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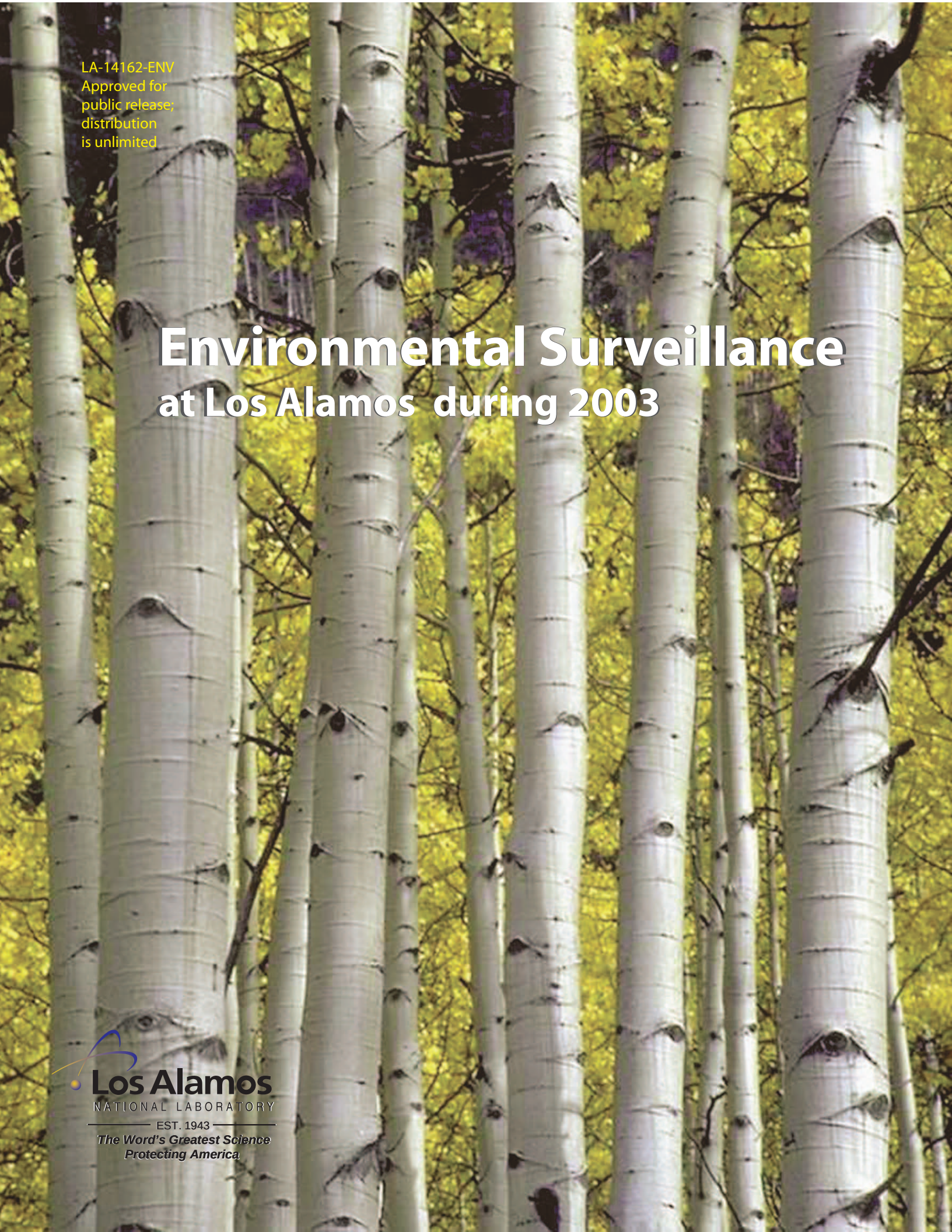

Environmental Surveillance at Los Alamos during 2003

Los Alamos
NATIONAL LABORATORY
EST. 1943
The Word's Greatest Science Protecting America

Enhancing Our Stewardship of the Environment

The Laboratory places a priority on simultaneously fulfilling our mission responsibilities and our environmental stewardship responsibilities. The overall goal of our stewardship efforts is to minimize negative impacts and ensure a healthy environment. We monitor our performance to demonstrate the fulfillment of these responsibilities. This annual environmental report describes the 2003 successes of our environmental stewardship. The monitoring information focuses on operations. The monitoring program addresses changes from baseline conditions before the Cerro Grande fire of 2000 and will aid in evaluating any future impacts the Laboratory may have, especially those resulting from contaminant transport off-site.

The program involves a number of different organizations within the Laboratory, as well as coordination with outside organizations and agencies. The primary Laboratory organizations involved are the Meteorology and Air Quality Group (RRES-MAQ), the Water Quality and Hydrology Group (RRES-WQH), the Solid Waste Regulatory Compliance Group (RRES-SWRC), the Ecology Group (RRES-ECO), and the Environmental Restoration Project (RRES-RS).

The Risk Reduction and Environmental Stewardship (RRES) is incorporated to strengthen the Laboratory's commitment to managing the entire life-cycle of nuclear materials from generation to permanent disposal as well as to understanding and safeguarding the natural environment on a local to global scale. Over the next two decades, billions of dollars will be invested globally in managing nuclear materials and waste, cleaning up the environment, and protecting and restoring the natural environment. To this end, RRES has highlighted the following strategic environmental science program thrust areas:

- Natural Resources Protection and Restoration,
- Nuclear Waste and Materials Management, and
- Repository Science.

The role of this division is to reduce the risk of current and historic Laboratory activities to the public, workers, and the environment through natural and cultural resource protection, pollution prevention, waste disposition, and remediation activities. The division serves as the steward of the Laboratory reservation by developing and implementing integrated natural and cultural resource management.

This report summarizes the results of the ongoing routine environmental monitoring and surveillance program, for which the Laboratory collects more than 12,000 environmental samples each year from more than 450 sampling stations in and around the Laboratory. In addition, we have summarized results from sampling for effects of the Cerro Grande fire, especially where the fire has resulted in alterations of trends in environmental conditions seen in past years. We will continue to follow the alterations resulting from the wildfire over the next few years to determine if conditions return to prefire levels.

In the aftermath of the events of September 11, 2001, enhanced security actions by the Department of Energy resulted in the removal of many environmental World Wide Web pages from public access. At this writing, it is unknown how many pages these actions have affected and when the pages will be accessible again to the general public. If you have difficulty reaching the sites referenced in this document, please contact me, Jean Dewart, at dewart@lanl.gov or 505/665-0239. We will make every attempt to get you the information that you desire.

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Environmental Surveillance at Los Alamos during 2003

Environmental Surveillance Program:

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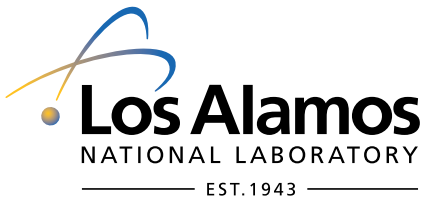
Water Quality and Hydrology (Group RRES-WQH)
505-665-0453

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

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



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Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory), Risk Reduction and Environmental Stewardship, as required by US Department of Energy Order 5400.1, *General Environmental Protection Program*, and US Department of Energy Order 231.1, *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 2003. Chapter 3 provides a summary of the maximum radiological dose a member of the public could have potentially received from Laboratory operations. The environmental 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.

We've also enclosed a disk with detailed tables of data from 2003.

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This report is also available on the World Wide Web at
http://www.airquality.lanl.gov/pdf/ESR/LA-14162-ENV.pdf
and the supplemental data tables are available at
http://www.airquality.lanl.gov/ESRIndex2003.htm

Preface

EXECUTIVE SUMMARY
Environmental Surveillance—2003

Los Alamos
NATIONAL LABORATORY
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Table ES-1. Environmental Statutes under which LANL Operates

Federal Statute	*What it Covers*	*Status*
Resource Conservation and Recovery Act (RCRA)	Generation, management, and disposal of hazardous waste and cleanup of inactive, historical waste sites.	The Laboratory is operating under an extension of the previous permit while seeking to renew its RCRA permit. Negotiations are continuing on the order NMED issued in 2002 that required extensive site investigation and monitoring. NMED issued two other compliance orders in early 2004.
Emergency Planning and Community Right-to-Know Act (EPCRA)	The public's right to know about chemicals released into the community	As required, for 2003 the Laboratory reported releases and waste disposal totaling 56,756 lb of lead, 6,960 lb of mercury and 331 lb of nitric acid.
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. The dose to the Maxim Exposed Individual (MEI) from LANL air emissions was 0.65 mrem, much less than the annual limit of 10 mrem. The principal contributor to the dose was the Los Alamos Neutron Science Center (LANSCE).
Clean Water Act (CWA)	Air quality and emissions into the air from facility operations	Discharges met requirements in 100% of samples from sanitary effluent outfalls, 99.5% of samples from industrial effluent outfalls, and 100% of water quality parameter samples at both types of outfalls. The groundwater protection program completed six new wells; initial sampling showed trace levels of tritium, perchlorate, or nitrate in some of the wells.
Safe Drinking Water Act (SDWA)	Drinking water supplies	Los Alamos County provides the Laboratory's drinking water supply. During 2003, drinking water met all limits for chemicals, radiological materials, and bacteria.
Toxic Substances Control Act (TSCA)	Chemicals such as PCBs	The Laboratory continues to operate under an administrative extension of its TSCA letter of authorization. The Laboratory disposed of 4,400 kg of capacitors and 6,949 kg of fluorescent light ballasts in 131 shipments to an off-site, EPA-permitted treatment and disposal facility.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Storage and use of pesticides	The Laboratory's storage and use of pesticides remained in compliance with regulatory requirements.
Endangered Species Act (ESA)	Rare species of plants and animals	The Laboratory's biology team reviewed new projects and ensured compliance with the Endangered Species Act.
National Historic Preservation Act (NHPA) and others	Cultural resources	The cultural resources team worked on 26 projects in the field and identified 19 new archeological sites and 25 new historic buildings; 49 historic buildings were determined eligible for the National Register.
National Environmental Policy Act (NEPA)	Consideration of potential environmental impacts in deciding on new operations	The NEPA team completed 2 environmental assessments for which FONSI determinations were made and prepared a third; also the team prepared a supplementary analysis to determine if further environmental assessment was necessary for one project.

EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL or the Laboratory) is managed by the University of California under a contract administered by the National Nuclear Security Administration (NNSA) of the Department of Energy (DOE). This report (1) presents environmental data and analyses that characterize performance in 2003 and (2) addresses compliance with environmental regulations. Using comparisons with standards and regulations, this report concludes that the environmental effects from Laboratory operations are small and do not pose a threat to human health or the environment.

Environmental Compliance at Los Alamos in 2003 (See Chapter 2.)

Many activities at LANL use or produce materials that are radioactive or otherwise hazardous. Laboratory policy implements DOE requirements by directing employees to protect the environment and meet compliance requirements of applicable state and federal environmental-protection regulations. Federal and state regulations provide specific requirements and standards to implement these statutes and maintain environmental qualities. The Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. The DOE and its contractors are also subject to the Department's requirements for control of radionuclides. Table ES-1 presents a summary of the Laboratory's status in regard to environmental statutes and regulations.

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

Pathway	*Dose*	*Location*	*Trends*
Air	0.65 mrem/yr	East Gate	None; remains well below regulatory limits
Direct irradiation	2.5 mrem/yr	TA-18, Pajarito Road	None
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 wildlife	<0.1 rad/day	All sites	None
Dose to aquatic biota	<1 rad/day	All sites	None

Table ES-3. Where Can We See LANL Impacts on Air?

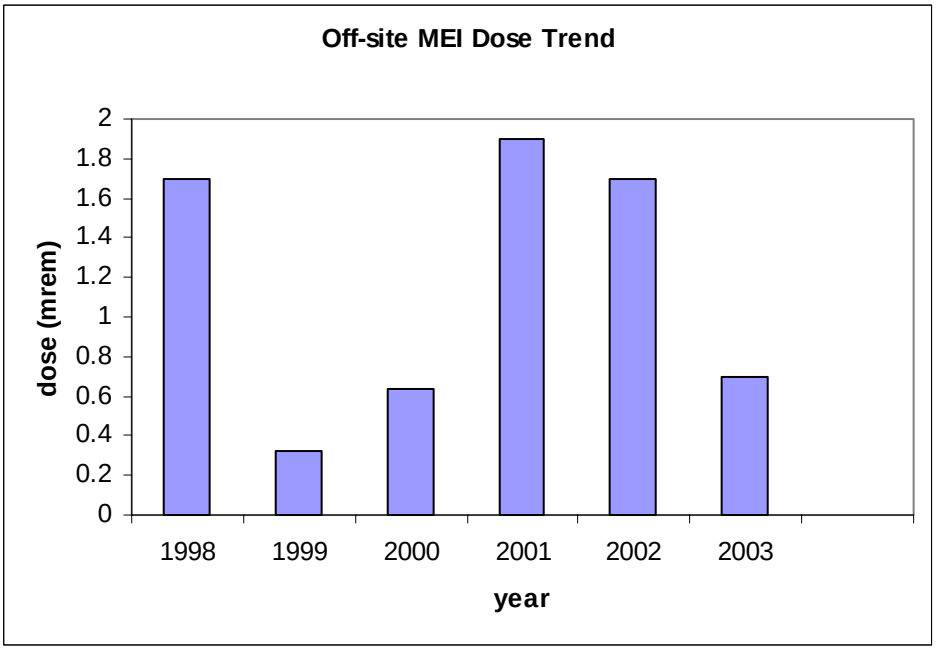
Radionuclide or Air Contaminant	*On-Site*	*Off-Site*	*LANL-Caused Off-Site Significance (% of the EPA Standard)*
Tritium	Yes, found at most sampling locations	Yes, measurable at many perimeter samples	About 1%
Gross alpha and gross beta	No, but in two previous years found at Area G from transuranic releases	No detectable measurements off-site	No standard
Uranium	Yes, multiple locations found with measurable depleted uranium	Yes, increased frequency of depleted uranium found at perimeter locations after the Cerro Grande fire, but less frequently in 2003 than 2002	Less than 1%
Americium and plutonium	Yes, found mostly at TA-21 and Area G	Yes, plutonium-239 found near TA-1 and occasionally at other perimeter samplers	About 1%
Beryllium	No, but in previous years short-term concentrations have been above background	No, off-site concentrations all appeared to be natural beryllium, not Laboratory-caused	No standard
Cobalt-60	Yes, found in one sample on-site during the Omega reactor D&D	No detectable off-site measurements	No impact
PM 2.5 (particles less than 2.5 µm in diameter)	Not measured	No, off-site measurements comparable with background levels (about one-half of the EPA standard)	No impact
PM 10 (particles less than 10 µm in diameter)	Not measured	No, off-site measurements comparable with background levels (about one-third of the EPA standard)	No impact

Environmental Radiological Dose Assessment (See Chapter 3.)

Table ES-2 shows the sources and locations of radiological doses and Figure ES-1 shows trends of doses to the maximally exposed individual (MEI) over the last few years at an off-site location.

We calculated potential radiological doses to members of the public that resulted from LANL emissions. During 2003, the population within 80 km of LANL received a collective dose of 0.88 person-rem. The maximum air-pathway dose to a member of the public was 0.65 mrem and was at East Gate. The maximum all-pathway dose to a member of the public was on Pajarito Road adjacent to TA-18 and was 2.5 mrem. These values are similar to previous ones from recent years. Background radiological doses in this area range from about 300 to 500 mrem/yr. No health effects are expected from doses attributable to Laboratory emissions. Calculated doses to nonhuman biota remained below DOE established limits for aquatic and terrestrial systems.

Figure ES-1



Air Surveillance (See Chapter 4.)

Table ES-3 shows locations where radionuclides and other atmospheric releases from LANL have impacted the air.

The radiological air-sampling network, referred to as AIRNET, measures environmental levels of airborne radionuclides that may be released from Laboratory operations. These radionuclides include plutonium, americium, uranium, and tritium. Ambient concentrations during 2003 were generally comparable to or less than concentrations in 2002. Measurable concentrations of tritium were found at most on-site locations and at off-site locations near the perimeter of the Laboratory. Plutonium and americium were occasionally found on site, primarily near decontamination and decommissioning (D&D) operations and at Technical Area (TA) 54, Area G,

Table ES-4. Where Can We See Radiological Stack Emission Impacts?

Radionuclide	*Predicted Off-Site Dose (Location)*	*Emission Trend*
Tritium	0.055 mrem (airport)	Slight decrease site wide
Uranium, plutonium, americium	<0.01 mrem (all)	None
Carbon-11, oxygen-15, nitrogen-13, argon-41 (LANSCE emissions)	0.33 mrem (East Gate)	Decreasing

the Laboratory's low-level radioactive waste disposal site. Low concentrations of americium and plutonium were also detected in several perimeter samples. Depleted uranium was detected on-site and near the perimeter of the Laboratory. No detectable concentrations of any radionuclides attributable to LANL were detected at regional samplers in Santa Fe, Española, or El Rancho.

Three investigations took place in 2003 and revealed the following:

- The number of samples with depleted uranium has increased since the Cerro Grande fire—a catastrophic wildfire that burned almost 50,000 acres within and around LANL—at both on-site and perimeter samplers. However, the number of samples with depleted uranium was lower in 2003 than in the previous two years.
- Measurable increases in tritium in the eastern part of the Los Alamos town site have occurred in 2002 and 2003 because of the increases in tritium emissions from the D&D activities at TA-21.
- Cobalt-60 was detected on-site near the D&D activities for the Omega reactor facility.

Direct reading particulate matter samplers were operated at three off-site locations during 2003. Two samplers were operated at each location to measure two different sizes of particulate matter: PM 10 and PM 2.5 (particles less than 10 and 2.5 micrometers in diameter, respectively). Higher wind speeds cause increases in concentrations for both sizes. However the PM 10 concentrations increase faster than the PM 2.5 concentrations because resuspended soil and dust particles tend to be larger than several micrometers. Conversely, other sources, such as industrial processes and forest fires, that produce particles by combustion or condensation have a much greater impact on the PM 2.5 concentrations. Concentrations of particulate matter in Los Alamos County are generally lower than much of the rest of New Mexico because of more precipitation and fewer surface soil disturbances.

Quarterly concentrations of beryllium were similar to those in 2002. Concentrations were consistent with expected values from resuspension of soils with naturally occurring beryllium. The dustiest locations—the Los Alamos County Landfill, Jemez Pueblo, and TA-54—had the highest measured concentrations.

Meteorology

Los Alamos weather for 2003 continued a 6-year trend of warm temperatures and a dryer-than-normal climate. The average annual temperature in 2003 of 50.5°F exceeded the normal annual average of 47.9°F by 2.6 degrees. The total precipitation in 2003 of 9.9 in. was 52% of normal (18.95 in.). The current drought is one of the two most severe droughts of the 80-year instrumental record for Los Alamos, the other occurring in the early-to-mid 1950s.

Air Emissions

While emissions of tritium from TA-21 sites were slight elevated because of ongoing D&D, total emissions from tritium-handling facilities in 2003 decreased slightly from 2002. Tritium operations are being consolidated as older sites are shut down. Emissions of plutonium and uranium isotopes have remained approximately the same since 2000. Emissions from the Los Alamos Neutron Science Center (LANSCE) were reduced from 2002 levels because of the operation of emissions controls systems.

No air releases occurred during 2003 that required reporting to the National Response Center. Table ES-4 presents the locations of stack-emission sampling.

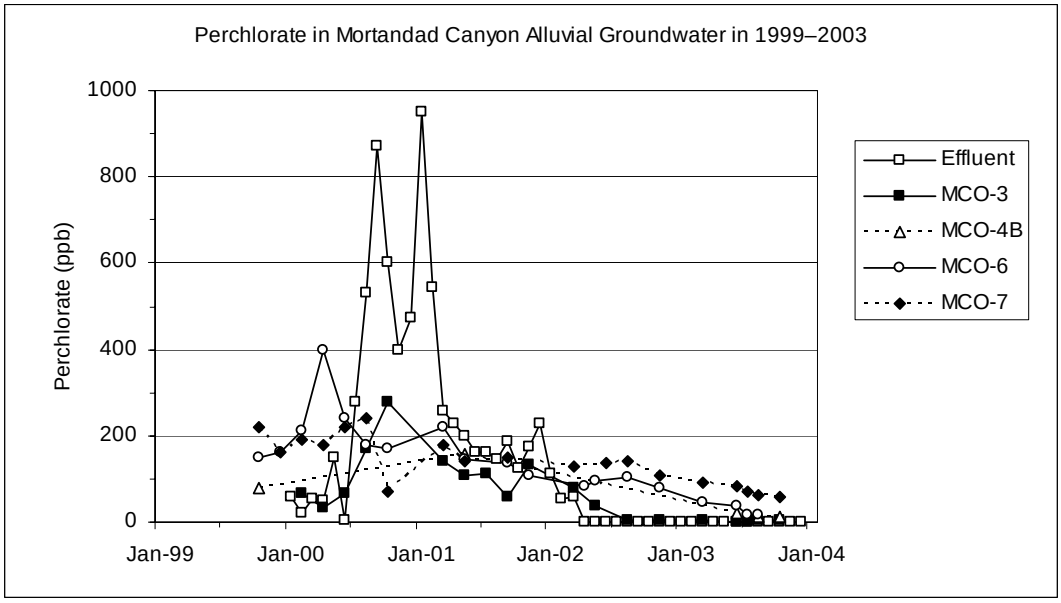
Direct Penetrating Radiation

During 2003, measurements of direct penetrating radiation at most LANL locations were similar to 2002 measured values. The maximum public dose is 2.5 mrem/yr on Pajarito Road adjacent to Pajarito Laboratory (TA-18); this is higher than last year as a result of increased operations at TA-18. At TA-54, Area G, average neutron radiation levels were 50% higher, largely as a result of neutron sources recovered by the off-site source recovery project, *http://osrp.lanl.gov/*. The maximum public dose at the boundary of the San Ildefonso Sacred Area north of Area G is 0.65 mrem/year, which is well below the all-pathway limit of 100 mrem/year.

Table ES-5. Where Can We See LANL Impacts on Groundwater?

Chemical	*On-Site*	*Off-Site*	*Significance*	*Trends*
Tritium	Below MCL in alluvial and intermediate groundwater because of improvement in LANL discharges into Mortandad Canyon	No	Not used as a drinking water supply	Decreasing as effluent quality improves
Other radionuclides	Above DOE or EPA drinking water limits in alluvial groundwater because of LANL discharges in DP, Los Alamos, and Mortandad Canyons	No	Not used as a drinking water supply; radionuclides have not penetrated to deeper groundwater	Some constituents are fixed in location; some decreasing as effluent quality increases
Perchlorate	In alluvial and intermediate groundwater of Mortandad Canyon; found in regional aquifer in Mortandad and Pueblo canyons	Yes, in Pueblo Canyon	No established regulatory standard; values exceed EPA provisional risk level in alluvial groundwater and deeper groundwater	Decreasing in Mortandad Canyon alluvial groundwater as effluent quality improves; insufficient data for other groundwater
Nitrate	In alluvial and intermediate groundwater and regional aquifer in Pueblo and Mortandad canyons; above MCL in Mortandad Canyon intermediate groundwater	Yes, in Pueblo Canyon	Potential effect on drinking water; likely non-LANL source in Pueblo Canyon	Alluvial groundwater levels in Mortandad Canyon decreasing as effluent quality improves
High explosives	In alluvial, intermediate, and possibly regional groundwater in the southwestern part of LANL	No	Presence in regional aquifer uncertain	Insufficient data

Figure ES-2



Groundwater Monitoring (See Chapter 5.)

Table ES-5 shows a summary of LANL impacts on groundwater.

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. In some canyons, 6 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. 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 aquifers.

In recent years, elevated alluvial groundwater concentrations of strontium-90, plutonium, americium, tritium, nitrate, perchlorate, high-explosives (HE), barium, and molybdenum have approached or exceeded drinking water standards or risk-based drinking water levels in a few locations and over a limited area on site. Beginning in 2001, no groundwater has had tritium activities that exceeded the EPA drinking water Maximum Contaminant Level (MCL) of 20,000 pCi/L. Intermediate groundwater concentrations of HE, chlorinated solvents, tritium, perchlorate, and nitrate exceed or approach drinking water standards or risk-based drinking water levels in a few locations on-site. The regional aquifer shows traces of tritium and nitrate that are below drinking water risk levels. Perchlorate exceeds the EPA Region 6 risk level of 3.7 ppb (which corresponds to a hazard index of one) in a well in Mortandad Canyon, and in a nearby newly drilled borehole, nitrate is just below the New Mexico groundwater standard of 10 mg/L (nitrate as nitrogen). A Los Alamos County water supply well in Pueblo Canyon shows tritium at 1/500th of the EPA MCL, nitrate at about three times background or 1/10th of the MCL, and perchlorate at a concentration just below the EPA Region 6 risk level of 3.7 ppb.

One regional aquifer well (R-25) may show HE and chlorinated solvents near drinking water risk levels, but the results appear to be caused by well construction problems rather than indicating regional aquifer contamination. The HE and solvents at R-25 have not reached the regional aquifer and are probably restricted to the perched zone that lies at the 750-ft depth.

In order to improve the perchlorate detection limit, LANL and the NMED DOE Oversight Bureau began investigating use of the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) method for perchlorate analysis to replace the currently used ion chromatography (IC) method in 2001. In late 2003, LANL began using both methods for all perchlorate measurements in water. LANL and the NMED DOE Oversight Bureau conducted a performance study of the LC/MS/MS method during 2003. This study found perchlorate in every groundwater sample analyzed from across northern New Mexico, at levels ranging from 0.12 to 0.66 ppb with a mean of 0.27 ppb. This result suggests that perchlorate may be widespread in groundwater at concentrations below 1 ppb.

LANL has shut off or significantly improved the water quality of most liquid effluent discharges (High-Explosive Wastewater Treatment Facility [HEWTF] and Radioactive Liquid Waste Treatment Facility [RLWTF]); and, with some exceptions (strontium-90), water quality in shallow groundwater has improved rapidly as a result of these Laboratory actions. In one example, the RLWTF has sharply reduced tritium activity in its discharge since 2000 to below 20,000 picocuries per liter (pCi/L), with a corresponding decrease in tritium in the alluvial groundwater since then. Also, perchlorate concentrations in the RLWTF effluent have been reduced to below detection limits with a corresponding decrease of concentration in downstream alluvial groundwater (Figure ES-2).

Table ES-6. Where Can We See LANL Impacts on Surface Water and Sediments?

Chemical	*On-Site*	*Off-Site*	*Significance*	*Trends*
Radionuclides	Higher than background in sediments because of LANL contributions in Pueblo, Los Alamos, and Mortandad canyons	Yes, in Los Alamos/ Pueblo canyons; slightly to moderately elevated in the Rio Grande and Cochiti Reservoir	Sediments below health concern except 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, Los Alamos, and Mortandad canyons because of LANL contribution	Yes, in Los Alamos/ Pueblo canyons	Minimal exposure potential because events are sporadic	Flows in Pueblo Canyon occurring more often after fire; flows in LANL canyons to near prefire levels
Polychlorinated biphenyls (PCBs)	Detected in sediment in nearly every canyon	Yes, particularly in the Los Alamos/ Pueblo canyons	Minimal exposure potential; data suggests they may accumulate in Rio Grande fish; findings include non-Laboratory and Laboratory sources	None
	Detected in Sandia Canyon runoff and base flow	No		None
High explosive residues and barium	Detections above screening values in Cañon de Valle base flow	No	Minimal potential for exposure	None
Polycyclic aromatic hydrocarbons (PAHs)	Detections near or above applicable risk-based screening levels in Sandia and Mortandad canyons	Yes, in Los Alamos/ Pueblo canyons	Origins uncertain; probably multiple sources	None

Watershed Monitoring (See Chapter 6.)

Table ES-6 shows the locations of LANL-impacted surface water and sediments.

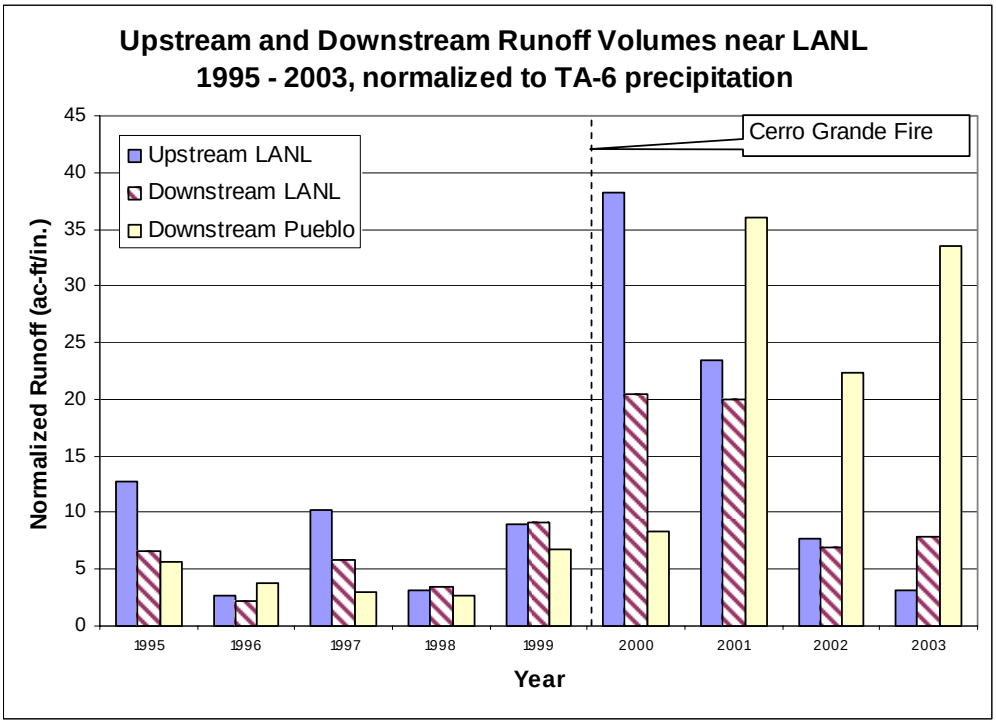
Watersheds that drain the Laboratory are dry for most of the year. No perennial surface water extends completely across the Laboratory in any canyon. Storm runoff occasionally extends across the Laboratory but is short-lived. Wildlife drink from the stream channels when water is present.

LANL activities have caused contamination of sediments in several canyons, mainly because of 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 lingers from Laboratory operations conducted more than 50 years ago.

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.

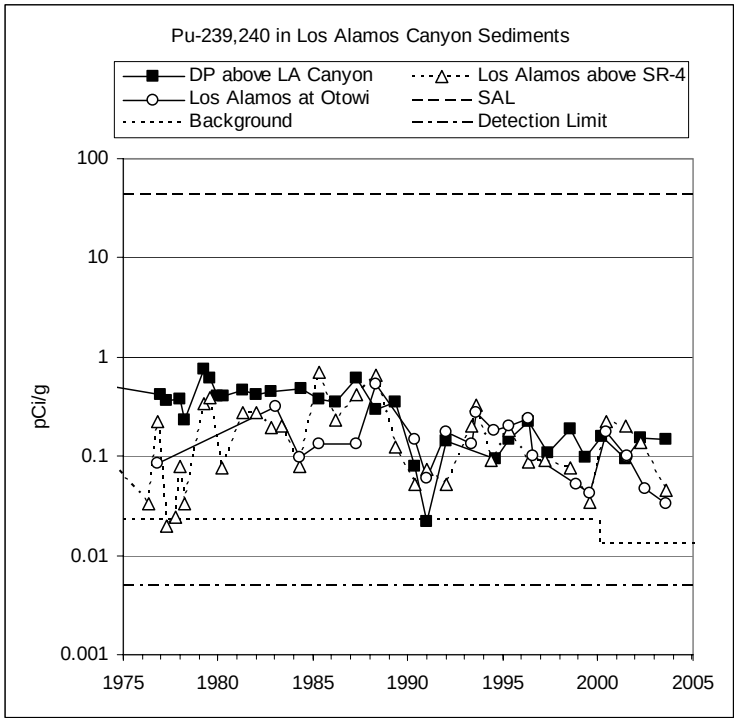
Runoff volumes in watersheds crossing current LANL boundaries have recovered to near pre-Cerro Grande fire levels (Figure ES-3). However, storm runoff in watersheds north of LANL, including Pueblo Canyon, remains high and continues the accelerated downstream movement of LANL-contaminated sediments from Pueblo Canyon into lower Los Alamos Canyon and the Rio Grande.

Figure ES-3



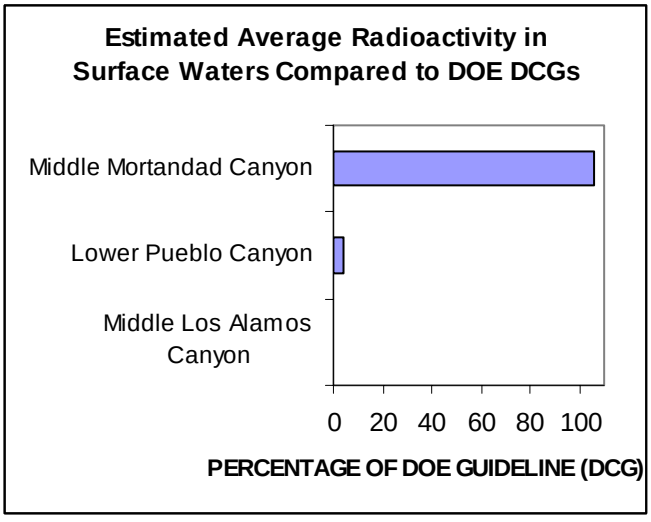
The overall pattern of radioactivity in channel sediments, such as along lower Los Alamos Canyon, has not greatly changed (Figure ES-4). Radioactivity in bottom sediments in Cochiti Reservoir has increased slightly to moderately but remains well below health-based screening levels.

Figure ES-4



Radioactivity in surface water below current radioactive effluent discharges in Mortandad Canyon was near the 100-mrem DOE Derived Concentration Guideline (DCG) for public exposure, but the water is not used as a drinking source and flows do not extend off-site (Figure ES-5). Samples of base flow (persistent surface waters) collected near the Laboratory or from the Rio Grande in 2003 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 standards or above background levels. Several Los Alamos area watersheds were recently added to the State of New Mexico's water quality impaired list for gross alpha activity and total selenium concentrations. Our review indicates that these high values appear to be related to natural causes and concentrations significantly declined in 2003.

Figure ES-5



Soil Monitoring (See Chapter 7.)

Table ES-7 shows Laboratory impacts on mesa-top soils.

Soil acts as an integrating medium that can account for contaminants released to the environment. Therefore, we collect soil surface samples within (on-site) and around the perimeter of the Laboratory (institutional program) and within and around the perimeter of the Laboratory's principal (1) low-level waste disposal area (Area G) and (2) explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]) (facility program)—these programs are conducted to determine the impacts of Laboratory operations on human health and the environment. We analyze samples from these areas for radionuclides and heavy metals and then compare them with samples collected from regional (background) areas located a great distance away from the Laboratory. Concentrations, trends, and doses were assessed. Findings included the following.

- Most radionuclide concentrations (activity) in soils collected from on-site (12 sites) and perimeter (10 sites) stations around LANL were nondetectable, and of the radionuclides that were detected, most were still within regional statistical reference levels (RSRLs). RSRLs represent natural and fallout sources.
- The few radionuclides in soils from on-site and perimeter stations that were detected above RSRLs included mostly plutonium-239,240, and were probably a result of fallout because of higher precipitation events.
- Two soil samples, one collected from an on-site location (TA-21 [DP-Site]) and one from a perimeter site (west airport) contained concentrations of plutonium-239,240 above the RSRL and were associated with Laboratory activities (Figure ES-6). All concentrations, however, were far below the SAL. The SAL, based on a conservative (residential) 15-mrem/yr protective dose limit, identifies contaminants of concern.
- Most all sites, with the exception of one perimeter site (west airport), from either perimeter or on-site areas had barium, beryllium, mercury, and lead concentrations below RSRLs and do not appear to be increasing over time. The only one metal (lead) that was above the RSRL was far below the EPA screening level.
- Mercury concentrations in all soils, including regional soils, appear to be decreasing over time.

AREA G

- Most soil samples collected at Area G contained detectable concentrations of tritium (87%); plutonium-239,240 (87%); plutonium-238 (60%); and americium-241 (53%) above RSRLs. All concentrations are below LANL SALs.
- The highest levels of tritium in soils were detected in the south portion of Area G near the tritium shafts and appear to be increasing over time, whereas the highest concentrations of the plutonium isotopes were detected in the northern and northeastern portions

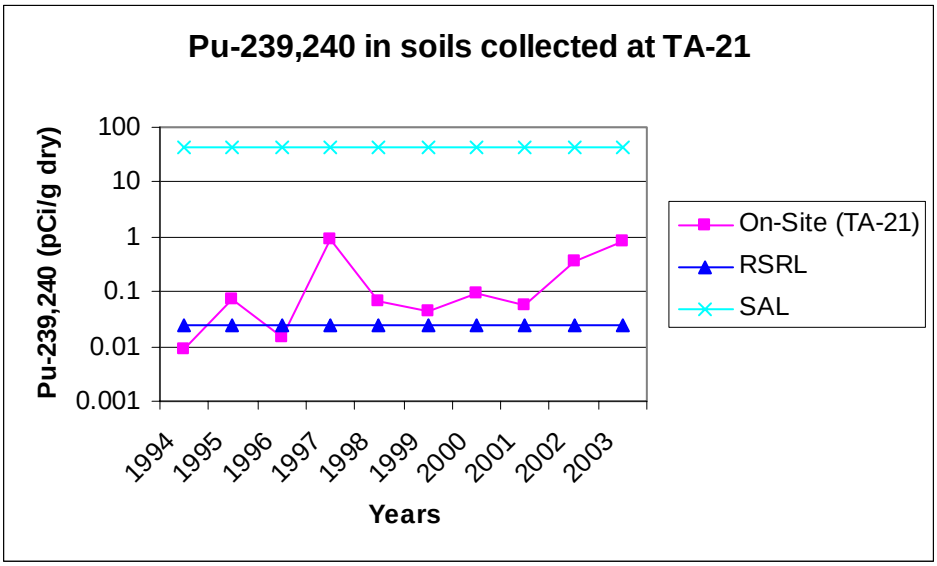
DARHT

- Most radionuclides, with the exception of uranium; cesium-137; and plutonium-239,240, and trace elements, with the exception of antimony, selenium, and copper, in some soil and sediment samples were below baseline statistical reference levels (BSRL). BSRLs were established for a four-year-long preoperational period before DARHT operations. All elements were below LANL and EPA SALs and are of no concern.
- No distinctive trends were evident in any of the radionuclides or metals over time.

Table ES-7. Where Can We See LANL Impacts on Mesa-Top Soils?

Chemical	*On-Site*	*Off-Site*	*Significance*	*Trends*
Tritium	Yes, at some sites, particularly at Area G, TA-54, because of LANL contributions	Yes, in a few perimeter areas north of LANL	Far below screening level; no health risk	Increasing at Area G, TA-54, particularly in the south/southwestern section, near the tritium shafts
Other radionuclides	Yes, mostly plutonium-239,240 at Area G and TA-21	Yes, plutonium-239,240 in a few perimeter areas north of LANL	Far below screening levels; no health risk	Plutonium-239,240 is highly variable from sample to sample
Metals	Few detections: lead, mercury, barium, beryllium	Mostly no, but lead was detected in one soil sample	Far below screening levels; no health risk	Decreasing, particularly mercury

Figure ES-6



Foodstuffs and Nonfoodstuffs Biota Monitoring (See Chapter 8.)

Table ES-8 presents a summary of Laboratory impacts on foodstuffs.

A wide variety of wild and domestic edible plant, fruit, and fish and animal products are harvested in the area surrounding the Laboratory. Therefore, we collected foodstuff and nonfoodstuff biota within and near LANL property to help determine the impacts of Laboratory operations on human health, through the food chain, and to the environment. Also, we collected nonfoodstuff biota at Area G, the Laboratory's principal low-level waste disposal area and the Laboratory's principal explosive test facility (DARHT). Concentrations, trends and doses were assessed.

Produce was analyzed for radionuclides and perchlorates; fish were analyzed for radionuclides, mercury, and perchlorates; small (rabbits) and big (deer and elk) game animals were analyzed for radionuclides; and, vegetation was analyzed for radionuclides. Findings included the following.

- The concentrations of most radionuclides in fruits, vegetables, and grains collected from regional areas were indistinguishable from worldwide fallout and/or natural sources.
- Produce and water samples collected from Los Alamos and White Rock/Pajarito Acres town sites irrigated with local groundwater sources and samples collected from Cochiti and Santa Clara pueblo areas irrigated with Rio Grande water contained no perchlorate concentrations above the minimum reporting level (MRL) or the minimum detection level (MDL).
- Most radionuclides in bottom-feeding fish collected from Cochiti Reservoir, downstream of LANL, were nondetectable or within RSRLs. The radionuclides that were detected above the RSRLs were isotopes of naturally occurring uranium.
- All individual mercury concentrations in bottom-feeding fish (fillets) collected from Cochiti Reservoir were similar to concentrations upstream of LANL (Abiquiu reservoir) and far below the US Food and Drug Administration's ingestion limit of 1 µg mercury/g wet weight. Long-term data show that mercury concentrations in fish from both reservoirs are decreasing over time.
- Results of the analysis of perchlorate in predator and bottom-feeding fish from Cochiti and Heron reservoirs show no concentrations in any of the fish (fillet) samples above the MRL.
- Rabbits collected from San Ildefonso lands contained five times higher concentrations of strontium-90 in muscle and bone tissues as compared with RSRLs. All other radionuclides were within RSRLs. Although strontium-90 has been reported in above-background concentrations in mice within Mortandad canyon approximately 0.5 miles north of where the rabbit samples were collected, more samples are required from both San Ildefonso and regional background areas before any conclusions can be made as to whether or not these levels are due to Laboratory operations.
- Most radionuclide concentrations in muscle and bone tissues of deer collected from the perimeter areas—Los Alamos and San Ildefonso—were nondetectable or below RSRLs. Only tritium was detected above the RSRL in muscle and bone tissues of deer collected from Los Alamos and San Ildefonso areas, but the differences were small.

Table ES-8. Where Can We See LANL Impacts on Foodstuffs?

Media	*Chemical*	*On-Site*	*Off-Site*	*Significance*	*Trends*
Produce	**Tritium**	Not collected in 2003, but historically slightly higher than background	Yes, in a few perimeter areas north and southeast of LANL	Dose, <0.1 mrem/yr; no health risk	None
Produce	**Other radionuclides**	No	No	Dose, <0.1 mrem/yr; no health risk	None
Produce	**Perchlorate**	N/A	No	No health risk	None
Produce	**Metals**	No	No	No health risk	None
Fish	**Radionuclides**	N/A	No	Dose, <0.1 mrem/yr; no health risk <1 rad/day; no risk to aquatic organisms	None
Fish	**Perchlorate**	N/A	No	No health risk	None
Fish	**Mercury**	N/A	No	Dose, <1 µg/g wwt; however, there are various fish ingestion advisories by NMED	Decreasing
Vegetation	**Tritium**	Higher than back-ground, especially at Area G	No	Dose <1 rad/day; no risk to terrestrial plants	None
Vegetation	**Other radionuclides**	Plutonium-239,240 higher than back-ground at Area G	No	Dose, <1 rad/day; no risk to terrestrial plants	None
Rabbits	**Radionuclides**	N/A	Strontium-90 in muscle and bone from San Ildefonso	Dose, <0.1 mrem/yr; no health risk <0.1 rad/day; no risk to terrestrial wildlife	N/A
Deer/Elk	**Radionuclides**	Not collected in 2003, but historically slightly higher than background	Mostly no, but tritium in some tissues	Dose , <0.1 mrem/yr; no health risk <0.1 rad/day; no risk to terrestrial wildlife	None

- All radionuclide concentrations in muscle and bone of elk collected from LANL and perimeter (San Ildefonso) lands were nondetectable or below RSRLs.
- Nonfoodstuff biota test results from on-site locations for understory vegetation show that most radionuclide concentrations in samples from on-site and perimeter stations were nondetectable or within RSRLs. The very few detections that were above RSRLs included plutonium-239,240 in understory vegetation at TA-21, which correlates well with the soils data. These results remain well below levels that would exceed limits for the protection of nonhuman biota.

AREA G

- Most radionuclides, with the exception of tritium and plutonium-239,240, in vegetation and small mammals were within RSRLs.
- Tritium and plutonium-239,240 were both significantly higher in vegetation and small mammals from both on-site and off-site areas surrounding Area G as compared with RSRLs. The highest tritium concentrations were detected in the southwestern portion of Area G, and some foliar contamination from plutonium in/on a few plant samples was detected in the northern sections of Area G.
- One mouse sample from on-site exhibited unusually high levels of plutonium-238; plutonium-239,240; cesium-137; americium-241; and strontium-90. This sample was from animals collected from the southeastern portion of the site. There is no apparent reason why this particular sample exhibited such high values and does not correlate well with past data.
- A vegetation transect study using tree branch tips collected at various distances (approximately 10, 50, 100, 150, and 200 m) from the perimeter of Area G in seven directions showed that tritium concentrations in trees collected nearest the perimeter boundary (10 to 16 m) around Area G were higher than the RSRL. From there, most transects showed decreasing concentrations with distance and at around 90 m were similar to RSRLs.

DARHT

- Most radionuclides, with the exception of uranium, and trace elements, with the exception of copper and selenium, in vegetation were below BSRL values.

1. Introduction

A. Laboratory Overview

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 (LASO) and the Albuquerque Operations Office.

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. Los Alamos National Laboratory enhances global security by

- ensuring the safety and reliability of the US nuclear deterrent;
- reducing the global threat of weapons of mass destruction; and
- solving national problems in energy, infrastructure, and health security (LANL 2001a).

In the "Strategic Plan (2001–2006)," Los Alamos National Laboratory personnel explain LANL's vision and role as follows: "We serve the nation by applying the best science and technology to make the world a better and safer place . . . . Inseparable from its commitment to excellence in science and technology is LANL's commitment to completing all endeavors in a safe, secure, and cost-effective manner" (LANL 2001b).

2. Geographic Setting

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 above 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. San Ildefonso Pueblo borders the Laboratory to the east.

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 1-2.) 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.

3. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande Rift, a major North American tectonic feature. Three major local faults constitute the modern rift boundary, and each is potentially seismogenic. 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 1-3) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. Deposited by major eruptions in the Jemez Mountains' volcanic center 1.2–1.6 million years ago, the tuff is more than 1,000 ft thick in the western part of the plateau and thins to about 260 ft eastward above the Rio Grande.

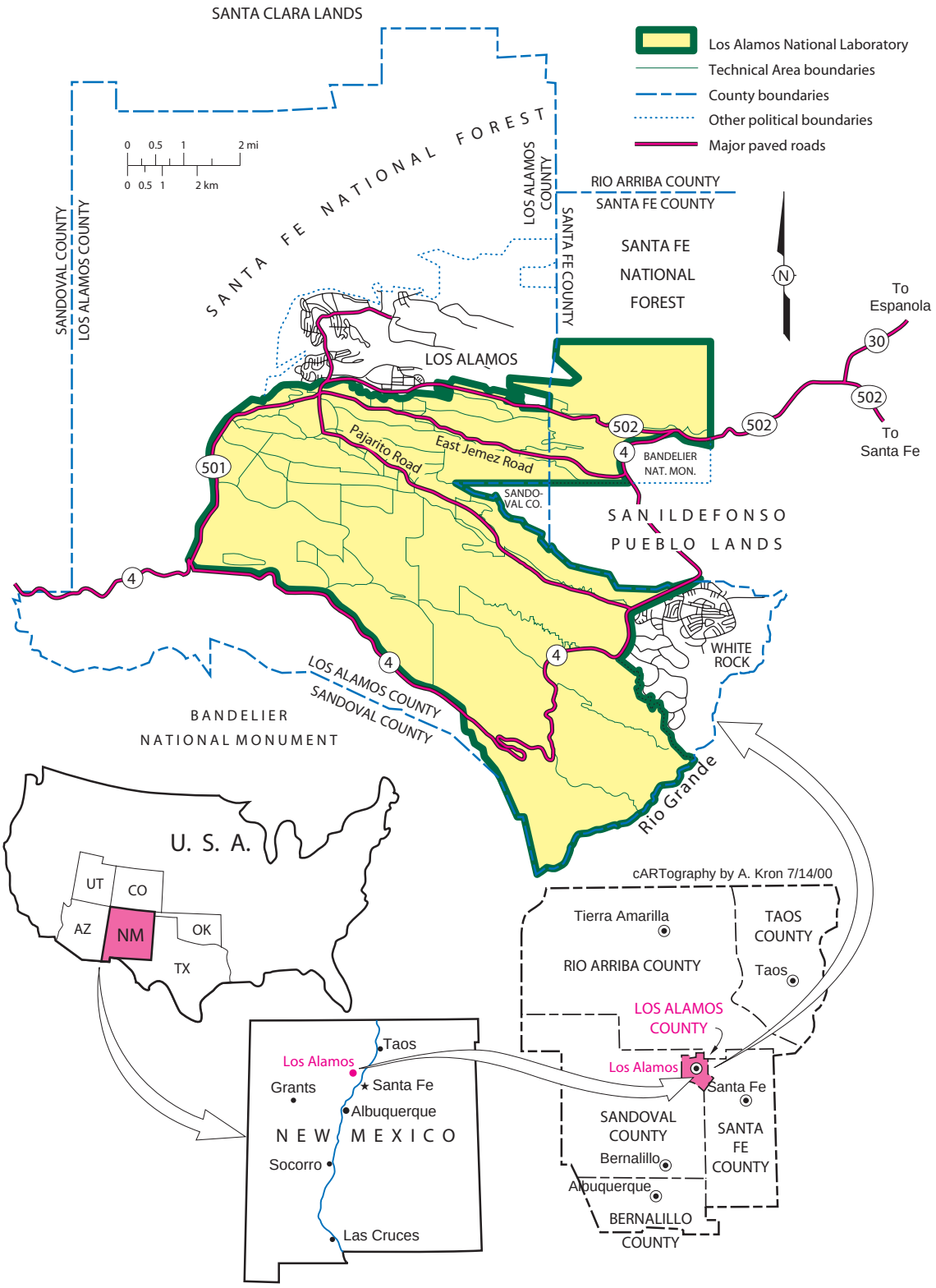


Figure 1-1. Regional location of Los Alamos National Laboratory.

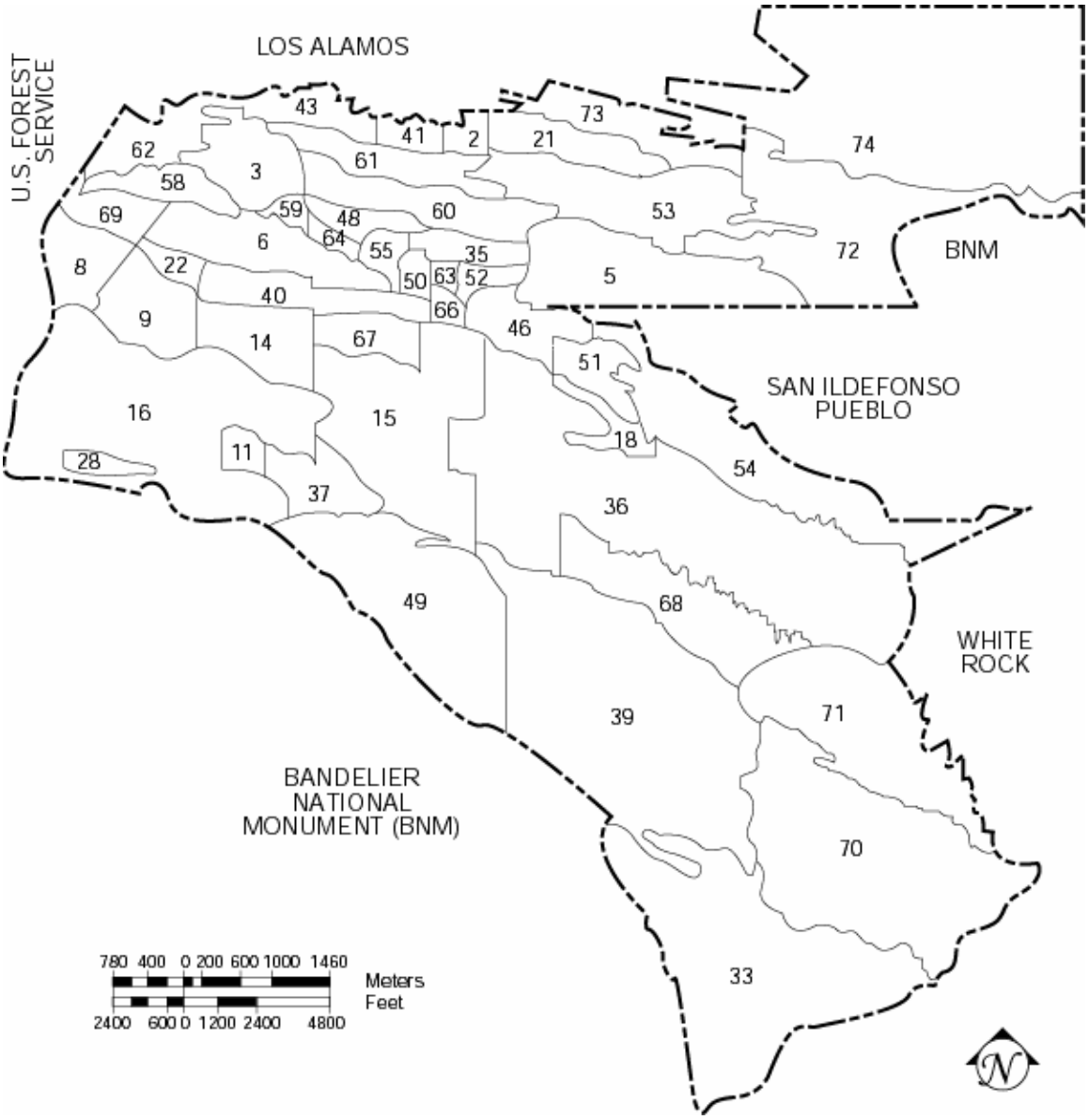


Figure 1-2. Technical Areas of Los Alamos National Laboratory in relation to surrounding landholdings.

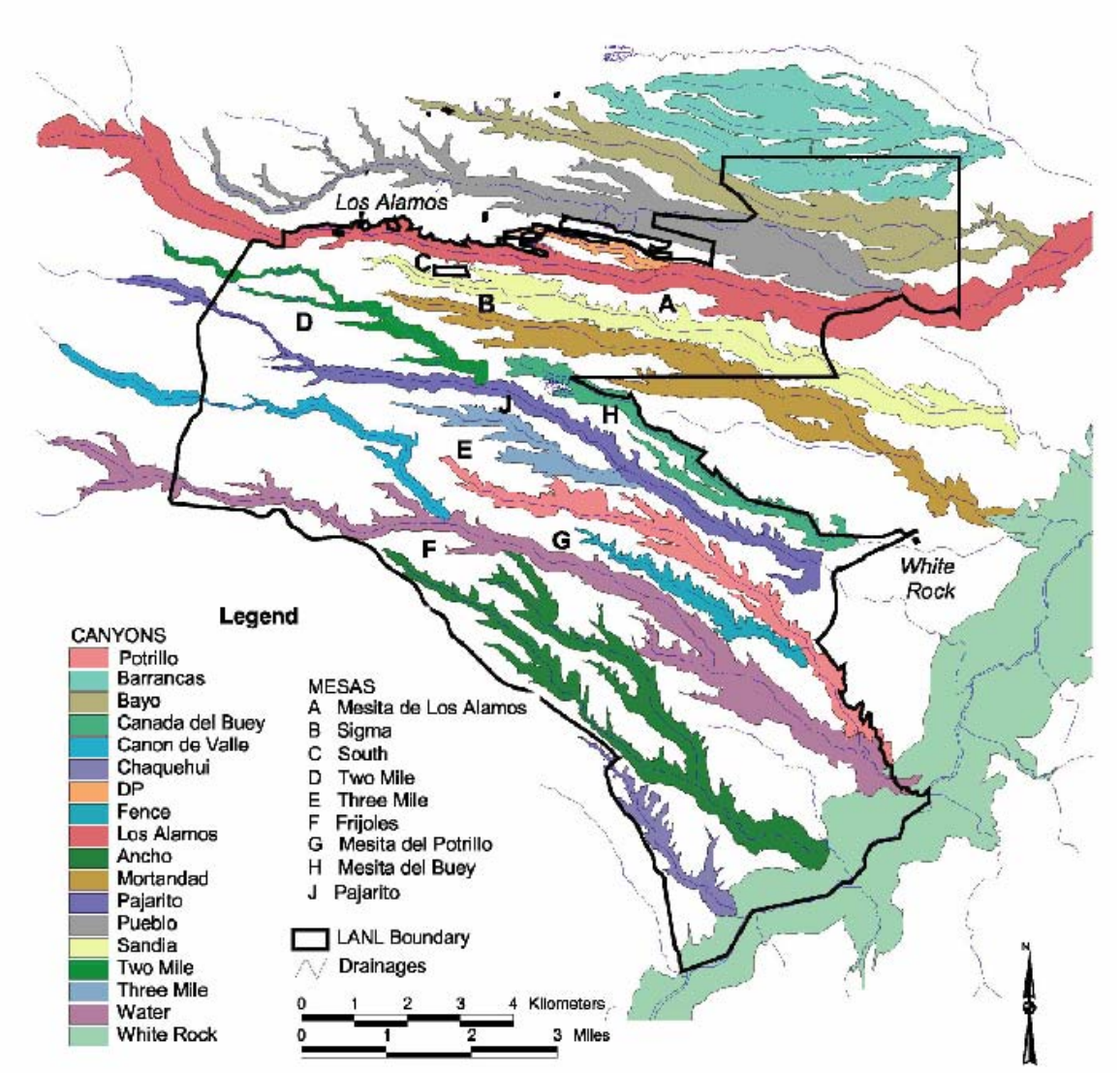


Figure 1-3. Major canyons and mesas.

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 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 Rito de los Frijoles, receives an estimated 4,300–5,500 acre-feet of water annually from the aquifer.

4. Biology and Cultural Resources

The Pajarito Plateau is a biologically diverse and archaeologically rich area. This diversity is illustrated by the presence of more than 900 species of plants; 57 species of mammals; 200 species of birds, including 112 species known to breed in Los Alamos County; 28 species of reptiles; 9 species of amphibians; over 1,200 species of arthropods; and 12 species of fish (primarily found in the Rio Grande, Cochiti Reservoir, and the Rito de los Frijoles). No fish species have been found within LANL boundaries. Roughly 20 of these plant and animal species are designated as threatened species, endangered species, or species of concern at the federal and/or state level.

Approximately 80% 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.

B. Management of Environment, Safety, and Health

1. Environmental Management System Description

LANL is actively developing and implementing an Environmental Management System (EMS) pursuant to DOE Order 450.1 (Environmental Protection Program) using ISO 14001 standards as a model. It is LANL's intent to be able to self-declare an EMS by December 2004, and to be prepared to submit for independent third party ISO 14001 certification by December 2005.

Key steps in EMS development have already been taken. Gap analyses comparing DOE O 450.1 and ISO 14001 standard requirements with existing Integrated Safety Management (ISM) systems were conducted in FY03. An EMS Core Team and EMS Element Teams (Policy, Planning, Implementation Checking and Corrective Action, and Management Review) were chartered and produced an EMS Program Plan in January 2004.The current LANL ISM Description Document has been revised to reflect EMS requirements. In March 2004, LANL Director Pete Nanos 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 has been drafted. A Memorandum of Agreement has been approved between LANL and major subcontractors to assure site-wide coordination of EMS development. Regular progress briefings are being provided to LANL groups, divisions, and management units as well as to the NNSA Site Office.

A critical step in integrating the EMS with ISM is the direct translation of the developed environmental aspects and impacts into the Automated Job Hazard Analysis tool being inaugurated under Phase II of LANL's Integrated Work Management (IWM) program. More than 20 environment subject matter experts were engaged in this integration process. Future work approval will require evaluation of environmental hazards, controls, and pollution prevention opportunities, meeting many DOE O 450.1 and ISO 14001 EMS requirements.

2. Pollution Prevention Program Description

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 Los Alamos' national security, energy, and science missions. Specific P2 activities include

- data collection and reporting on DOE P2 goals;
- waste volume forecasting 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 P2 program has recognized projects that have saved the Laboratory over $7 M during the past 2 years.

3. Risk Reduction and Environmental Stewardship Division

The Risk Reduction and Environmental Stewardship (RRES) Division is a Laboratory support organization that primarily provides a broad range of technical expertise and assistance in areas such as environmental protection, pollution prevention, National Environmental Policy Act (NEPA) requirements, wildfire protection, and natural and cultural resources management. RRES Division is in charge of 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 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 231.1 (DOE 1995). RRES Division has the responsibility and the authority for serving as the central point of institutional contact, coordination, and support for interfaces with regulators, stakeholders, and the public, including the DOE/NNSA, the US Defense Nuclear Facilities Safety Board, the New Mexico Environment Department, and the Environmental Protection Agency.

RRES Division provides line managers with assistance in preparing and completing environmental documentation. Such documentation includes reports required by (1) NEPA of 1969 and (2) the federal Resource Conservation and Recovery Act (RCRA) and (3) its state counterpart, the New Mexico Hazardous Waste Act, as documented in Chapter 2 of this report. With assistance from Laboratory legal counsel, RRES Division helps to define and recommend Laboratory policies for applicable federal and state environmental regulations and laws and DOE orders and directives. RRES Division is responsible for communicating environmental policies to Laboratory employees and makes appropriate environmental training programs available.

The Environmental Surveillance Program resides in four RRES Division groups—Meteorology and Air Quality (RRES-MAQ), Water Quality and Hydrology (RRES-WQH), Solid Waste Regulatory Compliance (RRES-SWRC), and Ecology (RRES-ECO). These groups initiate and promote Laboratory programs for environmental assessment and are responsible for environmental surveillance and regulatory compliance under the auspices of the division's Environmental Protection Program (RRES-EP).

RRES Division uses approximately 600 sampling locations for routine environmental monitoring. The maps in this report present the general location of monitoring stations. For 2003, 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, burning 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 impacts of LANL operations on the environment. RRES 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.

C. References

DOE 1988: US Department of Energy, "General Environmental Protection Program," US Department of Energy Order 5400.1 (1988).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (1990).

DOE 1995: US Department of Energy, "Environmental Safety and Health Reporting," US Department of Energy Order 231.1 (1995).

Gardner et al. 1999: J. N. Gardner, A. Lavine, G. WoldeGabriel, D. Krier, D. Vaniman, F. Caporuscio, C. Lewis, P. Reneau, E. Kluk, and M. J. Snow, "Structural Geology of the Northwestern Portion of Los Alamos National Laboratory, Rio Grande Rift, New Mexico: Implications for Seismic Surface Rupture Potential from TA-3 to TA-55," Los Alamos National Laboratory report LA-13589-MS (March 1999).

LANL 2001a: Los Alamos National Laboratory, "Our Mission," *http://int.lanl.gov/goals/*.

LANL 2001b: Los Alamos National Laboratory, "Strategic Plan (2001–2006)," *http://int.lanl.gov/planning/strategic_plan.html*.

Purtymun and Johansen 1974: W. D. Purtymun and S. Johansen, "General Geohydrology of the Pajarito Plateau," *New Mexico Geological Society Guidebook* (25th Field Conference, Ghost Ranch, New Mexico, 1974).

1. Introduction

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 2003 and the specific operations and/or sites affected.

B. Compliance Status

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 Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, establishes a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. The EPA has authorized the State of New Mexico to implement the requirements of the program, which it does through the New Mexico Hazardous Waste Act and state regulations of New Mexico Administrative Code (NMAC), Title 20, Chapter 4, Part 1, as revised January 1, 1997 (20.4.1 NMAC). Federal and state laws regulate management of hazardous wastes based on a combination of the following: the facility's status;

Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2003

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA[a] Hazardous Waste Facility	Hazardous- and mixed-waste storage and treatment permit	November 1989	November 1999 Administratively continued	NMED[b]
	RCRA General Part B renewal application	submitted January 15, 1999		
	Request for supplemental information	submitted October 2000		NMED
	RCRA mixed-waste Revised Part A application	submitted April 1998	– – –	NMED
	TA-50/TA-54 permit renewal application	submitted January 15, 1999		
	TA-54 Characterization, High-Activity Processing, and Storage Facility	submitted September 19, 2000		NMED
	TA-16 permit renewal application	submitted September 2000		NMED
	TA-55 Revisions to permit application	January 2002	– – –	NMED
	TA-50 Revisions to permit application	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
HSWA[c]	RCRA corrective activities	March 1990	December 1999 Administratively continued	NMED
TSCA[d]	Disposal of PCBs[e] at TA-54, Area G	June 25, 1996	June 25, 2001 Administratively continued	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	December 23, 2000	December 23, 2005*	EPA
	Construction General Permits (21) for the discharge of storm water from construction activities	varies	July 1, 2008**	EPA
CWA Sections 404/401	Individual dredge and fill permits (32)	varies	varies	COE[j]/NMED
Groundwater Discharge Plan, Fenton Hill	Discharge to groundwater	June 5, 2000	Terminated: 8/29/03	NMOCD[k]
Groundwater Discharge Plan, TA-46 SWWS Facility[l]	Discharge to groundwater	January 7, 1998	January 7, 2003***	NMED

Table 2-1. Environmental Permits or Approvals under Which the Laboratory Operated during 2003 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Groundwater Discharge Plan,	Land application of dry sanitary sewage sludge	June 30, 1995	Terminated: 11/25/03	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	not yet issued		NMED
Air Quality (20.2.72 NMAC)	Portable rock crusher	June 16, 1999	None	NMED
	TA-3 Steam Plant-flue gas recirculation	September 27, 2000 Revised, November 26, 2003	None	NMED
	Generator at TA-33	October 10, 2002	None	NMED
	Asphalt Plant at TA-60	October 29, 2002	None	NMED
	Data disintegrator	October 22, 2003	None	NMED
Air Quality (NESHAP)[n]	Beryllium machining at TA-3-102	March 19, 1986	None	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
Open Burning (20.2.60 NMAC)	Air curtain destructors	June 20, 2001	September 30, 2003	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 Facility
[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

large- or small-quantity generation; and 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.

b. Resource Conservation and Recovery Act Permitting Activities. 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, incorporating 40 CFR §270.51. 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 Laboratory submitted updated permit applications in January 1999 to reflect changes in Laboratory operations and has since responded to numerous information requests from the NMED. These responses provided additional information or details about RCRA waste-management practices at the Laboratory and are part of the public administrative record the NMED maintains for the permit.

Laboratory personnel again revised the permit applications in 2003 to include the additional information requested by the NMED, to incorporate new formats or language suggested by the NMED, or to upgrade descriptions of waste-management procedures or units that had changed after the original applications were developed. It is the Laboratory's understanding that the revised permit applications will be available to supplement the public review and comment period when the draft renewal permit is issued by NMED.

The General Part B Permit Renewal Application, Revision 2.0 (submitted to NMED in August 2003), contains procedures and plans common to most of the Laboratory's hazardous and mixed waste management units. Site-specific information was included with the Technical Area (TA) 54 Part B Permit Renewal Application, Revision 3.0 (June 2003); the TA-16 Part B Permit Renewal Application, Revision 4.0 (June 2003); and the TA-55 Part B Permit Application, Revision 2.0 (September, 2003). The TA-50 Part B was previously submitted in 2002. In September and October of 2003, the Laboratory published a series of informational advertisements in local newspapers explaining the documents and the permit renewal process to facilitate future public involvement in the draft permit review.

Several closure plans were submitted to NMED in 2003 and await final approval for the removal of the waste management units. These included the Closure Plan for the TA-16-401 and -406 Sand Filters (March 2003); the Closure Plan for Interim Status Container Storage Units TA-50-1, Room 59 and TA-50-37 (July 2003); the Closure Procedure for the Exhaust System at TA-50-37 (August 2003); the Closure Plan for Container Storage Unit at TA-50-114 (August 2003); and the Closure Plan for TA-50-37, Room 117 (August 2003). The Earth and Environmental Sciences Division submitted a final closure certification report for Material Disposal Area P to NMED in January 2003 (see below).

c. Resource Conservation and Recovery Act Corrective Action Activities.

The DOE established the Remediation Services (RS) Project, initially called the Environmental Restoration Project, in 1989 to characterize and remediate over 2,100 potential release sites (PRSs) known, or suspected, to be contaminated from historical operations. Many of the sites remain under DOE control; however, some have been transferred to Los Alamos County or to private ownership (at various locations within the Los Alamos town site). Remediation and cleanup efforts are regulated by and coordinated with the NMED and/or DOE.

In 2003, RS Project activities included drafting and finalizing several characterization and remediation reports for NMED, conducting characterization field work on sites that could potentially be affected by upcoming infrastructure and construction projects, and formally tracking all work performed.

Some characterization and remediation reports included

- Completion Report for Solid Waste Management Unit (SWMU) 21-024(f) and areas of concern (AOCs) 21-030 and C-21-015;
- Investigation Work Plans and Historic Investigation Reports for Material Disposal Areas C, G, and L;
- Completion Report for SWMU 21-013(d)-99;
- Material Disposal Area H Correction Measures Study Report;

- DP Road Completion Report;
- PRS 16-021(c)-99, 260 Outfall, Phase III RCRA facility investigation Report;
- Second reformatted Material Disposal Area P deliverable, the Phase II Closure Implementation Report;
- SWMU 21-018(a)-99, Interim Measures Completion Report; and
- Completion Report for SWMU 21-024(i).

Continued field investigations included

- Sampling at PRS 3-012(b)-00 in support of the Turbine Generator Project.
- Sampling at SWMUs 3-010(a) and 3-011 in support of the TA-3 Parking Structure Project.
- Sampling at SWMU 3-056(l) in support of the Beryllium Facility Storage Vault Project.
- Sampling at SWMUs 03-028, 03-036(a, c, & d), 03-045(g); and 60-002 and AOCs 03-043(b); 03-036(b); and C-03-016 in support of the TA-3/TA-60 Asphalt Batch Plant Project.

d. Other Resource Conservation and Recovery Act Activities. In 1995, the Risk Reduction & Environmental Stewardship's Solid Waste Regulatory Compliance (RRES-SWRC) Group began a compliance assurance program in cooperation with waste-management coordinators to assess the Laboratory's performance in managing hazardous and mixed waste in a way that would meet the requirements of federal and state regulations, DOE orders, and Laboratory policy. RRES-SWRC communicates findings from individual self-assessments to waste generators, waste-management coordinators, and managers who help line managers implement appropriate actions to ensure continual improvement in LANL's hazardous waste program. In 2003, RRES-SWRC completed 1,099 self-assessments.

e. Resource Conservation and Recovery Act Compliance Inspection. From March 31 to April 28, 2003, the NMED conducted a hazardous-waste-compliance inspection at the Laboratory (Table 2-2).

f. Site Treatment Plan. The Laboratory met all 2003 Site Treatment Plan (STP) deadlines and milestones. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order (CO) to both the DOE and the University of California (UC), requiring compliance with the STP. The plan documents the use of off-site facilities for treating mixed waste generated at LANL and stored more than one year. Through 2003, the Laboratory treated and disposed of more than 700 m^3 of STP mixed waste

g. Underground Storage Tanks. The Laboratory no longer has any registered underground storage tanks (USTs), as defined by 40 Code of Federal Regulations (CFR) 280, "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks." The UST TA-16-197 was excavated in February 2003 and was sent to an off-site recycler. There was no evidence of any release of fuel from the tank, and therefore no further action was required. The UST TA-15-R312-DARHT was never used to store a petroleum product or other regulated substance as defined under the New Mexico Petroleum Storage Tank regulations. NMED agreed to rescind the registration of the TA-15-R312 UST. The NMED conducted one formal UST inspection at the Laboratory during 2003 (i.e., the TA-16-197 tank removal).

h. 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. The Laboratory submitted a closure plan for Area J to the NMED in May 1999. LANL completed the physical closure of Area J in 2002 by placing cover material over the filled pits and reseeding the site. Personnel from the NMED Solid Waste Bureau did not inspect Area J closure activities during 2003. The NMED Secretary approved the Area J Closure Plan in October 2003. Area J is now under long-term post-closure care and monitoring.

Table 2-2. Environmental Inspections and Audits Conducted at the Laboratory during 2003

Date	Purpose	Performing Agency
03/14/03	Asbestos inspection at TA-48, Bldg.1	NMED[a]
03/31/03–04/28/03	RCRA[b] hazardous waste compliance inspection	NMED
05/21/03–05/28/03	NPDES[c] Outfall Inspection	NMED
08/27/03	Asbestos inspection at TA-3, Bldg. 287	NMED
10/06/03	FIFRA[d]	NMDA[e]
12/19/03	Asbestos inspection at TA-48, Gas Line	NMED

(No PCB[f], Storm Water, SDWA[g], 404, or Groundwater Discharge Plan inspections were conducted in 2003.)

[a]New Mexico Environment Department
[b]Resource Conservation and Recovery Act
[c]National Pollutant Discharge Elimination System
[d]Federal Insecticide, Fungicide, and Rodenticide Act
[e]New Mexico Department of Agriculture
[f]Polychlorinated biphenyls
[g]Safe Drinking Water Act

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 included 1,526 tons of trash and 709 tons of construction and demolition debris.

i. Resource Conservation and Recovery Act Training. The LANL RCRA training program is a required component of, and is described in, the LANL Hazardous Waste Facility Permit. Laboratory environmental training is in compliance with the Hazardous Waste Facility Permit and regulatory requirements.

Waste Generation Overview (WGO) live training is a LANL requirement for all waste generators, with the exception of commercial solid waste generators. Waste generators are retrained every three years by taking WGO Refresher, a Web-based course, or by retaking the WGO live course. During 2003, 669 workers completed WGO live training, and 295 workers received credit for the Web-based course. The Web-based refresher course was first offered in the year 2001 at the time the recurrent training requirement was initiated, and more than 2,000 workers have taken advantage of the ease of updating their training on the Web.

RCRA Personnel training is designed to meet initial RCRA training requirements for less-than-90-day accumulation area and treatment, storage, and disposal facility workers. Annual recurrent training requirements are met by completing RCRA Refresher Training. During 2003, 146 workers completed RCRA Personnel Training, and 569 workers completed RCRA Refresher Training. Of the 569 workers who received credit for RCRA Refresher Training, 370 met this requirement through the completion of Hazardous Waste Operations (HAZWOPER) Refresher for Hazardous Waste Site Workers, which included RCRA Refresher Training as part of the 8-hour Occupational Safety and Health Act-required training.

The LANL Environment, Safety, and Health Training Group updated the following environmental related courses during 2003:

- HAZWOPER: Refresher for Treatment, Storage, and Disposal Facility Workers, excluding the RCRA Refresher module; and
- Waste Documentation Forms.

j. Hazardous Waste Report. The Hazardous Waste Report covers hazardous and mixed waste generation, treatment, and storage activities performed at LANL during calendar year 2003 as required by RCRA, under 40 CFR 264.42 – Biennial Report. In 2003, the Laboratory generated about 251,000 kg of RCRA hazardous waste, 1,351 kg of which were generated by the RS Project. The waste is recorded for over 12,000 waste movements, or treatment or storage actions, resulting in more than 790 Waste Generation and Management forms in the Hazardous Waste Report. The entire report is available on the RRES-SWRC web page at *http://swrc.lanl.gov/programs/hazwaste/biennial/2003LANLBiennial.pdf*.

2. Comprehensive Environmental Response, Compensation, and Liability Act

As part of the Conveyance and Transfer project, the Ecology Group (RRES-ECO) prepared environmental baseline survey documents for three subparcels of land during 2003. These documents contain the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) 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 CERCLA.

The three tracts for which surveys were completed include

A-8	DP Road Tract South,
A-15	TA-21 West Tract, and
C-4	White Rock Y Tract.

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

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

b. Compliance Activities. In 2003, the Laboratory submitted two annual reports to fulfill its requirements under EPCRA, as shown on Table 2-3 and described here.

Emergency Planning Notification. Title III, Sections 302–303, of EPCRA require the preparation of emergency plans for more than 360 extremely hazardous substances if stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees (1) 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 2003.

Emergency Release Notification. Title III, Section 304, of EPCRA requires facilities to provide emergency release notification of leaks, spills, and other releases of listed chemicals into the environment, if these chemicals exceed specified reporting quantities. Releases must be reported immediately to the state and local emergency planning committees and to the National Response Center. The Laboratory did not have any leaks, spills, or other releases that exceeded any reporting thresholds in 2003.

Material Safety Data Sheet/Chemical Inventory Reporting. Title III, Sections 311–312, of EPCRA require facilities to provide an annual inventory of the quantity and location of hazardous chemicals 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

Table 2-3. Compliance with Emergency Planning and Community Right-to-Know Act during 2003

Statute	Brief Description	Compliance
EPCRA Sections 302-303 Planning Notification	Requires emergency planning notification to state and local emergency planning committees.	LANL sent notification to appropriate agencies (July 30, 1999) informing officials of the presence of hazardous materials in excess of specific threshold planning quantities and of the current facility emergency coordinator. An additional update adding sodium cyanide to the list was provided 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 (NRC).	There were no leaks, spills, or other releases of chemicals into the environment that required EPCRA Section 304 reporting during 2003.
EPCRA Sections 311-312 MSDSs 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 2003 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, mercury, and nitric acid exceeded the reporting thresholds in 2003, requiring submittal of Toxic Chemical Release Inventory Reporting Forms (Form Rs) to the EPA and the state emergency response commission.

50 chemicals and explosives at the Laboratory that were stored on-site in quantities that exceeded threshold limits during 2003.

