ceremonially by San Ildefonso tribal members, and uses may include ingestion or direct contact.

We compare concentrations of radionuclides in surface water with the 100-mrem DOE Derived Concentration Guides (DCGs) for public dose (DOE 1990). Although the DCGs primarily regulate radioactive liquid effluent discharges, we compare the quality of on-site surface waters with the DCGs as a benchmark to identify possible areas of concern. At the levels of radioactivity that are found in the environment, the predominant human health concern is long-term exposure. For protection of biota populations, we compare concentrations of radionuclides in surface water with the DOE Biota Dose Guidelines (BCGs; DOE 2002). The DCGs and BCGs are based on annual averages.

2. Gross Alpha in Surface Water

The New Mexico Water Quality Control Commission (NMWQCC 2002a) has promulgated radioactivity-related stream standards to protect livestock watering. Specific standards have been developed for Ra-226, plus Ra-228, tritium, and total gross alpha. Monitoring results of storm runoff after the Cerro Grande fire have shown widespread gross alpha activities greater than the wildlife habitat standard of 15 pCi/L. In response to these findings, the New Mexico Environment Department (NMED) designated several Los Alamos area drainages as water-quality impaired and added them to the federal Clean Water Act §303(d) List (NMED 2003a). The affected drainages noted with heightened gross alpha concentrations are Guaje Canyon, Pueblo Canyon, Los Alamos Canyon, Mortandad Canyon, Pajarito Canyon, and Water Canyon. In the 2002 and 2003 surveillance reports, it was shown that the gross alpha activities generally correspond to the suspended sediment concentrations, and upstream concentrations were comparable to on-site concentrations and largely due to the natural radioactivity in the surface sediments. Although concentrations have progressively declined since the Cerro Grande fire, one-half of the surface water samples in 2004 contained gross alpha concentrations greater than the livestock standard. Because gross alpha is a general screening measurement that does not identify and quantify specific alpha emitters in the water, the gross alpha measurement is of limited value in assessing radiological hazards. Therefore, we do not discuss gross alpha results further 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 Table S6-1.

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

Medium	Standard or DCG	Risk- or Dose- Based Screening Level	Reference	Location	Notes
Surface water					
Radio-nuclides	Derived Concentration Guides Biota Concentration Guides	New Mexico Radiation Protection Regulations	DOE Order 5400.5 20.3.4 NMAC	On-site and off-site	DCGs based on 100-mrem/year dose rate limit; surface waters are present sporadically or are not available for long-term access and do not provide persistent drinking water. BCGs based on 1 rad/day exposure limit for aquatic animals and terrestrial plants, and 0.1 rad/day for terrestrial animals. Comparison based on time-weighted average over the year per DOE Order 5400.5 and 20.3.4 NMAC.
Radio-nuclides	State stream standards		20.6.4 NMAC	On-site and off-site	Based on the protection of livestock watering for combined activity of Ra-226 and -228 and gross alpha. Standards are not specific about exposure duration or comparison criteria; for screening purposes, compare single sample results to standards.
Non-radio-nuclides	State water quality standards for surface and ground waters	EPA cancer risk 10^{-5} and HI=1 risk levels for NM toxic pollutants with no NM standard	20.6.2 NMAC	On-site and off-site	We compare average surface water concentrations for aquatic life chronic exposures. Individual results from all waters compared with livestock, wildlife, acute aquatic life standards, and human health persistent toxic standards. Comparisons with groundwater quality standards are used to determine potential for stream flows to impact underlying bodies.
Sediments					
Radio-nuclides		No standards; Screening levels	Environmental Remediation and Surveillance Program	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 residential or outdoor worker exposure parameters; based upon a dose rate limit 15 mrem/year. Recreational scenario should be optional for where residential use is impractical, e.g., many canyon bottoms.
Non-radio-nuclides		No standards; Screening levels cancer risk 10^{-5} and HI-1 risk levels for NM toxic pollutants with no NM standard	EPA Region VI	On-site and off-site	Screening levels derived to determine if more detailed assessment is needed to evaluate impacts to the public; comparisons may be made for residential or outdoor worker exposure parameters. Residential levels are appropriate for off-site areas with unrestricted land use; outdoor worker levels are appropriate for on-site areas with public access.

3. Nonradioactive Constituents in Surface Water

We compare concentrations of nonradioactive constituents with the New Mexico Water Quality Control Commission (NMWQCC) General, Wildlife Habitat, Livestock Watering, and Human Health Standards (NMWQCC 2002a). Through 2004, the Laboratory canyons have not been classified with specific designated uses and, therefore, according to NMWQCC (2002a), by default are protected for the uses of livestock watering and wildlife habitat. In addition, the NMWQCC assigned criteria for persistent toxic substances to protect fish consumption by humans (also called human health standards) to all tributaries of waters with a designated fisheries use, regardless if those tributaries themselves have any fish or actually contribute significant flow to the receiving waters. The location of the upstream limits of these fish consumption standards has not been defined but is assumed to include all canyons and most drainages within the Laboratory boundaries. The standards protecting fish consumption require that all fish-consumption criteria be met at all points within all tributaries. Because Laboratory canyons drain to the Rio Grande, a designated fishery, we also screen the water quality data against the standards designed to protect the health of fish themselves and other aquatic organisms.

Given the short-term duration of the runoff events at LANL, we compare the results against the acute (short-term) aquatic life standards. Where perennial waters are found, we compare the results against both the acute and chronic (long-term) aquatic life standards. 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 2002b).

Evaluation of storm runoff results is complicated by several factors. Runoff events are short-lived, so they do not result in long-term exposure. The higher concentrations of many compounds found in runoff samples reflect constituents that are part of the large suspended sediment load of runoff, rather than dissolved constituents. We give consideration, therefore, to how much of the contaminant load is due to natural causes versus possible Laboratory-related causes. To evaluate storm runoff results, we developed preliminary threshold values for some metals and radioactivity parameters for the 2002 surveillance report (Gallaher et al., 2004). The thresholds are used to identify data that signify possible effects from Laboratory operations. A value is greater than the threshold if it is greater than the upper 95% prediction limit for concentrations measured at background locations in 2001 and 2002 samples. Alternatively, we can calculate the suspended sediment concentrations for metals and radioactivity in a water sample and screen against Pajarito Plateau background soils concentrations (Ryti et al., 1998). Above-background results merit further investigation to determine whether they are from Laboratory sources.

4. Sediments

We screen sediment results to screening action levels to identify concentrations of a constituent that may require further assessment (ER 2001). The Laboratory's Remediation Services Project uses residential screening action levels (SALs) to identify radionuclide activity levels of interest (ER 2001). Comparisons with SALs are used to readily distinguish the areas with most potential concern: concentrations below the SALs are not considered to be of concern to public health, whereas concentrations greater than the SALs would trigger the Laboratory's Remediation Services Project to perform more detailed investigations. Industrial worker screening levels for radionuclides (Perona et al., 1998) are applicable on Laboratory land because it is not available for residential development. This reflects the current land use status for the Laboratory. In the long term, it is possible that residential development patterns could change if Laboratory boundaries are modified.

Concentrations of nonradioactive compounds in sediments may be compared with residential and industrial outdoor worker soil-screening levels developed by Environmental Protection Agency (EPA) Region 6 (EPA 2003). All of these screening levels are conservative (protective) because they are calculated based on the assumption that humans will be continually exposed to the chemicals or radionuclides, which is not the case on LANL property. We can also compare sediment data with background levels of metals or background activities of radionuclides that are naturally occurring or result from atmospheric fallout (Ryti et al., 1998; McLin and Lyons 2002).

D. Sampling Locations and Data Analysis Methods

1. Regional Monitoring Locations

Regional base-flow and sediment-sampling stations (Figure 6-1) are located in northern New Mexico. Samples from regional stations provide a basis for estimating background concentrations of nonradioactive compounds and background activities of radionuclides that are naturally occurring or result from atmospheric fallout. We obtained regional sediment samples from stations on the Rio Grande and the Jemez River and from Abiquiu Reservoir on the Rio Chama. We were unable to collect samples from Cochiti Reservoir in 2004 because of the work restrictions imposed by the Laboratory stand-down. Sampling stations in the Rio Grande drainage system are located up to approximately 60 km upstream and downstream of the Laboratory.

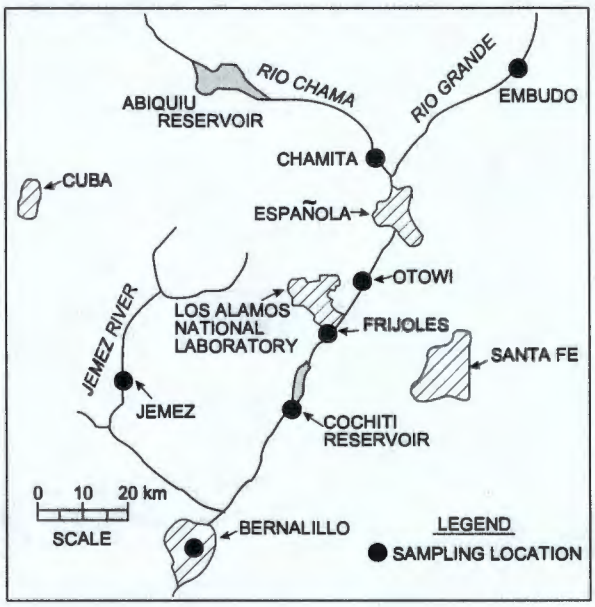

Figure 6-1. Regional base-flow and sediment-sampling locations.

2. On-Site and Perimeter Monitoring Locations

We sample surface water and sediments in all major canyons that cross Laboratory land, including those canyons with either persistent or brief flows. We sample stream sediments to evaluate any accumulation of undissolved contaminants in the aquatic environment (DOE 1991). During 2002, we reevaluated the locations of base-flow and sediment stations. In many cases, we consolidated station locations with nearby gauging stations to collect surface water and sediment samples at the same location. In other cases, sediment stations were adjusted to reflect current channel locations or to move the station above effects of disturbance by construction or post–Cerro Grande fire mitigation activity.

We collect base-flow samples from Pajarito Plateau stations within and near the Laboratory and snowmelt at upstream and downstream gauging stations at the Laboratory boundary. We collect base-flow grab samples annually from locations where effluent discharges or natural runoff maintains persistent stream flow (Figure 6-2).

After 1996, storm runoff samples are collected using stream-gauging stations with automated samplers (Figure 6-3). The stream-gauging stations collect samples when a significant rainfall causes flow in a monitored portion of a drainage. Many gauging stations are located where drainages cross the Laboratory's boundaries. We also sample storm runoff at several mesa-top sites that allow us to target specific industrial activities. These sites have negligible runoff from other sources.

Sediment stations on the Pajarito Plateau (Figure 6-4) 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 (Pueblo, Los Alamos, and Mortandad) that have experienced past or present liquid radioactive releases from upstream of the Laboratory to their confluence with the Rio Grande.

We collected sediments from drainages downstream of two material disposal areas. 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 6-5) to monitor possible transport of radionuclides from the area.

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 Area AB (Figure 6-6).

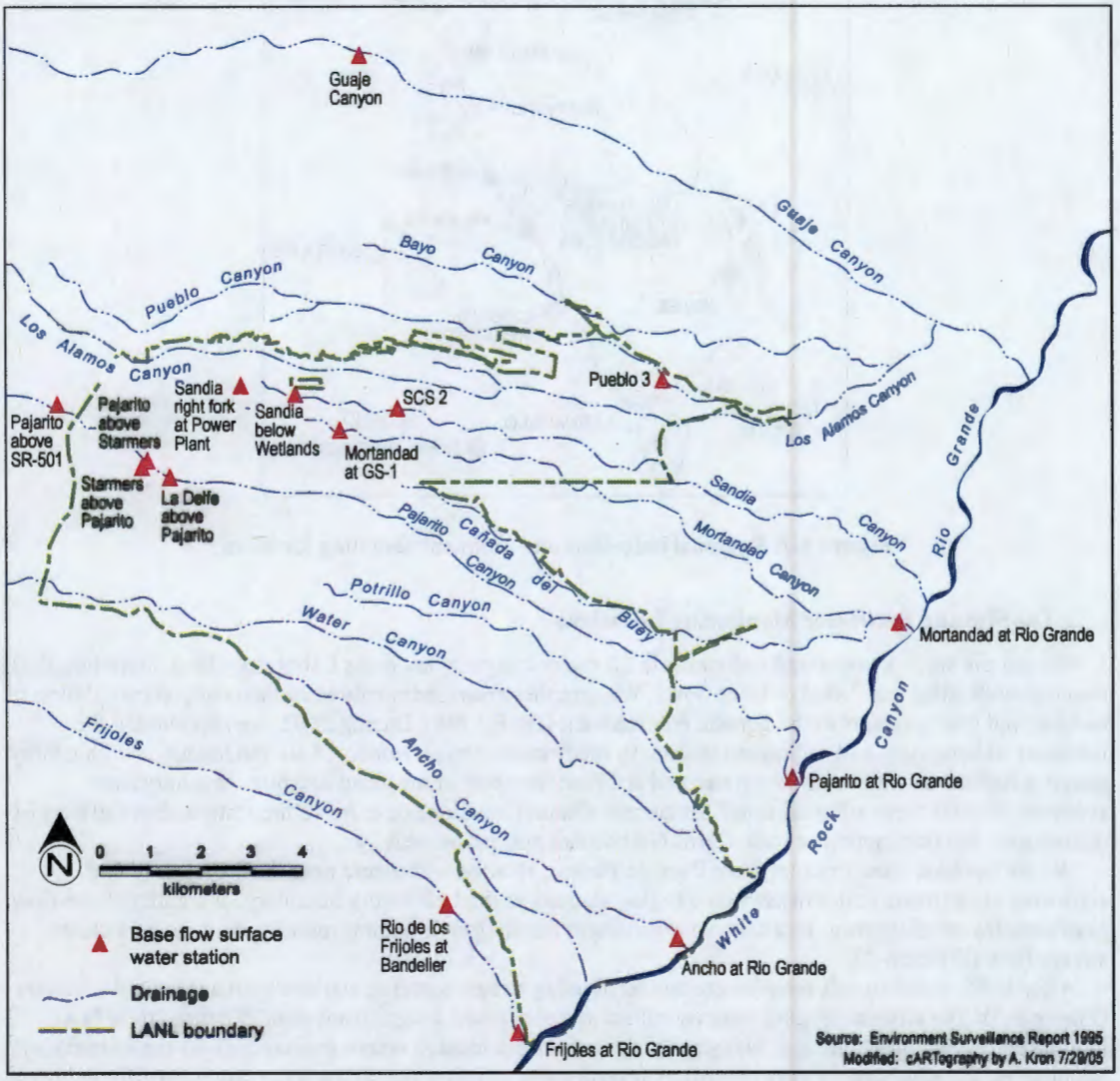

Figure 6-2. Base-flow sampling locations in the vicinity of Los Alamos National Laboratory.

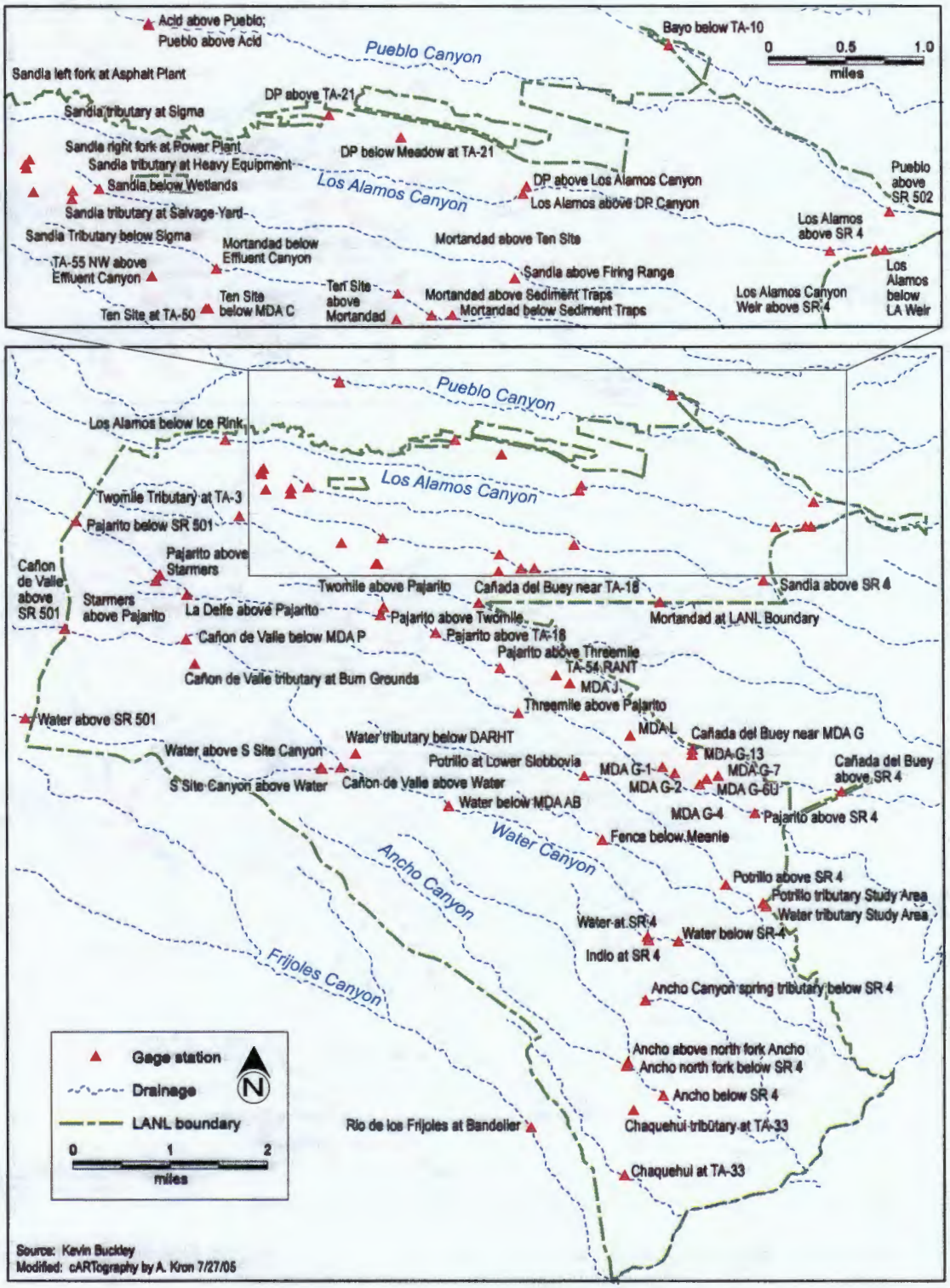

Figure 6-3. Storm runoff sampling (gauging) stations in the vicinity of Los Alamos National Laboratory.