Toxic Release Inventory Reporting. EO 12856 requires all federal facilities to comply with Title III, Section 313, of EPCRA. This section requires reporting of total annual releases to the environment of listed toxic chemicals that exceed activity thresholds. Beginning with reporting year 2000, new and lower chemical-activity thresholds were put in place for certain persistent, bioaccumulative, and toxic (PBT) chemicals and chemical categories. The thresholds for PBTs 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 2003 and, therefore, was required to report the uses and releases of these chemicals. The reported materials were lead, mercury, and nitric acid. The largest use of reportable lead is at the on-site firing range where security personnel conduct firearms training. The largest use of reportable mercury is at the reservoirs of mercury that LANSCE uses as shields on the neutron beam shutter system. The largest use of nitric acid is at the plutonium processing facility. In 2003 the facility ramped up operation of a new process called Mixed Oxides fuels (MOX). 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 following releases of lead were reported: 14.5 lb of air emissions, 120 lb of water releases, 5,832 lb of on-site land releases from the firing range, and 50,790 lb of lead waste shipped off site for disposal. Of this 50,790 lb of lead waste, 38,700 lb was a result of the one-time decontamination and decommissioning (D&D) of the Omega West reactor. Reported releases for mercury were 1.0 lb of air emissions, 1.4 lb of water releases, and 6,950 lb of mercury waste shipped off-site. Of the 6,950 lb shipped off site 6,907 lb were sent to a recycling facility. Reported releases for nitric acid were 169 lb of air emissions and 162 lb of nitric acid waste shipped off-site for disposal.

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 2003, the Laboratory shipped 131 containers of PCB waste off-site for disposal. The quantities of waste disposed of include 4,400 kg of capacitors; 1.1 kg of laboratory waste; 481 kg of PCB-contaminated electrical equipment; and 6,949 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. Some of these items have exceeded TSCA's 1-year storage limitation and are covered under the Final Rule for the Disposal of PCB, dated August 28, 1998.

There was one operational problem in 2003 with the improper disposal of a solidified low-level radioactive PCB liquid in an Area G PCB disposal shaft. It is permissible to solidify low-level radioactive liquids for land disposal but not PCB liquids. Approximately one quart of radioactive PCB oil was solidified with an absorbent at a LANL technical area and then was sent to Area G for disposal. Upon discovery of the improper disposal, LANL promptly notified the US EPA Region 6 PCB Coordinator and retrieved the PCB container from the shaft. Training sessions on proper PCB waste management were held with LANL waste management coordinators. EPA took no enforcement action regarding this event.

The 5-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 2004. The EPA did not perform any PCB inspections in 2003.

Approximately 35 TSCA reviews were conducted on imports and exports of chemical substances for the Laboratory's Property Management Group (SUP-2) Customs office. One export of a TSCA-regulated substance (a bacterium) required a formal TSCA Section 12b written notice to the US EPA.

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides and the protection of workers who use these chemicals. Sections of this act that are applicable to the Laboratory include requirements for certification of workers who apply pesticides. The New Mexico Department of Agriculture (NMDA) has the primary responsibility to enforce pesticide use under the FIFRA. 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 NMDA and the DOE's Los Alamos Site Office (LASO) did not conduct assessments or inspections of the Laboratory's pesticide application program in 2003. The NMDA's Bureau of Pesticide Management conducted an annual inspection of the Laboratory's pesticide storage area in 2003 and found that the storage area was being maintained in accordance with NMDA regulations.

Amount of pesticides used during 2003 included the following:

- VELPAR L (herbicide) 99 gal.
- TELAR (herbicide) 27 g
- 2-4-D Amine (herbicide) 6 gal.
- Max Force Ant Bait (insecticide) 7 oz
- TEMPO (insecticide) 3.1 gal.
- STINGER WASP (insecticide) 47 oz

6. Clean Air Act

The NMED or the EPA regulates Laboratory operations and air emissions. In December 1995, LANL submitted to the NMED an operating permit application as required under Title V of the Clean Air Act (CAA) Amendments and Title 20 of the NMAC, Chapter 2, Part 70–Operating Permits (20.2.70 NMAC). An updated application was submitted on November 27, 2002. The application is comprehensive and contains for each regulated emission source a process description, emission estimates, and proposed means of monitoring, recordkeeping, and reporting. In addition, Chapter 4 of the Application, *http://www.lanl.gov/orgs/rres/maq/OpPermitLANL.htm*, presents a description of the air quality requirements applicable to the Laboratory. During 2003, the Meteorology and Air Quality Group (RRES MAQ) submitted five amendments to the application.

During the 2003 time frame, the NMED held a 30-day public comment period for the proposed permit and, after conclusion of this period, initiated a 45-day comment period for the EPA. The EPA did not provide comments on the proposed permit. It was expected that the Title V Operating Permit would be issued in 2003, but, because of concerns raised by public organizations during the 30-day comment period, the issuance of the permit has been delayed. When issued, the permit will specify the operational terms and limitations imposed on LANL to continue to ensure that all federal and state air quality standards are being met. In the interim, LANL operates under the provisions of source-specific permits and complies with applicable sections of the state and federal air quality regulations.

LANL is a major source under the operating permit program based on the potential to emit for nitrogen oxides (NO_x), carbon monoxide, and volatile organic compounds (VOCs). In 2003, the major contributors of these air pollutants, and regulated air pollutants in general at LANL, were the Air Curtain Destructors (ACDs).

LANL reports annual emissions for sources covered under the Title V Operating Permit Application—including multiple boilers, two steam plants, a paper shredder, a carpenter shop, three degreasers, a rock crusher, multiple storage tanks, and asphalt-production. LANL also reports emissions from chemical use associated with research and development activities, three ACDs used to burn wood and slash from forest-thinning activities, and permitted beryllium activities. Emissions reported for 2003 are shown in Table 2-4. Smaller sources of air pollutant emissions, such as nonregulated boilers, emergency generators, and space heaters, are located throughout LANL. The NMED considers these smaller sources insignificant; therefore, these sources are not required to be included in the annual emissions inventory.

LANL staff calculates air emissions using emission factors from source tests, manufacturer data, and EPA documentation. Calculated emissions are based on actual production rates, fuel and fuel usage, and/or material throughput rates. In 2003, ACDs, LANL's primary sources of regulated air pollutants, contributed 25 tons of NO_x, 14 tons of carbon monoxide, 1.3 tons of sulfur oxides (SO_x), 19 tons of particulate matter (PM), and 36 tons of VOCs. Emissions from forest thinning would have been much higher if traditional methods such as open burning or prescribed burning were used instead of the ACDs. Figure 2-1 provides a comparison among recent emissions inventories reported to the NMED. PM, carbon monoxide, and VOC emissions were higher in 2003 because of extensive use of the ACDs.

Historically, the TA-3 steam plant has been the primary source of regulated air pollutants. However, Flue Gas Recirculation equipment was operational for all of 2003 on the three boilers operated at LANL's TA-3 steam plant. Stack tests demonstrated a 64% reduction in NO_x at the steam plant. NO_x emissions from the TA-3 steam plant were 17 tons in 2003 compared with 40 tons reported in 2002.

Table 2-4. Calculated Actual Emissions for Regulated Pollutants (tons) Reported to NMED

	Pollutants					
Emission Units	**NOx**	**SOx**	**PM**	**CO**	**VOC**	**HAPs**
Asphalt Plant	0.015	0.003	0.042	0.24	0.005	0.0046
TA-21 Steam Plant	1.6	0.016	0.12	1.34	0.09	0.029
TA-3 Steam Plant	16.94	0.27	2.25	11.67	1.6	0.529
Regulated Boilers	6.44	0.039	0.586	4.41	0.365	0.12
R&D Chemical Use	NA	NA	NA	NA	11.2	7.32
Air Curtain Destructors	24.6	1.3	19.1	14.3	36	3.3
Degreaser	NA	NA	NA	NA	0.012	0.012
Paper Shredder	NA	NA	0.0014	NA	NA	NA
Rock Crusher	0	0	0	0	0	0
Carpenter Shop (TA-3-38)	NA	NA	0.038	NA	NA	NA
Storage Tanks	NA	NA	NA	NA	0.047	NA
TOTAL	**49.6**	**1.6**	**22.1**	**32.0**	**49.3**	**11.3**

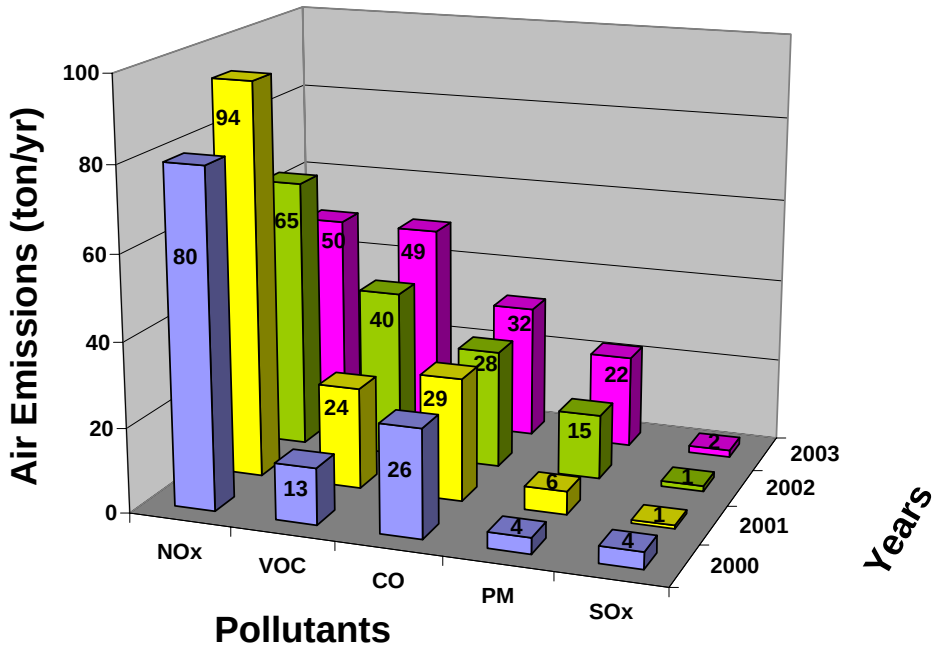


Figure 2-1. Criteria pollutant emissions from LANL from 2000 to 2003.

The installation of the Flue Gas Recirculation equipment and lower fuel usage account for the lower emissions from the TA-3 steam plant in 2003.

Chemical use associated with R&D activities also contributed to the VOC and hazardous air pollutant (HAP) emissions. Detailed analysis of chemical tracking and procurement records indicates that LANL procured approximately 11 tons of VOCs, which is lower than the 15 tons reported for 2002. For a conservative estimate of air emissions, LANL assumed the total quantity of VOCs purchased to be

emitted. Combined VOC emissions from ACDs and chemical usage were 47 tons in 2003, or 96% of LANL's total VOC emissions.

The HAP emissions reported from R&D activities generally reflect the quantities procured during the calendar year. In a few cases, LANL evaluated procurement values and operational processes in more detail to report actual emissions in place of the procured values. The total quantity of HAP emissions based on chemical procurements for 2003 was 7.3 tons. Sources contributing to the HAP emissions included the following: R&D activities, 7.3 tons; ACDs, 3.3 tons; TA-3 steam plant, 0.53 tons; and numerous small boilers, 0.15 tons for a total of 11.3 tons.

On February 21, 2003, the NMED requested that LANL provide a facility-wide air quality impact analysis to address nitrogen dioxide (NO_2), carbon monoxide, sulfur dioxide (SO_2), PM less than 10 micrometers in aerodynamic diameter (PM_{10}), and total suspended particulates (TSP). The purpose of the request was to ensure that emission limits requested in the Title V Operating Permit Application do not exceed the New Mexico Ambient Air Quality Standards or the National Ambient Air Quality Standards. The modeling results demonstrate that the simultaneous operation of LANL's air emission sources at maximum capacity as described in the Title V Operating Permit Application will not exceed any state or federal ambient air quality standards. The modeling analysis is described on line at *http://www.airquality.lanl.gov/OpPermitGenInf.htm*.

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 2003 were $12,761.25.

a. New Mexico Air Quality Control Act.

Construction Permits. LANL reviews plans for new and modified projects, activities, and operations to identify all applicable air quality requirements including the need to revise the operating permit application, to apply for construction permits, or to submit notifications to the NMED. During 2003, Laboratory performed approximately 200 air quality reviews, submitted 2 permit applications, and received 1 permit. Also, nine sources, including natural-gas-fired boilers, hot water heaters, generators and other equipment, were exempt from construction permitting but required written notification to the NMED (20.2.72 NMAC). LANL currently operates under the air permits listed in Table 2-1.

On August 18, 2003, a Notice of Intent application was submitted to the NMED for the short term and temporary operation of a screening system to be used in conjunction with the ACDs. One week later, the NMED determined that the screening system would require a permit. Because of the project timeline, a permit was not pursued and the screening system was not used.

On October 22, the NMED issued a construction permit for the TA-52 data disintegrator. The data disintegrator is to be operated at LANL under Air Quality Permit No. 2195-H to destroy classified media. The construction permit application calls for the installation of a cyclone separator and a cloth tube filter. Installation of these units did not begin in 2003.

On November 26, 2003, an application to modify the construction permit for the TA-3 steam plant to add a new combustion turbine was submitted. The new 20-MW combustion turbine would be a standby or peaking unit that would operate between 2,000 and 4,000 hours per year. The permit is anticipated in 2004.

In addition to permits issued to LANL, on March 5, the NMED issued a construction permit for a concrete crusher to SG Western Construction, Inc. The crusher is to be operated on LANL property by SG Western Construction personnel.

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 2003 were conducted within the terms specified in the permit. The results of these operations are reported annually to the NMED to document compliance with permit requirements.

Major changes to the Open Burning Regulation (20.2.60 NMAC) were adopted by the Environmental Improvement Board on November 17, 2003, and became effective on December 31, 2003. Under the new open burn regulation, LANL will have to prepare new permit applications for some ongoing activities. Operations regulated under the hazardous waste provisions of RCRA and operations to burn vegetative material will be allowed to continue without a new 20.2.72 NMAC permit. The other ongoing operations

will be required to undergo the permitting process. The new applications must be submitted by June 30, 2004.

In addition to operational burns, the Laboratory also conducted prescribed burning to assist with fire-mitigation activities. On June 20, 2001, LANL was granted an open-burn permit to operate three ACDs within the Laboratory boundaries. The original permit expired on December 31, 2002. A letter from the NMED extended the permit until September 30, 2003. During 2003 operations, nearly 18,000 tons of slash from fire-mitigation activities were burned. The extensive use of these units resulted in an increase in reported emissions of criteria pollutants and HAPs. Operations ceased on September 30, 2003.

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 that involve 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 2003 included 14 large renovation jobs and demolition projects for which the NMED received advance notice. These projects, combined with other smaller activities, generated approximately 271 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, three inspections by the NMED during the year identified no violations. RRES-MAQ has placed its "Quality Assurance Project Plan" for the Asbestos Report Project at *http://www.airquality.lanl.gov/QA.htm* on the World Wide Web.

Degreasers. LANL has three halogenated degreasers listed in the operating permit application. However, only one unit is in operation. The solvent cleaning machine, or degreaser, uses the regulated halogenated solvent, Trichloroethylene, which is both a VOC and HAP.

b. Federal Clean Air Act.

Ozone-Depleting Substances. Title VI of the CAA contains specific sections that establish regulations and requirements for ozone-depleting substances (ODSs), such as halons and refrigerants. The main sections applicable to the Laboratory prohibit individuals from knowingly venting an ODS 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 2003, for all equipment. In 2003, four chillers remained in operation, which are subject to the 2005 phase-out goal. LANL is making progress toward achieving these 2005 and 2010 goals.

Radionuclides. Under the National Emission Standard for Hazardous Air Pollutants for Radionuclides (Rad NESHAP), the EPA limits the effective dose equivalent (EDE) of radioactive airborne releases from a DOE facility, such as LANL, to any member of the public to 10 mrem/yr. The 2003 EDE (as calculated using EPA-approved methods) was 0.65 mrem. The location of the highest dose was at East Gate. Operations at LANSCE made the principal contribution to that highest dose. The RRES-MAQ QA Project Plan for the Rad NESHAP Compliance Project is available at *http://www.lanl.gov/orgs/rres/maq/QA.htm* on the World Wide Web.

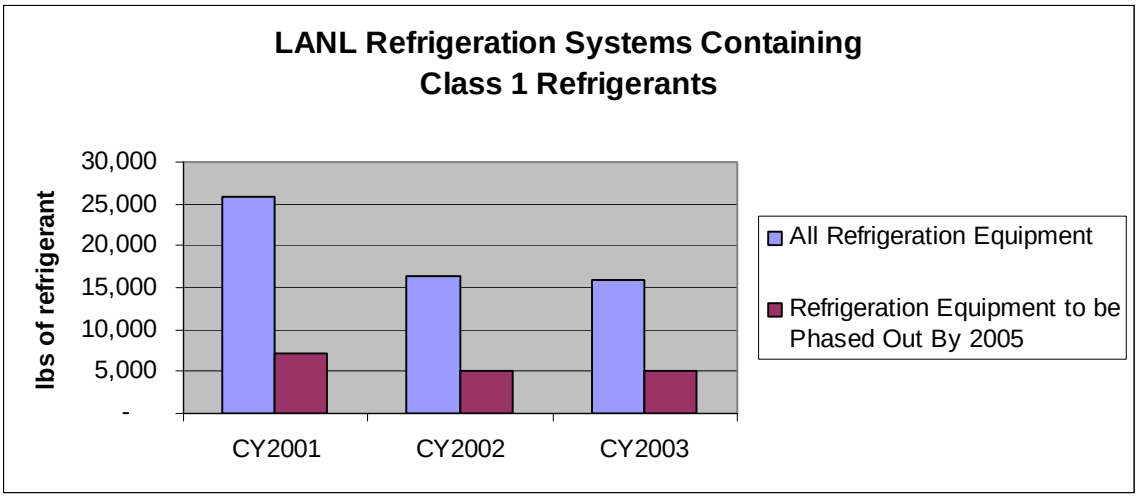


Figure 2-2. LANL refrigeration systems containing class 1 refrigerants.

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 2003, more than 100 reviews involved the evaluation of air-quality requirements associated with the use of radioactive materials. One of these proposed projects that involves repackaging of radioactive waste met the criteria requiring EPA pre-approval. LANL submitted the approval application in January 2002, and approval was granted in March 2002. However, changes in scope and project delays on this activity required the pre-approval application to be resubmitted in 2003 after plans were finalized.

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.

During the past 5 years, the Laboratory has achieved a reduction in outfalls by (1) removing process flows at industrial outfalls and (2) completing the transfer of the drinking water system to Los Alamos County. No NPDES outfalls were deleted in 2003; however, a July 2002 request to the EPA Region 6 to delete two NPDES outfalls is still pending. These two outfalls, plus two additional outfalls, will not be included in the Laboratory's NPDES Permit re-application to be submitted in August of 2004. 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.

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 2003, 5 of the 958 samples collected from industrial outfalls exceeded effluent limits. None of the 132 samples collected from the Sanitary

Wastewater Systems (SWWS) Plant's outfall exceeded effluent limits. To view the Laboratory's NPDES permit go to *http//wqdbworld.lanl.gov* on the World Wide Web.

The following is a summary of the corrective actions taken by the Laboratory during 2003 to address the NPDES outfall permit noncompliances cited above.

(1) **TA-3 Strategic Computing Complex (SCC) Cooling Tower.** On May 29, 2003, a total residual chlorine (TRC) concentration of 0.30 mg/L exceeded the NPDES monthly average and daily maximum permit limit of 0.011 mg/L (counts as two instances of exceedance). The cause of this noncompliance was an electric power surge at the facility that reset the conductivity controller (for the cooling tower blow-down) back to its default factory setting. At the factory setting, the chlorine neutralization pump was not operating frequently enough to properly neutralize chlorine as the discharge leaves the SCC. The controller was re-set and a surge protector installed to prevent future power surges from reaching the conductivity controller.

(2) **TA-55 Cooling Tower.** On September 16, 2003, a total phosphorus result of 24.5 mg/L exceeded the monthly average permit limit of 20.0 mg/L. The cooling tower operators have been unable to determine the cause of the elevated result. A prior total phosphorus compliance result collected in June 2003 was 0.051 mg/L and two subsequent results from October 2003 were 0.051 mg/L and 0.052 mg/L.

(3) **TA-3 Sigma Cooling Tower.** On October 8, 2003, a TRC concentration of 0.11 mg/L exceeded the NPDES monthly average and daily maximum permit limit of 0.011 mg/L (counts as two instances of exceedance). The cause of the noncompliance was the absence of a dechlorination system. A dechlorination system was installed on October 9, 2003.

b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program. The Laboratory's WA-Site (TA-46) SWWS Facility 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 removed and disposed of as a New Mexico Special Waste. During 2003, the SWWS Facility generated approximately 41 dry tons (82,614 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 conducted an NPDES Outfall Compliance Evaluation Inspection (CEI) on May 21, 22, 27, and 28, 2003, at eight facilities throughout the Laboratory (Table 2-2). The Laboratory received an overall Facility Evaluation Rating of "Satisfactory" on the NPDES Compliance Inspection Report.

Listed below is a summary of the corrective actions taken by the Laboratory to address the following deficiencies noted in the CEI Report.

(1) A nonpermitted discharge of potable water was discovered on May 22, 2003, at the TA-3 Power Plant. The discharge was immediately discontinued, and the valve locked out. Following this incident, power plant management and operators began weekly meetings with environmental personnel to discuss potential environmental problems resulting from planned changes at the facility.

(2) The annual Discharge Monitoring Report (DMR) did not include details of two exceedences of the selenium permit limit that were communicated to EPA and NMED in August 2003 and September 2003. It was later determined that the selenium exceedences were false-positive results because of interference from bromine (used as a biocide in the cooling towers). As a result, there were no permit exceedences. This was confirmed when the original samples were reanalyzed using an alternate EPA approved method. The Laboratory has developed a tracking system for possible permit exceedences to ensure proper notifications are made, including information accompanying the DMRs.

(3) The NMED inspector identified a potential upset condition at the SWWS Plant on February 13, 2003. According to the inspector, floating solids passing through the clarifier's weir to the outfall constitutes an upset condition requiring notification to the EPA. LANL reported to the NMED that no effluent was discharged to the environment on that date because the SWWS Plant operators were holding all effluent on-site in the facility's reuse pond. As soon as the plant operators became aware of the condition, they held wastewater in the equalization basins to minimize flows to the clarifier. Additionally, an automatic sludge blanket indicator was installed on the clarifier and tied into the notification system to prevent reoccurrence.

(4) The NMED inspectors observed large amounts of grease in the SWWS Plant's clarifier. Additionally, NMED inspectors noticed that the operator's laboratory bench sheets documented floating solids in the plant's effluent on that date. The SWWS Plant operators characterized the floating solids as "trace" or "de minimus;" some amount of floating solids are always present in the chlorine contact chamber, and their presence has historically not effected NPDES or Groundwater Discharge Plan compliance. To address NMED's concern, the TA-3 Otowi building cafeteria is now pumping its grease traps more frequently, and plans are being made to install a more efficient grease collection system. In addition, the SWWS Plant has installed fine screens on the clarifier to reduce the amount of grease leaving the clarifier.

(5) NMED inspectors determined that NPDES compliance samples collected from Room 116 at the Radioactive Liquid Waste Treatment Facility (RLWTF) did not qualify as "representative" of the permitted discharge activity. NMED reported that the 40-year-old discharge pipe might be leaching out residual radioactivity and other potential contaminants causing a deterioration of effluent quality. In response, LANL replaced the existing effluent discharge line, and new piping was installed to the sample sink in Room 116. Following completion of this work, the RLWTF performed operational sampling of the effluent to document that the quality of the effluent discharged to Mortandad Canyon is representative.

d. National Pollutant Discharge Elimination System Storm Water Construction Program. The NPDES Construction General Permit program regulates storm water discharges from identified construction activities. In 2003, the Laboratory applied for and was granted coverage under EPA's new 2003 Construction General Permit. During 2003, the Laboratory managed 21 construction projects most of which were initially permitted under the July 6, 1998, EPA Region 6 NPDES General Permit for Storm Water Discharges from Construction Activities. Under the new NPDES Construction Regulations, all construction sites disturbing one or more acres, including those that are part of a larger plan of development collectively disturbing one or more acres, are required to have an NPDES Construction Permit. The NPDES Construction Permit regulates storm water discharges from construction sites. At most LANL construction sites, the Facility Manager or the LANL Construction Project Manager (for new construction projects) and the General Contractor all apply individually for permit coverage for the site.

The NPDES Construction General Permit requires that owners of each planned construction activity develop and implement a Storm Water Pollution Prevention (SWPP) Plan before beginning soil disturbance activities. Generally, a SWPP Plan describes the site-specific interim and permanent stabilization, managerial and structural solids, erosion and sediment control best management practices used to reduce the pollutants in storm water discharges associated with the construction activity and assure compliance with the terms and conditions of the NPDES Construction General Permit. Additionally, State of New Mexico certification of the Construction General Permit requires that a SWPPP must include (1) site-specific interim and permanent stabilization measures and (2) erosion and sediment control best management practices (BMPs) that are designed to prevent, to the maximum extent practicable, an increase in the sediment yield and flow velocity from preconstruction, predevelopment conditions to assure that applicable water quality standard are met. This requirement applies to discharges both during construction and after construction operations have been completed. Also under state certification requirements, the SWPPP must identify and document the rationale used for selecting BMPs and other controls. The SWPPP must also describe design specifications, construction specifications, maintenance schedules (including a long-term maintenance plan), and criteria for inspections. BMP selection must be made based on the use of appropriate soil loss prediction models or equivalent,

generally accepted soil loss prediction tools. And finally, each SWPP Plan must describe and implement measures necessary to protect listed endangered or threatened species and critical habitat. In 2003, the Laboratory implemented and maintained 51 SWPP Plans and addendums to SWPP Plans.

Construction sites with SWPP Plans are inspected in accordance with NPDES Construction General Permit Regulations. Inspection reports document the condition of the site to ensure NPDES Construction General Permit compliance. In 2003, LANL performed 675 storm water inspections at construction sites.

To manage its NPDES Construction Permits the Laboratory has developed a Geographic Information System (GIS) -based tracking system. The system maintains records for each site, such as

- site and BMP coordinates,
- SWPP Plan inspections,
- the condition of BMPs,
- SWPP deficiencies, and
- deficiency corrections.

General Permit information for the Laboratory is accessible to the public through postings in the Laboratory's Community Involvement Office Reading Room.

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 SWMUs). The UC and the DOE are co-permittees under the NPDES Multi-Sector General Permit 2000 (MSGP-2000) for LANL. The permit regulates storm water discharges from LANL industrial activities.

The permit requires the development and implementation of a SWPP Plan. Currently, LANL maintains and implements 17 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 proceeding period is reported in Shaull 2004 and in DMRs.

Compliance with the permit may be evaluated in two different ways: First, by identification of potential pollutants that may impact surface water quality and providing controls to limit the impact of those pollutants. Secondly, by monitoring storm water runoff, (1) Laboratory surface waters that receive storm water runoff should meet state water-quality standards; (2) certain types of industries found at LANL require that "benchmark parameter monitoring," or "sector-specific monitoring," be conducted under the storm water permit, and (3) visual inspection of storm water runoff is required to assess odor, floating solids, foam, oil sheen, and other indicators of storm water pollution.

The current strategy for implementation of the MSGP-2000 at LANL includes the following elements: (1) development and implementation of SWPP plans at 23 industrial activity locations;
(2) development and implementation of a Storm Water Monitoring Plan that provides detail on collecting storm water runoff at watershed-based and site-specific facilities gauging stations; and (3) development and implementation of a best management practice installation, inspection, and maintenance program.

f. National Pollutant Discharge Elimination System Storm Water Program Inspection. No inspections were conducted by either the NMED or the EPA at MSGP-regulated facilities during 2003.

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, 40CFR 112) and the NMED Petroleum Storage Tank Bureau Regulations (20 NMAC 5).

Between August 2002 and July 2003, a Laboratory-wide Comprehensive Tank Survey was conducted on over 2,300 tanks and pressure vessels at the Laboratory. The survey's objectives were to identify and inventory all existing tanks and underground piping, assess the condition of each tank, and identify potential vulnerabilities. Vulnerabilities were prioritized based upon the potential for endangering the

health and safety of workers and the environment from overpressurization, evidence of spills or leaks, and corrosion. Additional vulnerabilities identified were inadequate monitoring and secondary containment, the physical condition of the tank or piping, and insufficient information on the tank.

The Comprehensive Tank Survey developed and implemented the following:

- A database and GIS to manage tanks and pressure vessels,
- A tank numbering protocol,
- A record of tank ownership, and
- A system for identifying and prioritizing potential vulnerabilities.

The Comprehensive Tank Survey identified 2,389 tanks and pressure vessels. Approximately 1,830 (76.6%) were pressure vessels with operating pressures greater than 15 psig (pounds per square inch gauge), and 559 (23.4%) were storage tanks with operating pressures less than 15 psig. The survey identified 158 (6%) tanks and pressure vessels as potential vulnerabilities. Of the 2,231 tanks and pressure vessels not identified as potentially vulnerable, 1,143 were identified as needing further inspections and maintenance activities. The remaining 1,088 tanks and pressure vessels did not pose a potential vulnerability. Water Quality and Hydrology (RRES-WQH) developed a corrective action plan in coordination with facility managers and tank owners to address the potential vulnerabilities. Pending approval by Laboratory management, implementation of this Action Plan is anticipated for March 2004.

h. Spill Prevention Control and Countermeasures Program. The Laboratory's Spill Prevention Control and Counter measures (SPCC) Program, as required by the CWA (40 CFR 112, Oil Pollution Prevention), develops comprehensive plans to meet EPA requirements that regulate water pollution from oil spills. Table S2-1 in the Data Supplement shows the SPCC plans and tanks regulated by this program at the Laboratory for 2003. New regulations under the federal Clean Water Act require the Laboratory's SPCC Plans to be modified by August 17, 2004. Implementation of the modifications to SPCC Plans is required before February 18, 2005. The primary modifications address storage capacity compliance, inspection frequency, and integrity testing requirements. In 2003, there were 12 existing SPCC Plans at the Laboratory that required modifications to comply with the new regulations.

On August 15, 2003, the NMED-Petroleum Storage Tank Bureau (PSTB) implemented new regulations that combined requirements for USTs and ASTs (20 NMAC 5). The new regulations will require the development of Corrosion Prevention Plans and AST upgrades for tank systems regulated by the NMED-PSTB. Table S2-1 in the Data Supplement shows a list of NMED-PSTB ASTs regulated by this program at the Laboratory for 2003. The Laboratory is in the process of completing these requirements for the AST systems. Additionally, registration fees ($100 per tank) are required to be submitted to the NMED-PSTB annually as of September 2002.

During 2003, the following four AST systems were removed from the Laboratory's SPCC Plan list and/or NMED-PSTB registration list: TA-3 Asphalt Batch Plant, TA-21 Steam Plant, TA-35 ATLAS, and TA-50 WCRRF. The TA-3-Asphalt Batch Plant (TA-3-1968 and -1969 ASTs) and the TA-21 Steam Plant (TA-21-57 AST and a 600-gal. AST) were decommissioned. The TA-35 ATLAS AST system was removed from Laboratory property and transported to the Nevada Test Site. The TA-50 WCRRF AST system's storage volume capacity was discovered to be less than 1,320 gal., and it no longer required an SPCC Plan. Additionally, in 2003, the TA-35-301 26,000-gal. steam turbine oil AST system was identified during the Comprehensive Tank Survey as needing an SPCC Plan, and one was completed in 2003. Eleven new and proposed tank systems were identified as requiring SPCC Plans before February 18, 2005. The Laboratory is in the process of developing those plans to meet the regulatory requirements and deadlines.

On February 21, 2002, the Laboratory notified the EPA, the NMED, and the National Response Center (NRC) of a discharge of approximately 48,000 gal. 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 and submitted the *TA-21-57 Aboveground Storage Tank Diesel Fuel Oil Environmental Assessment and Characterization, Revision 1, Reports* to the NMED on December 5, 2003.

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 characterization of the diesel contaminated soil and is in the process of completing a characterization report.

i. Dredge and Fill Permit Program. Section 404 of the CWA requires the Laboratory to obtain permits from the US Army Corps of Engineers (COE) to perform work within perennial, intermittent, or ephemeral watercourses. Section 401 of the CWA requires states to certify that Section 404 permits issued by COE 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.

During 2003, two Section 404/401 permits were issued to the Laboratory for the Rendija Land Transfer Boulder Placement project. This bank stabilization and boulder placement activity was covered by Nationwide Permit No. 13 and Nationwide Permit No. 18, respectively.

The NMED or COE did not inspect active sites permitted under the Section 404/401 regulations during 2003.

8. Safe Drinking Water Act

a. Introduction. 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. This section presents the results from SDWA compliance monitoring conducted by Los Alamos County in 2003. Also in 2003, the Laboratory conducted additional, confirmation monitoring of the Los Alamos Water Supply System for Quality Assurance purposes. These data are presented in Chapter 5.

In 2003, the county conducted no radiochemical sampling for SDWA compliance purposes. Results of nonradiochemical sampling revealed no exceedences of 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 on-line at: *http://www.lac-nm.us/*.

The NMED did not conduct an inspection of the drinking-water system in 2003.

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.

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 and to design an adequate monitoring system that could detect releases of groundwater contaminants from waste management operations (Figure 2-3). The goal of the project is to develop greater understanding of the geology, groundwater flow, and geochemistry beneath the 43-square-mile Laboratory area for monitoring system design and to assess any impacts that Laboratory activities may have had on groundwater quality.

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

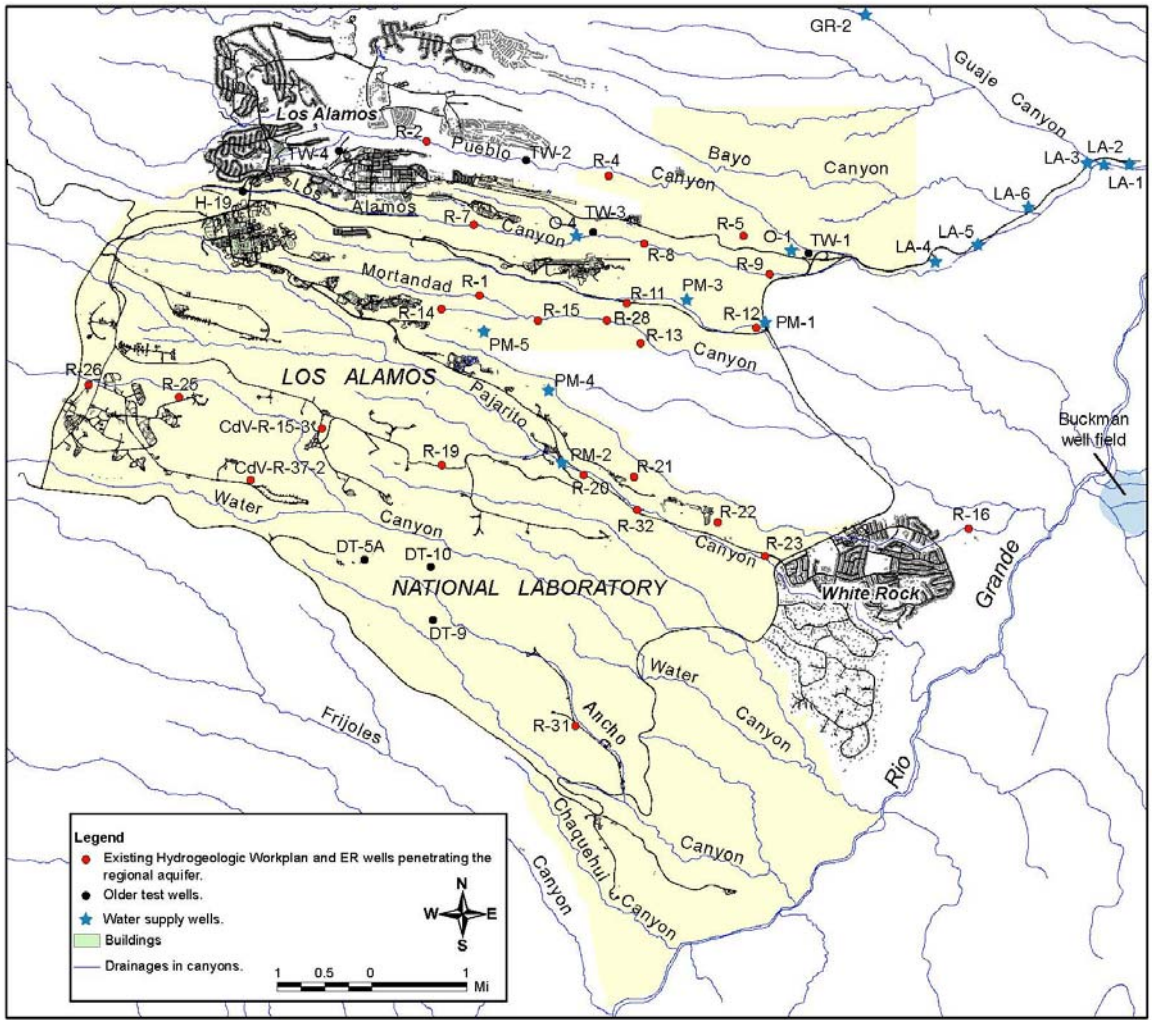


Figure 2-3. Map of hydrogeologic workplan regional aquifer characterization wells.

(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.

At the beginning of 2003, the Laboratory had three approved groundwater discharge plans to meet NMWQCC regulations (Table 2-1): one for TA-57 (Fenton Hill), one for the SWWS Plant, and one for the land application of dried sanitary sewage sludge from the 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 2003. During 2003, two groundwater discharge plans were terminated, TA-57 (Fenton Hill) and the land application of sewage sludge. On August 29, 2003, the NM Oil Conservation Division terminated the Fenton Hill discharge plan at the Laboratory's request; decommissioning of the Fenton Hill Hot Dry Rock Geothermal Project ended the Laboratory's need for the discharge plan. Similarly, on November 25, 2003, the NMED terminated the discharge plan for the land application of dried sanitary sludge at the Laboratory's request. The Laboratory stopped land-applying sludge in 1995 and had no plans to return to this activity. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the RLWTF at TA-50. As of December 31, 2003, NMED approval of the plan was still pending.

b. Compliance Activities. Hydrogeologic Workplan activities during 2003 included installing six wells in the regional aquifer. The wells are as follows:

- R-1 and R-28 in Mortandad Canyon
- R-2 and R-4 in Pueblo Canyon
- R-11 in Sandia Canyon
- R-26 in Cañon de Valle

Initial sampling of these wells has shown various detectable levels of nitrate, perchlorate and tritium (Longmire and Counce 2004).

The conceptual model with regard to interconnection between alluvial groundwater, intermediate saturated zones, and the regional aquifer has been refined based the data collected in the drilling, sampling, and testing of new wells. The conceptual model is that contaminants are transported in surface water or alluvial groundwater from source areas to areas where infiltration occurs. Infiltration is most likely to occur where the Bandelier Tuff thins or is not present (for example, Los Alamos Canyon near the low-head weir on Highway 4) or where a structure pools water (for example, in Mortandad Canyon at the sediment traps). Infiltration can carry contaminants to intermediate perched groundwater and to the regional aquifer. The conceptual model is supported by the following key water chemistry conclusions:

- Measurable activities of tritium (although far below the drinking water standard) observed in wells R-9, R-9i, R-12, R-15, R-22, R-28, R-11, and R-4 suggest that a component of groundwater is less than 60 years old. These wells are located in areas where the geologic or anthropogenic conditions facilitate infiltration.
- Wells R-19, R-26, R-13, R-14, R-2, and R-1 do not have detectable tritium, and the age of groundwater at these wells probably ranges between 3,000 and 10,000 years. These wells are in locations where infiltration is insignificant.
- Mobile (nonadsorbing) solutes, including tritium, nitrate, and perchlorate, serve as a tracer chemical and identify areas where infiltration has reached intermediate perched groundwater or the regional aquifer. These tracers have migrated hundreds of feet in the near surface during the past 60 years. Concentrations and activities of these chemicals are below regulatory standards and/or health advisory limits in the regional aquifer at R-wells.

The Laboratory's "Groundwater Annual Status Summary Report" (Nylander et al. 2003) provides the most recent information on newly collected groundwater data. Additionally, sample, water-level, well-construction, and other programmatic data can be reviewed online on the Laboratory's Water Quality Database (*http://wqdbworld.lanl.gov/*).

10. National Environmental Policy Act

Supplement Analysis for the Proposed Disposition of Certain Large Containment Vessels. On June 12, 2003, the DOE National Environmental Policy Act (NEPA) Compliance Officer at LASO determined that a supplement analysis (SA) should be prepared to determine whether the existing Site-Wide Environmental Impact Statement for Continued Operations of Los Alamos National Laboratory (SWEIS) adequately addresses the environmental effects of a proposed project or whether additional documentation is required under NEPA. The proposal is to clean-out, decontaminate, and dispose of certain large containment vessels used to contain certain dynamic experimental explosive shots involving plutonium and other actinides into the Chemistry and Metallurgy Research Building located at TA-3. This SA specifically compares key impact assessment parameters of the proposed action with (a) the LANL operations capabilities evaluated in the 1999 SWEIS in support of DOE's long-term hydrodynamic testing program at LANL, as well as (b) the waste disposal capabilities evaluated in the SWEIS in support of LANL operations. It also provides an explanation of any differences between the proposed action and activities described in the SWEIS analysis.

Environmental Assessment for Proposed Corrective Measures at Material Disposal Area H within Technical Area 54. An environmental assessment (EA) was prepared to assess the potential environmental consequences of implementing a corrective measure at Material Disposal Area H within TA-54 at LANL. The assessment considers five corrective measure options. There are three containment corrective measure options and two excavation and removal corrective measure options. The no action alternative is also considered.

Environmental Assessment for the Proposed Consolidation of Certain Dynamic Experimentation Activities at the Twomile Mesa Complex. The proposed action is to construct and operate offices, laboratories, and shops within the Twomile Mesa Complex, located at TA-22, TA-6, and TA-40, where work would be consolidated from other locations at LANL. The Proposed Action would also remove or demolish certain vacated structures that are no longer needed and includes constructing 15 to 25 new structures over a 10-year time frame. The no action alternative is also considered. The NNSA issued a Finding of No Significant Impact (FONSI) for this EA on November 3, 2003.

Environmental Assessment for the Proposed Trails Management Program. The proposed action is the establishment of a trails management program at LANL (LANL Trails Management Program). This program would address both public use of trails within LANL and also trail use by workers at LANL and by officially invited guests. Alternatives include trails closure (this alternative would result in the closing of all existing trails to the general public and to LANL workers for recreational use purposes) and the no action alternative. The NNSA issued a FONSI for this EA on September 2, 2003.

11. Cultural Resources

The Heritage Resources and Environmental Planning Team began the second year of a multiyear program of archaeological excavation in support of the Land Conveyance and Transfer program. The DOE/NNSA is in the process of conveying to the County of Los Alamos approximately 2,000 acres of Laboratory lands. Seventeen archaeological sites have been excavated during the first 2 field seasons, with over 120,000 artifacts and 2,000 samples being recovered. Together they provide new insights into past lifeways on the Pajarito Plateau from 5000 BC to AD 1300. From a compliance perspective, these excavations resolve adverse effects to archaeological sites anticipated from future development of the recently acquired lands by Los Alamos County. These sites are also ancestral places to the Pueblo people. Representatives from the Pueblo of San Ildefonso acted as tribal consultants and monitors on the project.

During 2003, a site rehabilitation team from San Ildefonso Pueblo conducted rehabilitation at 107 archaeological sites throughout LANL that were identified by the Pueblo Assessment Team. This rehabilitation consisted of the removal of burned snags, the thinning and slashing of some unburned or partially burned trees, the placement of straw wattles, the filling of stump holes, and revegetation using the seeds of native grasses and shrubs. In addition, 3-strand smooth wire fences were erected along and around 87 sites along fire break roads or otherwise potentially vulnerable to fire suppression activities. Single sites, as well as clusters of sites, were fenced.

We conducted one new field study this year. We worked on 25 projects that utilized or required some field verification of previous survey information. In addition to the 19 new archaeological sites identified this fiscal year, we identified 25 historic buildings. Although no archaeological sites were determined eligible for the National Register of Historic Places, 49 historic buildings were determined eligible.

During 2003, a total of 42 sites were fenced for protection, as part of 3 conservation zones, in a parcel of land that is to be transferred to Los Alamos County in FY 2004 or FY 2005. Also, the Cerro Grande Fire Rehabilitation Project rehabilitated 107 sites and fenced 87 additional sites for protection.

C. Current Issues and Actions

1. New Mexico Hazardous Waste Management Compliance Orders

The Laboratory received CO-99-01 on December 28, 1999, in response to an NMED inspection conducted August 10–September 18, 1998. The inspection team visited approximately 544 sites at the Laboratory. The CO alleged 30 violations. Total penalties proposed were almost $850,000. In 2000, the Laboratory prepared and submitted its response to the CO and requested a hearing. Negotiations to

resolve this CO were completed in 2003, and the Laboratory and NMED reached agreement on a $282,033 penalty.

On February 9, 2004, NMED issued a CO (HWB 04-03) as a result of issues or deficiencies alleged to have been found during the 2003 inspection (Table 2-2) and reported in the 2002 report as a Notice of Violation. NMED listed 21 violations including

- failure to test and reevaluate routine wastes,
- failure to sample nonroutine wastes,
- failure to verify knowledge of process determinations,
- failure to perform annual verification of routine waste,
- failure to perform waste verification after change in process,
- failure to mark the start accumulation date,
- failure to comply with the 90-day time restriction,
- failure to have control of satellite accumulation area, and
- failure to locate satellite accumulation areas at or near the point of generation.

The initial penalty assessed was $1,413, 931. The Laboratory is reviewing the CO and will formally respond to NMED during the 45-day response period

2. Asbestos

On March 26, 2003, the NMED issued a Warning Letter to LANL and a Notice of Violation (NOV) to KSL Services for a February 24, 2003, incident in which KSL Services removed asbestos flooring at TA-48 RC-1 without appropriate advance notification to the NMED. The original project was to remove flooring containing asbestos, and the scope did not trigger regulatory requirements for notification. As the work proceeded, the scope of the job increased and exceeded the regulatory requirements for notification. This 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 appropriate action was taken by LANL and KSL Services.

3. NMED Order

The NMED issued an order in November 2002 requiring extensive site investigating and monitoring, and negotiations are ongoing.

D. Consent Decree

The Concerned Citizen's for Nuclear Safety (CCNS) filed a lawsuit against DOE and Siegfried Hecker, Director of the Laboratory in 1994, alleging violations of the Clean Air Act. The parties settled the lawsuit out of court on January 25, 1997. At the end of 2002, all of the Laboratory's responsibilities under the Consent Decree were completed (ESP 2004). On October 16, 2003, Judge James Parker, US District Court for the District of New Mexico, ruled that the Consent Decree was terminated. Further information can be obtained on the internet at *http://www.airquality.lanl.gov/ConsentDecree.htm.*

E. References

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

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)

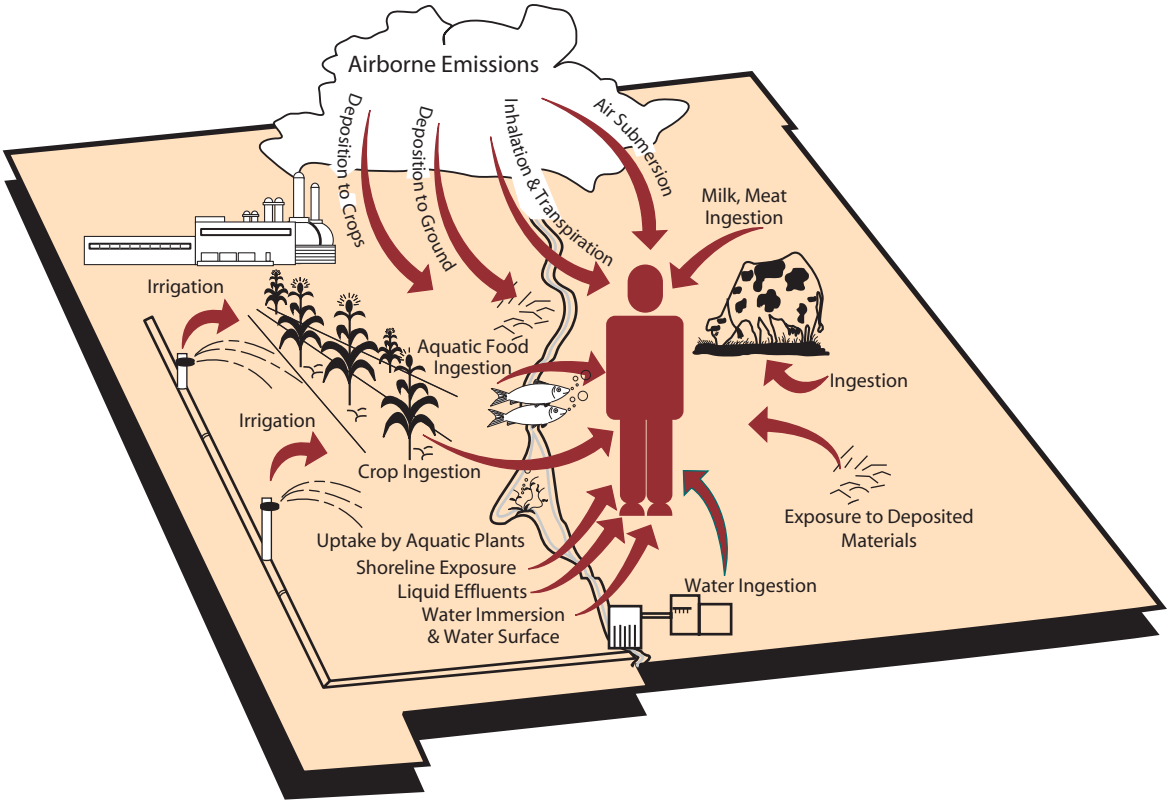
Longmire and Counce 2004: P. Longmire and D. Counce, "Water Chemistry Results for Wells R-1, R-2, R-4, R-11, R-26, and R-28," Presentation at Groundwater Protection Program Quarterly Meeting, April 12, 2004, in Pojoaque, New Mexico, Los Alamos National Laboratory document LA-UR-04-2387 (2004).

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

Nylander et al. 2003: C. L. Nylander, K. A. Bitner, G. L. Cole, E. H. Keating, S. Kinkead, P. Longmire, B. Robinson, D. B. Rogers, and D. Vaniman, "Groundwater Annual Status Report for Fiscal Year 2002," Los Alamos National Laboratory document LA-UR-03-0244 (March 2003).

Shaull et al. 2003: D. A. Shaull, "Surface Water Data at Los Alamos National Laboratory: 2002 Water Year," Los Alamos National Laboratory report LA-14019-PR (March 2003).

3. Environmental Radiological Dose Assessment



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A. Overview of Radiological Dose Equivalents

Radiological dose equivalents presented here are calculated using standard methods. The "effective dose equivalent" (EDE), 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 Los Alamos National Laboratory (LANL or the Laboratory) operations. The Department of Energy (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.)

B. Public Dose Calculations

1. 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.

The doses for cases 1 and 2 for the past 11 years are shown in Figures 3-1 and 3-2. The two graphs are similar because the Los Alamos Neutron Science Center (LANSCE) is the major contributor to both. Generally, the year-to-year fluctuations are the result of variations in the number of hours that LANSCE runs, whereas the downward trend is the result of efforts to reduce the LANSCE emissions by installing delay lines and fixing small leaks.

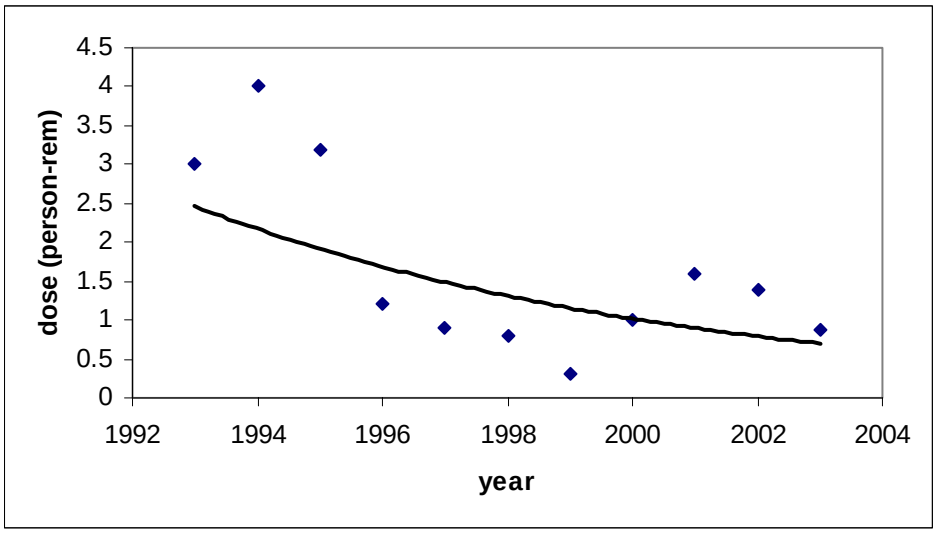

Figure 3-1. Trend of collective dose (person-rem) to the population within 80 km of LANL.

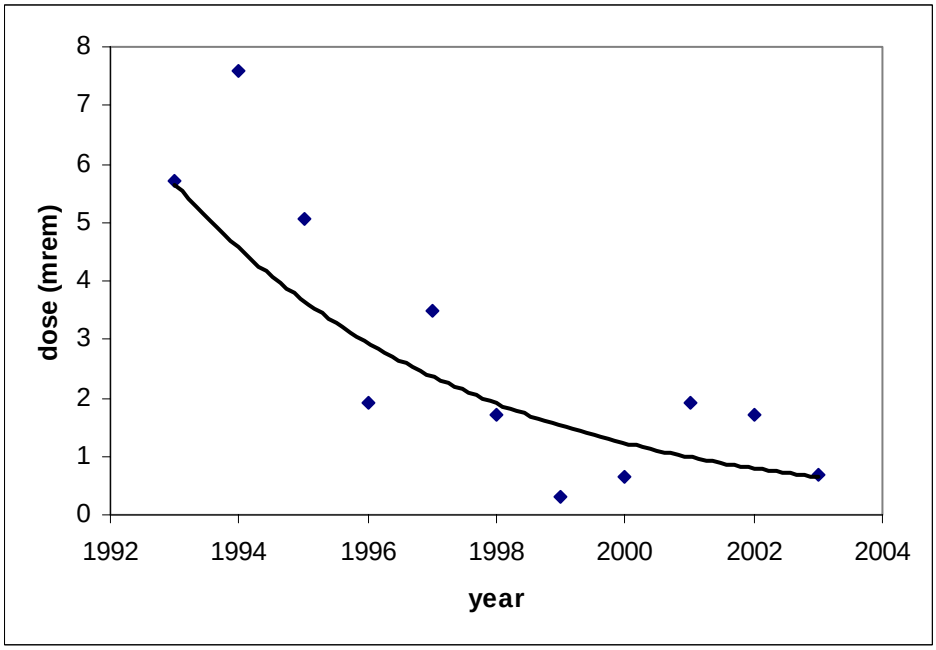

Figure 3-2. Trend of dose (mrem) to the maximally exposed individual off-site.

2. 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 D, 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.

a. Direct Radiation Exposure. Direct radiation from gammas or neutrons is measured at about 100 locations near LANL (Chapter 4, Section C). Doses above natural background were observed near Technical Area (TA) 18 and TA-54.

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 C.2 of this chapter) and near TA-18 (Section C.3).

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).

b. 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 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 C). Because the radioactive half-lives are short, these doses decrease steeply with distance; e.g., the annual dose is 0.3 mrem at East Gate, 1 km to the north of LANSCE, and is less than 0.01 mrem at a location in Los Alamos 5 km to the west-north-west.

c. Water (Ingestion Pathway). We report measurements of radionuclide concentrations in groundwater in Chapters 5 and surface water and sediments in Chapter 6. For all radionuclides except uranium, the doses were less than 0.1 mrem/year. Natural uranium in the drinking water contributes a dose of about 0.1 mrem/year in Los Alamos County and more in parts of the Rio Grande valley. We conclude that the LANL contribution to the drinking-water dose is too small to measure and is much less than 0.1 mrem/year.

d. Soil (Direct Exposure Pathway). We report measurements of radionuclide concentrations in surface soil in Chapter 7. The doses from the cesium-137 and strontium-90 concentrations are on the order of 0.1 mrem/year, but 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 total dose from tritium in soil is about 0.01 mrem/year. Similarly, the transuranics may include a small contribution from LANL, but the dose is 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 less than 0.1 mrem/year.

e. Food (Ingestion Pathway). We report measurements of the radioactive content of foods in Chapter 8. The results are similar to those reported in previous years. Tritium concentrations near the LANL perimeter are measurably higher than regional concentrations, but the resulting doses are far

below 0.1 mrem/year. Strontium-90 measurements in rabbits are reported in Chapter 8 (Section A-5); the concentrations are similar to those reported nationwide and lead to a human dose of about 0.05 mrem/year (UNSCEAR 2000). The concentrations of other nuclides are consistent with global fallout, and the resulting doses are also far below 0.1 mrem/year. We conclude that the LANL contribution to the food dose is too small to measure and is much less than 0.1 mrem/year.

f. 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-402-700-01.0, "Occupational Radiation Protection. Chapter 14, Part 3. Releasing Items." In keeping with the principle of maintaining radiation dose levels to "As Low as Reasonably Achievable," it is Laboratory policy to not 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.

C. Dose Calculations and Results

1. Population within 80 Kilometers

We used the local population distribution to calculate the dose from Laboratory operations during 2003 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 2003 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was 0.88 person-rem, which compares with 1.4 person-rem reported for 2002. Tritium contributed about 83% of the dose, and short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE contributed about 16%.

No observable health effect is expected from these doses.

2. 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 2003, there were two locations with almost equal MEI doses: 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 San Ildefonso Pueblo 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 carbon-11, nitrogen-13, and oxygen-15, are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential radiation dose. We modeled the dose from LANSCE and from the LANL stacks using CAP88, an atmospheric dispersion and dose calculation computer code. The CAP88-modeled doses (Jacobson 2004) were 0.33 mrem from LANSCE and 0.23 mrem from other LANL stacks. We added 0.09 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 0.65 mrem.

The second location is the boundary of the San Ildefonso Pueblo Sacred Area north of Area G. As reported in Chapter 4 Section C.4, transuranic waste awaiting shipment to WIPP emits neutrons. The measured neutron dose is 12 mrem. After subtracting 2-mrem background and applying the standard occupancy factor of 1/16 (NCRP 1976), the individual dose is 10/16 = 0.625 mrem. To estimate the contributions from radionuclides at this location, we calculated the dose from the LANL stacks: 0.015/16 = 0.001 mrem; and we added the maximum dose measured by the AIRNET stations along the

northern boundary of Area G: 0.39/16 = 0.02 mrem. Thus, we conclude that the MEI dose at this location was also 0.65 mrem, approximately equal to the MEI dose at East Gate.

The off-site MEI dose, 0.65 mrem, is far below the currently applicable standards; and based on previous studies we conclude it causes no observable health effects.

3. 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 photon radiation are located on Pajarito Road. We collected data continuously throughout 2003 (Chapter 4, Section C), and these data allow us to calculate doses that might have been received by members of the public. The measured dose was 40 mrem. After subtracting 2 mrem from natural background and including an estimated 2 mrem from gammas, the total dose (during 24 hours a day and 365 days a year) was 40 mrem. Following the guidance of the NCRP (NCRP 1976), we multiplied this total by1/16 to account for occupancy (an occupancy factor of 1/16 corresponds to an average of half an hour of exposure every 8-hour workday). This calculation indicates a dose of 2.5 mrem to a member of the public on Pajarito Road during 2003. All other pathways, including CAP88 calculations for the air pathway, add less than 0.1 mrem to the calculated dose. This dose is 2.5% of the DOE public all-pathway dose limit of 100 mrem.

4. Doses in Los Alamos and White Rock

We used the AIRNET data (reported in Chapter 4, Section A) to calculate the average air concentrations for the 21 perimeter stations near Los Alamos and White Rock and subtracted the concentrations at the 4 regional stations. These concentrations were converted to doses using the factors in DOE 1988b. To these doses, we added the contributions from LANSCE, calculated using CAP88 for 2 representative locations: 5 km west-north-west of LANSCE in Los Alamos and 6.8 km southeast of LANSCE in White Rock.

a. Los Alamos. During 2003, the measurable contributions to the dose at an average Los Alamos residence were as follows: 0.01 mrem from LANSCE, 0.01 mrem from plutonium, and 0.04 mrem from tritium. These add to 0.06 mrem. Other nuclides each contribute less than 0.01 mrem.

b. White Rock. During 2003, the measurable contributions to the dose at an average White Rock residence were as follows: 0.01 mrem from LANSCE and 0.02 mrem from tritium. These add to 0.03 mrem. Other nuclides each contribute less than 0.01 mrem.

The contributions from direct radiation, food, water, and soil were 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.

D. 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 potassium-40, which is present in all food and in all living cells.

In addition, members of the US population receive an average dose of 50 mrem/year from medical and dental uses of radiation, 10 mrem/year from man-made products such as stone or adobe walls, and less than 1 mrem/year from global fallout from nuclear-weapons tests (NCRP 1987a). Therefore, the total annual dose from sources other than LANL is approximately 300–500 mrem. The estimated LANL-attributable 2003 dose to the MEI, 2.5 mrem, is less than 1% this dose.

E. 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.

F. Biota Dose Assessment

In 2002, the DOE established radiological dose rate limits for the protection of non-human biota: 0.1 rad/day for terrestrial wildlife and 1 rad/day for terrestrial plants and aquatic organisms (DOE 2002). At the same time, the department published Biota Concentration Guides (BCGs) for individual radionuclides; the BCGs represent environmental media concentrations that are equivalent to the dose rate limits. For multiple radionuclides, one calculates the sum of the ratios of measured values to the corresponding BCGs. If this sum of the ratios exceeds 1, the limit is exceeded and further investigation may be warranted. We calculated a sum of ratios for terrestrial wildlife of 0.07 rad/day in the area of highest soil concentrations measured in 2003 (supplemental data table S3-1). This is well below the target value of 1 rad/day. For aquatic organisms, we calculated a value of about 4.5 rad/day. The measured values used here were immediately below the outfall at TA-50 which discharges radioactive liquid waste. Water concentrations are much smaller elsewhere. Also, this area does not carry water (i.e., aquatic habitat) year around. Weighting concentrations by the time during the year in which water is flowing, the adjusted sum of the ratios comes to 0.7, well within the 1 rad/day dose limit. We conclude that environmental concentrations of radionuclides pose no threat to the health of non-human biota inhabiting the Laboratory's environs.

G. References

DOE 1988a: US Department of Energy, "External Dose Conversion Factors for Calculating Dose to the Public," US Department of Energy report DOE/EP-0070 (July 1988).

DOE 1988b: US Department of Energy, "Internal Dose Conversion Factors for Calculating Dose to the Public," US Department of Energy report DOE/EP-0071 (July 1988).

DOE 1991: US Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," US Department of Energy report DOE/EH-0173T (January 1991).

DOE 1993: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order DOE 5400.5 (January 1993).

DOE 2002: US Department of Energy, "A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota," US Department of Energy Technical Standard 1153-2002 (August 2000). [Available at *http://homer.ornl.gov/oepa/public/bdac/*].

EPA 1986: US Environmental Protection Agency, "National Emission Standards for Hazardous Air Pollutants," Code of Federal Regulations, Title 40, Part 61 (1986).

EPA 1988: Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," EPA-520/1-88-020, Federal Guidance Report No. 11 (September 1988).

EPA 1993: Environmental Protection Agency, "External Exposure to Radionuclides in the Air, Water, and Soil," EPA-402-R-93-081, Federal Guidance Report No. 12 (September 1993).

EPA 1997: Environmental Protection Agency, "Exposure Factors Handbook," EPA/600/C-99/001 (August 1997).

EPA 2000: US Environmental Protection Agency, "Primary Drinking Water Regulations; Radionuclides; Final Rule," Code of Federal Regulations, Title 40, Parts 9, 141, and 142 (December 2000).

HPS 1996: Health Physics Society, "Radiation Risk in Perspective," Health Physics Society Position Statement, *HPS Newsletter* (March 1996).

Jacobson 2004: Keith W. Jacobson, "US DOE Report: 2003 LANL Radionuclide Air Emissions," Los Alamos National Laboratory report LA-14155-PR (2004).

NCRP 1975: National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States," National Council on Radiation Protection and Measurements report 45 (November 1975).

NCRP 1976: National Council on Radiation Protection and Measurements, "Structural Shielding and Evaluation for Medical Use of X-Rays and Gamma Rays of Energies Up to 10 MeV, Recommendations of the National Council on Radiation Protection and Measurements," National Council on Radiation Protection and Measurements report 49 (1976).

NCRP 1987a: National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States," National Council on Radiation Protection and Measurements report 93 (September 1987).

NCRP 1987b: National Council on Radiation Protection and Measurements, "Exposure of the Population in the United States and Canada from Natural Background Radiation," National Council on Radiation Protection and Measurements report 94 (December 1987).

NRC 1977: Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I," Nuclear Regulatory Commission Report, Regulatory Guide 1.109 (October 1977).

4. Air Surveillance

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A. Ambient Air Sampling *(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 the Laboratory's air-sampling program. Most of the regional airborne radioactivity comes from the following sources: (1) natural radioactive constituents in particulate matter (such as uranium and thorium), (2) terrestrial radon diffusion out of the earth and its subsequent decay products, (3) material formation from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and common atmospheric gases), and (4) fallout from past atmospheric nuclear weapons tests conducted by several countries. 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).

Risk Reduction and Environmental Stewardship Division Meteorology and Air Quality Group (RRES-MAQ) personnel compare ambient air concentrations, as calculated from the AIRNET sample measurements, with environmental-compliance standards or workplace-exposure standards, depending on the location of the sampler. 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 2003, the Laboratory operated approximately 50 environmental air samplers to measure concentrations of radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as follows: (1) regional, (2) pueblo, (3) perimeter,

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

	Units	EPA Concentration Limit[b]	Annual Averages[c] 1999	2000	2001	2002	2003
Gross Alpha	fCi/m^3	NA[d]	1.0	1.0	0.8	0.8	0.8
Gross Beta	fCi/m^3	NA	13.4	13.0	13.9	13.3	13.6
Tritium[e]	pCi/m^3	1,500	0.5	0.8	–0.1	–0.1	–0.1
^{90}Sr	aCi/m^3	19,000	NA	NA	NA	4	11
^{238}Pu	aCi/m^3	2,100	–0.2	0.0	0.0	0.0	–0.2
^{239,240}Pu	aCi/m^3	2,000	0.1	0.0	0.1	0.3	–0.1
^{241}Am	aCi/m^3	1,900	–0.2	0.3	–0.2	0.3	–0.7
^{234}U	aCi/m^3	7,700	16.1	17.1	17.9	21.7	21.0
^{235}U	aCi/m^3	7,100	1.2	0.9	1.3	2.4	1.8
^{238}U	aCi/m^3	8,300	15.2	15.9	17.7	21.8	20.0

[a] Data from regional air-sampling stations operated by LANL during the last 5 years. (Locations can vary by year.)

[b] Each EPA limit corresponds to 10 mrem/yr.

[c] Gross alpha and beta annual averages are calculated from gross air concentrations. All other annual averages are calculated from net air concentrations.

[d] NA = not available.

[e] Tritium annual averages have been corrected for the tritium lost to bound water in the silica gel media.

(4) decontamination and decommissioning (D&D) samplers (for areas where the sources are primarily D&D operations), (5) Technical Area (TA) -15 and TA-36, (6) TA-54, or (7) other on-site locations.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures. Generally, each AIRNET sampler continuously collects particulate matter and water-vapor samples for approximately 2 weeks per sample. Particulate matter is collected on 47-mm polypropylene filters at airflow rates of about 0.11 m^3 per minute. The vertically mounted canisters each contain about 135 g of silica gel with an airflow rate of about 0.0002 m^3 per minute; the gel collects the water-vapor samples. This silica gel is dried in an oven to remove most residual water before being used in the field. The gel is a desiccant that removes moisture from the sampled air; the moisture is then distilled, condensed, collected as a liquid, and shipped to the analytical laboratory. The AIRNET project plan (ESH-17 2000) 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. Using a palm-held microcomputer, RRES-MAQ personnel recorded the 2003 field sampling data, including timer readings, volumetric airflow rates at the start and stop of the sampling period, and comments pertaining to these data. We later transferred these data to the AIRNET database.

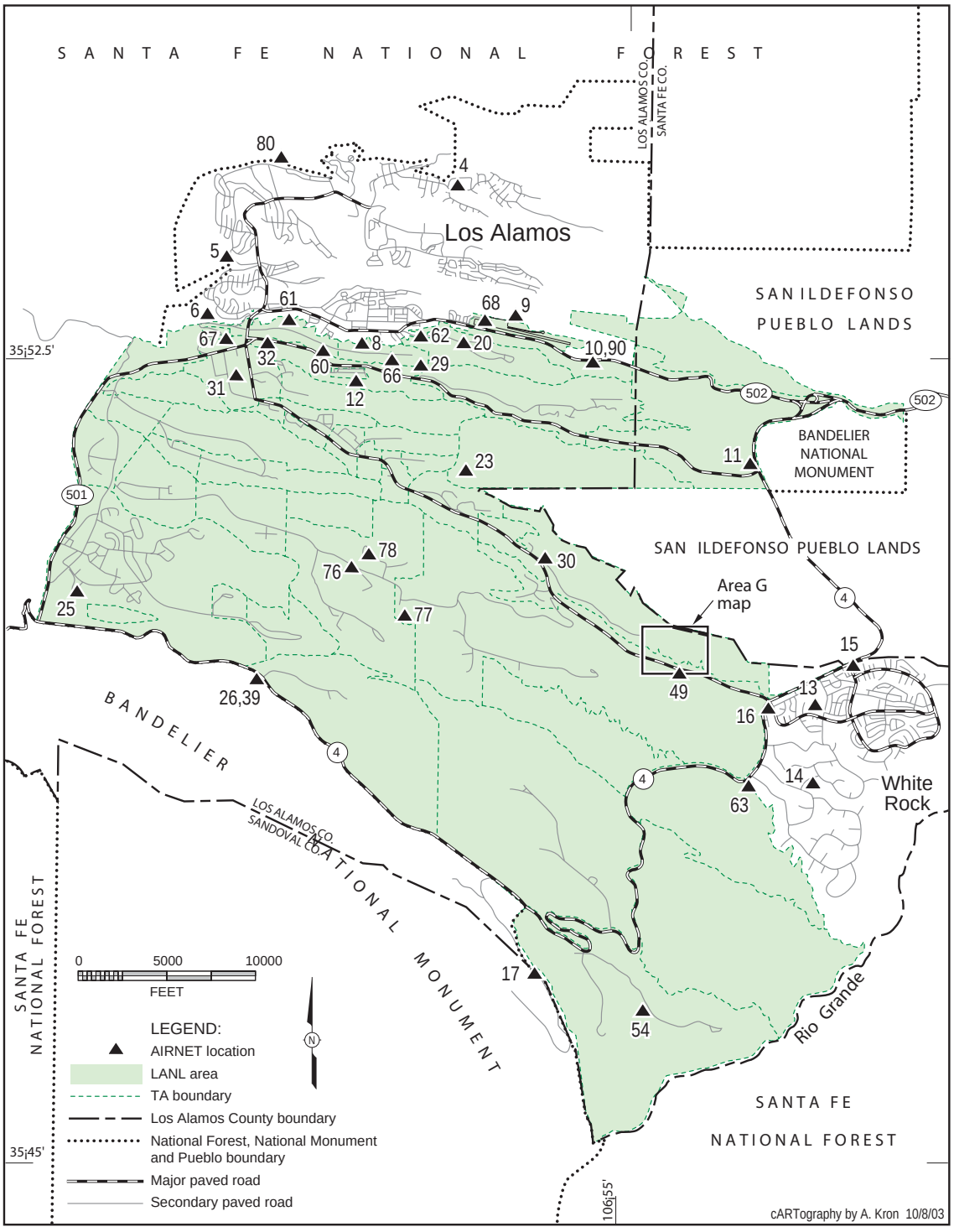

Figure 4-1. Off-site perimeter and on-site Laboratory AIRNET locations.

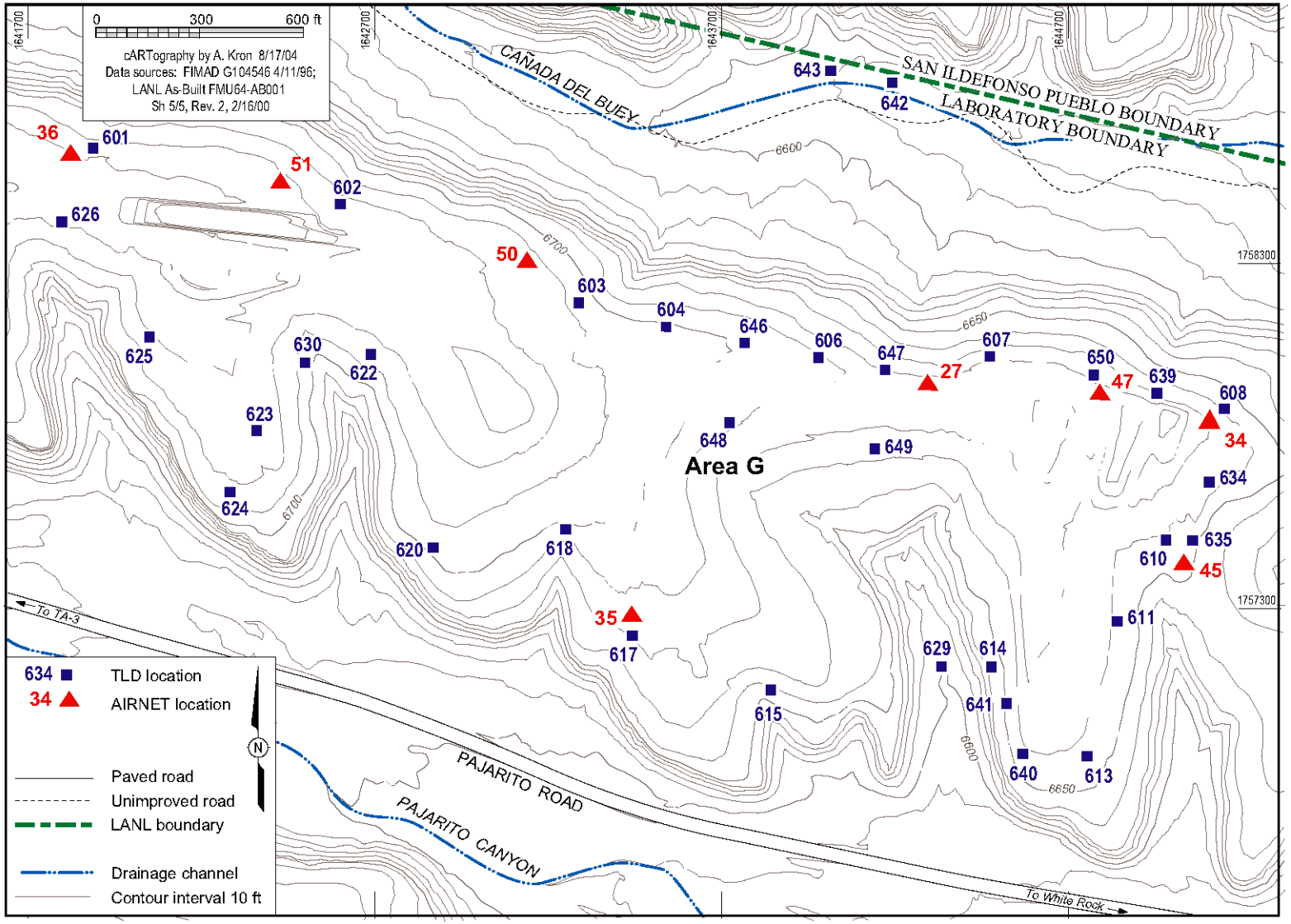

Figure 4-2. Technical Area 54, Area G, map of AIRNET and TLD locations. (This figure has been edited for operational security purposes.)

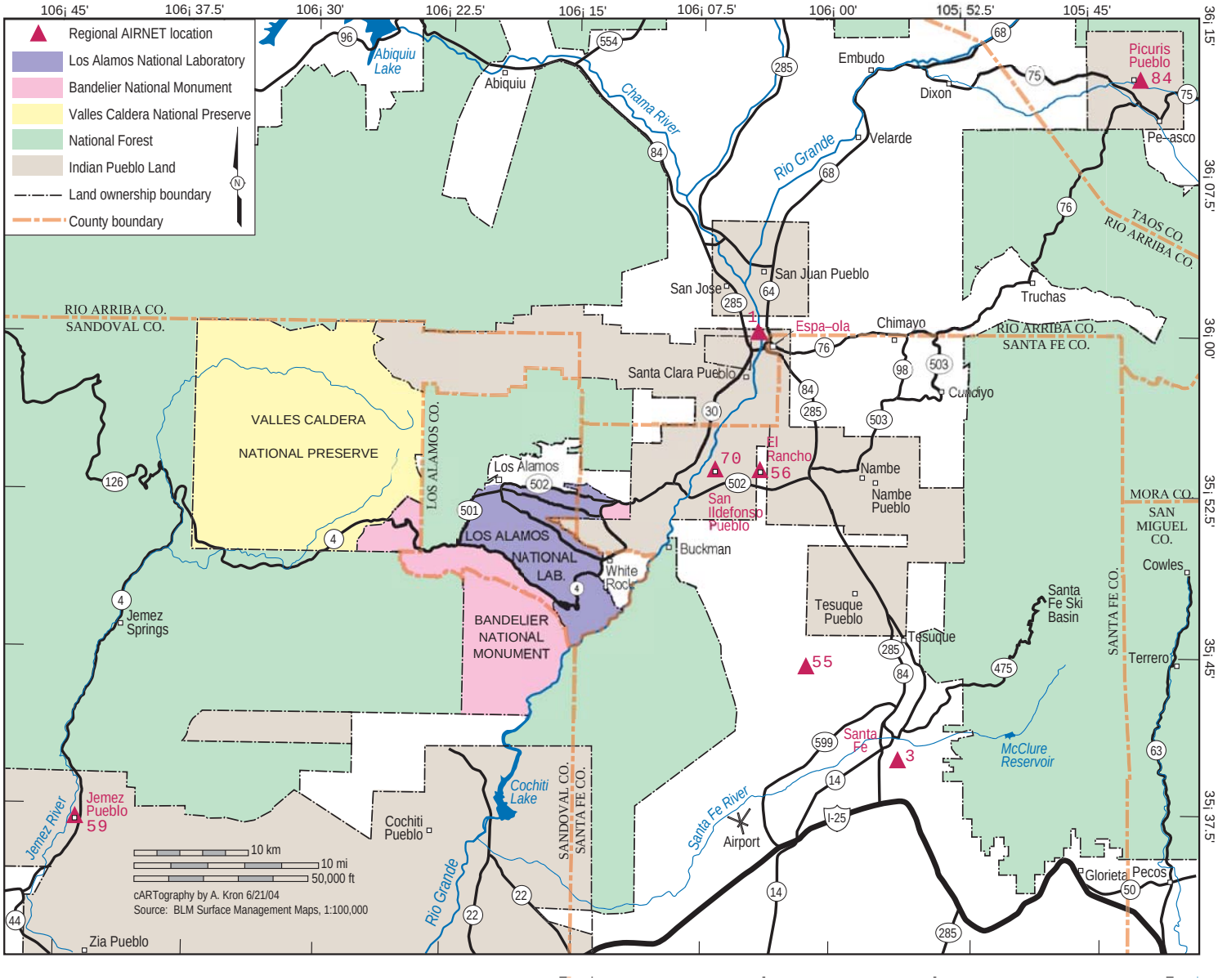

Figure 4-3. Regional and pueblo AIRNET locations.

c. Analytical Chemistry. A commercial laboratory analyzed each 2003 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 2003, clumps usually ranged from six to nine filters. To prepare a quarterly composite for isotopic analyses for each AIRNET station, we combined half-filters from the six or seven sampling periods at each site during the quarter. Analysts dissolved these composites, separated them chemically, and then analyzed for isotopes of americium, plutonium, and uranium using alpha spectroscopy. Every 2 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 40 Code of Federal Regulations (CFR) 61, Appendix B. The AIRNET project plan provides a summary of the target minimum detectable activity (MDA) for the biweekly and quarterly samples.

d. Laboratory Quality Control Samples. For 2003, RRES-MAQ 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 (QA) requirements for the AIRNET program.