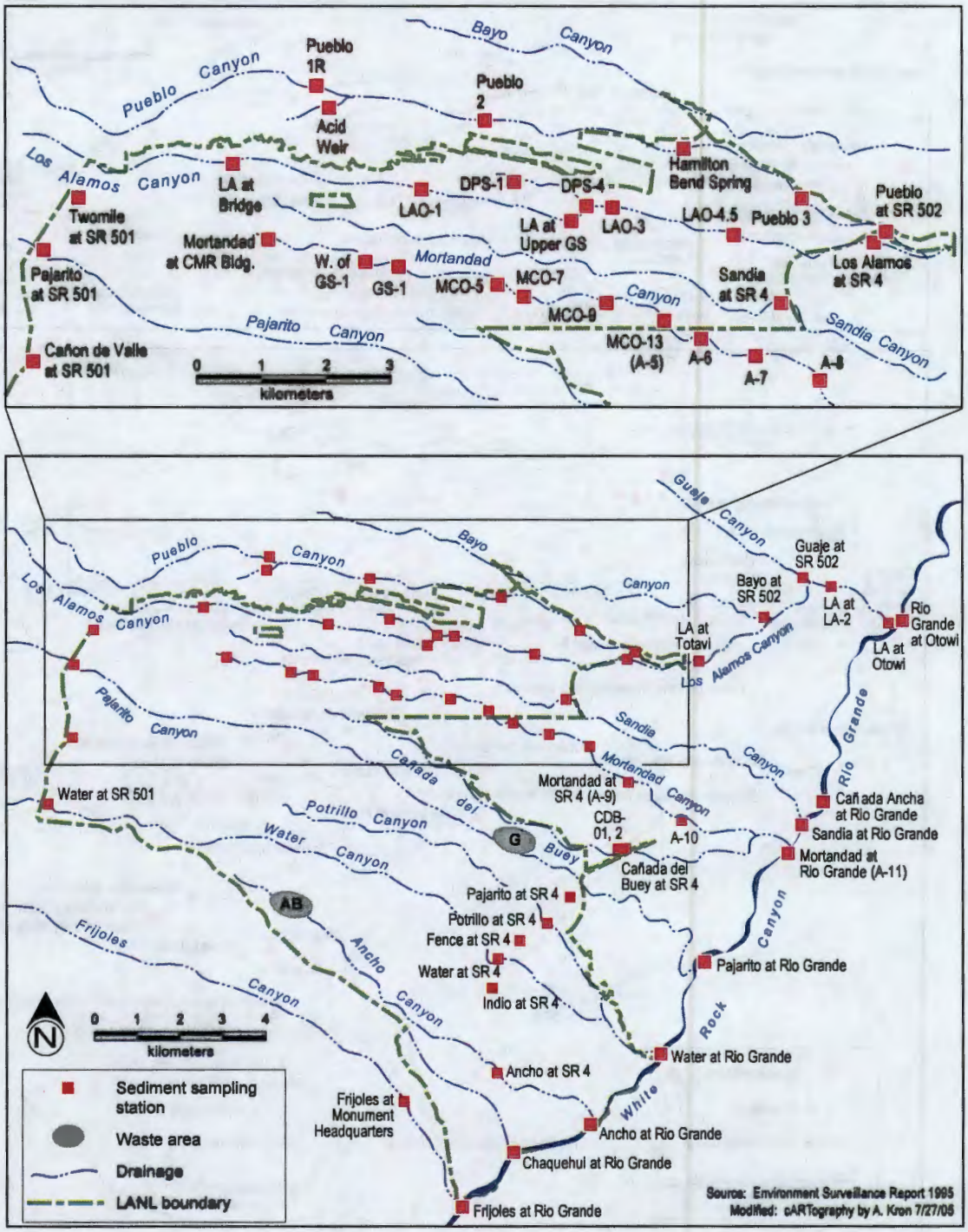

Figure 6-4. Sediment sampling locations in the vicinity of Los Alamos National Laboratory. Material disposal areas with multiple sampling locations are shown in Figures 6-5 and 6-6.

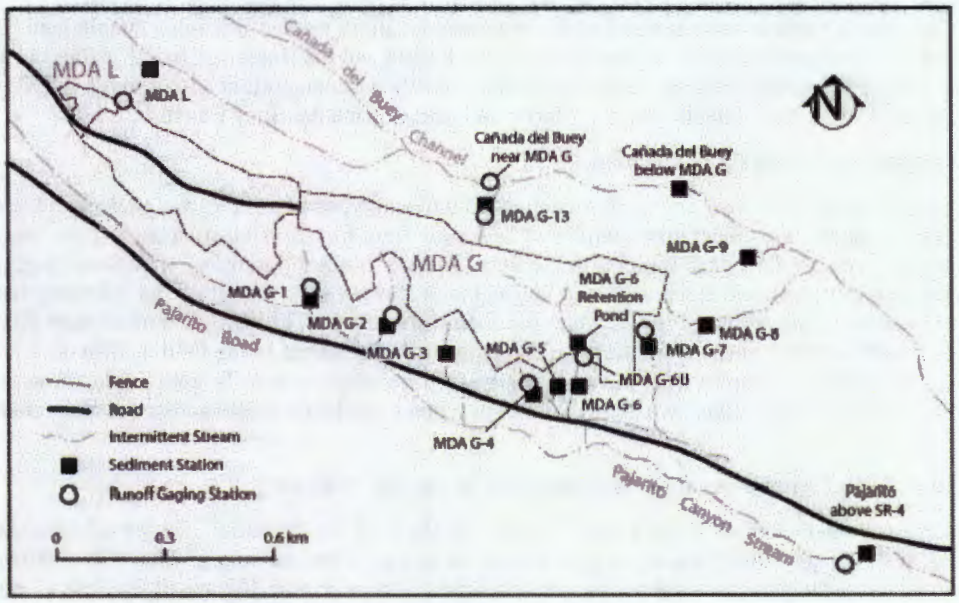

Figure 6-5. Sediment and storm runoff sampling stations at TA-54, Area L, and Area G.

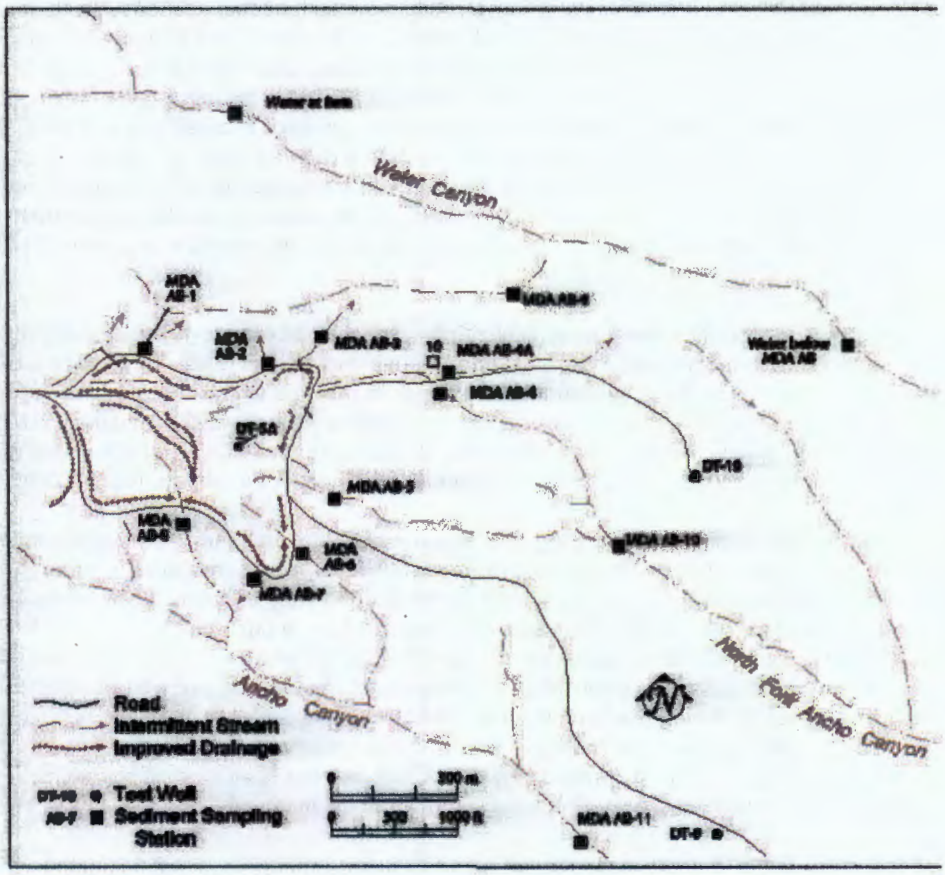

Figure 6-6. Sediment sampling stations at Area AB, TA-49.

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 the Pueblo are Los Alamos/Pueblo, Sandia, Mortandad, and Canada del Buey Canyons.

3. Sampling and Analysis Procedures

Our procedures for sampling and analysis depended on what types of samples were taken and where and how they were taken. We collect grab samples of base flow from free-flowing streams near the bank. We filter and preserve base flow grab samples in the field. The storm runoff (gauging) stations are equipped with automated samplers, which are activated during major flow events. We submit a time-weighted composite sample of the collected runoff water for chemical analysis. The analytical laboratory filters and preserves runoff samples, because filtering highly sediment-laden waters in the field is difficult.

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

4. Estimation of Annual Average Radioactivity in Surface Waters

In order to compare surface water sample results with the DOE DCGs and BCGs, we calculated the time-weighted average annual radioactivity in waters, focusing on the stream segments with relatively persistent waters—the perennial and intermittent stretches with more than 20 days of flow per year (Fisher 2003). Although none of these waters is used as a drinking water source, the persistent waters represent those with the greatest potential for human or biota exposure. 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., 2005) to distinguish the flow regimes; periods with no flow were assigned concentrations of zero. 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 divided by its particular DCG. 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.

5. 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 2004. To add confidence to the 2004 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 suggest 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. 2004 Watershed Monitoring Data Tables

The Data Supplement contains tables of all the 2004 watershed-related surface water and sediment analytical results. 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 annually analyzed for gross alpha, gross beta, and selected radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, uranium isotopes, and tritium). In 2004, we added cobalt-60, potassium-40, neptunium-237, radium-226, radium-228, and sodium-22 to our base list of radionuclides analyzed. Table S6-1 in the Data Supplement lists the results of radiochemical analyses of surface water for 2004. 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; from these values, specific activities for each isotope were used to calculate the total uranium concentration.

To emphasize values that are detections greater than DOE DCGs, Table S6-2 lists radionuclides detected in surface water at concentrations greater than the DCGs. Detections are defined as values that exceed both the analytical method detection limit (MDL) (where available) and three times the individual measurement uncertainty. The right-hand column of Table S6-2 show how the results compare with the DCGs.

Qualifier codes are shown in some tables because some analytical results that meet the detection criteria are not detections: in some cases, the analyte was found in the laboratory blank or was below the MDL, but the analytical result was reported as the minimum detectable activity. The tables show two categories of qualifier codes: those from the analytical laboratory and those from secondary validation. For an explanation of the qualifier codes, see Table S5-5 in the Data Supplement.

The results of radiochemical analyses of sediments appear in Table S6-8. Table S6-9 lists radiological detections for results that are higher than river or reservoir sediment background levels and identify values that are near or above SALs. Table S6-8 shows all tritium detections regardless of screening levels.

F. 2004 Watershed Monitoring Findings

The overall quality of most surface water in the Los Alamos area is very good, with very low levels of dissolved solutes. Of the more than 100 analytes tested 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 shows indications of some effect from Laboratory operations, often for just a few analytes.

Although many of the above-background results in sediment and surface water are from the major liquid effluent discharges (Figure 5-4), other possible sources include isolated spills, photographic-processing facilities, highway runoff, and residual Cerro Grande ash (Gallaher and Koch 2005). At monitoring locations below other industrial or residential areas, particularly in the Los Alamos and Pueblo canyon watersheds, above-background contaminant levels reflect contributions from non-Laboratory sources, such as urban runoff.

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. 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.

2. 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 subdrainages. Each of the canyons draining the watershed also receives urban runoff from the Los Alamos town site.

Past release of radioactive liquid effluents into Pueblo, DP, and Los Alamos Canyons has introduced americium-241, cesium-137, plutonium-238, plutonium-239,240, strontium-90, and tritium among other radionuclides, into canyon bottoms. 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. We evaluated the significance of these heightened levels by comparing against DOE DCGs and BCGs for waters and against risk-based screening levels for sediments.

Table 6-2 and Figure 6-7 compare the annual average levels of radioactivity in persistent surface waters at Los Alamos against the DOE's 100-mrem DCGs (see section 6.D.4 for details of calculation). Table 6-2 also compares the average concentrations against the Biota Concentration Guides. Figures 6-8 through 6-10 compare radioactivity in stream sediments to background activities and screening levels.

Table 6-2. Estimated Annual Average Surface Water Concentrations of Radionuclides in Selected Canyons Compared with the DCGs and BCGs.

			Estimated 2004 Average Conc. (pCi/L)					
Radionuclide	DCG[a] (pCi/L)	BCGs[b] (pCi/L)	Lower Pueblo Canyon	DP Canyon below TA-21	LA Canyon between DP and SR-4	Mortandad Canyon below Effluent Canyon	Max Percent of DCG	Max Percent of BCG[b]
H-3	2000000	300000000	0.7	64	14	12600	0.6	0.004
Sr-90	1000	300	0.6	23	0.4	4	2	8
Cs-137	3000	20000*	0.02	1	0.4	42	1	0.2*
U-234	500	200	0.1	0.8	0.1	3	0.6	1
U-235,236	600	200	0.01	0.05	0.01	0.2	0.03	0.08
U-238	600	200	0.1	0.1	0.1	0.3	0.04	0.1
Pu-238	40	200	0.001	0.02	0.005	5	13	3
Pu-239,240	30	200	0.3	0.1	0.05	5	16	2
Am-241	30	400	0.01	0.2	0.07	8	27	2
	Sum of ratios to DCGs		0.011	0.04	0.005	0.6		
	Sum of ratios to BCGs		0.004	0.08	0.003	0.1		

[a]DCG = DOE 100-mrem Derived Concentration Guides for Public Exposures (DOE 1990)

[b]BCG = DOE Biota Concentration Guides (DOE 2002)

*The BCG for Cs is a site-specific modified BCG from McNaughton 2005

Individual storm runoff events in Pueblo Canyon sometimes contain plutonium-239,240 levels above the 100-mrem DOE DCG for public exposure (based on water ingestion). However, none of the individual radionuclides was greater than its associated 100-mrem DOE DCG on an annual average, and storm runoff is not a source of drinking water. The time weighted sum of ratios for 2004 (see section D4) was estimated to be lower than 0.05 in lower Pueblo Canyon, DP Canyon, and Los Alamos Canyon below DP Canyon (Figure 6-7, Table 6-2). This describes the upper-limit radionuclide concentrations that potentially could be ingested if a hypothetical person drank from the stream channel whenever flow was present.

There were insufficient data in 2004 to estimate the total inventory of radionuclides that were carried beyond the downstream boundary of the Laboratory via Los Alamos and Pueblo Canyons. The enhanced frequency of sampling conducted after the Cerro Grande fire allowed estimates to be made for the years 2000 through 2003 (Gallaher and Koch 2005). Over the four-year study period, it was estimated that plutonium-239,240 transport beyond the Laboratory's downstream boundary increased by as much as 50 to 80 times over that seen in the late 1990s.

Plutonium has moved down Pueblo Canyon, through Los Alamos Canyon, off-site across San Ildefonso Pueblo lands, and reaches the Rio Grande near the Otowi Bridge (Graf 1997; Reneau et al., 1998). Plutonium-239,240 contamination from the Acid Canyon discharge has been traced in stream sediments more than 55 km from the effluent source into lower Cochiti Reservoir (Gallaher and Efurd 2002).

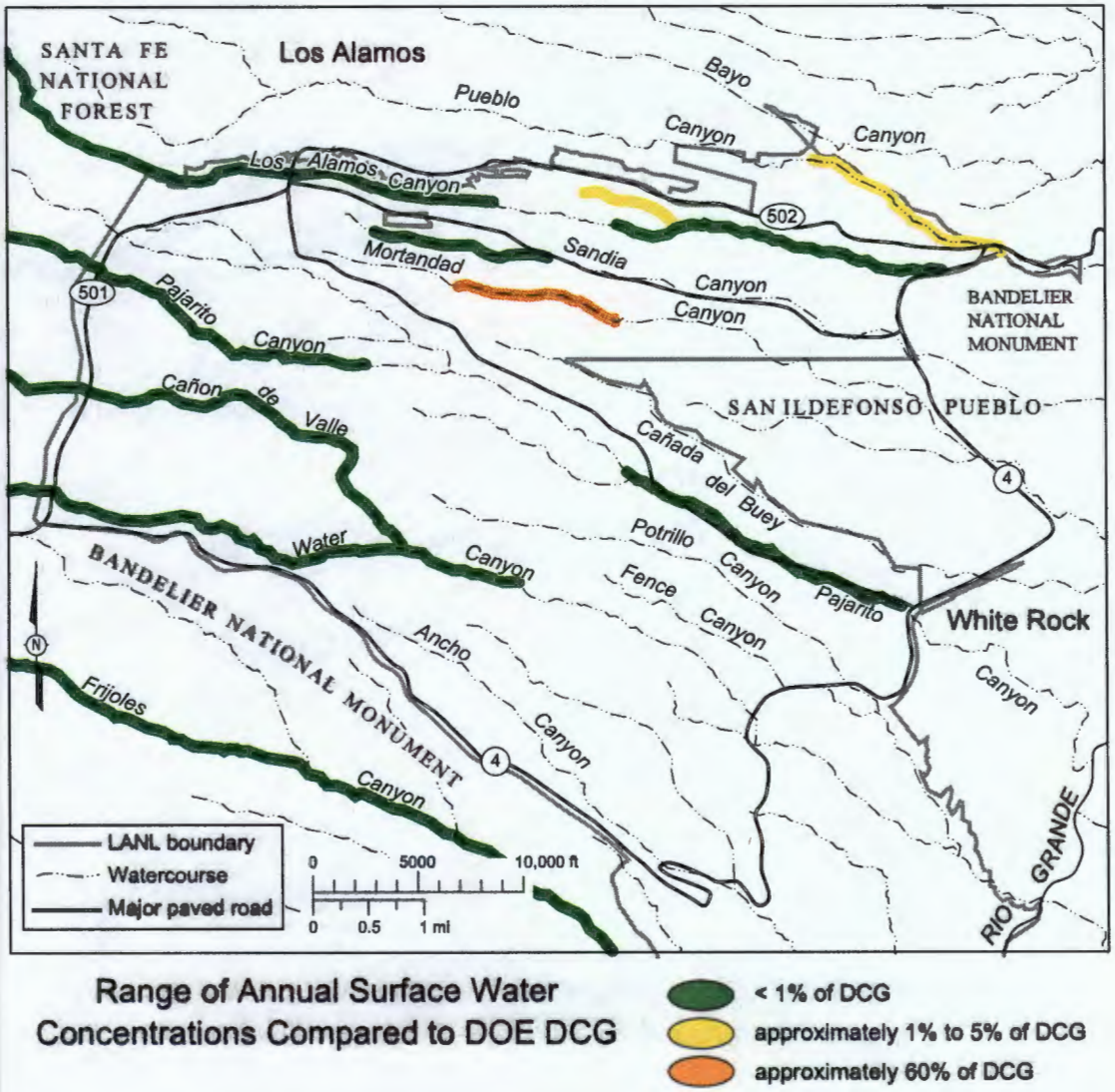

Figure 6-7. Annual average radioactivity in persistent surface waters compared with the DOE Derived Concentrations Guides (DGCs). Persistent waters include perennial and intermittent stream segments (Fisher 2003). The figure shows an integrated perspective of how the activities of a mixture of 9 key LANL radionuclides compare to the DCGs (see text for details).