4. Ambient Air Concentrations

a. Explanation of Reported Concentrations. Tables 4-2 through 4-13 summarize the ambient air concentrations calculated from the field and analytical data. Data from individual sites are given in Tables S4-1 though S4-10 in the Data Supplement. The number of measurements is normally equal to the number of samples analyzed. The number of measurements less than the uncertainty is the number of calculated net air concentrations that are less than their individual propagated net 2 standard deviations (std dev) analytical uncertainties. These concentrations are defined as "not having measurable amounts of the material of interest." The MDAs 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 2003 — Group Summaries

Station Grouping	Number of Biweekly Measurements	Number of Measurements <2s Uncertainty	Mean (fCi/m^3)	95% Confidence Interval[a] (fCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (fCi/m^3)
Regional	78	0	0.76	±0.07	01	0.81
Pueblo	51	0	0.81	±0.08	70	0.87
Perimeter	652	0	0.72	±0.02	67	0.90
TA-15 and TA-36	78	0	0.68	±0.06	76	0.71
D and D	57	0	0.72	±0.05	29	0.81
TA-54 Area G	210	1	0.76	±0.03	50	0.80
Other On-Site	130	0	0.73	±0.05	30	0.83

Concentration Guidelines
Concentration guidelines are not available for gross alpha concentrations.

[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 2003 — Group Summaries

Station Grouping	Number of Biweekly Measurements	Number of Measurements <2s Uncertainty	Mean (fCi/m^3)	95% Confidence Interval[a] (fCi/m^3)	Maximum Annual Concentration Station ID	(fCi/m^3)
Regional	78	0	13.6	±0.9	01	15.0
Pueblo	51	0	14.0	±1.1	70	15.5
Perimeter	652	0	12.4	±0.3	17	13.5
TA-15 and TA-36	78	0	12.4	±0.7	77	12.6
D and D	57	0	11.6	±0.7	20	12.2
TA-54 Area G	210	0	12.4	±0.5	38	13.5
Other On-Site	130	0	12.4	±0.6	30	12.9

Concentration Guidelines
Concentration guidelines are not available for gross beta concentrations.

[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 2003 — Group Summaries

Station Grouping	Number of Biweekly Measurements	Number of Measurements <2s Uncertainty	Mean (pCi/m^3)	95% Confidence Interval[a] (pCi/m^3)	Maximum Annual Concentration Station ID	(pCi/m^3)
Regional	78	76	–0.1[b]	±0.2	01	0.03
Pueblo	50	48	–0.1	±0.3	70	0.06
Perimeter	647	196	3.9	±0.3	09	13.1
TA-15 and TA-36	77	20	2.9	±0.5	78	3.2
D and D	57	3	10.1	±1.7	72	17
TA-54 Area G	210	0	163	±92	35	1200
Other On-Site	130	26	11.1	±5.6	25	41

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 1,500 pCi/m^3.
DOE Derived-Air Concentration (DAC) Guide for workplace exposure is 20,000,000 pCi/m^3. See Appendix A, "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

[a]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b]See Appendix B for an explanation of negative values.

Table 4-5. Airborne Plutonium-238 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	11	–0.2[b]	±0.2	01	0.0
Pueblo	8	8	–0.4	±0.4	70	–0.3
Perimeter	101	100	–0.1	±0.1	66	0.6
TA-15 and TA-36	12	10	0.4	±0.4	77	0.6
D and D	9	7	0.0	±0.7	72	1.2
TA-54 Area G	33	26	1.3	±2.0	34	9.8
Other On-Site	20	19	–0.1	±0.3	31	0.2

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 2,100 aCi/m^3.
DOE Derived-Air Concentration (DAC) Guide for workplace exposure is 3,000,000 aCi/m^3. See Appendix A, "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

[a]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b]See Appendix B for an explanation of negative values.

Table 4-6. Airborne Plutonium-239,240 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	11	–0.1[b]	±0.2	01	0.1
Pueblo	8	7	0.6	±0.9	70	1.3
Perimeter	101	87	1.2	±1.2	66	23.7
TA-15 and TA-36	12	11	0.0	±0.3	78	0.1
D and D	9	4	1.5	±1.7	72	3.9
TA-54 Area G	33	14	5.1	±3.4	45	16.6
Other On-Site	20	18	0.2	±0.3	31	0.4

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 2,000 aCi/m^3.

[a]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b]See Appendix B for an explanation of negative values.

Table 4-7. Airborne Americium-241 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	11	–0.7[b]	±0.3	55	–0.5
Pueblo	8	8	–0.2	±0.8	59	0.1
Perimeter	101	101	–0.1	±0.1	13	0.6
TA-15 and TA-36	12	12	–0.3	±0.3	76	–0.2
D and D	9	8	0.6	±1.0	72	1.1
TA-54 Area G	33	22	2.8	±1.7	34	11.3
Other On-Site	20	20	–0.3	±0.3	23	–0.1

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 1,900 aCi/m^3.
DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3. See Appendix A. "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

[a]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b]See Appendix B for an explanation of negative values.

Table 4-8. Airborne Uranium-234 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	0	21.0	±9.5	56	29.9
Pueblo	8	0	25.3	±6.5	59	29.9
Perimeter	101	1	10.6	±2.2	32	57.7
TA-15 and TA-36	12	0	9.5	±3.3	77	10.9
D and D	9	0	13.4	±7.3	29	19.0
TA-54 Area G	33	0	28.7	±10.3	50	59.5
Other On-Site	20	0	8.6	±2.2	30	11.2

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 7,700 aCi/m^3.
DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3. See Appendix A. "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

[a]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b]See Appendix B for an explanation of negative values.

Table 4-9. Airborne Uranium-235 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	6	1.8	±1.2	01	3.4
Pueblo	8	3	1.7	±0.7	41	2.2
Perimeter	101	73	0.9	±0.3	32	5.5
TA-15 and TA-36	12	11	0.5	±0.5	77	0.9
D and D	9	5	1.3	±0.6	20	1.8
TA-54 Area G	33	17	1.8	±0.8	34	4.2
Other On-Site	20	16	0.7	±0.4	30	0.9

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 7,100 aCi/m^3.
DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3. See Appendix A. "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

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

Table 4-10. Airborne Uranium-238 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	0	20.0	±8.9	56	29.8
Pueblo	8	0	26.4	±4.4	59	30.0
Perimeter	101	0	12.9	±2.3	32	55.7
TA-15 and TA-36	12	0	22.2	±11.5	77	26.4
D and D	9	0	13.5	±6.9	29	19.5
TA-54 Area G	33	0	33.4	±13.0	50	69.1
Other On-Site	20	0	11.0	±3.3	23	13.6

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 8,300 aCi/m^3.
DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3. See Appendix A, "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

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

Table 4-11. Airborne Strontium-90 Concentrations for 2003 — Group Summaries

Station Grouping	Number of Quarterly Measurements	Number of Measurements <2s Uncertainty	Mean (aCi/m^3)	95% Confidence Interval[a] (aCi/m^3)	Maximum Annual Concentration Station ID	Maximum Annual Concentration (aCi/m^3)
Regional	11	10	11.1	±24.0	56	37.1
Pueblo	8	8	–3.0[b]	±19.1	59	1.1
Perimeter	36	36	1.8	±7.1	90	11.8
TA-15 and TA-36	4	4	0.0	±24.7	77	0.0
D and D	2	2	–5.0	±163.2	72	–5.0
TA-54 Area G	4	4	11.5	±16.9	27	11.5
Other On-Site	12	12	12.4	±12.2	25	15.3

Concentration Guidelines
EPA 40 CFR 61 Concentration Limit 19,000 aCi/m^3.
DOE Derived Air-Concentration (DAC) Guide for workplace exposure is 2,000,000,000 aCi/m^3. See Appendix A, "Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived-Air Concentrations."

[a]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.
[b]See Appendix B for an explanation of negative values.

Table 4-12. Airborne Gamma-Emitting Radionuclides Potentially Released by LANL Operations

Gamma-Emitting Radionuclide	Number of Biweekly Measurements	Number of Measurements <MDA[a]	Mean Concentration (fCi/m^3)	Measured MDA as % of Required MDA[b]
^{73}As	205	205	<<1.01	0.2%
^{74}As	205	205	<<0.66	0.6%
^{109}Cd	205	205	<<0.32	1.1%
^{57}Co	198[c]	198	<<0.17	0.3%
^{60}Co	205	204	<<0.33	38.8%
^{134}Cs	205	205	<<0.30	22.0%
^{137}Cs	205	205	<<0.27	28.7%
^{54}Mn	205	205	<<0.33	2.3%
^{22}Na	205	205	<<0.34	26.3%
^{83}Rb	205	205	<<0.62	3.7%
^{86}Rb	205	205	<<5.32	19.0%
^{103}Ru	205	205	<<0.30	0.2%
^{75}Se	205	205	<<0.27	3.1%
^{65}Zn	205	205	<<0.69	15.1%

[a]Minimum detectable amount.
[b]Required MDA is for 0.5 mrem annual dose.
[c]Co-57 was not requested for all measurements, but documentation from the analytical lab indicates all measurements similar and below MDA.

Table 4-13. Airborne Concentrations of Gamma-Emitting Radionuclides that Naturally Occur in Measurable Quantities

Gamma-Emitting Radionuclide	Number of Measurements	Number of Measurements <MDA[a]	Average[b] Air Concentration (fCi/m^3)
^{7}Be	205	0	78
^{210}Pb	193	12	14

[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. It should be noted that some values in the tables are negative. See Appendix B for an explanation of negative values.

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 immediate 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 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 2003, we collected and analyzed about 1,250 air samples for gross alpha and gross beta activity. The annual means for all of the stations are less than half of the NCRP's estimated average (2 fCi/m^3) 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 (STP) 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 the Laboratory. These data show variability similar to the gross alpha concentrations. All of the annual averages are below 20 fCi/m^3, the NCRP-estimated national average for beta concentrations, but the gross beta measurements include little if any lead-210 because of its low-energy beta emission. We also calculate the gross beta measurements on the actual sampled air volumes instead of STP volumes. The primary source of measured gross beta activity in the particulate matter samples is the bismuth-210 in the radon-222 decay chain.

Gross alpha and beta activities in air exhibit considerable temporal variability as shown in Figures 4-4 and 4-5. Variability among sites within AIRNET is usually much less than variability over time.

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 T_2O) because the dose impact is about 14,000 times higher than if it were hydrogen gas (DOE 1988b).

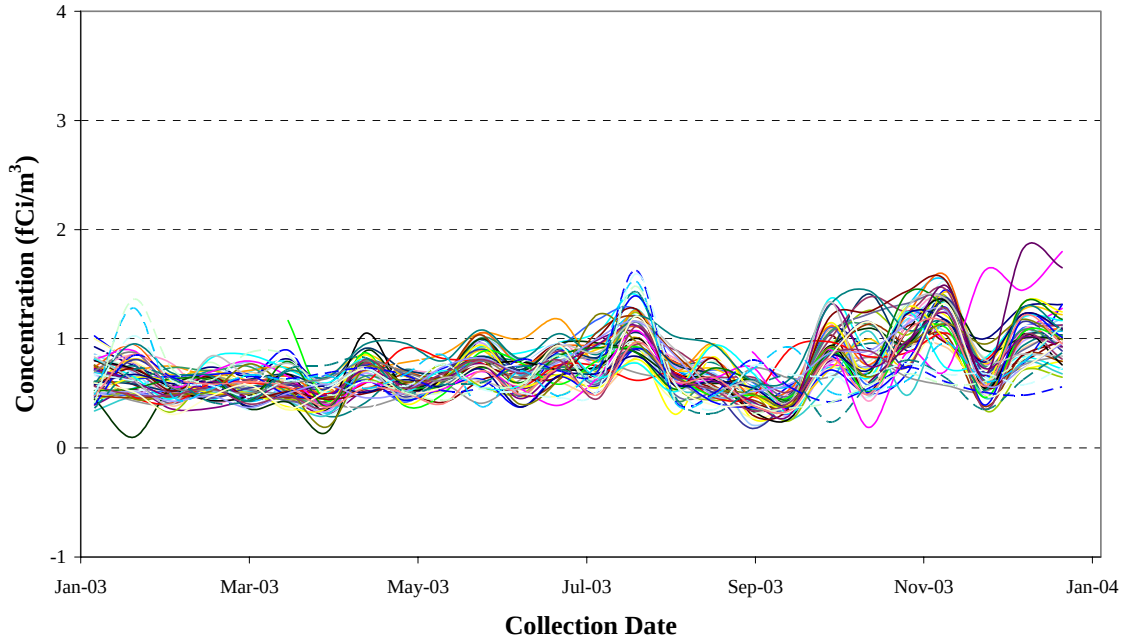

Figure 4-4. Gross alpha measurements (fCi/m^3) by sampling site.

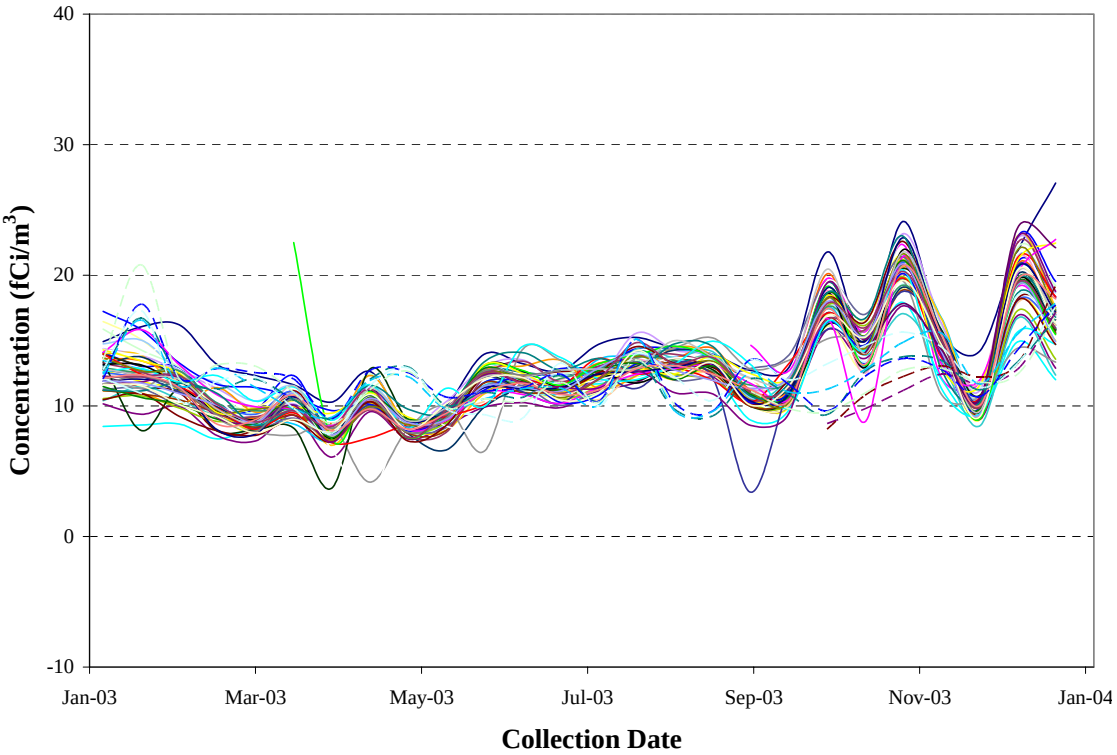

Figure 4-5. Gross beta measurements (fCi/m^3) by sampling site.

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 for 2003 at the regional and pueblo stations were not significantly different from zero (Table 4-4). The average concentration for the perimeter samplers was significantly greater than zero, as were the average concentrations for all of the on-site groups. The highest concentrations were measured at TA-54, Area G. These data indicate that the Laboratory does produce measurable amounts of tritium. All annual mean concentrations at each sampling site were well below the applicable EPA and DOE standards.

The highest off-site annual concentration, 13 pCi/m^3, was at the Los Alamos Airport, which is close to TA-21. This concentration is equivalent to about 1% of the EPA public dose limit. Emissions from TA-21 were higher in 2003 and regularly caused concentrations to exceed investigation levels. The RRES-MAQ Group measured elevated concentrations at a number of on-site stations, with the highest annual concentration at TA-54, Area G. This annual mean concentration, 1,194 pCi/m^3, is only 0.006% of the DOE DAC for worker exposure and is measured at a location near shafts containing tritium-contaminated waste.

d. Plutonium. While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), this element is not naturally present in measurable quantities in the ambient air. All measurable sources 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.

The RRES-MAQ environmental air monitoring team found no detectable concentrations of plutonium-238 at any of the regional, pueblo, or perimeter sampling stations (Table 4-5). Three on-site quarterly concentrations were above their uncertainties, with all three being from site 34 at TA-54, Area G. Concentrations at this location are quantitative and above background levels. The 2003 annual concentration of Pu-238 at site 34 was 10 aCi/m^3, which corresponds to 0.0005% of the DOE DAC for worker exposure.

No detectable concentrations of plutonium-239,240 were found at any of the regional or pueblo samplers except for one quarterly sample, which was slightly greater than its 2s uncertainty (Table 4-6). Six perimeter quarterly concentrations were above their 2s uncertainties, but two of these were only slightly higher. The other four perimeter quarterly concentrations were well above their uncertainty levels. All four of these measurements were for samples collected at site 66 (Los Alamos Inn-South). The annual mean concentration at this location was 24 aCi/m^3 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. About 20 on-site quarterly concentrations were above their uncertainties with most of them at Area G. We recorded the highest annual on-site concentration for plutonium-239,240 at Area G. The concentration was 17 aCi/m^3, which is less than 0.001% 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 (Table 4-7). No detectable concentrations of americium-241 were measured at any of the regional, pueblo, or perimeter sampling stations. All seven on-site quarterly samples with detectable concentrations of americium-241 were measured at Area G. The highest annual on-site concentration (11 aCi/m^3 at station 34 in Area G) is less than 0.001% 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. Relative isotopic abundances are generally 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 1.0 (as calculated from Walker et al. 1989). Because known LANL uranium emissions are enriched (excess uranium-234 and -235) or depleted (excess uranium-238), we can use comparisons of isotopic concentrations to estimate LANL contributions. Using excess uranium-234 to detect the presence of enriched uranium 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, and the dose, in natural uranium, is about an order of magnitude higher for uranium-234 than for uranium-235.

All annual mean concentrations of the three uranium isotopes were well below the applicable EPA and DOE standards (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. Both the regional and pueblo groupings had higher average concentrations of uranium-234 and uranium-238 than the perimeter group. The higher concentrations for the regional and pueblo groups result from 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 2003, 14 samples at 13 sites had excess uranium-238 as shown in Figure 4-6. We measured no excess uranium-234 during 2003. These excess uranium-238 concentrations were identified by statistically comparing the uranium-234 and uranium-238 concentrations. If the concentrations in a sample were more than three standard deviations apart, the sample was considered to have excess enriched or depleted uranium.

g. Strontium-90. Strontium-90 is present worldwide from atmospheric weapons testing and locally from the historical experiments and nuclear reactor operations. We began measuring strontium-90 on a select set of quarterly composites with the first quarter of 2002 and ended the sampling at the end of 2003. All except one of the 81 samples collected in 2003 were less than their 2s uncertainties (Table 4-11). The one value greater than its 2s uncertainty was less than its 3s uncertainty. Because the expected number of samples greater than their 2s uncertainties is about 2% or 2 samples, it is likely that this value was caused by random variability in the analytical process. No other measurements indicate that it is a detection of strontium-90.

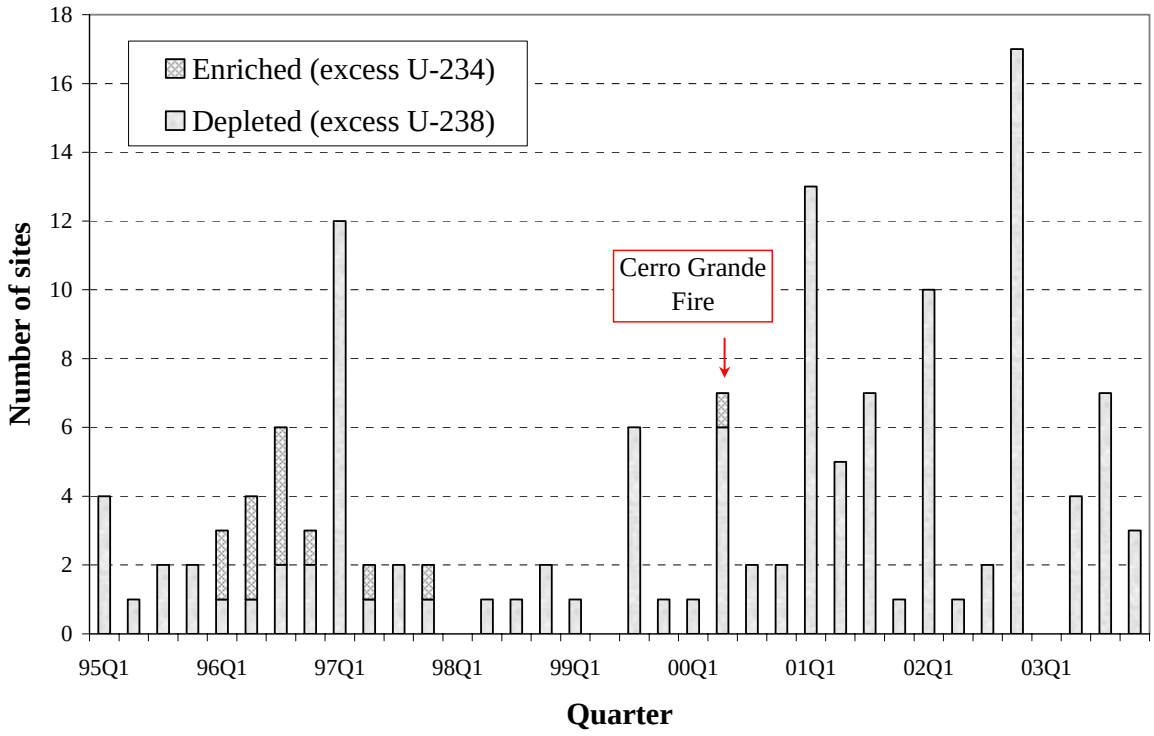

Figure 4-6. AIRNET sites with excess isotopic uranium.

h. Gamma Spectroscopy Measurements. In 2003, RRES-MAQ personnel conducted gamma spectroscopy measurements on biweekly filters grouped across sites for a single sampling period known as "clumps" (Tables 4-12 and 4-13). We investigate any measurement above its MDA other than beryllium-7, potassium-40, and lead-210, which are natural radionuclides normally present in measurable concentrations. Any other measurable concentration is highly unlikely unless there is an actual release. A cobalt-60 MDA was exceeded for the sampler associated with the Omega West reactor dismantling (29). The cobalt-60 concentration of 3 fCi/m^3 for this single-sample clump was associated with the TA-2 D&D activities (removal of the Omega West reactor facility) and confirmed as part of a replicate quality control (QC) analysis. If this concentration were present the entire year, it would correspond to an annual dose of 18% (1.8 mrem) of the EPA 10-mrem standard. However, as a two-week measurement, it represents less than 1% of the EPA public dose limit. The beryllium-7 and lead-210 measurements were the only radionuclides measured above their MDAs.

5. Investigation of Elevated Air Concentrations

Two action level categories 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. Alert levels are based on dose and require a more thorough, immediate follow-up.

In 2003, no air sampling values exceeded alert action levels, yet a few exceeded investigate levels. When a measured air concentration exceeds either action level, the RRES-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.

Three significant investigations occurred in 2003 and dealt with the following: (1) the number of samples with depleted uranium (DU) has increased since the Cerro Grande fire as described in Section A.6; (2) tritium emissions remained higher at TA-21 because of D&D activities; and (3) cobalt-60 was detected near the D&D activities for the Omega West reactor facility as described in Section A.4.h.

a. Sites near TA-21 with Tritium Investigations. During 2002 and 2003, various planned operations at TA-21 emitted larger-than-normal quantities of tritium. The two primary facilities, TA-21-155 and TA-21-209, together emitted slightly more than 1,000 Ci of tritiated water (HTO) per year. These quantities are roughly one and one-half to three times the typical annual HTO emissions for these facilities in previous years. When biweekly HTO emissions have approached and exceeded 30 Ci, the measured levels of airborne tritium typically exceed investigation levels at one or more locations. Figure 4-7 shows the 2-week HTO emissions from TA-21 and the maximum and average tritium concentrations as measured by nearby AIRNET samplers. Both maximum and average ambient tritium concentrations were strongly correlated with TA-21 emissions, indicating that the samplers provided sufficient coverage and that TA-21 was the primary source. At the end of the 2003, higher tritium emissions were measured at TA-21, but these were believed overestimated because of facility operational issues. The low ambient tritium concentrations provide additional support that the emissions were overestimated.

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) because of high winds during dry conditions optimal for soil resuspension. Furthermore, since the first quarter of 1998, the uranium-238 concentrations have been consistently higher than the uranium-234 concentrations, indicating the presence of DU in some samples. The station at TA-36 was not included in these averages because of the persistent and known presence of DU in the samples.

As shown in Figure 4-6, DU has usually been detected in at least one sample per quarter. All of the samples with DU were collected on LANL property or within Los Alamos County. In the 6 years before 2001, we collected only 15 quarterly composite samples with excess uranium-238 off-site. For the three years from 2001 through 2003, 23 off-site samples with excess uranium-238 were collected. The number of quarterly composites with DU was not as high in 2003 as it was in 2002 or 2001, but it was still higher

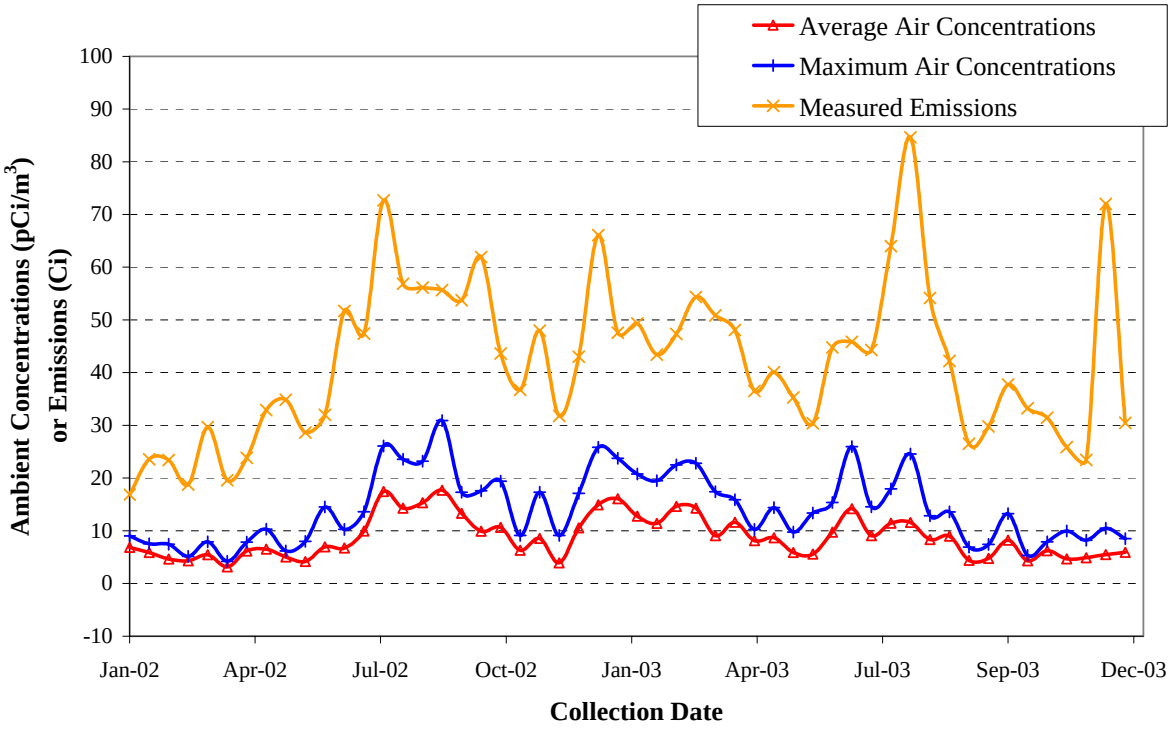

Figure 4-7. Tritium oxide emissions at TA-21 and nearby ambient concentrations in the Los Alamos town site.

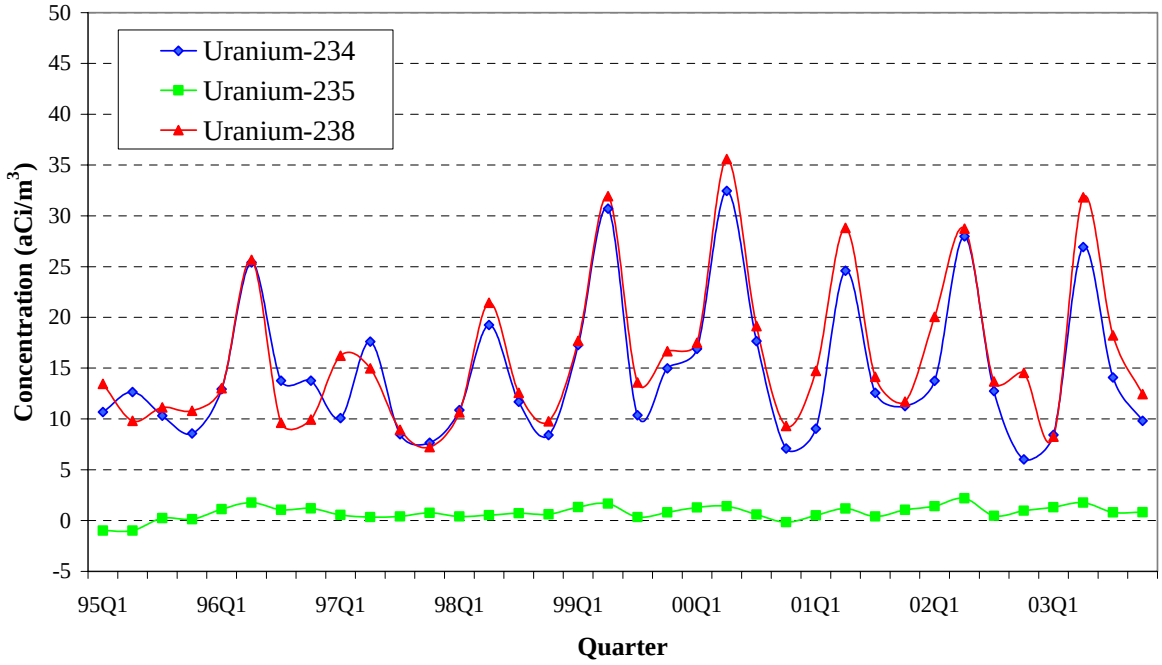

Figure 4-8. AIRNET quarterly uranium concentrations (network-wide concentrations excluding site 77).

than five of the six years from 1995 through 2000. This may indicate that the below-average rainfall is still having an effect even though the disturbances from fire-mitigation activities have decreased. It should be noted that the off-site concentrations of DU are comparable to or less than historical natural uranium concentrations.

Only a few samples show excess enriched uranium, and most of these occurred in 1996. Some evidence indicates that these samples were contaminated in a laboratory, but this contamination has not been proved, and the concentrations are still counted as valid environmental measurements.

Station 77 (Figure 4-9) at TA-36 is located in a posted radiation-control area where DU is still present as surface contamination from explosive tests. This location has been previously identified with measured excess ambient concentrations of uranium-238 (Eberhart et al. 1999, ESP 1999, ESP 2000, and ESP 2001). Of the 36 quarterly composites analyzed for isotopic uranium at this site, 30 had excess uranium-238. The 2003 uranium-238 and -234 concentrations at this site were 26 and 11 aCi/m^3 respectively. If we assume that about 15% of the activity in DU is uranium-234, the calculated LANL contributions at this location were about 3 aCi/m^3 of uranium-234 and 18 aCi/m^3 of uranium-238. Therefore, the combined estimated LANL contribution at this on-site controlled-access location is about 0.0001% of the DOE DAC for workplace exposure.

b. Plutonium and Americium. Only 2 quarterly measurements during the last 8 years for the regional and pueblo samples were above their 3 std dev analytical uncertainties. However, on-site measurements of plutonium-238, plutonium-239, and americium-241 are clearly higher for the TA-21 and the 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. Graphs of the annual concentrations by isotope and general station locations are shown in Figures 4-10, 4-11, and 4-12. Annual average concentrations for plutonium-239 and

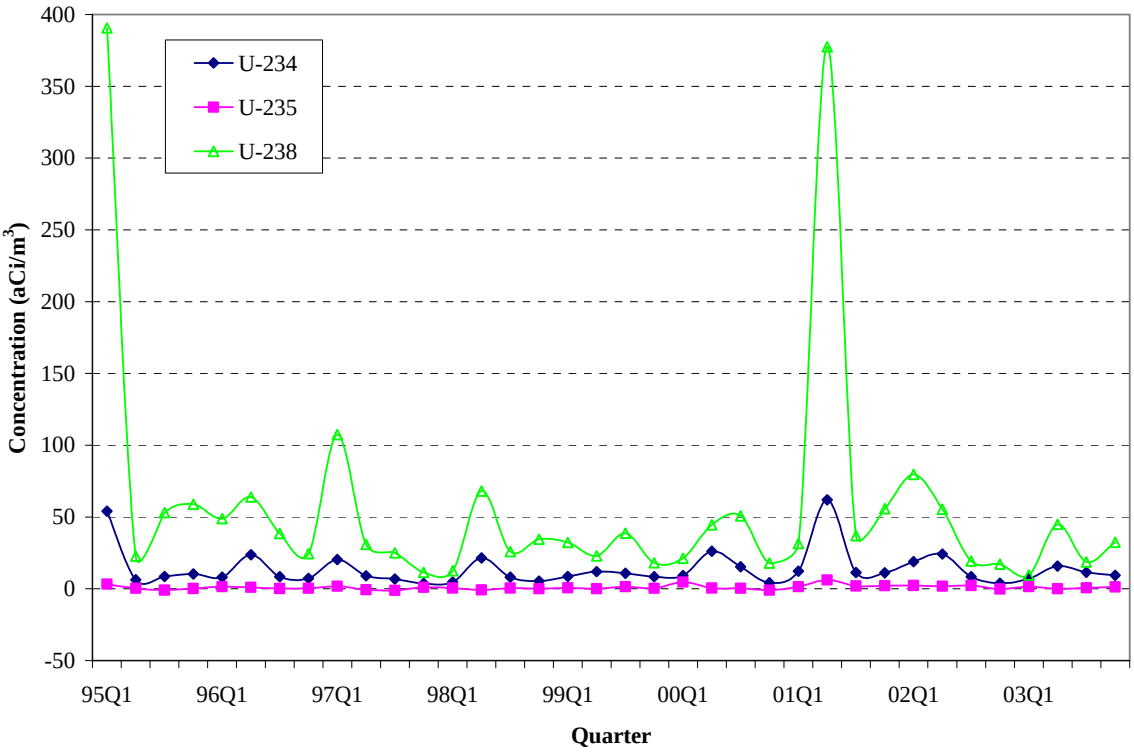

Figure 4-9. Site 77 uranium concentrations.

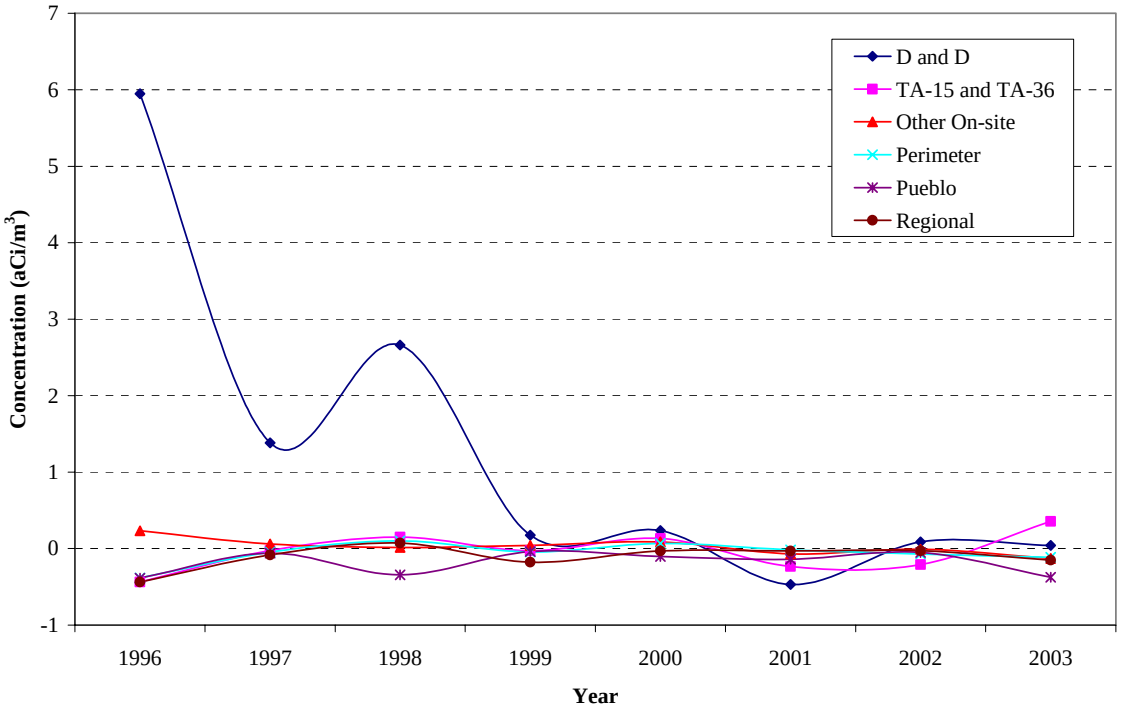

Figure 4-10. Plutonium-238 concentration trends.

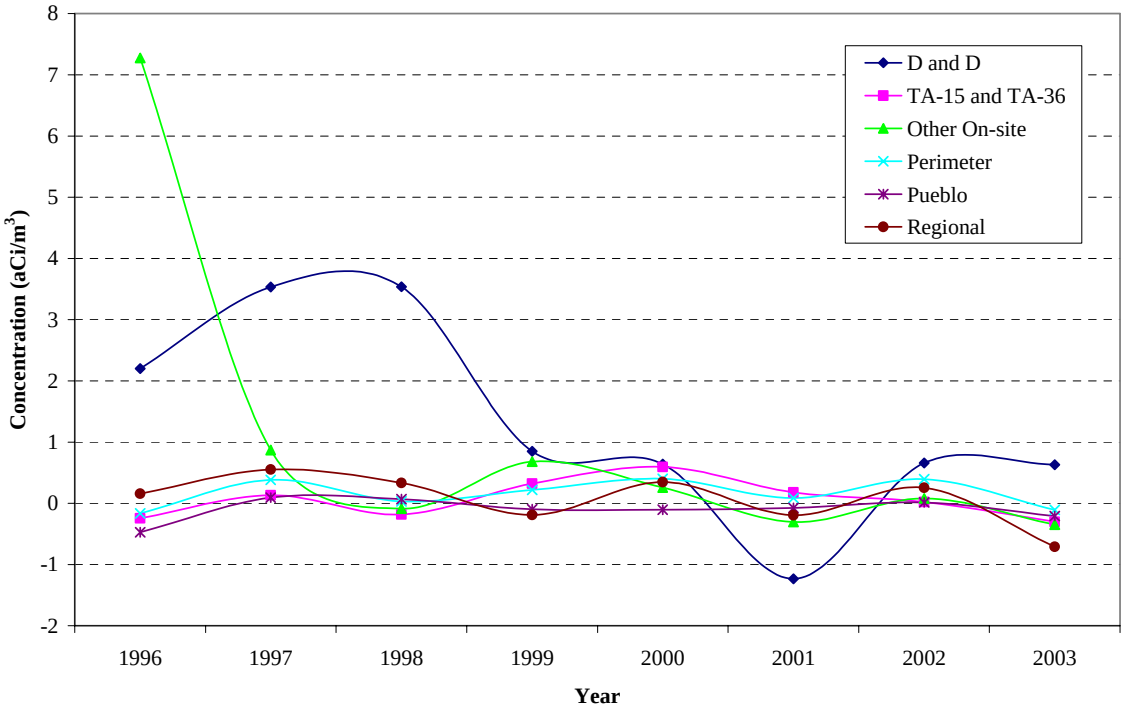

Figure 4-11. Americium-241 concentration trends.

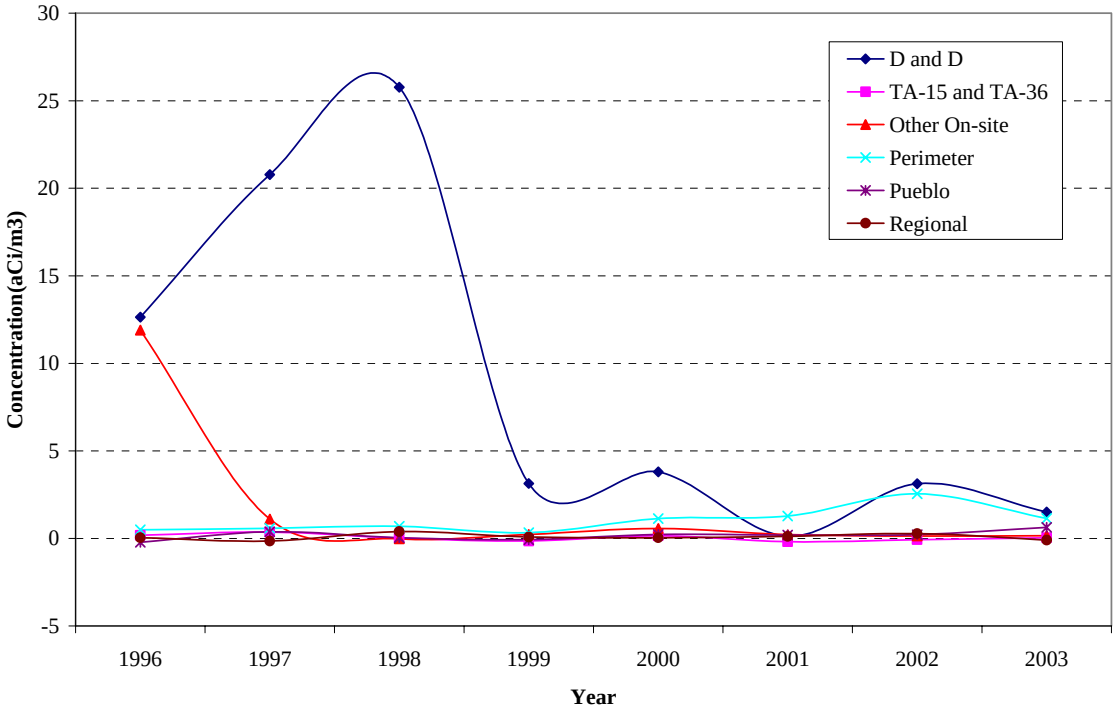

Figure 4-12. Plutonium-239,240 concentration trends.

americium-241 are above zero for the TA-54, Area G, sampling stations. Concentrations at the TA-54 samplers had been decreasing for several years with the exception of the high concentrations caused by the soil-screening operation in 2002 (Figure 4-13) (ESP 2004). 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). The measurable impact of emissions from TA-21 is described in section A.5.a.

B. Stack Sampling for Radionuclides

1. Introduction

Radioactive materials are an integral part of many activities at the Laboratory. Some operations involving these materials may be vented to the environment through a stack or other forced air release point. RRES-MAQ personnel 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, the Laboratory must sample the stack in accordance with Title 40 CFR 61, Subpart H (EPA 1989). During 2003, 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 2003, LANL personnel 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 (VAP), (3) tritium, and (4) gaseous mixed activation products

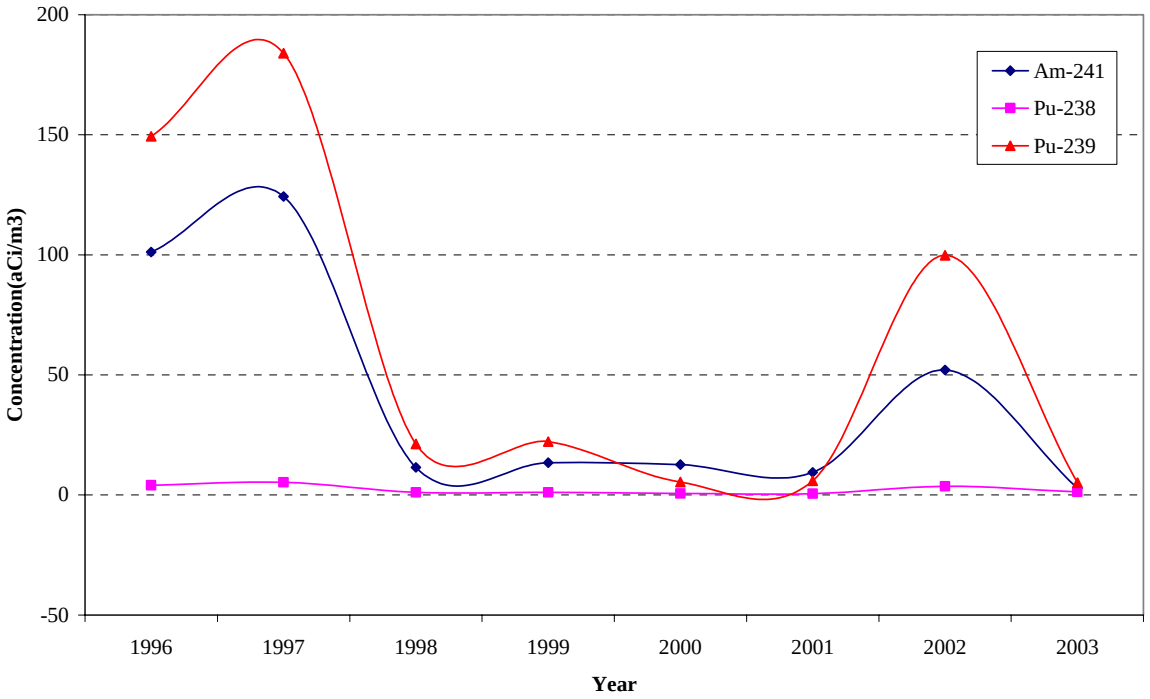

Figure 4-13. Americium and plutonium concentration trends for TA-54, Area G.

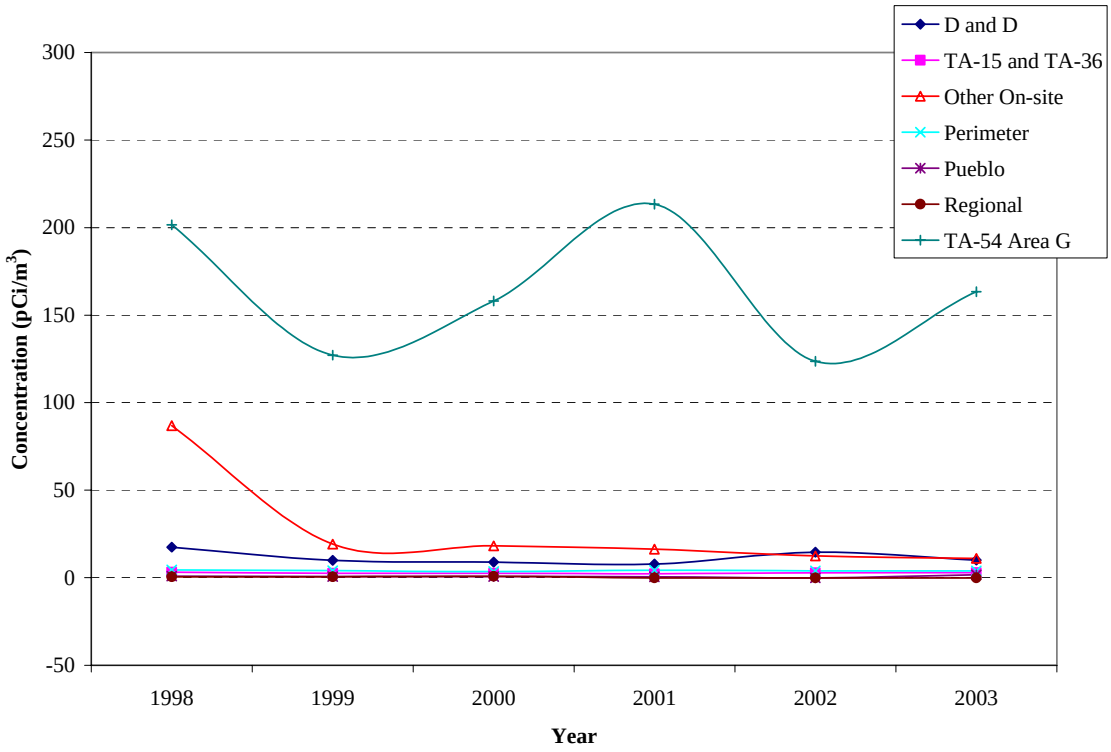

Figure 4-14. Tritium concentration trends.

(GMAP). For each of these emission types, the Laboratory 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 (CMR) 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 analyzed weekly using gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, RRES-MAQ composites these samples to be shipped to an off-site commercial laboratory. The commercial laboratory 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 data are then used to calculate emissions.

A charcoal cartridge samples VAP emissions such as selenium-75 and bromine-82 generated by Los Alamos Neutron Science Center (LANSCE) operations and by hot cell activities at CMR and TA-48. A continuous sample of stack air is pulled through a charcoal filter that adsorbs vaporous emissions of radionuclides. We use gamma spectroscopy to determine the amount and identity of the radionuclide(s) present on the filter.

We use a collection device known as a bubbler to measure tritium emissions from the Laboratory's tritium facilities. This device enables the laboratory 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 operates by pulling 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). After "bubbling" through these three vials, essentially all HTO is removed 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. The amount of HTO and HT is determined by analyzing the ethylene glycol for the presence of tritium using liquid scintillation counting.

In previous years, stacks at LANSCE were monitored for tritium. After a 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 2003 from LANSCE are based on 2001 tritium generation rates.

We measure GMAP emissions resulting from activities at LANSCE 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. We use gamma spectroscopy and decay curves to identify specific radioisotopes.

3. Sampling Procedures and Data Analysis

a. Sampling and Analysis. We chose analytical methods to comply with EPA requirements (40 CFR 61, Appendix B, Method 114).

b. Particulate Matter Emissions. We generally removed and replaced the glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions weekly and transported them to the Health Physics Analysis Laboratory (HPAL). Before screening the samples for the presence of alpha and beta activity, the HPAL 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 HPAL performed final analyses after the sample had been allowed to decay for approximately one week. In addition to alpha and beta analyses, the HPAL used gamma spectroscopy to identify the energies of gamma ray emissions from the samples. Because the energy of decay is specific to a given radioactive isotope, the HPAL could determine the identity of any isotopes detected by the gamma spectroscopy. The amount, or activity, of an isotope could then be found by noting the number of photons detected during analysis. LANSCE glass-fiber filters were analyzed using only gamma spectroscopy.

In October 2003, the weekly analyses for these glass-fiber filters were transferred to an off-site analytical laboratory. Similar protocols were followed as at HPAL; a screening count after approximately 72 hours, then a final analysis after a week of decay time.

Because gross alpha/beta counting cannot identify specific radionuclides, the glass-fiber filters were composited every six months for radiochemical analysis at an off-site commercial laboratory. 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, RRES-MAQ compared the results of the isotopic analysis with gross activity measurements.

c. Vaporous Activation Product Emissions. We generally removed and replaced the charcoal canisters that sample facilities with the potential for significant VAP emissions weekly. These samples were transported to the HPAL where gamma spectroscopy, as described above, identified and quantified the presence of vaporous radioactive isotopes. Again, these analyses were transferred to an off-site analytical laboratory in October 2003.

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 the HPAL on a weekly basis. The HPAL added an aliquot of each sample to a liquid scintillation cocktail and determined the amount of tritium in each vial by liquid scintillation counting. Tritium analyses are still performed at HPAL.

e. Gaseous Mixed-Activation Product Emissions. We used continuous monitoring, rather than offline 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 offline. 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 measured by this ionization chamber 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 composition of these GMAP emissions was analyzed with the gamma spectroscopy system. Using decay curves and energy spectra to identify the various radionuclides, RRES-MAQ personnel determined the relative composition of the emissions. Decay curves were typically taken 1 to 3 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 Laboratory stack emissions during 2003 totaled approximately 2,060 Ci. Of this total, tritium emissions composed approximately 1,380 Ci, and air activation products from LANSCE stacks contributed nearly 620 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and thorium were less than 1 Ci. Emissions of particulate/vapor activation products totaled approximately 61 curies, dominated by LANSCE stacks.

Table 4-14 provides detailed emissions data for Laboratory buildings with sampled stacks. Table 4-15 provides a detailed listing of the constituent radionuclides in the groupings of GMAP and particulate/vapor activation products. Table 4-16 presents the half-lives of the radionuclides typically emitted by the Laboratory. During 2003, nonpoint source emissions of activated air from the LANSCE facility (TA-53) comprised approximately 116 Ci carbon-11 and 5 Ci argon-41, whereas TA-18 contributed 1.0 Ci argon-41.

5. Long-Term Trends

Figures 4-15 through 18 present radioactive emissions from sampled Laboratory 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 2002, but are fairly consistent over time (apart from the large release in 2001). GMAP emissions decreased from 2002 levels. Emissions from plutonium and uranium isotopes stayed relatively steady since 2000.

Table 4-14. Airborne Radioactive Emissions from Laboratory Buildings with Sampled Stacks in 2003 (Ci)

TA-Bldg	^{3}H[a]	^{241}Am	Pu[b]	U[c]	Th[d]	P/VAP[e]	G/MAP[f]	^{90}Sr
TA-03-029		2.27E-07	3.31E-06	7.06E-06	6.24E-07			2.10E-07
TA-03-102		1.03E-10		2.55E-08	7.19E-09			
TA-16-205	1.36E+02							
TA-21-155	4.61E+02							
TA-21-209	7.19E+02							
TA-48-001					1.12E-09	6.66E-04		
TA-50-001		6.89E-09	7.37E-09		5.59E-08			
TA-50-037					3.38E-09			3.41E-09
TA-50-069		7.58E-11	2.72E-09	8.19E-10	1.18E-10			
TA-53-003	6.91E-01					3.50E-10	2.02E+00	
TA-53-007	3.73E+00					6.04E+01	6.17E+02	
TA-55-004	6.02E+01	5.85E-07	1.55E-06		3.90E-08			5.62E-08
Total[g]	1.38E+03	8.19E-07	4.87E-06	7.09E-06	7.37E-07	6.04E+01	7.39E+02[h]	2.70E-07

[a]Includes both gaseous and oxide forms of tritium.
[b]Includes ^{238}Pu, ^{239}Pu, and ^{240}Pu.
[c]Includes ^{234}U, ^{235}U, and ^{238}U. Does NOT include radioactive progeny of ^{238}U.
[d]Includes ^{228}Th, ^{230}Th, and ^{232}Th.
[e]P/VAP-Particulate/vapor activation products. Includes measured radionuclides and short-lived radioactive progeny.
[f]G/MAP-Gaseous/mixed activation products.
[g]Some differences may occur because of rounding.
[h]Total for G/MAP includes 121 curies released from diffuse sources at TA-53.

The decrease in emissions from tritium handling facilities from 2002 to 2003 is due in part to the elimination of two monitored stacks, at TA-33-86 and TA-41-4. Monitoring at these stacks ceased in 2002. TA-33-86 was completely removed as part of the D&D process; whereas all emissions sources at TA-41-4 were removed in 2002, and continued monitoring showed no potential for significant releases.

Another cause for the decrease is the completion of active source removal activities at TA-21-155. This building was transferred to the D&D group for management. Continued emissions from this facility result from off-gassing of contaminated equipment remaining in the building. Continued monitoring is warranted due to the higher level of off-gassing, relative to the levels observed at TA-41-4, for example. 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 the Laboratory is consolidating most tritium operations, and the TA-21-209 building is being prepared for D&D. 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 D&D preparation.

The large spike in emissions from 2001 is because of a single release of 7,600 curies 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 2003, LANSCE operated in the same configuration as 2001–2002, 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 2003 (extending the end of the 2002 cycle),

Table 4-15. Detailed Listing of Activation Products Released from Sampled Laboratory Stacks in 2003 (Ci)

TA-Bldg.	Radionuclide	Emission
TA-48-001	Ga-68	3.33E-04
TA-48-001	Ge-68	3.33E-04
TA-53-003	C-11	2.02E+00
TA-53-003	Co-60	3.50E-10
TA-53-007	Ar-41	1.29E-01
TA-53-007	Au-193	3.01E+01
TA-53-007	Au-195	6.26E-03
TA-53-007	Br-82	3.54E-03
TA-53-007	C-10	2.38E-01
TA-53-007	C-11	5.06E+02
TA-53-007	Hg-193	3.01E+01
TA-53-007	Hg-195	6.26E-03
TA-53-007	Hg-195m	5.45E-03
TA-53-007	Hg-197	7.15E-02
TA-53-007	Hg-197m	1.97E-02
TA-53-007	Hg-203	1.13E-04
TA-53-007	N-13	2.78E+1
TA-53-007	N-16	1.91E-01
TA-53-007	O-14	1.60E-01
TA-53-007	O-15	6.93E+01
TA-53-007	Se-75	1.77E-06

Table 4-16. Radionuclide: Half-Life Information

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

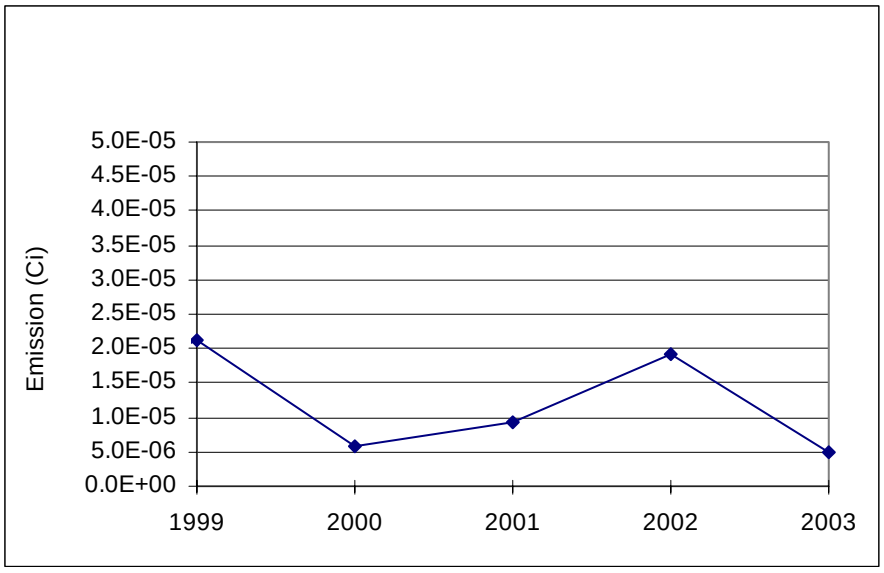

Figure 4-15. Plutonium emissions from sampled Laboratory stacks since 1999.

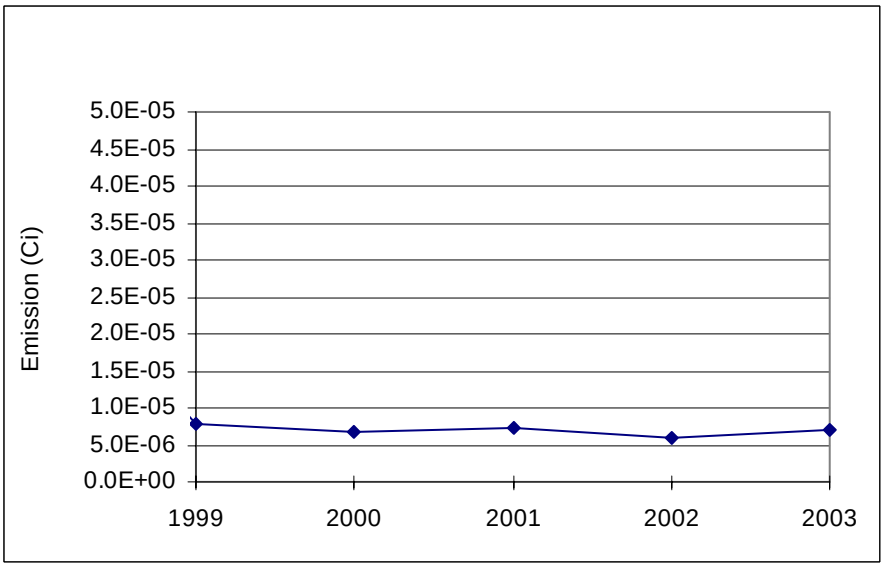

Figure 4-16. Uranium emissions from sampled Laboratory stacks since 1999.

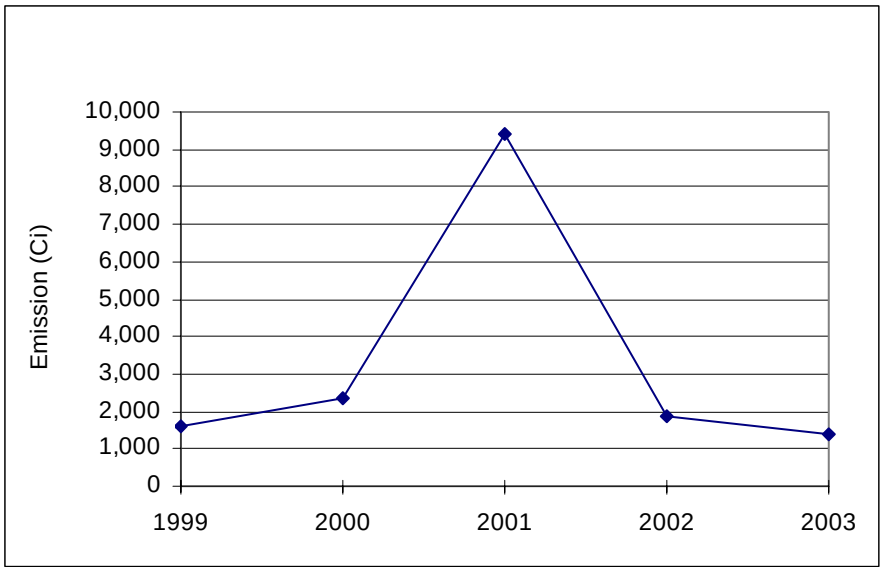

Figure 4-17. Tritium emissions from sampled Laboratory stacks since 1999.

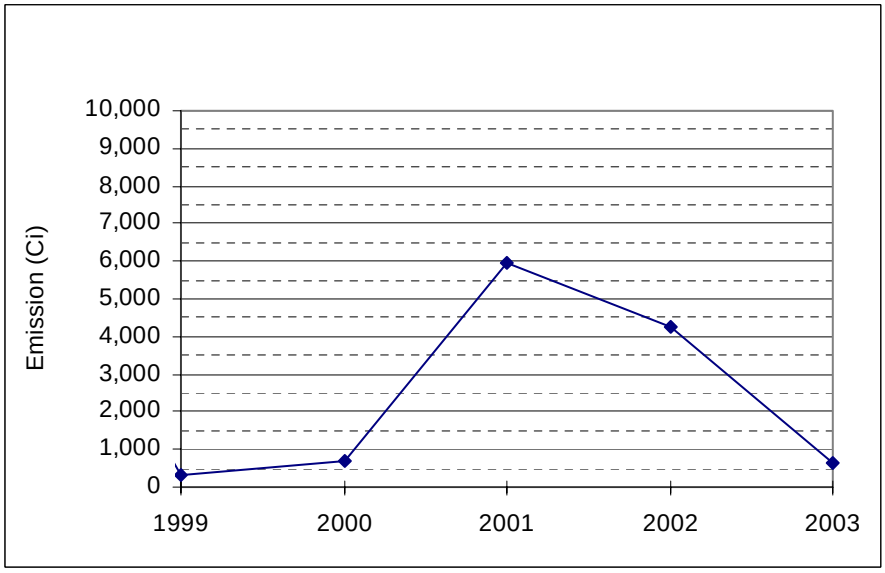

Figure 4-18. G/MAP Emissions from sampled Laboratory stacks since 1999.

then from July–December 2003. GMAP emissions from LANSCE underwent a significant decrease from 2002 to 2003. This decrease is due partially to successful implementation of an emissions control system that dramatically reduced the rate of generation of air emissions and is partially a function of the facility operational parameters. The control system is a "delay line," which retains the short-lived activation products for a short time period before release out the stack. This time interval allows decay of the short-lived radionuclides to nonradioactive components. The overall rate of emissions from the facility was quite low in the early part of the 2003 run cycle, then it began to increase in November and December as the beam power increased and other operational parameters changed. The emissions from 2003 remained well below any regulatory limits.

Figure 4-19 shows the individual contribution of each of these emission types to the total Laboratory 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, since 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. Because of the close proximity of the LANSCE facility to the Laboratory site boundary, GMAP emissions remain the greatest source of off-site dose from the airborne pathway.

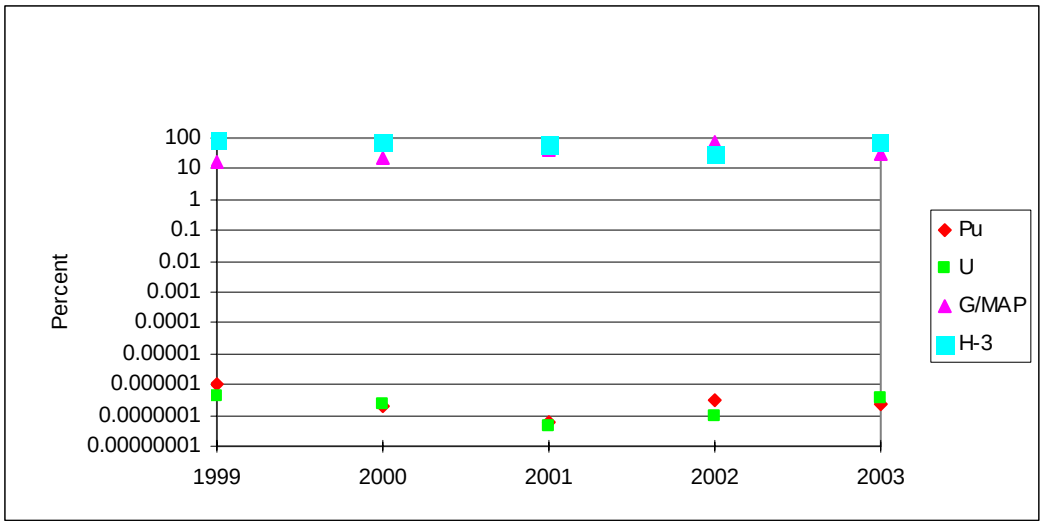

Figure 4-19. Fraction of total stack emissions resulting from plutonium, uranium, tritium, and G/MAP since 1999.

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

1. Introduction

The RRES-MAQ Group 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. In publicly accessible locations, the dose rate from man-made radiation is much smaller than, and difficult to distinguish from, natural radiation.

2. Monitoring Network

a. Dosimeter Locations. In an attempt to distinguish any impact from Laboratory operations, the RRES-MAQ Group has located 122 thermoluminescent dosimeter (TLD) stations around the Laboratory and in the surrounding communities (Figure 4-20).

b. Neutron Dosimeters. We monitor potential neutron doses with 61 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 dosimeter zero is established with reference to dosimeters in a shielded vault. The 2-mrem neutron dose reported at the background stations is the difference between approximately 10 mrem in the field and approximately 8 mrem in the vault. Therefore a neutron reading of 2 mrem/yr is a normal background reading.

3. Quality Assurance

RRES Division operating procedures outline the QA/QC protocols. The Health Physics Measurements Group (HSR-4) calibration lab calibrates the dosimeters every calendar quarter. The DOE Laboratory Accreditation Program has accredited the dosimeters that HSR-4 provides, and HSR-4 provides QA for the dosimeters. We estimate the uncertainty in the TLD data from the standard deviation of data from dosimeters exposed to the same dose. The overall one standard deviation 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 Laboratory operations are at TA-18, TA-21, LANSCE (TA-53), and TA-54, Area G.

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 public neutron dose was 40 mrem on Pajarito Road outside the TA-18 parking lot (station 187). Pajarito Road had restricted public access throughout 2003. Assuming an occupancy factor of 1/16, this translates to an individual public dose of 2.5 mrem for the year.

TA-21, Area T, is contaminated with 50 pCi/g of cesium-137 (LANL 1991, pp. 16–124). The calculated dose rate (station 323) from this contamination is 200 mrem/yr. This is about 100 mrem/yr above background and is in reasonable agreement with the measurement considering that the dosimeter is on the boundary fence of Area T. Area T is not accessible to the public.

The TA-53 lagoons, which previously contained some activated material, have now been remediated and current doses at stations 114 and 115 are close to background levels. Access by the public to TA-53 is nevertheless 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 (WIPP). 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 during 2003 was 2.5 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 DOE.

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

1. Introduction

During 2003, the RRES-MAQ continued, in an abbreviated form, the short-term nonradiological monitoring (NonRadNet) air-monitoring program implemented in 2001 to provide baseline nonradiological data under normal conditions. The objectives of NonRadNet are to

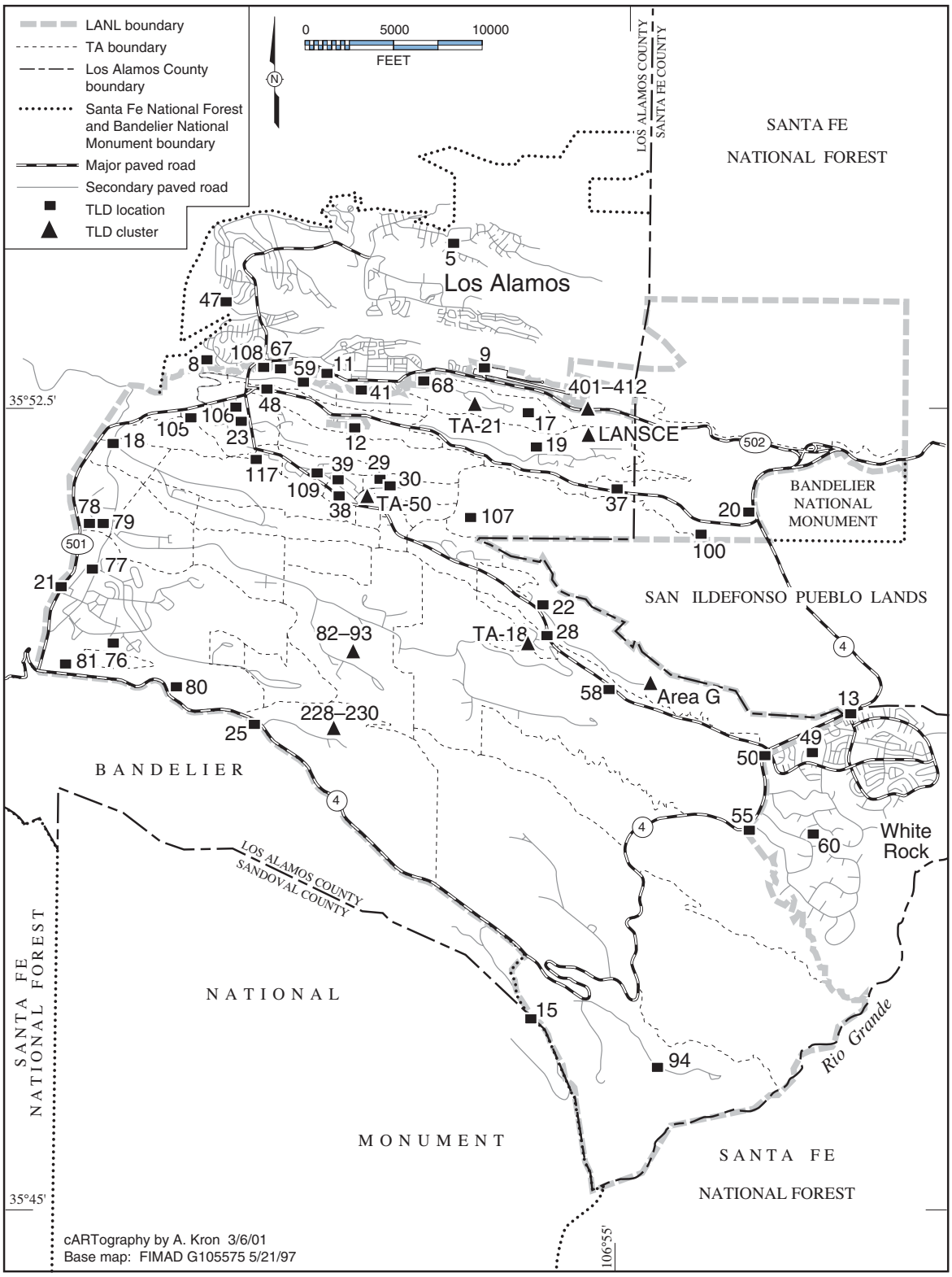

Figure 4-20. Off-site perimeter and on-site Laboratory TLD locations.

- develop the capability for collecting nonradiological air-monitoring data,
- conduct monitoring to develop a database of typical background levels of selected nonradiological species in the communities nearest the Laboratory, and
- measure LANL's potential contribution to nonradiological air pollution in the surrounding communities.

2. Air-Monitoring Network

During 2003, continuous particulate matter (PM) monitoring took place at three locations—two in Los Alamos and one in White Rock. The White Rock sampling is collocated with the existing AIRNET station at the White Rock Fire Station. One Los Alamos station is collocated with the existing AIRNET station at the Los Alamos Medical Center. The other Los Alamos station was located near the intersection of Diamond Drive and East Jemez Road for the month of January, and then near 48th Street (and areas that were burned during the Cerro Grande fire) from April through December. Both these locations lie between the main technical area of the Laboratory and the population center of the Los Alamos town site. Two monitors are operated at each location: one for particles with diameters of 10 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 (TEOM) ambient particulate monitor (fitted with either PM-10 or PM-2.5 sample inlets) collects continuous PM-10 and PM-2.5 concentrations ($\mu g/m^3$).

4. Ambient Air Concentrations of Particulate Matter

We have achieved nearly complete collection of PM-2.5 and PM-10 data for the entire year on TEOM sampling units (69 out of 72 months of data for the 6 units). The 24-hour maxima and annual averages for both particle sizes at the three locations are shown in Table 4-17. The annual average for PM-10 is 16 $\mu g/m^3$ at all locations; for PM-2.5 it is half this value. These averages are significantly below the EPA standards. In addition, the 24-hour maxima for both PM-2.5 and PM-10 at all three locations are also significantly less than the EPA standards. The EPA standards are displayed in Table 4-17.

Table 4-17. PM-2.5 and PM-10 Concentration Data Summary for 2003

Station Location	Constituent	Maximum 24 Hour ($\mu g/m^3$)	Annual Average ($\mu g/m^3$)
48th Street	PM-10	74	16
	PM-2.5*	27	8
Los Alamos Medical Center	PM-10	65	16
	PM-2.5	28	8
White Rock Fire Station	PM-10	90	17
	PM-2.5	27	8
EPA Standard	PM-10	<150	<50
	PM-2.5	<65	<15

*Monitor at corner of Jemez Road and Diamond Drive during January 2003.

5. Detonation and Burning of Explosives

The Laboratory tests explosives by detonating them at firing sites operated by the Dynamic Experimentation Division. The Laboratory maintains monthly shot records that include the type of explosives used and other material expended at each site. Table S4-18 (in the Data Supplement) summarizes the amounts of expended materials for the last three years. The Laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 2003, the Laboratory burned 2.2 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 2003 were less than the amounts for which impacts are analyzed in the DOE (1999).

6. Beryllium Sampling

New Mexico no longer has an ambient-air-quality standard for beryllium to compare with AIRNET measurements. Therefore, we selected another air-quality standard to use for comparison purposes: the National Emission Standard for Hazardous Air Pollutants (NESHAP) standard of 10 ng/m^3 (40 CFR Part 61), can be, with EPA approval, an alternative to meeting the emission standard for beryllium. LANL is not required to use this alternative standard because the permitted sources meet the emission standards, but it is used in this case for comparative purposes.

We continued to analyze quarterly composite samples from 26 sites for beryllium during 2003. These sites are located near potential beryllium sources at LANL or in nearby communities. Our previous results indicate that the source of beryllium in our AIRNET samples was naturally occurring beryllium in resuspended dust caused by vehicular traffic on dirt roads, construction activities, or wind in dry weather.

Air concentrations for 2003, shown in Table S4-19 (in the Data Supplement), remain very similar to those measured in recent years. All values are 2% or less than the NESHAP standard.

The highest measured beryllium concentrations in air occur at TA-54 (Area G), the Los Alamos County Landfill, the Jemez Pueblo Visitor's Center, the San Ildefonso Pueblo Plaza, and in Santa Fe. Since none of these sites have any beryllium-handling operations, the source of the beryllium is most likely from resuspended soil. This is further supported by the measured beryllium-to-manganese ratio values (see Table S4-20 in the Data Supplement) being similar to those of uncontaminated soil. Area G is located in the drier portion of the Laboratory, making wind resuspension a more important contributor to air-particle concentration. Resuspension of fine dust particles is also common during trucking operations at the county landfill. Jemez and San Ildefonso pueblos have reported significant levels of blowing dust, especially during the spring season.

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 RRES-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 (Baars et al. 1998) 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/monplan/mmp1998.pdf.*

2. Monitoring Network

A network of six towers gathers meteorological data (winds, atmospheric state, precipitation, and fluxes) at the Laboratory (see Figure 4-21 and the Meteorological Monitoring Plan [Baars et al., 1998]). 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

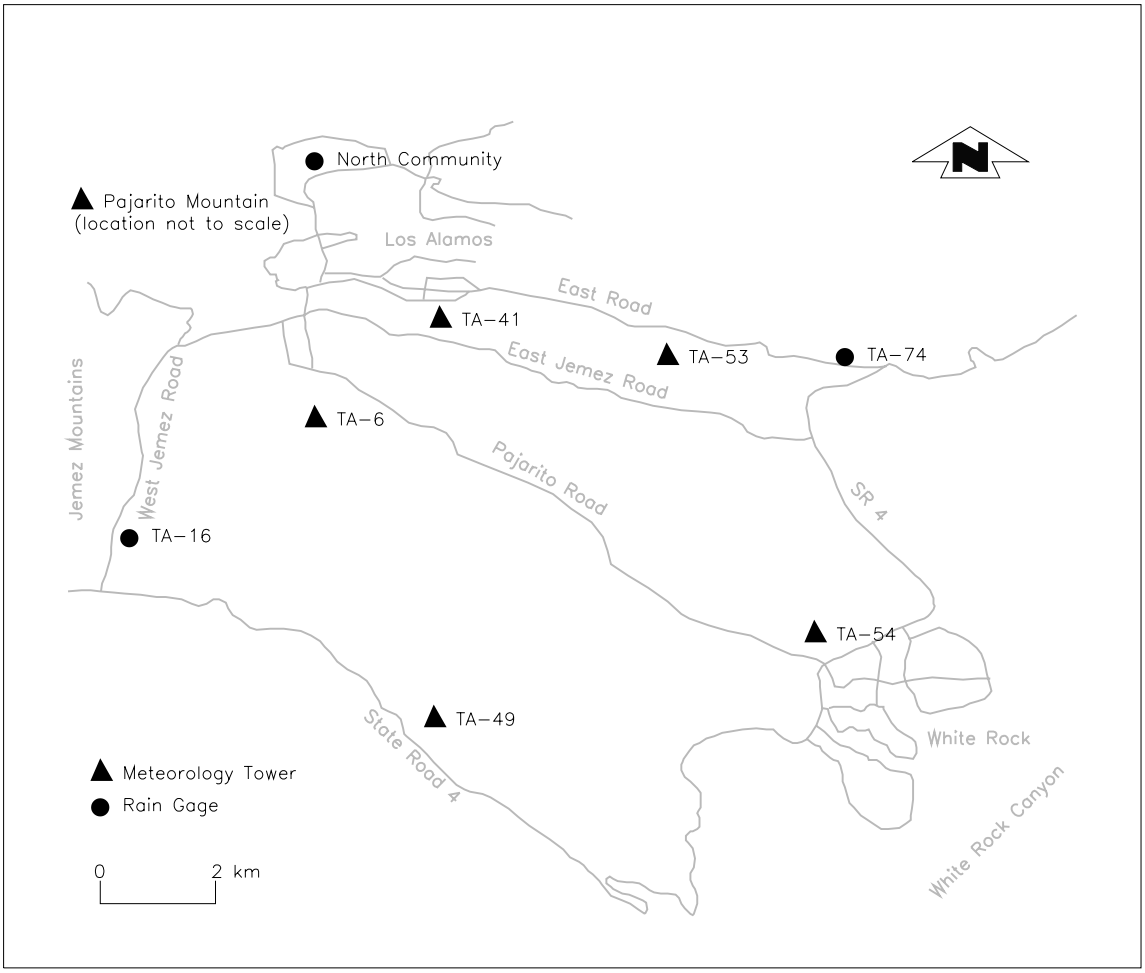

Figure 4-21. Meteorological network.

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.

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 RRES-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 long-wave radiative cooling of the earth at night. This radiative cooling is not ameliorated by downward long-wave radiation that would occur in the presence of clouds and water vapor. Communities nearby, such as White Rock and Española, see even greater fluctuations because they receive a cool nighttime flow that drains from the Pajarito Plateau as it slopes downward to the east toward the Rio Grande and a nighttime flow southward down the Rio Grande valley itself.

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.

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. By convention, the 30-yr period of 1971 to 2000 is used to determine climatological averages. However, decadal variability in precipitation produces considerable variation in precipitation-related averages depending on the 30-year period chosen. During the 1980s, for example, the annual average snowfall was 77.8 in. compared with the annual average snowfall since 1931 (including the 1980s) of 52.3 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. The snow is usually has an equivalent water-to-snowfall ratio of about 1:15. Large snowfalls may occur locally as a result of orographic lifting of the storms by the Jemez Mountains (i.e., higher snowfall occurs when storms come from lower elevations south and east of Los Alamos). The record single-day snowfall is 22 in., which occurred once in 1978 and once in 1987. 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 late June 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. The RRES-MAQ Group began measuring lightning activity in 1998, and, according to this sample, 64% of the detected local lightning activity occurred during July and August. Lightning is most commonly observed during warmer months; 97% of the lightning activity counted since 1998 occurred between the months of May and September. Lightning has a very strong diurnal cycle, as shown in Figure 4-22. Activity is minimal from the early morning until 11 am when it begins to

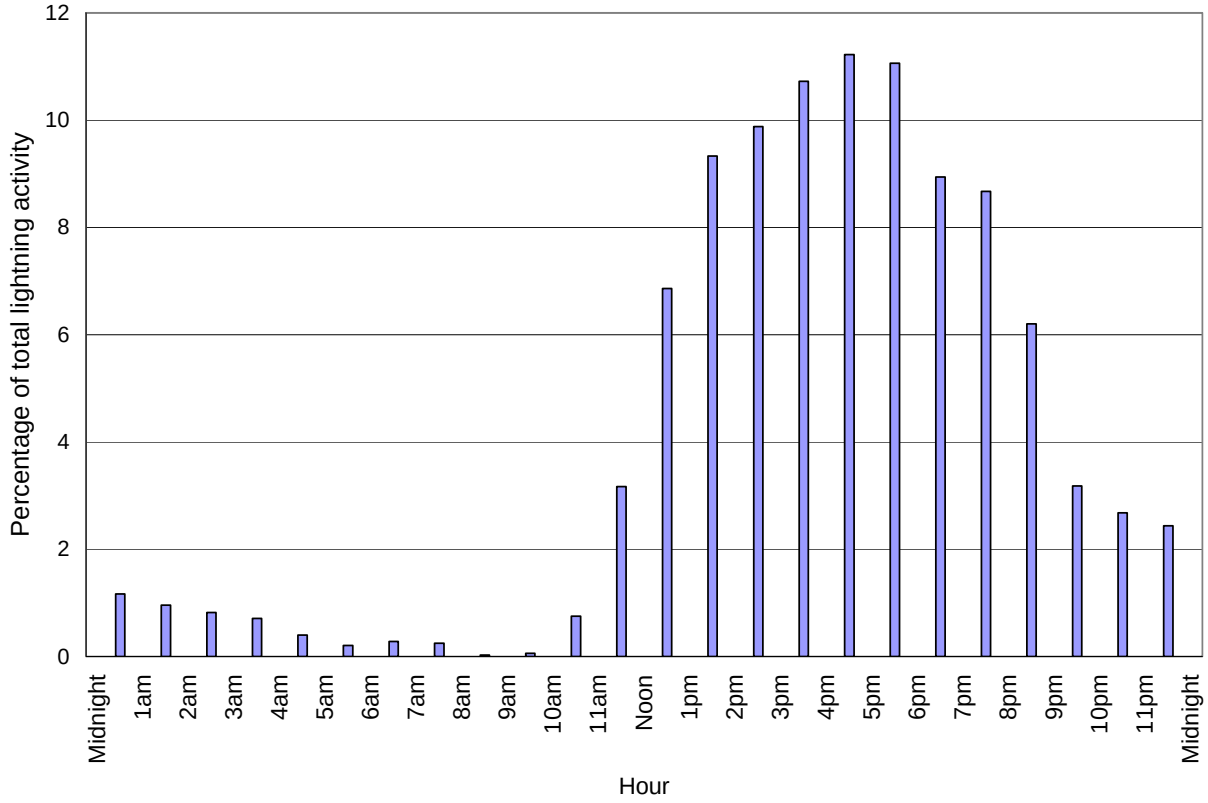

Figure 4-22. Diurnal histogram of lightning activity.

increase rapidly, reaching a maximum between 3 pm and 6 pm. Lightning activity can remain quite strong until 9 pm or later.

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.

Daytime winds (sunrise to sunset), based on 15-minute-averaged wind observations for 2003 at the four Pajarito Plateau towers and the Pajarito Mountain tower, are shown in the form of wind roses (Figure 4-23). 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 indistinguishable. For this reason, one year of winds is enough to produce a climatology.

Daytime winds measured by the four Pajarito Plateau towers are predominately from the south, consistent with the typical upslope flow of heated daytime air moving up the Rio Grande valley. Nighttime winds (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

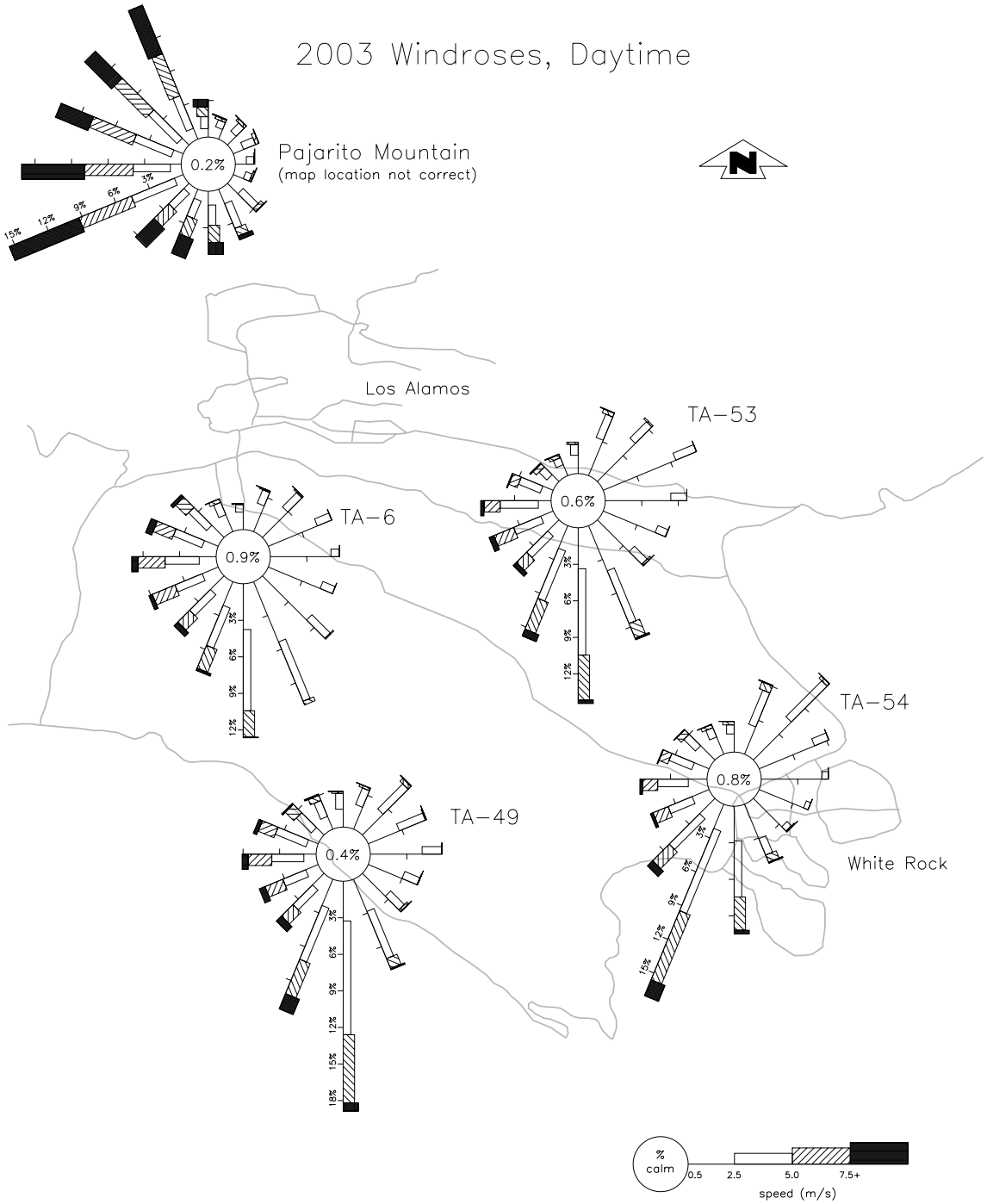

Figure 4-23. Daytime wind roses, 2003.

downslope katabatic flow of cooled mountain air (Figure 4-24). 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.

5. 2003 in Perspective

Figure 4-25 presents a graphical summary of Los Alamos weather for 2003. The figure depicts the year's monthly average temperature ranges, monthly precipitation, and monthly snowfall totals compared with monthly normals (averages for each of 12 calendar months during the 1971–2000 time period).

Los Alamos weather during 2003 continued a 6-year trend of warmer-than-normal temperatures and a dryer-than-normal climate, but 2003 was the warmest and driest of these 6 years. The average annual temperature in 2003 of 50.5˚F exceeded the normal annual average of 47.9˚F by 2.6 degrees. The total precipitation in 2003 of 9.93 in. was 52% of normal (18.95 in.). The year 2003 was the warmest year since 1954 and the driest year since 1956. Monthly precipitation totals were below normal every month of the year except February. The annual snowfall total of 15.3 in. was only 26% of normal (58.7 in.).

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-26 shows the historical record of temperatures in Los Alamos from 1924 through 2003. The data before 1924 are sparse and, 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 4-26. Only 1953 and 1954 were warmer than 2003. To aid in showing longer-term trends, the 7-year running mean is also shown. The warm spell during the past few years is similar in severity to the warm spell during the early-to-mid 1950s.

Figure 4-27 shows the historical record of the annually summed total precipitation. As with the historical temperature profile, the 7-year running mean is shown in addition to the plot of totals for each year. The year 2003 was the second driest year during the 80-year record; only 1956 was drier. The current drought appears to be similar in severity to droughts during the late 1930s and early-to-mid 1950s. Note that from about 1982 until the beginning of the current drought, Los Alamos enjoyed greater-than-normal annual precipitation. This is particularly apparent in the 7-year mean.

F. Quality Assurance Program in the Air Quality Group *(Terrance Morgan)*

1. Quality Assurance Program Development

During 2003, the RRES-MAQ Group revised three quality plans that affect collection and use of air-quality-compliance data. We also issued five new implementing procedures and revised approximately 20 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 RRES-MAQ processes perform satisfactorily. All current quality-related documents are available on the RRES-MAQ public (Green) Web site (*www.airquality.lanl.gov).*

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) taken on 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 using 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 AIRNET biweekly gross alpha/beta data are returned from the analytical laboratory. 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 RRES-MAQ staff to evaluate every data group received from a supplier.

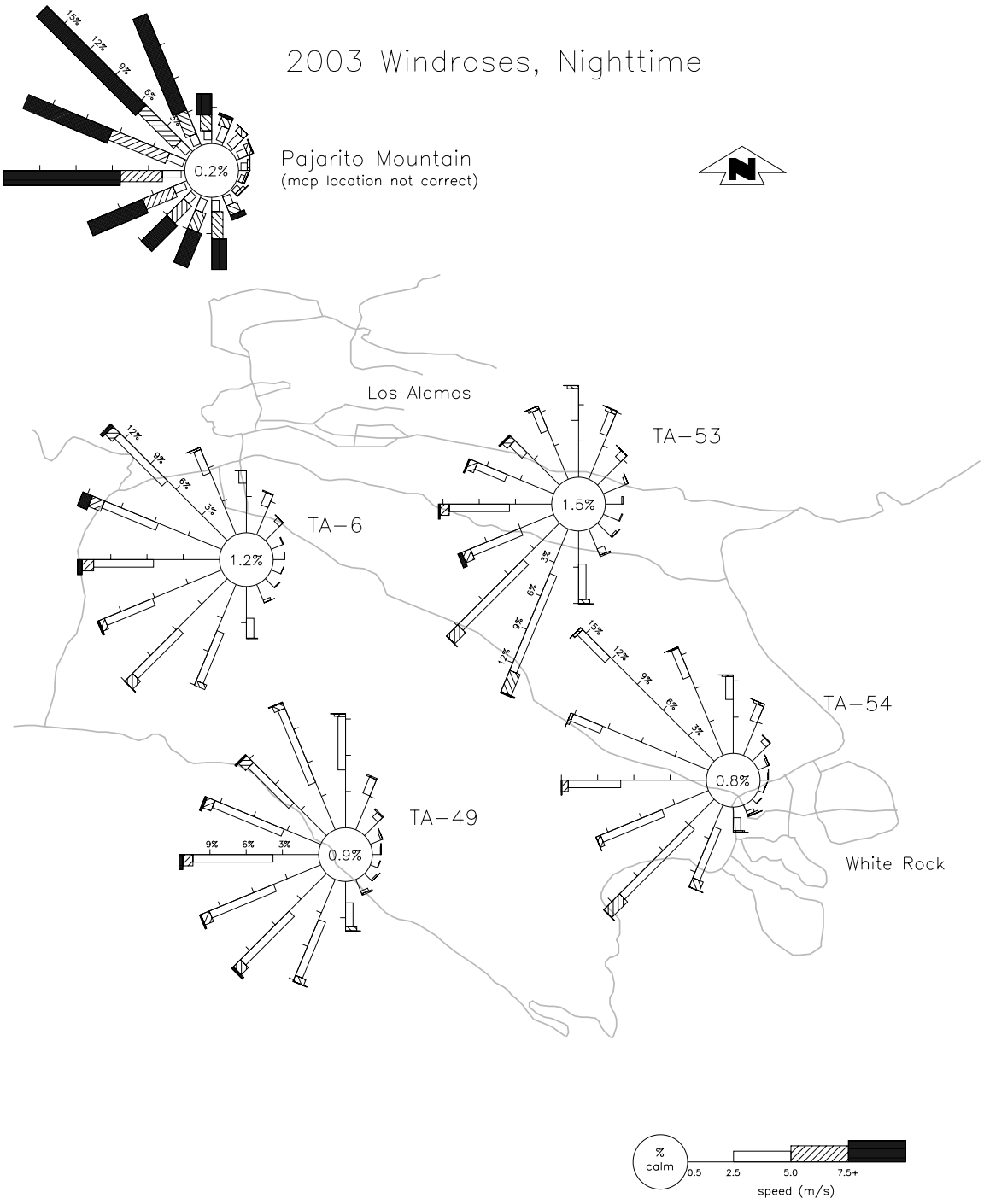

Figure 4-24. Nighttime wind roses, 2003.

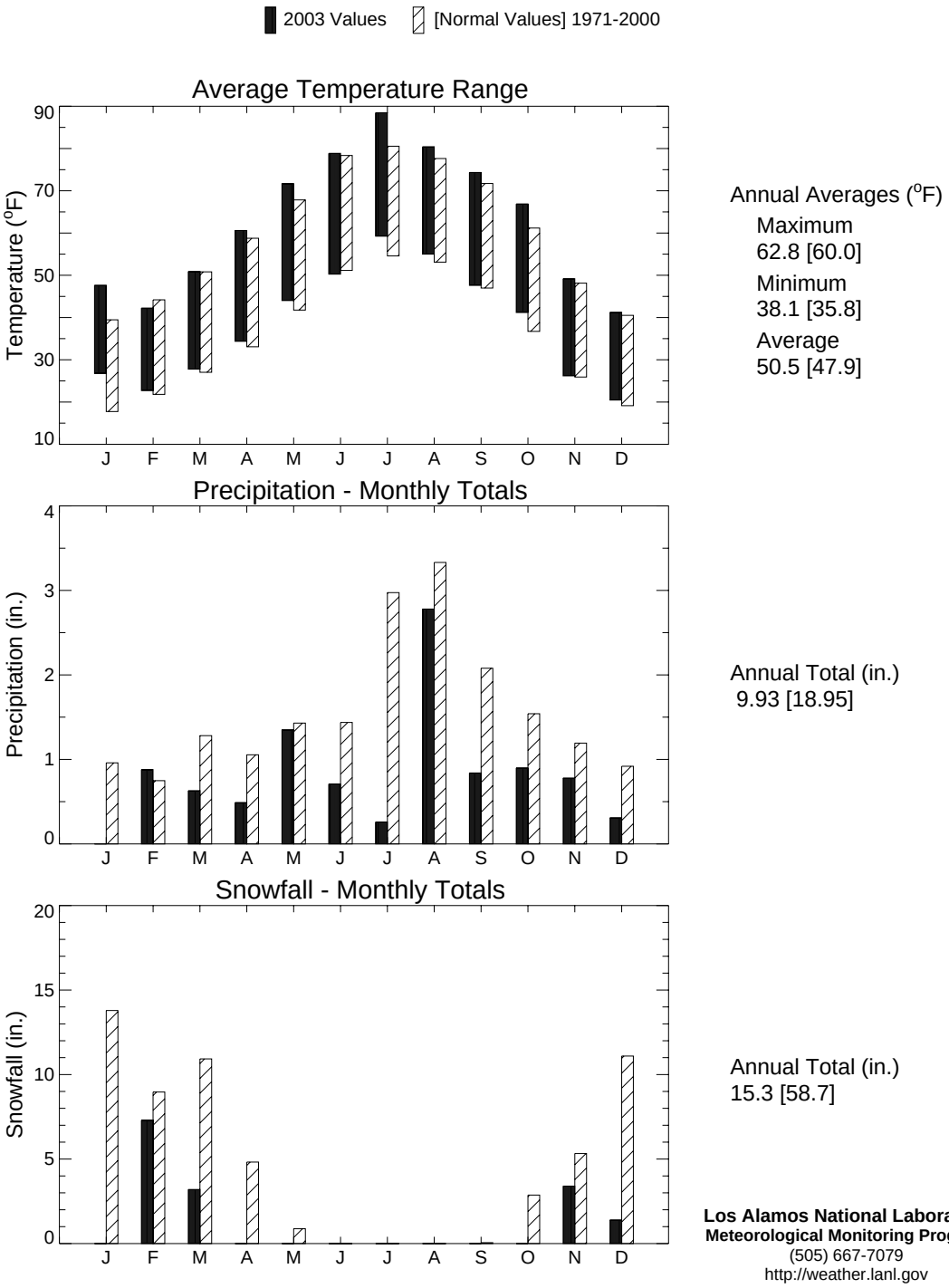

Figure 4-25. Weather summary for Los Alamos in 2003 at TA-6 station, elevation 7,424 ft. (Numbers in brackets are 30-year averages, and nonbracketed numbers are for 2003.)

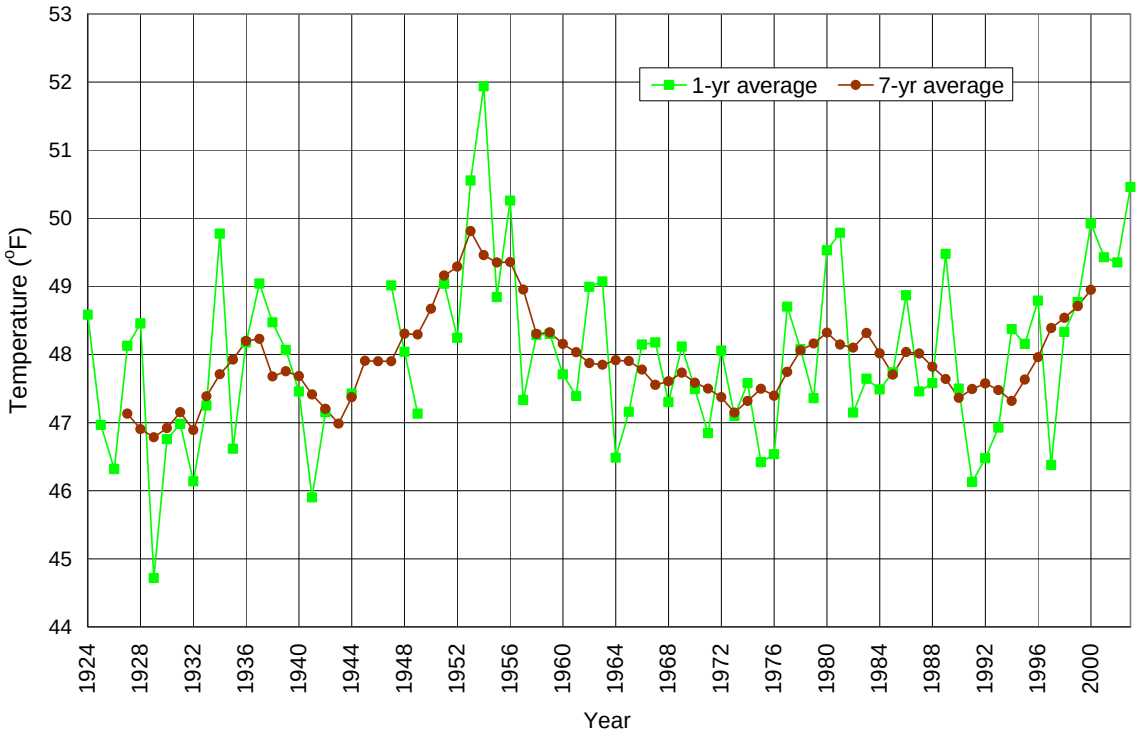

Figure 4-26. Temperature history for Los Alamos.

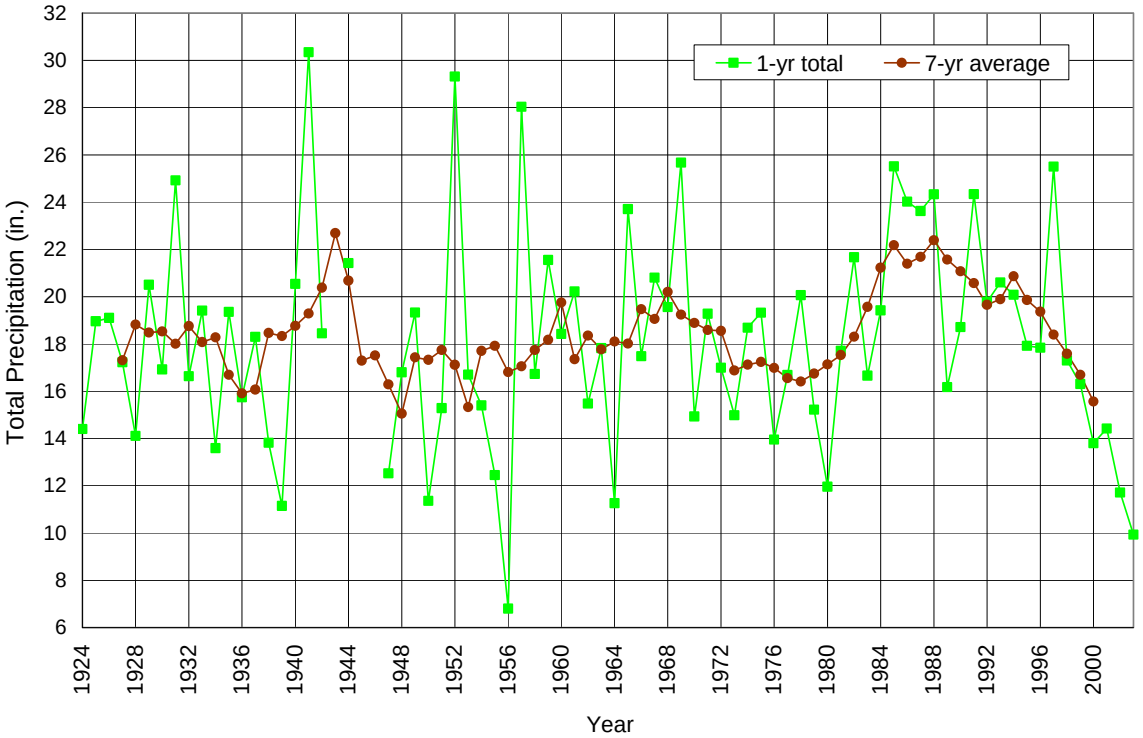

Figure 4-27. Total precipitation history for Los Alamos.

3. Analytical Laboratory Quality Assessment

Specific statements of work (SOWs) 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 SOWs are sent to potentially qualified suppliers who then undergo pre-award on-site assessment by experienced and trained RRES-MAQ quality systems and chemistry-laboratory assessors. SOW 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. Five of these SOWs were reissued as controlled documents in 2003.

Each analytical laboratory conducts its chain-of-custody and analytical processes under its own quality plans and analytical procedures. The RRES-MAQ Group submits independently prepared blind spiked samples with each sample set to be analyzed for tritium. Preliminary data are returned to the RRES-MAQ Group by e-mail in an electronic data deliverable of specified format and content. Each set of samples contains all the internal QA/QC data generated by the analytical laboratory during each phase of chemical analysis (including laboratory control standards, process blanks, matrix spikes, duplicates, and replicates, when applicable). All data are electronically 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 each network.

5. Analytical Data Quality Assessment Results

Analytical-data completeness for both sampling programs was 100%. The Clean Air Act requires an EPA-compliant program of QC samples be included as an integral part of the sampling and analysis process. RRES-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 our 2003 program of quality monitoring indicates that all analytical laboratories maintained the same high level of control that the RRES-MAQ Group has observed in the past several years.

6. Analytical Laboratory Assessments

During 2003, one internal and three external laboratories performed all chemical analyses reported for AIRNET and RADAIR samples.

- The Wastren-Grand Junction analytical laboratory (associated with the DOE's Grand Junction Project Office) provided biweekly gross alpha, gross beta, and isotopic gamma analytical services for AIRNET.
- Paragon Analytics, Inc., Fort Collins, Colorado, provided biweekly AIRNET tritium and weekly RADAIR stable beryllium analytical services.
- Wastren-Grand Junction provided analytical-chemistry services for alpha-emitting isotopes (americium, plutonium, polonium, thorium, and uranium), beta-emitting isotopes (lead-210), and stable beryllium on AIRNET quarterly composite samples.
- Wastren-Grand Junction also provided all inorganic elemental analyses for the AIRNET program.
- LANL's on-site Health Physics Analytical Laboratory in the Health Physics Measurements Group (HSR-4) performed instrumental analyses of tritium in stack emissions.

- Wastren-Grand Junction also analyzed semester composites of in-stack filters for alpha- and beta-emitting isotopes (lead-210 and strontium-90).

The Wastren-Grand Junction analytical laboratory (associated with the DOE's Grand Junction Project Office) closed in December 2003. The few remaining sample sets for 2003 submitted after mid-December were analyzed by Paragon Analytics.

RRES-MAQ personnel performed assessments of all laboratories during 2003. All analytical laboratories participated in national performance-evaluation studies during 2003. The detailed results of these performance evaluations are included in each assessment report (Gladney and Morgan 2004; Gladney 2004). Overall, the study sponsors judged the analytical labs that participated in these national studies to have acceptable performance for almost all analytes attempted in all matrices.

G. Unplanned Releases

On November 25, 2003, at 7:50 a.m., the TA-3-22 Power Plant exceeded the stack-emission opacity limit of 20%. This occurred during a quarterly verification test to switch fuel from natural gas to fuel oil. During the verification test, the Power Plant No. 2 Boiler exceeded the stack opacity limit of 20% during the first nine minutes of the test. The combustion air was adjusted to lower the opacity to below the 20% opacity limit. All appropriate notifications were made to the New Mexico Environment Department.

H. References

Baars et al. 1998: J. Baars, D. Holt, and G. Stone, "Meteorological Monitoring at Los Alamos," Los Alamos National Laboratory document LA-UR-98-2148 (May 1998).

Bowen 1990: B. M. Bowen, "Los Alamos Climatology," Los Alamos National Laboratory report LA-11735-MS (May 1990).

Bowen 1992: B. M. Bowen, "Los Alamos Climatology Summary," Los Alamos National Laboratory report LA-12232-MS (March 1992).

DOE 1988a: US Department of Energy, "Radiation Protection for Occupational Workers," US Department of Energy Order 5480.11 (1988).

DOE 1988b: US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," US Department of Energy DE88-014297 (July 1988).

DOE 1999: US Department of Energy, "Site-Wide Environmental Impact Statement for Continued Operation of the Los Alamos National Laboratory," DOE/EIS-0238 (January 1999).

Eberhart et al. 1999: C. F. Eberhart, J. M. Dewart, D. H. Kraig, and E. S. Gladney, "Detecting Emissions of Uranium Using Ambient Isotopic Measurements" in extended abstracts from "PM-2000: Particulate Matter and Health—The Scientific Basis for Regulatory Decision-Making," Los Alamos National Laboratory document LA-UR-99-5724 (January 2000).

Eisenbud and Gesell 1997: M. Eisenbud and T. Gesell, *Environmental Radioactivity from Natural, Industrial, and Military Sources*, 4th ed. (Academic Press, San Diego, California, 1997).

EPA 1989: US Environmental Protection Agency, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," *Code of Federal Regulations*, Title 40, Part 61, Subpart H (December 15, 1989).

ESH-17 2000: Air Quality Group, "Sampling and Analysis Plan for Radiological Air Sampling Network (AIRNET)," Air Quality Group document ESH-17-AIRNET (August 2000).

ESP 1999: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1998," Los Alamos National Laboratory report LA-13633-ENV (September 1999).

ESP 2000: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1999," Los Alamos National Laboratory report LA-13775-ENV (December 2000).

ESP 2001: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 2000," Los Alamos National Laboratory report LA-13861-ENV (September 2001).

ESP 2002: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 2001," Los Alamos National Laboratory report LA-13979-ENV (October 2002).

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

Gladney and Morgan 2004: E. S. Gladney and T. L. Morgan, "Final Report, LANL ESH-17 Assessment of Paragon Analytics Quality Program, October 9–10, 2001," RRES-MAQ: 04-148, letter to Deb Sheib, Paragon Analytics, Inc., May 17, 2004.

Gladney 2004: E. S. Gladney, "Final Report, LANL MAQ "Desk-top" Assessment of HSR-4 Health Physics Analytical Laboratory—December 2003," MAQ:04-103, memo to Robert Martin, Health Physics Analysis Laboratory, March 30, 2004.

LANL 1991: "SWMU Aggregate Descriptions and Sampling Plans," in "TA-21 Operable Unit RFI Work Plan for Environmental Restoration," Los Alamos National Laboratory document LA-UR-91-962 (May 1991).

McNaughton et al. 2000: M. W. McNaughton, D. H. Kraig, and J. C. Lochamy, "Siting of Environmental Direct-Penetrating-Radiation Dosimeters," Los Alamos National Laboratory document LA-UR-00-1168 (2000).

NCRP 1975: National Council on Radiation Protection and Measurements, "Natural Background Radiation in the United States," National Council on Radiation Protection and Measurements report 45 (November 1975).

NCRP 1987: National Council on Radiation Protection and Measurements, "Ionizing Radiation Exposure of the Population of the United States," National Council on Radiation Protection and Measurements report 93 (September 1987).

Walker et al. 1989: F. W. Walker, J. R. Parrington, and F. Feiner, *Nuclides and Isotopes*, 14th ed. (General Electric Company, 1989).

4. Air Surveillance

5. Groundwater Monitoring

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A. Introduction

Los Alamos National Laboratory (LANL or the Laboratory) routinely analyzes groundwater samples from the Pajarito Plateau and 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 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 Groundwater Protection Program (RRES-GPP) and the Water Quality and Hydrology Group (RRES-WQH) implement the Laboratory's groundwater monitoring program. The RRES-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).

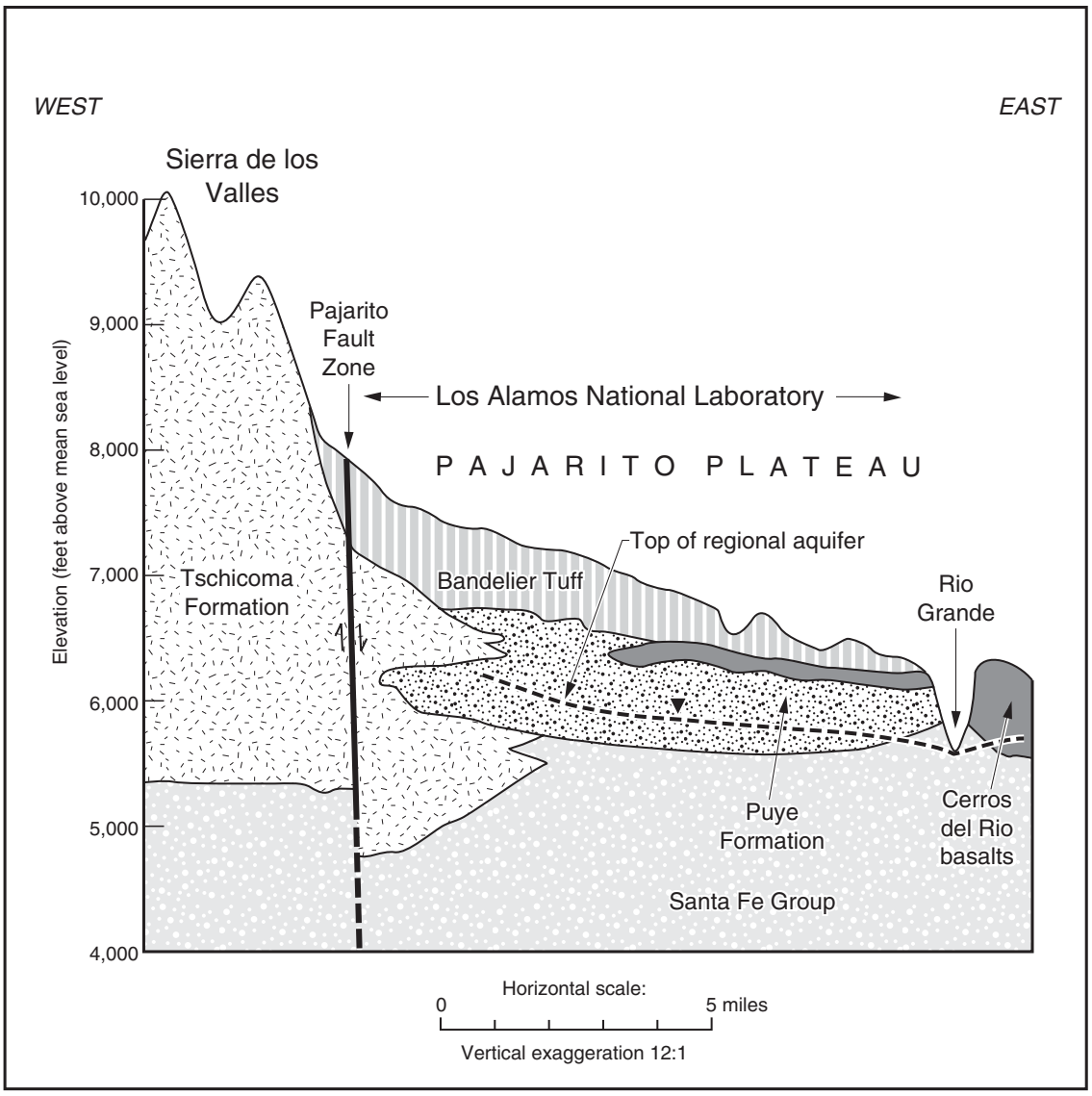


Figure 5-1. Generalized geologic cross section of the Pajarito Plateau.

The Rio Grande borders the Laboratory on the east. Rocks of the Bandelier Tuff cap the Pajarito Plateau. The tuff formed from volcanic ashfall deposits and pyroclastic flows erupted from the Jemez Mountains volcanic center approximately 1.2 to 1.6 million years ago. The tuff is more than 1,000 ft thick in the western part of the plateau and thins eastward to about 260 ft adjacent to the Rio Grande.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains (Figure 5-1). The Puye Formation conglomerate underlies the tuff beneath the central and eastern portion of the plateau. The Cerros del Rio basalt flows interfinger with the Puye Formation conglomerate beneath the Laboratory. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 ft thick.

2. Groundwater Occurrence

Los Alamos has a semiarid climate with average rainfall approximately 18.7 in. /yr. The plateau has ponderosa forest at higher elevations that gives way to piñon-juniper woodlands as elevation decreases. The plateau is separated into finger mesas by east-west-oriented canyons. These contain riparian vegetation and small streams that for the most part have short-lived or intermittent flow.

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 underflow of groundwater from the Sierra de los Valles appears to be the main source of recharge for the regional aquifer. 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.

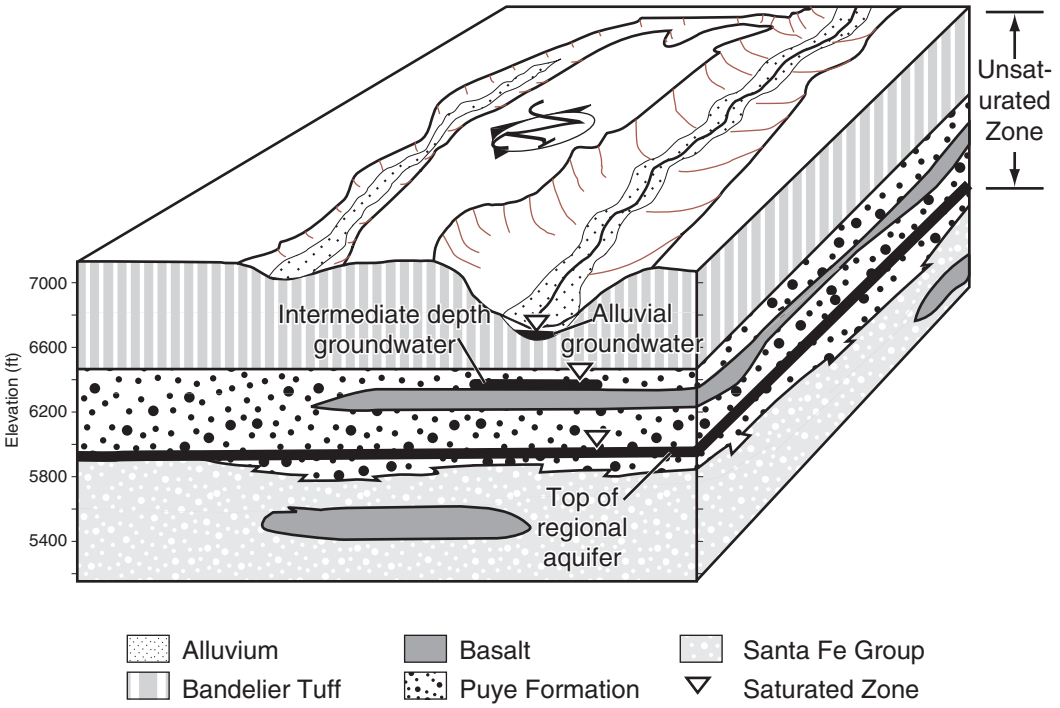


Figure 5-2. Illustration of geologic and hydrologic relationships in the Los Alamos area, showing the three modes of groundwater occurrence.

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, limit their volumetric contribution to recharge reaching the regional aquifer.

C. Groundwater Standards

We apply regulatory standards and risk levels to evaluation of groundwater samples according to the plan shown in Table 5-1. The regulatory standards that apply to concentrations of radionuclides in samples from the water supply wells, which draw water from the regional aquifer, are (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). (See Appendix A for a discussion of standards.) The regulatory standards that apply to radioactivity in samples from groundwater sources other than water supply wells are DCGs based on the DOE's 100-mrem public dose limit for water ingestion. 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 non-cancer causing substances. We used the EPA Region 6 tap water screening levels for

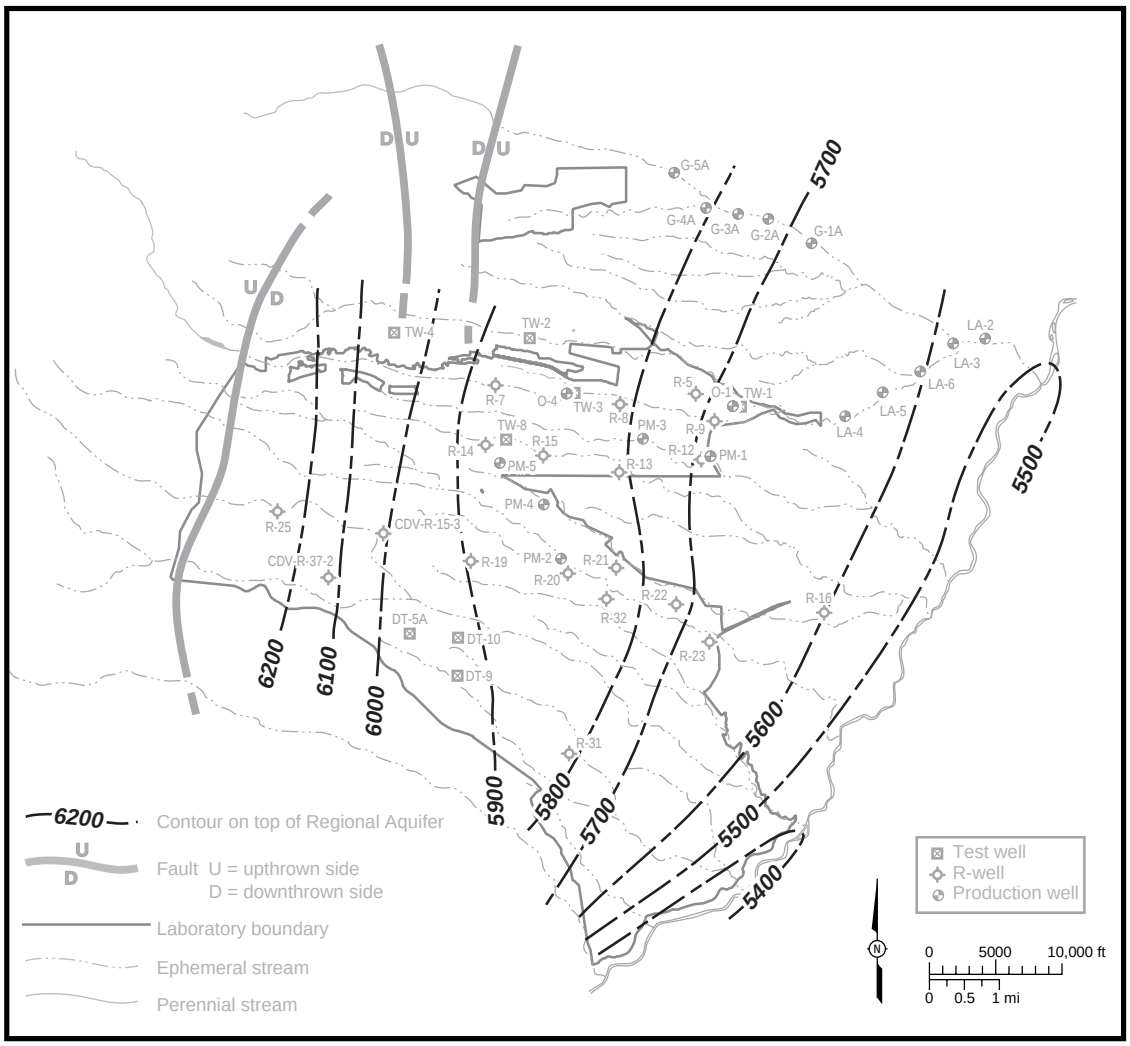


Figure 5-3. Generalized water level contours for the regional aquifer (Nylander et al. 2003).

screening the NMWQCC toxic pollutant compounds (*http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm*). For cancer-causing substances, the Region 6 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 used by tribal members and wildlife. 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. Overview of Groundwater Quality

1. Groundwater Contaminant Sources

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

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

Constituent	Sample Location	Regulatory Standard	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 NMAC, 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 NMAC, NMED Consent Order	On-site and off-site	All groundwater is protected by NMED regulations, 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

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 important 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 affected deeper intermediate perched groundwater and the regional aquifer to a lesser degree. 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.

2. Radioactive Liquid Waste Treatment Facility Discharges

Mortandad Canyon presently receives radioactive effluents from the Technical Area (TA) 50 Radioactive Liquid Waste Treatment Facility (RLWTF) from its tributary Effluent Canyon. Since the RLWTF began operating in 1963, the radionuclides in the RLWTF effluent have often exceeded the 100-mrem DOE public dose limit. The effluent also contains nitrate and fluoride that formerly caused perched alluvial groundwater concentrations to exceed the New Mexico groundwater standards of 10 mg/L (nitrate as nitrogen) and 1.6 mg/L. In April 1999, the RLWFT began operating a reverse osmosis and ultrafiltration system that removes additional radionuclides and nitrate from the effluent. Discharges from the plant now meet the New Mexico groundwater standards for nitrate and fluoride, and the RLWTF effluent has met the 100-mrem DOE DCGs continuously since December 10, 1999.

No perchlorate was detected in RLWTF effluent in 2003 at a method detection limit (MDL) of 2 ppb. The RLWTF started operating a system for removing perchlorate from the plant effluent on March 26, 2002. Before removal, perchlorate was measured in RLWTF effluent at annual average concentrations of 254 parts per billion (ppb) in 2000 and 169 ppb in 2001. During 2002, the year removal began, the annual average RLWTF effluent perchlorate concentration was 16 ppb, with none detected in the effluent after March 31, 2002.

E. Groundwater Contaminant Distribution at Los Alamos

The following sections provide an overview of the extent of groundwater contamination at the Laboratory. More detail on sources, contaminant history, and current monitoring results for each location is given in later sections of this chapter. The accompanying maps represent a synthesis of the last several years of groundwater data collected for Laboratory environmental monitoring and characterization programs. The discussion with the maps serves as a general overview to introduce groundwater contaminants, sources, and locations.

The 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 or indicate locations where analytical measurements suggest detections that are contradicted by other measurements. 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. Strontium-90 and Transuranics

Release of radioactive liquid effluents into DP Canyon, Los Alamos Canyon, and Mortandad Canyon has introduced strontium-90 into the alluvial groundwater that persists at levels above the 8-pCi/L EPA drinking water MCL, as indicated in Figure 5-5 (Rogers 2001). Strontium-90 has not been found in

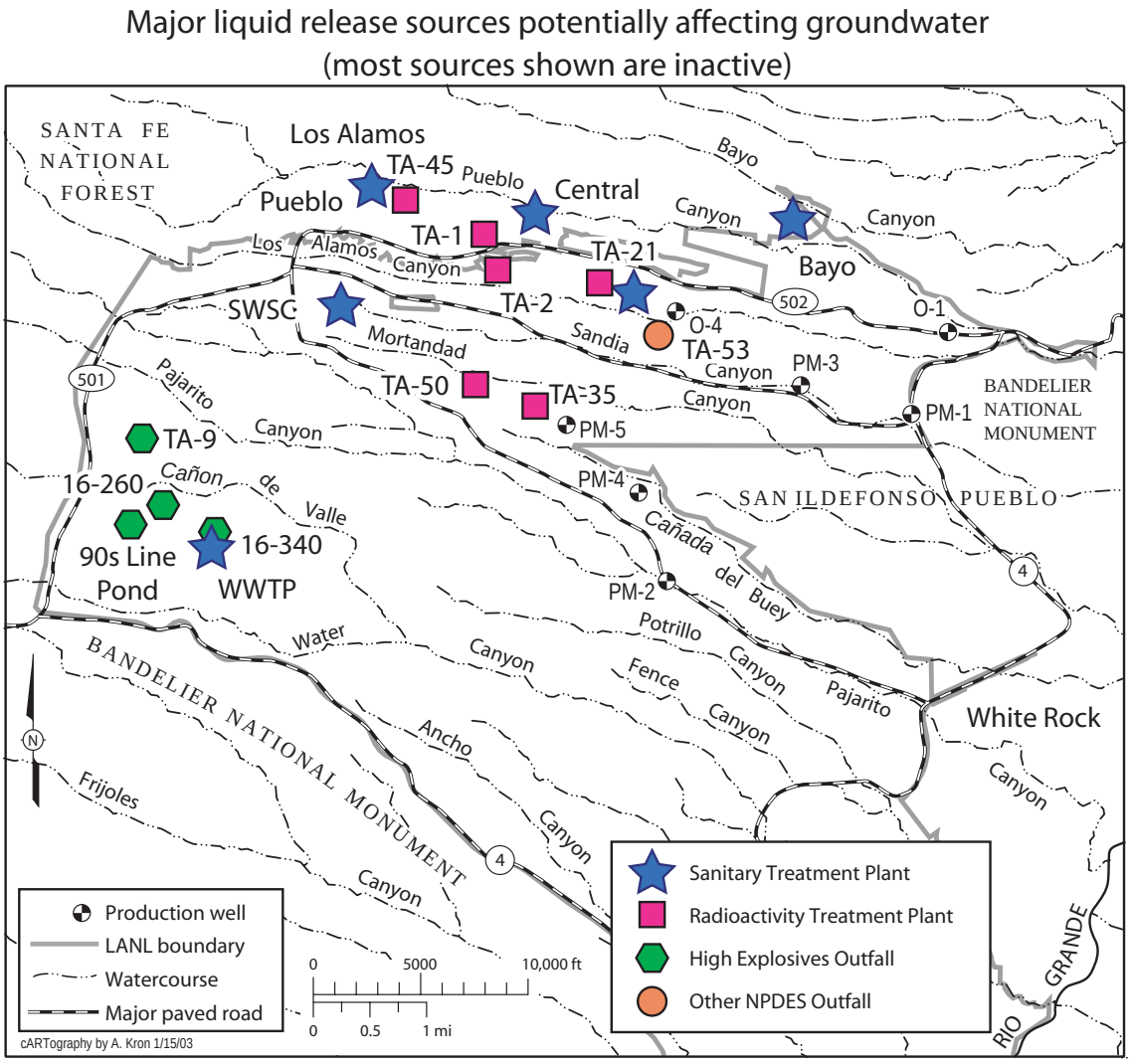


Figure 5-4. Major liquid release sources (effluent discharge) potentially affecting groundwater. Most sources shown are inactive.

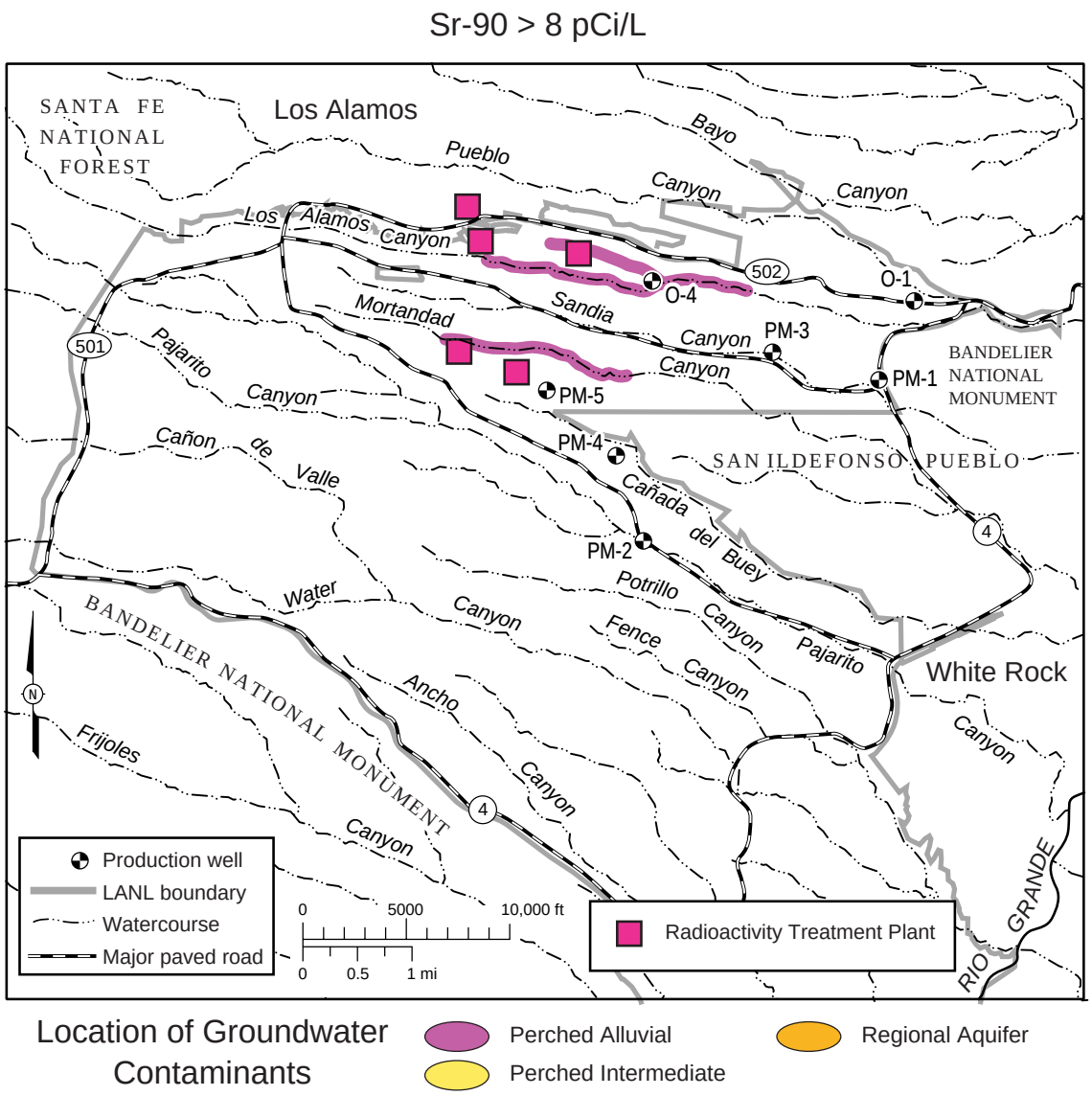


Figure 5-5. Location of groundwater contamination by strontium-90 above the 8 pCi/L EPA MCL. The maximum 2003 values in Mortandad and DP/Los Alamos Canyon alluvial groundwater were 10.2 and 7.6 times the MCL, respectively. Different colors indicate the affected groundwater zones. Along canyons, the extent 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.

deeper groundwater. In almost every intermediate perched or regional aquifer sample, no strontium-90 is detected; the occasional detections are analytical outliers and not repeatable. The discharge from the RLWTF into Mortandad Canyon creates a localized area of alluvial groundwater with plutonium-238; plutonium-239,240; and americium-241 measured above the 4-mrem DOE DCG for drinking water (although this water is not used for drinking). (See Figure 5-6.)

2. Nitrate and Perchlorate

Until recently, the RLWTF discharge also contained perchlorate and nitrate at high levels. Before effluent quality improvement in 1999, the discharge caused nitrate (as nitrogen) levels in alluvial and intermediate perched groundwater in Mortandad Canyon to exceed 10 mg/L, the New Mexico groundwater standard (Figure 5-7). Before additional treatment was added in 2002, perchlorate concentrations in these groundwater zones reached 200 ppb, well above the EPA Region 6 risk level of 3.7 ppb (which corresponds to HI = 1). Perchlorate was present in Mortandad Canyon alluvial and intermediate groundwater at concentrations up to 150 ppb in 2002 and 2003 (Figure 5-8). In 2003, perchlorate was detected in a regional aquifer monitoring well in Mortandad Canyon at 4.8 ppb using the liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS) analytical method. Beginning in late 2003, our detection limit for perchlorate, using the LC/MS/MS method, is 0.2 ppb (compared with 4 ppb for the ion chromatography [IC] method, EPA method 314). Perchlorate was also found in alluvial groundwater in Cañon de Valle in 2000.

In Pueblo Canyon, nitrate (as nitrogen) has been found in previous years above 10 mg/L in alluvial and intermediate perched groundwater. Samples in one regional aquifer monitoring well consistently show nitrate at approximately 5 mg/L (6.1 mg/L in Test Well 1 in 2003). The nitrate is likely from the Bayo Canyon sanitary wastewater treatment plant, but it may also have come from past Laboratory radioactive effluent discharges into Acid Canyon. These Acid Canyon discharges also probably contained large concentrations of perchlorate, based on a similarity of past Laboratory activities to present operations. Perchlorate is found within the regional aquifer in Pueblo Canyon, notably in water supply well O-1. In prior years, a few perchlorate values from this well reached 5 ppb, but most were slightly below the 4-ppb detection limit of the IC method. In 2003, the maximum was 4.3 ppb with the IC method and 2.8 ppb using the LC/MS/MS method. O-1 also contains a consistent 35–45 pCi/L of tritium and higher nitrate (as nitrogen) than any other regional aquifer well. O-1 nitrate (as nitrogen) has been about 1.7 mg/L compared with approximately 0.5 mg/L in other water supply wells.

3. Tritium

During the last 10 years, tritium has been found above the 20,000 pCi/L EPA MCL at the Laboratory only in alluvial groundwater in Mortandad Canyon. At the end of 2000, the RLWTF adopted a voluntary goal of having tritium activity in its effluent below 20,000 pCi/L. Average annual tritium activity in the RLWTF effluent dropped below 20,000 pCi/L in 2001 and was 10,400 pCi/L in 2003. Tritium activity in alluvial groundwater downstream has dropped correspondingly and been below the MCL since 2001, with a maximum value 8,770 pCi/L in 2003. Underlying intermediate perched groundwater showed tritium at nearly 15,000 pCi/L at a 500-ft depth during 2002. In the regional aquifer, the source of drinking water, wells have shown tritium at up to 80 pCi/L in Test Well 8, well below the EPA MCL. Fourteen subsequent measurements from Test Well 8 between 1995 and 1996 averaged 12 pCi/L. Nearby monitoring well R-15 had 18 pCi/L.

Elsewhere in the Laboratory, tritium has been found in the intermediate perched groundwater and the regional aquifer at trace levels (up to about 360 pCi/L) in locations that include Pueblo, Los Alamos, and Sandia canyons and TA-16 in the southwest portion of the Laboratory. In the past, alluvial groundwater in Los Alamos Canyon has shown significant tritium levels from effluent discharges and the Omega West Reactor leak, but tritium activity has fallen below a few hundred pCi/L in recent years. Rogers (1998) summarized the occurrence of tritium in groundwater at the Laboratory.

4. Molybdenum

A short section of alluvial groundwater in Los Alamos Canyon has molybdenum concentrations near or above the New Mexico groundwater standard of 1,000 µg/L (Figure 5-9). The highest value in 2003

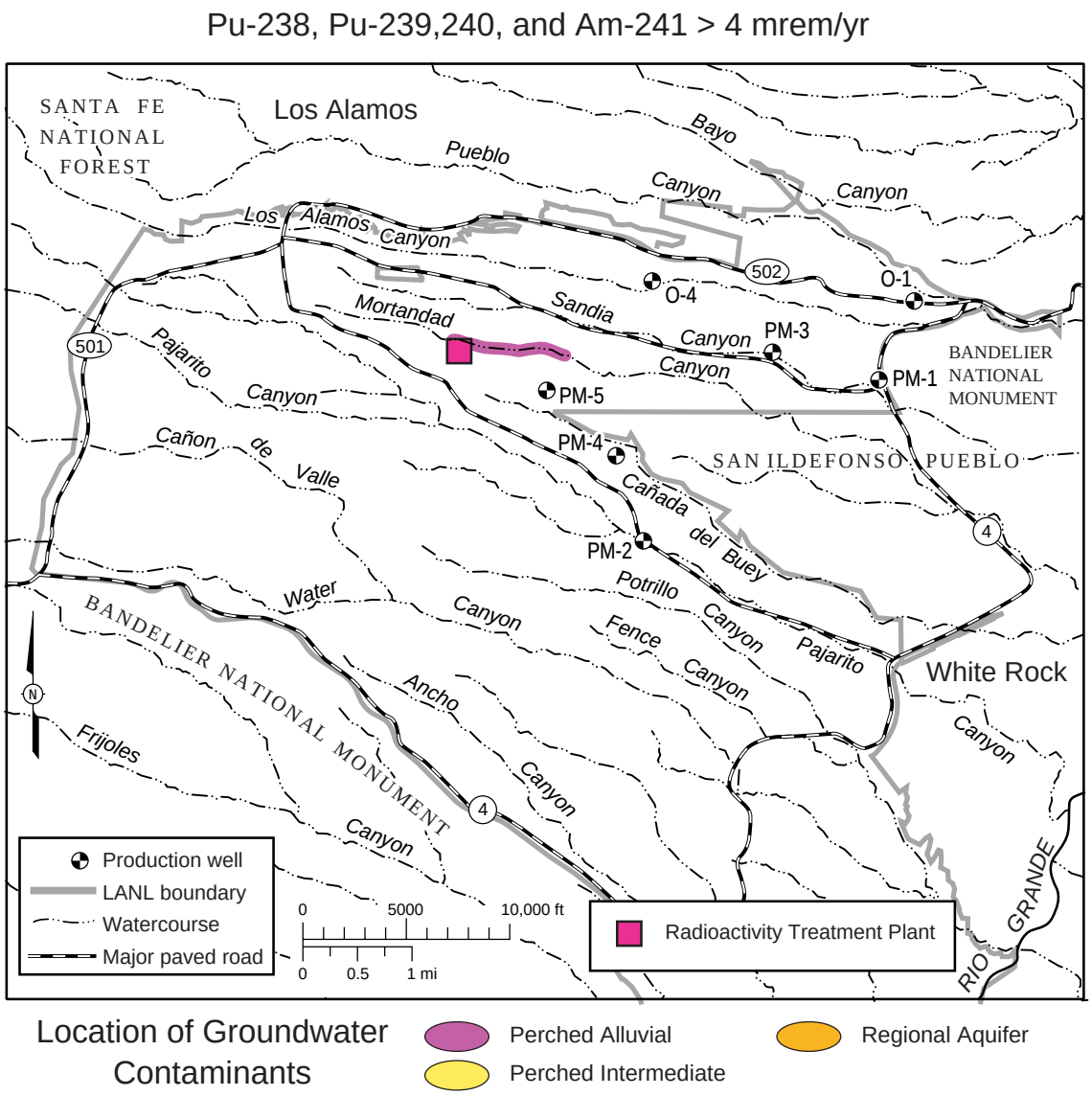


Figure 5-6. Location of groundwater contamination by plutonium-238; plutonium-239,240; and americium-241 above the 4-mrem DOE DCG for drinking water. The 2003 maximum values in Mortandad Canyon alluvial groundwater for plutonium-238; plutonium-239,240; and americium-241 were 1.4, 1.3, and 1.4 times the 4-mrem limit, respectively. Different colors indicate the affected groundwater zones.

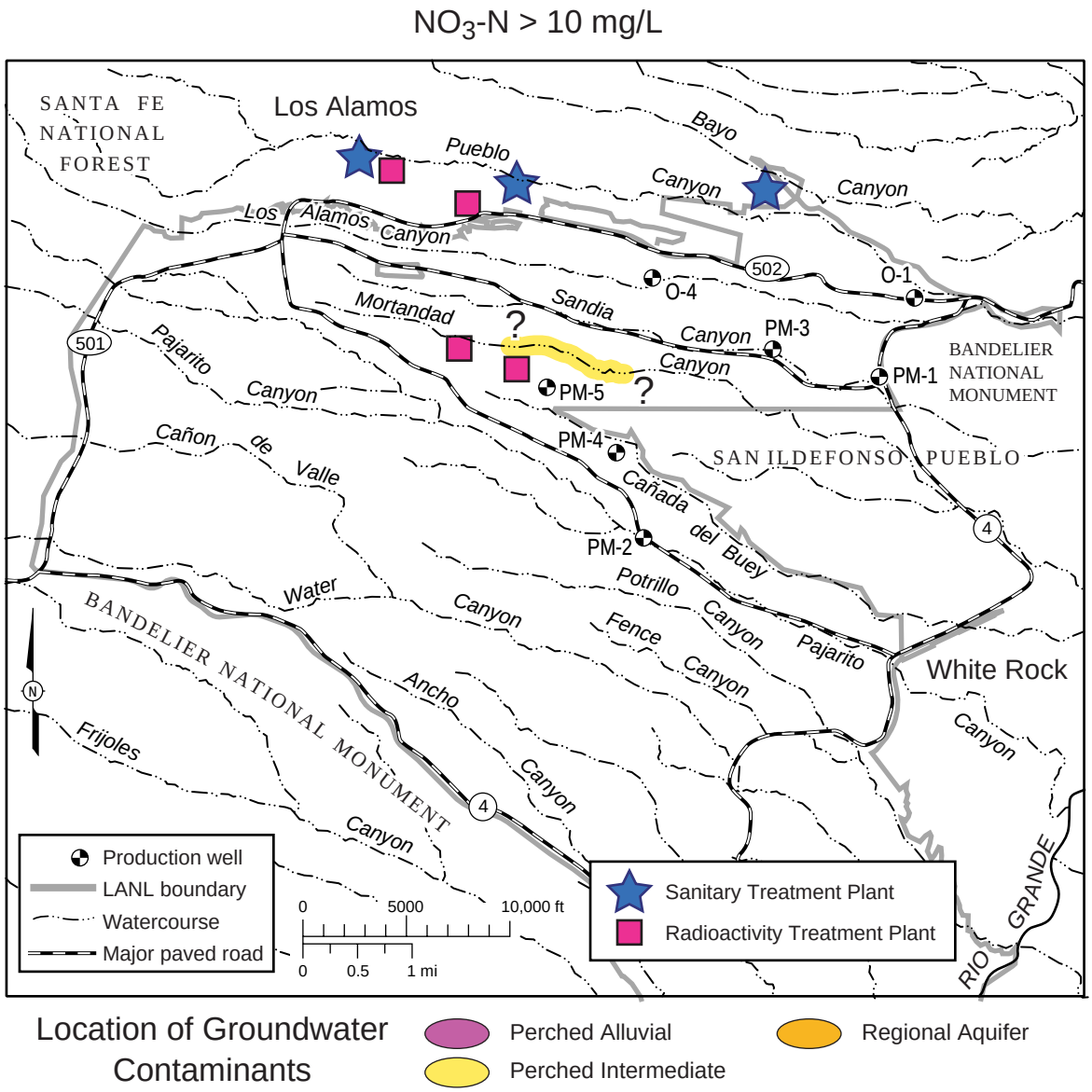


Figure 5-7. Location of groundwater contamination by nitrate (as nitrogen) above the 10 mg/L EPA MCL. Maximum values in Mortandad Canyon were 80% of the MCL in alluvial groundwater during 2003 and 132% of the MCL in intermediate groundwater during 2002. In Pueblo Canyon, maximum values in alluvial and intermediate groundwater and the regional aquifer were 22%, 39%, and 61% 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.

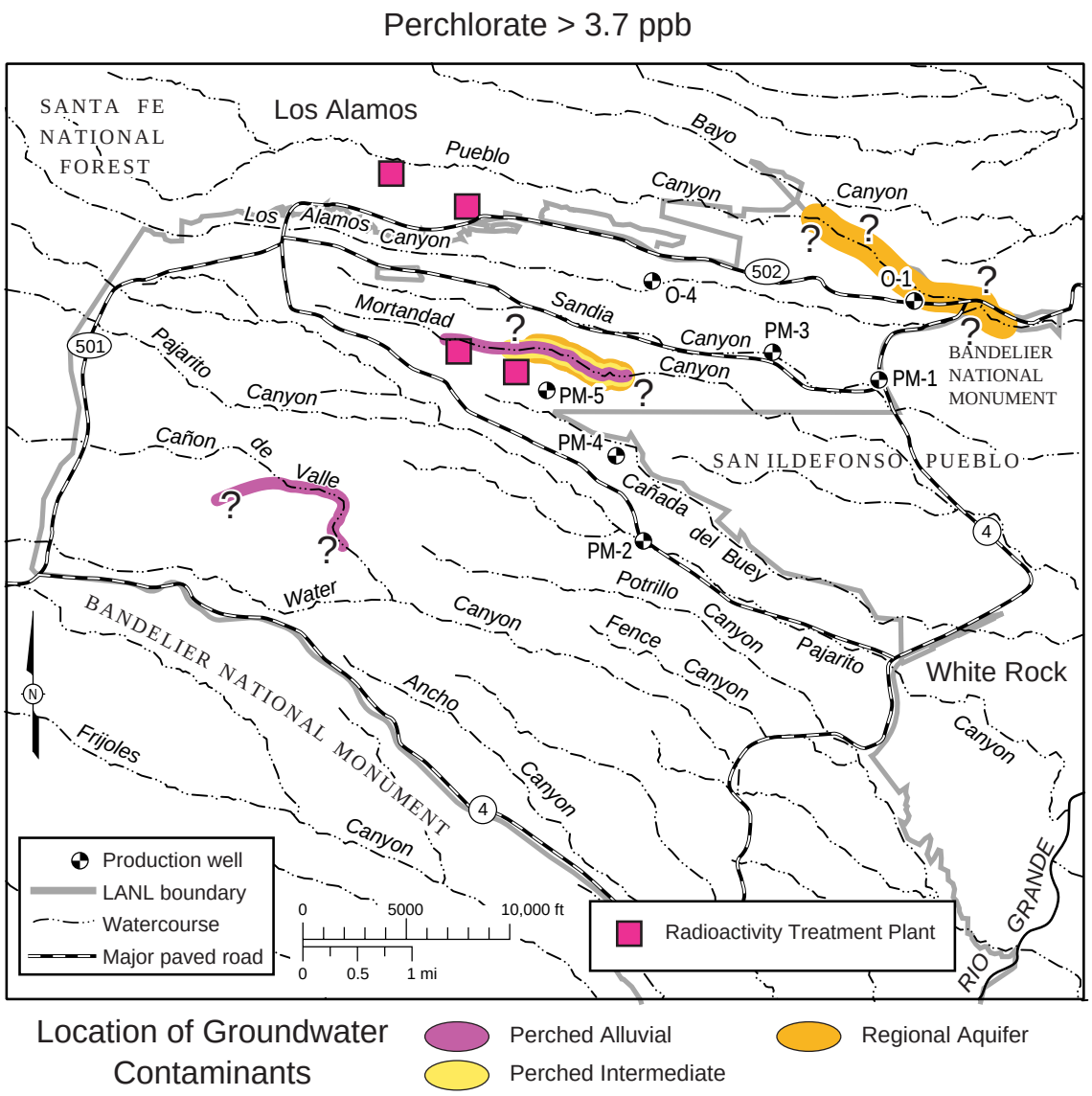


Figure 5-8. Location of groundwater contamination by perchlorate above the 3.7 ppb EPA Region 6 risk level. Maximum values in Mortandad Canyon were 148 ppb in alluvial groundwater during 2003 and 142 ppb in intermediate groundwater during 2002. In Pueblo Canyon regional groundwater the maximum was 4.3 ppb with the IC method and 2.8 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.

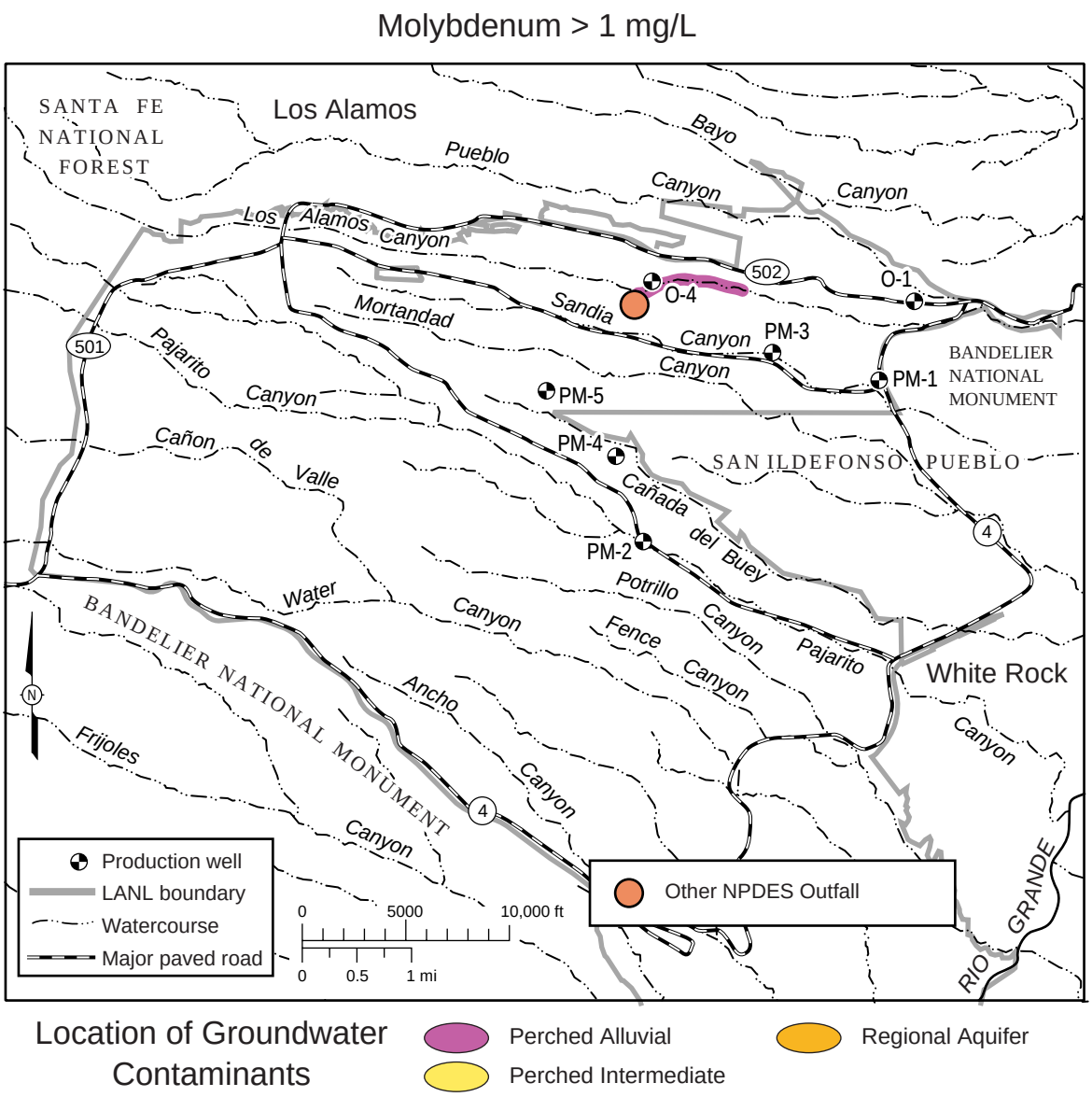


Figure 5-9. Location of groundwater contamination by molybdenum above the 1 mg/L New Mexico Groundwater Standard for Irrigation Use. The maximum 2003 value in Los Alamos Canyon alluvial groundwater was 82% of the groundwater standard. Different colors indicate the affected groundwater zones.

was 82% of the New Mexico standard. The source of this molybdenum is sodium molybdate, a water-treatment chemical commonly used in cooling towers. Historically, sodium molybdate was used as a tracer in managing water chemistry in three cooling towers at TA-53. These cooling towers have recently been replaced with two new cooling towers. The Laboratory discontinued use of sodium molybdate in June 2002.