Throughout the watershed, radionuclide concentrations in sediments remained below residential SALs. Plutonium-239,240 activities in lower Los Alamos Canyon ranged up to 0.5% of the SAL. Analysis of sediments from Pueblo and Los Alamos Canyons found no significant changes in radionuclide concentrations from the previous year. Temporary increases in plutonium-239,240 and cesium-137 concentrations after the Cerro Grande fire have fallen to near pre-fire levels (Figure 6-11). Over many decades, plutonium concentrations in Acid Canyon have declined moderately, whereas concentrations in lower Pueblo Canyon have risen slowly.

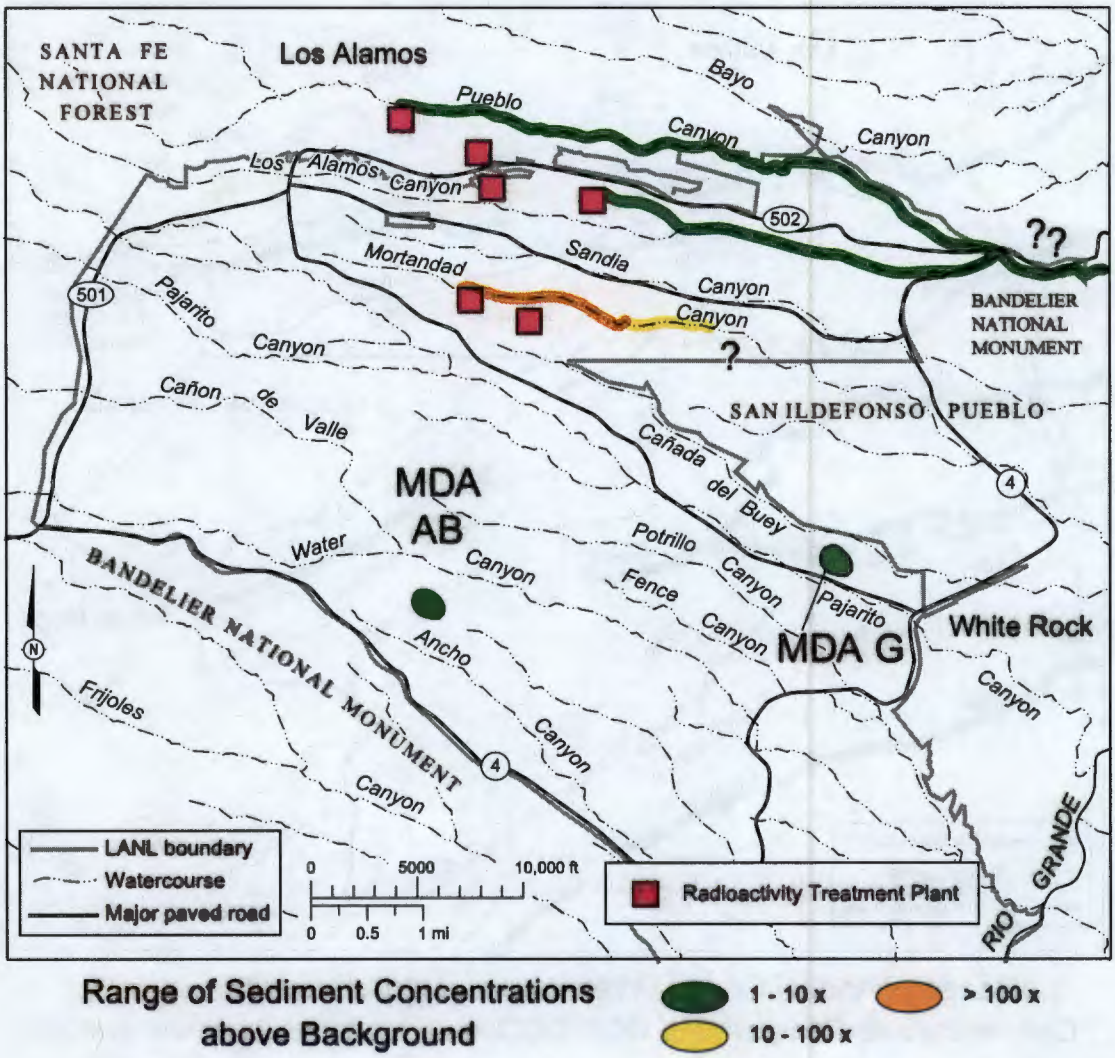

Figure 6-8. Location of the active stream channel sediment with Am-241 concentrations above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). Question marks indicate where contaminant extent is uncertain. The highest value in 2004 was in Mortandad Canyon, at 160 times background, 31% of the residential SAL, and 22% of the industrial worker SAL.

Nonradiological constituents detected at significant concentrations in the Los Alamos Canyon watershed include polychlorinated biphenyls (PCBs), benzo(a)pyrene, mercury, copper, lead, and zinc. The PCB Aroclor-1260 was detected in a stormwater runoff sample in Los Alamos Canyon above DP at a concentration estimated to be 70 times greater than the New Mexico human health standard and 7 times the wildlife habitat standard (Figure 6-12). Analysis detected benzo(a)pyrene in sediment samples from Acid Canyon above Pueblo at 11 times the EPA residential soil-screening level and in a sediment sample from Los Alamos Canyon below DP Canyon at 22 times the residential screening level (Figure 6-13).

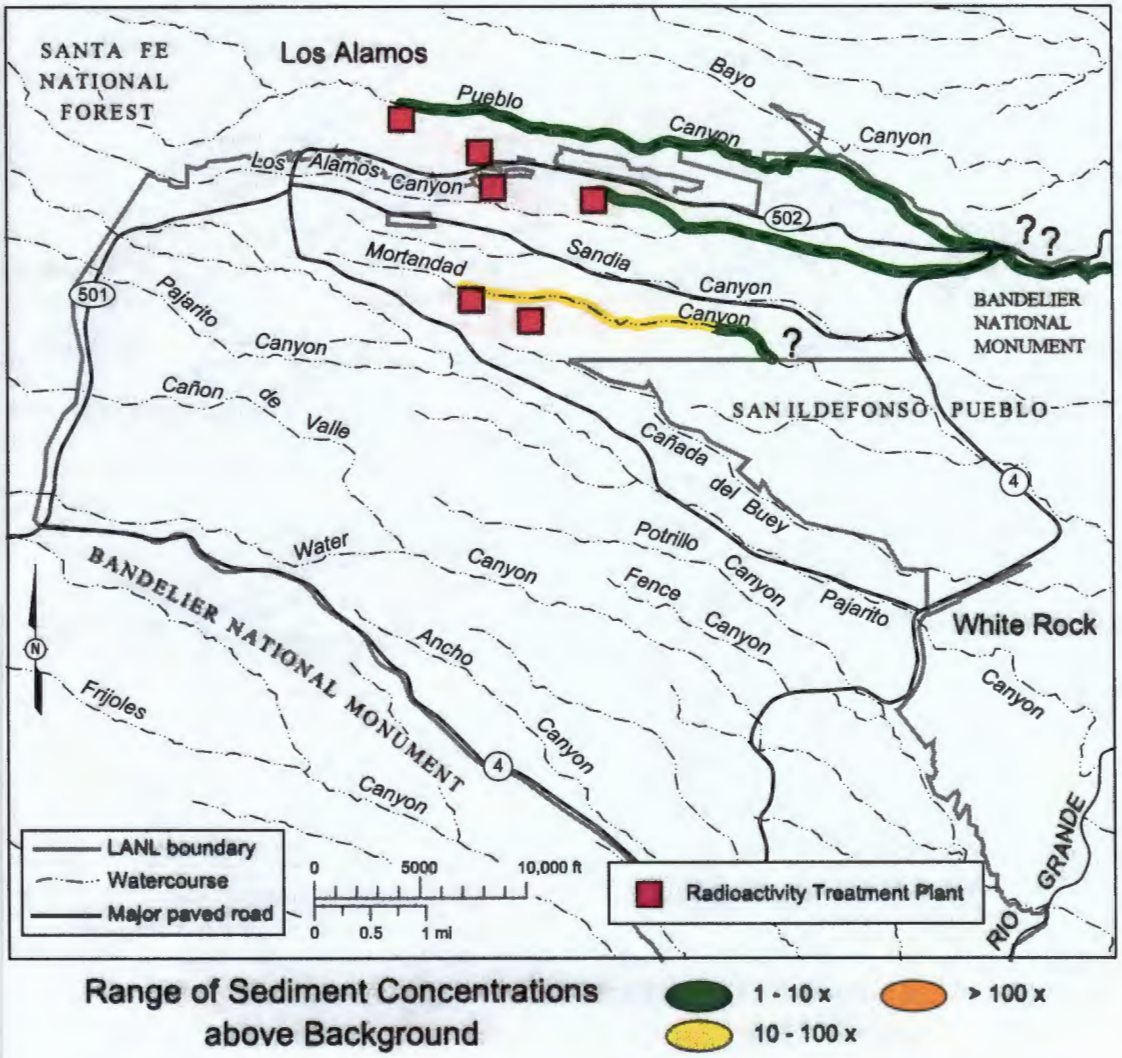

Figure 6-9. Location of the active stream channel sediment with cesium-137 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). Question marks indicate where contaminant extent is uncertain. The highest value in 2004 was in Mortandad Canyon, at 20 times background, 2.1 times the residential SAL, and 0.58 times the industrial worker SAL.

Environmental Remediation and Surveillance Program conducted detailed sediment investigations and concluded that the major source of benzo(a) pyrene in the drainage was urban runoff, rather than a Laboratory-related source (LANL 2004).

Mercury was detected in Los Alamos Canyon above DP Canyon slightly (1.5 times) above the wildlife habitat standard (Figure 6-14). LANL mercury and PCB 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, lead, and zinc were detected above the NM acute aquatic life standards (Figure 6-15). Elevated concentrations of these latter metals were found in DP Canyon above LANL facilities at TA-21 and are likely derived from urban runoff sources, rather than Laboratory operations.

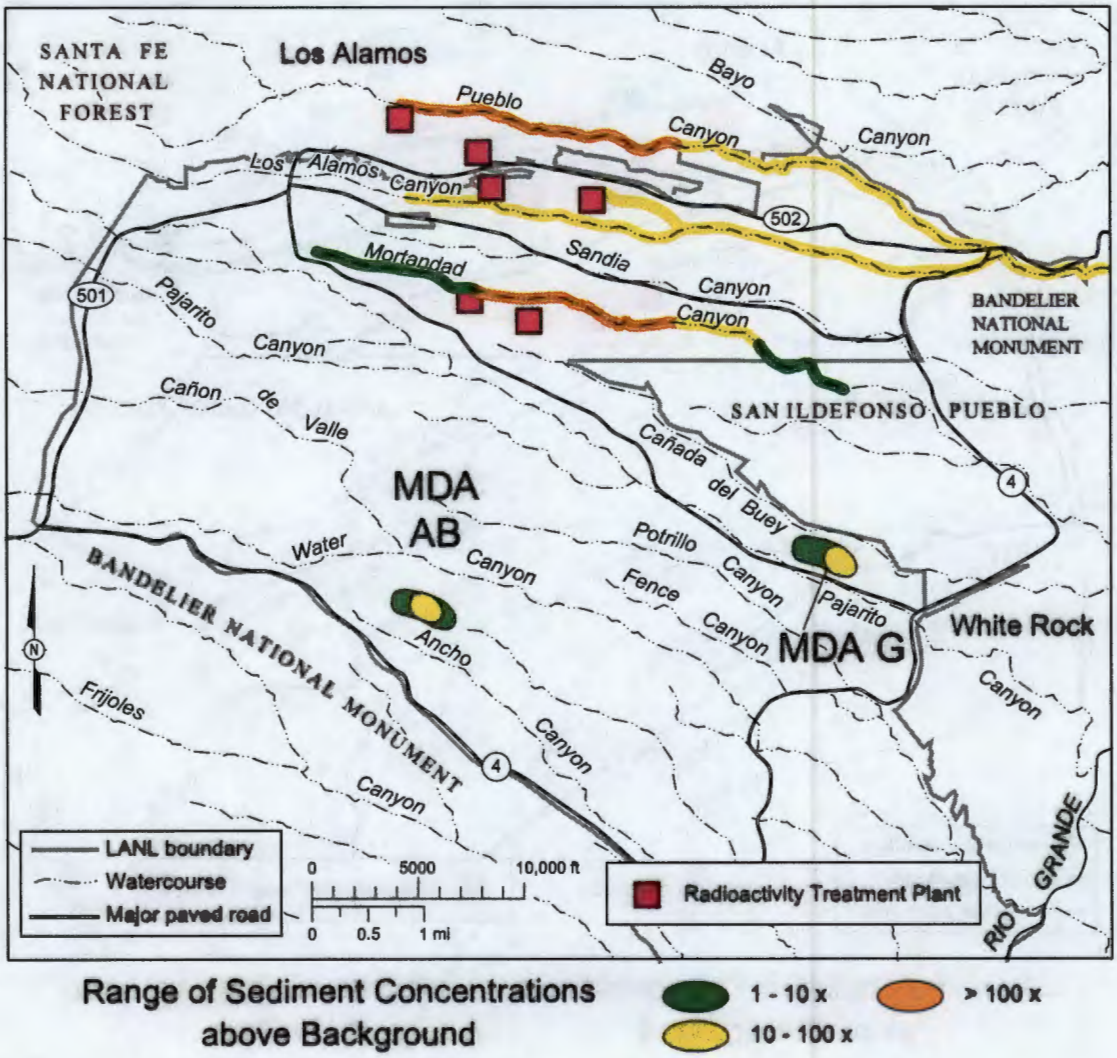

Figure 6-10. Location of the active stream channel sediment with Pu-239,240 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). The highest value in 2004 was in Mortandad Canyon, at 758 times background, 22% of the residential SAL, and 16% of the industrial worker SAL.

3. 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 San Ildefonso Pueblo land before joining the Rio Grande. Effluent discharges primarily from power plant blowdown supported perennial flow conditions along a 2-mile reach below TA-3. Only one day with flow was recorded at the Laboratory boundary in water year 2004 (Shaull et al., 2005). Monitoring results have consistently shown minimal off-site contamination from the Laboratory in Sandia Canyon.

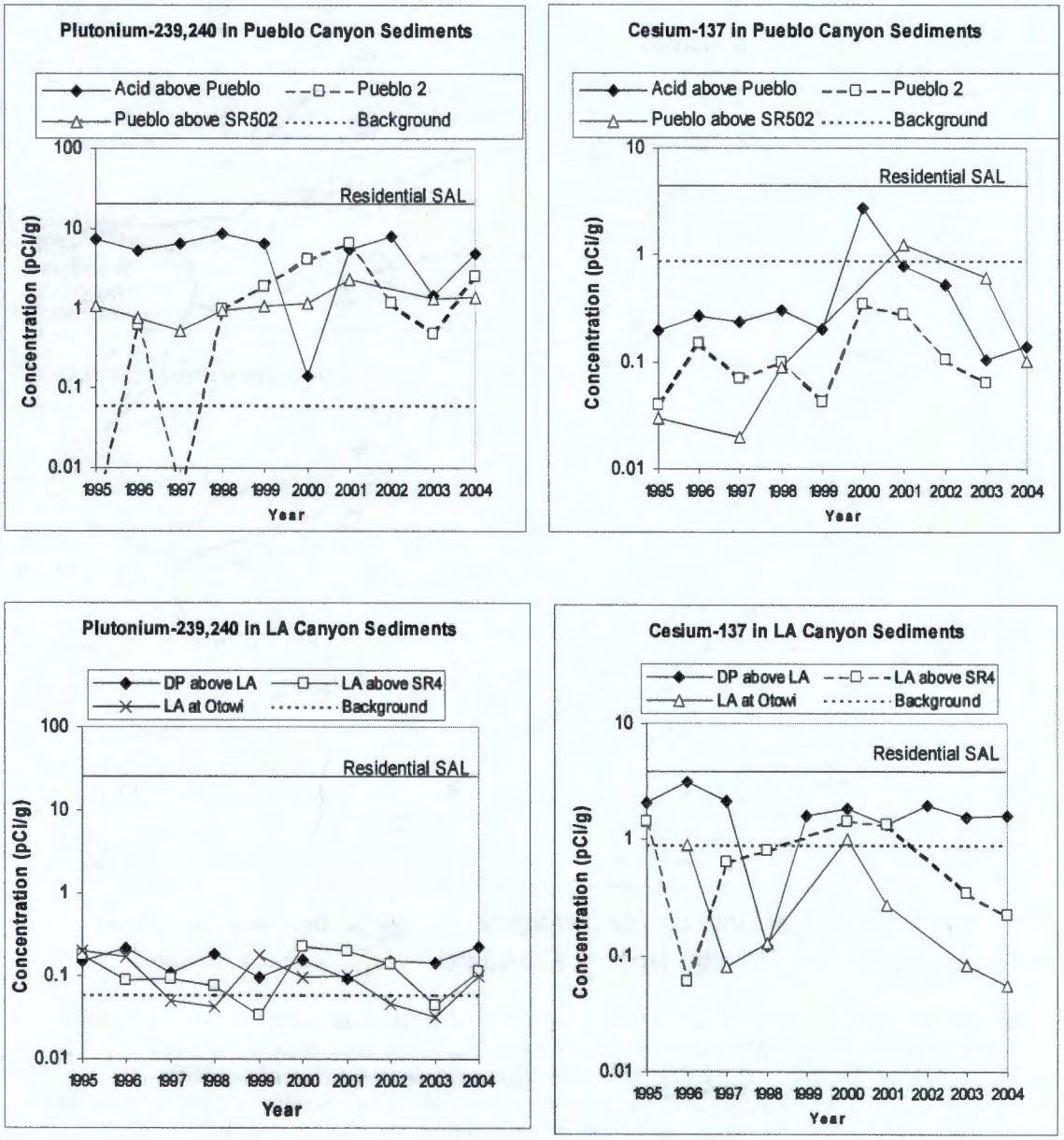

Figure 6-11. Long-term radioactivity trends in Los Alamos and Pueblo Canyon sediments. Note the logarithmic scale on the vertical axes of the graphs.

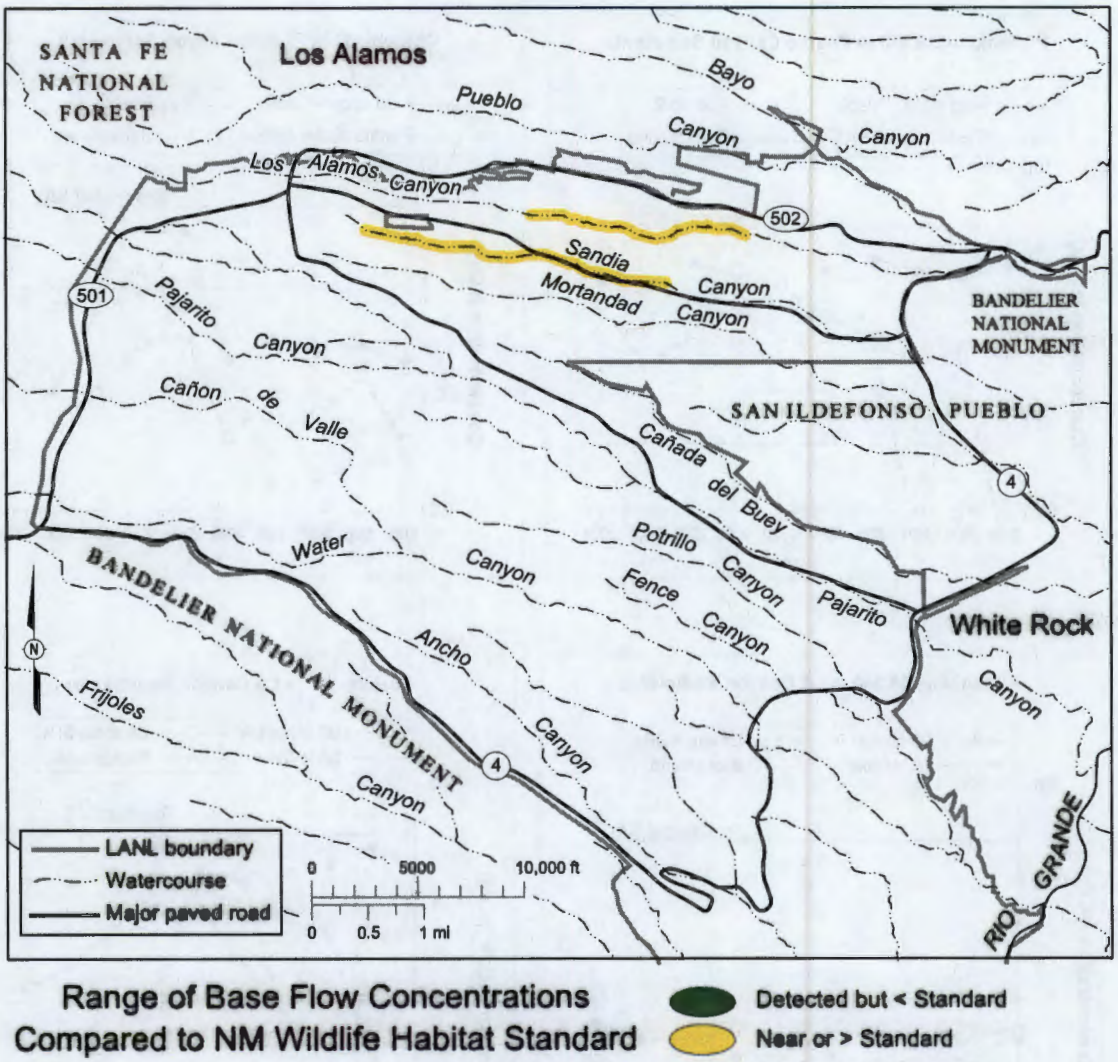

Figure 6-12. Location of surface water with the total PCB detected or near the New Mexico Wildlife Habitat stream standard. Different colors indicate where PCBs was detected or was above the Human Health standard. The colors also reflect where the PCBs were above the New Mexico fish consumption/Human Health standard. The highest value in 2004 was in Sandia Canyon, at an estimated concentration 394 times the human health standard and 48 times the wildlife standard.

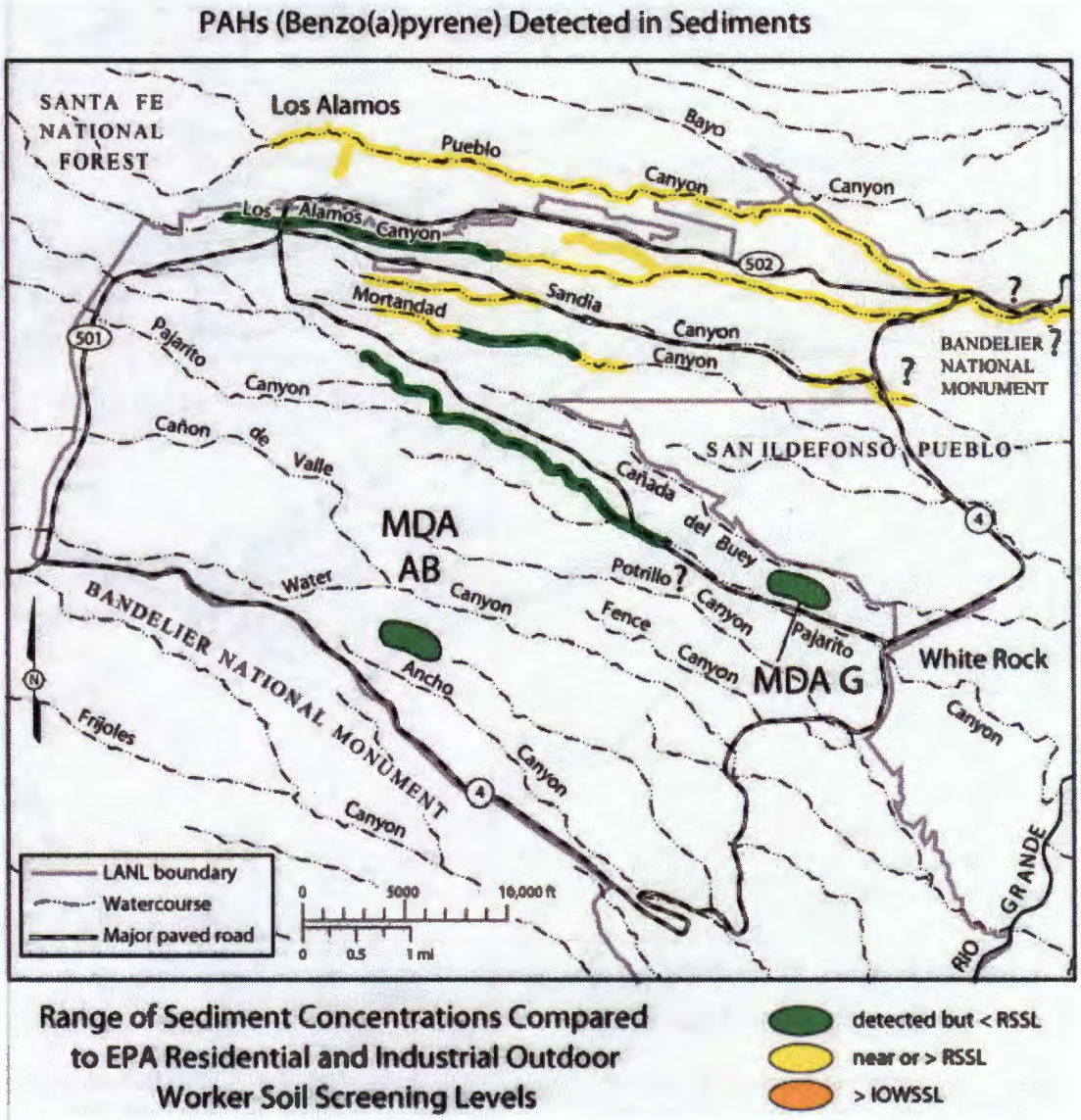

Figure 6-13. Location of sediment with benzo(a)pyrene, a polycyclic aromatic hydrocarbon, detected or above screening levels. Different colors indicate where polycyclic aromatic hydrocarbons are detected or are above the EPA Region 6 residential soil screening level. The highest value in 2004 was in Los Alamos Canyon, at 22 times the residential soil screening level and 5.6 times the industrial outdoor worker soil screening level.

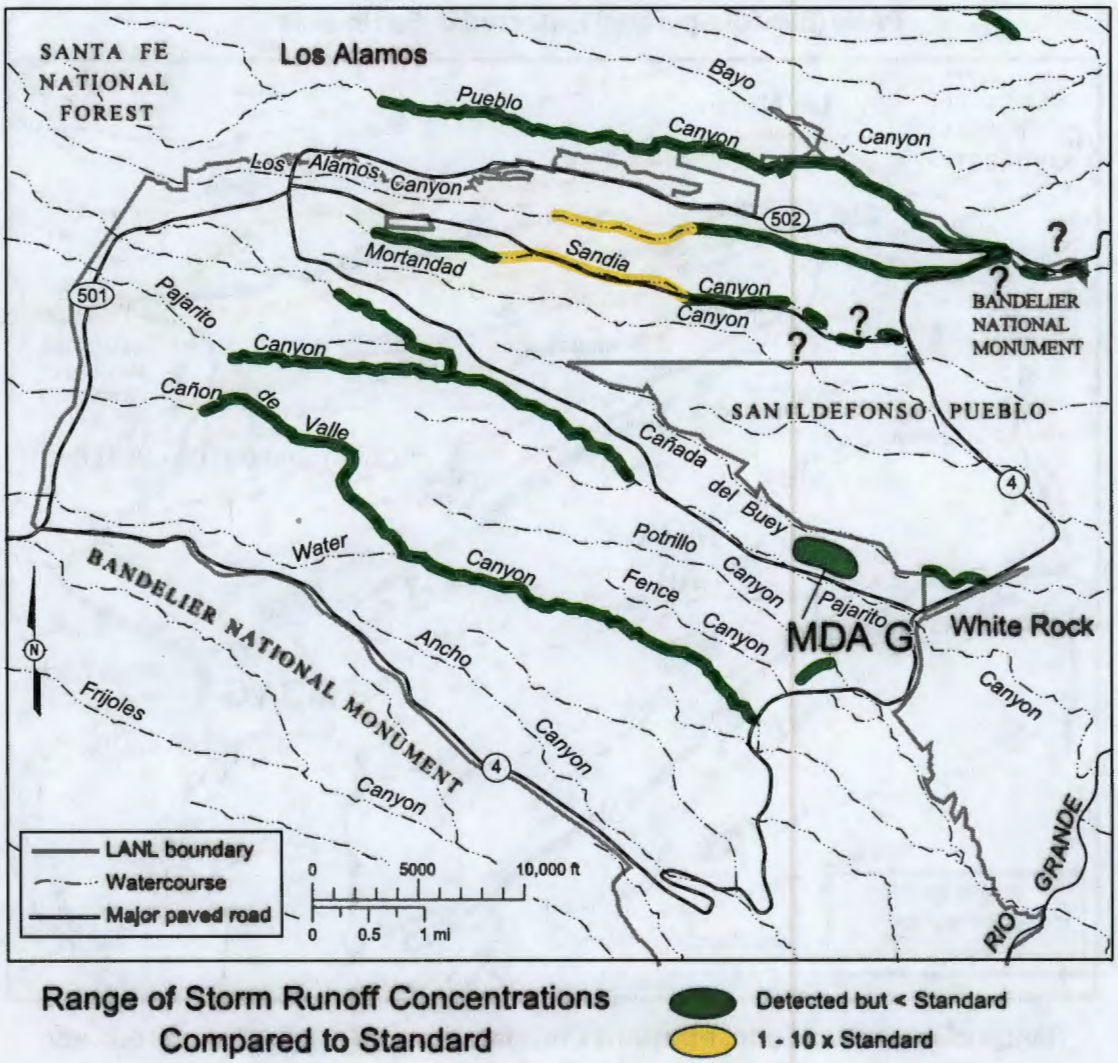

Figure 6-14. Location of storm runoff with total mercury above the New Mexico Wildlife Habitat stream standard. Different colors indicate the proportion of concentration to the standard. The highest 2004 watercourse values were in Los Alamos Canyon at 1.5 times the standard and in Sandia Canyon at 1.2 of the standard.

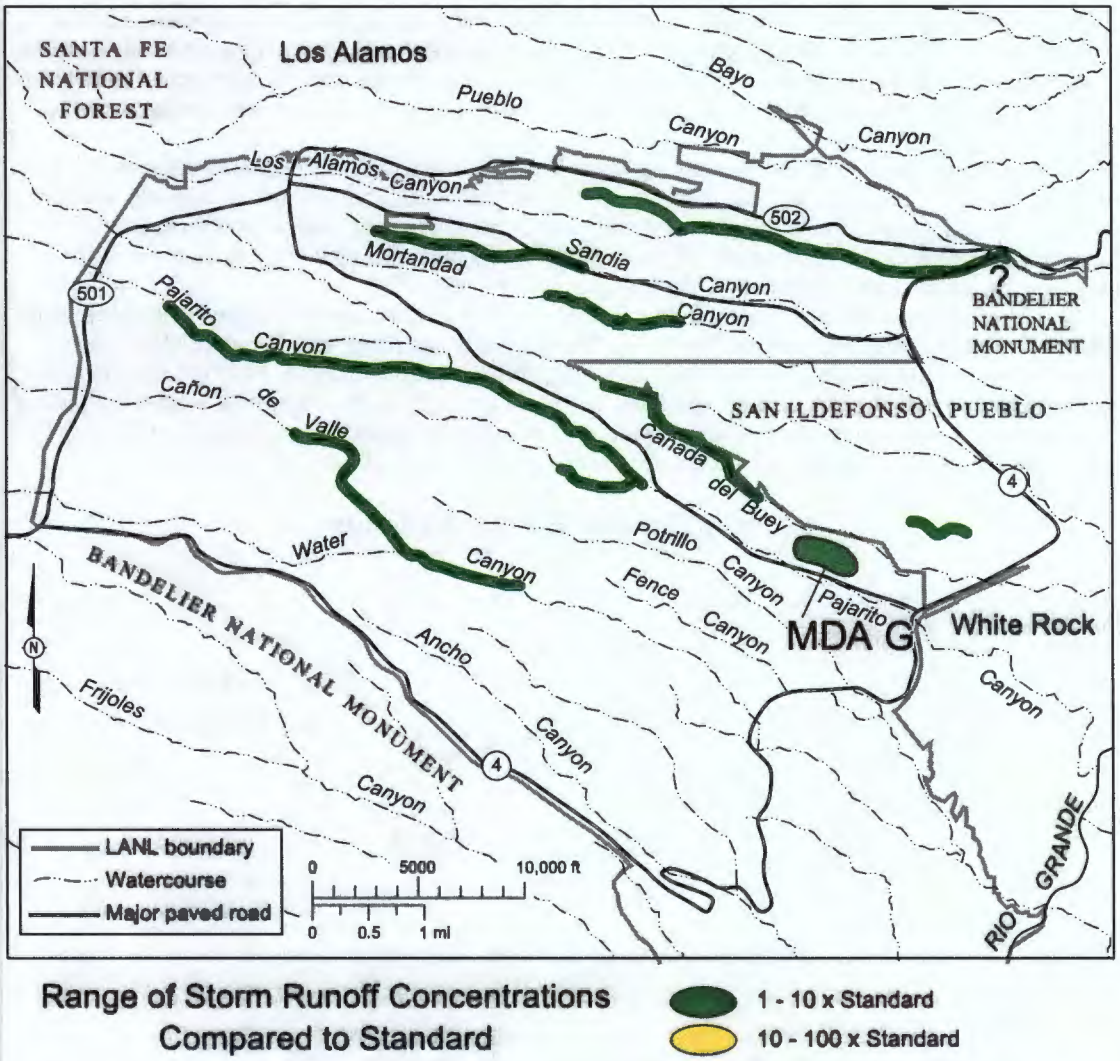

Figure 6-15. Location of storm runoff with dissolved copper above the New Mexico Acute Aquatic Life stream standard. Different colors indicate the proportion of concentration to the standard. The highest 2004 watercourse values were in Sandia Canyon at 12 times the standard and in Mortandad Canyon at 3.6 times the standard. Dissolved lead and zinc concentrations above the standard were detected in DP/Los Alamos and Sandia Canyons within the same shaded areas shown for copper. The highest dissolved lead and dissolved zinc concentrations were measured in Sandia Canyon at 2 and 9 times the standard, respectively.

The upper portion of the canyon contains some of the highest PCB concentrations of any watercourse within the Laboratory boundaries. Three samples collected below the Sandia Canyon wetland contained Aroclors 1254 and 1260 concentrations greater than the New Mexico stream standards for fish consumption/human health and wildlife protection by up to 350 and 35 times, respectively. The Aroclor 1260 was also detected above state fish consumption/human health and wildlife standards in a runoff sample collected above the firing range that is located approximately two miles upstream of the Laboratory 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. Sediment samples collected in the upper portion of Sandia Canyon contained

PCB concentrations more than one-half the EPA residential soil screening level. Downstream sediment concentrations of PCBs decline quickly and are near background (fallout) ranges at the LANL downstream boundary. PCB concentrations at Sandia below the wetlands in 2004 were approximately one-fourth those measured in 2002 (Figure 6-16). PCB concentrations at the other canyon stations were consistent with previous years.

Along an approximately two-mile segment below TA-3 are found above-background concentrations of chromium, copper, mercury, and zinc in surface water and sediments. Storm runoff occasionally contains concentrations above regulatory standards. Measurements in 2004 found dissolved concentrations of copper and lead above the acute aquatic life standard by 2 to 9 times and total mercury concentrations above the wildlife habitat standard by 2 times (Figures 6-14 and 6-15).