5. High-Explosives and Barium

The Laboratory formerly released wastewater from several HE processing sites in TA-16 and TA-9 into Water Canyon and Cañon de Valle (a tributary). Alluvial groundwater in Cañon de Valle shows barium above 1 mg/L, the New Mexico groundwater standard (Figure 5-10), and RDX above 6.1 ppb, an EPA risk-based groundwater action level. This EPA tap water screening level corresponds to a 10^{-5} excess cancer risk. Intermediate perched groundwater in this area also shows RDX above 6.1 ppb (Figure 5-11).

F. 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 5-12 and 5-13). The springs and wells are described by Purtymun (1995) and Nylander et al. (2003). 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 sample the regional aquifer (except Basalt Spring, an intermediate groundwater sampling point) and are shown in Figure 5-14.

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. New wells, 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 in 2002 and 2003.

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.

RRES-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 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 (SDWA) requirements. This chapter reports on supplemental SDWA sampling carried out by RRES-WQH. Koch and Rogers (2003) summarized operation of the water supply system for the years 1998–2001. Additional regional aquifer samples come from wells located on 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. Larger White Rock Canyon springs and springs on San Ildefonso Pueblo lands are sampled annually, with the remainder scheduled for sampling in alternate years.

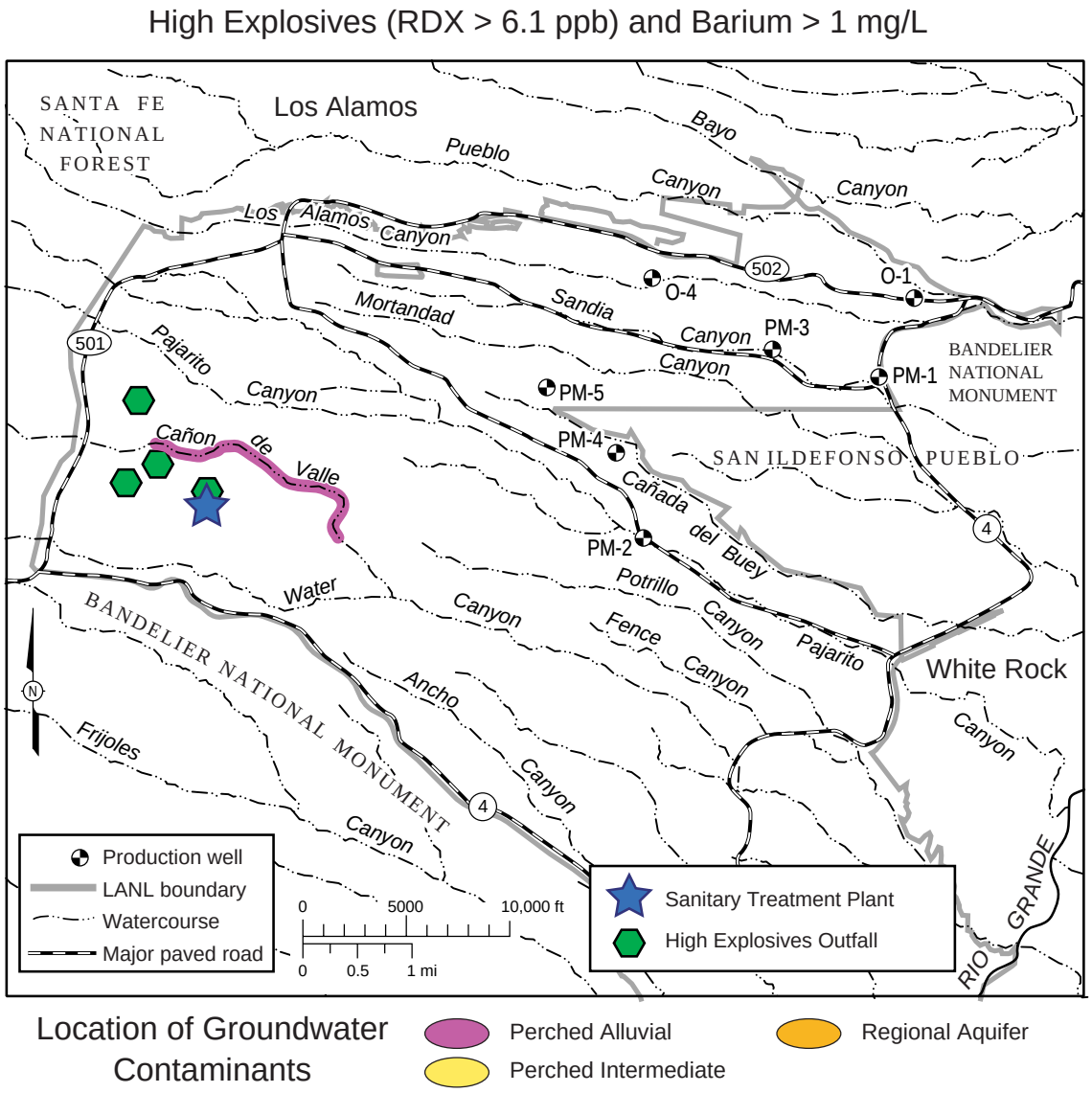


Figure 5-10. Location of groundwater contamination by RDX above the EPA Region 6 screening level of 6.1 ppb and barium above the New Mexico groundwater standard of 1 mg/L in perched alluvial groundwater. This map is based on data obtained by the Environmental Restoration Project. Different colors indicate the affected groundwater zones.

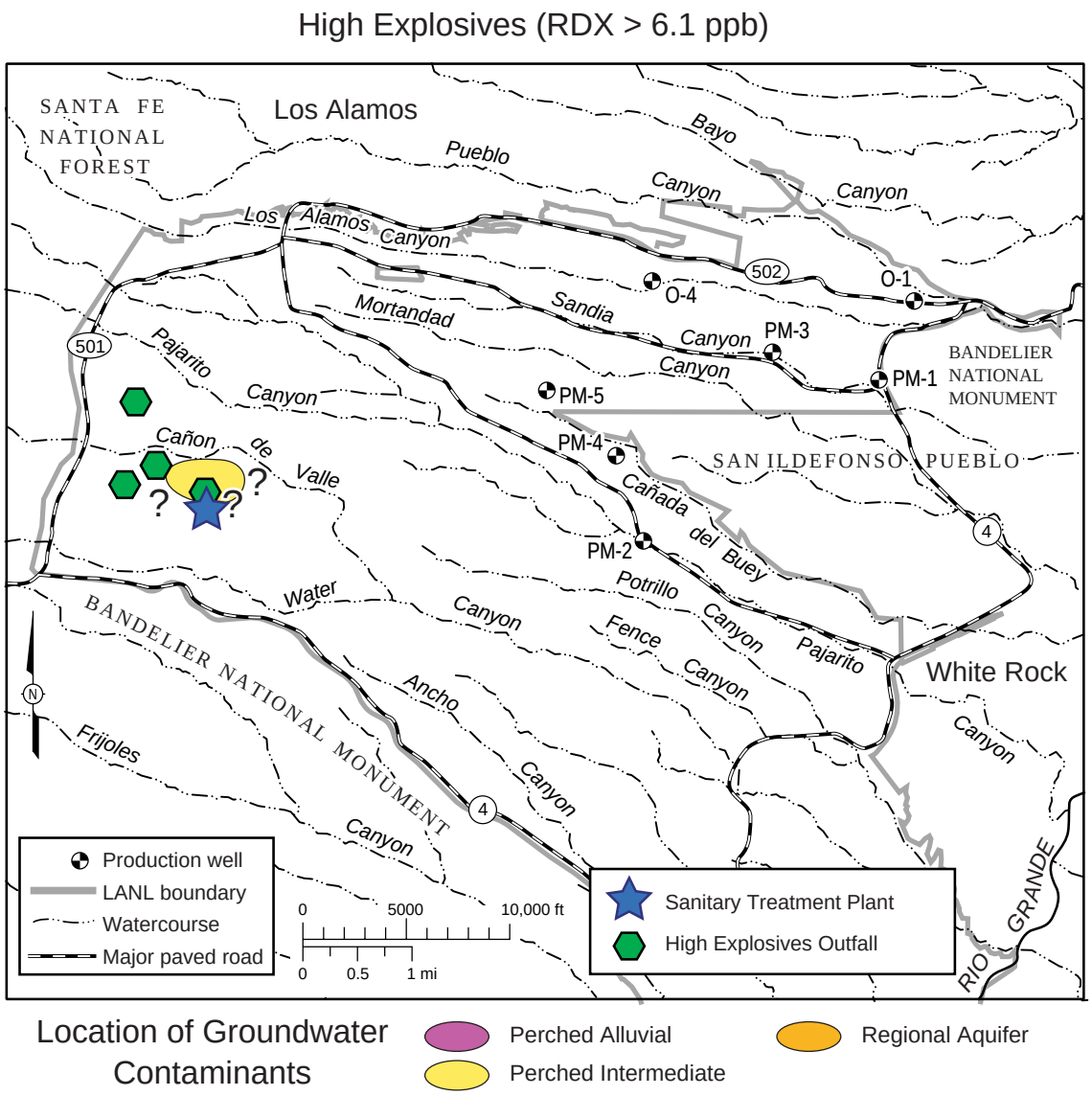


Figure 5-11. Location of groundwater contamination by RDX above the EPA Region 6 screening level of 6.1 ppb in perched intermediate groundwater. Maximum 2003 values for RDX in intermediate groundwater at well R-25 were 9 to 12 times the 6.1 ppb EPA Region 6 10^{-5} excess cancer risk screening level. Different colors indicate the affected groundwater zones.

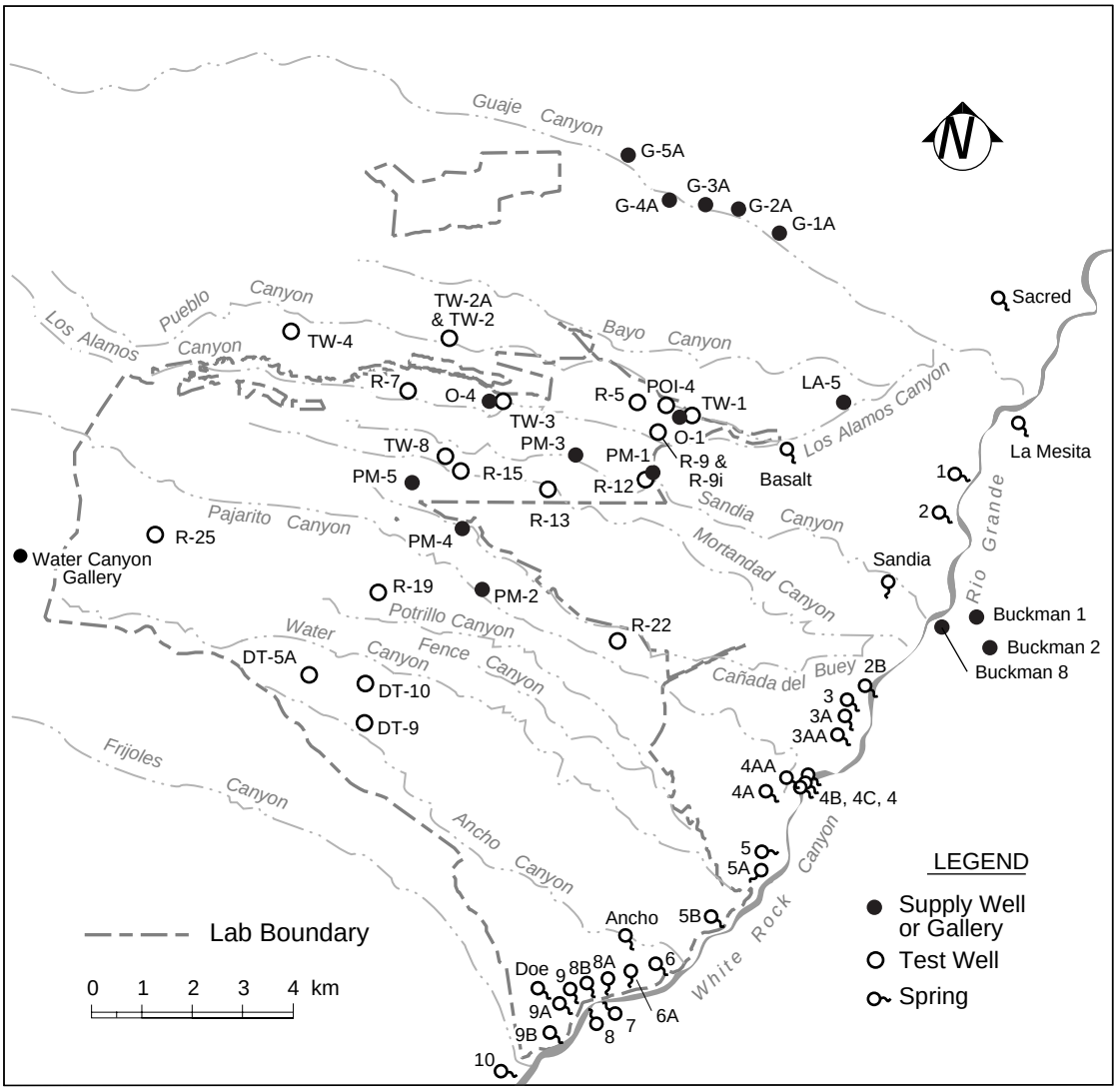


Figure 5-12. Springs and wells used for intermediate perched and regional aquifer monitoring.

2. Alluvial Groundwater Monitoring

To determine the effect of present and past industrial discharges on water quality, RRES-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. Many alluvial wells that might ordinarily hold water could not be sampled in 2003 because of the particularly dry conditions during the winter and summer.

G. 2003 Groundwater Sampling Results

For scheduling reasons, some of our calendar year sampling for 2003 extended into early 2004, so data from both years appear on the data tables. A column on the data tables identifies the groundwater zones sampled, whether alluvial, intermediate, or regional, and indicates if the location is a spring. For wells with several sampling ports, the saturated zone sampled and the port depth appear in the table. We

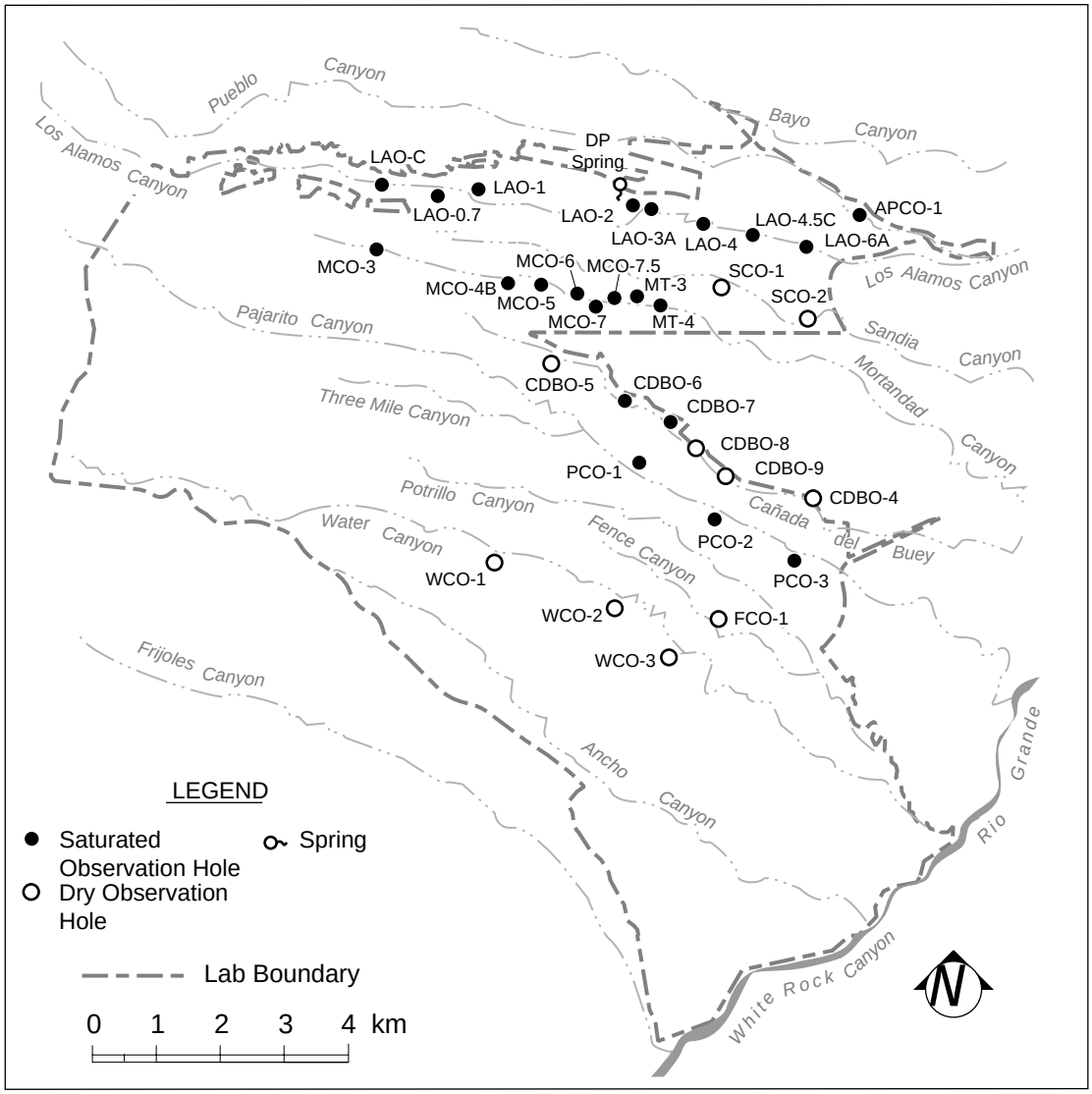


Figure 5-13. Springs and wells used for alluvial groundwater monitoring.

exclude from the data tables values that are R qualified ([Inorganic] -The data are not usable. [Organic] - The data are unusable [compound may or may not be present.] Resampling and reanalysis is necessary for verification) or X qualified (reported concentration is a false positive) by the analytical laboratory or during secondary validation.

Table S5-1 in the Data Supplement lists the results of radiochemical analyses of groundwater samples for 2003. The table also lists the total propagated one-sigma (one standard deviation) analytical uncertainty and the analysis-specific minimum detectable activity (MDA), where available. Uranium was analyzed by isotopic methods and chemical methods for total uranium; total uranium is also calculated in the table from the isotopic values using specific activities for each isotope.

Table S5-2 shows low-detection-limit tritium results from analyses done by the University of Miami.

To emphasize analytical results that are detections, Table S5-3 in the Data Supplement lists radionuclides detected in groundwater samples. Detections are defined as values that exceed both the analytical method detection limit (where available) and three times the individual measurement uncertainty. Qualifier codes are shown in Table S5-3 because some analytical results that meet the

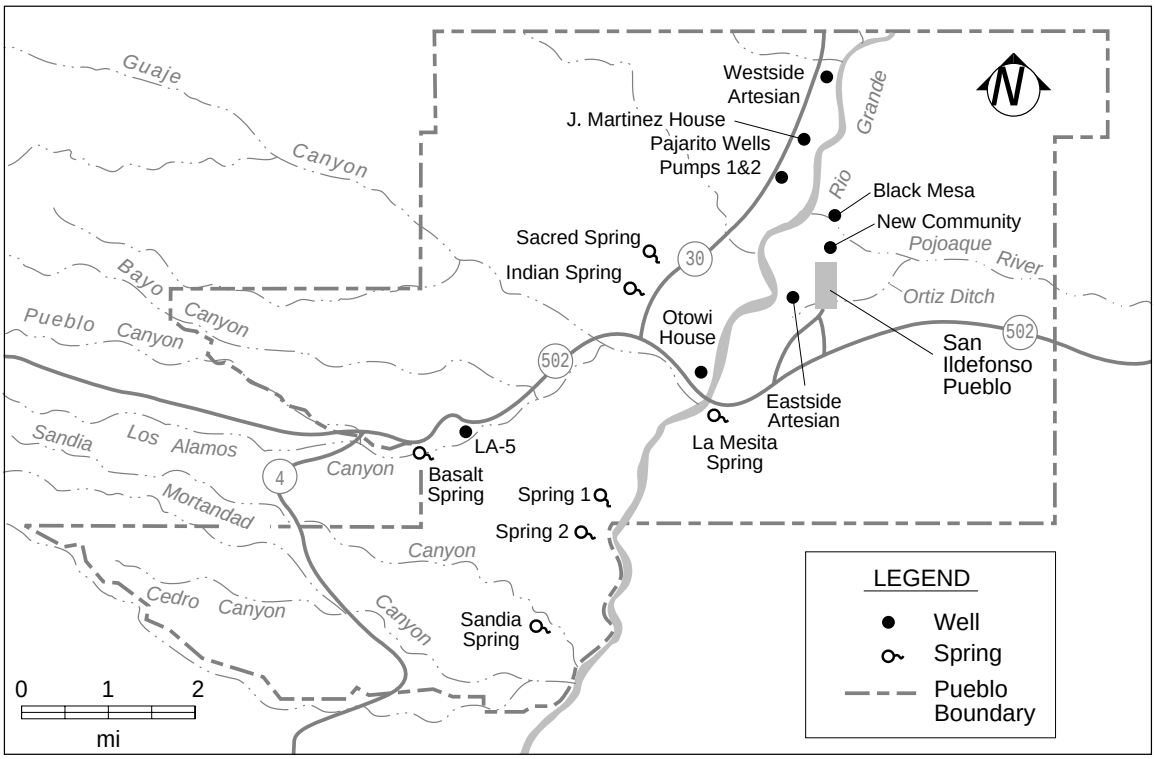


Figure 5-14. Springs and wells used for groundwater monitoring on San Ildefonso Pueblo.

detection criteria are not detections: in some cases, for example, the analyte was found in the laboratory blank. In others, the result was below the method detection limit, but the analytical result was reported as the MDA. The table shows two categories of qualifier codes: those from the analytical laboratory and those from secondary validation (Tables S5-4, S5-5, and S5-6 in the Data Supplement).

Because gross alpha and gross beta are usually detected, Table S5-3 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 S5-3 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 standards shown. The DCGs assume that the radioactivity comes solely from americium-241 and plutonium-239,240 for gross alpha, or from strontium-90 for gross beta, and are thus conservative.

Table S5-7 in the Data Supplement lists the results of general chemical analyses of groundwater samples for 2003. Table S5-8 lists groundwater perchlorate results. The value for the IC perchlorate MDL (EPA:314.0) is 4 ppb according to our independent analytical laboratory, although the table gives smaller values for some results. The value for the LC/MS/MS method (SW-846:8321A(M)) detection limit is variously given by the analytical laboratory as 0.05 ppb and 0.2 ppb, with the latter value sometimes referred to as the reporting limit or level of quantitation. See the Quality Assurance (QA) section (section 5.J) for a further discussion of these methods and a performance study of the LC/MS/MS method. The results of trace metal analyses appear in Table S5-9.

In 2003, RRES-WQH personnel analyzed samples from selected springs and monitoring wells for organic constituents (this sampling is summarized in Table S5-10 in the Data Supplement). Samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), diesel-range organics (DROs), and HEs. Analytical methods are given in Appendix A, Table A-4; and analytes for each suite are listed in Appendix A, Tables A-5 through A-8. RRES-WQH personnel 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 samples, including equipment and trip blanks. Equipment blanks use distilled water in 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 S5-11 in the Data Supplement shows organic compounds detected above the analytical laboratory's reporting level in 2003, as well as results from field quality-control (QC) samples.

In the following sections, we discuss the results for each of the three groundwater modes in the major watersheds that encompass the Laboratory.

1. Overview of 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 gross alpha from springs and wells in this area is from the decay of naturally occurring uranium in the water. The only value that exceeded half the 100-mrem DOE public dose DCG values in 2003 was for gross alpha in a City of Santa Fe water supply well (not from a LANL source). The EPA MCL for gross alpha does not apply because it does not include contribution to gross alpha by uranium. Uranium is covered by a separate 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, although the gross alpha values at several monitoring wells in Mortandad Canyon reached 20% to 40% of the public dose DOE DCG. Only results for americium-241; strontium-90; plutonium-238; and plutonium-239,240 values from alluvial groundwater in Mortandad and DP/Los Alamos canyons and uranium-234 and uranium-238 values in Buckman well No. 2 exceeded the 4-mrem DOE DCGs applicable to drinking water. Strontium-90 exceeds the 8-pCi/L EPA MCL in alluvial groundwater by a factor of over 10 in DP and Los Alamos canyons and by a factor of up to 7.5 in Mortandad Canyon. Uranium is present at up to 65% of the EPA MCL in Spring 2B along the Rio Grande. Isotopic measurements indicate this uranium is of natural composition.

A large number of americium-241 detections occurred during 2003 in samples from regional aquifer monitoring or supply wells. Reanalysis of these samples did not confirm the original detections, and in many cases duplicate laboratory analysis or analysis of field duplicates produced nondetects. Thus, there appear to have been a number of americium-241 false positives in water samples during 2003.

2. Overview of Perchlorate in Groundwater

LANL and the New Mexico Environment Department (NMED) DOE Oversight Bureau (DOB) began investigating use of the LC/MS/MS method to replace the IC method in 2001. The goal was to find a method that improved the MDL over the 4 ppb MDL of the IC method, in this case to less than 0.2 ppb. Performance issues delayed implementation of the LC/MS/MS method for regular analysis of samples. In late 2003, LANL began using both methods for all perchlorate measurements in water. LANL and the NMED DOB conducted a performance study of the LC/MS/MS method (summarized in the QA section [section 5.J]) during 2003. This study found perchlorate in every groundwater sample analyzed from across northern New Mexico, at levels ranging from 0.12 to 0.66 ppb with a mean of 0.27 ppb. This result suggests that perchlorate may have 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 does not appear to be related to any known perchlorate sources.

3. 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 S5-2). 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-1A and G-2A had arsenic at about 14% and 18%, respectively, of the EPA MCL of 50 ppb. For the new MCL of 10 ppb which will be effective in 2006, these values would be 70% and 90% of the MCL. Using the LC/MS/MS method, perchlorate was found in each well at concentrations ranging from 0.27 to 0.37 ppb. No strontium-90 was detected during sampling. Chloromethane was found in samples from G-1A and G-3A and butanone [2-] in G-1A. Both compounds were found in a field blank collected during the sampling trip indicating possible field sample contamination. In G-1A, the compounds were found in a field duplicate but not the corresponding sample, further casting doubt on the detections. Each supply well was tested for HE with no compounds detected.

4. 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. Fifteen low-detection-limit tritium results for supply well O-1 averaged 45.7 pCi/L, indicating a subdued effect of past tritium-bearing surface water recharge on tritium activity at the regional aquifer. As described earlier, in 2003, O-1 samples showed perchlorate at 4.3 ppb with the IC method and 2.8 ppb using the LC/MS/MS method, and O-1 also has above-background nitrate. Because of a leaking fuel tank found at TA-21 during 2002, well O-1 was tested monthly for DROs; the DRO compound was found at a low level only in January 2004 but not in other samples suggesting a false positive. O-1 was also tested once for HE with no detections. Test Well 1 showed nitrate (as nitrogen) at 61% of the 10-mg/L EPA MCL in the regional aquifer.

Past Test Well 1 samples have shown tritium at 277 pCi/L to 360 pCi/L. In 2003, a Test Well 1 sample showed 3.5 pCi/L. For a Test Well 8 sample, collected in the same batch, one result was 140 pCi/L, while a field duplicate at Test Well 8 indicated 4 pCi/L. It is likely that this 140 pCi/L value applies to Test Well 1 and that the bottles were switched at some point: values near 4 pCi/L (apparently found for Test Well 1) are more in line with most results from Test Well 8, which has averaged about 12 pCi/L. Test Well 4 was a nondetect for tritium at an MDA of 1 pCi/L, consistent with previous data.

Test Well 1 and Test Well 4 have shown levels of iron, lead, and manganese in the range of the EPA MCLs. These levels were related to aging steel and galvanized well components. Test Well 1 showed high levels of aluminum, iron, and lead in 2003.

Intermediate well POI-4 had a detection of plutonium-239,240 in a performance evaluation blank but not in the well sample. Alluvial well APCO-1 had strontium-90 at 6% of the 8-pCi/L EPA MCL. The Cerro Grande fire impacted the Pueblo Canyon watershed heavily, causing high manganese, aluminum, and iron concentrations in the range of EPA Secondary MCLs in many surface water and shallow perched alluvial groundwater samples. Alluvial well APCO-1 again had elevated manganese and iron concentrations in the range of EPA Secondary MCLs. The well also had boron at 56% of the New Mexico groundwater standard, likely because of sanitary effluent from the Los Alamos County wastewater treatment plant. Dimethyl phthalate, a plasticizer commonly introduced during laboratory sample analysis, was also found in samples from this well.

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 that contained 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.

In the regional aquifer sample from Test Well 3, cesium-137 was found in one sample but not in a duplicate or reanalysis, a finding that suggests that the detection is a false positive. Test Well 3 had a nondetect for tritium at the 1 pCi/L MDA; 12 past values have ranged from nondetect to 52 pCi/L. Regional aquifer well R-9 had 21 pCi/L of tritium, suggesting a slight impact of recent surface recharge (Blake et al. 1995). The two intermediate horizons in R-9i had tritium values of about 233 pCi/L and 110 pCi/L, indicating a subdued impact from surface recharge. Supply well O-4 had a nondetection for tritium, below the MDA of 1 pCi/L. The tritium values for these latter three wells are consistent with previous data.

Supply well O-4 had perchlorate detected at 0.39 ppb using the LC/MS/MS method, similar to other supply wells in northern New Mexico. Wells R-7, R-9, and R-9i showed high levels of iron and manganese in the range of EPA Secondary MCLs. These metal concentrations are a temporary effect of well construction (Longmire 2002a, Longmire and Goff 2002). As with other older monitoring wells, Test Well 3 has high iron, lead, and manganese in the range of EPA MCLs because of aging steel and galvanized well components but did not show these constituents in 2003 sampling. Test Well 3 showed a low level of di-n-butylphthalate, a plasticizer probably introduced during laboratory analysis or sampling. Supply well O-4 was tested twice for HE and monthly for DRO; the DRO compound was found at a low level only in December 2003 suggesting a false positive. Basalt Spring showed bis(2-ethylhexyl)phthalate in a sample; however, this compound was also found in the performance blank suggesting contamination during analysis or by sampling equipment.

Alluvial groundwater in DP and Los Alamos canyons continues to show strontium-90 at 2.6 to 7.6 times the 8-pCi/L EPA MCL. The strontium-90 value in DP Spring also exceeded the 4-mrem DOE DCG for drinking water dose. Tritium was barely detectable at a 150-pCi/L detection limit, in contrast to values of 10,000 to 100,000 pCi/L in previous decades (Rogers 1998). Americium-241 was detected at 8% of the 4 mrem DCG in DP Spring near the mouth of DP Canyon. DP Spring showed fluoride at about half the New Mexico groundwater standard. High manganese, aluminum, and iron concentrations (in the range of EPA Secondary MCLs) have reflected Cerro Grande fire effects on water quality; aluminum and iron also correlate to turbidity in the water samples (Riebsomer 2003). In 2003, only DP Spring had high iron levels, and only alluvial monitoring well LAO-0.7 had high manganese.

Molybdenum in alluvial groundwater in Los Alamos Canyon decreased to 82% of the 1-mg/L New Mexico groundwater standard in monitoring well LAO-3A during 2003 from 250% of the limit in 2002 (Figure 5-15). 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 in part because of a large range in stream flow caused by drought conditions.

Acetone was found in samples from DP Spring and LAO-1. Acetone is commonly found as a false positive because it is used in laboratory analysis. Isopropyltoluene[4-] was found at a low level in LAO-2.

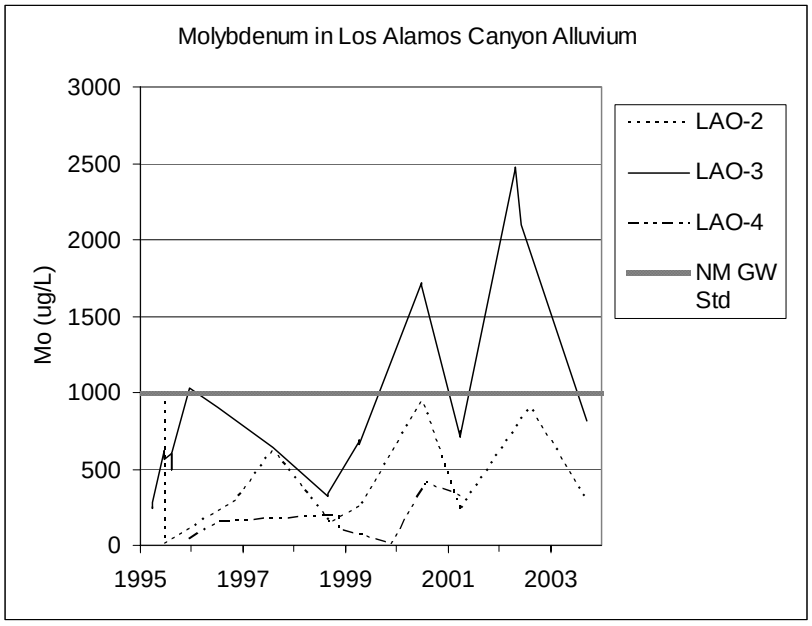


Figure 5-15. Molybdenum histories in Los Alamos Canyon alluvial groundwater compared with the New Mexico groundwater standard.

5. 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.

Supply well PM-1 had an apparent detection of americium-241, but reanalysis of the sample indicated a nondetect. Well R-12 at the eastern Laboratory boundary had low levels of tritium in two intermediate zones and the regional aquifer, indicating a slight effect on these horizons by recent recharge. Samples from supply well PM-3 showed no tritium using the 1 pCi/L detection limit.

Perchlorate was found in samples from PM-1 and PM-3 at concentrations of 0.4 to 0.5 ppb using the LC/MS/MS method. 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 monthly for DROs and less frequently for HE; no HE compounds were detected. One detection of DRO at a low level occurred but is likely a false positive based on nondetections in the other samples.

6. 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 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 here have ever contained water. Because treated effluent from the Laboratory's SWS 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.

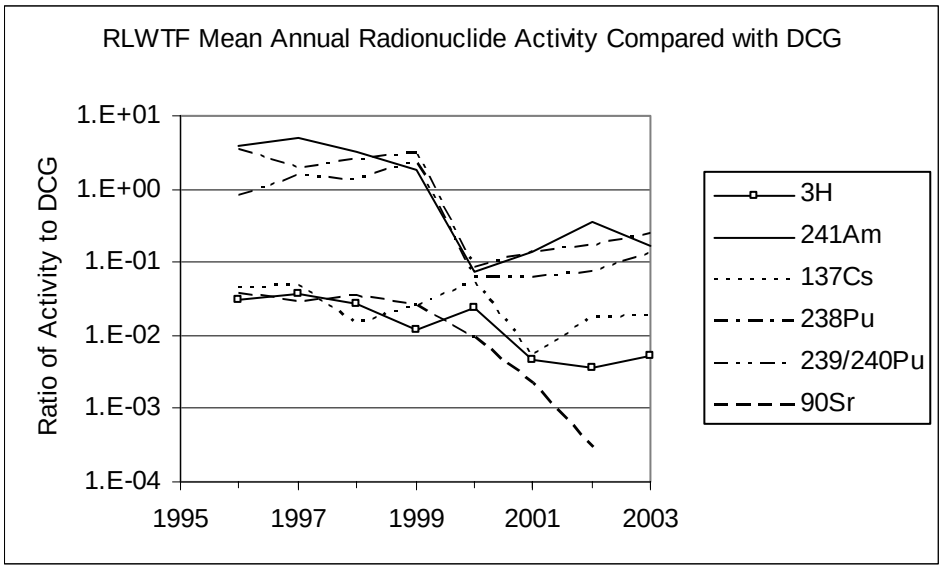
a. 2003 Radioactive Liquid Waste Treatment Facility Discharges. The yearly discharge data for radionuclides from 2001 through 2003 by the RLWTF into Mortandad Canyon appear in Table S5-12 in the Data Supplement. Table S5-12 also shows mean annual levels in effluent for each radionuclide and the ratio of this to the 100-mrem DOE DCG for public dose. Figure 5-16 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 new reverse osmosis and ultrafiltration system began operating at the RLWTF in April 1999. This system is designed to remove additional radionuclides from the effluent and to ensure 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 the end of 2000, the RLWTF adopted a voluntary goal of tritium activity below 20,000 pCi/L in its effluent. 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 fallen below 20,000 pCi/L (which is 1% of the public dose DCG).

During 2003, the nitrate (as nitrogen) concentrations of all effluent discharges from the RLWTF were less than 10 mg/L. The average 2003 effluent total nitrate + nitrite (as nitrogen) concentration (value of 1.1 mg/L) was below the New Mexico groundwater standard of 10 mg/L. In 2003, the nitrate concentration in Mortandad Canyon base flow at the surface water station Mortandad below Effluent Canyon was 1.5 mg/L.

The fluoride concentration in the discharge also has declined over the last few years. The 2003 effluent fluoride concentration (average value of 0.38 mg/L) was below the New Mexico groundwater standard of 1.6 mg/L. In 2003, the fluoride concentration in Mortandad Canyon at the surface water station Mortandad below Effluent Canyon was 0.36 mg/L.

RLWTF annual perchlorate discharges in 2000, 2001, and 2002 were 4.74 kg, 2.29 kg, and 0.175 kg, respectively. For 2003, the annual perchlorate discharge was effectively zero. The resulting annual



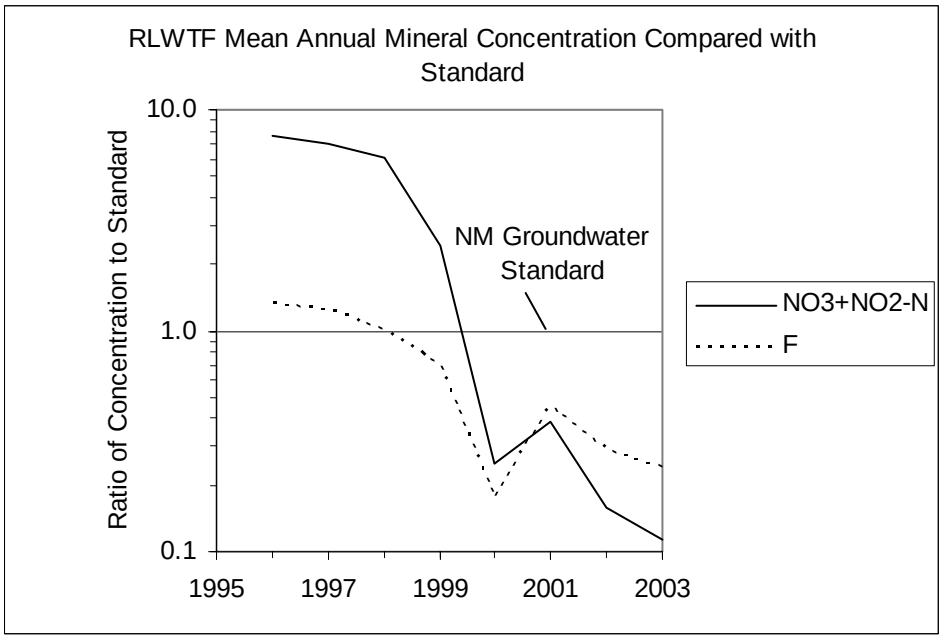


Figure 5-16. Ratio of 1996–2003 average annual radionuclide activity and mineral concentration in RLWTF discharges to the 100-mrem public dose DOE DCGs or New Mexico groundwater standards.

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. The new 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.

b. Mortandad Canyon Intermediate Groundwater and Regional Aquifer. One sample from regional aquifer well R-15 had a plutonium-239,240 detection, but none was detected in two analyses of a duplicate sample suggesting an analytical error. As described earlier, there appeared to be a mix-up between low-detection tritium samples for Test Well 1 in Pueblo Canyon and Test Well 8 in Mortandad Canyon. The former well had a history of tritium values of several hundred pCi/L but had a value of 3.5 pCi/L in 2003, while Test Well 8 had recent values averaging 12 pCi/L, but showed 140 pCi/L in 2003. The mix-up is supported by a duplicate sample at Test Well 8 that showed 4 pCi/L. Nearby monitoring well R-15 had 18 pCi/L. Perchlorate at 4.8 ppb was found in R-15 using the LC/MS/MS method, the first definite regional aquifer perchlorate detection beneath Mortandad Canyon. Test Well 8 samples did not detect perchlorate but used the IC method with a higher detection limit.

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 because of 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), and 142 µg/L of perchlorate (no MCL, EPA Region 6 risk level of 3.7 µg/L, which corresponds to HI = 1).

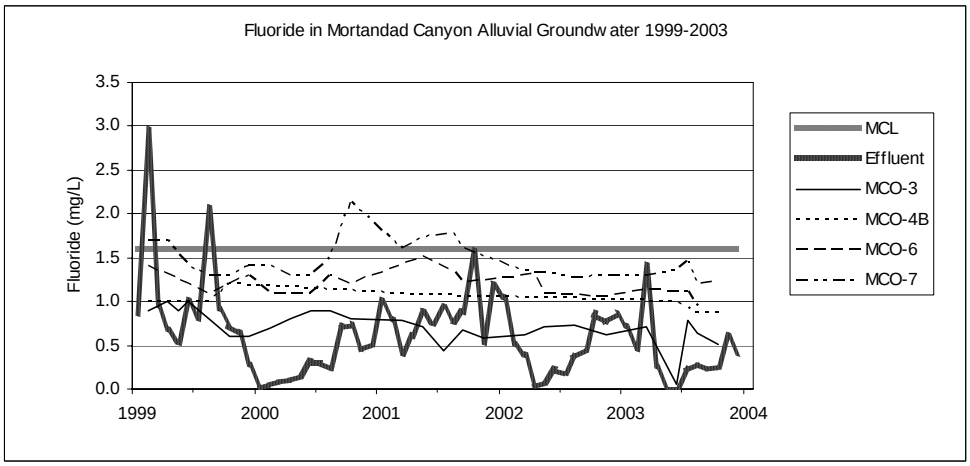
c. Alluvial Groundwater. Radionuclide levels in Mortandad Canyon alluvial groundwater are, in general, highest nearest to the TA-50 RLWTF outfall at well MCO-3 and decrease down the canyon. Most radionuclides are adsorbed to sediment closer to the outfall. The levels of strontium-90 and gross beta usually exceed EPA drinking water criteria in many of the wells. In some years, the levels of strontium-90; plutonium-238; plutonium-239,240; and americium-241 exceed the 4-mrem DOE drinking water DCGs, but the levels do not exceed the 100-mrem DOE DCGs for public dose for ingestion of environmental water.

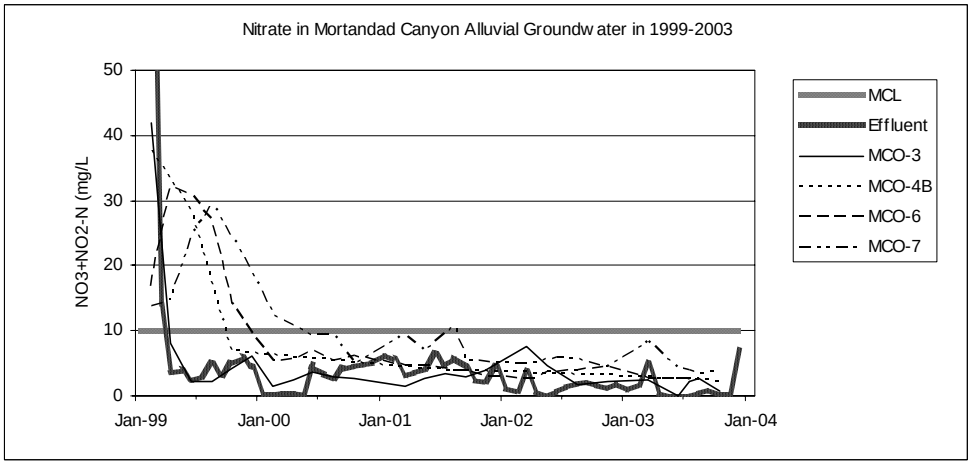
In 2003, americium-241 at MCO-3 was 140% of the 4-mrem DCG but was 59% of the DCG at MCO-4B and 80% of the DCG at MCO-5, MCO-6, and MCO-7. Gross beta values ranged from more than 90% to 135% of the EPA screening level in alluvial groundwater samples. Tritium was found at activities ranging from 3,000 pCi/L to 4,500 pCi/L (compared with the MCL of 20,000 pCi/L). Plutonium-238 and plutonium-239,240 at MCO-3 were at 137% and 148%, respectively, of the 4-mrem DOE DCGs. Plutonium-238 and plutonium-239,240 were also found at MCO-5 at 6% and 1% of the 4-mrem DCGs.

Under the Laboratory's groundwater discharge plan application for the RLWTF, RRES-WQH collected separate quarterly samples for nitrate, fluoride, perchlorate, and total dissolved solids during 2003 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 standard of 10 mg/L (nitrate as nitrogen) (Figure 5-17), and fluoride concentrations were at or below the NMWQCC groundwater standard of 1.6 mg/L. MCO-7 and MCO-7.5 had nitrate (as nitrogen) at about 80% of the NMWQCC groundwater standard. All of the Mortandad Canyon alluvial groundwater samples had fluoride concentrations greater than half the New Mexico groundwater standards and MCO-7.5 was at the standard. As shown in Figure 5-17, the nitrate (nitrate as nitrogen) and fluoride concentrations of effluent discharge from the RLWTF after March 1999 have been less than the New Mexico groundwater standards.

Perchlorate was detected in groundwater during 2003 at every alluvial groundwater well sampled in Mortandad Canyon. Perchlorate concentrations increased down canyon from about 2 ppb to 5 ppb near the RLWTF outfall to 148 ppb at downstream well MCO-7.5. 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.

Aluminum, iron, and manganese were found at high concentrations relative to water quality standards in several alluvial wells. As with other alluvial wells the presence of these metals is probably related to sample turbidity and lingering chemical effects of ash from the Cerro Grande fire.





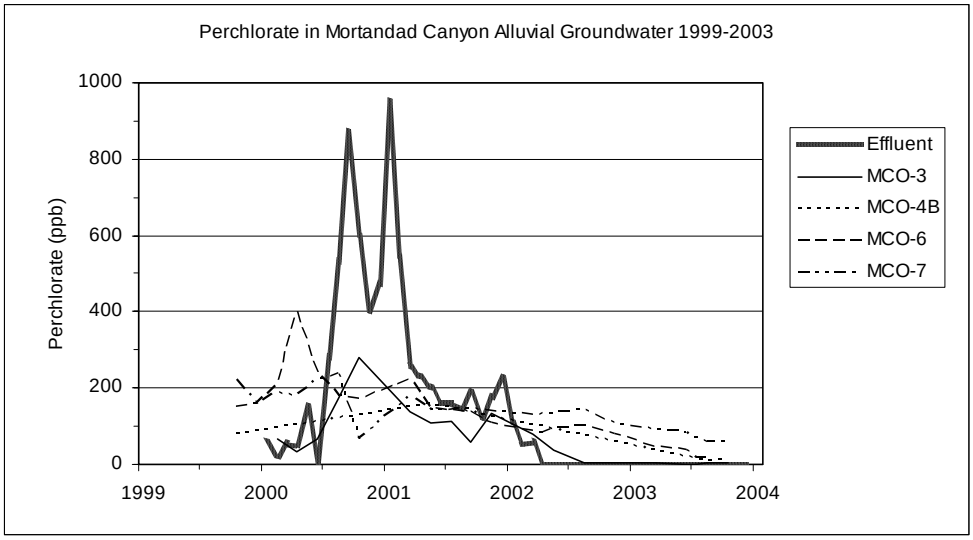


Figure 5-17. Fluoride, nitrate, and perchlorate in RLWTF effluent and Mortandad Canyon alluvial groundwater from 1999 through 2003.

d. Long-Term Radioactivity Trends. Figure 5-18 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. Because of its strong adsorption to sediments, cesium-137 is not detected in groundwater samples. 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, a short distance downstream from the outfall. Radioactivity levels at this station vary daily depending on whether 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 Mortandad below Effluent Canyon because groundwater responds more slowly to variations in runoff water quality.

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 alluvium have been below the EPA MCL since 2001 (Figure 5-18). 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 in since then.

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

In 2003, strontium-90 was detected in surface water at Mortandad below Effluent Canyon and in all alluvial groundwater observation wells down to MCO-7. The 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.

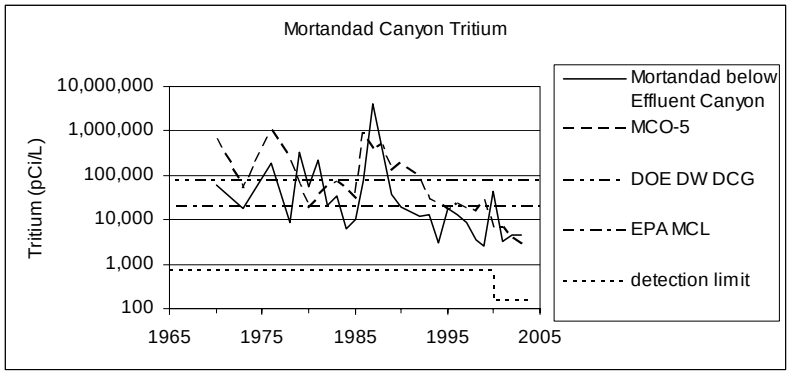
Both plutonium isotopes were detected at Mortandad below Effluent Canyon and at MCO-3 and MCO-5 in 2003. Both isotopes have been historically detected at Mortandad below Effluent Canyon and at MCO-3 at levels near the 100-mrem DOE public dose DCGs (30 pCi/L for plutonium-239,240 and 40 pCi/L for plutonium-238), 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.

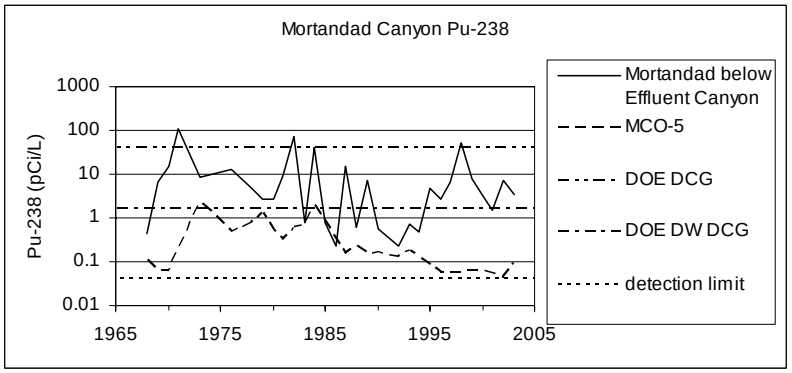
e. Cañada del Buey. Water supply wells PM-4 and PM-5 are on the mesa top just south of Cañada del Buey. In 2003, PM-5 had one detection of americium-241, a likely false positive as the result was not supported by reanalysis of the sample. Neither of the wells had tritium detectable by the low-detection-limit method (MDA about 1 pCi/L). PM-4 did not operate much during 2003 and had few sample events. In early 2004, three sampling rounds have found perchlorate in PM-5 at 0.30 to 0.35 ppb using the LC/MS/MS method, a range similar to other supply wells in northern New Mexico. No HE compounds were detected in samples from these wells.

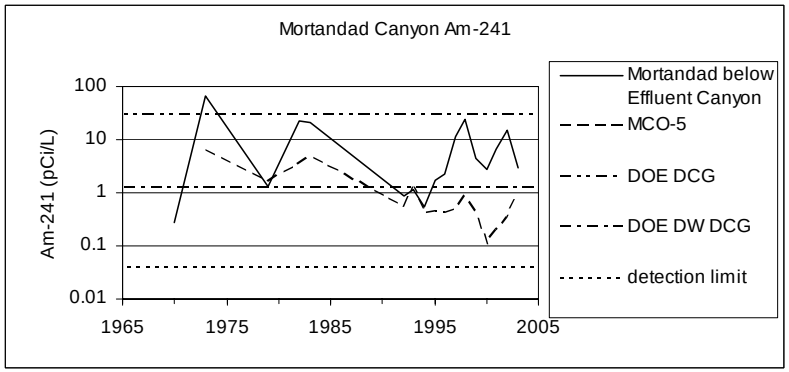
No alluvial wells were sampled in Cañada del Buey in 2003 because of lack of water in the alluvium.

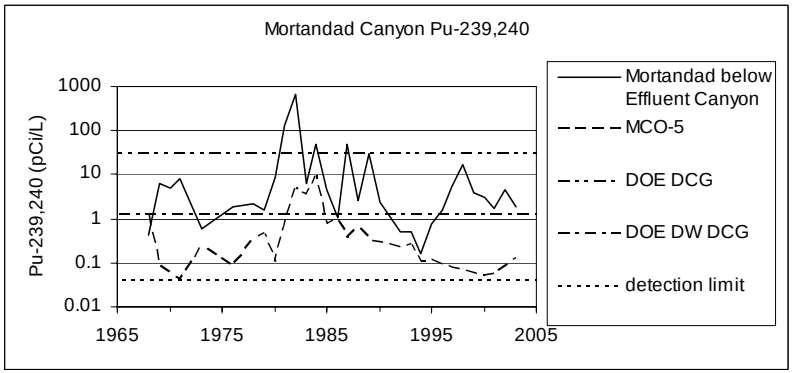
7. Pajarito Canyon (Includes Twomile and Threemile Canyons)

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. Some firing sites border portions of Twomile and Threemile canyons. A nuclear materials experimental facility at TA-18 occupies the floor of Pajarito Canyon. Areas used for disposal of organic solvents and low-level radioactive waste occupy the mesa north of the lower part of the canyon. Three shallow observation wells were constructed in 1985 as part of a compliance agreement









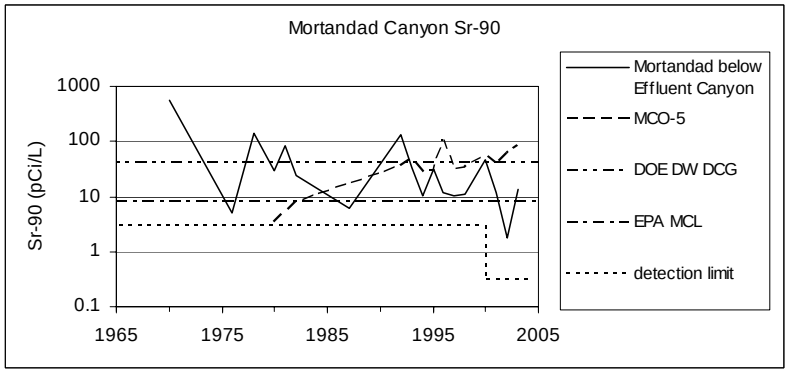


Figure 5-18. Average annual radioactivity in Mortandad Canyon surface water and alluvial groundwater.

with the State of New Mexico to determine whether technical areas in the canyon or solid-waste disposal activities on the adjacent mesa were affecting the quality of shallow groundwater. No effects were observed.

In 2002, supply well PM-2 also had a detection of americium-241 that was not supported by reanalysis of the sample, so is likely a false positive. PM-2 did not have tritium detectable by the low-detection-limit method (MDA about 1 pCi/L). No HE compounds were detected in the well.

Technetium-99 was detected in regional aquifer-monitoring well R-22 ports 3 and 4 during the first of four sampling rounds, but it was not detected during subsequent sampling (Longmire 2002c). The values were just above the detection limit, casting uncertainty on the results. The 2002 sampling found technetium-99 in only 2 of 12 analyses: these samples were the equipment blank and field blank collected during sampling of port 1. No technetium-99 was detected in any R-22 sample in 2003 (Table S5-13). R-22 showed tritium at 2-to-3 pCi/L in the uppermost of five regional aquifer ports and at 13 pCi/L in the deepest port. These results are consistent with previous sampling observations. In 2003, the middle port showed tritium at 1.2 pCi/L, not high enough to be considered above background levels.

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. Tritium was detected in one of four analyses of a sample from the third regional port of R-19 at a detection limit of about 1 pCi/L. Past samples have not detected tritium.

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). In R-22, sampling for VOCs and SVOCs again found only one compound, 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). Nitrobenzene was found at near the detection limit in the fourth port of R-22 and in the uppermost regional aquifer port at R-19. One of these results was qualified as a tentatively identified compound during secondary validation.

No alluvial wells were sampled in Pajarito Canyon in 2003 because of lack of water in the alluvium.

8. 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 for the High Explosives Wastewater Treatment Facility. 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 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) were introduced into regional aquifer screens during the 17 months before packer installation. Concentration histories for the ports from five sampling episodes indicate that concentrations for several analytes are decreasing and stabilizing over time. These concentration results now 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 the 2003 sampling of R-25 and during previous characterization sampling (ESP 2002, Longmire 2003). Two constituents were the HE compounds RDX and TNT, and two were the organic chlorinated solvents tetrachloroethene (tetrachloroethylene, perchloroethylene or PERC) and trichloroethene (trichloroethylene or TCE). Samples collected in 2003 showed several of these constituents at several depths at concentrations near EPA MCLs or EPA Region 6 tap water screening levels.

Tritium histories for the ports (Figure 5-19) 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,

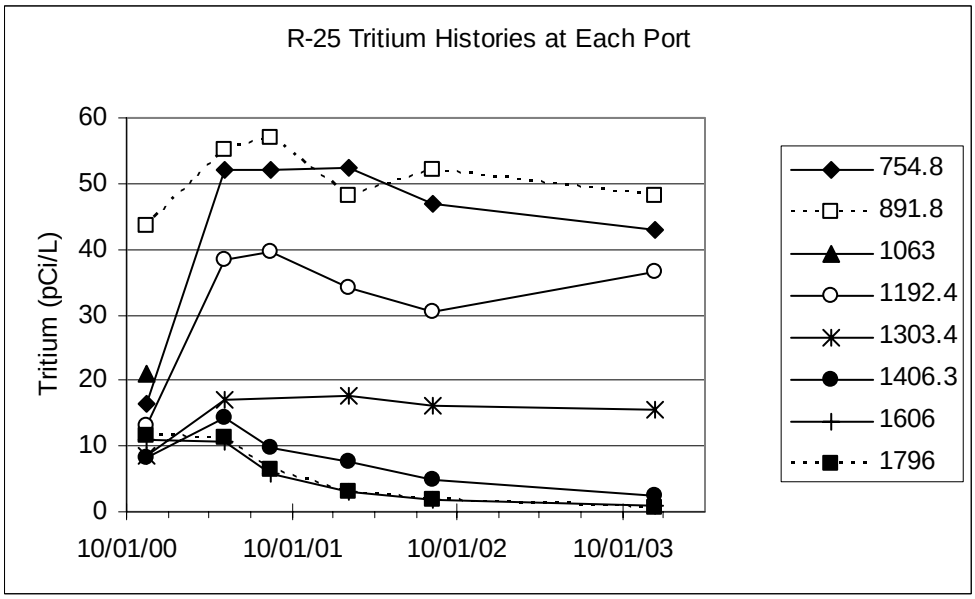


Figure 5-19. Tritium histories at R-25 ports. The legend indicates the depth of the port in feet.

following the first sample round. This suggests that tritium activity in the groundwater surrounding these ports is no longer affected by groundwater mixing during construction and that the well casing has isolated the groundwater zones from each other. 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 continue 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 this location.

We found HE constituents and their degradation products during drilling of R-25 and subsequent sampling (Broxton et al. 2002b). RDX occurs in the upper port of the intermediate perched zone at an average concentration of 50 µg/L (Figure 5-20), compared with an EPA tap water screening level of 6.1 µg/L (corresponding to 10^{-5} excess cancer risk). Concentrations of RDX at other ports in the first characterization-sampling event ranged from 5 µg/L to 28 µg/L and have declined to 0.09 µg/L to 1.6 µg/L in the deeper ports where RDX is still detected. The sampling results may not yet rule out the presence of RDX in the regional aquifer ports. However, 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. TNT concentration histories (Figure 5-20) 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 aquifer ports are steadily decreasing, averaging 0.19 µg/L in the three ports where it was detected in August 2002. Cyclotetramethylenetetra nitramine and amino-4,6-dinitrotoluene[2-] were also detected in several samples, 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 (Figure 5-21). 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. PERC was detected in four of six samples in the upper port at an average concentration of 1.2 µg/L (EPA tap water screening level of 1 µg/L, corresponding to 10^{-5} excess cancer risk). This compound was detected in three of six sampling events at two other intermediate perched ports, including the most recent three samples at the 1,192-ft port 4 at the base of the perched

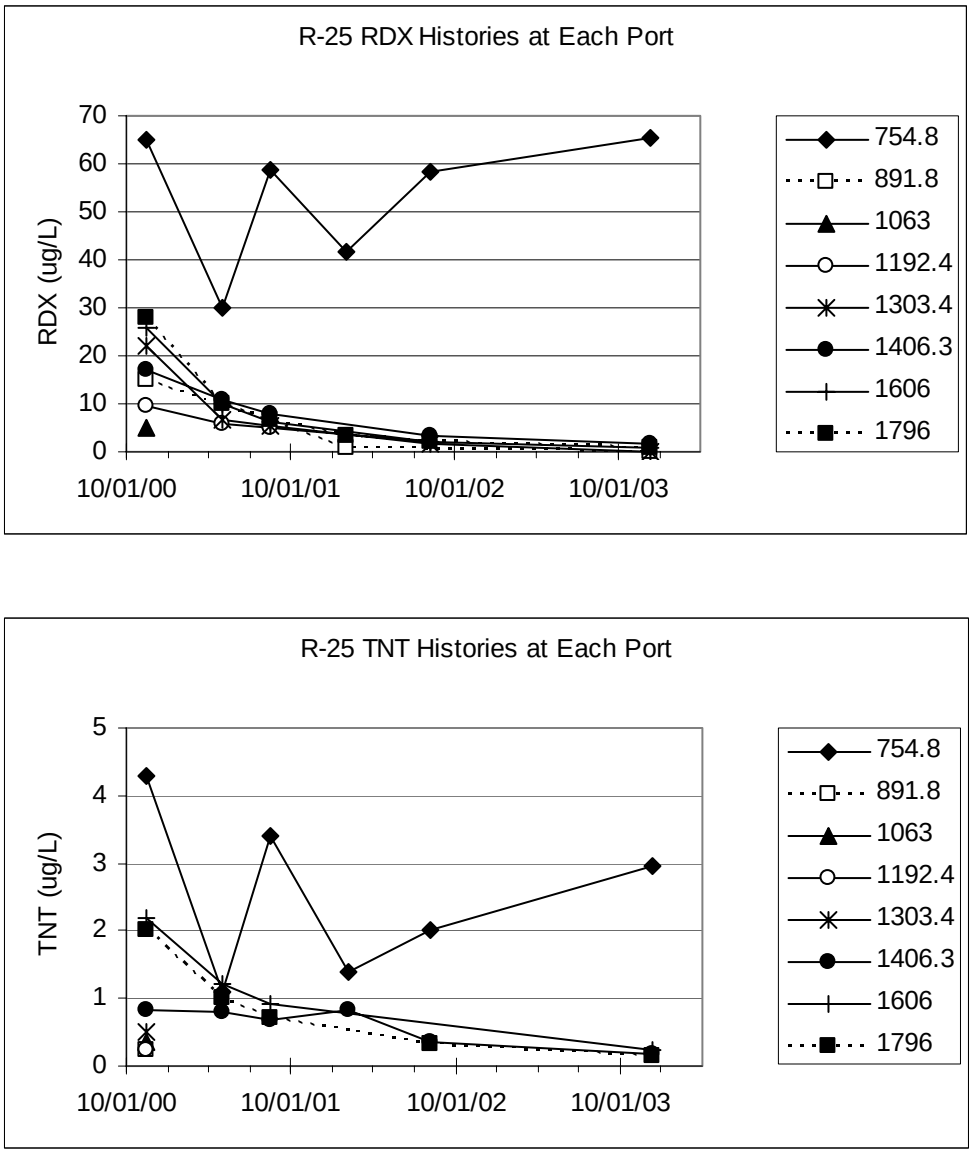
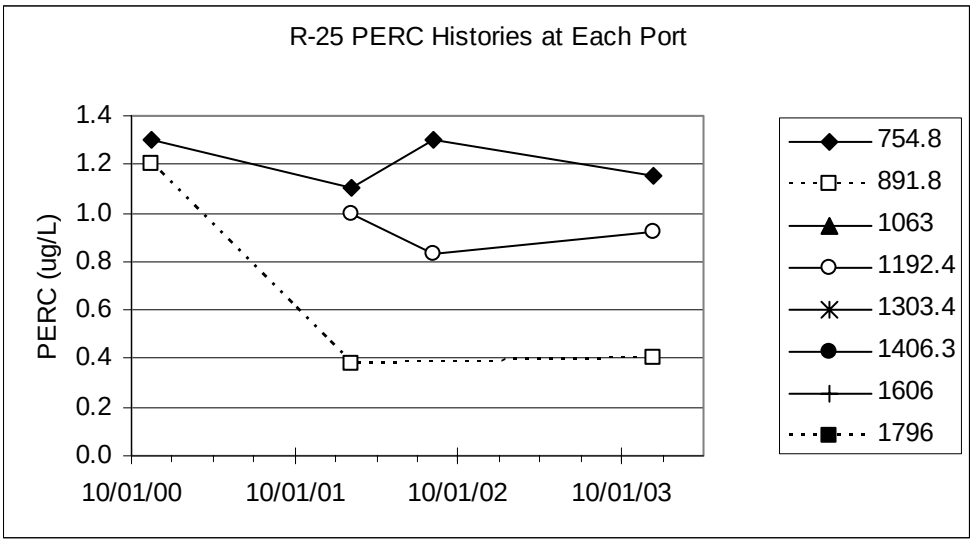


Figure 5-20. RDX and TNT histories at R-25 ports. The legend indicates the depth of the port in feet.



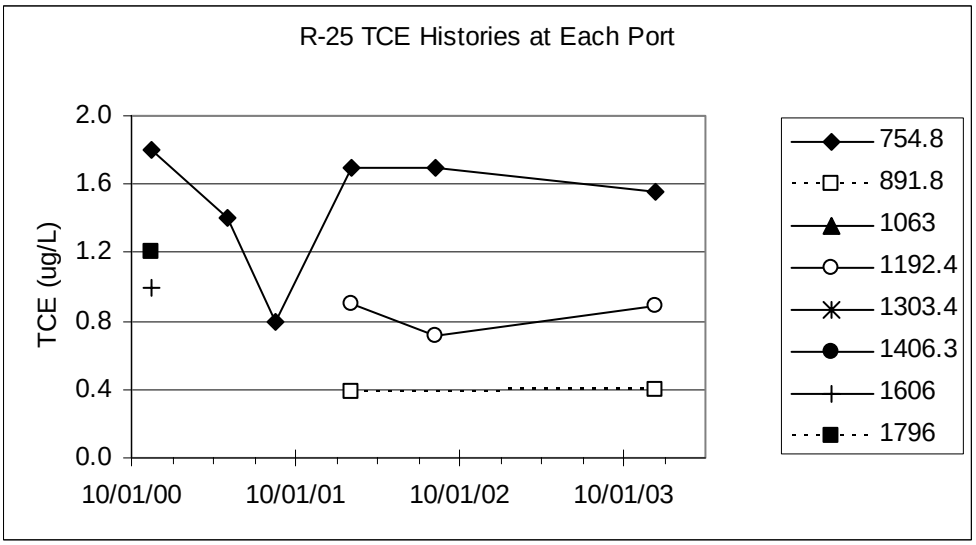


Figure 5-21. PERC and TCE histories at R-25 ports. The legend indicates the depth of the port in feet.

zone. The average of these results was 0.8 µg/L. TCE was found in all six samples from the upper port at an average concentration of 1.5 µg/L (EPA tap water screening level of 0.3 µg/L). TCE was detected in the three most recent samples at port 4 (as was PERC) and also twice at the intermediate port at 891 ft.

Several R-25 ports showed levels of iron and manganese (EPA MCLs), a temporary effect of well construction found in other recently drilled wells (Longmire 2002d). Nickel and chromium occurred at levels above EPA MCLs, possibly another temporary effect of well construction. Boron in port 2 was 57% of the New Mexico groundwater standard. Boron may be the result of infiltration of Laboratory effluents. In addition to analyzing samples for HE compounds, samples were analyzed for SVOC and VOC compounds. Other than the compounds previously discussed, no compounds were detected that were not generally also found in field, trip, or equipment blanks.

Samples from the Water Canyon Gallery, which comes from intermediate perched groundwater flowing from volcanics in the Sierra de los Valles west of the Laboratory boundary, contained no detected radionuclides or constituents above drinking water standards. Strontium-90 was detected in a field blank for the Water Canyon Gallery.

9. 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. During 2003, americium-241 was found in a sample from DT-9 but not confirmed by reanalysis, suggesting it was a false positive. Tritium was detected in this well using a MDA of 200 pCi/L; however, this value is likely a false positive as prior values using the low-detection limit method have been mainly nondetects below 1 pCi/L. Otherwise, no radionuclides were detected in these wells in 2003, and no other inorganic constituents except aluminum, iron, and manganese (related to aging well casings or to turbidity) exceeded regulatory standards. All three wells were sampled for HE compounds, with no HE compounds detected. Monitoring wells DT-5A and DT-10 were sampled for other organic compounds. Only acetone was detected: this is a common analytical laboratory contaminant.

10. 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). New evidence indicates that springs such as Spring 2B represent discharge of perched groundwater, in the case of Spring 2B fed by sources near the river such as sanitary effluent discharge. 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 levels, the only radionuclide detections in White Rock Canyon springs were uranium in La Mesita Spring and plutonium-238 in Spring 2. Naturally occurring uranium is commonly detected in La Mesita Spring. The plutonium-238 value was just above the detection limit and is likely a false positive.

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 (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. The newly identified Spring 2B had 12 pCi/L of tritium, also in the range of rainfall values.

Liquid scintillation tritium results ranged from 200 pCi/L to 600 pCi/L with an MDA of 160 pCi/L and, in addition to being contradicted by the low-detection-limit results, were found by the analytical laboratory to result from analytical error. Sample reanalysis resulted in nondetections for these locations.

Many of the springs were sampled for perchlorate and analyzed with the LC/MS/MS method in early 2004. The results ranged from 0.23 ppb to 0.66 ppb, similar to the range found in water supply wells in the Los Alamos area and across northern New Mexico. The perchlorate values found in the springs appear to relate to the geologic setting where they discharge. The springs discharge from 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. 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 early 2004, perchlorate concentrations for the group I springs (Spring 3 series, 4 series, Spring 5) averaged 0.50 ppb. Group II springs discharge from coarse-grained Tesuque Formation sediments on both sides of the river. For the group II springs (Springs 6, 6A, 8A, 9, 9A, Doe Spring) perchlorate concentrations averaged 0.29 ppb.

Spring 2 contained fluoride at 74% of the New Mexico groundwater standard. The fluoride occurs naturally in springs and wells in the area. Spring 4A had selenium at 50% to 80% of the New Mexico wildlife habitat surface water standard. This selenium is also likely of natural origin. Several organic compounds were detected in spring samples but their occurrence is too sporadic to confidently indicate their presence in groundwater rather than being sampling or analytical artifacts. SVOCs were found in Spring 4, including benzo(b)fluoranthene, benzo(k)fluoranthene, chlorophenol[2-], and naphthalene. The first two compounds are polycyclic aromatic hydrocarbons often found as a result of combustion. Chlorophenol is used in bactericides, fungicides, and preservatives and has low water solubility. Naphthalene is used in insecticides and repellants. Dichlorobenzidine[3,3'-] was found in Spring 8A; it is used in organic pigments. Chloroaniline[4-] and acetone were found in Spring 9. Chloroaniline[4-] is used in dyes, pharmaceuticals, and agricultural chemicals, and acetone is a common analytical laboratory contaminant.

Spring 2B is located on the west side of the Rio Grande below the White Rock Overlook and was discovered by the NMED DOB during 2002. The spring issues at the river's edge and has a small flow. Initial chemical analysis by NMED indicated that the spring chemistry differed significantly from nearby springs such as Spring 2 and Spring 3. The high nitrate and uranium contents of Spring 2B water suggested that it has a different source than other nearby springs and that its chemistry shows anthropogenic impact. Several lines of chemical evidence show that the water discharging at Spring 2B comes from the White Rock sanitary treatment plant located at nearby Overlook Park. Much of this sanitary effluent flows down lower Mortandad Canyon to the Rio Grande, whereas a portion evidently infiltrates and flows through the underlying basalt rock to discharge at Spring 2B.

Table 5-2 summarizes concentrations of some significant analytes from measurements by NMED and compares these concentrations with the range of values obtained for surface water samples at the nearby station Mortandad at Rio Grande. This station is just north of Spring 2B and samples stream water that is nearly wholly supplied by the discharge from the White Rock sanitary treatment plant. Principal constituents found at elevated levels in sanitary effluent include boron, chloride, sulfate, and nitrate. The levels of these compounds in samples from Spring 2B and Mortandad at Rio Grande are similar. Also, isotopic analysis of the nitrate in Spring 2B and surface water from Mortandad at Rio Grande (Table 5-3) show that they come from a similar, sanitary-effluent-derived source, based on published ranges for nitrogen isotopic data (Clark and Fritz 1997). These nitrogen isotope values are quite unlike other nearby springs such as Spring 3.

The tritium level in Spring 2B is at the low end of the range for precipitation and surface water in northern New Mexico and suggests a contribution of rainfall to Spring 2B water. The barium value reported by NMED for Spring 2B is higher than other springs or the nearby surface water. However, a similarly high value reported for Sandia Spring at the same time is four times values previously observed at that site.

The uranium concentration in Spring 2B of 18 µg/L is higher than other springs on the west side of the Rio Grande (the highest, Spring 2, averages 4 µg/L). However, Spring 3B just across the river has had average uranium concentrations of 20 µg/L, and nearby Buckman well No. 2 contained 248 µg/L of uranium in 2002 and 111 µg/L in 2003. The uranium content of rocks in the Los Alamos area is high,

Table 5-2 Comparison of Chemistry for Spring 2B and Mortandad at Rio Grande Surface Water (Sanitary Effluent)

Spring 2B (NMED 11/05/02)		Range of Results for Mortandad at Rio Grande Surface Water Data (mid 70s to 2003)					
Analyte	Result	Min	Max	Mean	No. of Samples	Units	Notes
H-3	10.8	ND*	One detect in 1983 at 1400 ± 400	ND	22	pCi/L	spring similar to nearby springs
U	17.9	50% ND	2.7	1.1	26	µg/L	spring higher than sanitary effluent
B	140	ND	572	349	10	µg /L	spring similar to sanitary effluent
Ba	190	ND	93	62	11	µg /L	spring higher than sanitary effluent
Cl	36	4	74	43.5	22	mg/L	spring similar to sanitary effluent
NO_3-N	5.5	ND	13.6	6.4	22	mg/L	spring similar to sanitary effluent
SO_4	26.1	25.7	49	34.7	19	mg/L	spring similar to sanitary effluent

*Not detected.

Table 5-3. Nitrogen Isotope Values ($\delta^{15}N$ ‰ air of NO_3) from Locations along the Rio Grande near Spring 2B, 02/25/03

Location	Media	Result	Duplicate	Notes
Spring 3	Groundwater	+4.1		range for plants, soils
Spring 3A	Groundwater	+4.5		range for plants, soils
Spring 2B	Groundwater	+17.3	+16.8	range for sanitary effluent
Mortandad at Rio Grande (Sanitary Effluent)	Surface Water	+10.3	+11.0	range for sanitary effluent

uranium is easily dissolved from rocks by water, and many wells and springs in the Rio Grande valley have high levels of naturally occurring uranium. It is likely that as it flows underground to the Rio Grande, wastewater from the White Rock sanitary treatment plant has dissolved uranium from the surrounding rocks. Isotopic analysis of uranium ratios from Spring 2B shows that the uranium is of natural origin, based on the ratio of uranium-238 to uranium-235 (Table S5-14). The uranium concentration in other nearby springs and surface water was too low to measure uranium-235 and determine an isotopic ratio.

11. 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 2003, Westside Artesian well had the highest total uranium of 25 µg/L, and

New Community well and Black Mesa well had 14 µg/L (values calculated from isotopic results). These measurements are consistent with the levels in previous samples.

No uranium isotope values in these wells 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.

Americium-241 seemed to be detected in Westside Artesian well, but was not found in a duplicate sample or a reanalysis, strongly indicating the result was a false positive.

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 was not detected in 2002 in any San Ildefonso Pueblo wells at the 4-µg/L detection limit of the IC method.

The boron value in the Westside Artesian well was 240% of the NMWQCC groundwater standard of 750 µg/L. This value was similar to the values of past years. This well had arsenic at about 11% of the EPA MCL of 50 ppb. For the new MCL of 10 ppb which will be effective in 2006, this value would be 57% of the MCL. No PCBs, SVOCs, or VOCs were found in San Ildefonso Pueblo well samples, except that bis(2-ethylhexyl)phthalate was found in one of two duplicate samples at the J. Martinez House well and a sample from the Black Mesa well. This compound was found in a performance evaluation blank collected the next day at Basalt Spring and is a common analytical laboratory contaminant. Also, because the compound was not found in the duplicate sample at J. Martinez House well, indications are strong that the result is a false positive.