Last year's report described the detection of perchlorate in a January base-flow sample taken below the power plant, at a concentration of 18.5 µg/L. The Water Quality and Hydrology Group (ENV-WQH) 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 2004 detected perchlorate concentrations of 0.5 to 0.7 µg/L using the more-sensitive LC/MS/MS method at a detection limit of 0.05 µg/L.

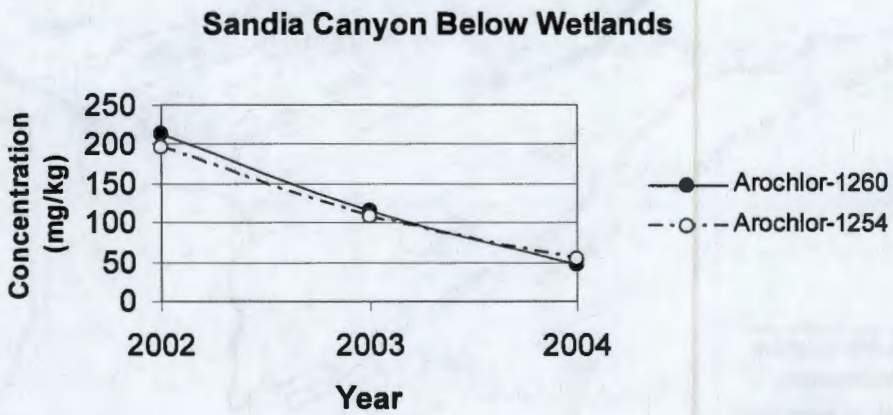

Figure 6-16. Recent trends of PCB concentrations in stream sediments at the Sandia Below Wetlands station.

4. 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 San Ildefonso Pueblo land before joining the Rio Grande.

One Mortandad Canyon stormwater runoff sample collected below the Radioactive Liquid Waste Treatment Facility (RLWTF) effluent discharge point contained americium-241 concentration 1.4 times greater than the DOE 100-mrem DCG for public dose. When considered together with analyses of base flow, the annual time-weighted average of americium-241 is below its DCG. When the mixture of radionuclides is considered (see discussion in D.4), the waters also are below the 100-mrem DCG (time weighted sum of ratios is 60% of DCG). Effluent discharges from the RLWTF during 2004 were well below the DCG (17% of DCG; Watkins and del Signore 2005). Stream flow in Mortandad Canyon does not extend off-site and is not used as a drinking water supply.

Despite the history of extensive releases into the Mortandad Canyon watershed, radioactivity in sediments is only slightly elevated above background levels at the Laboratory's eastern boundary, downstream of the effluent discharges. 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 RLWTF discharge (Figures 6-8 through 6-10). The absence of stream flow near the Laboratory boundary is the main reason for the drop-off in sediment radioactivity downstream. Cesium-137 concentrations in active channel sediment upstream of the sediment traps were greater than residential

SALs (ER 2001) by up to two times (Figure 6-17). The sediment traps are located approximately 2 miles upstream of the Laboratory's eastern boundary. At the boundary, the cesium-137 concentrations were within background ranges.

Analysis detected dissolved copper concentrations above the New Mexico Acute Aquatic Life stream standard by 2 to 4 times in base-flow and runoff samples collected at the Mortandad below Effluent Canyon station. Benzo(a)pyrene was detected in a sediment sample at the same location at 2.1 times the EPA residential soil-screening level (Figure 6-13). As discussed in detail in the 2002 and 2003 reports, potential sources are many and include road runoff, the Cerro Grande fire, and industrial sources.

Radioactivity in sediment around Area G and in Cañada del Buey was generally consistent in 2004 with previous years. Upward trends of plutonium-239,240 and other radionuclides were noted in the previous 2003 ESR report at sediment sampling stations G-7 and G-8, which are both located along the eastern portion of Area G (Figure 6-18). Radioactivity at these sediment stations returned in 2004 to within typical ranges measured in the late 1990s for those sites. Plutonium-239,240 concentrations in Cañada del Buey were within or slightly elevated above background levels (Ryti et al. 1998).

a. Long-Term Trends. Figure 6-17 shows activities of plutonium-238, plutonium-239,240, and cesium-137 at four sediment stations in Mortandad Canyon. All of the stations are located below the RLWTF discharge. The stations MCO-9.5 and the LANL boundary are located below the sediment traps. For the plots discussed in this section, we describe only detections of a particular radionuclide in sediments; samples without such detections are not included.

Radioactivity levels in sediments just below the RLWTF have not changed appreciably in the past decade, but recent monitoring results show that the levels near the Laboratory boundary are higher than previously recognized before 2001. The plots show that plutonium and cesium activities at MCO-8.5 and -9.5 increased significantly in 2001; relocating the sampling stations to the active channel caused this increase.

5. Pajarito Canyon (includes Two Mile and Three Mile Canyons)

Pajarito Canyon heads on the flanks of the Sierra de los Valles on US Forest Service lands. The canyon crosses the south-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 sediments from channels draining Area G. Concentrations of these radionuclides were commonly 5 to 10 times background. While present at elevated concentrations, all of the radionuclides were at levels below residential SALs.

We detected dissolved copper concentrations greater than the New Mexico Acute Aquatic Life standard in channels throughout the Pajarito Canyon watershed, including Starmers, Three Mile, Two Mile, and Pajarito Canyons (Figure 6-15). Review of sediment data from the drainage does not indicate a Laboratory source for the copper. All 2004 sediment results from the drainage were within background concentrations (Ryti et al. 1998), except for at one location at the Laboratory's eastern boundary (Pajarito above State Road 4).

A sediment sample from Pajarito Canyon SR 4 contained many metals and radionuclides elevated two to five times above background. Cesium-137 concentrations were 4 times above background and 68% of the residential SAL. The 2004 results indicate a source(s) other than Area G because cesium-137 is not substantially elevated in sediments around Area G. The sample station was relocated in 2002. Previously the station was below 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 higher 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) also were 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.

Concentrations of organic compounds in sediments from Pajarito Canyon are low and far below EPA residential soil screening levels, with one exception. Benzo(a)pyrene was reported at 1.5 times the residential soil screening level in a sample from Pajarito above TA-18. Low levels of PCBs were detected at levels below the EPA residential soil-screening level in Pajarito Canyon sediments. Around Area G, PCBs concentrations reported in sediments at stations G-6 and G-7 were near the analytical detection limit. PCBs were not detected in stormwater runoff samples collected around Area G.

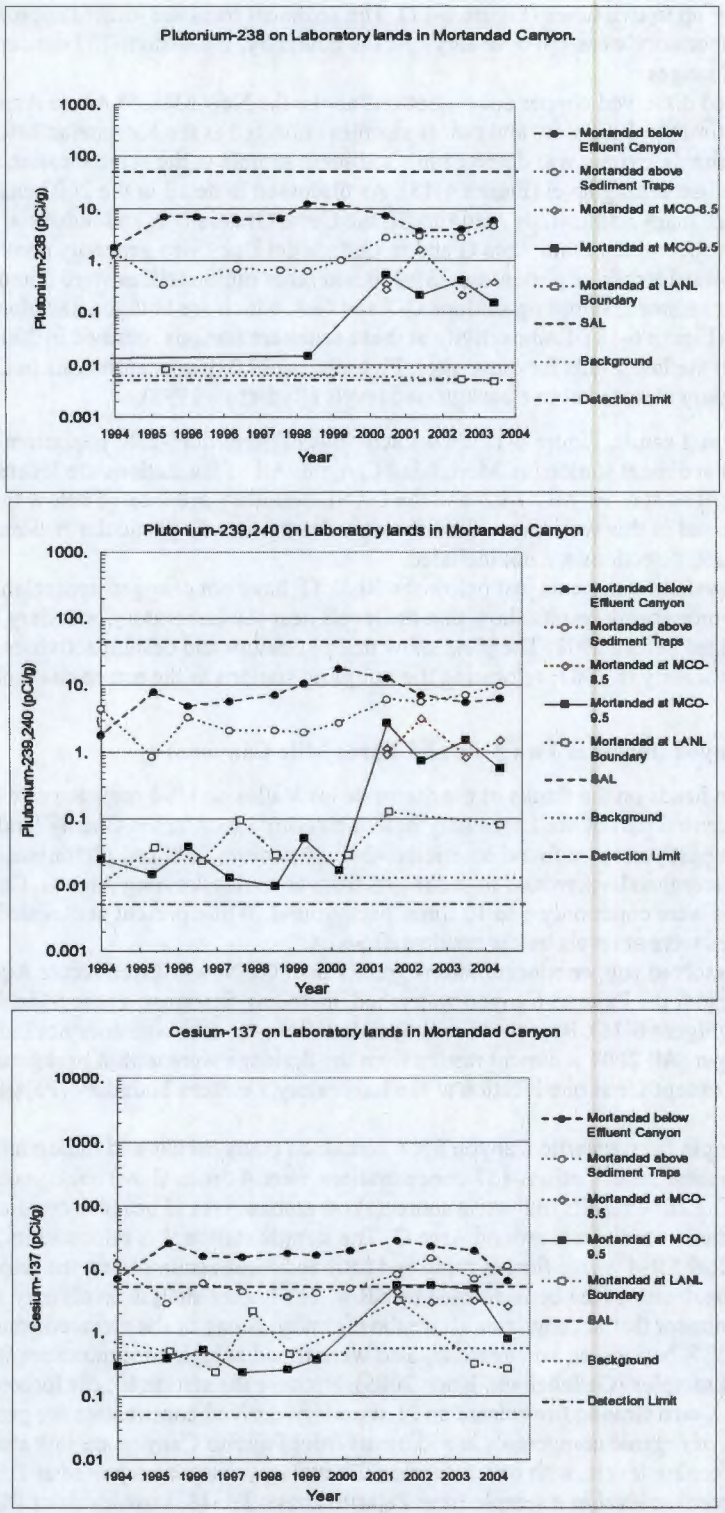

Figure 6-17. Long-term radioactivity trends in Mortandad Canyon sediments. Note the logarithmic scale on vertical axes of the graphs.

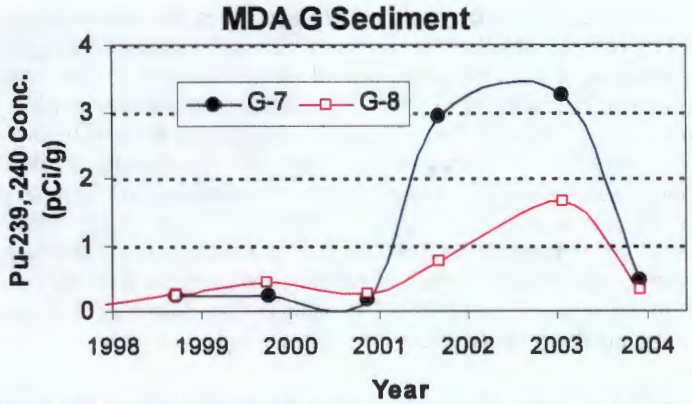

Figure 6-18. Recent trends of Pu-239,240 activities at Material Disposal Area G sediment stations G-7 and G-8.

6. 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 historically and currently take place. Elevated concentrations of barium, HMX, and RDX have been previously measured in sediment and surface water. In 2004, dissolved barium was present in base flow at up to 85% of the New Mexico groundwater standard, and RDX occasionally is present in surface water above the 6.1-ppb EPA Tap Water Health Advisory in Cañon de Valle. Average concentrations for barium and RDX for 2004 are below these regulatory reference levels. The Laboratory's Remediation Services Project is investigating this area extensively in support of a Resource Conservation and Recovery Act Corrective Measures Study.

Area AB at TA-49 was the site of underground nuclear-weapons testing from 1959 to 1961 (Purtymun and Stoker 1987; ESP 1988). These tests involved HEs and fissionable material insufficient to produce a nuclear reaction. Area AB drains into Ancho and Water Canyons. Legacy surface contamination is responsible for the above-background concentrations of plutonium and americium present in the sediments downstream of this site. However, the site of highest surface contamination at Area AB drains north to Water Canyon, but no above-background plutonium extends more than 110 yards beyond Area AB.

G. Special Study of PCBs in the Los Alamos Area using Congener Analyses

PCBs are typically not detectable in Los Alamos surface waters when analyzed using standard EPA analytical methods, except in an occasional runoff sample from Los Alamos or Sandia Canyons. This presents an incomplete picture of PCB concentrations in surface waters, however, because the detection limits of the standard analytical methods are many orders of magnitude greater than regulatory limits prescribed by the New Mexico human health stream standard of 0.0017 µg/L. Starting in 2000 through 2003, the NMED and LANL have analyzed selected surface waters and sediments in the vicinity of the Laboratory using a much more sensitive nonstandard procedure, the EPA Method 1668 for the analysis of PCB congeners. Because the results from this special study have not been discussed in previous ESR reports, we include a brief summary here of the findings.

The congener analyses showed that stormwater runoff in northern New Mexico often contained detectable PCB concentrations, above the NMWQCC human health standard of 1.7 ng/L. Concentrations greater than the human health standard were found in Pajarito Plateau samples and in Rio Grande samples, both above and below the Laboratory.

On the Pajarito Plateau, stormwater runoff in every watershed tested contained total PCB concentrations greater than the human health standard: Pueblo Canyon (822 ng/L maximum), Los Alamos Canyon (125 ng/L), Sandia Canyon (253 ng/L), Pajarito Canyon (298 ng/L), and Water Canyon (121 ng/L). Depending on the location, Laboratory sources, urban runoff, and atmospheric deposition may contribute to the

contaminant load. For example, immediately below a urbanized area that drains into the north tributary of Pueblo Canyon, NMED measured a PCB concentration of 521 ng/L, indicating a significant urban source.

PCB concentrations measured in the Rio Grande were substantially lower than measured on the Pajarito Plateau, with a maximum concentration of 12.8 ng/L measured at the confluence with Ancho Canyon. Concentrations upstream of the Laboratory were generally comparable to those below.

The special study indicated that PCBs are commonly present in stormwater runoff at concentrations greater than the NMWQCC human health standard. This is a widespread and regional problem. Drainages within the Laboratory boundaries as well as drainages removed from Laboratory influences likely contain elevated PCB concentrations. Impacts to the Rio Grande from Pajarito Plateau drainages appear to be slight, with concentrations measured above the Laboratory comparable to those below.

Detailed results from the congener analyses are available in the following references: NMED (2003b), Mullen and Koch (2004), and Gallaher and Koch (2004).

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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6. Watershed Monitoring

7. Soil Monitoring

7. Soil Monitoring

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A. Introduction

A soil-sampling-and-analysis program provides the most direct means of determining the inventory, concentration, distribution, and long-term accumulation of radionuclides and other contaminants around nuclear facilities (DOE 1991). A soil characterization program provides information about potential pathways (such as soil ingestion, food crops, resuspension into the air, and contamination of groundwater) 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

(1) an institutional component that monitors soil contaminants within and around LANL in accordance with Department of Energy (DOE) Orders 450.1 (DOE 2003) and 5400.5 (DOE 1993); and

(2) a facility component that monitors soil contaminants within and around the Laboratory's

- principal low-level 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:

(1) radionuclide and nonradionuclide (heavy metals and organic constituents) concentrations in soils collected from potentially impacted areas (lab-wide and facility-specific);

(2) trends over time (i.e., whether radionuclides and nonradionuclides are increasing or decreasing over time); and

(3) 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 Environmental Stewardship Division's soil-sampling team first compares the analytical results of soil samples collected from the Laboratory's on-site and perimeter areas to regional (RSRLs) or baseline (BSRLs) statistical reference levels. Where the levels exceed RSRLs (or BSRLs), we then compare the concentrations to the screening levels; and, finally, if needed, to the standards. Table 7-1 summarizes the levels and/or standard used to evaluate the soil monitoring program.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from soil data collected from regional background locations away from the influence of the Laboratory over the past five years. (Note: For a list of regional locations see Fresquez 2004a.) RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of the 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 (preoperational) 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 to 1999, before the operation 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 (Fresquez et al. 2001a). (Note: Prior evaluations of BSRLs with RSRLs show no statistical differences between the two. The soil-sampling team uses BSRLs at DARHT to meet Mitigation Action Plan requirements.)
- Screening levels: LANL's Environmental Restoration Project developed screening (action) levels for radionuclides to identify contaminants of concern on the basis of a conservative (e.g., residential) 15-mrem protective dose limit (ER 2002). We compared nonradionuclides to the human health medium-specific screening levels that the US Environmental Protection Agency (EPA) has set at a 10^{-6} risk (EPA 2004). If a constituent exceeds an SL, then the reason for that increase is more thoroughly investigated
- Standard: If screening levels are exceeded, then a dose to a person would be calculated using the RESRAD computer model (Yu et al. 1995). 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 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	On-site, Perimeter and Area G	100 mrem	15 mrem	RSRL
	DARHT	100 mrem	15 mrem	BSRL
Nonradionuclides	On-site and Perimeter		10^{-6} risk (resident)	RSRL
	Area G		10^{-6} risk (industrial)	RSRL
	DARHT		10^{-6} risk (industrial)	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 three 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 LANL have been very low and, for the most part, have not increased over time, soils will now be sampled once every three years.

Although the soil-sampling program was changed to a three-year sampling cycle, the Pueblo de San Ildefonso requested that we collect two perimeter soil samples on their lands that are downwind of Area G , the Laboratory's principal low-level radioactive waste disposal site. Area G, approximately 63 acres in size, is located in the Laboratory's Waste Disposal Site (TA-54) at the Laboratory's eastern boundary.

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 by Paragon Analytics, Inc., 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 barium, beryllium, mercury, lead, and selenium.

2. Radionuclide Analytical Results

When we compared the radionuclide concentrations from both sites with regional background concentrations, we found that most radionuclides (with the exception of plutonium-239,240 in the San Ildefonso sample, and uranium 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 uncertainty and is not significantly different from zero (Keith 1991; Corely et al. 1981).

The 0.038 pCi/g dry amount of plutonium-239,240 we detected in the San Ildefonso soil sample was just above the RSRL value of 0.032 pCi/g but far below the SL of 44 pCi/g dry. Comparing the concentrations of plutonium-239,240 to soil samples that have been collected since 1996 from this same location show that, for the most part, levels have been within regional background concentrations (Figure 7-2). Similarly, the levels of uranium isotopes in the soil sample collected from the Tsankawi/PM-1 site show only a slightly higher level than the RSRL. And a comparison of the isotopic ratio of uranium-234 to uranium-238 in the Tsankawi/PM-1 sample shows that the uranium is of natural origin and probably not a Laboratory contribution because there are no firing sites close by.

3. Nonradionuclide Analytical Results

The results of the trace metal analysis—barium, beryllium, mercury, lead, and selenium—in soils collected from San Ildefonso Pueblo lands can be found in Table S7-2. All concentrations of metals in soils from San Ildefonso Pueblo lands were below RSRLs.