12. Buckman Well Field

In 2003, RRES-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 111 µg/L of uranium compared with the EPA MCL of 30 µg/L (effective 12/08/03), a value in line with earlier values (and much less than the 2002 value of 248 µg/L) obtained for that well. Buckman No. 1 had 16 µg/L of uranium and Buckman No. 8 had 15 µg/L.

The gross alpha value in Buckman well No. 2 exceeded the 100-mrem DOE public dose DCG values in 2003, and the gross alpha values in Buckman No. 1 and Buckman No. 8 were about one-third of the DCG. The gross alpha levels in these wells are attributable to the presence of uranium. The DCG for gross alpha assumes that the radioactivity comes solely from americium-241 and plutonium-239,240, and, as such, the DCG is conservative. The uranium-234 and uranium-238 values in Buckman well No. 2 well exceeded the 4-mrem DOE DCG for drinking water, and the uranium-234 values for Buckman No. 1 and Buckman No. 8 were about 40% of the DCG. The gross alpha values in these wells were also near the EPA primary drinking-water standard of 15 pCi/L. The gross alpha values for Buckman No. 1 and No. 8 were 75% and 67% of the MCL and for Buckman No. 2 was 240% of the MCL. The EPA MCL for gross alpha, however, does not include the contribution to gross alpha by radon or uranium.

No tritium was detected in these wells at a detection limit of about 1 pCi/L. No perchlorate was found in samples from the Buckman wells, at the IC method 4-µg/L detection limit. The wells were each sampled twice for HE compounds; none were detected.

H. Los Alamos County Water Supply Sampling Program

1. Introduction

On September 5, 2001, DOE completed the transfer of ownership of the Los Alamos water supply system to Los Alamos County. To demonstrate compliance with MCLs, the SDWA requires Los Alamos County to collect samples from the water supply wellheads and from various points in the water distribution systems of the Laboratory, Los Alamos County, and Bandelier National Monument. The Laboratory conducts supplemental monitoring of the water supply wells to provide QA, not for SDWA compliance purposes. This section presents the results from the Water Supply Sampling Program's QA monitoring conducted during 2003. The Laboratory also conducts annual monitoring of these wells under the Environmental Surveillance Program; these results are described in previous portions of this chapter.

In 2003, the Laboratory's monitoring network for the Water Supply Sampling Program consisted of the following 11 water supply wells in operation at the time of sampling: Guaje wells G-1A, G-2A,

G-3A, G-4A, G-5A; Pajarito Mesa wells PM-1, PM-2, PM-3, PM-5; and Otowi wells O-1, O-4. PM-4 was out of service at the time of sampling. LANL's sample collection, preservation procedures, and analytical methods follow the requirements specified in federal and state drinking water regulations. Laboratory staff performed chemical and radiological sampling and submitted the samples for analysis to General Engineering Laboratories (GEL), Charleston, SC. The RRES-WQH Group has staff certified to perform drinking water sampling and maintains both electronic and hardcopy files of all data collected from QA testing.

2. Radiochemical Analytical Results

In 2003, RRES-WQH staff collected samples from 11 of the 12 supply wells to determine the radiological quality of the drinking water. As shown in Table S5-15, the concentrations of gross alpha and gross beta activity were less than the EPA screening levels.

3. Nonradiological Analytical Results

In 2003, we collected samples from 11 water supply wells for inorganic constituents in drinking water. As shown in Table S5-16 all inorganic constituents at all locations were less than the EPA MCLs.

In 2003, we sampled the 11 water supply wells for VOCs. No VOCs were detected at concentrations greater than the analytical laboratory's detection limits at any of the sample locations with the exception of chloromethane at G-1A, G-3A, O-1, and PM-2. Table S5-17 presents the chloromethane results at all sample locations. Chloromethane was detected in a duplicate sample at G-1A, but was absent from the original sample at G-1A. Chloromethane was also detected in a field blank at PM-3 suggesting that a contaminant source was present in the sampling and/or analytical environments. Chloromethane is a common industrial chemical that is used in the manufacture of silicones, synthetic rubbers, and paints. It has also been associated with smoke from cigarettes, wood, grass, coal, and certain plastics. We have found no prior chloromethane detections at these 11 locations.

I. Unplanned Releases

1. Radioactive Liquid Materials

No unplanned radioactive liquid releases occurred in 2003.

2. Nonradioactive Liquid Materials

There were ten unplanned releases of nonradioactive liquid in 2003. The following is a summary of these discharges.

- Two vandalized alluvial groundwater wells (LAO-C and LAO-0.7) in Los Alamos Canyon at TA-41 and TA-43
- One unplanned release of potable water at TA-11-04 to a Solid Waste Management Unit (SWMU) 11-004(a)-99
- Two hydraulic fluid releases:
    1. TA-3-261
    2. TA-36 Fire Road 140
- Two diesel contaminated soil areas discovered:
    1. TA-3 Power Plant AST (TA-3-26)
    2. TA-16-7 D&D Site
- Four unplanned releases of untreated sanitary sewage from the TA-46 SWWS Plant's collection system:
    1. TA-3-2327 Manhole #618
    2. TA-3-261 Manhole #696
    3. TA-16-532
    4. TA-53-1049

RRES-WQH investigated all unplanned releases of liquids as required by the NMWQCC Regulations 6.2 NMAC 1203. Upon cleanup, personnel from NMED and NMED DOB inspect the unplanned release sites to ensure adequate cleanup. The Laboratory is in the process of administratively closing out all releases for 2003 with NMED DOB. The laboratory anticipates these unplanned release investigations will be closed out when NMED DOB personnel become available for final inspections.

J. Quality Assurance

1. Introduction

RRES-WQH personnel conducted QA activities in 2003 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.

2. Analytical Laboratories

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

The RRES-WQH Group 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 S5-4, S5-5, and S5-6 in the Data Supplement list qualifier and validation flag codes that accompany 2003 sediment and water data.

When staff members identify documentation or contract-compliance problems during validation, they contact the analytical laboratory and attempt to resolve or clarify the problem. In 2003, this process required RRES-WQH Group's largest analytical services provider to issue a series of package-specific nonconformance reports (NCRs). Most of the NCRs written in response to these problems concerned minor documentation and paperwork errors or typographical errors on individual data reports.

Two NCRs were issued that involved analytical issues. The first was determined to be a sample mix-up by the laboratory during sample login. This was resolved with no loss of data. The second was a set of tritium results for a sampling event from 10/06/2003 through 10/08/2003 reported under SDG 89802. Samples from 12 locations were reported with elevated tritium that did not match historical data for these sites. GEL was contacted and an NCR was issued. There was sufficient sample left for reanalysis and the laboratory reanalyzed the samples under SDG 104174. Results for all reanalysis were nondetects.

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 2003 were completed.

4. Radiological Data

Negative values are sometimes reported in radiological measurements. (See Technical Aspects of Quality Assurance at WQH during 2003 in the Data Supplement.) 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 Regulatory 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. The RRES-WQH Group 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.

6. Detection-Limit Issues

The RRES-WQH Group SOW requires that analytical laboratories verify their calculated MDLs empirically.

7. Participation in Laboratory Intercomparison Studies

The RRES-WQH Group SOW requires that analytical laboratories participate in several independent national performance evaluation (PE) programs. These include the Environmental Measurement Laboratory Quality Assessment Program and the DOE Mixed Analyte Performance Evaluation Program (MAPEP) for radiochemistry analysis and the EPA Water Supply, the EPA Water Pollution, the EPA NPDES Discharge Monitoring Report-Quality Assurance Study, and the MAPEP programs for organic and inorganic constituents.

Results for these PE programs 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 PE results are categorized as "not acceptable," and those corrective actions are spot-checked during various analytical laboratory oversight activities.

8. Quality Control Samples

The required analytical laboratory batch QC is defined by the analytical method, the 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, the RRES-WQH Group 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 [DI] water), and field duplicates.

On the whole, the equipment and field blanks, field duplicates, and laboratory duplicates were satisfactory, indicating no significant handling issues from sampling and analyses. Results of equipment and field blanks, along with performance evaluation blanks (deionized water) are shown in Tables S5-18, S5-19, and S5-20 in the Data Supplement. Detections in the blanks are shown in Tables S5-21, S5-22, and S5-23, also in the Data Supplement.

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. Except for three sample mix-ups, all reported results were at or near the detection limit.

b. Field Duplicates. Field duplicate samples are distinct samples of the same matrix collected as closely as possible to the same point in space and time. Duplicate samples processed and analyzed by the same analytical laboratory provide intralaboratory information about the precision of the entire measurement system, including sample acquisition, homogeneity, handling, shipping, storage, preparation, and analysis. Duplicate samples may also be used to identify errors such as mislabeled samples or data entry errors.

c. 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. Comparison of laboratory duplicates and field 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.

9. Perchlorate Performance Study

During 2003, RRES-WQH conducted a PE of the LC/MS/MS (method SW-846:8321A[M]) for low-level (that is, less than 1 ppb) analysis of perchlorate in groundwater. The NMED DOB participated in the study and analyzed samples using a different analytical laboratory. Samples from eight groundwater sources from around LANL and northern New Mexico and from two deionized water sources were spiked at various concentrations and submitted to GEL for analysis. The objectives of the PE study were as follows:

- Determine if the LC/MS/MS method works in environmental groundwater samples.
- Verify the MDL of 0.05 ppb
- Verify the method practical quantitation limit (PQL) of 0.2 ppb
- Determine whether perchlorate is present in LANL area and regional groundwater samples.

To assure accuracy, samples were spiked by a commercial analytical laboratory, Environmental Resource Associates (ERA), with various concentrations of perchlorate. The spike concentrations were selected in a range that would test the MDL and practical quantification limit (PQL) of the LC/MS/MS method and submitted in duplicate for a total of 90 samples. The spike concentrations are shown in Table 5-4.

An additional 15 QC samples consisting of trip, field, and equipment blanks accompanied the spiked DI water and groundwater samples that were submitted. All samples were submitted blind to the analytical laboratory.

Table 5-4. LC/MS/MS Perchlorate Performance Study Spike Sample Purpose and Concentrations

Sample Purpose	Sample Spike Concentration (ppb)
Unspiked	0.0
~ MDL	0.05
> MDL and <PQL	0.10
~ PQL	0.20
> PQL	0.50

Results of the PE study are shown in Table 5-5. The results for a spiked DI water sample prepared by ERA and for Groundwater A are shown in Figures 5-22 and 5-23.

The slope and the coefficient of determination for each data set are shown in Table 5-5. A slope of less than one indicates signal suppression at increasing perchlorate concentrations. The coefficient of determination (R^2) between the data and the linear model is an indicator of consistency of the method ($R^2 = 1.0$ indicates the highest consistency). Note that an R^2 value near 1 does not necessarily imply precision. Table 5-5 also includes the method of standard additions (MSA) calculation result. When the composition of a sample matrix affects the analysis of an analyte, the MSA can be used to help to overcome the problems of measurement of that particular analyte. The values of the average results (of unspiked samples) and the calculated MSA values differ by as much as 39% (indicating a high bias in some reported values) to –33% (indicating a low bias in some reported values).

The LC/MS/MS technique measures perchlorate comprising naturally occurring chlorine isotopes chlorine-35 and chlorine-37. The isotopic data derived from the PE study demonstrated a slightly low bias of the ratio of perchlorate comprising chlorine-35 to chlorine-37. Even with this slightly low bias, the results indicate that the isotopic data can provide a useful and accurate means to discriminate perchlorate signals from other compounds.

Table 5-5. Summary of Results of LC/MS/MS Perchlorate Performance Study

Source	Average result (µg/L)	MSA (µg/L)	Percent difference of average result to MSA	MDL	PQL	slope	R^2
DI water	<0.05	<0.05		0.05	0.2	0.95	0.9982
A	0.31	0.32	-3	0.05	0.2	0.99	0.9738
B	0.39	0.28	39	0.05	0.2	0.98	0.9754
D	0.63	0.66	-5	0.05	0.2	0.94	0.9786
E	0.16	0.21	-24	0.05	0.2	0.86	0.9623
F	0.08	0.12	-33	0.05	0.2	0.75	0.9859
G	0.13	0.17	-24	0.1*	0.4*	0.76	0.8880
H	0.25	0.23	9	0.1*	0.4*	0.94	0.9291
I	0.17	0.17	0	0.05	0.2	0.86	0.9519
mean	0.27	0.27					

*Samples were diluted, resulting in higher MDL and PQL.

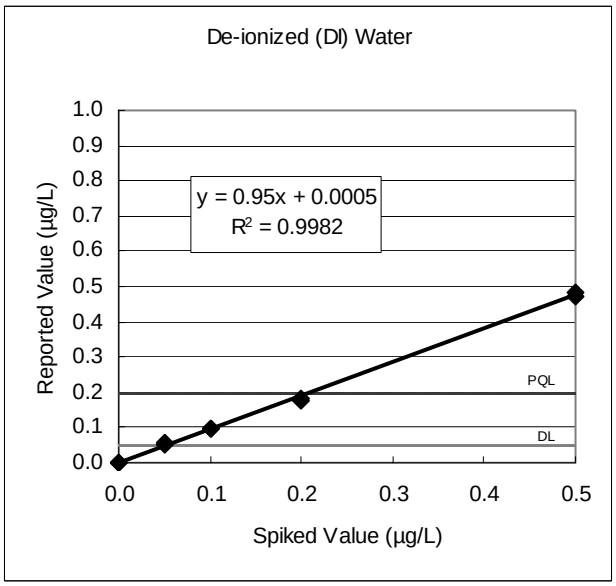


Figure 5-22. LC/MS/MS performance study results for DI water spikes.

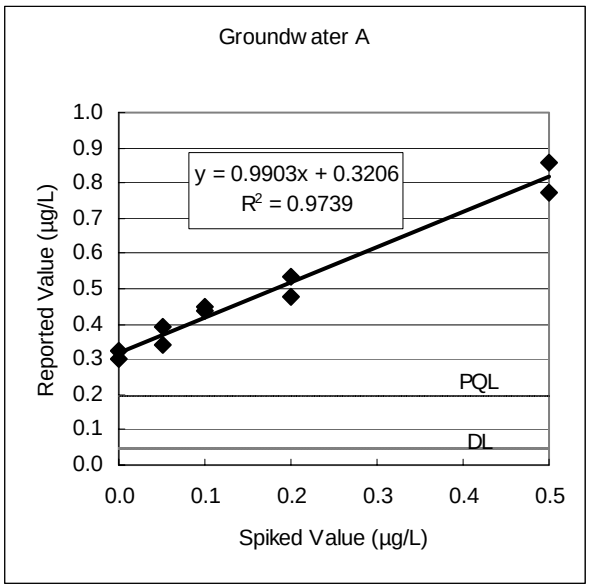


Figure 5-23. LC/MS/MS performance study results for groundwater A.

We concluded the following from the PE study:

- There was no perchlorate observed in any of the DI spikes or the blank QC samples. The results indicate the samples are free from contamination and that random false positive results are not expected in DI water.
- A low bias at increasing concentrations exists, likely the result of signal suppression from sample matrix composition.
- PE study isotopic results have a low bias. However, chlorine isotopic data demonstrate that such data may provide a useful and accurate means to discriminate false positive signals from perchlorate signals.
- Perchlorate appears to be ubiquitous in groundwater in northern New Mexico at concentrations in the range of 0.2 to 0.4 and possibly 0.6 ppb.

As mentioned earlier, 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 in samples in that study does not appear to be related to any known perchlorate sources.

K. References

Adams et al. 1995: A. I. Adams, F. Goff, and D. Counce, "Chemical and Isotopic Variations of Precipitation in the Los Alamos Region of New Mexico," Los Alamos National Laboratory report LA-12895-MS (February 1995).

Blake et al. 1995: W. D. Blake, F. Goff, A. I. Adams, and D. Counce, "Environmental Geochemistry for Surface and Subsurface Waters in the Pajarito Plateau and Outlying Areas, New Mexico," Los Alamos National Laboratory report LA-12912-MS (May 1995).

Broxton et al. 2002a: D. Broxton, D. Vaniman, P. Longmire, B. Newman, W. Stone, A. Crowder, P. Schuh, R. Lawrence, E. Tow, M. Everett, R. Warren, N. Clayton, D. Counce, E. Kluk, and D. Bergfeld, "Characterization Well MCOBT-4.4 and Borehole MCOBT-8.8 Completion Report," Los Alamos National Laboratory report LA-13993-MS (December 2002).

Broxton et al. 2002b: D. Broxton, R. Warren, P. Longmire, R. Gilkeson, S. Johnson, D. Rogers, W. Stone, B. Newman, M. Everett, D. Vaniman, S. McLin, J. Skalski, and D. Larssen, "Characterization Well R-25 Completion Report," Los Alamos National Laboratory report LA-13909-MS (March 2002).

DOE 1991: "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," DOE/EH-0173 (January 1991).

Clark and Fritz 1997: I. D. Clark and P. Fritz, *Environmental Isotopes in Hydrology* (Lewis Publishers, Boca Raton, 1997).

Emelity 1996: L. A. Emelity, "A History of Radioactive Liquid Waste Management at Los Alamos," Los Alamos National Laboratory document LA-UR-96-1283 (1996).

ESP 1981: Environmental Surveillance Program, "Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant (TA-45) and the Effluent Receiving Areas of Acid, Pueblo, and Los Alamos Canyons, Los Alamos, New Mexico, Final Report," Los Alamos National Laboratory report LA-8890-ENV/US Department of Energy report DOE/EV-0005/30 (May 1981).

ESP 1988: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1987," Los Alamos National Laboratory report LA-11306-ENV (May 1988).

ESP 2002: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 2001," Los Alamos National Laboratory report LA-13979-ENV (September 2002).

EST 2003: Environmental Science and Technology, "Perchlorate Mystery Surfaces in Texas," *Environ. Sci. Technol.* **37**, 376A (2003).

Glatzmaier 1993: T. G. Glatzmaier, "RFI Work Plan for Operable Unit 1157, Environmental Restoration Program," Los Alamos National Laboratory document LA-UR-93-1230 (July 1993).

Koch and Rogers 2003: R. J. Koch and D. B. Rogers, "Water Supply at Los Alamos, 1998–2001," Los Alamos National Laboratory report LA-13985-SR (March 2003).

LANL 1996: Water Quality and Hydrology Group, "Groundwater Protection Management Program Plan, Rev. 0.0," Los Alamos National Laboratory document LA-UR-02-1667 (January 1996).

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

Longmire 2002a: P. Longmire, "Characterization Wells R-9 and R-9i Geochemistry Report," Los Alamos National Laboratory report LA-13927-MS (April 2002).

Longmire 2002b: P. Longmire, "Characterization Well R-12 Geochemistry Report," Los Alamos National Laboratory report LA-13952-MS (June 2002).

Longmire 2002c: P. Longmire, "Characterization Well R-32 Geochemistry Report," Los Alamos National Laboratory report LA-13986-MS (September 2002).

Longmire 2002d: P. Longmire, "Characterization Well R-19 Geochemistry Report," Los Alamos National Laboratory report LA-13964-MS (July 2002).

Longmire 2003: P. Longmire, personal communication to David Rogers (June 2, 2003).

Longmire and Goff 2002: P. Longmire and F. Goff, "Characterization Well R-7 Geochemistry Report," Los Alamos National Laboratory report LA-14004-MS (December 2002).

Martin 1993: B. Martin, "RFI Work Plan for Operable Unit 1082, Environmental Restoration Program," Los Alamos National Laboratory document LA-UR-93-1196 (July 1993).

NMWQCC 2000: New Mexico Water Quality Control Commission, "State of New Mexico Standards for Interstate and Intrastate Surface Waters" (effective February 23, 2000).

NMWQCC 2002: New Mexico Water Quality Control Commission, "Ground and Surface Water Protection" (September 15, 2002).

Nylander et al. 2003: C. L. Nylander, K. A. Bitner, G. L. Cole, E. H. Keating, S. Kinkead, P. Longmire, B. Robinson, D. B. Rogers, and D. Vaniman, "Groundwater Annual Status Report for Fiscal Year 2002," Los Alamos National Laboratory document LA-UR-03-0244 (March 2003).

Purtymun 1995: W. D. Purtymun, "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory report LA-12883-MS (January 1995).

Purtymun and Stoker 1987: W. D. Purtymun and A. K. Stoker, "Environmental Status of Technical Area 49, Los Alamos, New Mexico," Los Alamos National Laboratory report LA-11135-MS (November 1987).

Purtymun et al. 1980: W. D. Purtymun, R. J. Peters, and J. W. Owens, "Geohydrology of White Rock Canyon from Otowi to Frijoles Canyon," Los Alamos Scientific Laboratory report LA-8635-MS (December 1980).

Riebsomer 2003: E. Riebsomer, "Chemistry Variation during Purging of Alluvial Wells at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-02-7605 (May 2003).

Rogers 1998: D. B. Rogers, "Impact of Tritium Disposal on Surface Water and Groundwater at Los Alamos National Laboratory through 1997," Los Alamos National Laboratory report LA-13465-SR (July 1998).

Rogers 2001: D. B. Rogers, "Impact of Strontium-90 on Surface Water and Groundwater at Los Alamos National Laboratory through 2000," Los Alamos National Laboratory Report LA-13855-MS (December 2001).

5. Groundwater Monitoring

6. Watershed Monitoring

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A. Introduction

Los Alamos National Laboratory (LANL or 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.

The Cerro Grande fire in May 2000 caused chemical and hydrologic changes that have complicated our interpretation of the monitoring results. In the absence of forest cover, runoff from the burned areas above the Laboratory is now greater and occurs more rapidly. The runoff contains concentrations of fallout radionuclides, metals, and solutes that are higher than concentrations measured before the fire (Gallaher et al. 2002, Koch et al. 2001, Johansen et al. 2001, Katzman et al. 2001). Because postfire runoff has carried sediment and ash from the burned areas onto LANL lands, we continue to consider how the fire has influenced surface water and sediment monitoring results. There are indications that storm water runoff and sediment transport from most of the burned watersheds have recovered to near prefire levels.

B. Hydrologic Setting

Watersheds that drain Laboratory land 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 components. 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.); and
- 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 exposure concerns, such as wildlife watering. We thus discuss snowmelt and base flow together, separate from storm runoff. 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.

Since the Cerro Grande fire, total volumes of runoff and peak rates of discharge have increased in Pajarito Plateau drainages. Even with the increased flows, however, none of the canyons on Laboratory lands average annually more than 1 cubic foot per second (cfs) of flow. It is unusual for the combined mean daily flow from all LANL canyons to be greater than 10 cfs (Figure 6-1). By comparison, flows in the Rio Grande commonly average approximately 800 to 1,000 cfs (USGS 2004). 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.

Severe drought conditions in the Los Alamos vicinity continued in 2003 for the fifth consecutive year. The snowmelt runoff in 2003 was virtually nonexistent (Shaull et al. 2004). Most summer storm runoff events were considerably less intense than the ones in 2000 and 2001. Nonetheless, significant runoff events with peak flows greater than 500 cfs occurred in Ancho, Pueblo, and Rendija Canyons. Total runoff volume at downstream gauges in 2003 showed recovery to prefire averages for the watersheds crossing current LANL lands. However, flow volumes in Pueblo Canyon remain more than 5 times higher than the prefire average, indicating that the Cerro Grande wildfire is still affecting the hydrology of the area (Figure 6-2). The largest peak runoff event for the year was recorded in Pueblo Canyon on August 23, 2003, at 749 cfs (Shaull et al. 2004).

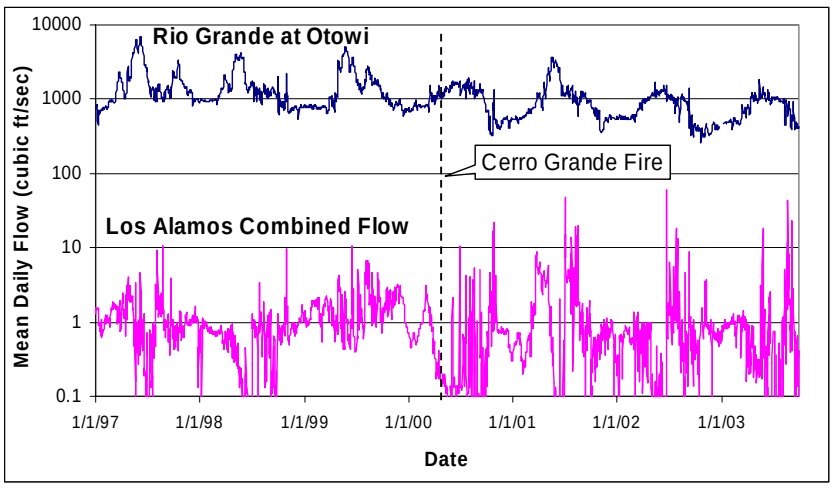


Figure 6-1. Mean daily flow from all Los Alamos canyons (Pueblo Canyon to Ancho Canyon) and in the Rio Grande at Otowi.

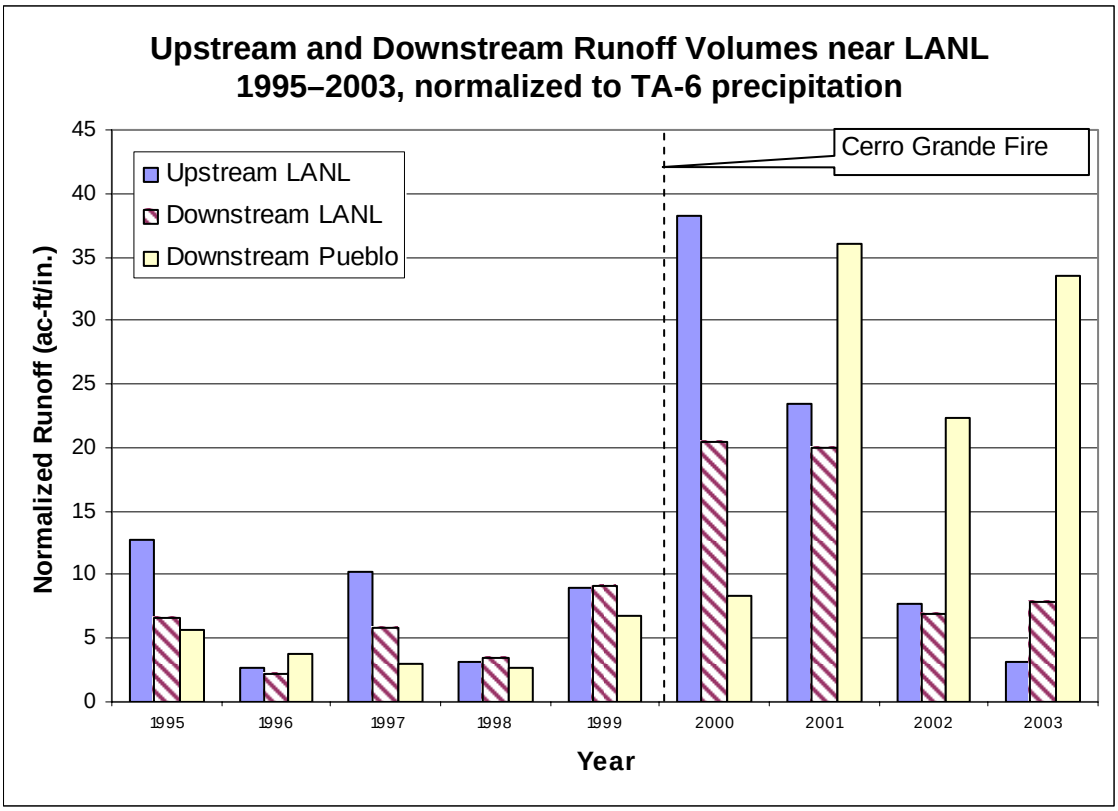


Figure 6-2. Annual summer storm runoff at selected LANL gages, normalized to TA-6 precipitation. Runoff volumes are total flows at gages along the upstream and downstream boundaries of current LANL lands (Los Alamos Canyon south to Ancho Canyon) and at a gage in lower Pueblo Canyon. Normalized values are calculated by dividing the runoff volumes by the amount of summer precipitation measured at the TA-6 meteorological station. (Modified from Gallaher and Koch 2004).

C. Surface Water and Sediment Standards

To evaluate Laboratory impacts, we compare analytical results for surface water and sediment samples with regulatory standards or with risk-based screening levels. The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though wildlife does use the water. While there is minimal direct use of the surface water within the Laboratory, stream flow may extend beyond the LANL boundaries where there is the potential 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. Table 6-1 summarizes the standards used to evaluate the monitoring data.

We compare concentrations of radionuclides in surface water with the 100-mrem Department of Energy (DOE) Derived Concentration Guides for public dose. Although the DCGs primarily regulate radioactive liquid effluent discharges and drinking water, we also 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. The DCGs are based on annual averages.

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). The Laboratory canyons have not been classified with specific designated uses and, therefore, according to NMWQCC (2002b), by default are protected for the uses of livestock

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

Medium	Standard	Risk-based Screening Level	Reference	Location	Notes
Surface water					
Radionuclides	Derived 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. Comparison based on time-weighted average over the year per DOE Order 5400.5 and 20.3.4 NMAC.
Radionuclides	State stream standards		20.6.4 NMAC	On-site and off-site	Based on the protection of livestock watering for combined activity of radium-226 and -228, total gross alpha. To be consistent with NM Radiation Protection Regulations, we base on yearly average.
Non-radionuclides	State water quality standards for surface and ground waters	EPA 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 over the year for wildlife, livestock, and aquatic life chronic exposures. Individual results from all waters compared with acute aquatic life standards and human health persistent toxic standards. Surface waters are usually present sporadically or are not available for long-term access and do not provide persistent drinking water; however, comparisons with groundwater quality standards is used to determine potential for stream flows to impact underlying bodies.
Sediments					
Radionuclides		No standards; Screening levels	LANL Remediation Services	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-radionuclides		No standards; Screening Levels	EPA 10^{-5} and HI=1 risk levels for NM toxic pollutants with no NM standard	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. Recreational scenarios are used for where residential use is impractical, e.g., many canyon bottoms are restricted.

watering and wildlife habitat. In addition, the NMWQCC (2002b) 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 new 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 persistent 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 2002a).

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.

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 (RRES-RS) uses residential screening 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 RRES-RS 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. 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. 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. Overview of Surface Water and Sediment Quality

1. Contaminant Sources

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 for in sediment and surface water within the Laboratory, most are within normal ranges or 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. 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.

2. Contaminant Maps

We reviewed recent watershed monitoring results to develop a preliminary 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 (Figures 6-3 through 6-11) to show general patterns of where potential contamination from Laboratory operations was measured in surface water or sediment during 2002 or 2003. Few runoff events have occurred during the last 2 years because of extended drought, so we based the maps on 2 years of data to include more samples in each watershed. 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 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.

Table 6-2 lists representative highest values measured for key analytes in sediment and surface water samples in 2003. The table also lists the location and provides and comparison of the results to screening values or regulatory standards.

a. Radionuclides. Past release of radioactive liquid effluents into Pueblo, DP, and Los Alamos Canyons and current releases into Mortandad Canyon have introduced americium-241; cesium-137; plutonium-238; and plutonium-239,240, 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. Heightened 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 for waters and against risk-based screening levels for sediments. Figure 6-3 compares the annual average levels of radioactivity in persistent surface waters at Los Alamos against the DOE's 100-mrem DCGs (see section 6.G.1 for details of calculation). Figures 6-4 through 6-7 compare radioactivity in stream sediments to background activities and screening levels.

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, flows for the entire year average approximately 5% of the DCG (Figure 6-3), and storm runoff is not a source of drinking water. Plutonium has moved down Pueblo Canyon, through Los Alamos Canyon, and into the Rio Grande (Graf 1997; Reneau et al. 1998). Plutonium is found in active channel sediments in Pueblo Canyon at levels more than 30 times above fallout levels (Figure 6-6) but remain below risk-based SALs. Sediments containing plutonium-239,240 at levels more than 10 times fallout background extend off site down Los Alamos Canyon onto San Ildefonso Pueblo land. Downstream of the Laboratory, average plutonium-239,240 levels have risen by 9 times in Cochiti Reservoir bottom sediments, reflecting accelerated erosion of Laboratory-derived plutonium from Pueblo Canyon after the Cerro Grande fire. The plutonium concentrations in these sediments, however, remain below a level that would pose a threat to health and the environment.

In Mortandad Canyon, radioactive effluent discharges for 2003 were in compliance with DOE Order 5400.5. Surface water below the effluent discharge point contained radioactivity near the DCGs on an annual average, but the water is not a drinking water source and does not extend beyond the Laboratory boundary (Figure 6-3). Three short-term storm runoff events contained americium-241; plutonium-238; and plutonium-239,240 concentrations nearly one order of magnitude greater than the DCGs; the americium-241 and plutonium-239 concentrations were the largest measured in waters at LANL since the mid-1990s. Cesium-137 activities in active channel sediment are greater than residential SALs (ER 2001) by up to five times in many samples (Figure 6-5). These cesium-137 values also were up to 1.5 times the industrial worker screening level. Americium-241 activities in Mortandad Canyon sediments are more

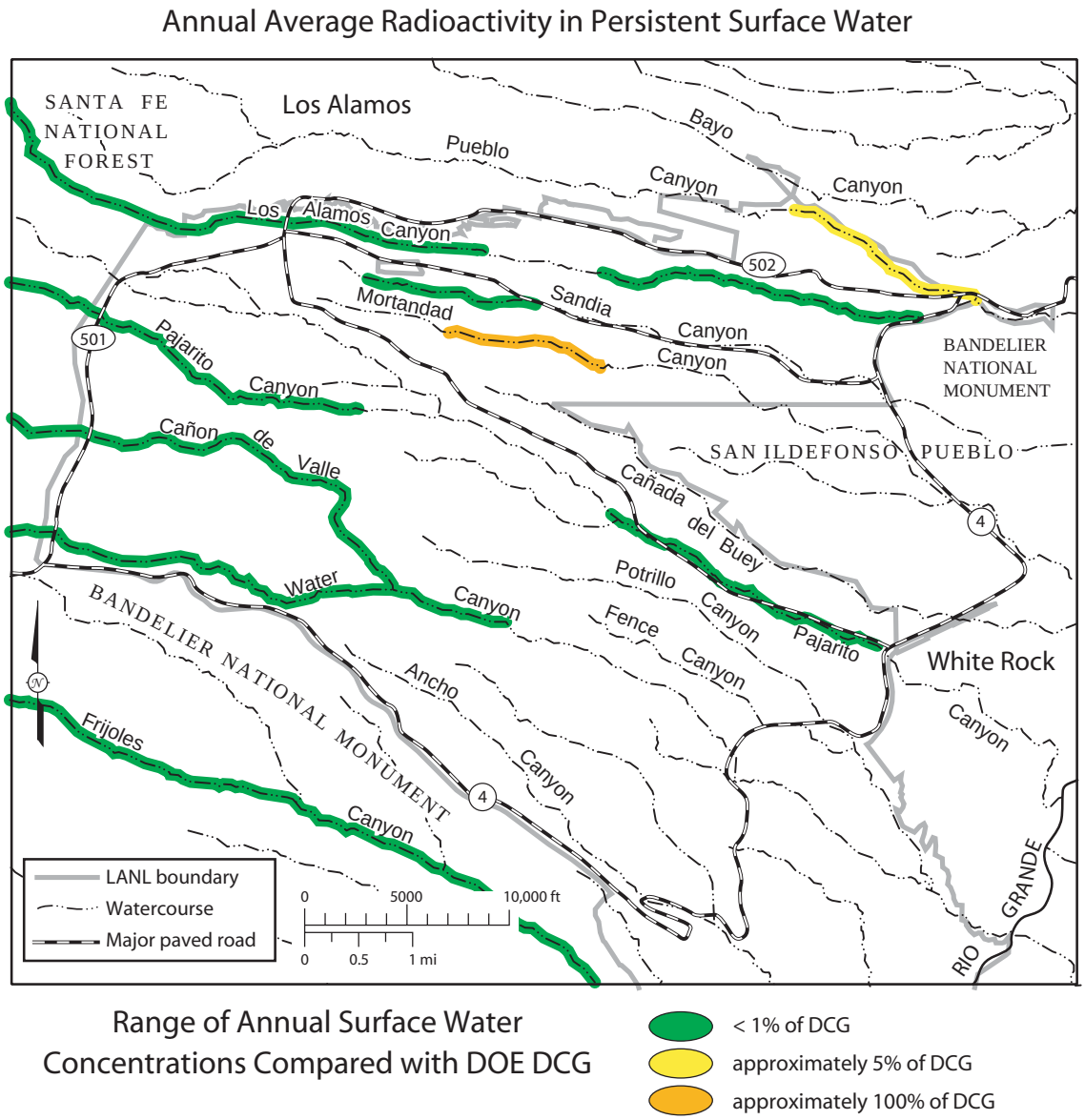


Figure 6-3. Location of persistent surface waters with annual average levels of radioactivity near the DOE Derived Concentrations Guides (DCGs). Persistent waters include perennial and intermittent stream segments (Fisher 2003). The figure shows an integrated perspective of how the activities of a mixture of five key LANL radionuclides compared with the DCGs (see text for details).

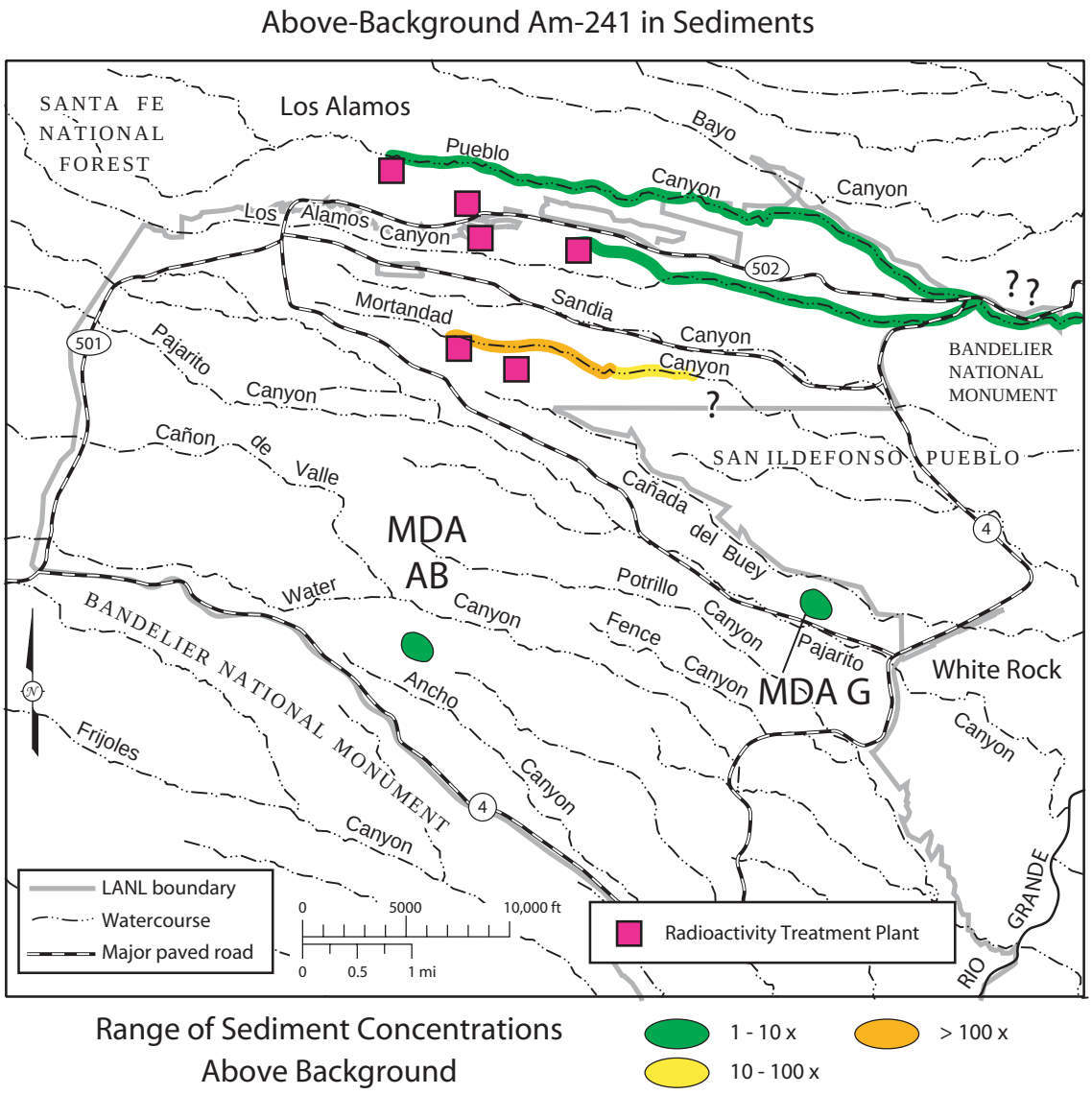


Figure 6-4. Location of the active stream channel sediment with americium-241 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). The highest value in 2003 was in Mortandad Canyon, at 180 times background, 35% of the SAL, and 25% of the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

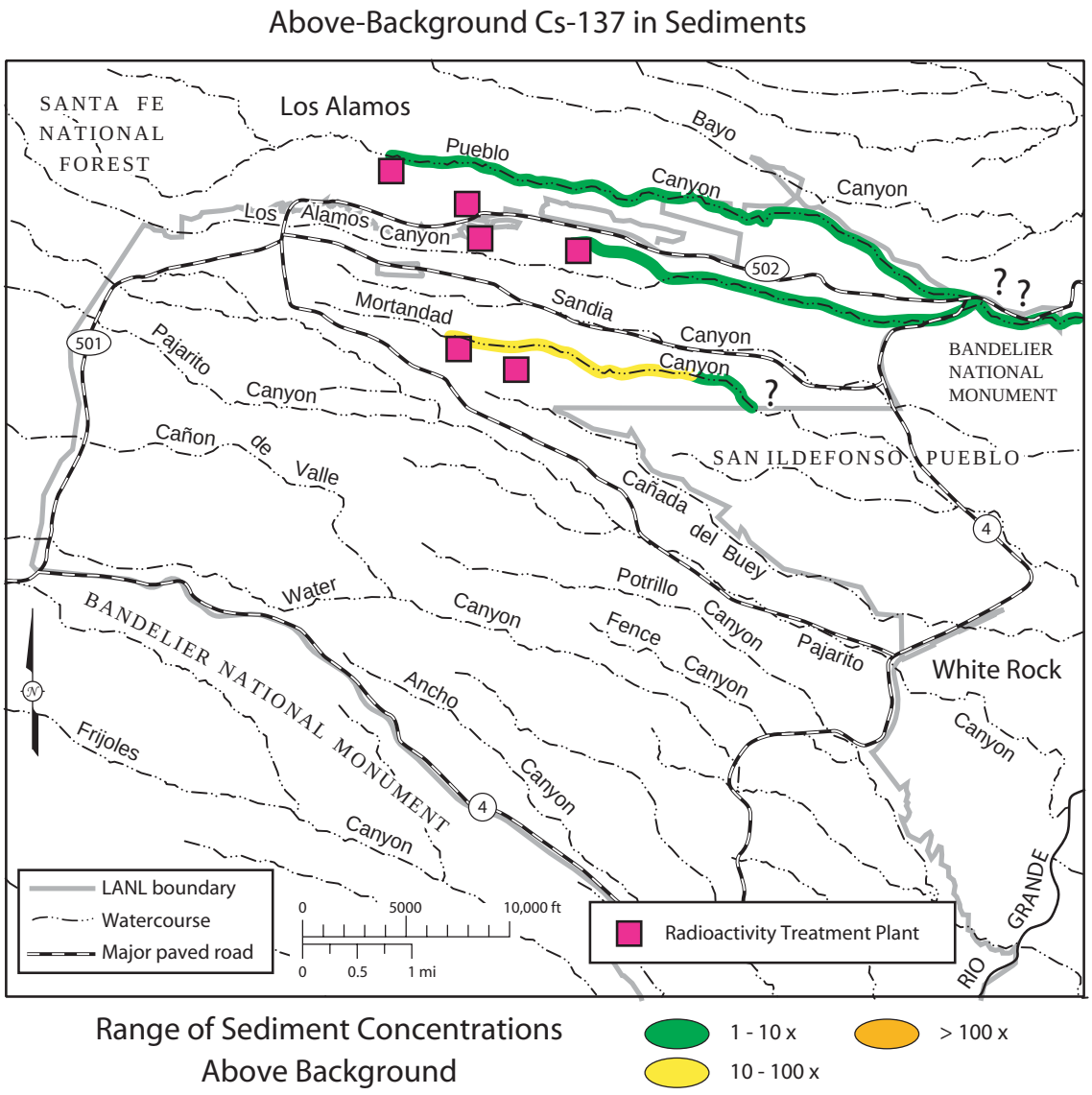


Figure 6-5. Location of the active stream channel sediment with cesium-137 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). The highest value in 2003 was in Mortandad Canyon, at 21 times background, 3.9 times the SAL, and 1.1 times the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

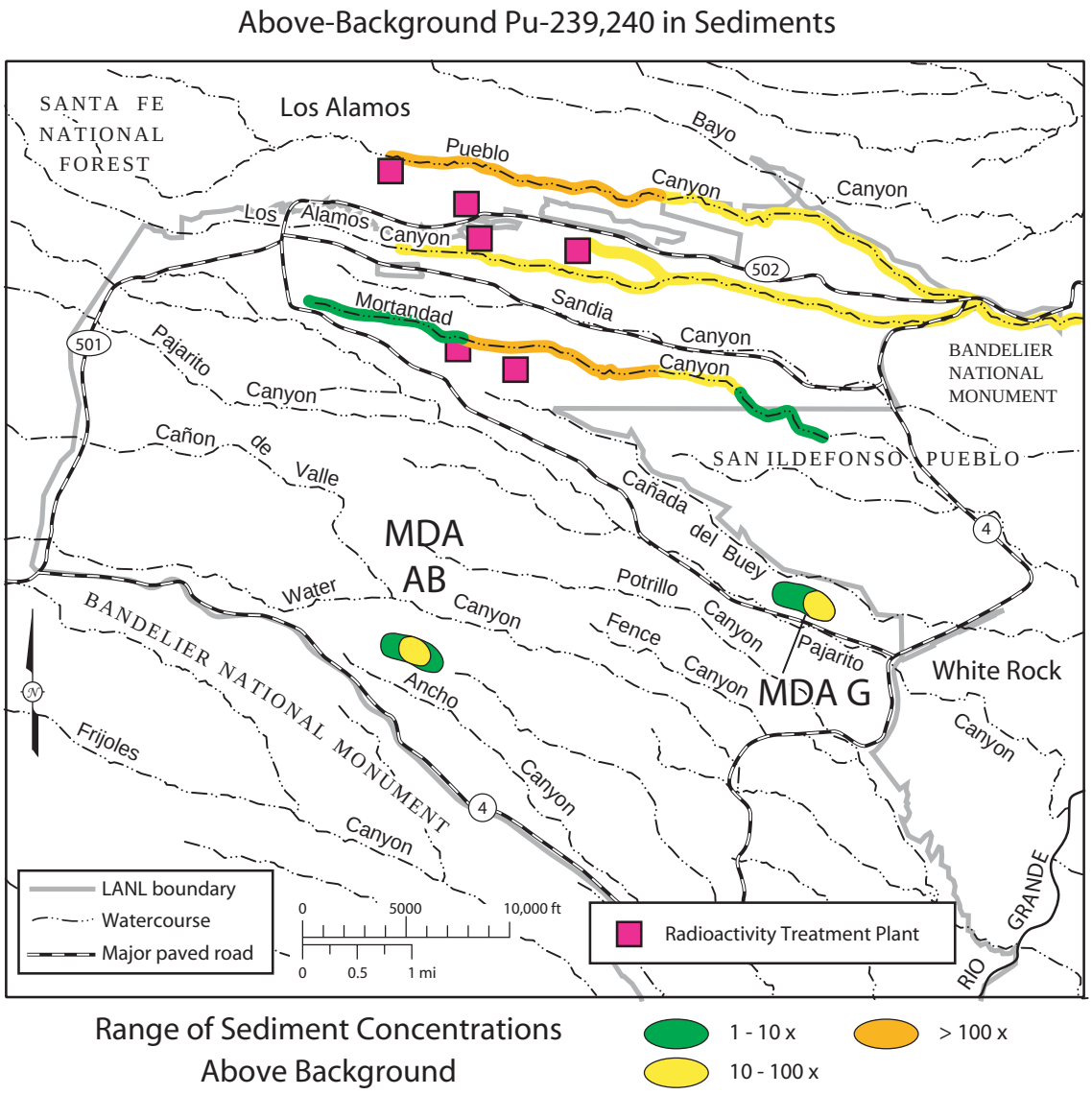


Figure 6-6. Location of the active stream channel sediment with plutonium-239,240 activity above the fallout levels derived from McLin and Lyons (2002). Different colors indicate the proportion of concentration to the fallout level. Shaded squares show locations of past or current radioactive effluent sources (see Chapter 5 in text). The highest value in 2003 was in Mortandad Canyon, at 690 times background, 20% of the SAL, and 15% of the industrial worker screening level. SALs are used as a conservative point of reference, which assumes residential use. A realistic dose assessment based on current and foreseeable land use is presented in Chapter 3.

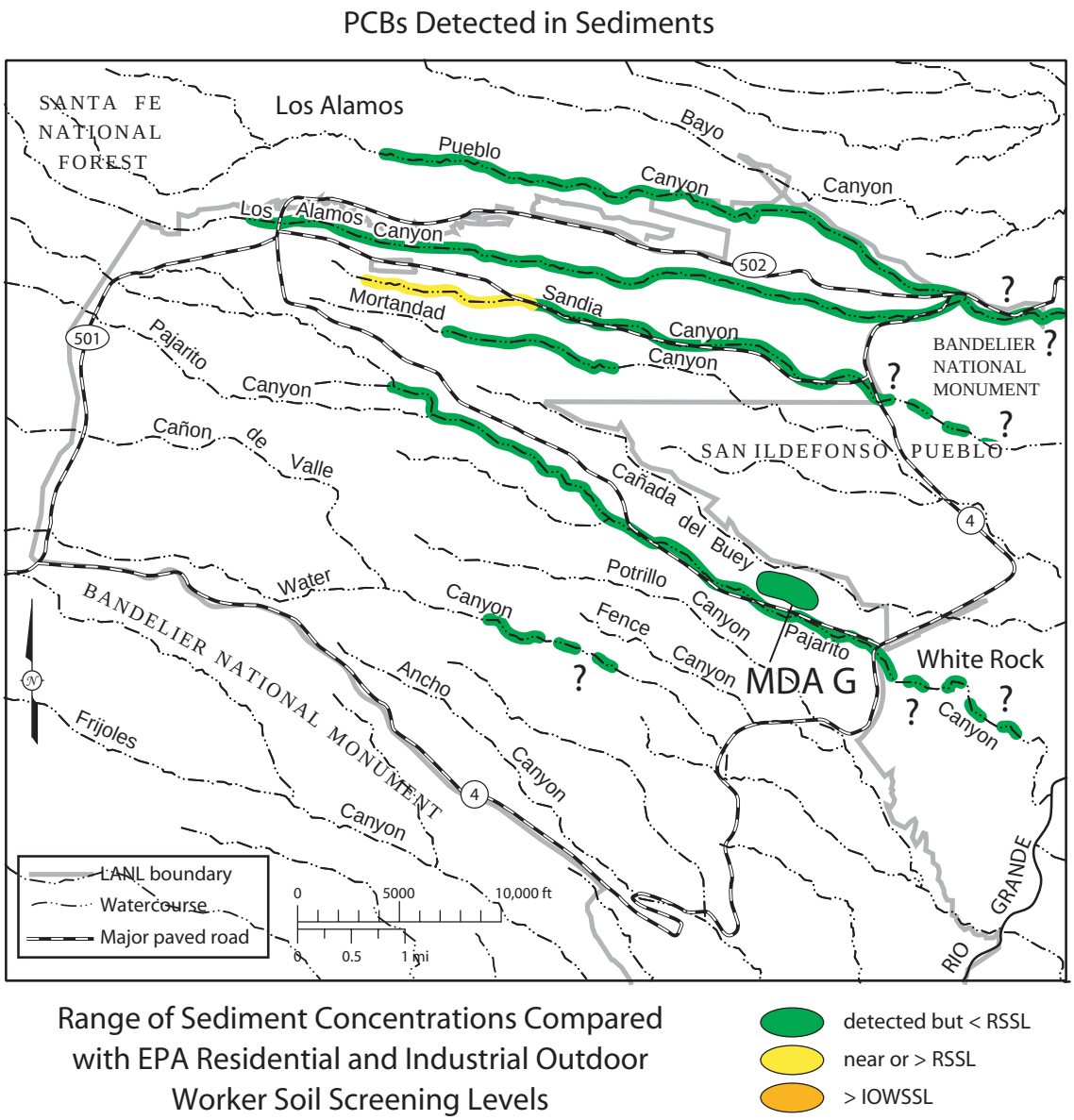


Figure 6-7. Location of sediment with PCBs detected or above screening levels. Different colors indicate where PCBs are detected or are above the EPA Region 6 residential soil screening level (no values were above the industrial screening level). The highest value in 2003 was in Mortandad Canyon, at 1.8 times the residential soil screening level and 0.4 times the industrial outdoor worker soil screening level.

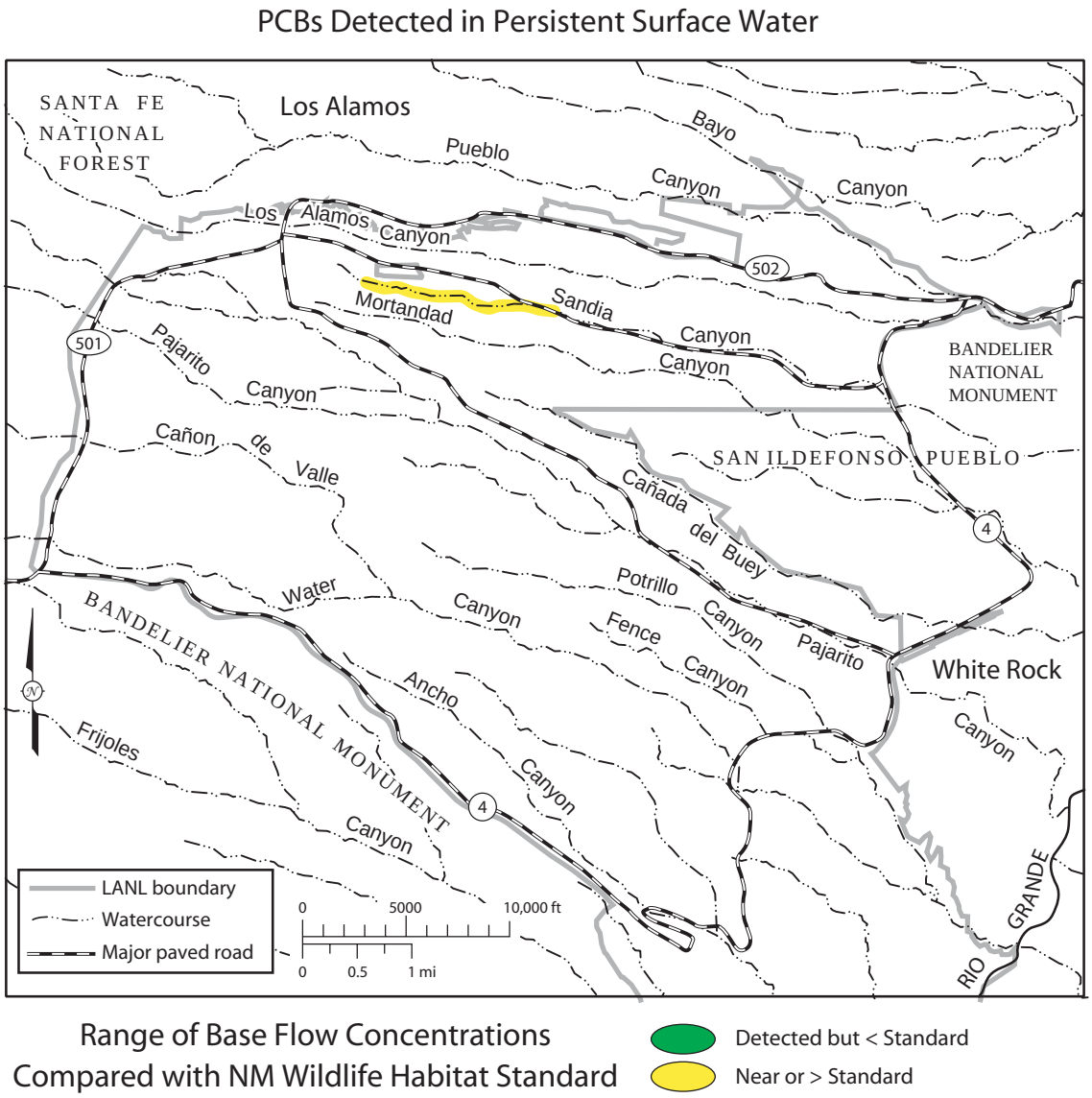


Figure 6-8. Location of base flow with the total PCB detected or near the New Mexico Wildlife Habitat stream standard. Different colors indicate where PCBs were detected or were above Wildlife Habitat standard. The highest value in 2003 was in Sandia Canyon, at an estimated concentration 7 times the wildlife standard and 58 times the human health standard.

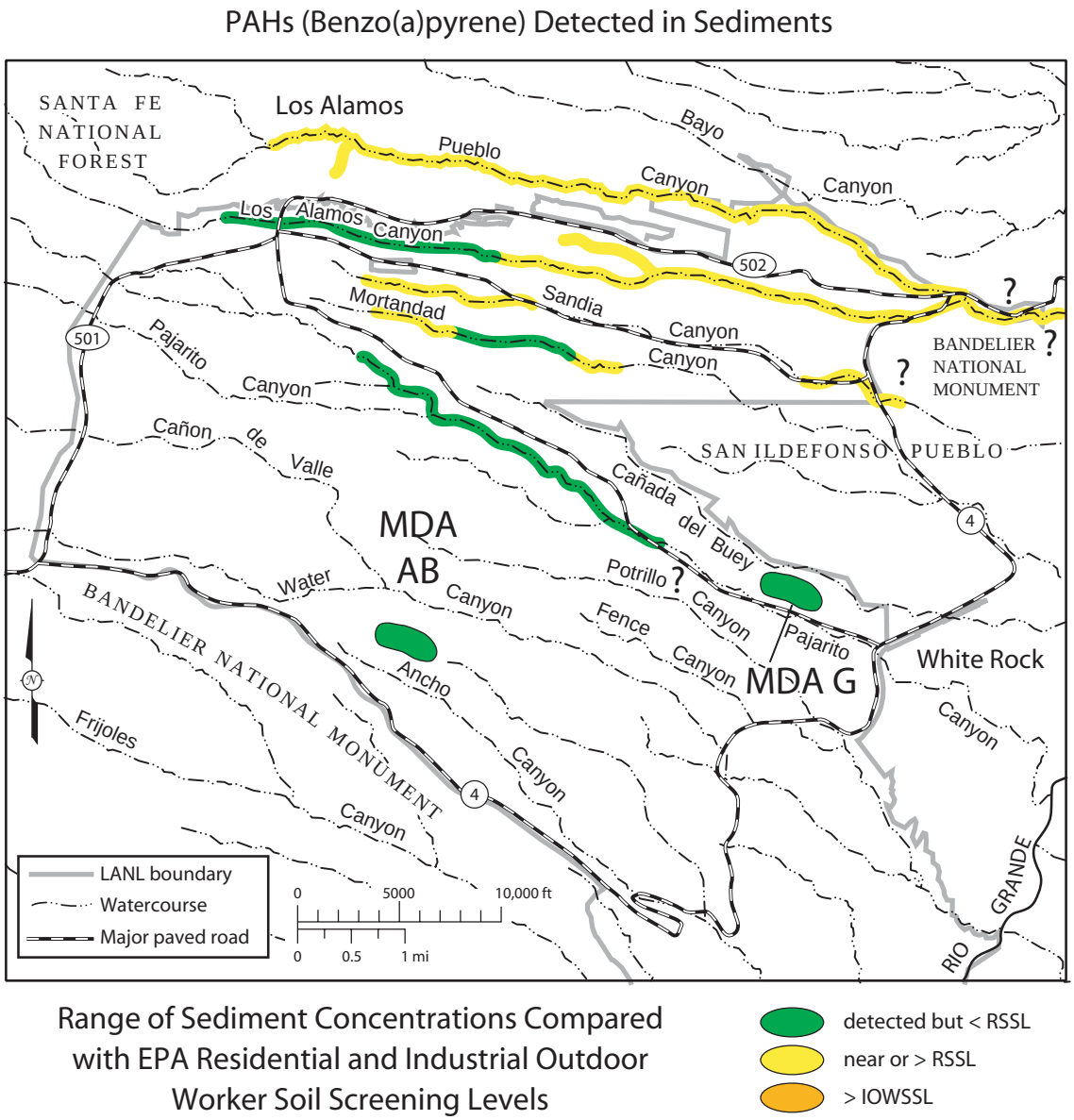


Figure 6-9. Location of sediment with benzo(a)pyrene, a PAH, detected or above screening levels. Different colors indicate where PAHs are detected or are above the EPA Region 6 residential soil screening level (no values were above the industrial screening level). The highest value in 2003 was in Sandia Canyon, at 3.6 times the residential soil screening level and 0.95 times the industrial outdoor worker soil screening level.

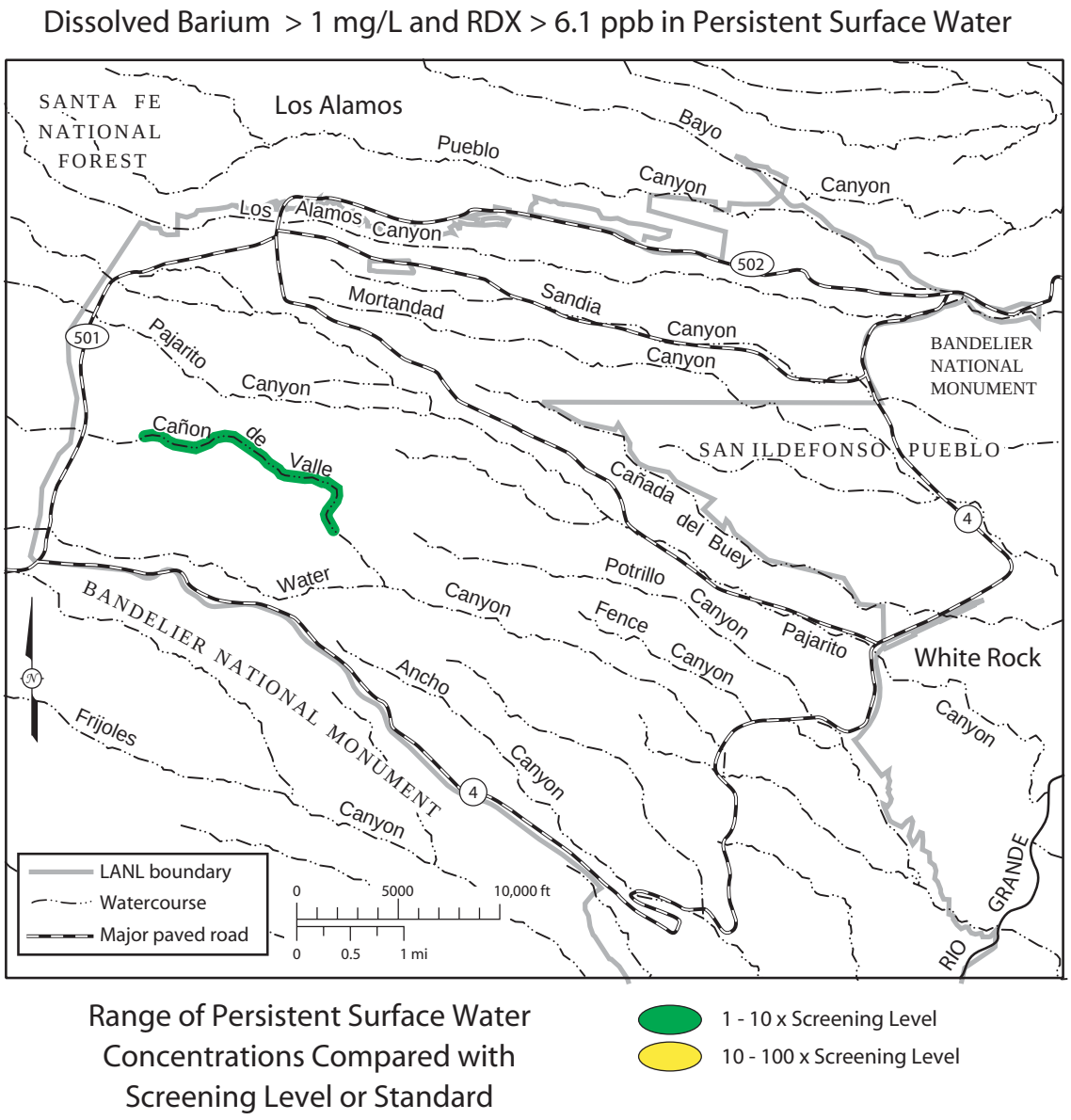


Figure 6-10. Location of persistent surface water with dissolved barium above 1 mg/L and RDX above 6.1 ppb. This map is based on data obtained by the Remediation Services. The 1 mg/L is the New Mexico groundwater standard for dissolved barium, and the 6.1 ppb RDX EPA tap water screening level corresponds to a 10^{-5} excess cancer risk. The comparison is for screening purposes, as these streams are not drinking water sources.

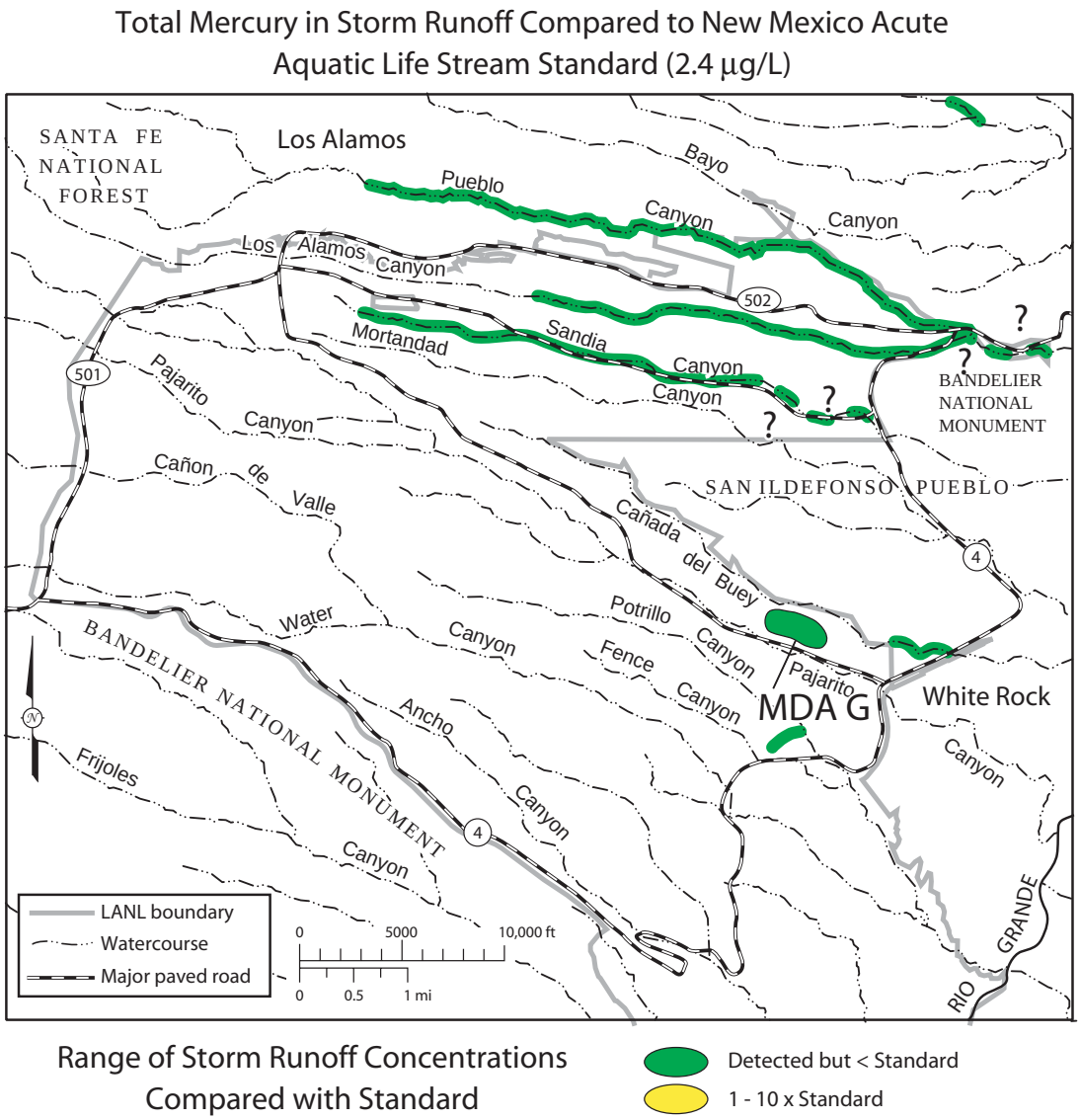


Figure 6-11. Location of storm runoff with total mercury above the New Mexico Acute Aquatic Life stream standard. Different colors indicate the proportion of concentration to the standard. The highest 2003 values were in Cañada del Buey at 54% of the standard and in Los Alamos Canyon at 46% of the standard. The New Mexico Environment Department measured total mercury above the standard by 1.5 times in storm runoff samples collected in Los Alamos Canyon. Reference to the aquatic life stream standard is for comparison; this standard applies to fisheries like the Rio Grande; streams within LANL do not have fish.

Table 6-2. List of Highest Values in Sediment and Storm Runoff Samples Compared with Screening Levels for 2003.

Analyte	Location	Year	Result	Units	Background Screening Level Type[1]	Screening Value[2]	Ratio of Result/ Screen
Sediment							
Am-241	Mortandad below Effluent Canyon	2003	13.7	pCi/g	Fallout Background	0.076	180.26
Cs-137	Mortandad below Effluent Canyon	2003	19.8	pCi/g	Fallout Background	0.56	35.36
Pu-238	Mortandad below Effluent Canyon	2003	11.5	pCi/g	Fallout Background	0.0087	1321.84
Pu-239,240	Mortandad below Effluent Canyon	2003	8.9	pCi/g	Fallout Background	0.013	684.62
Pu-239,240	Area G-7	2003	3.25	pCi/g	Fallout Background	0.013	250.00
Aroclor-1260 (PCB)	Sandia below Wetlands	2002	213	µg/kg			
Benzo(a)pyrene (PAH)	Sandia rt fork at Power Plant	2003	222	µg/kg			
Benzo(a)pyrene (PAH)	Pueblo above SR-502	2003	147	µg/kg			
Benzo(a)pyrene (PAH)	Pueblo above Acid	2003	91.9	µg/kg			
Chromium	Sandia below Wetlands	2003	199	µg/kg	Soil Background	19.3	10.31
Base flow		2003					
Copper (Dissolved)	Mortandad at Rio Grande	2003	22.1	µg/L			
Zinc (Dissolved)	Sandia rt fork at Power Plant	2003	390	µg/L			
Aroclor-1260 (PCB)	Sandia below Wetlands	2003	0.1	µg/L			
Runoff							
Am-241	Mortandad below Effluent Canyon	2003	526	pCi/L	Runoff Background	NA	11400.00
Pu-238 (Total)	Mortandad below Effluent Canyon	2003	685	pCi/L	Runoff Background	NA	7600.00
Pu-239,240 (Total)	Mortandad below Effluent Canyon	2003	605	pCi/L	Runoff Background	NA	11900.00
Barium (Dissolved)	Cañon de Valle	2003	5210	µg/L			
RDX (Total)	Cañon de Valle	2002	2.7	µg/L			
Zinc (Dissolved)	Sandia Tributary at Heavy Equipment	2003	594	µg/L			
Zinc (Dissolved)	Twomile tributary at TA-3	2003	383	µg/L			
Chromium (Total)	Sandia below Wetlands	2003	222	µg/L	Runoff Background	NA	11.50
Copper (Dissolved)	Twomile tributary at TA-3	2003	41.6	µg/L			
Copper (Dissolved)	Sandia Tributary at Heavy Equipment	2003	20.4	µg/L			
Mercury (Total)	Area G-6U	2003	3.9	µg/L			
Hexachlorobenzene	Sandia below Wetlands	2003	0.71	µg/L			

Table 6-2. Continued

Analyte	Location	Year	Result	Units	Residential Screening Level Type or Standard[1]	Screening Value	Ratio of Result/ Screen	Industrial Screening Level Type or Standard[1]	Screening Value	Ratio of Result/ Screen
Sediment										
Am-241	Mortandad below Effluent Canyon	2003	13.7	pCi/g	Residential SAL	39	0.35	Industrial	56	0.25
Cs-137	Mortandad below Effluent Canyon	2003	19.8	pCi/g	Residential SAL	5.3	3.74	Industrial	19	1.03
Pu-238	Mortandad below Effluent Canyon	2003	11.5	pCi/g	Residential SAL	49	0.23	Industrial	65	0.18
Pu-239,240	Mortandad below Effluent Canyon	2003	8.9	pCi/g	Residential SAL	44	0.20	Industrial	60	0.15
Pu-239,240	Area G-7	2003	3.25	pCi/g	Residential SAL	44	0.07	Industrial	60	0.05
Aroclor-1260 (PCB)	Sandia below Wetlands	2002	213	µg/kg	EPA RSSL	220	0.97	EPA IOWSSL	830	0.26
Benzo(a)pyrene (PAH)	Sandia rt fork at Power Plant	2003	222	µg/kg	EPA RSSL	60	3.70	EPA IOWSSL	230	0.97
Benzo(a)pyrene (PAH)	Pueblo above SR-502	2003	147	µg/kg	EPA RSSL	60	2.45	EPA IOWSSL	230	0.64
Benzo(a)pyrene (PAH)	Pueblo above Acid	2003	91.9	µg/kg	EPA RSSL	60	1.53	EPA IOWSSL	230	0.40
Chromium	Sandia below Wetlands	2003	199	µg/kg						
Base flow		2003								
Copper (Dissolved)	Mortandad at Rio Grande	2003	22.1	µg/L	Aquatic Life (chronic)	13.4	1.65			
Zinc (Dissolved)	Sandia rt fork at Power Plant	2003	390	µg/L	Aquatic Life (chronic)	117	3.33			
Aroclor-1260 (PCB)	Sandia below Wetlands	2003	0.1	µg/L	NM Human Health	0.0017	58.82			
Runoff										
Am-241	Mortandad below Effluent Canyon	2003	526	pCi/L				DCG	30	17.53
Pu-238 (Total)	Mortandad below Effluent Canyon	2003	685	pCi/L				DCG	40	17.13
Pu-239,240 (Total)	Mortandad below Effluent Canyon	2003	605	pCi/L				DCG	30	20.17
Barium (Dissolved)	Cañon de Valle	2003	5210	µg/L	NM Groundwater	1000	5.21			
RDX (Total)	Cañon de Valle	2002	2.7	µg/L	Tap Water	0.61	4.43			
Zinc (Dissolved)	Sandia Tributary at Heavy Equip.	2003	594	µg/L	Aquatic Life (acute)	117	5.0			
Zinc (Dissolved)	Twomile tributary at TA-3	2003	383	µg/L	Aquatic Life (acute)	117	3.27			
Chromium (Total)	Sandia below Wetlands	2003	222	µg/L						
Copper (Dissolved)	Twomile tributary at TA-3	2003	41.6	µg/L	Aquatic Life (acute)	13.4	3.10			
Copper (Dissolved)	Sandia Tributary at Heavy Equip.	2003	20.4	µg/L	Aquatic Life (acute)	13.4	1.52			
Mercury (Total)	Area G-6U	2003	3.9	µg/L	Aquatic Life (acute)	2.4	1.63			
Hexachlorobenzene	Sandia below Wetlands	2003	0.71	µg/L	NM Human Health	0.0077	92.21			

[1]**Sources of screening levels for sediment:**
RSSL- EPA Region 6 Residential Soil Screening Level; IOWSSL- EPA Region 6 Industrial Outdoor Worker Soil Screening Level; Fallout Background- from McLin and Lyons 2002; Soil Background- from Ryti et al.1998; Residential SAL- l from ER 2001; Industrial worker screening level- for an industrial scenario at 15 mrem/y dose, Perona et al. 1998.

[1]**Sources of screening levels for storm runoff:**
Background concentration in storm runoff varies for each sample depending on suspended sediment concentration. NM Groundwater: New Mexico Water Quality Control Commission groundwater standards (NMWQCC 2002b); Tap Water - EPA Region 6 Tap Water Screening Level; Aquatic Life (acute): New Mexico Water Quality Control Commission stream standards (NMWQCC 2002b); (we assumed 100 mg/L hardness to calculate screening levels for Zn, Cu); DCG - DOE 100 mrem public dose Derived Concentration Guide; Wildlife Habitat: NMWQCC stream standard for total mercury.

[2]For storm runoff, background was calculated for each sample based on suspended sediment concentration, using a linear regression fit to a large group of samples. Background concentration in runoff for silver is assumed to be the typical analytical detection limit of 1 ug/L.

than 100 times fallout levels. Plutonium-239,240 is found in Mortandad Canyon sediments at levels more than 100 times above fallout levels (Figure 6-6), but those levels remain below SALs. Some sediment radioactivity at levels slightly above fallout extends beyond the San Ildefonso Pueblo boundary for possibly up to 2 miles (Gallaher et al. 1997).