D. Facility Monitoring

1. Monitoring Network

Facility-specific soil monitoring is done at Area G (Lopez 2002) and at DARHT (Nyhan et al. 2001a). The soil-sampling team collects approximately 15 soil-surface samples at designated places within and around the perimeter of Area G on an annual basis (Figure 7-3). These samples were analyzed by Paragon Analytics, Inc., for tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; uranium-234; uranium-235; and uranium-238.

DARHT, approximately 20 acres in size, is located at R-Site (TA-15) at the Laboratory's southwestern end. We collect approximately four soil and four sediment samples annually at designated locations 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; and uranium isotopes, and for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium.

We compare Area G's results for radionuclides in soils to RSRLs, whereas we compare DARHT results for radionuclides and nonradionuclides in soils and sediments to BSRLs.

2. Radionuclide Analytical Results for TA-54, Area G

Many soil samples collected at Area G contained concentrations of tritium, plutonium-239,240, plutonium-238 , and americium-241 above RSRLs. (Note: All data can be found in Fresquez and Lopez 2005.) In contrast, the levels of cesium-137, strontium-90, and uranium isotopes in all of the soil samples at Area G were either nondetectable or within RSRLs. The highest levels of tritium in soils were detected outside the perimeter of Area G's southern portion near the tritium waste disposal shafts. Highest concentrations of the plutonium isotopes were detected in the northern and northeastern portions of Area G and are probably associated with the TRU waste storage areas. These data are similar to past years (Nyhan et al. 2003a, Fresquez et al. 2004a) and all are below LANL screening levels.

The highest reported concentrations of tritium in samples collected within and around Area G during the last seven years show increasing trends between 1998 and 2002, and then a decline between 2002 and 2004 (Figure 7-4). It is not completely known why the concentrations of tritium in soils at these two locations at Area G dropped so dramatically, but the low soil water contents at the surface during these drought years may be but one factor, as tritium is associated with the water cycle. As for the plutonium-239,240 concentrations in the two "worst case" soil areas at Area G, one sample, located on the outside of the perimeter fence line on the northeast corner, is generally decreasing, whereas the other sample, located inside the fence line on the north side, is statistically ($\alpha = 0.05$) increasing over time (Figure 7-5).

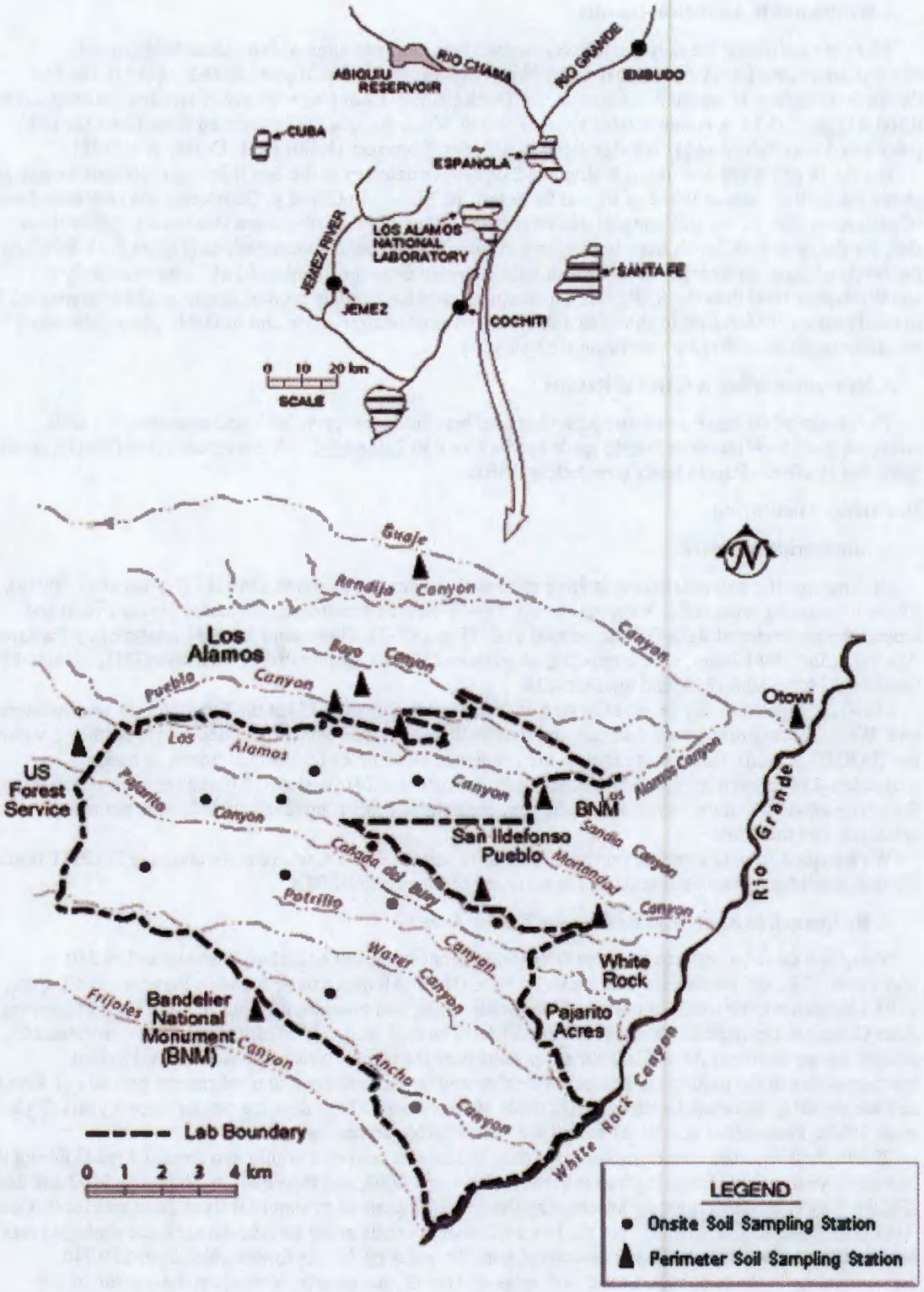

Figure 7-1. Off-site regional and perimeter and on-site Laboratory soil sampling locations.

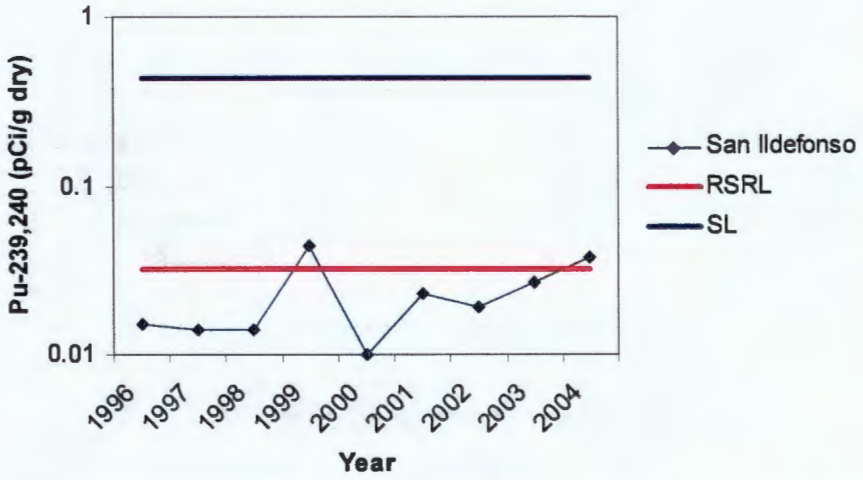

Figure 7-2. plutonium-239,240 concentrations in soil samples collected from San Ildefonso Pueblo lands over time approximately one-half mile northeast of Area G as compared to the regional statistical reference level (RSRL) and to the screening level (SL).

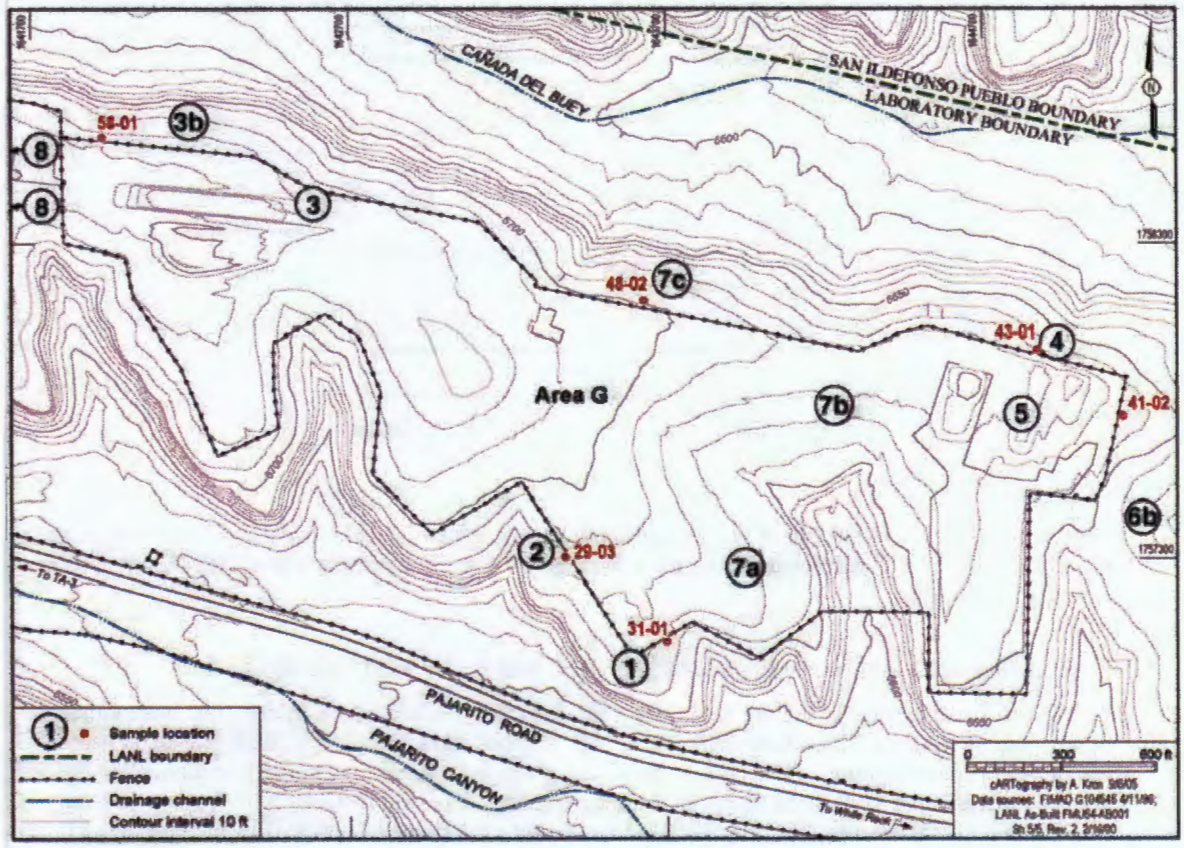

Figure 7-3. Site/sample locations of soils and vegetation at Area G. Site #8 is located farther west than shown.

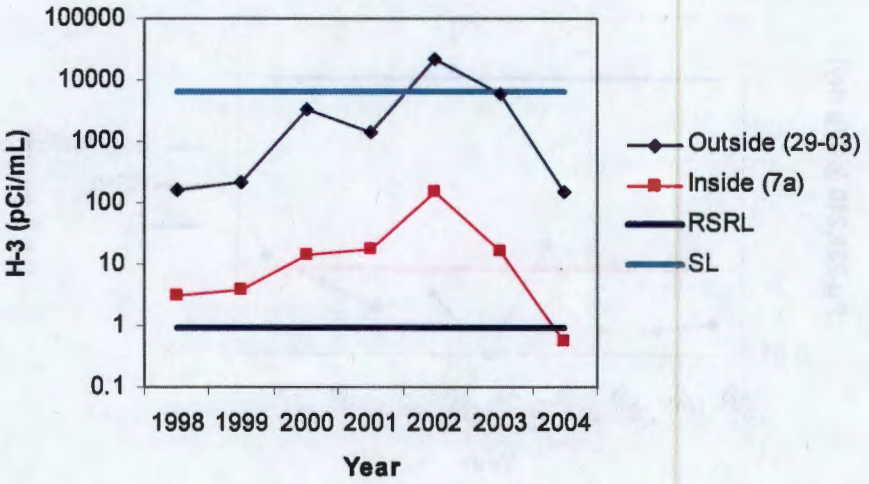

Figure 7-4. Tritium in surface soils collected from two selected (worst case) locations within and around Area G at TA-54 from 1998 to 2004 as compared to the regional statistical reference level (RSRL) and screening level (SL).

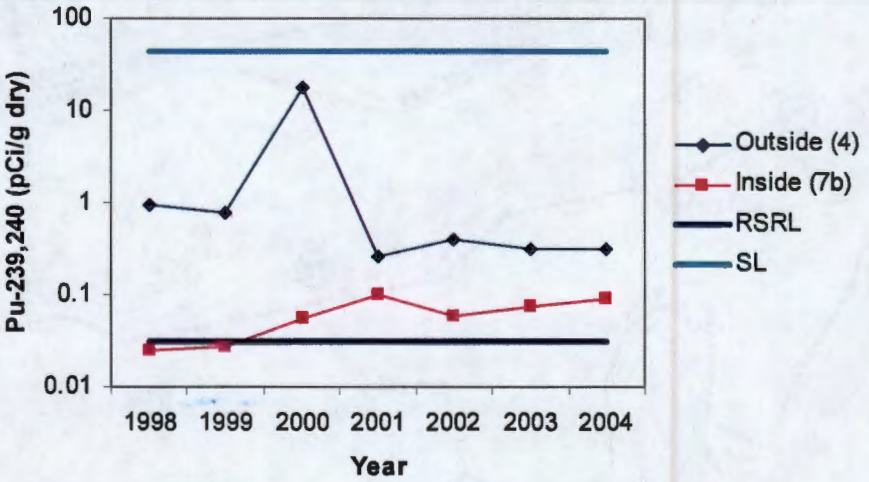

Figure 7-5. Plutonium-239,240 in surface soils collected from two selected (worst case) locations at Area G at TA-54 from 1998 to 2004 as compared to the regional statistical reference level (RSRL) and screening level (SL).

3. Radionuclide and Nonradionuclide Analytical Results for TA-15, DARHT

Most soil, and especially sediment, samples contained radionuclide concentrations that were either nondetectable or below BSRL values. (Note: All data can be found in Fresquez 2004b.) Also, most radionuclide concentrations in DARHT soils and sediments were generally similar to radionuclide concentrations found in regional background concentrations (Fresquez 2004a).

Radionuclides that were above the BSRLs included concentrations of cesium-137 and uranium-238 in three out of the four soil samples, and plutonium-239,240 and americium-241 in one out of the four soil samples. These data, at least for cesium-137 and uranium-238, had exhibited similar results in past years (Nyhan et al. 2003b; Fresquez et al. 2004b). All radionuclides, however, were far below screening levels. Some of the soil samples had isotopic uranium ratios consistent with depleted uranium. Depleted uranium,

a metal used as a substitute for the enriched uranium in weapon components tested at LANL, was also detected in vegetation (Fresquez 2004b), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) collected from around the DARHT grounds.

Most trace metal elements in soil and sediment samples collected at the DARHT facility were below BSRLs. The metals that were detected above the BSRLs included beryllium in one of four soil samples nearest the firing point, and selenium and thallium in some samples. All samples, however, were still far below the EPA screening levels. In the last two years, we have found elevated concentrations of antimony in many of the soil/sediment sampling locations. In 2004, however, the antimony concentrations in all of the soil/sediment samples were at baseline levels.

E. Quality Assurance/Quality Control

The soil-sampling team conducts soil-surface sampling according to written, standard quality-assurance/quality-control (QA/QC) procedures and protocols. These QA/QC procedures and protocols are identified in the overall "QA Project Plan (QAPP) for the Soils, Foodstuffs, and Biota Monitoring Project" (RRES-MAQ-QAPP, 2004); and, in the following operating procedures:

- "Soil Sampling," RRES-MAQ-707, R5, 2004;
- "Facility Soil and Vegetation Sampling," RRES-MAQ-711, R5, 2004;
- "Processing and Submitting Samples," RRES-MAQ-706, R5, 2004; and
- "Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota," RRES-MAQ-712, R0, 2004.

These procedures ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results is conducted in a correct and 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.

Members of the soil-sampling team collect soil samples for the analysis of radionuclide and trace elements (e.g., metals) from the 0- to 2-in. depth to capture the majority of contaminants from current air emissions and from fugitive dust. All samples are collected from relatively level, open (unsheltered by trees or buildings), rock-free, and undisturbed areas, and from the same (general) locations year after year. Paragon Analytics, Inc., of Fort Collins, Colorado, a company that met all QA/QC requirements, analyzed the soil samples for radionuclides and nonradionuclides.

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7. Soil Monitoring

8. Foodstuffs and Biota Monitoring

8. Foodstuffs and Biota Monitoring

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A. Foodstuffs Monitoring

1. Introduction

A wide variety of wild and domestic edible vegetable, fruit, grain, and animal products are harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes an important pathway by which radionuclides (Whicker and Schultz 1982) and nonradionuclides (metals and organics) (Gough et al. 1979) can be transferred to humans. Therefore, we collected 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 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 are in DOE (1991).

The objectives of the program are:

(1) measure radioactive and nonradioactive contaminants in foodstuffs from on-site (the Los Alamos National Laboratory [LANL]) and perimeter areas, and then compare them to regional (background) areas;

(2) determine trends over time; and

(3) estimate dose from the consumption of the foodstuffs. Chapter 3 discusses potential radiation doses to individuals from the ingestion of foodstuffs.

This year, we focus on the collection and analysis of radionuclides and metals in domestic produce from neighboring communities. Also, wild edible plants collected from Pueblo de San Ildefonso lands within Mortandad Canyon were analyzed and assessed.

2. Foodstuffs Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides to foodstuffs, we first compare analytical results of foodstuffs samples collected from perimeter areas to regional statistical reference levels (RSRLs). Where the levels exceed RSRLs, we then compare the concentrations to screening levels (SLs) if available; and, if needed, to standards, if available. Table 8-1 summarizes the levels and/or the standards used to evaluate the foodstuffs monitoring program.