Above-background radioactivity in sediments also occurs in the vicinity of two material disposal areas. Sediments near Area G (Technical Area [TA] 54) show americium-241 at less than 10 times fallout levels, and plutonium-238 and plutonium-239,240 at more than 10 times fallout levels. Area AB (TA-49) has sediments with americium-241 at less than 10 times fallout levels, and plutonium-239,240 at more than 10 times fallout levels. Storm runoff near Area G carries similarly elevated levels of these radionuclides.

b. Polychlorinated Biphenyls. Polychlorinated biphenyls (PCBs) are synthetic organic chemicals that are used in a variety of industrial applications such as electrical transformers. We have detected PCBs in sediments in nearly all the major canyons that flow across Laboratory land. The highest concentrations typically are in upper Sandia Canyon near the Laboratory's main technical area, where concentrations are slightly greater than EPA residential soil-screening levels and about 40% of the industrial outdoor worker screening level (Figure 6-7). A base flow surface water sample from Sandia Canyon contained PCBs at concentrations greater than the New Mexico Wildlife Habitat and Human Health Standards (Figure 6-8). There are numerous potential PCB sources in upper Sandia Canyon. Health standards and the water quality standards for PCBs are concerned with long-term exposure. To assess the levels of PCBs in the northern Rio Grande watershed, LANL is participating in a special study with state, local, and tribal government agencies.

c. Polycyclic Aromatic Hydrocarbons in Sediment. Polycyclic aromatic hydrocarbons (PAHs) are complex hydrocarbons formed by incomplete combustion of petroleum products or organic matter or are in products such as asphalt or tar. PAHs are commonly found in urban runoff. PAHs (benzo(a)pyrene, benzo(b)fluoranthene, and benzo(a)anthracene) at levels near or well above the EPA residential soil-screening levels are present in the following canyons—Acid, DP, Los Alamos, Sandia, Pajarito, and Mortandad—and are found at Areas G and AB (Figure 6-9). Values for benzo(a)pyrene in Los Alamos Canyon in 2001 were 4 times the EPA industrial outdoor worker soil screening level, and a 2003 value in Sandia Canyon was 65% of this screening level. Sources of the PAHs are not clear, but the Cerro Grande fire is a likely contributor. The proximity of some of the higher concentrations to developed areas indicates that highway runoff is also a major contributor. Detailed investigations by the RRES-RS Project showed significant contribution of PAHs from town site runoff into DP Canyon, a tributary of Los Alamos Canyon (LANL 2004).

d. High Explosives and Barium. The Laboratory formerly released wastewater containing high levels of several high explosives (HEs) and barium from processing sites in TA-16 and TA-9 into Water Canyon and Cañon del Valle. The base flow surface water contains cyclonite (RDX, an HE compound) above 6.1 ppb, an EPA risk-based tap water action level, and dissolved barium concentrations greater than the NM groundwater standard of 1 mg/L (Figure 6-10).

e. Mercury. About 20% of storm runoff samples contain detectable levels of mercury but at levels below acute aquatic life standards (Figure 6-11). Laboratory spills of mercury have occurred in the past, but it is uncertain if the mercury in the runoff is from LANL operations. Background levels of mercury in waters and sediments are appreciable, and we have measured mercury in runoff and sediment samples from Guaje Canyon at a background location far from Laboratory operations. Mercury in runoff is an issue because it can enter the Rio Grande and accumulate in fish. The contribution of Los Alamos-area mercury into the Rio Grande and Cochiti Reservoir cannot be differentiated from other possible contributors in sediment or water samples.

E. Monitoring Network

1. Regional Monitoring Locations

Regional base flow and sediment-sampling stations (Figure 6-12) are located in northern New Mexico and southern Colorado. Samples from regional stations provide a basis for estimating background

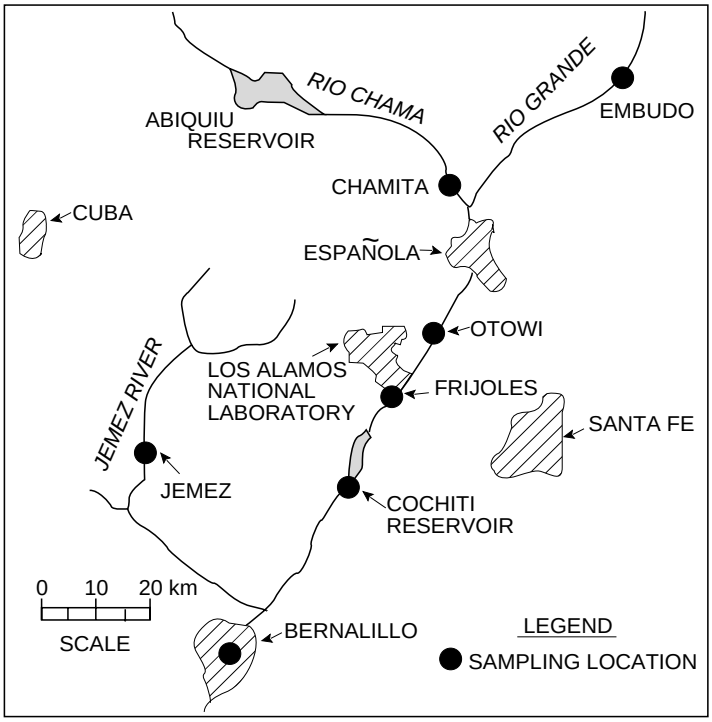


Figure 6-12. Regional base-flow and sediment-sampling locations.

concentrations of nonradioactive compounds and background activities of radionuclides that are naturally occurring or result from atmospheric fallout. We obtained regional sediment samples from reservoirs on the Rio Grande and the Rio Chama and at stations on the Rio Grande and the Jemez River. Sampling stations in the Rio Grande drainage system are located up to 200 km upstream and 60 km downstream of the Laboratory.

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 6-13).

After 1996, we have collected storm runoff samples using stream-gauging stations with automated samplers (Figure 6-14). 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 6-15) 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

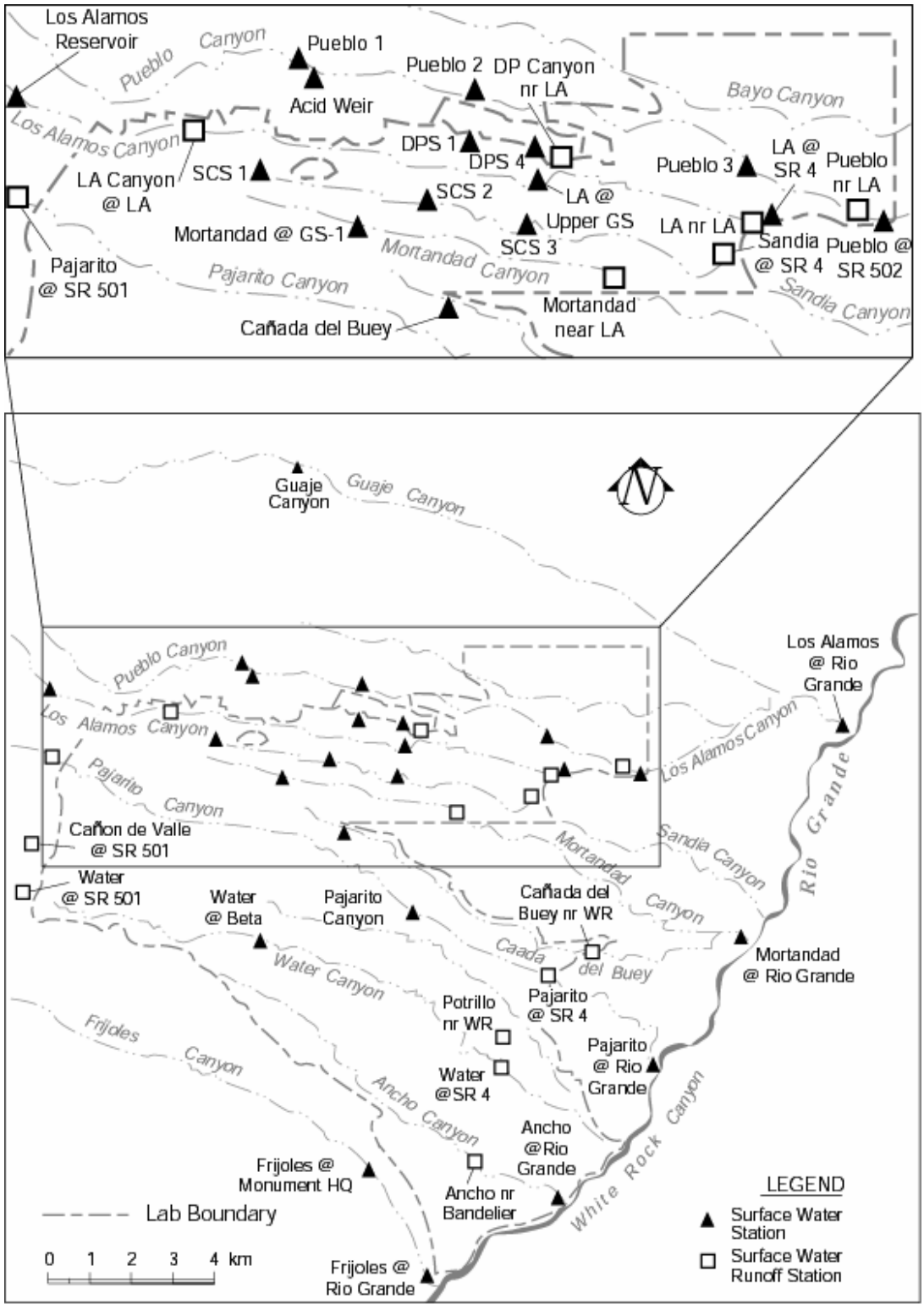


Figure 6-13. Base-flow sampling locations in the vicinity of Los Alamos National Laboratory.

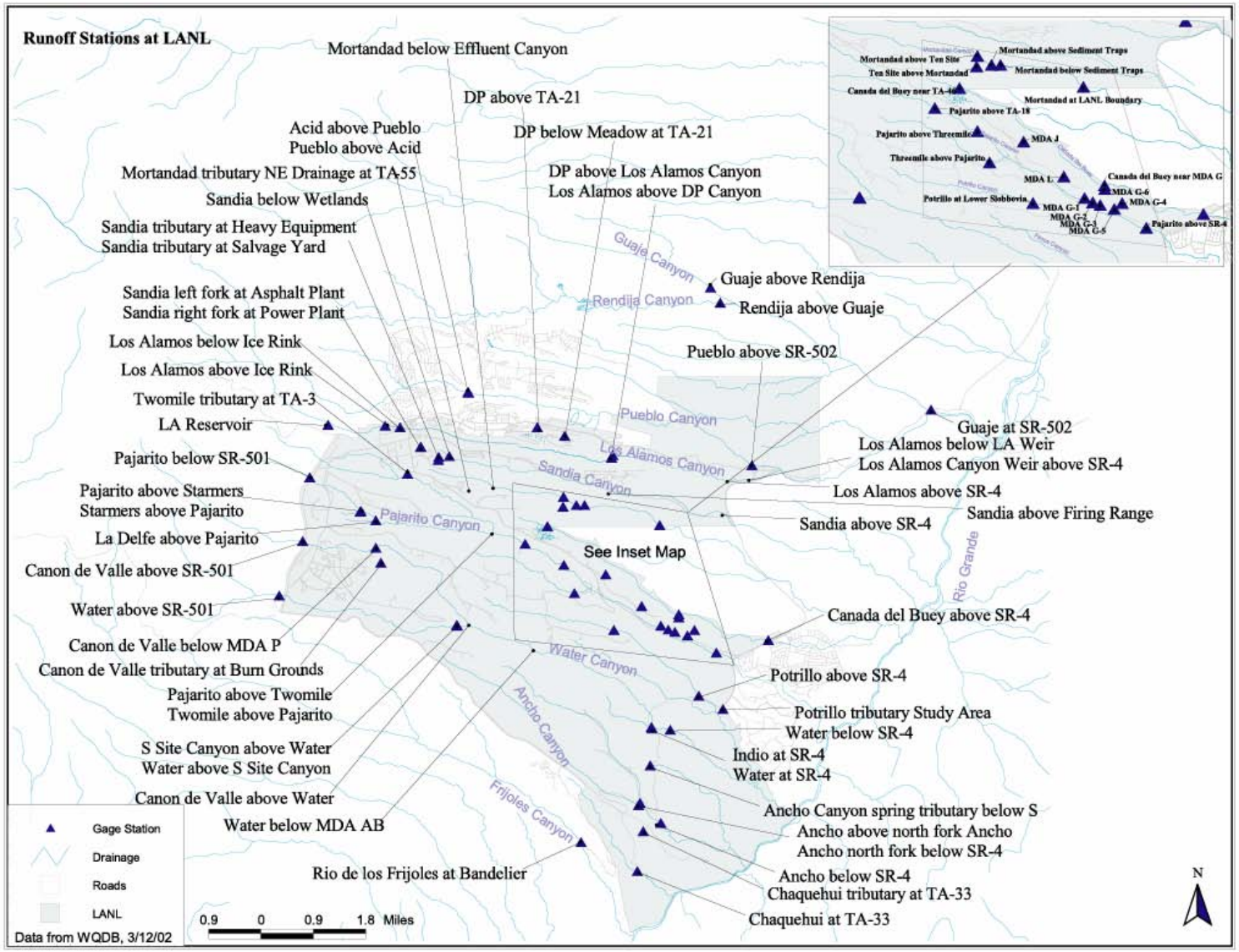


Figure 6-14. Storm runoff sampling (gauging) stations in the vicinity of Los Alamos National Laboratory.

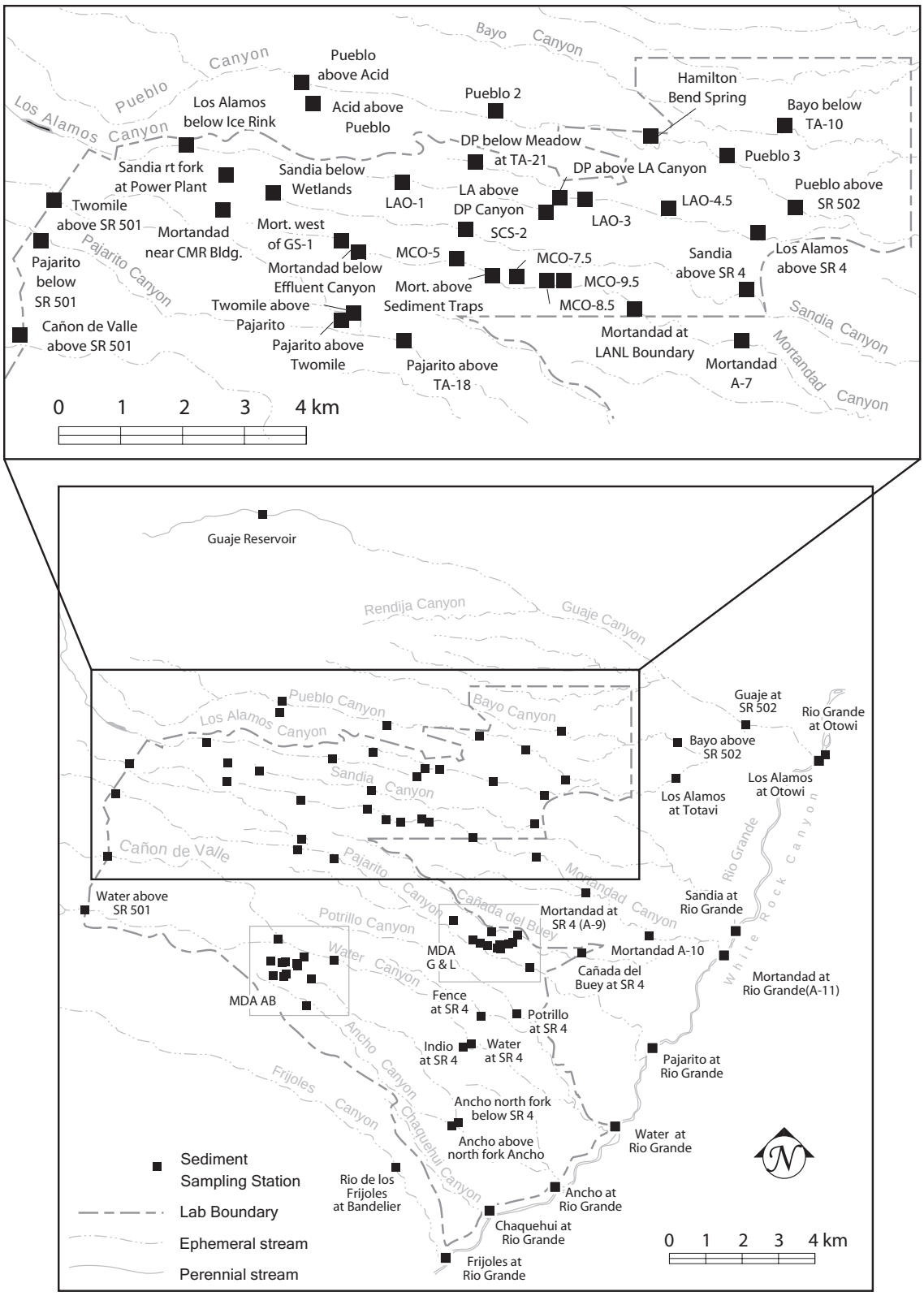


Figure 6-15. Sediment sampling locations in the vicinity of Los Alamos National Laboratory. Material disposal areas with multiple sampling locations are shown in Figures 6-16 and 6-17.

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 also collected sediments from drainages downstream of two material disposal areas. Material disposal area G at TA-54 is an active waste storage and disposal area. Nine sampling stations were established outside its perimeter fence in 1982 (Figure 6-16) 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 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 6-17).

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 watersheds that pass through LANL onto the Pueblo are Los Alamos, Sandia, and Mortandad 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 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.

F. 2003 Watershed Monitoring Data Tables

The Data Supplement contains tables of all the 2003 base flow, storm runoff, 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 analyzed for gross alpha, gross beta, and selected radionuclides (americium-241; cesium-137; plutonium-238; plutonium-239,240; strontium-90; uranium isotopes; and tritium). Table S6-1 in the Data Supplement list the results of radiochemical analyses of base flow for 2003. 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, Table S6-2 lists radionuclides detected in base flow and compares the results with regulatory standards. 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 columns of Table S6-2 show how the results compare with the standards shown.

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 Tables S5-4, S5-5, and S5-6 in the Data Supplement.

The results of radiochemical analyses of storm runoff appear in Table S6-3 and those for sediments appear in Table S6-4. Tables S6-5 and S6-6 (reservoir sediments) list radiological detections for results that are higher than river or reservoir sediment background levels and identify values that are near or above SALs. Table S6-4 shows all tritium detections regardless of screening levels.

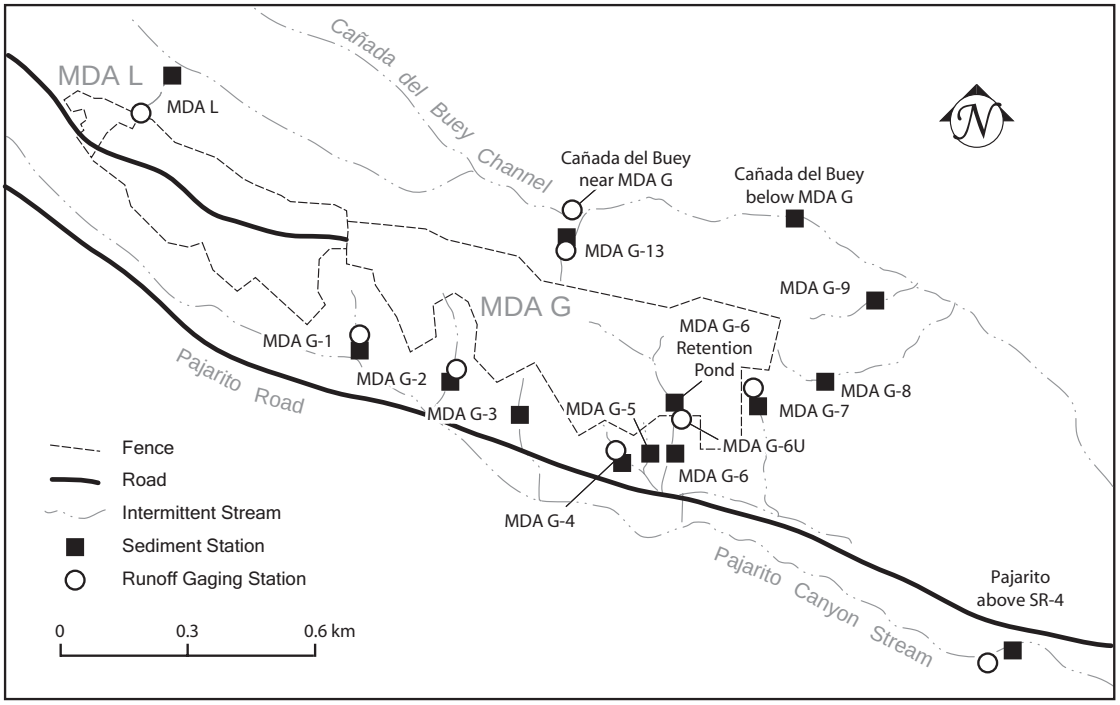


Figure 6-16. Sediment and storm runoff sampling stations at TA-54, Area L and Area G.

Table S6-7 lists the results of general chemical analyses of base flow water samples for 2003, and those for storm runoff appear in Table S6-8. The results of trace metal analyses base flow, storm runoff, and sediments appear in Tables S6-9 through S6-11, respectively.

In 2003, we analyzed samples for organic constituents at selected surface water and sediment stations. Samples were analyzed for volatile organic compounds (surface water only), semivolatile organic compounds, PCBs, and HE. Analytical methods are given in Table A-4 and analytes for each suite are listed in Tables A-5 through A-8, all in Appendix A. The stations and organic suites for which we sampled are listed in Table S6-12 for surface water and in Table S6-14 for sediments. For surface water samples, 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 detected in field quality-control samples, including equipment and trip blanks. Trip blanks go along during sampling to determine whether organic constituents come from sample transportation and shipment. Only method blanks are available for comparison with organic results for sediments. Table S6-13 shows organic compounds detected in surface waters above the analytical laboratory's reporting level in 2003 and results from field quality-control samples. Table S6-15 shows organic compounds detected in sediments.

G. Site-Wide Monitoring Issues

1. Radioactivity in Surface Water

Some storm runoff events in Mortandad Canyon and Pueblo Canyon contained individual radionuclides above the 100-mrem DOE DCGs for public dose, but the annual average concentrations were within the DCG guidelines. There is a minimal opportunity for exposure to the surface water, as the

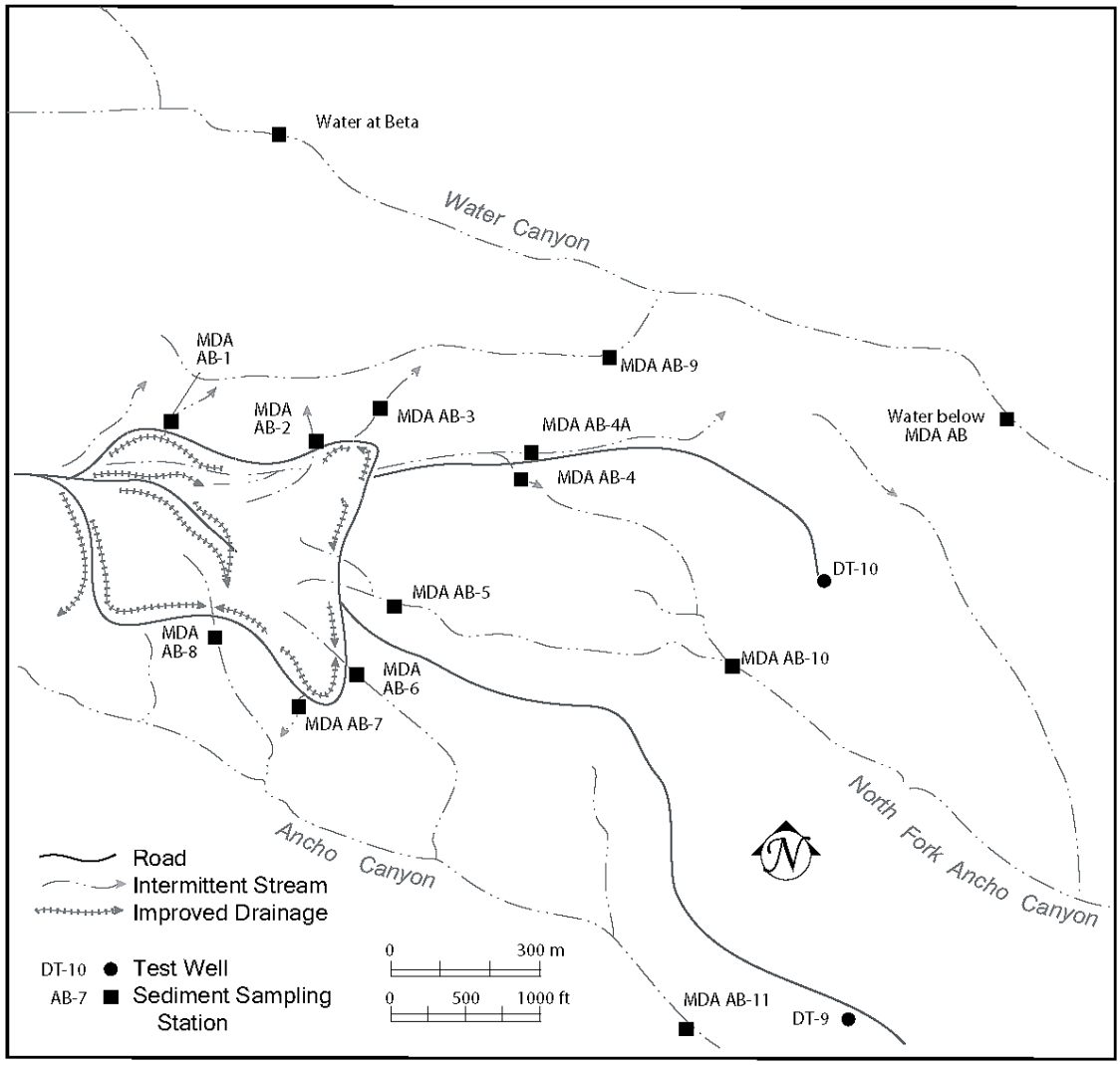


Figure 6-17. Sediment sampling stations at Area AB, TA-49. (This figure has been edited for operational security purposes.)

water is not used as a drinking water source. The DCGs are derived with continuous exposure to water for the period of 1 year assumed (DOE 2003).

In order to compare surface water sample results with the DCGs, we calculated the time-weighted average annual radioactivity in waters, focusing on the stream segments with 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 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; and strontium-90. Tritium was not included in this calculation because it was largely absent from persistent surface waters, or present at insignificant concentrations. Concentrations measured during base flow periods and during storm runoff periods were weighted proportionally after reviewing stream flow records (Shaull et al. 2004) to distinguish the flow regimes; periods with no flow were assigned concentrations of zero. The review of 2003 data found remarkably consistent occurrence of storm runoff—runoff was present approximately 3% of the total time in Pueblo, Los Alamos, Sandia, and Mortandad Canyons.

For waters containing more than one radionuclide, a ratio was found for each radionuclide. The concentration of each radionuclide divided by its particular DCG value results in a ratio. 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.

Figure 6-3 and Table 6-3 summarize the calculated annual average concentrations of the individual radionuclides in the persistent surface waters and compares them against the 100-mrem DCGs. None of the individual radionuclides were greater than their associated 100 mrem DCGs on an annual average. Along a short segment of Mortandad Canyon below the TA-50 Radioactive Liquid Waste Treatment Facility (RLWTF), the sum of the measured radioactive constituents in Mortandad Canyon was near the DCG (ratio of 1.06). Effluent discharges from the RLWTF were well below the DCG (58% of DCG; Watkins and Worland 2004), but the stream flow entrains additional radioactivity from mobilization of contaminated stream sediments. Stream flow in Mortandad Canyon does not extend off site and is not used as a drinking water supply. Persistent surface water in lower Pueblo Canyon contained summed annualized radioactivity approximately 5% of the 100 mrem DCG, whereas other surface waters that occasionally may flow off-site showed average levels less than 1% of the DCG.

2. Gross Alpha and Selenium Levels in Storm Runoff

Monitoring results of storm runoff after the Cerro Grande fire have shown widespread gross alpha activities greater than 15 pCi/L and total recoverable selenium concentrations greater than 5 µg/L. The New Mexico surface water stream standards are 15 pCi/L for selected alpha emitters, and 5 µg/L for selenium (NMWQCC 2002a). In response to these findings, the New Mexico Environment Department 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 are Guaje Canyon (selenium, gross alpha), Rendija Canyon (selenium), Pueblo Canyon (selenium, gross alpha), Los Alamos Canyon (selenium, gross alpha), Mortandad Canyon (gross alpha), Pajarito Canyon (selenium, gross alpha), and Water Canyon (selenium, gross alpha).

Figure 6-18 shows the trends in gross alpha activities and total suspended solids concentrations in storm runoff samples collected in the four years since the Cerro Grande fire. In 2001 and 2002, gross alpha activities were approximately the same, remaining several orders of magnitude greater than the stream standard. The largest gross alpha activities were in runoff from Guaje, Rendija, and Pueblo Canyons during large runoff events. The gross alpha activities generally correspond to the total suspended solids concentrations. The data indicate that the elevated alpha activities are due predominantly to enhanced natural sediment loads from increased sediment transport after the fire, rather than a LANL source. By 2003, the gross alpha activities in storm runoff were similar to those in 2000 and prefire years.

Table 6-3. Estimated Average Annual Concentrations of Radionuclides for Persistent Waters in Pueblo and Mortandad Canyons Compared with the 100-mrem DCGs.

		Lower Pueblo Canyon (at SR-502)		Mortandad below Effluent Canyon	
Radionuclide	**DOE 100-mrem DCG for Public Exposure (pCi/L)**	**Estimated 2003 Time-Weighted Annual Average**	**Ratio to DCG**	**Estimated 2003 Time-Weighted Annual Average**	**Ratio to DCG**
Am-241	30	0.070	0.0023	10.9	0.363
Cs-137	3000	0.203	0.0001	21.0	0.007
Pu-238	40	0.031	0.0008	14.2	0.355
Pu-239,240	30	1.225	0.0408	9.6	0.319
Sr-90	1000	0.629	0.0006	13.2	0.013
		Sum of Ratios	0.04		1.06

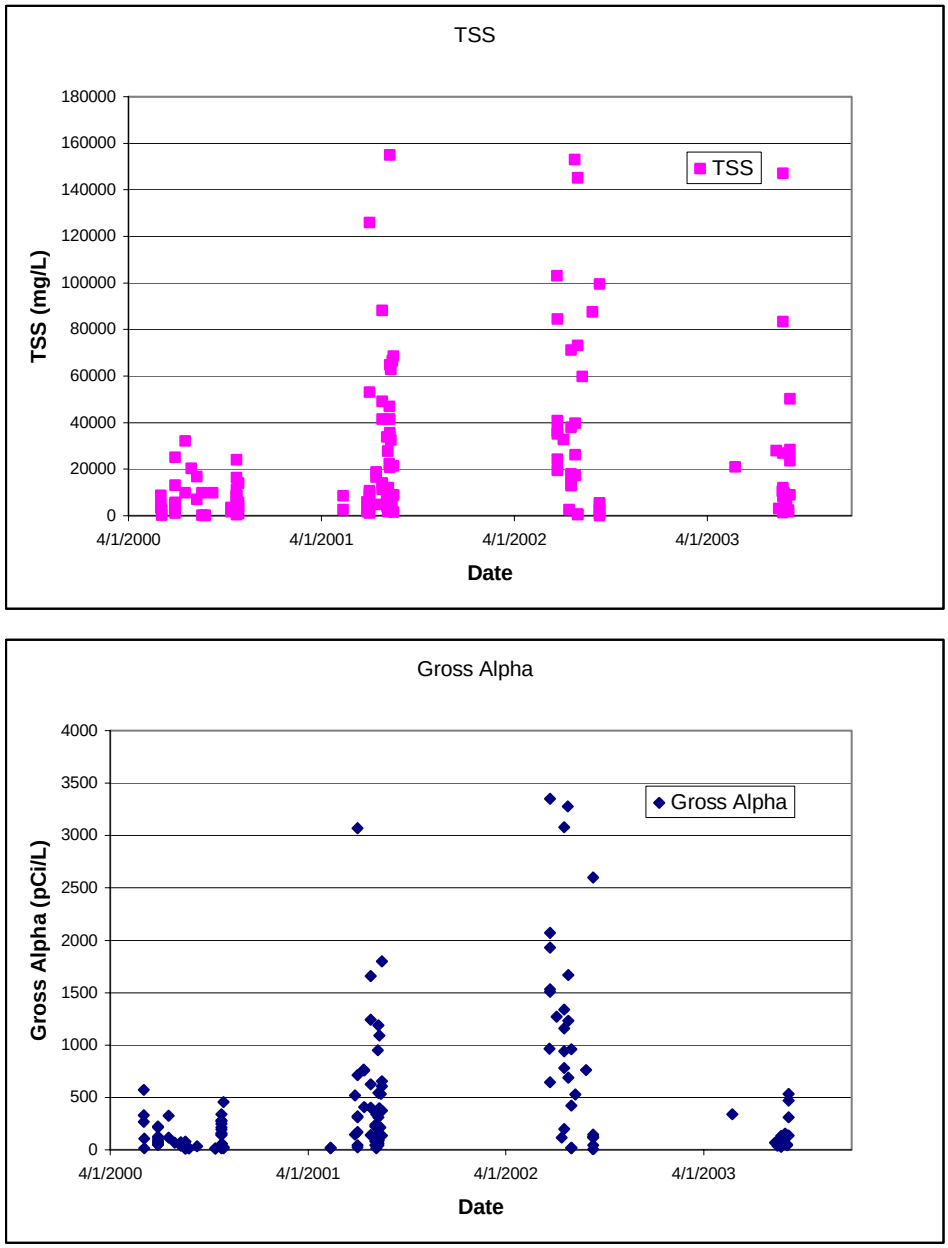


Figure 6-18. Time trends in total suspended solids and total gross alpha activity in storm runoff on Pajarito Plateau, 2000 through 2003.

Despite the significant decline in gross alpha activities in 2003, approximately 42% of all storm runoff samples were greater than the state stream standard. Only one base-flow sample result though was greater than 15 pCi/l. Because any wildlife watering on the Pajarito Plateau would need to depend on base flow for a sustained water source, rather than storm runoff, they typically would be exposed to surface water with concentrations below the standard.

To examine further if elevated concentrations might be due to LANL operations or from natural sources, we assessed how gross alpha activity varies with location. In Figure 6-19 we compared gross alpha activities in LANL upstream and off-site (background) storm runoff samples against those collected on-site or downstream of the Laboratory. Gross alpha activities are compared with an independent measure (total suspended solids) to account for the sediment load. Figure 6-19 shows no appreciable differences in gross alpha activities upstream or downstream of LANL, indicating that the elevated concentrations are largely due to other factors than LANL operations, and probably are the result of higher sediment transport in storm runoff that occurred as a secondary result of the Cerro Grande fire. While LANL has historically released alpha emitters into some canyons, particularly Pueblo Canyon and DP Canyon, the net effect apparently has been slight compared with the total gross alpha activities measured at upstream stations.

Figure 6-20 shows the time series of detected selenium concentrations detected in storm runoff samples collected from major drainages from 1998 through 2003. In 2003, only 15% of samples contained detectable selenium, and only runoff events in Los Alamos Canyon contained greater than 20 µg/L total selenium. Of 229 sample results for the year, only 11 (4%) were greater than the wildlife habitat standard. The data indicate that runoff concentrations after the fire progressively decline over the four-year period, and selenium is not detected in most samples. The downward trend in the selenium detection rate and concentrations in subsequent years after the fire for runoff from fire-impacted areas is possibly related to a general flushing of Cerro Grande ash from the landscape. The elevated concentrations of selenium in Los Alamos Canyon in 2003 suggest possibly a LANL-related source of selenium in that canyon or a delayed scour of ash from the drainage because of upstream hydrologic controls (Los Alamos Reservoir).

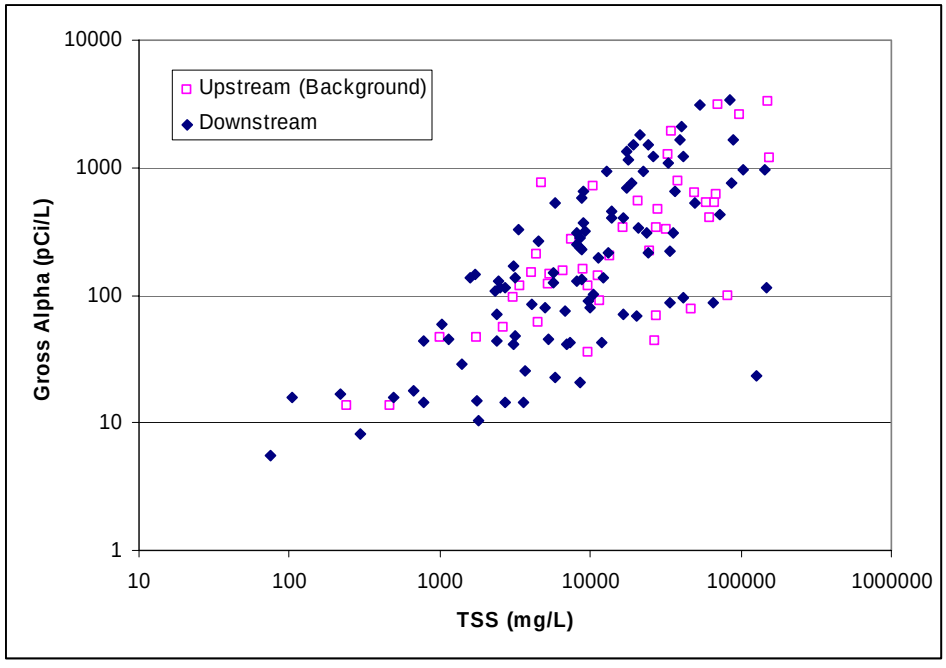
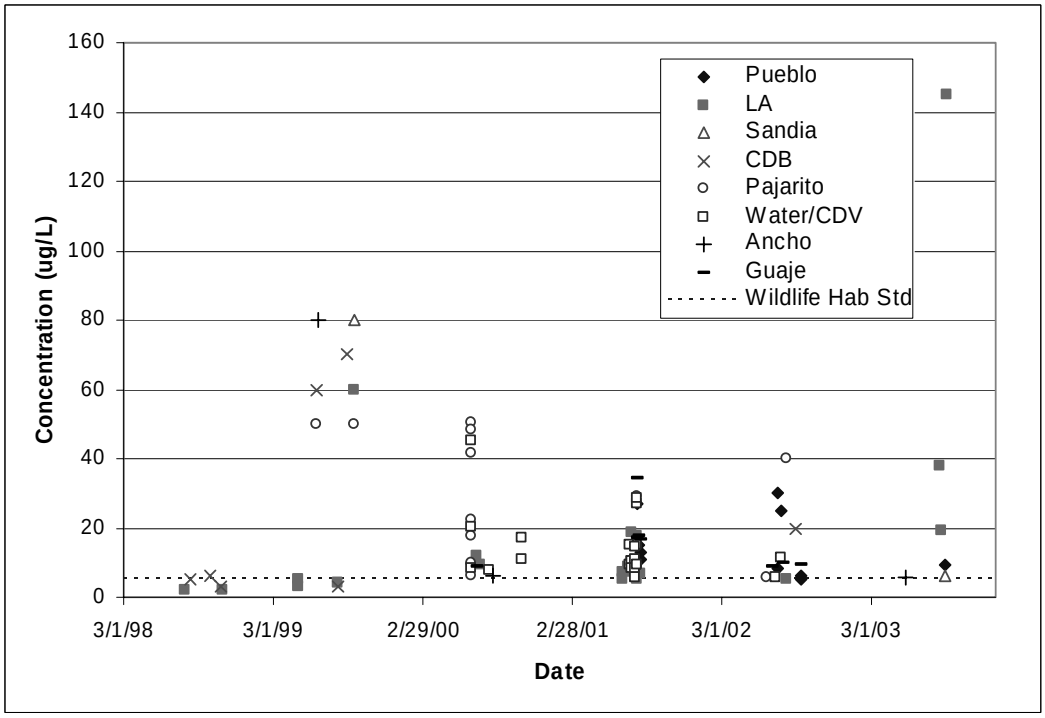


Figure 6-19. Comparison of total gross alpha activity with suspended sediment solids in storm runoff at sites located upstream (background) and on-site and downstream of LANL operations.



Note: Data include results from background sites and stations downstream of LANL operations.

Figure 6-20. Time trends in total recoverable selenium (detections only) in storm runoff, 2000 through 2003, and percentage of samples with detections (inset).

To examine further if elevated selenium concentrations in runoff were due to LANL operations or from natural sources, we assessed how concentrations varied with location. In Figure 6-21 we compare selenium concentrations in "background" storm runoff samples collected upstream or north of LANL against those collected on-site or downstream of LANL for the period 2000 through 2003. Selenium concentrations were compared with an independent measure (iron) to account for the sediment load. The regression analysis line-fit plots show a good correlation between iron and selenium concentrations and slightly higher selenium concentrations at upstream locations; the data indicate that the elevated concentrations of selenium in runoff are largely due to natural factors, probably a combination of suspended sediment load and ash content in runoff. Because only detectable concentrations of selenium were used in the analyses (median detection limit 2.36 µg/L), the regression plots likely show higher than expected concentrations of selenium in nature near the y-intercept value.

3. Perchlorate in Surface Water

Across the country, perchlorate is increasingly recognized as one of the most significant pollutants in waters because of its environmental persistence and toxicity. In 2003, we continued to monitor for perchlorate in all water samples. We used the conventional EPA method 314.0 to analyze 42 base flow and 67 storm runoff samples for perchlorate (Table S6-7). With one exception, perchlorate was not detected in any of these samples at a minimum detection limit of 4 µg/L. A base-flow sample from Sandia Canyon below the power plant showed detectable levels of perchlorate, but the source is uncertain; follow-up samples of the power plant effluent contained no detectable perchlorate. The overall absence of perchlorate in this year's samples is consistent with 2002 results.

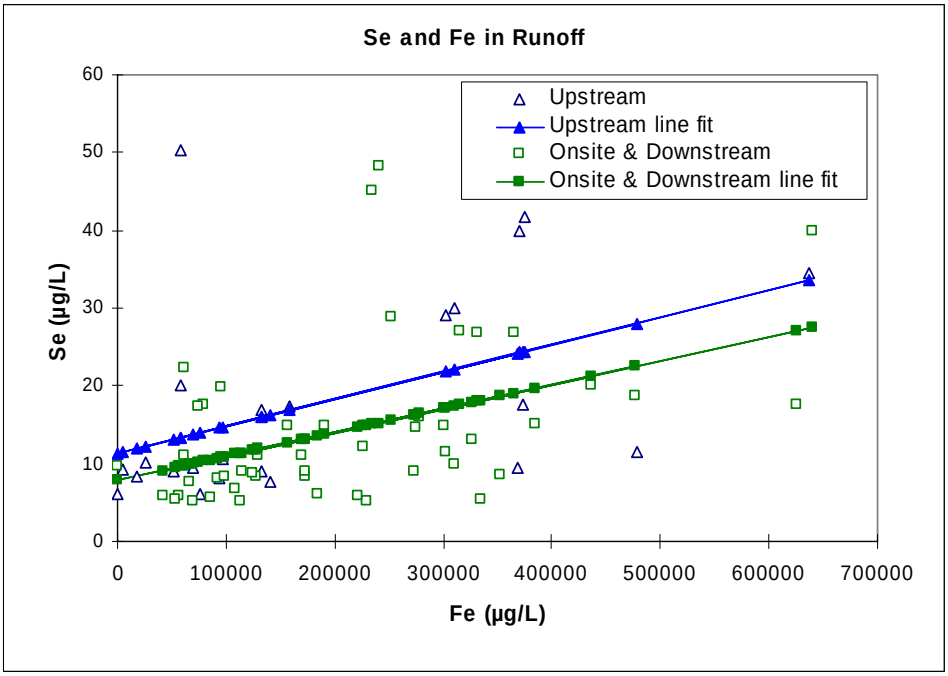


Figure 6-21. Comparison of selenium concentrations in runoff at upstream sites with on-site and downstream LANL sites.

4. Postfire Changes in the Rio Grande

After the Cerro Grande fire, increased flows in watercourses have accelerated the downstream movement of stream sediments and contaminants into the Rio Grande. During the largest runoff events of each of the past four years, flows extended across the Pajarito Plateau to the Rio Grande. Several risk analyses of the early sampling results concluded that health risks associated with use of Rio Grande water did not significantly increase when compared with prefire conditions (RAC 2002, IFRAT 2002, Kraig et al. 2002).

The principal impact of postfire runoff on the Rio Grande has been to sediment quality, rather than any lasting impact to the water column. We have not identified any LANL-related or fire-associated condition that would preclude normal use of the river or reservoir (Gallaher and Koch 2004).

Past studies have identified cesium-137 and plutonium-239,240 to be among the contaminants most likely to reflect post fire effects. Ash and storm runoff samples taken in 2000 after the fire and upstream of the Laboratory found cesium-137 levels to be more than 10 times higher than normal (Johansen et al. 2001; Katzman et al. 2001; Gallaher et al. 2002). Several studies (Bitner et al. 2001) have shown that fires concentrate fallout-derived cesium-137 from vegetation into the soil where it is available for redistribution by runoff. In addition, large runoff events in Pueblo Canyon beginning in 2001 have accelerated the transport of Laboratory-derived plutonium-239,240 into lower Los Alamos Canyon and the Rio Grande (ESP 2002; NMED 2003b).

The sampling results indicate small to moderate increases in cesium-137 and plutonium-239,240 activities in Cochiti Reservoir bottom sediments, but no apparent changes in dissolved metal concentrations in the Rio Grande or reservoir. Cesium-137 levels in Cochiti Reservoir bottom sediments increased quickly after the fire by 3 to 5 times in September 2000; but since then, the cesium-137 levels have decreased to near prefire levels at most sampling locations (Figure 6-22). The median postfire cesium-137 activity in Cochiti Reservoir sediments is approximately 10% of the risk-based residential SAL of 5.3 pCi/g. The downward trend in cesium-137 activities since September 2000 indicates that the increase probably was associated with the initial flush of fallout-derived ash into the Rio Grande.

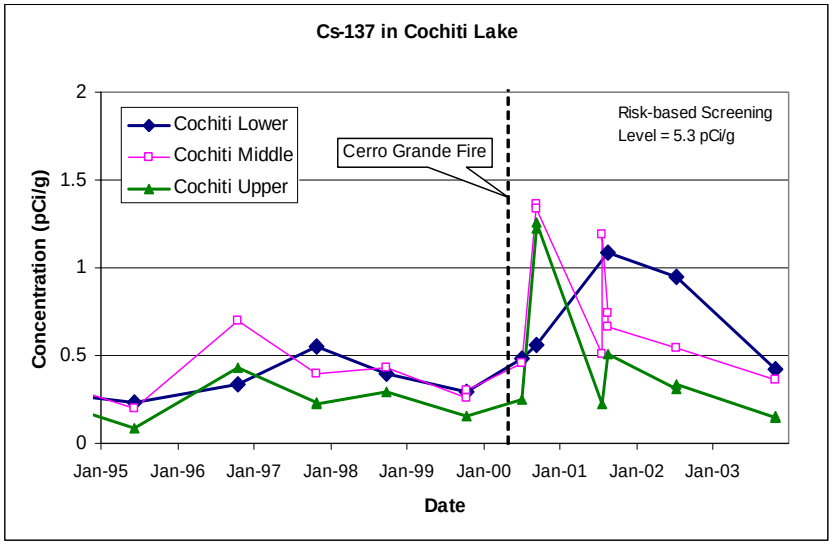


Figure 6-22. Cesium-137 trends in Cochiti Reservoir bottom sediments before and after the Cerro Grande fire.

Plutonium-239,240 activities in Cochiti Reservoir bottom sediments showed increases after the Cerro Grande fire in the upper and middle sections of the reservoir (Figure 6-23), yet remained far below the risk-based residential SALs. At the upper station, activities continually increased throughout the 3-year period 2000–2002 to approximately 6 times above prefire levels. At the middle station, plutonium-239,240 activities continue to rise, reaching a historical high in 2003 of approximately 22 times above prefire levels. A slight increase was found in the lower station near Cochiti Dam in 2003. The median postfire plutonium-239,240 activity in Cochiti Reservoir sediment is approximately 0.1% of the SAL of 44 pCi/g.

Dissolved metal concentrations in 18 Rio Grande samples collected below the Laboratory since 2000 were lower than levels prescribed in EPA primary drinking water standards. Dissolved metal concentrations measured in postfire samples were generally comparable with or lower than prefire values.

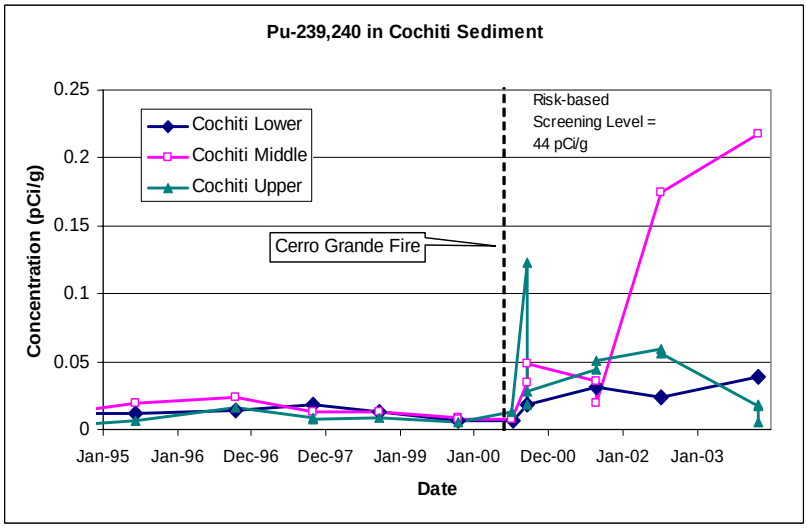


Figure 6-23. Plutonium-239,240 trends in Cochiti Reservoir bottom sediments before and after the Cerro Grande fire.

H. Watershed Monitoring Issues

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.

In 2003, concentrations of radionuclides and metals appeared to be within background ranges both in active channels sediments and in suspended sediments carried by storm runoff.

Two runoff samples collected in Guaje Canyon above Rendija contained dissolved concentrations of aluminum, iron, lead, and manganese several times greater than the New Mexico groundwater standard. The dissolved lead concentration in one runoff sample also was slightly greater than the acute aquatic life standard. Each of these metals is a natural component of soils, and the results likely are related to turbidity rather than anthropogenic effects. Similar results were found in previous years.

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

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.

Throughout the watershed, contaminant concentrations remained below risk-based SALs. In sediments of both Los Alamos and Pueblo Canyons, above-background levels of plutonium and cesium-137 extend for tens of kilometers from the sources in Acid and DP Canyons (Figures 6-4 and 6-6). The contamination extends off-site across San Ildefonso Pueblo lands and reaches the Rio Grande near the Otowi Bridge. 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).

Plutonium-238 and plutonium-239,240 activities in middle and lower Pueblo Canyon were elevated in 2003 approximately 2 times prefire levels, a decline from a peak in 2001 at about 4 times prefire levels (Figure 6-24). In 2003, cesium-137 activities in lower Pueblo Canyon ranged from 1 to 2 times prefire levels. Cesium-137 in Pueblo Canyon sediments had temporarily increased by as much as 10 times prefire levels in 2001. Although radioactivity levels in lower Los Alamos Canyon slightly increased after the fire (Figure 6-25), overall they are comparable with the long-term prefire trends. Plutonium-239,240 activities in lower Los Alamos Canyon ranged up to 0.5% of the SAL.

In the 2001 and 2002 reports, we showed that large-magnitude floods in Pueblo Canyon significantly accelerated the downstream movement of plutonium following the Cerro Grande fire. While most of the other canyons at LANL appear to have recovered to near prefire conditions, flows in Pueblo Canyon remain dynamic. The enhanced stream flows have resulted in accelerated alternating channel degradation and aggradation, accelerated bank erosion, vertical and lateral channel migration, and head cutting into contaminant packages (Ford-Schmid and Englert 2004). These trends were recently analyzed by Gallaher and Koch (2004) and are summarized in Table 6-4. In 2003, stream flow in lower Pueblo Canyon accounted for 81% of the total crossing LANL's downstream boundary and for 99% of the plutonium-239,240 transport beyond the boundary.

Despite the recent enhanced movement of radioactivity from Pueblo Canyon, the effect on radioactivity at downstream sites on the Pajarito Plateau has been slight. This indicates that possibly (1) sediments carried by runoff were diluted by the large volume of sediments contained in the flood or (2) the large runoff events carried much of the extra sediment load directly into the Rio Grande where it mixed with a larger volume of sediments.

In 2002, we identified a possible upward trend in mercury concentrations in Pueblo Canyon sediments, based on a limited data set, possibly triggered by post-Cerro Grande conditions. Results for 2003 do not support the trend, and concentrations were again within normal ranges. Mercury was detected in three storm runoff samples collected in Pueblo Canyon upstream of LANL operations. A recent RRES-RS study of mercury patterns in Pueblo Canyon stream sediments showed an origin that was upstream of LANL operations (LANL 2004).

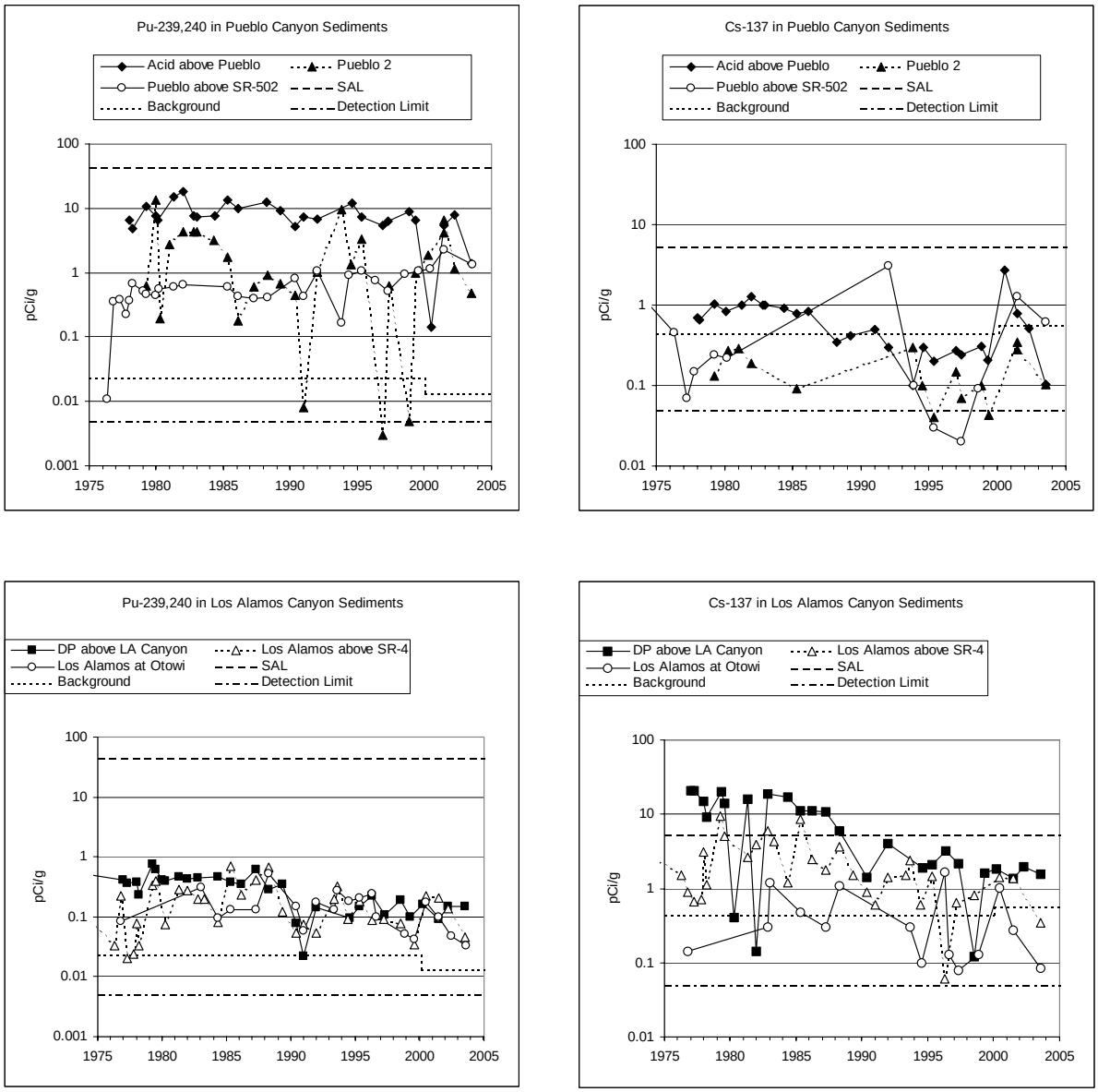


Figure 6-24. Long-term radioactivity trends in Los Alamos and Pueblo Canyon sediments.

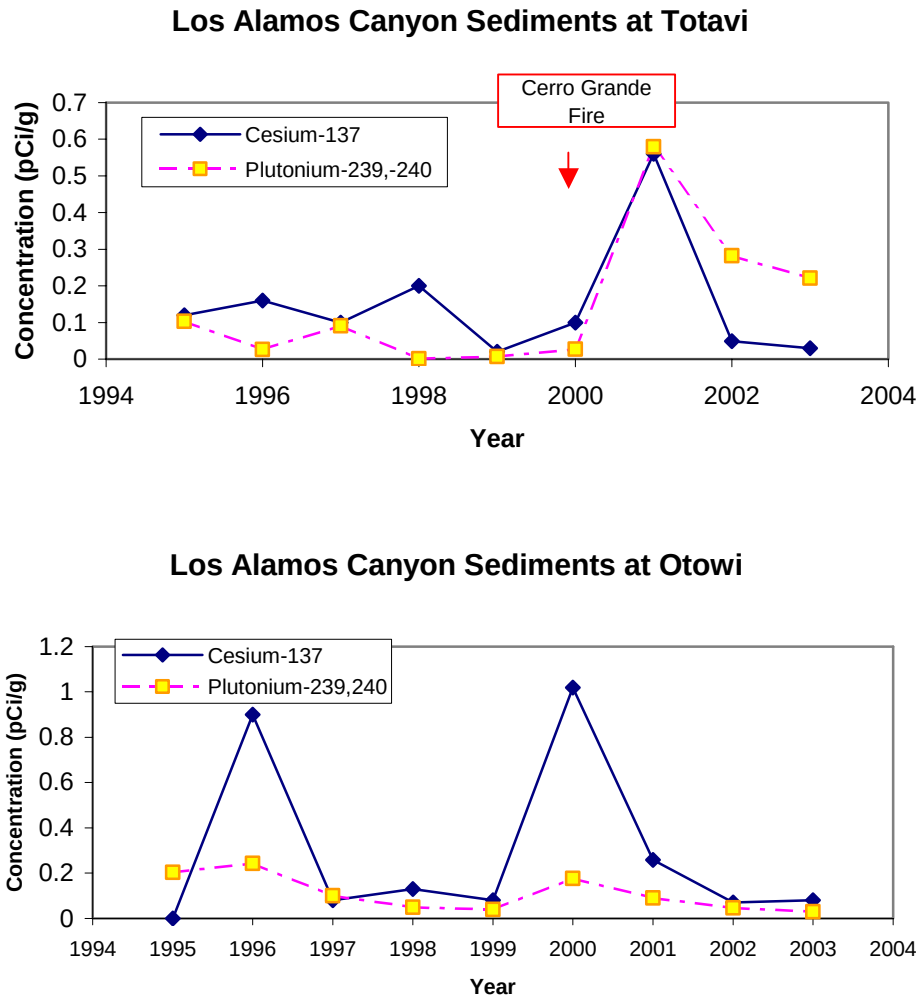


Figure 6-25. Recent radioactivity trends in lower Los Alamos Canyon sediments.

Table 6-4. Estimated Percentage of Streamflow and Plutonium-239,240 in Pueblo Canyon Surface Water Compared with the Total Amounts Passing LANL's Downstream Boundary.

Year	Percentage of total streamflow derived from Pueblo Canyon	Percentage of total Pu-239,240 derived from Pueblo Canyon
2000	29%	75%
2001	64%	95%
2002	76%	100%
2003	81%	99%

Source: Gallaher and Koch 2004.

3. Sandia Canyon

Sandia Canyon heads on the 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. While one

storm in 2003 caused runoff to flow into the normally dry lower reaches of Sandia Canyon, only 2 days with flow were recorded at the Laboratory boundary in water year 2003 (Shaull et al. 2004). Monitoring results have consistently shown minimal off-site contamination from the Laboratory in Sandia Canyon.

The upper portion of the canyon contains the some of highest PCB concentrations of any LANL watercourse. A base-flow sample collected below the Sandia Wetland contained the PCB Arochlor 1260 at an estimated concentration greater than the New Mexico stream standards for wildlife habitat and fish consumption/human health. The Arochlors 1254 and 1260 and hexachlorobenzene were also detected above state fish consumption/human health standards in other runoff samples collected below the wetland. The human health standards protect people from ingesting contamination through fish consumption but there are no fish in Sandia Canyon. Further, there is little probability of flows from the canyon reaching the Rio Grande. Thus, the principal water-associated PCB concern in the canyon is for local impacts to wildlife over long periods of time. Runoff was present in the channel only about 3% of the time in 2003, and base-flow water quality conditions are more important from an exposure perspective.

Sediment samples collected in the upper portion of Sandia Canyon contained PCBs and the PAH benzo(a)pyrene at concentrations near or greater than the EPA residential soil screening level. Benzo(a)pyrene was measured in a sediment sample taken near the power plant at 95% of the industrial outdoor worker screening level. Downstream sediment concentrations of PCBs decline quickly and are near background ranges at the LANL downstream boundary (Figure 6-26).

Out-of-the-ordinary concentrations of the following metals were detected in Sandia Canyon storm runoff samples: chromium, copper, mercury, and zinc. A potential source for the chromium is a water treatment biocide chemical formerly used in cooling towers at LANL throughout the 1980s. There are multiple Laboratory and non-Laboratory sources for the other metals. Most of these metals are sediment-associated, and the calculated suspended sediment concentrations are below screening levels. Water samples collected below the heavy equipment yard and the power plant, however, contained dissolved concentrations of copper (runoff), lead (runoff), and zinc (base flow and runoff) above the New Mexico acute and chronic aquatic life standards. Reference to the aquatic life standard is for comparison; this standard applies to fisheries like the Rio Grande while streams within LANL are not designated as fisheries.

Perchlorate was detected in a January base-flow sample taken below the power plant, at a concentration of 18.5 µg/L. Subsequent analyses by the Water Quality and Hydrology Group (RRES-WQH) in March of outfalls 001 (power plant) and 03A027 (cooling tower) discharging to Sandia Canyon did not detect perchlorate using EPA Method 314 at a detection limit of 4 µg/L.

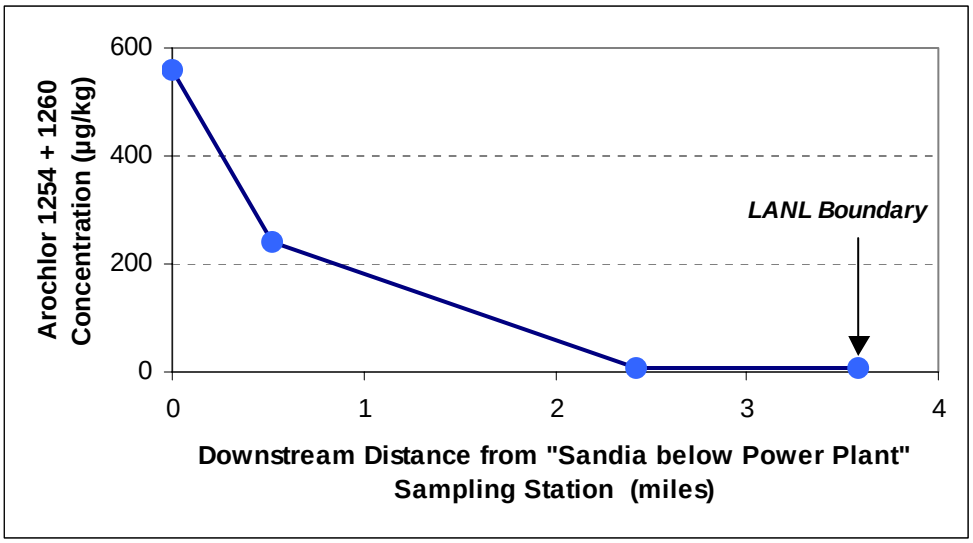


Figure 6-26. Downstream changes in PCB concentrations in stream sediments along Sandia Canyon.

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.

Three Mortandad Canyon storm runoff samples collected below the RLWTF effluent discharge point contained americium-241; plutonium-238; and plutonium-239,240 activities greater than the DOE 100-mrem DCG for public dose by an average of 9 times. The activities were the highest measured by the surveillance program since automated samplers were installed in the mid- to late-1990s; the americium-241 and plutonium-238 activities were higher than historical maximums by more than 10 times. Our review of stream flow records for the year showed that runoff was present in the channel only about 3% of the time. When considered together with analyses of base flow, the annual time-weighted average of the individual radionuclides is below their respective DCGs. However, when the mixture of radionuclides is considered (see discussion in G.1), the waters are near the 100-mrem DCG (ratio of 1.06). Effluent discharges from the RLWTF were well below the DCG (58% of DCG; Watkins and Worland 2004), but the stream flow entrains additional radioactivity from mobilization of contaminated stream sediments. 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 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 activities in sediments at the boundary are orders of magnitude lower than at upstream stations closer to the RLWTF discharge (Figures 6-4 through 6-6). The absence of stream flow near the Laboratory boundary is the main reason for the drop-off in sediment radioactivity downstream. Using mass spectrometry analyses, Gallaher and others (Gallaher et al. 1997) concluded that Laboratory-derived plutonium at levels near fallout values might extend 3.2 km (2 mi) beyond the Laboratory boundary.

The PCB Arochlors 1242 and 1254 were detected in the middle reach of Mortandad Canyon at 1.8 times and 0.9 times the EPA residential soil-screening level, respectively (Figure 6-7). There are insufficient PCB data to fully define the source of the PCBs, but the concentrations and general location are consistent with a LANL source.

Except for two locations, radioactivity in sediment around Area G and in Cañada del Buey was consistent in 2003 with previous years. Upward trends of plutonium-239,240 and other radionuclides were evident at sediment sampling stations G-7 and G-8, which are both located along the eastern portion of Area G (Figure 6-27). Sampling station G-8 is part of the Mortandad Canyon drainage system, whereas G-7 is part of the Pajarito Canyon drainage. Although below risk-based screening levels, the upward trends since 2001 likely indicate operational changes or construction activities at the eastern edge of the site.

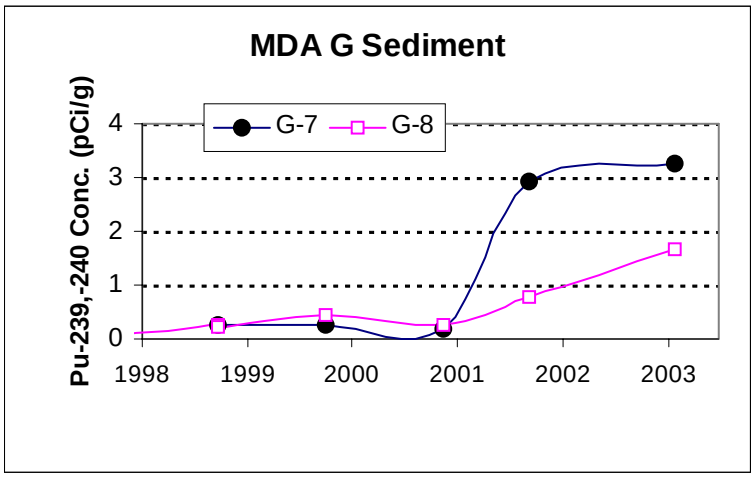


Figure 6-27. Recent trends of plutonium-239,240 activities at Area G sediment stations G-7 and G-8.

a. Long-Term Trends. Figure 6-28 shows activities of plutonium-238, plutonium-239,-240, and cesium-137 at five stations in Mortandad Canyon. All of the stations are located below the RLWTF discharge. The stations MCO-8.5 and -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. 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.

Cesium-137 activities in sediments below the RLWTF discharge point have been greater than the SAL. At the Laboratory boundary in 2003, cesium-137 activities were less than 10% of the SAL.

5. Pajarito Canyon (includes Twomile and Threemile Canyons)

Pajarito Canyon heads on the flanks of the Sierra de los Valles on US Forest Service lands. The canyon crosses the south-central part of the Laboratory before entering Los Alamos County lands in White Rock.

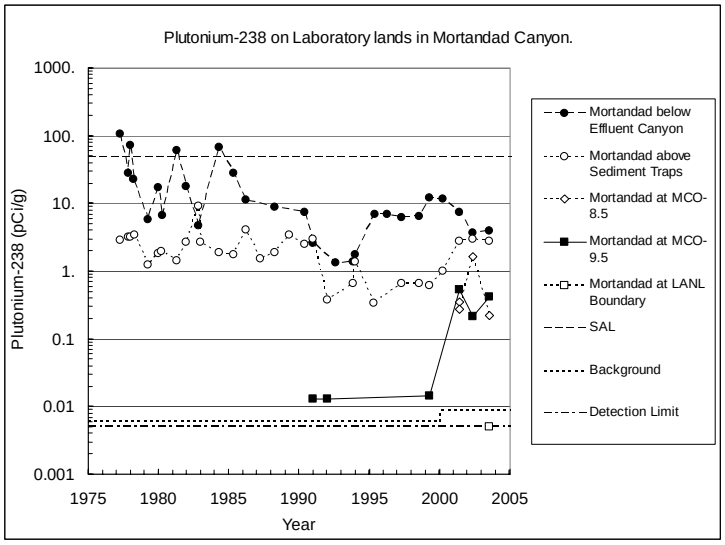
We found americium-241; plutonium-238; and plutonium-239,240 at activities greater than background in a number of sediment samples collected in the vicinity and downstream of Area G. Both plutonium isotopes were about 10 times background at the G-6 retention pond. These results are generally consistent with past values, with one exception. An upward trend is evident in plutonium-239,240 activity at G-7 (Figure 6-27), as discussed previously for Mortandad Canyon. Mercury was detected often in sediment and storm runoff samples from the small tributary channels that drain the southern perimeter of Area G, though levels were below standards.

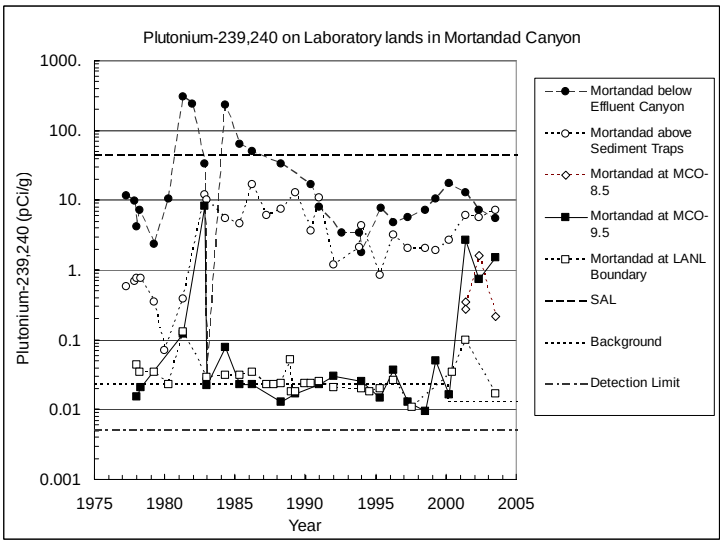
A sediment sample from Pajarito Canyon above State Road (SR) 4 contained many metals and radionuclides elevated two to five times above background. The sample station was relocated in 2002. Previously the station was below SR-4 where flow is rapid and little sediment accumulates; the relocated station is in a depositional area upstream of the berm formed by SR-4. The higher analyte levels may be caused by 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 et al. 2002). Because the station is now located where sediment accumulates, both fire-related and Laboratory-derived constituents are probably present.

PCBs and PAHs were detected at levels below the EPA residential soil-screening level in Pajarito Canyon sediments.

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 tributary Cañon de Valle pass through the southern portion of the Laboratory where explosives development and testing take place. Elevated concentrations of barium, cyclotetramethylenetetra nitramine (HMX), and RDX have been measured in sediment and surface water. Sampling of springs in the vicinity of the 260 outfall showed elevated concentrations of barium and boron from Laboratory operations. Dissolved barium is present in base flow above New Mexico groundwater standards, and RDX is present in surface water above the 6.1-ppb EPA Tap Water Health Advisory in Cañon de Valle. This area is undergoing extensive investigation by RRES-RS 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.





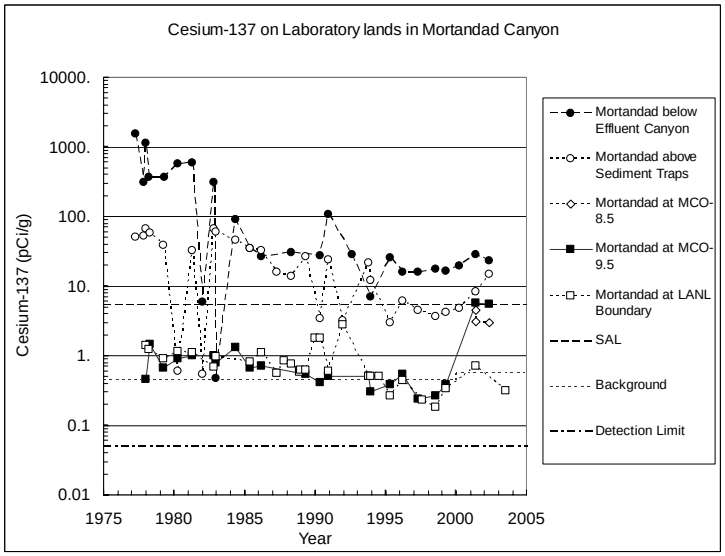


Figure 6-28. Long-term radioactivity trends in Mortandad Canyon sediments.

I. 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.

J. References

Bitner et al. 2001: K. Bitner, B. Gallaher, and K. Mullen, "Review of Wildfire Effects on Chemical Water Quality," Los Alamos National Laboratory report LA-13826-MS (May 2001).

DOE 1991: "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," DOE/EH-0173 (January 1991).

DOE 2003: "Strategy for Evaluation of Surface Water Quality Relative to DOE Order 5400.5," Department of Energy memorandum from Rex J. Borders, Albuquerque Operations Office, to G. Turner, Los Alamos Site Office, January 9, 2003.

EPA 2003: US Environmental Protection Agency Region 6, "EPA Region 6 Human Health Medium-Specific Screening Levels 2003–2004" (December 2003), *http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm*.

ER 2001: Environmental Restoration Project, "Derivation and Use of Radionuclide Screening Action Levels," Los Alamos National Laboratory document LA-UR-01-990 (March 2001).

ESP 1988: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 1987," Los Alamos National Laboratory report LA-11306-MS (May 1988).

ESP 2002: Environmental Surveillance Program, "Environmental Surveillance at Los Alamos during 2001," Los Alamos National Laboratory report LA-13979-ENV (September 2002).

Fisher 2003: F. M. Fisher, "Perennial Water Segments at the Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-03-5768.

Ford-Schmid and Engert 2004: R. Ford-Schmid and D. Engert: "Post Cerro Grande Fire Channel Morphology in Lower Pueblo Canyon and Storm Water Transport of Plutonium-239,240 in Suspended Sediments," Abstract in "Geologic and Hydrogeolgic Framework of the Española Basin—Proceedings of the 3rd Annual Española Basin Workshop, Santa Fe, New Mexico, March 2–3, 2004," M. R. Hudson, ed., U.S. Geological Survey Open-File Report 2004-1093.

Gallaher and Efurd 2002: B. M. Gallaher and D. W. Efurd, "Plutonium and Uranium from Los Alamos National Laboratory in Sediments of the Northern Rio Grande Valley," Los Alamos National Laboratory report LA-13974 (August 2002).

Gallaher et al. 1997: B. M. Gallaher, D. W. Efurd, D. J. Rokop, T. M. Benjamin, and A. K. Stoker, "Survey of Plutonium and Uranium Atom Ratios and Activity Levels in Mortandad Canyon," Los Alamos National Laboratory report LA-13379-MS (October 1997).

Gallaher et al. 2002: B. M. Gallaher, R. Koch, and K. Mullen, "Quality of Storm Runoff at Los Alamos National Laboratory in 2000 with Emphasis on the Cerro Grande Fire," Los Alamos National Laboratory report LA-13926 (May 2002).

Gallaher et al. 2004: B. M. Gallaher, D. B. Rogers, K. I. Mullen, and R. J. Koch, "6. Watershed Monitoring," in "Environmental Surveillance at Los Alamos during 2002," Los Alamos National Laboratory Report LA-14085-ENV (January 2004).

Gallaher and Koch 2004: B. M. Gallaher and R. J. Koch, "Cerro Grande Fire Impacts to Water Quality and Stream Flow near Los Alamos National Laboratory: Results of Four Years of Monitoring," Los Alamos National Laboratory document, in preparation.

Graf 1997: W. L. Graf, Plutonium and the Rio Grande: Environmental Change and Contamination in the Nuclear Age (Oxford University Press, New York, 1997).

IFRAT 2002: Interagency Flood Risk Assessment Team, Risk Assessment Working Group, "Assessment of Potential Risks from Enhanced Surface Water Runoff in CY2001 due to the Cerro Grande Fire" (New Mexico Environment Department, Hazardous Waste Bureau, Santa Fe, New Mexico, May 28, 2002).

Johansen et al. 2001: M. Johansen, B. Enz, B. Gallaher, K. Mullen, and D. Kraig, "Storm Water Quality in Los Alamos Canyon Following the Cerro Grande Fire," Los Alamos National Laboratory report LA-13816-MS (April 2001).

Katzman et al. 2001: D. Katzman, R. Ryti, and S. Reneau, "Cerro Grande Ash as a Source of Elevated Radionuclides and Metals," in *New Mexico Decision-Makers Field Guide No. 1: Water, Watersheds, and Land Use in New Mexico* (New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico, May 2001).

Koch et al. 2001: R. J. Koch, D. A. Shaull, B. M. Gallaher, and M. R. Alexander, "Precipitation Events and Storm Water Runoff Events at Los Alamos National Laboratory after the Cerro Grande Fire," Los Alamos National Laboratory report LA-13849-MS (July 2001).

Kraig et al. 2002: D. Kraig, R. Ryti, D. Katzman, T. Buhl, B. Gallaher, and P. Fresquez, "Radiological and Nonradiological Effects after the Cerro Grande Fire," Los Alamos National Laboratory report LA-13914 (March 2002).