- Regional background levels: RSRLs are the upper-level background concentration (mean plus three standard deviations) for radionuclides and nonradionuclides calculated from foodstuffs data collected from regional locations away from the influence of the Laboratory (> 9 miles away) (DOE 1991) over the past five years. (Note: For a list of regional locations see the section A3a, "Monitoring Network".) RSRLs represent natural and fallout sources, are calculated annually, and can be found in the annual issues of the Environmental Surveillance Report.
- SL: The Meteorology and Air Quality Group Dose assessment team at the Laboratory developed screening levels for radionuclides to identify the contaminants of concern on the basis of a conservative 1 mrem protective dose limit (RRES-MAQ-DOSE, R0, 2003). Nonradionuclides, like mercury in fish, are compared to the Environmental Protection Agency water quality criterion (EPA 2001). If a constituent exceeds the SL, then the reason for that increase will be more thoroughly investigated.

- Standard: Based on the concentrations of radionuclides in foodstuffs, we calculate a dose to a person (see Chapter 3). This dose is compared with the 100-mrem/yr DOE all pathway dose standard. Nonradionuclides, like mercury and polychlorinated biphenyls in fish, are compared to Food and Drug Administration levels (FDA 2000).

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 in edible portion (wet)	0.3 µg/g in edible portion	RSRLs
Polychlorinated Biphenyls	Perimeter	Fish	2 µg/g in edible portion		RSRLs
	On-site and Perimeter	Animals	3 µg/g in edible portion		RSRLs

3. Domestic Edible Plants

a. Monitoring Network. Approximately 44 crop samples (fruits, vegetables, and grains) were collected from regional and perimeter areas in the summer and fall of 2004 and analyzed for radionuclides and other trace elements (Figure 8-1). Regional background areas sampled included Jemez Springs, Española, Santa Clara, Dixon, Ojo Sarco, and Velarde. Perimeter locations sampled included the Los Alamos town site, White Rock/Pajarito Acres, the Pueblo de San Ildefonso, and the Pueblo of Cochiti (including the neighboring community of Sile). Produce samples collected from the perimeter areas were compared with crop samples collected from regional areas. Radionuclides and metals in produce from background areas are due to worldwide fallout and to natural sources. The analyses included the following radionuclides: tritium, plutonium-238, plutonium-239,240, strontium-90, americium-241, cesium-137, and uranium isotopes. The metals that were analyzed include barium, beryllium, mercury, lead, and selenium.

4. Radionuclide Analytical Results

Radionuclide concentrations in produce collected from regional and perimeter locations during the 2004 growing season can be found in Table S8-1 of the detailed data tables in the attached disk. Most radionuclide concentrations in fruits, vegetables, and grains collected from perimeter areas were nondetectable and are consistent with past years. A nondetectable value is one in which the result is lower than three times the total propagated uncertainty and is not significantly ($\alpha = 0.01$) different from zero (Keith 1991, Corely et al. 1981).

Of the very few radionuclides that were detected in perimeter crops, almost all were below RSRLs. RSRLs are generated from a wide variety of crop data collected from regional areas away from the influence of the Laboratory over the last five years. One of the radionuclides that was detected above the RSRL ($>183 \times 10^{-3}$ pCi/g dry) was strontium-90 in one lettuce plant from the Los Alamos town site (195×10^{-3} pCi/g dry). This result, albeit just above the RSRL, is not unusual as radionuclides differ in concentration from plant species to plant species (Seel et al. 1995), and strontium-90, an analog of calcium, has been shown to be higher in lettuce and lettuce-type plants (average = 173×10^{-3} pCi/g dry) than other nonleafy crop plants (average = 29×10^{-3} pCi/g dry) (Fresquez et al. 2002). Also, this amount was far below the SL of 1 pCi/g dry for strontium-90 (e.g., < 1 mrem). Other radionuclides in perimeter crops that were detected above RSRLs included U-234 and U-238 in carrot samples collected from the Los Alamos townsite. However, the ratio of U-234 to U-238 indicate that this is natural uranium and not a Laboratory contribution. Therefore, all radionuclides in crop plants from all communities surrounding the Laboratory were indistinguishable from natural or fallout levels.

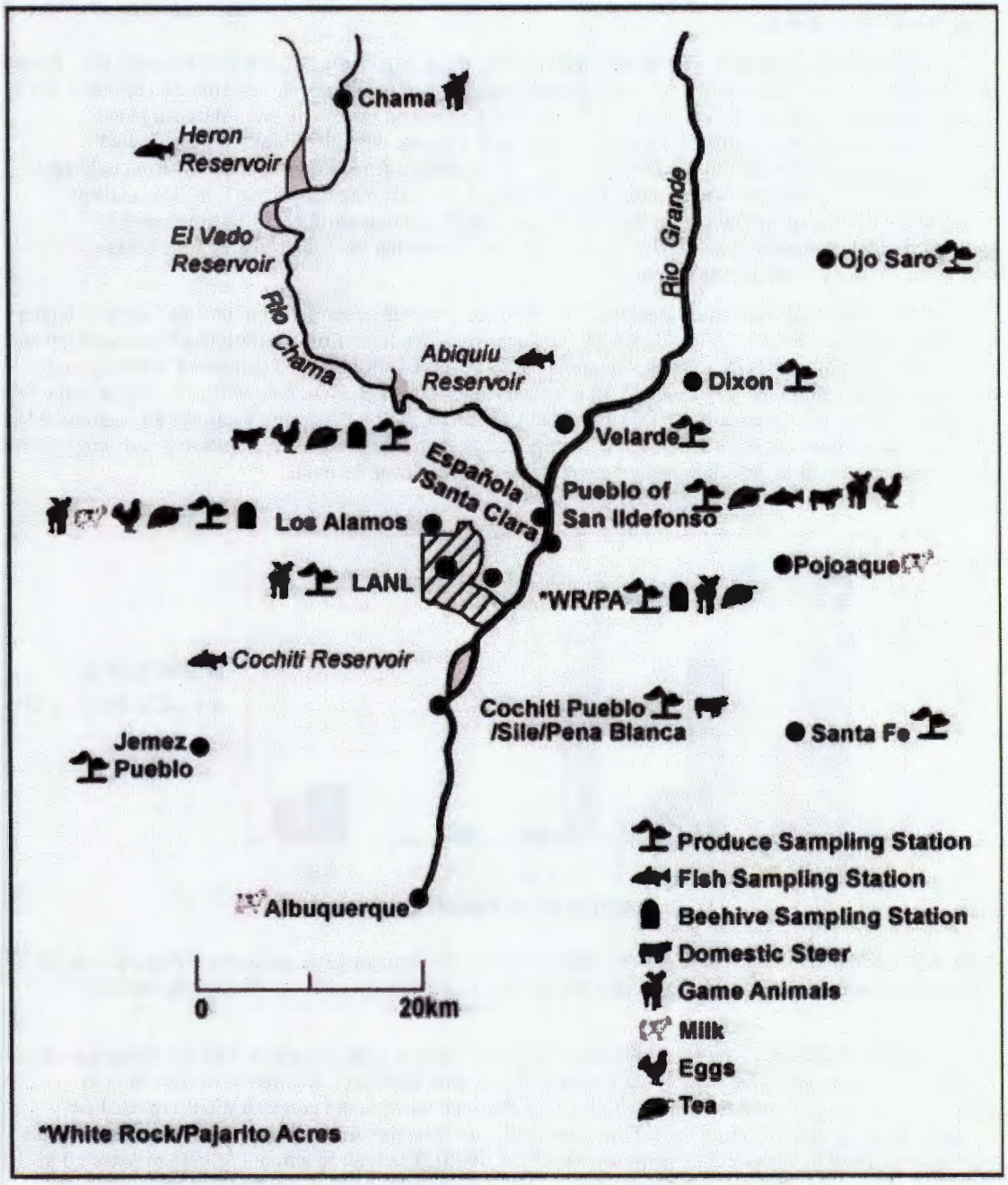

Figure 8-1. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations.

5. Nonradionuclide Analytical Results

All trace element concentrations in vegetable and fruit samples collected from Los Alamos, White Rock/Pajarito Acres, Cochiti/Sile, and San Ildefonso Pueblo were below or very similar to the RSRLs (Table S8-2). Results are similar to past years and no increasing trends are noted.

6. Wild Edible Plants

a. Monitoring Network. Common purslane (Portulaca sp.), is one of the most important wild foods in New Mexico with usage dating back a thousand years (TSFNM 2004), and wild spinach (Spinacia sp), a common leafy green, were collected within Mortandad Canyon on Pueblo de San Ildefonso lands. Composite samples (two of purslane and one of spinach) of these wild plant foods 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 included the following radionuclides: tritium, plutonium-238, plutonium-239, 240, strontium-90, americium-241, cesium-137, and uranium isotopes. The metals that were analyzed include barium, beryllium, mercury, lead, and selenium.

b. Radionuclide Analytical Results. The analyses detected a few radionuclides that were in higher concentrations than the RSRLs (Table S8-3). Purslane contained higher concentrations of strontium-90 and plutonium-239,-240, and wild spinach contained higher levels of strontium-90 compared with regional background concentrations (Figure 8-2). All concentrations, however, were below SLs. This year is the first time these plants have been sampled in Mortandad Canyon on Pueblo lands and analyzed for radionuclides; therefore, these data cannot be compared with past results. This study will be repeated and soil samples will also be collected so that the relationship between plants and soil can be made.

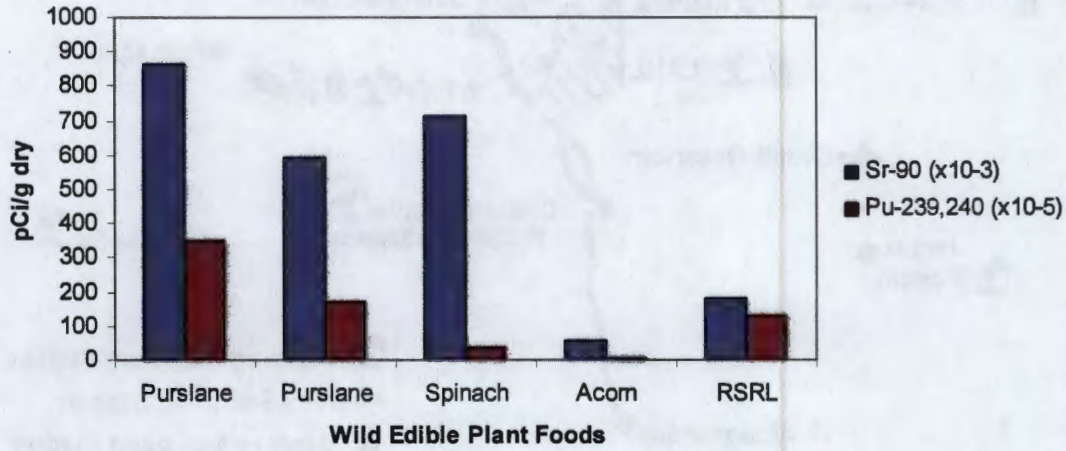

Figure 8-2. Sr-90 and Pu-239,240 concentrations in wild edible plant foods collected within Mortandad Canyon on San Ildefonso Pueblo lands as compared to regional statistical reference levels (RSRLs).

c. Nonradionuclide Analytical Results. All trace element concentrations, with the exception of barium, in wild edible plants were either undetected or below RSRLs (Table S8-4). Barium in both purslane samples was about three times higher than regional background concentrations reported for common produce plants (Figure 8-3). There are no SLs or standards for barium in food plants, but barium is bioaccumulated by many edible plant species (EHC 1990). The highest amount of barium detected in purslane plants (320 µg/g dry) collected within Mortandad Canyon on San Ildefonso Pueblo lands, for example, is below that found in mulberry (470 µg/g), walnut (550 µg/g), grape (630 µg/g), and Brazil nut (2,400 µg/g) plants (Robinson et al. 1950). The other wild food plant, spinach (22 µg/g of barium), that was collected in the same area as the purslane plants was very similar in barium concentrations to other leafy plants like lettuce (22 to 36 µg/g). Therefore, the bioaccumulation of barium by purslane plants is suspected. In any case, since this was the first time these plants have been sampled in Mortandad Canyon on Pueblo lands and analyzed for metals, we will repeat this study next year. We also will collect soil samples so that a correlation to plant samples can be made.

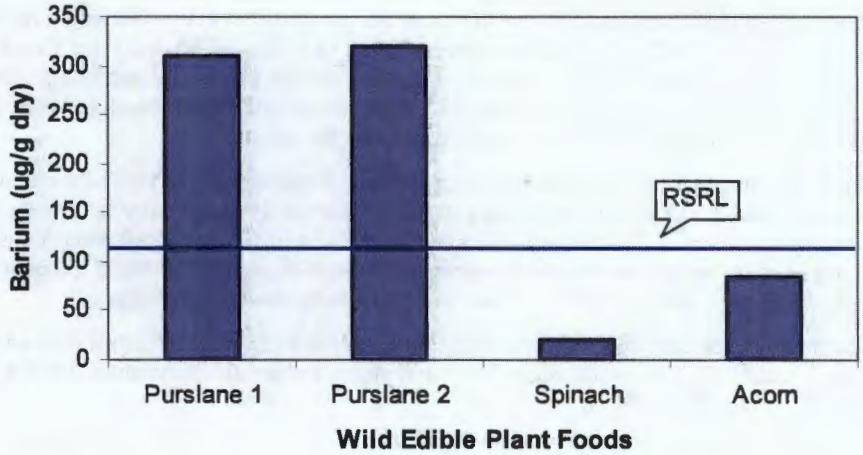

Figure 8-3. Barium concentrations in wild edible plant foods collected from within Mortandad Canyon on San Ildefonso Pueblo lands as compared to the regional statistical reference level (RSRL).

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 and reptiles, birds, and vegetation, within and around LANL on a systematic basis or for special studies for radiological and nonradiological constituents.

The three objectives of the nonfoodstuffs biota program are to determine

(1) on-site and perimeter contaminant concentrations in biota and compare them with regional background concentrations,

(2) trends over time, and

(3) dose to plants and animals.

Chapter 3 includes the results of the biota dose in 2004 at LANL.

2. Nonfoodstuffs Biota Standards

To evaluate Laboratory impacts from radionuclides and nonradionuclides in nonfoodstuffs biota, we first compare the analytical results of biota samples collected from on-site and perimeter areas with regional (RSRLs) or with baseline (BSRLs) statistical reference levels. 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 concentration (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 the Environmental Surveillance Report.
- Baseline levels: BSRLs are the concentrations of radionuclides and nonradionuclides in biota 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 two standard deviations. (Note: Prior evaluations of BSRLs with RSRLs show no statistical differences between the two, and the use of BSRLs at DARHT is for Mitigation Action Plan reasons.)

- SL: Screening levels for radionuclides in nonfoodstuffs biota were set at 10% of the standard by the Meteorology and Air Quality Group dose assessment team at the Laboratory to identify the contaminants of concern. Nonradionuclides are compared with Toxicity Reference Values (LANL 2004) reported by the Environmental Restoration Program (Ryti et al. 1999). If a constituent exceeds the SL, the reason for that increase will be more thoroughly investigated.
- Standards: Based on the concentrations of radionuclides in biota, we calculate a dose and compare it with the 1 rad/d DOE dose standard for terrestrial plants and aquatic biota and 0.1 rad/d for terrestrial animals (DOE 2002).

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 rad/d	0.1 rad/d	RSRLs
	DARHT	Terrestrial plants	1 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		TRVs[a]	RSRLs
	DARHT	Biota		TRVs	BSRLs

[a]TRVs = Toxicity Reference Values (LANL 2004)

3. Institutional Monitoring

No institutional monitoring of vegetation was performed in 2004—samples are usually collected every third year. For a discussion of results reported in past years, see Gonzales et al. (2000) for results from sampling conducted in 1998 and Fresquez and Gonzales (2004) for results from sampling conducted in 2002 and 2003. In general, all radionuclide concentrations in vegetation from perimeter and on-site areas are low, and most were either nondetectable or within RSRLs. Only a few radionuclides, particularly plutonium-239,-240 and uranium, in both overstory and understory vegetation from on-site areas, were detected. An on-site area where plutonium-239,-240 was noted to be in higher concentrations in/on native vegetation as compared with the RSRL was at Technical Area (TA)-21 (DP-Site). The values, however, were still very low, and the difference between on site concentrations and regional background concentrations was small. Also, the uranium isotopic ratio in vegetation from some on-site areas indicated depleted uranium deposition. Depleted uranium, a metal used as a substitute for the enriched uranium in weapons components tested at LANL, is probably a result of airborne deposition from firing sites (Hansen 1974).

4. Facility Monitoring

a. Monitoring Network. Facility-specific biota monitoring is conducted 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. 2001a). We compared results for 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. A complete description of the Area G and the DARHT sites and sampling methodology can be found in Fresquez and Lopez (2004) and Fresquez (2004), respectively. 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. Unwashed overstory (trees) and understory (grass and forb) vegetation samples were collected at nine locations within and around the perimeter of Area G (Figure 7-3). Most radionuclides were either nondetectable or less than the RSRLs for vegetation. (Note: All data can be found in Fresquez and Lopez 2004.) The exceptions were tritium in overstory and some understory vegetation, particularly in the south portion of Area G. Of the eight overstory samples collected within and around the perimeter of Area G, for example, all of the samples contained detectable concentrations of tritium greater than the RSRL of 2.3 pCi/mL. The tritium concentrations in overstory samples ranged from 2.3 to 83,000 pCi/mL, and the largest amount was detected in vegetation collected adjacent to the tritium shafts. Concentrations of tritium in deep-rooted overstory vegetation at this site appear to be fluctuating greatly from year to year (Figure 8-4). Also, a few plant samples had some foliar contamination from americium-241 and plutonium isotopes in/on them—the highest concentrations occurring in the northern sections of Area G. All radionuclide concentrations were below the SL (0.1 rad/day) and DOE dose limit of 1 rad/day for the protection of terrestrial plants (DOE 2002).

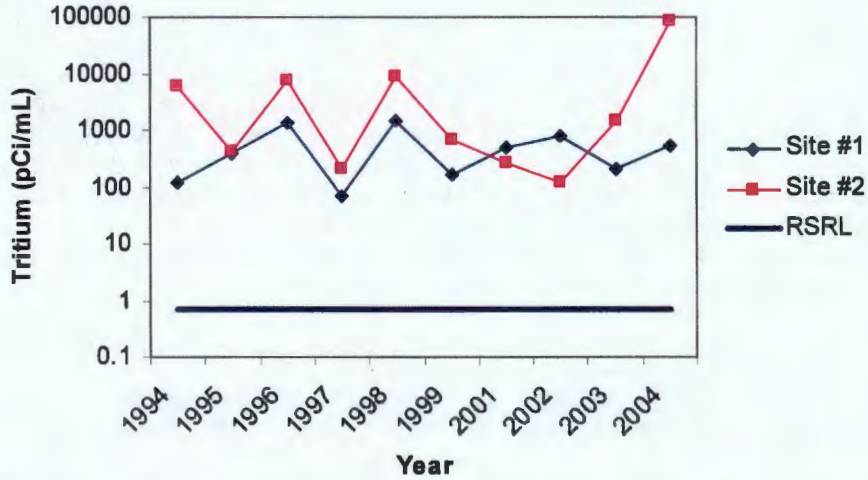

Figure 8-4. Tritium in overstory vegetation collected from two selected (worst case) locations outside of Area G at TA-54 from 1994 to 2004 as compared to the regional statistical reference level (RSRL) (see Figure 7-3 for location information).

ii. Small Mammals. Field mice (*Peromyscus spp.*) and rock squirrels (*Sciurus spp.*) were collected at Area G from 2001 through 2003 for the following purpose: (1) identify radionuclides occurring in small mammal (whole body) tissues as a result of living and foraging on the waste management area and (2) determine if doses to small mammals are of concern. (Note: These are the most recent data available; all data can be found in Fresquez et al. 2005.) In addition, we collected mice from the proposed expansion area to the west of Area G to gain baseline information. Most radionuclides, with the exception of cesium-137 and strontium-90, in whole-body burdens of mice were detectable and higher than the RSRL. This pattern reflects elevated radionuclide levels found in the vegetation that provides the principal food source for the rodents (Fresquez and Lopez 2004). These body burdens are similar to past results (Bennett et al. 1996a, 1998, 2002). The highest tritium concentrations in mice collected at Area G were associated with the tritium disposal pits located on the south end, whereas concentrations of the actinides varied widely. One sample, collected in 2003 over the inactive disposal pits (site #7a), showed unusually high levels of cesium, strontium, and transuranics not seen in past years (Fresquez et al. 2004a). We will collect animals from this area in subsequent years to determine if this anomaly persists. Although uranium concentrations in mice from Area G were higher than RSRLs, the U isotopic ratios of most samples indicated that the uranium was naturally occurring.

Most radionuclides, with the exception of tritium, in rock squirrels collected from within Area G at site #7a were either nondetectable or within RSRLs. These results are in contrast to the results obtained for the mice samples at site #7a; radionuclides in mice samples were much higher than in rock squirrels. The difference in radionuclide concentrations between mice and rock squirrels may be due to the differences in their foraging habits and living area.

Although levels of some radionuclides were elevated above background levels in tissues of mice at Area G, average doses received were quite low, around 0.005 rad/day. This amount is below the SL (0.01 rad/day) and DOE dose limit of 0.1 rad/day for the protection of terrestrial animals (DOE 2002).

c. Radionuclide and Nonradionuclide Analytical Results for DARHT (TA-15)

i. Vegetation. Unwashed overstory and understory vegetation were collected at four locations around the DARHT facility. Sample results were compared with BSRL data established for a four-year-long preoperational period (Fresquez et al. 2001). All radionuclides, with the exception of U-238 in overstory vegetation, were either nondetectable or within BSRL values. (Note: All data can be found in Fresquez 2004.) All of the overstory vegetation samples collected around the DARHT facility contained U-238 concentrations just above the BSRL and correlate with the U-238 concentrations in soils. The uranium on all of the overstory (and some understory) plants had U-234 and U-238 ratios consistent with that of depleted uranium. Depleted uranium, a metal used as a substitute for the enriched uranium in weapon components tested at LANL, was also detected in soils (Fresquez 2004), bees (Hathcock and Haarmann 2004), and small mammals (Fresquez 2005) at DARHT. Trace elements, with the exception of copper and selenium in overstory and selenium in understory vegetation, were below the BSRL values. Copper and selenium concentrations in overstory and selenium in understory vegetation are similar to past years, although they do not correlate very well with the soil's data. Nyhan et al. (2003) discusses the consequences of elevated copper and particularly selenium in plants.

ii. Small Mammals. Samples of (whole body) field mice (Peromyscus spp.) were collected from within the grounds of the DARHT facility at LANL, Technical Area 15, from 2001 through 2003. (Note: These are the most recent data available, and all data can be found in Fresquez 2005.) Results, which represent three years since the start of operations in 2000, were compared with BSRL data established over a four-year-long preoperational period (Bennett et al. 2000).

Most radionuclides in whole-body tissue of mice collected from 2001 through 2003 were either at nondetectable levels or below BSRLs for mice. The few radionuclides that were above BSRLs included uranium isotopes, and the ratios of U-234 to U-238 in nearly 60% of the samples were consistent with depleted uranium. Depleted uranium was also detected in soil, vegetation, bee, and small mammal samples from around the DARHT grounds. Although the amounts of uranium in some mice samples were just above BSRLs, all concentrations resulted in doses below the SL (0.01 rad/day) and DOE limit of 0.1 rad/day for the protection of terrestrial animals (DOE 2002).

iii. Bees. During 2003, honey bees were collected from four colonies located at the DARHT at LANL, analyzed for various radionuclides and trace elements, and compared to BSRL for bees (Haarmann 2001). (Note: These are the most recent data available, and all data can be found in Hathcock and Haarmann 2004.) All of the radionuclides and nonradionuclides, with the exception of copper, were within BSRLs. The ratio of U-234 and U-238 in bees indicates a depleted uranium source. The indication of depleted uranium was consistent with the soil, vegetation, and small mammal data..

C. Special Monitoring Study: Polychlorinated Biphenyls (PCBs) in the Rio Grande Using Semi-permeable Membrane Devices ("Fat Bags")

Polychlorinated biphenyls are extensively distributed worldwide and ubiquitous in the environment. Concern has existed for years that LANL has released PCBs into the environment that may have reached the Rio Grande. From 1997 to 2002, studies were conducted on PCBs in fish taken from the Rio Grande and from Cochiti and Abiquiu reservoirs (Gonzales and Fresquez 2003). The studies assessed potential effects to both nonhumans and humans that consume the fish and to determine whether LANL has contributed to the PCB burdens. Generally, the studies identified more risk to humans than to nonhumans. Some cases have shown concentrations of PCBs in fish above LANL to be higher than below LANL, and in other cases the reverse has been true. Conclusions about contributions from LANL have been less than definitive because the fish are mobile, possibly spending time upstream and downstream from LANL. This study complements the fish studies by sampling PCB congeners in the Rio Grande using stationary

semipermeable membrane devices. We sampled dissolved PCBs from the Rio Grande at two locations above LANL and three locations below LANL in 2002 and 2003. Total PCB concentrations upstream of LANL ranged from 3.12 to 4.02 ng/g (ppb) compared to 3.13 to 3.98 ng/g (ppb) at the location downstream of LANL. Semi-permeable membrane devices concentrated PCBs from water by a factor of about 10^4. Using somewhat of a "fingerprinting" method, homologue patterns of the sampled PCBs were compared with patterns of brand-name formulations to establish whether the "parent" aroclor(s) (PCB mixtures) of the Rio Grande samples are of the same aroclors found at LANL. Results showed only a small amount of similarity between the type of aroclors indicated in the Rio Grande below LANL and aroclors known to exist at LANL. Also it was concluded that, for the particular time period studied, LANL was not likely contributing PCBs to the Rio Grande as indicated by the statistically similar total PCB concentrations between the two stations above LANL and the station immediately below LANL. This same conclusion has been made in reports on the previous fish studies. For more information on this study, see Gonzales and Montoya (2005).

D. Quality Assurance/Quality Control

The team conducts foodstuffs and nonfoodstuffs sampling according to Quality Assurance/Quality Control (QA/QC) procedures and protocols identified in the overall "Quality Assurance Project Plan" for the Soil, Foodstuffs and Biota Monitoring Project" (RRES-CMT-QAPP, R1); and the following procedures:

- "Facility Soil and Vegetation Sampling," RRES-MAQ-711, R5, 2004,
- "Rodent Trapping," RRES-ECO-BIO-HCP/OP-035, R3,
- "Managing and Sampling Honey Bee Hives" RRES-ECO-301, R0, 2004,
- "Processing and Submitting Samples," RRES-MAQ-706, R5, 2004; and
- "Analytical Chemistry Data Management and Review for Soil, Foodstuffs and Biota," RRES-MAQ-712, R0, 2004.

These procedures ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results, is conducted in a correct and 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. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting. Paragon Analytics, Inc. of Fort Collins, Colorado, analyzed the samples and met all LANL QA/QC requirements. Results for radionuclides, with the exception of tritium, are reported on a per gram ash basis. Tritium is reported on a per mL basis. To convert radionuclide units to a dry or wet weight basis for dose assessments, multiply the media results in a per gram ash weight basis by the appropriate ash/dry and dry/wet weight ratio provided in Fresquez et al. (2004b).

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Standards for Environmental Contaminants

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, or foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 450.1, "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 air or water are compared with DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for air are the radionuclide concentrations in air that, if inhaled continuously for an entire year, would give a dose of 100 mrem. Similarly, 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. Derived air concentrations (DACs) were developed for protection of workers and are the air concentrations that, if inhaled throughout a "work year," would give the limiting allowed dose to the worker. Table A-2 shows the DCGs and DACs.

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. A complete listing a 40 CFR 61 Subpart H is available in ESH-17 2000.

Nonradioactive Air Quality Standards. Table A-3 shows federal and state ambient air quality standards for nonradioactive pollutants.

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://eweb.lanl.gov/.

Drinking Water Standards. For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (NMEIB 1995). To view the New Mexico Drinking Regulations go to http//www.nmenv.state.nm.us/dwb/dwbtop.html. EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards. Concentrations of radionuclides in surface water samples may be compared with either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995) (*http://www.nmenv.state.nm.us/NMED_regs/swqb/20_6_4_nmac.pdf*). The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

Organic Analysis of Surface and Groundwaters: Methods and Analytes. Organic analyses of surface waters, groundwaters, and sediments are made using SW-846 methods. The specific compounds analyzed in each suite are listed in the supplemental tables for Chapters 5 and 6.

Table A-1. Department of Energy Dose Limits for External and Internal Exposures

	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. Department of Energy's Derived Concentration Guides for Water and Derived Air Concentrations[a]

Nuclide	f_1[b]	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)	DCGs for Air Inhalation by the Public (μCi/mL)	Class[b]	DACs for Occupational Exposure (μCi/mL)
^{3}H	—	2,000,000	80,000	1×10^{-7}[c]	—	2×10^{-5}[c]
^{7}Be	5×10^{-3}	1,000,000	40,000	4×10^{-8}	Y	8×10^{-6}
^{89}Sr	3×10^{-1}	20,000	800	3×10^{-10}	Y	6×10^{-8}
^{90}Sr	3×10^{-1}	1,000	40	9×10^{-12}	Y	2×10^{-9}
^{137}Cs	1×10^{0}	3,000	120	4×10^{-10}	D	7×10^{-8}
^{234}U	5×10^{-2}	500	20	9×10^{-14}	Y	2×10^{-11}
^{235}U	5×10^{-2}	600	24	1×10^{-13}	Y	2×10^{-11}
^{238}U	5×10^{-2}	600	24	1×10^{-13}	Y	2×10^{-11}
^{238}Pu	1×10^{-3}	40	1.6	3×10^{-14}	W	3×10^{-12}
^{239}Pu	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}
^{240}Pu	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}
^{241}Am	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}

[a] Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990); those for occupational exposure are based on radiation protection standards in 10 CFR 835. Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.
[b] Gastrointestinal tract absorption factors (f_1) and lung retention classes (Class) are taken from ICRP-30 (ICRP 1988). Codes: Y = year, D = day, W = week.
[c] Tritium in the HTO form.

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	Federal Standards Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030	
	24 hours	ppm	0.10	0.14	
	3 hours	ppm			0.5
Hydrogen sulfide	1 hour	ppm	0.010		
Total reduced sulfur	1/2 hour	ppm	0.003		
Total Suspended Particulates	Annual	$\mu g/m^3$	60		
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours	$\mu g/m^3$	150		
PM_{10}[a]	Annual	$\mu g/m^3$		50	50
	24 hours	$\mu g/m^3$		150	150
$PM_{2.5}$[b]	Annual	$\mu g/m^3$		15	15
	24 hours	$\mu g/m^3$		65	65
Carbon monoxide	8 hours	ppm	8.7	9	
	1 hour	ppm	13.1	35	
Ozone	1 hour	ppm		0.12	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	$\mu g/m^3$		1.5	1.5

[a]Particles ≤10 μm in diameter.
[b]Particles ≤2.5 μm in diameter.

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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 A

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-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.

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 (1*s*) for the station and group means.

Appendix B

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. 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
Bq	becquerel
Btu/yr	British thermal unit per year
Ci	curie
cm^3/s	cubic centimeters per second
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
ft^3/min	cubic feet per minute
ft^3/s	cubic feet per second
kg	kilogram
kg/h	kilogram per hour
lb/h	pound per hour
lin ft	linear feet
m^3/s	cubic meter per second
µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
mCi	millicurie
mg	milligram
mR	milliroentgen
m/s	meters per second
mrad	millirad
mrem	millirem
mSv	millisievert
nCi	nanocurie
nCi/dry g	nanocurie per dry gram
nCi/L	nanocurie per liter
ng/m^3	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m^3	picogram per cubic meter
PM_{10}	small particulate matter (less than 10 µm diameter)
$PM_{2.5}$	small particulate matter (less than 2.5 µm diameter)
R	roentgen
s, SD, or σ	standard deviation
s.u.	standard unit
sq ft (ft^2)	square feet
TU	tritium unit
>	greater than

Table B-3. Common Measurement Abbreviations and Measurement Symbols (Cont.)

<	less than
≥	greater than or equal to
≤	less than or equal to
±	plus or minus
~	approximately

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).

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 town site and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos town site.

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% 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 studies both static and dynamic behavior of multiplying assemblies of nuclear materials. The Category I quantities of special nuclear materials

(SNM) are used to support a wide variety of programs such as Stockpile Management, Stockpile Stewardship, Emergency Response, Nonproliferation, Safeguards, etc. Experiments near critical are operated by remote control using low-power reactors called critical assemblies. The machines are housed in buildings known as kivas and are used primarily to provide a controlled means of assembling a critical amount of fissionable material so that the effects of various shapes, sizes, and configurations can be studied. These machines are also used as a large-quantity source of fission neutrons for experimental purposes. In addition, this facility provides the capability to perform hands-on training and experiments with special nuclear materials in various configurations below critical. The special nuclear materials at this site are in the process of being 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 town site. 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.

Related Web Sites

For more information on environmental topics at Los Alamos National Laboratory, access the following Web sites:

http://www.lanl.gov/orgs/rres/maq/AirReports.htm	provides access to Environmental Surveillance reports and supplemental data tables.
http://www.lanl.gov	reaches the Los Alamos National Laboratory Web site.
http://www.energy.gov	reaches the national Department of Energy Web site.
http://labs.ucop.edu	provides information on the three laboratories managed by the University of California.
http://www.lanl.gov/orgs/rres/maq/index.htm	accesses LANL's Meteorology and Air Quality Group.
http://www.esh.lanl.gov/~esh18/	accesses LANL's Water Quality and Hydrology Group.
http://swrc.lanl.gov/	accesses LANL's Solid Waste Regulatory Compliance Group.
http://www.esh.lanl.gov/%7Eesh20/	accesses LANL's Ecology Group.
http://erproject.lanl.gov	provides information on LANL's Environmental Restoration Project.

Appendix D

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*.

COC Chain-of-Custody. A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.

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.

EA Environmental Assessment. A report that identifies potentially

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. PCB are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCB are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCB, 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% 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.
water year	October through September.
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.

AIRNET	Ambient Air Monitoring Network
AOC	area of concern
AQA	Analytical Quality Associates
AST	above-ground storage tank
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
ENV-ECO	Ecology Group (LANL)
ENV-MAQ	Meteorology and Air Quality Group (LANL)
ENV-SWRC	Solid Waste Regulatory Compliance Group (LANL)
ENV-WQH	Water Quality and Hydrology Group (LANL)
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

HSR-4	Health Physics Measurements Group (LANL) (Health, Safety, and Radiation Protection Division)
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
NCR	nonconformance report
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)

RLWTF	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
UC	University of California

Elemental and Chemical Nomenclature

Actinium	Ac	Molybdenum	Mo
Aluminum	Al	Neodymium	Nd
Americium	Am	Neon	Ne
Argon	Ar	Neptunium	Np
Antimony	Sb	Nickel	Ni
Arsenic	As	Niobium	Nb
Astatine	At	Nitrate (as Nitrogen)	NO_3-N
Barium	Ba	Nitrite (as Nitrogen)	NO_2-N
Berkelium	Bk	Nitrogen	N
Beryllium	Be	Nitrogen dioxide	NO2
Bicarbonate	HCO_3	Nobelium	No
Bismuth	Bi	Osmium	Os
Boron	B	Oxygen	O
Bromine	Br	Palladium	Pd
Cadmium	Cd	Phosphorus	P
Calcium	Ca	Phosphate (as Phosphorus)	PO_4-P
Californium	Cf	Platinum	Pt
Carbon	C	Plutonium	Pu
Cerium	Ce	Polonium	Po
Cesium	Cs	Potassium	K
Chlorine	Cl	Praseodymium	Pr
Chromium	Cr	Promethium	Pm
Cobalt	Co	Protactinium	Pa
Copper	Cu	Radium	Ra
Curium	Cm	Radon	Rn
Cyanide	CN	Rhenium	Re
Carbonate	CO_3	Rhodium	Rh
Dysprosium	Dy	Rubidium	Rb
Einsteinium	Es	Ruthenium	Ru
Erbium	Er	Samarium	Sm
Europium	Eu	Scandium	Sc
Fermium	Fm	Selenium	Se
Fluorine	F	Silicon	Si
Francium	Fr	Silver	Ag
Gadolinium	Gd	Sodium	Na
Gallium	Ga	Strontium	Sr
Germanium	Ge	Sulfate	SO_4
Gold	Au	Sulfite	SO_3
Hafnium	Hf	Sulfur	S
Helium	He	Tantalum	Ta
Holmium	Ho	Technetium	Tc
Hydrogen	H	Tellurium	Te
Hydrogen oxide	H_2O	Terbium	Tb
Indium	In	Thallium	Tl
Iodine	I	Thorium	Th
Iridium	Ir	Thulium	Tm
Iron	Fe	Tin	Sn
Krypton	Kr	Titanium	Ti
Lanthanum	La	Tritiated water	HTO
Lawrencium	Lr (Lw)	Tritium	^3H
Lead	Pb	Tungsten	W
Lithium	Li	Uranium	U
Lithium fluoride	LiF	Vanadium	V
Lutetium	Lu	Xenon	Xe
Magnesium	Mg	Ytterbium	Yb
Manganese	Mn	Yttrium	Y
Mendelevium	Md	Zinc	Zn
Mercury	Hg	Zirconium	Zr

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