LANL 2004: "Los Alamos and Pueblo Canyon Investigation Report," Los Alamos National Laboratory document LA-UR-04-2714 (April 2004).

McLin and Lyons 2002: S. G. McLin and D. W. Lyons, "Background Radioactivity in River and Reservoir Sediments near Los Alamos, New Mexico," Los Alamos National Laboratory report LA-13603-MS (May 2002).

NMED 2003a: "Approved 2002-2004 State of New Mexico §303(d) List for Assessed River/Stream Reaches Requiring Total Maximum Daily Loads (TMDLs)," New Mexico Environment Department Surface Water Quality Bureau (June 2003).

NMED 2003b: New Mexico Environment Department, "Plutonium in Storm Water at LANL," *Environmental Reporter* **9**, Issue 1 (New Mexico Environment Department DOE Oversight Bureau, Santa Fe, New Mexico, Spring 2003).

NMEIB 2004: New Mexico Environmental Improvement Board, "Environmental Protection Radiation Protection Standards for Protection Against Radiation," 20.3.4 NMAC (as amended through April 14, 2004).

NMWQCC 2002a: New Mexico Water Quality Control Commission, "Ground and Surface Water Protection," 20.6.2 NMAC (September 15, 2002).

NMWQCC 2002b: New Mexico Water Quality Control Commission, "State of New Mexico Standards for Interstate and Intrastate Surface Waters," 20.6.4 NMAC (as amended through October 11, 2002).

Perona et al. 1998: R. Perona, M. Tardiff, and R. Ryti, "Documentation of the Canyons Human Health Risk Screening Model," Los Alamos National Laboratory document LA-UR-98-55223 (December 1998).

Purtymun and Stoker 1987: W. D. Purtymun and A. K. Stoker, "Environmental Status of Technical Area 49, Los Alamos, New Mexico," Los Alamos National Laboratory report LA-11135-MS (November 1987).

RAC 2002: "Summary Report: Analysis of Exposure and Risks to the Public from Radionuclides and Chemicals Released by the Cerro Grande Fire at Los Alamos," Risk Assessment Corporation report submitted to the New Mexico Environment Department, RAC Report No. 5-NMED-2002-Final (2002).

Reneau et al. 1998: S. Reneau, R. Ryti, M. Tardiff, and J. Linn, "Evaluation of Sediment Contamination in Pueblo Canyon," Los Alamos National Laboratory document LA-UR-98-3324 (September 1998).

Ryti et al. 1998: R. T. Ryti, P. A. Longmire, D. E. Broxton, S. L. Reneau, and E. V. McDonald, "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory," Los Alamos National Laboratory document LA-UR-98-4847 (September 1998).

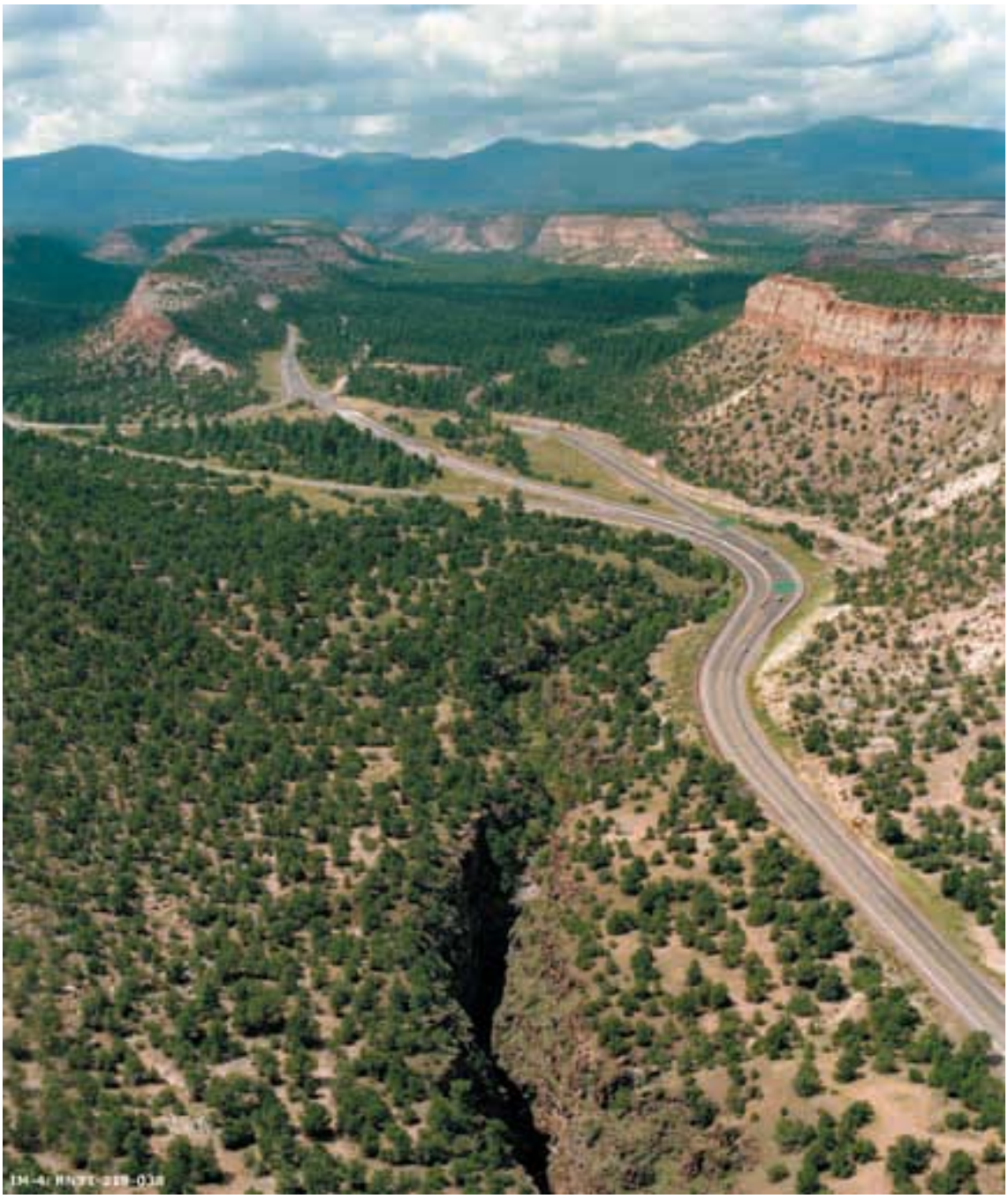
Shaull et al. 2004: D. A. Shaull, D. Ortiz, M. R. Alexander, and R. P. Romero, "Surface Water Data at Los Alamos National Laboratory 2003 Water Year," Los Alamos National Laboratory report LA-14131-PR (March 2004).

USGS 2004: US Geological Survey, "Surface-Water Data for New Mexico," *http://waterdata.usgs.gov/nm/nwis/sw*.

Watkins and Worland 2004: R. Watkins and P. Worland, "RLWTF Annual Report for 2003," Los Alamos National Laboratory document LA-CP-04-0314 (March 2004).

6. Watershed Monitoring

7. Soil Monitoring



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A. Introduction

Soil acts as an integrating medium that can account for contaminants released to the environment. These contaminants are released either directly in gaseous effluents (e.g., air-stack emissions), indirectly from resuspension of on-site contamination (e.g., firing sites and waste disposal areas), or through liquid effluents released to a stream that is subsequently used for irrigation over land surfaces (DOE 1991).

A soil-sampling and analysis program provides the most direct means of determining the inventory, concentration, distribution, and long-term buildup of radionuclides and other contaminants around nuclear facilities. The knowledge gained from a soil-sampling program is important for providing information about potential pathways, such as soil ingestion, food crops, resuspension into the air, and contamination of groundwater, that may result in a radiation or chemical dose to a person.

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, according to Department of Energy 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), according to DOE Orders 435.1 (DOE 1999a) and M 435.1-1 (DOE 1999b), and the Laboratory's principal explosive test facility (Dual Axis Radiographic Hydrodynamic Test [DARHT]), according to the Mitigation Action Plan (DOE 1996).

The objectives of these programs are to determine the following:

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

(2) trends over time (that is, whether radionuclides and nonradionuclides are increasing or decreasing over time); and

(3) committed effective dose equivalent to surrounding-area residents using the RESRAD computer model. See Chapter 3 for information on potential radiation doses to individuals from exposure to soils.

B. Quality Assurance/Quality Control

The Soil Sampling team conducts soil-surface sampling according to written, standardized quality assurance/quality control (QA/QC) procedures and protocols. These procedures and protocols are identified in the overall QA Project Plan for the Soils Monitoring Project (RRES-MAQ-SOILs, R4) and, more specifically, in the operating procedures entitled "Soil Sampling," RRES-MAQ-707, R5, 2004, and "Facility Soil and Vegetation Sampling," RRES-MAQ-711, R5, 2004. Accordingly, collection of samples for chemical analyses follows a set procedure to ensure proper collecting, processing, submitting, chemical analyzing, validating and verifying analyses, and tabulating of analytical results.

Personnel collect soil samples for radionuclide and heavy-metal analysis from the 0- to 2-in. depth and soil samples for the analysis of organic compounds from the 0- to 6-in depth. Radionuclides are collected at the 0- to 2-in. depth to capture the majority of contaminants from current air emissions and fugitive dust, whereas organics are collected at a deeper depth to capture more mobile constituents. 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. 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 soil samples for radionuclides and nonradionuclides. Organic constituents were not analyzed this year: soil samples are analyzed for organics about every third year. Paragon met all QA/QC requirements.

C. Institutional Monitoring

1. Monitoring Network

The team collected soil samples from 4 regional locations, 10 perimeter sites, and 12 sites within the LANL boundary (Figure 7-1). Areas sampled at LANL are not from contaminated areas known as potential release sites (PRSs). Instead, the majority of on-site soil-sampling stations are located on mesa tops close to and downwind from major facilities or operations at LANL. They are collected from the following areas: Technical Area (TA) 16 (S-Site), TA-21 (DP-Site), near TA-33, TA-50, TA-51, west of TA-53, east of TA-53, east of TA-54, Potrillo Drive/TA-36, near Test Well DT-9, R-Site Road East, and Twomile Mesa. We selected these locations to assess soils that may have been contaminated from air-stack emissions and fugitive dust (the resuspension of dust from PRSs and active firing sites).

The 10 perimeter stations are located within 4 km (2.5 mi) of the Laboratory. These stations reflect the soil conditions of the inhabited areas to the north of the Laboratory (East Airport, West Airport, North Mesa, and Sportsman's Club) and east (White Rock [east] and San Ildefonso). The other two stations, one located on US Forest Service land to the west (TA-8 [GT Site]) and the other located on US Park Service land, Bandelier National Monument (near TA-49) to the southwest, provide additional coverage.

Team members compare soil samples from all these areas with soils collected from regional locations in northern New Mexico that surround the Laboratory and where radionuclides, metals, and organic constituents are mostly from natural sources or worldwide fallout events. These areas are located near Borrego Mesa (near Santa Cruz dam) to the northeast, Rowe Mesa (near Pecos) to the southeast, Youngsville to the west, and Jemez to the southwest. All are at similar elevations to LANL, are more than 32 km (20 mi) away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations as required by the DOE (DOE 1991).

2. Radionuclide Analytical Results

Most radionuclide concentrations (activity) in soils collected from individual perimeter and on-site stations were nondetectable (Table S7-1). A nondetectable value is one in which the result is lower than three times the counting uncertainty and is not significantly ($\alpha = 0.01$) different from zero (Keith 1991, Corely et al. 1981). Of the radionuclides that were detected, most were still within regional statistical reference levels (RSRLs). RSRLs are the upper-level background concentration (mean plus three standard deviations) from data collected from regional areas away from the influence of the Laboratory over the last five years and represent natural and fallout sources. Normally, radionuclides caused by fallout vary from one area to another, depending on wind patterns, elevation, and precipitation (Whicker and Schultz 1982); and fallout likely is more concentrated in the area of the Laboratory because it lies at a higher elevation and receives more precipitation than the regional areas (Fresquez et al. 1996, 1998).

The few radionuclides in soils from perimeter and on-site stations that were detected above RSRLs included plutonium-239,240, albeit most values were just above the RSRL and were probably a result of fallout because of higher precipitation events. However, two soil samples, one collected from an on-site location (TA-21 [DP-Site]) and one from a perimeter site (West Airport) contained concentrations above regional fallout levels and were probably associated with Laboratory activities (Table 7-1). The west airport site is located just north and slightly downwind of TA-21. The former plutonium processing facility (TA-21, DP-Site) is currently undergoing decommissioning and decontamination work and shows a great deal of spacial variation in concentrations of plutonium-239,240 in soils over time (Figure 7-2).

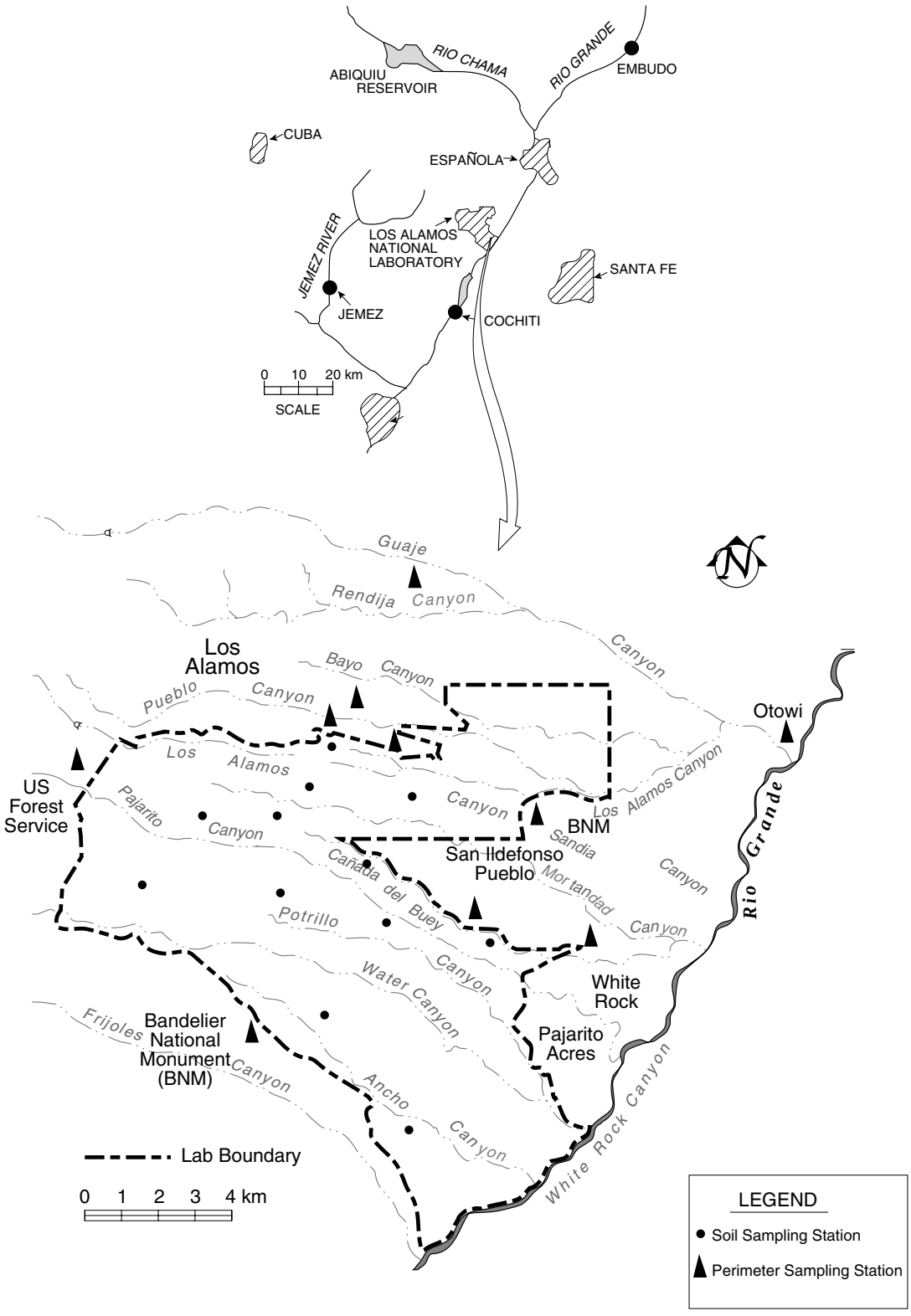

Figure 7-1. Off-site regional and perimeter and onsite Laboratory soil sampling locations.

Table 7-1. LANL-Derived Radionuclide Concentrations in Surface (0- to 2-in. depth) Soils Collected from Perimeter and On-Site Locations during 2003 as Compared with Reference Levels

Location	^{239,240}Pu (pCi/g dry)
Regional Stations	
	0.015 (0.0094)
RSRL[a]	0.031
SAL[b]	44
Perimeter Station:	
West Airport	0.53 (0.047)
On-Site Station:	
TA-21 (DP-Site)	0.80 (0.067)

[a]Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 3 std dev) based on data from the last five years.

[b]Los Alamos National Laboratory Screening Action Level based on RESRAD version 6.21 (ER 2002).

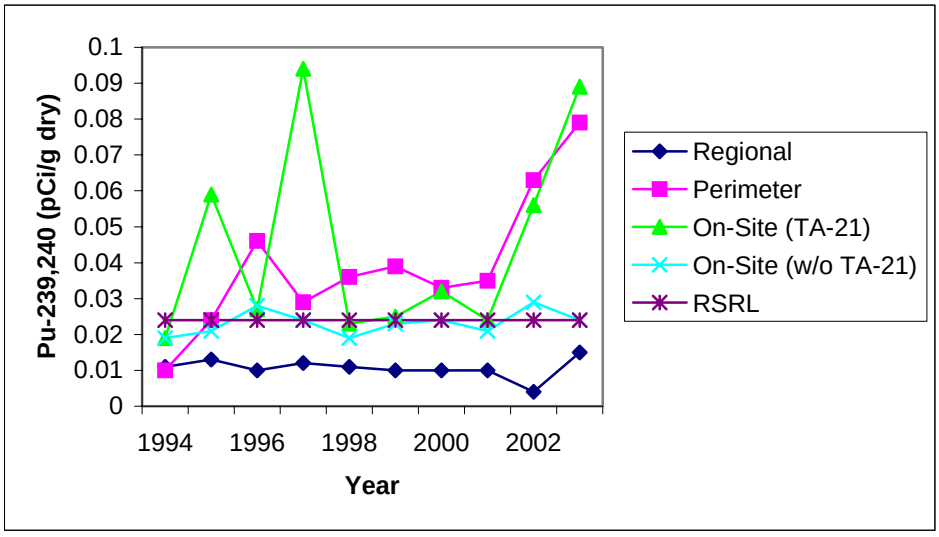

Figure 7-2. Mean concentrations of plutonium-239,240 collected from regional, perimeter, and on-site locations, 1994–2003.

The large spacial variability in plutonium-239,240 in soils collected from TA-21 (DP-Site) over the years may be a result of many factors. These factors may include the release of larger size particles from unfiltered stacks in the very early years; the movement of surface plutonium-239,240 by wind and water processes; and/or the release of plutonium-239,240 from the many PRSs around TA-21 (DP-Site).

Although TA-21 (DP-Site) contained plutonium-239,240 concentrations above the RSRL, the values are still very low (pCi range) and far below screening action levels (SALs). SALs were developed by the Remediation Services (RRES-RS) Project at the Laboratory to identify the contaminants of concern on the basis of a conservative (residential) 15-mrem/yr protective dose limit (ER 2002). Therefore, the concentrations and distributions of all observed radionuclides in soils from all sites (institutional site locations), including plutonium-239,240 at TA-21 (DP-Site) and West Airport site, collected in 2003 are of no significant health concern.

3. Nonradionuclide Analytical Results

In the past years, the team analyzed soils within and around LANL for 22 light, heavy, and nonmetal trace elements (occur at <1000 µg/g in soil) and 3 light and heavy abundant elements (occur at >1000 µg/g in soil). Most of these elements, with the exception of two light metals (barium and beryllium) and two heavy metals (mercury and lead), were either below the detection limit (the analytical reporting limit) or within RSRLs. Therefore, we analyzed only the four metal elements (barium, beryllium, mercury, and lead) that were consistently detected above the limits of detection in past years. In general, most all sites, with the exception of one perimeter site (West Airport), from either perimeter or on-site areas had barium, beryllium, mercury, or lead concentrations below RSRLs (Table S7-2) and do not appear to be increasing over time (Figures 7-3 to 7-5). In fact, mercury concentrations in all soils, including regional soils, appear to be decreasing over time. This decrease is not entirely understood but may be a reflection of improved air emissions from coal firing plants (Martinez 1999). Since the early 1980s, coal-burning power plants in the northwest corner of New Mexico have been required to install venturi scrubbers and bag houses to capture particulates and reduce air emissions.

The only metal (lead) that was above the RSRL, albeit just above, in a soil sample collected from a perimeter area was far below the Environmental Protection Agency (EPA) screening level (EPA 2000). EPA-derived screening levels for nonradionuclides are based on potential health concerns; and therefore, there are no metal concentrations in soils collected from perimeter or on-site stations that are of a significant health concern.

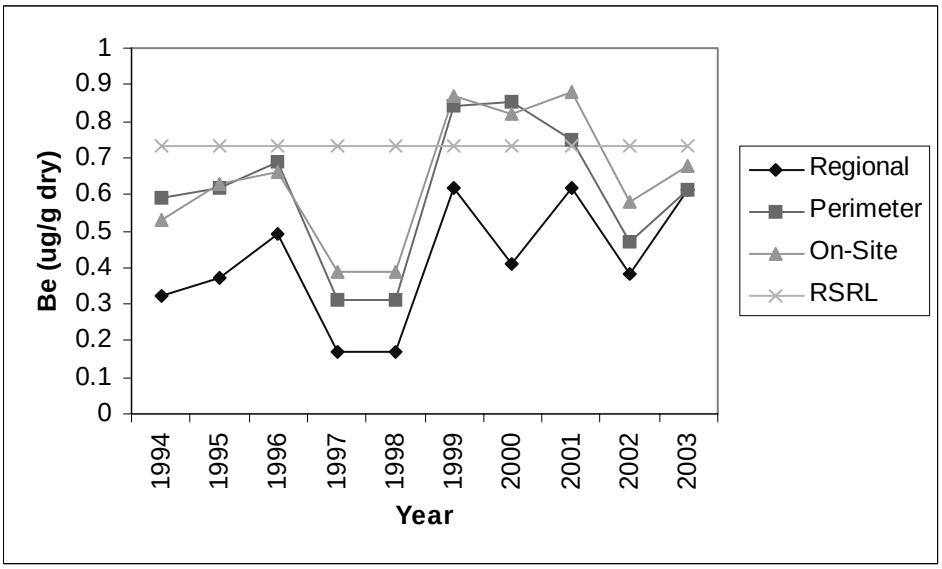

Figure 7-3. Mean concentrations of beryllium in soils collected from regional, perimeter, and on-site locations, 1994–2003.

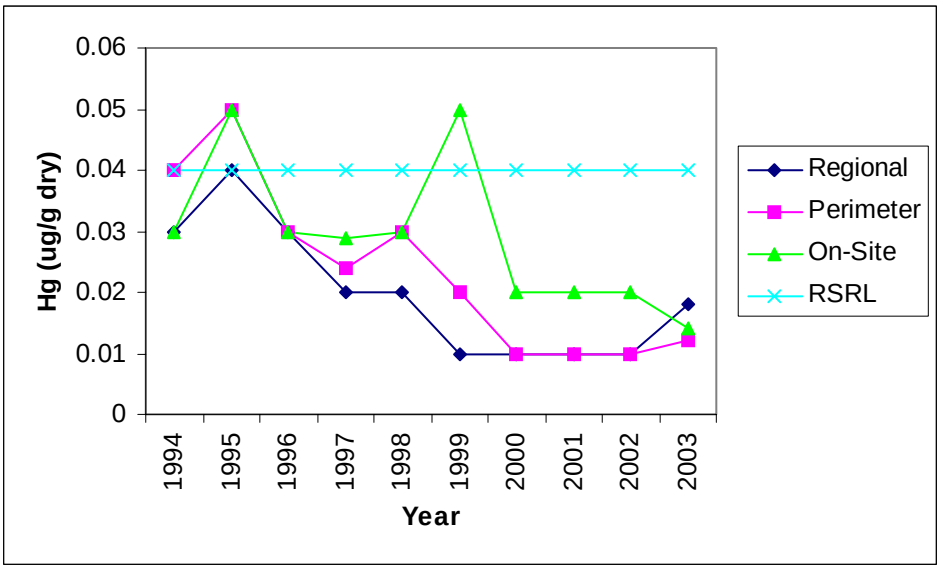

Figure 7-4. Mean concentrations of mercury in soils collected from regional, perimeter, and on-site locations, 1994–2003.

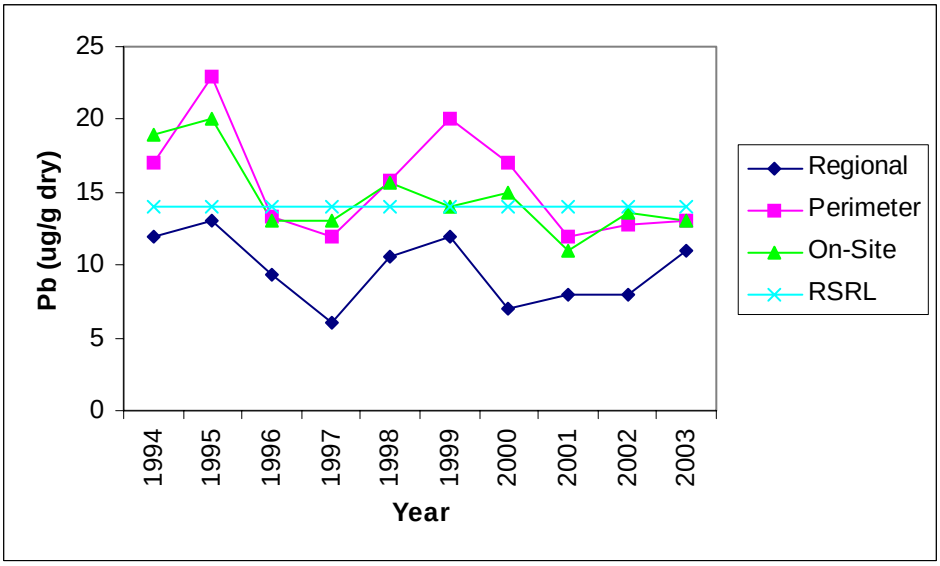

Figure 7-5. Mean concentrations of lead in soils collected from regional, perimeter, and on-site locations, 1994–2003.

D. Facility Monitoring

1. Monitoring Network

The two main facilities where soil monitoring takes place are the Laboratory's principal low-level radioactive waste disposal site (Area G) (Lopez 2002) (Figure 7-6) and the Laboratory's principal explosive test facility (DARHT) (Nyhan et al. 2001a) (Figure 7-7). Area G, approximately 63 acres in size, is located in the Laboratory's waste disposal site (TA-54) at the east end of the Laboratory. The team collects approximately 15 soil surface samples at designated places within and around the perimeter of Area G on an annual basis. DARHT, approximately 20 acres in size, is located at R-Site (TA-15) at the southwest end of the Laboratory. We collect approximately four soil and four sediment samples on an annual basis at designated locations within the DARHT grounds.

We compare results for radionuclides in soils collected at Area G with RSRLs, whereas we compare results for radionuclides and nonradionuclides in soils and sediments collected at DARHT with baseline statistical reference levels (BSRLs) (Fresquez et al. 2001). BSRLs are the concentrations of radionuclides and trace elements in soils and sediments around the DARHT facility (1996–1999) before the operation phase (2000 and after). 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 compliance reasons.)

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

A complete description of the results of radionuclides in soils collected from within and around the perimeter of Area G during the 2003 year can be found in Fresquez et al. 2004a.

In general, soil samples were collected at 15 locations within and around the perimeter of Area G (Figure 7-6). These samples were analyzed for tritium, plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; and total uranium. Most soil samples collected at Area G contained detectable concentrations of tritium (87%); plutonium-239,240 (87%); plutonium-238 (60%); and americium-241 (53%) above RSRLs. In contrast, the levels of cesium-137, strontium-90, and total uranium in 99% of the soil samples at Area G were within RSRLs. The highest levels of tritium in soils were detected in the south portion of Area G near the tritium shafts, whereas the highest concentrations of the plutonium isotopes were detected in the northern and northeastern portions. These data are similar to past years (Fresquez et al. 1999, Nyhan et al. 2000, Nyhan et al. 2001b) and are below LANL SALs.

Last year we reported tritium concentrations in a soil sample collected from the southern part of Area G that exceeded the SAL (Fresquez et al. 2004a). A follow-up study using vegetation as an investigative tool showed that the levels of tritium were very much restricted to the perimeter of the fence line and significantly decreased with distance (Fresquez et al. 2003). At about 90 meters away from the fence line, tritium concentrations in vegetation generally decreased to background levels. Soil samples collected from the same location this year show greatly lowered concentrations as compared with last year that are just below the SAL.

Concentrations of tritium and plutonium-239,240 in selected (worst-case) samples collected within and around Area G during the last six years can be found in Figures 7-8 and 7-9, respectively. For tritium, both sample locations show generally increasing trends over time. This result may reflect increasing tritium releases within the tritium shaft area and correlates very well with the AIRNET data (see Chapter 4). The concentrations of plutonium-239,240, on the other hand, albeit still higher than the RSRL, show generally even trends over time.

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

A complete description of the results of radionuclides and nonradionuclides in soils collected from within the DARHT grounds during the year 2003 can be found in Fresquez et al. (2004b).

In general, samples of soil and sediment were collected at four locations around the DARHT facility (Figure 7-7). All samples were analyzed for concentrations of tritium, plutonium-238; plutonium-239,240;

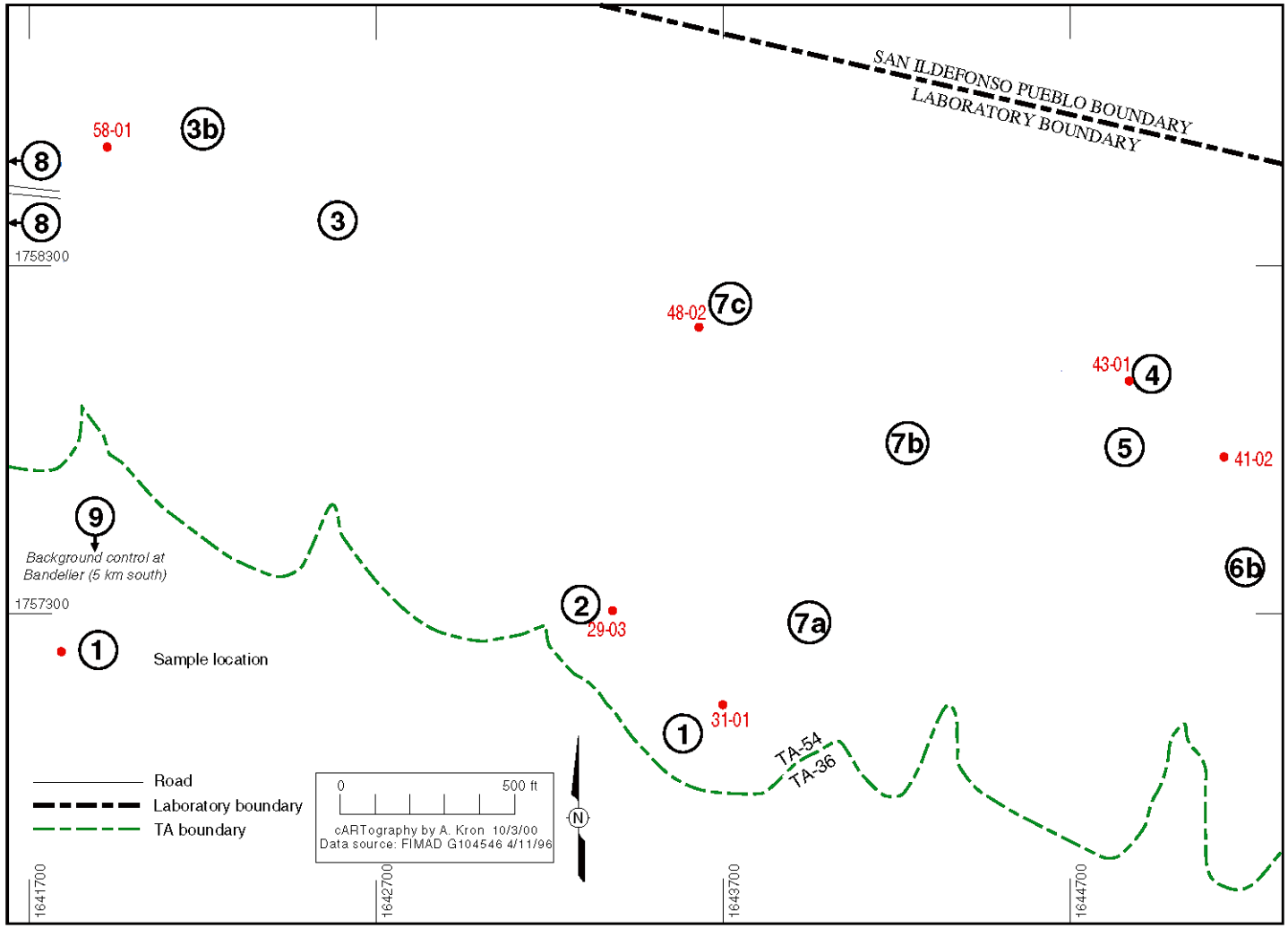

Figure 7-6. Site/sample locations of soils and vegetation at Area G. Site #8 is located farther west and Site #9 is located farther south than what is shown here. (This figure has been edited for operational security purposes.)

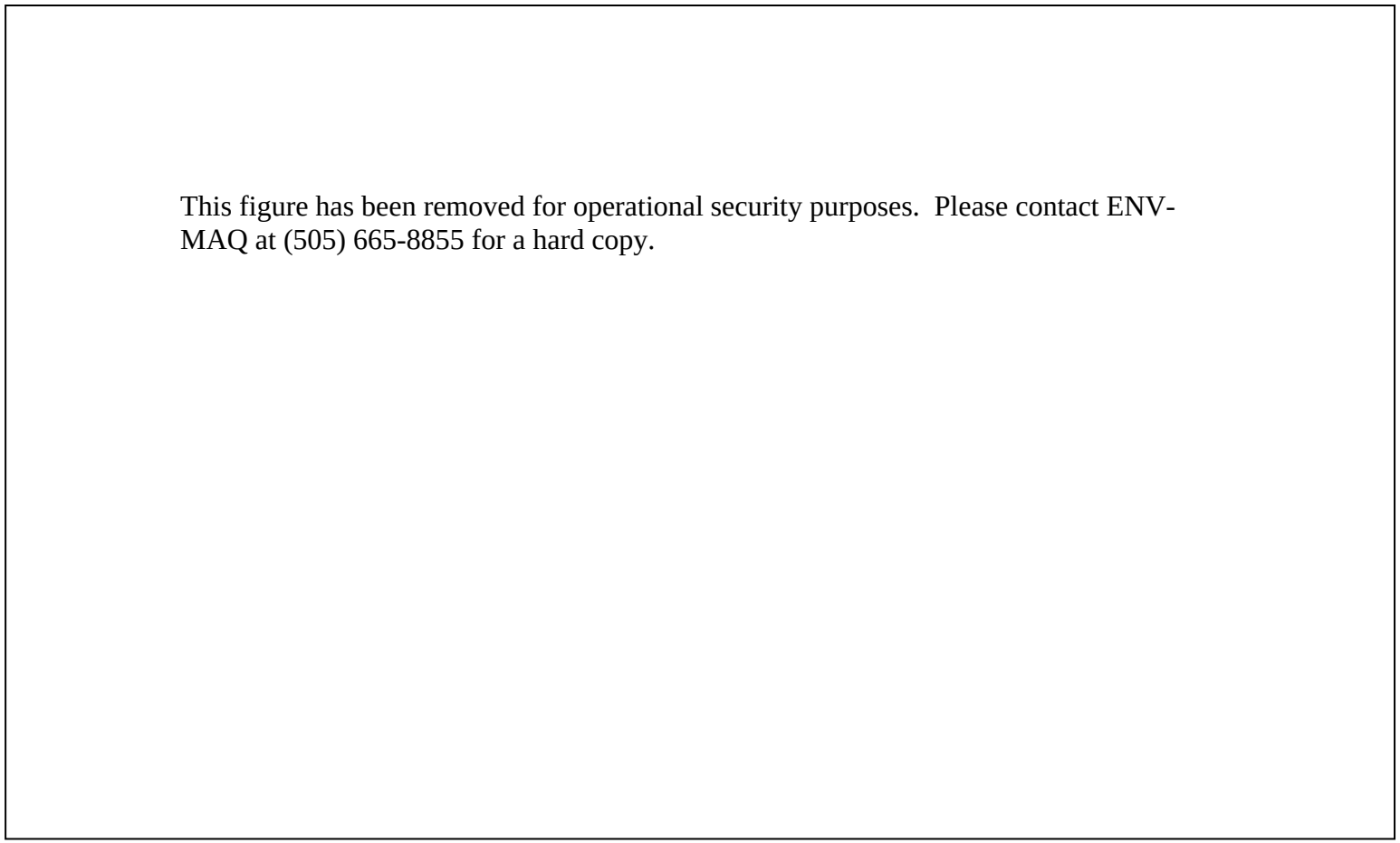

Figure 7-7. Sampling locations at the DARHT facility at TA-15.

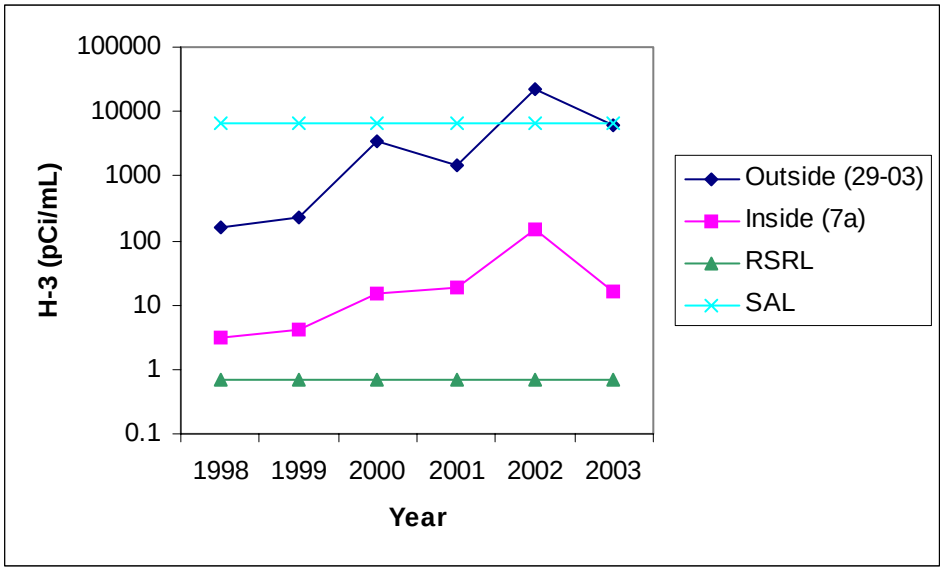

Figure 7-8. Tritium in soils collected from two selected locations within and around Area G at TA-54 from 1998 to 2003.

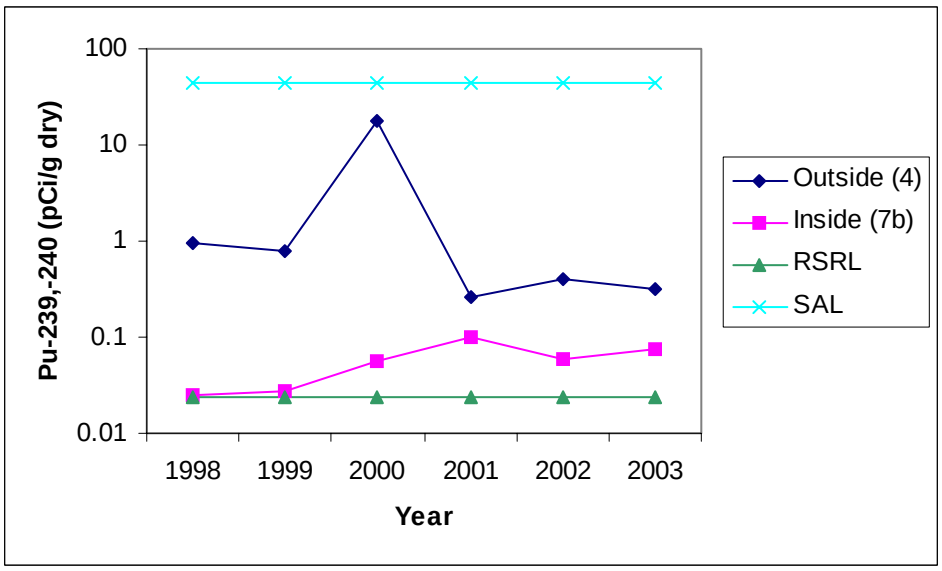

Figure 7-9. Plutonium-239,240 in soils collected from two selected locations at Area G at TA-54 from 1998 to 2003.

strontium-90; americium-241; cesium-137; and total uranium. Also, samples were analyzed for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and thallium. These results were compared with BSRL data established for a four-year-long preoperational period before DARHT operations (Fresquez et al. 2001), and to LANL and EPA SALs. Most radionuclides, with the exception of uranium, cesium-137; and plutonium-239,240; and trace elements, with the exception of antimony, selenium and copper, in soil and sediment samples were below BSRL values. All elements in all soils/sediments were still very low and far below SALs. No distinctive trends were evident in any of the radionuclides over time.

E. Special Monitoring Study

Concentration of Plutonium-239,240 in Soil Surface Samples Downwind from LANL: Second Year Results We have reported plutonium-239,240 concentrations in soils collected from both perimeter and on-site areas in past years to be significantly higher ($\alpha = 0.05$) than in soils from regional locations (see Figure 7-2). An alternate way to identify where the Laboratory has contributed plutonium to soils is to review the ratio of cesium-137 to plutonium-239,240. The ratio of cesium-137 to plutonium-239,240 concentrations from worldwide fallout (Hodge et al. 1996) is constant at 32 ± 1 (decay corrected to June 2002). A ratio smaller than 32 ± 1 would indicate the presence of a Laboratory contribution to plutonium in the soils.

On a preliminary basis, we have reviewed 26 years of cesium-137 and plutonium-239,240 ratios for soils at LANL, soils on the perimeter of LANL, and in regional soils (Table S7-3). Ratios from northern New Mexico regional soils compared well with cesium-137/plutonium-239,240 ratios from other background areas. Cesium-137 (decay corrected)/plutonium-239,240 ratios range from 2 to 27 in soils from on-site areas and from 5 to 28 in perimeter soils. This ratio indicates an impact from LANL operations on LANL perimeter and on-site soils, consistent with our comparisons of average plutonium in soils concentrations. The ratios in perimeter soils are smallest in the north, northeast direction from LANL, the predominant downwind direction from LANL.

To more thoroughly understand the extent of LANL-added plutonium to perimeter areas, team members in 2003 collected soil surface samples along a transect from LANL to regional areas in a northeasterly direction (predominant wind direction). Personnel collected composite soil samples beginning near the eastern end of the Los Alamos airport and then at every mile to a distance of 15 miles from LANL. We conducted all sampling and processing according to the protocols as defined in Section B of this chapter. Samples were analyzed for plutonium-238; plutonium-239,240; and cesium-137. The summary of results for plutonium-239,240 is in Figure 7-10, and the complete results are in the Data Supplement in Table S7-4. Soil samples from other sites within LANL that are associated with present (Los Alamos Plutonium Facility [TA-55]) and past (DP-Site [TA-21]) plutonium-processing work are included for reference.

Plutonium 238 and plutonium-239,240 results obtained during the 2003 year correspond very well to results recorded in calendar year 2002. Values of plutonium-238 were near zero and well below the RSRL in all sites sampled.

Detectable concentrations of plutonium-239,240 were higher in soils collected from on-site areas and at one location one mile from the LANL boundary, as compared with the RSRL. As expected, the concentrations of plutonium-239,240 in soils collected from the Laboratory boundary generally decrease with distance. This effect is produced because plutonium from global fallout is function of rainfall (Whicker and Schultz 1982), which decreases with altitude in northern New Mexico. Altitude decreases in the northeast direction from LANL, therefore precipitation decreases, and thus fallout decreases.

As speculated last year, the ratios did not correlate very well with the expected constant mainly because of the high variability in the cesium-137 data. Cesium-137 ranged from 0.19 to 0.62 pCi/g dry. The only sites that were consistent with ratios obtained last year were the on-site areas and the one sample collected one-mile from the LANL boundary, demonstrating a measurable, but small impact from Laboratory operations. The others were too inconsistent to call based on ratios; albeit, the ratios generally increase with distance from the Laboratory. Thus, we could determine no Laboratory impact beyond one mile from the site boundary.

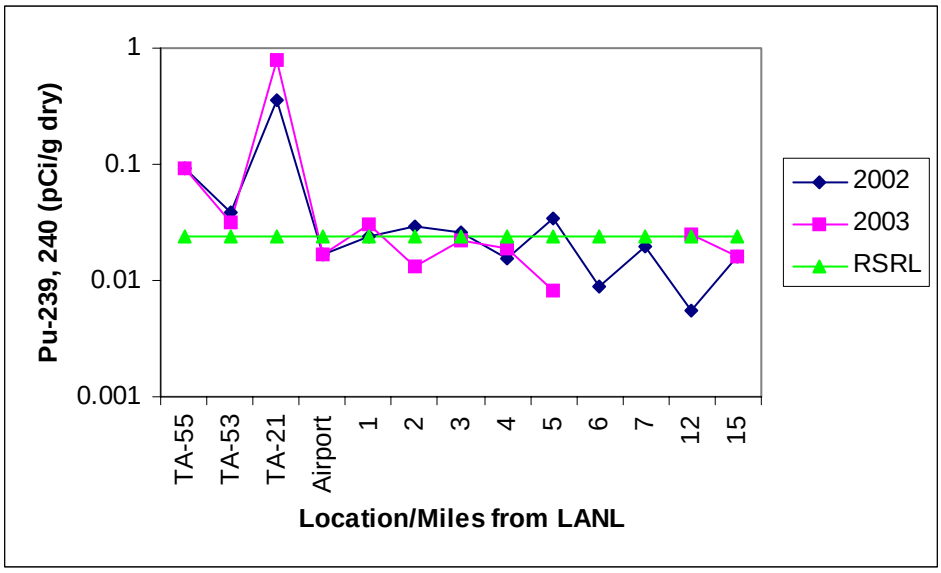

Figure 7-10. Plutonium-239,240 in soils collected along a transect radiating outward from LANL in the predominant wind direction over two years.

F. References

Corely et al. 1981: J. P. Corely, D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, and D. A. Waite, "A Guide for Environmental Radiological Surveillance at US Department of Energy Installations," Department of Energy report DOE/EP-0023 (1981).

DOE 1991: US Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," US Department of Energy report DOE/EH-0173T (January 1991).

DOE 1993: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (1993).

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

DOE 1999a: US Department of Energy, "Radioactive Waste Management," US Department of Energy Order 435.1 (July 9, 1999).

DOE 1999b: US Department of Energy, "Radioactive Waste Management Manual," US Department of Energy report DOE M 435.1-1 (July 9, 1999).

DOE 2003: US Department of Energy, "General Environmental Protection Program," US Department of Energy Order 450.1 (2003).

EPA 2000: US Environmental Protection Agency, "Human Health Medium Specific Screening Levels," Region 6, Multimedia Planning and Permitting Division, *www.epa.gov//region6/6pd/rcra_6/pd_7/screen.htm* (September 2000).

ER 2002: Environmental Restoration Project, "Derivation and Use of Radionuclide Screening Action Levels," Los Alamos National Laboratory document LA-UR-01-990, R1 (2002).

Fresquez et al. 1996: P. R. Fresquez, D. R. Armstrong, and M. A. Mullen, "Radionuclides and Radioactivity in Soils within and around Los Alamos National Laboratory, 1974 through

1994: Concentrations, Trends, and Dose Comparisons," Los Alamos National Laboratory report LA-13149-MS (1996).

Fresquez et al. 1998: P. R. Fresquez, D. R. Armstrong, and M. A. Mullen, "Radionuclides and Radioactivity in Soils Collected from within and around Los Alamos National Laboratory: 1974–1996," *J. Environ. Sci. Heal. A* **33** (2), 263–278 (1998).

Fresquez et al. 1999: P. R. Fresquez, M. H. Ebinger, R. Whesler, and L. Naranjo, Jr., "Radionuclide Concentrations in Soils and Vegetation at Radioactive-Waste Disposal Area G during the 1998 Growing Season (with a Cumulative Summary of ^{3}H and ^{239}Pu Over Time)," Los Alamos National Laboratory report LA-13647-PR (1999).

Fresquez et al. 2001: P. R. Fresquez, J. W. Nyhan, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, and Vegetation Around the DARHT Facility," in Nyhan et al. "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees Around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001), pp. 48–76.

Fresquez et al. 2002: P. R. Fresquez, G. J. Gonzales, T. Haarmann, J. Nyhan, and B. Gallaher, "Soil, Foodstuffs, and Associated Biota," in "Environmental Surveillance at Los Alamos during 2001," Los Alamos National Laboratory report LA-13979-ENV (2002), pp. 419–521.

Fresquez et al. 2003: P. R. Fresquez, L. M. Vasuez-Tator, and E. A. Lopez, "Tritium Concentrations in Vegetation as a Function of Distance from a Low-Level Radioactive Waste Site at Los Alamos National Laboratory," Los Alamos National Laboratory report LA-14091 (2003).

Fresquez et al. 2004a: P. R. Fresquez, J. W. Nyhan, and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2003 Growing Season," Los Alamos National Laboratory report LA-14108-PR (2004).

Fresquez et al. 2004b: P. R. Fresquez, J. W. Nyhan, and E. L. Taylor, "Concentrations of Radionuclides and Trace Elements in Soils and Vegetation Around the DARHT Facility during 2003," Los Alamos National Laboratory report LA-14099-PR (2004).

Hodge et al. 1996: V. Hodge, C. Smith, and J. Whiting, "Radiocesium and Plutonium: Still Together in 'Background' Soils after More than Thirty Years," *Chemosphere* **32**(1), 2067–2075 (1996).

Keith 1991: L. H. Keith, *Environmental Sampling and Analysis: A Practical Guide*, (CRC Press, Inc., Baca Raton, Fl., 1991).

Lopez 2002: E. Lopez, "MDA G and L Environmental Monitoring Plan for FY 2002," Los Alamos National Laboratory document LA-UR-02-6128 (2002).

Martinez 1999: P. Martinez, Environmental Engineer Specialist, Air Quality Bureau, New Mexico Environment Department (September 22, 1999), personal communication.

Nyhan et al. 2000: J. W. Nyhan, P. R. Fresquez, W. R. Velasquez, and E. A. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive-Waste Disposal Area G during the 1999 Growing Season," Los Alamos National Laboratory report LA-13771-PR (2000).

Nyhan et al. 2001a: J. W. Nyhan, P. R. Fresquez, K. D. Bennett, J. R. Biggs, T. K. Haarmann, D. C. Keller, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001).

Nyhan et al. 2001b: J. W. Nyhan, P. R. Fresquez, W. R. Velasquez, and E. A. Lopez, "Radionuclide Concentrations in Soils at Low-Level Radioactive Waste Disposal Area G during the 2000 Growing Season," Los Alamos National Laboratory report LA-13864-PR (2001).

Whicker and Schultz 1982: W. F. Whicker and V. Schultz, *Radioecology: Nuclear Energy and the Environment* (CRC Press, Inc., Boca Raton, Florida, 1982).

8. Foodstuffs and Biota Monitoring

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Philip Fresquez and Lars Soholt

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A. Foodstuff Monitoring *(Philip Fresquez)*

1. Introduction

A wide variety of wild and domestic edible plant, fruit, and animal products are harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes an important pathway by which radionuclides can be transferred to humans (Whicker and Schultz 1982). Therefore, over the past years we have 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 communities to determine the impacts of Los Alamos National Laboratory (LANL or the 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 the following: (1) measure radioactive and nonradioactive (metals and/or organic) contaminant constituents in foodstuffs from on-site (LANL), perimeter, and 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 focused on the collection and analysis of radionuclides in produce, fish, and small and large game animals.

2. Quality Assurance/Quality Control

The team conducts foodstuff sampling according to written, standardized Quality Assurance/Quality Control (QA/QC) procedures and protocols identified in the overall "Quality Assurance Project Plan (QAPP) for the Foodstuffs and Nonfoodstuffs Monitoring Project" (Foodstuffs-QAPP). More specifically, LANL personnel work according to the following operating procedures:

- "Produce Sampling," RRES-MAQ-701;
- "Fish Sampling," RRES-MAQ-702; and
- "Game Animal Sampling," RRES-MAQ-703.

The collection of samples for chemical analyses follows a set procedure to ensure proper collecting, processing, submitting, chemical analyzing, validating, and verifying of data and tabulating of analytical results. Stations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analyzing and reporting. Paragon Analytics, Inc., of Fort Collins, Colorado, analyzed the samples for tritium; cesium-137; strontium-90; uranium; plutonium-238; plutonium-239,240; and americium-241. In addition, mercury was analyzed in the fish samples. This company met all LANL QA/QC requirements.

Results are reported on a per gram dry basis. To convert units to a wet weight basis for dose assessments, multiply the media results in a per gram dry weight basis by the appropriate dry/wet weight ratio provided in Fresquez and Ferenbaugh (1999) and presented in each data table.

3. Produce

a. Monitoring Network. Crop samples (fruits, vegetables, and grains) were collected from regional areas in the summer and fall of 2003 and analyzed for radionuclides (Figure 8-1).

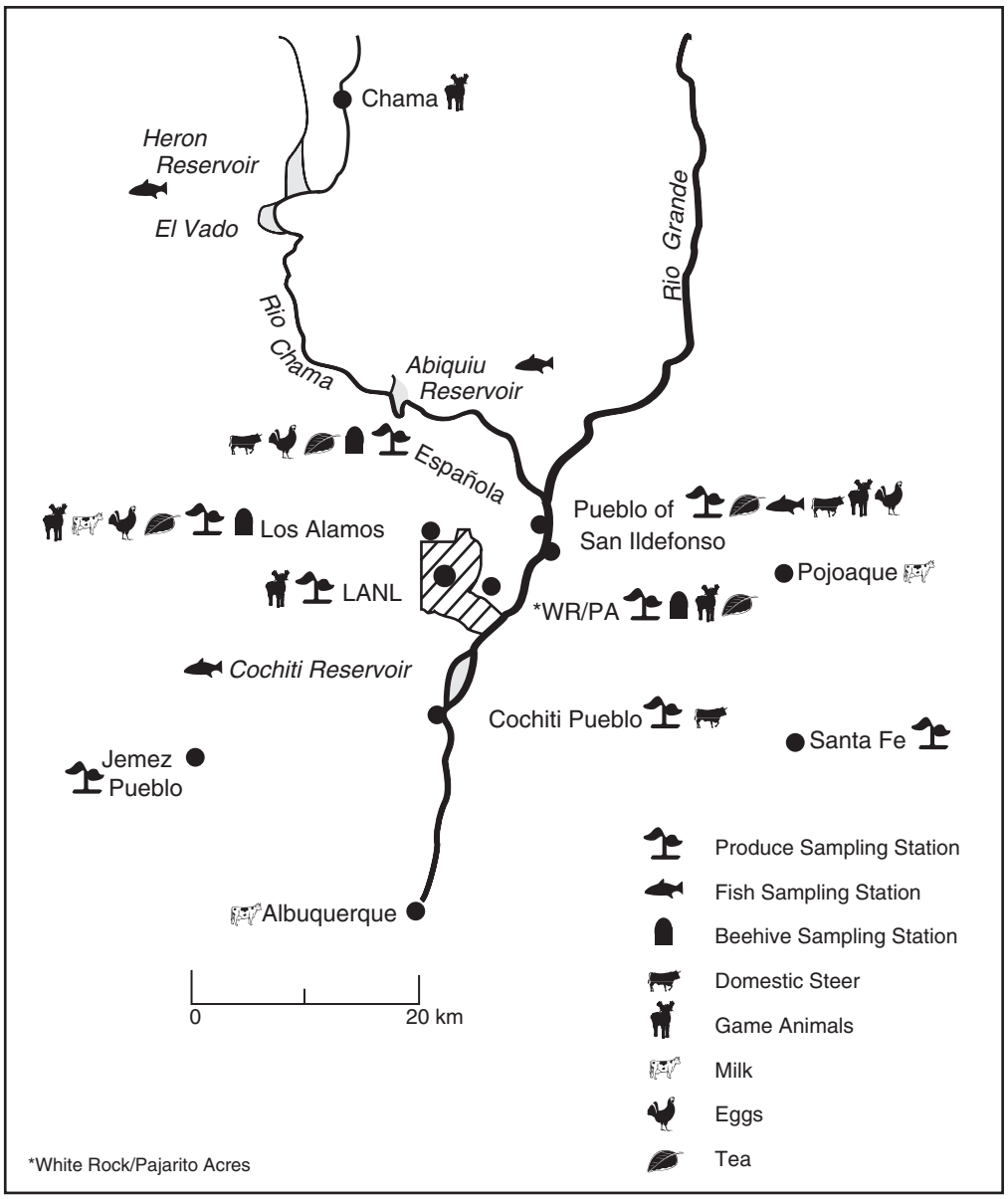

Figure 8-1. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations. (Map denotes general locations only.)

b. Radionuclide Analytical Results. The complete data set reporting results obtained from produce collected from regional locations during the 2003 growing season can be found in Table S8-1 of the Data Supplement. Most radionuclide concentrations in fruits, vegetables, and grains collected from regional areas were nondetectable. A nondetectable value is one in which the result is lower than three counting uncertainty and is not significantly ($\alpha = 0.01$) different from zero (Keith 1991, Corely et al. 1981).

Of the very few radionuclides detected, all were within or just above regional statistical reference levels (RSRLs). RSRLs are the upper-level background concentration (mean plus three standard deviations) from a variety of crop data collected from regional areas away from the influence of the Laboratory over the last five years and represent natural and fallout sources. The only crop plant that contained slightly higher levels of strontium-90 (143×10^{-3} pCi/g dry) than the RSRL (121×10^{-3} pCi/g dry) was a salad green called arugula. This result is not unusual as radionuclides differ in concentration from plant species to plant

species (Seel et al. 1995), and tissues associated with the top growth (stems and leaves) tend to accumulate more radionuclides than the fruiting bodies of the same plant species (Menzel 1965). Strontium-90, in particular, accumulates in leaves and growing shoots (Carini and Lombi 1997) and a comparison of past data (1995 through 2002) shows that lettuce-type plants collected from all sites, including regional areas, were significantly higher in strontium-90 (average = 173×10^{-3} pCi/g dry) than other nonleafy crop plants (average = 29×10^{-3} pCi/g dry) (Fresquez et al. 2002). Therefore, all radionuclides, including strontium-90, in crop plants from regional areas were indistinguishable from natural or fallout levels and are of no concern.

c. Special Study: Perchlorate Analysis of Vegetables and Irrigation Waters. Perchlorates are utilized at the Laboratory in explosive and actinide research and were released into the environment as treated and untreated effluent discharges. They are highly soluble, mobile, and long-lived, and they have migrated from shallow depths to deeper groundwater levels within LANL lands at concentrations around 5 ppb (LANL 2003). Perchlorates are readily taken up by plants (Smith et al. 2001), and the major source of water for home garden irrigation in the Los Alamos vicinity is from deep ground water sources. Perchlorates inhibit thyroid function but there is no current federal standard for protection of human health. Therefore, a special study was conducted to evaluate the possible existence of perchlorates in locally grown foods.

We collected five produce samples each from Los Alamos (lettuce [two], pepper, chard, and tomatoes) and White Rock/Pajarito Acres (chile, squash, tomatoes, lavender, and rhubarb) town sites irrigated with groundwater sources to determine the presence or absence of the perchlorate anion. Five vegetable samples each were also collected from Cochiti (squash, cucumbers, pumpkin, chile, and tomatoes) and Santa Clara (lettuce, egg plant, chile, tomatoes, and cucumbers) pueblo areas irrigated with Rio Grande water, downstream and upstream of LANL, respectively. In addition to vegetable samples, we collected water samples from each of the irrigation sources. The Groundwater Analysis Laboratory at Texas Tech University conducted the analysis by the ion chromatography (IC) method with suppressed conductivity detection (this is a modification of Environmental Protection Agency [EPA] 314 designed to work on high salinity samples) (Anderson and Wu 2002, Kang et al. 2003). Several split samples of vegetables were sent to the General Engineering Laboratory in California and were analyzed using liquid chromatography/mass spectrometry/mass spectrometry methodology. Results from both laboratories show no perchlorate concentrations in any of the vegetable samples or water samples above the minimum reporting level (MRL) or the minimum detection level (MDL). (**Note:** Experimental data indicate that the MRL for most vegetables is approximately 50 ppb, and the MDL ranges from 30 to 40 ppb. The MRL for surface and ground waters is 4 ppb in concurrence with EPA Method 314, and the MDL is 0.5 ppb.)

4. Fish

a. Monitoring Network. There are 19 canyons that, depending on the season, carry water through LANL lands to the Rio Grande. Cochiti Reservoir, a recreational fishery on the Rio Grande located approximately 5 miles downstream of LANL, is sampled to determine if fish are affected by Laboratory operations. Fish collected from Cochiti Reservoir are compared with fish collected upstream of the Laboratory—principally from Abiquiu Reservoir or Heron Reservoir, depending on the availability of water. Abiquiu and Heron are located on the Chama River and are upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands (Fresquez et al. 1994).

Samples that were collected in 2003 included bottom-feeding fish: white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*). In the past, we had collected both predator and bottom-feeding fish on an annual basis; however, because bottom-feeding fish forage on the bottom where radionuclides readily bind to sediments, they are better indicators of environmental contamination (Whicker and Schultz 1982).

b. Radionuclide Analytical Results. The complete set of results of the bottom-feeding fish collected from the reservoirs located upstream and downstream of LANL is found in the Data Supplement, Table S8-2. Most radionuclides in bottom-feeding fish collected from Cochiti Reservoir, downstream of LANL, were nondetectable or within RSRLs. The radionuclides that were detected above the RSRLs were isotopes of naturally occurring uranium (uranium-234 and uranium-238); and the ratio distribution shows that the uranium was of natural origin (Table 8-1). These results were similar to

Table 8-1. Mean (std dev) Uranium-234 and Uranium-238 Concentrations (dry weight)[a] in Bottom-Feeding Fish (muscle plus bone) Collected from Reservoirs Upstream and Downstream of Los Alamos National Laboratory during 2003

Location	^{234}U (10^{-3} pCi/g)	^{238}U (10^{-3} pCi/g)
Upstream (Heron Reservoir)	3.3 (1.6)	1.7 (0.91)
RSRL[b]	12	7.7
Downstream (Cochiti Reservoir)	9.2 (4.8)*	5.7 (3.1)*

[a]To convert units on a per gram dry weight basis to a wet weight basis for dose assessments, multiply result by 0.29 (Fresquez and Ferenbaugh 1999).

[b]Regional Statistical Reference Level; this is the upper-limit background concentration (mean + 3 std dev) based on data from the last five years.

*Means within the same column followed by an * were significantly different from Heron (background) using a Student's t-test at the 0.05 probability level.

radionuclide contents in crappie, trout, and salmon collected from comparable background reservoirs and lakes in Colorado (Whicker et al. 1972; Nelson and Whicker 1969) and New Mexico (Fresquez et al. 1996, Fresquez et al. 1998a) and more recently to radionuclide levels in fish collected along the length of the Rio Grande from Colorado to Texas (Booher et al. 1998). Also, the results compare well with findings in fish collected in the Rio Grande below LANL in 1998 (Fresquez et al. 1999a).

Concentrations of uranium in bottom-feeding fish at Cochiti have almost always been higher than in fish from upstream sources (Figure 8-2). The reasons for the higher naturally occurring uranium concentrations in fish from Cochiti as compared with fish collected from upstream reservoirs include (1) Cochiti receives greater amounts of sediments than the other reservoirs, (2) there are more uranium-bearing minerals around the Cochiti area, and (3) some uranium may be entering Cochiti Reservoir via the Santa Fe River as it flows past the edge of an abandoned uranium mine site (La Bajada Uranium mine).

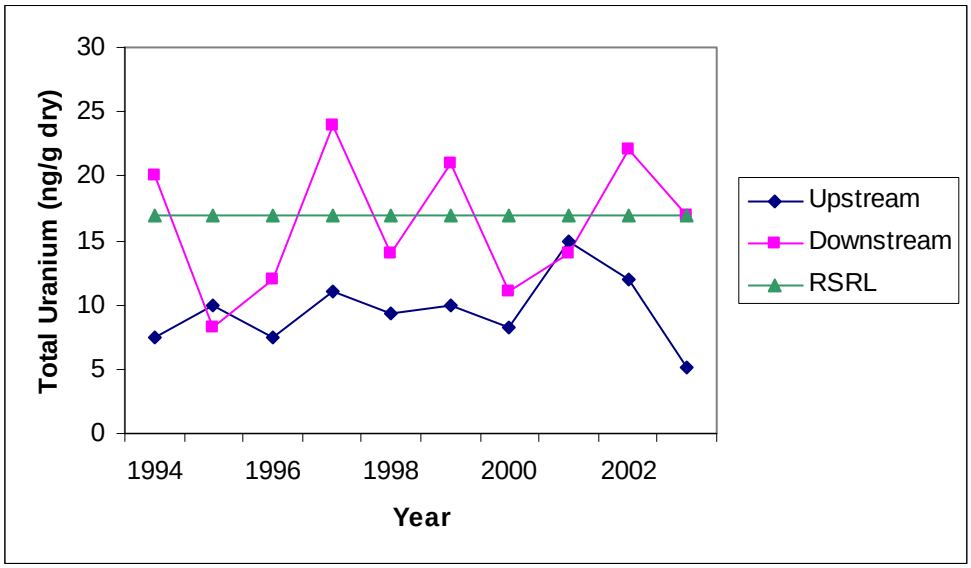

Figure 8-2. Total uranium in bottom-feeding fish collected from reservoirs upstream (Abiquiu/Heron) and downstream (Cochiti) of LANL from 1994 through 2003.

c. Nonradionuclide (Mercury) Analytical Results. In the past, we have analyzed a host of trace elements in the muscle (fillet) of predator and bottom-feeding fish collected from downstream (Cochiti) and upstream (Abiquiu or Heron) reservoirs. However, of all the trace elements measured only mercury was consistently detected above the detection limits. Moreover, mercury is a major problem in New Mexico fisheries including the Rio Grande (NMDA 1993). For these reasons, mercury was analyzed in bottom-feeding fish, and the results can be found in Table S8-3.

All individual mercury concentrations in bottom-feeding fish (fillets) collected from Cochiti Reservoir were below the RSRL and below the US Food and Drug Administration's ingestion limit of 1 µg mercury/g wet weight (Torres 1998). However, the New Mexico Department of Health has issued fish consumption guidelines for various species and sizes of fish at various lakes in New Mexico. These data compare well with other studies from the New Mexico Environment Department (Yanicak 2001) and in catfish collected from Conchas Lake (averaged 0.25 µg/g wet weight) (Bousek 1996) and Santa Rosa Lake (ranged 0.22 to 0.33 µg/g wet weight (Torres 1998).

Long-term data show that mercury concentrations in fish from the reservoirs are decreasing over time (Figure 8-3). Decreasing concentrations in mercury in fish from both reservoirs may be related to the reduction of emissions in coal-burning power plants and/or the reduction of carbon sources within the reservoirs (Fresquez et al. 1999b). Since the early 1980s, for example, coal-burning power plants in the northwest corner of New Mexico have been required to install venturi scrubbers and bag houses to capture particulates and reduce air emissions (Martinez 1999). Also, because the conversion of mercury to methyl mercury is primarily a biological process, mercury concentrations in fish tissue rise significantly in impoundments that form behind new dams and then the concentrations gradually decline to an equilibrium level as the carbon provided by flooded vegetation is depleted (NMED 1999).

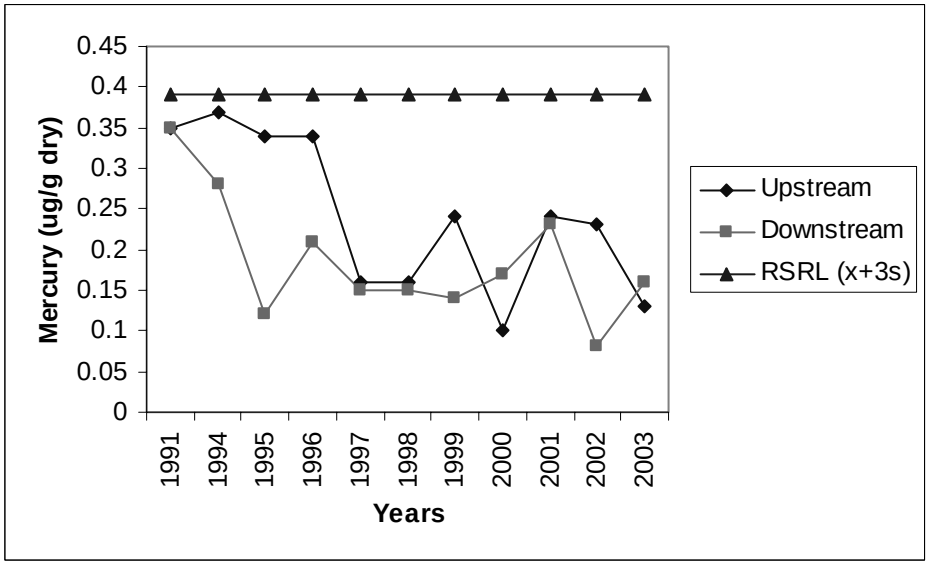

Figure 8-3. Mercury in bottom-feeding fish (fillet) collected from reservoirs upstream (Abiquiu/Heron) and downstream (Cochiti) of LANL from 1991 through 2003.

d. Special Study: Perchlorate Analysis of Fish. We collected five predator and five bottom-feeding fish each from Cochiti and Heron reservoirs (20 total fish) to determine the presence or absence of the perchlorate anion. The Groundwater Analysis Laboratory at Texas Tech University conducted the analysis on fillet samples by the IC method with suppressed conductivity detection (this is a modification of EPA 314 designed to work on high salinity samples) (Anderson and Wu 2002, Kang et al. 2003). Results show no perchlorate concentrations in any of the fish (fillet) samples collected from either Cochiti or Heron reservoirs above the MRL. (**Note:** Experimental data indicate that the MRL for fish fillets is approximately 100 ppb.) Other studies have shown that human exposure to perchlorate through

consumption of fish is low, mainly because perchlorate accumulates in the fish heads (where the thyroid is located), which is rarely consumed, rather than in the muscle fillet tissues (Anderson 2002).

5. Small Game Animals

a. Monitoring Network. Rabbits were collected from San Ildefonso Pueblo on the south rim of Mortandad Canyon by members of the tribal community. Pueblo members processed the samples in our laboratory, and the samples were submitted to Paragon Analytics, Inc. These two samples were composited and compared with similar (composited) rabbit species collected from regional background areas (Española).

b. Radionuclide Analytical Results. The complete data set can be found in the Data Supplement as Table S8-4. In general, most all radionuclides, with the exception of strontium-90 in rabbit muscle and bone, collected from San Ildefonso lands were nondetectable or within RSRLs. Strontium-90 in rabbit bone tissue from San Ildefonso, in particular, was over five times higher than regional background concentrations (Table 8-2). Although strontium-90 has been reported in above-background concentrations in mice within Mortandad Canyon approximately 0.5 miles north of where the rabbit samples were collected (Bennett et al. 1996a), more samples are required from both San Ildefonso and regional background areas before any conclusions can be made as to whether or not these levels are due to Laboratory operations. Bone (background) samples of rabbits from another part of the country, for example, have shown concentrations of strontium-90 (1.3 pCi/g dry) to be at the same level of those obtained from San Ildefonso (1.1 pCi/g dry) (PNNL 2002).

6. Large Game Animals

a. Monitoring Network. Mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus*) are common inhabitants of LANL lands. Resident populations of deer number from 50 to 100; elk number from 100 to 200 and increase to as many as 2,000 animals during the winter months (Fresquez et al. 1999c), reflecting large mammal migration to lower elevations. These animals may forage in contaminated lands and then migrate off to private and public lands where they are hunted for food.

Table 8-2. Strontium-90 Concentrations in Muscle and Bone Tissues of Rabbits Collected from Perimeter and Regional Background Areas

Tissue/Location	^{90}Sr (10^{-3} pCi/g dry)[e]
MUSCLE:	
San Ildefonso/Sacred Area/12-30-02[a]	15 (2.1)[b]
Regional Background[c]	2.3 (1.7)
RSRL[d]	7.4
BONE	
San Ildefonso	1075 (129)
Regional Background	154 (22)
RSRL	220

[a]Composite sample of two rabbits collected just east of LANL on the south rim of Mortandad Canyon (this location is between TA-5 and TA-51 on the western corner of the San Ildefonso sacred area).
[b](±1counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[c]Mean (and std dev) of two composite samples.
[d]The Regional Statistical Reference Level (mean + 3 std dev) is based on data collected from present results.
[e]To convert units in grams of dry weight to grams of wet weight for dose assessment, multiply muscle results by 0.24 and bone results by 0.40.

We collect samples of elk and deer as road kills; therefore, the availability of samples is beyond our control, but usually the collection of one or two animals per year from Laboratory and perimeter areas is possible. Since 1992, we have collected approximately 23 elk and 11 deer from Laboratory property and approximately 7 elk and 6 deer from the perimeter of LANL property. When an animal is collected, the muscle and bone are processed and analyzed for a number of radionuclides—the muscle because it is the major organ that humans consume and the bone because it may also be consumed, albeit indirectly, and many radionuclides like strontium and plutonium are deposited there. We then compare these data with meat and bone samples from elk and deer collected from regional background locations.

b. Radionuclide Analytical Results (Deer). Most radionuclide concentrations in muscle and bone tissues of deer collected from the perimeter areas—Los Alamos and San Ildefonso—were nondetectable or below RSRLs (Table S8-5). Only tritium was detected above the RSRL in muscle and bone tissues of deer collected from Los Alamos and San Ildefonso areas, but the differences were small (Table 8-3). Deer are common inhabitants of the LANL environment and may graze in areas with some residual contamination (Fresquez et al. 1995, Fresquez et al. 1998b).

c. Radionuclide Analytical Results (Elk). All radionuclide concentrations in muscle and bone of elk collected from LANL and perimeter (San Ildefonso) lands were nondetectable or below RSRLs (Table 8-4 and Table S8-6).

B. Biota Monitoring

1. Introduction

In addition to mandating the monitoring of human foodstuffs for contaminants, DOE Orders 450.1 (DOE 2003) and 5400.5 mandate the monitoring of nonfoodstuff biota for the protection of ecosystems (DOE 1993). Although monitoring of biota, mostly in the form of facility-specific or site-specific studies,

Table 8-3. Radionuclide Concentrations in Muscle and Bone Tissues of Deer Collected from Perimeter Areas[a]

Tissue/ Location	^{3}H (pCi/mL)[a]
MUSCLE:	
Los Alamos/Royal Crest/Truck Rt./8-8-01	**0.76 (0.16)[b]**
San Ildefonso/Sacred Area/11/22/02	**1.5 (0.20)**
San Ildefonso/Pueblo Canyon/1/13/03	0.66 (0.16)
State Road 4/Apache Springs/5-15-03	0.12 (0.13)
RSRL[c]	0.68
LEG BONE:	
Los Alamos	0.57 (0.15)
San Ildefonso	**1.2 (0.19)**
San Ildefonso	0.48 (0.15)
State Road 4	-0.03 (0.13)[d]
RSRL[c]	0.61

[a]Results are expressed in tissue moisture.
[b](±1counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[c]Regional Statistical Reference Level is the upper-level background concentration (mean + 3 std dev) based on data collected from 1991 to 2000 (n=5). Values in bold are higher than the RSRL.
[d]Appendix B for an explanation of the presence of negative values.

Table 8-4. Selected Radionuclide Concentrations in Muscle and Bone Tissues of Elk Collected from LANL and Perimeter (San Ildefonso) Areas

Tissue/ Location	^{241}Am (10^{-5} pCi/g dry)[a]	^{tot}U (ng/g dry)[a]
MUSCLE:		
LANL Elk/TA-18/Pajarito Rd/ 6-26-02/Cow	-13 (7.9)[bc]	0.35 (0.33)
San Ildefonso/Sacred Area/123-16-02/Cow (Muscle)	11 (13)	1.3 (0.48)
San Ildefonso (Liver)	3.4 (8.0)	13 (1.8)
RSRL[d]	24	2.1
LEG BONE:		
LANL Elk (TA-18)	122 (73)	9.3 (2.9)
San Ildefonso	261 (86)	8.4 (5.2)
RSRL[d]	52	8.5

[a]To convert units on a per gram dry weight basis to a wet weight basis for dose assessments, multiply muscle result by 0.26 and bone result by 0.79 (Fresquez and Ferenbaugh 1999).
[b]See Appendix B for an explanation of the presence of negative values.
[c](± counting uncertainty); values are the uncertainty of the analytical results at 65% confidence level.
[d]Regional Statistical Reference Level is the upper-level background concentration (mean + 2 std dev) based on data collected from 1991 to 2000 (n=9).

began in the 1970s with the Environmental Surveillance Program (ESP), in 1994 the DOE requested additional emphasis on nonfoodstuff biota. Laboratory personnel monitor nonfoodstuff biota, such as small mammals, amphibians and reptiles, birds, and vegetation within and around LANL on a systematic or special study basis for radiological and nonradiological constituents.

The two main objectives of the biota program are to determine (1) on-site contaminant concentrations in biota and compare them with off-site regional concentrations and (2) trends over time. On-site concentrations are the result of potential Laboratory-added contamination plus, in many cases, natural sources. With the issuance of the interim standard on evaluating radiation doses to aquatic and terrestrial biota (DOE 2002), a new and third objective is providing data for use in evaluating compliance with specified limits on radiation dose to plants and animals. Chapter 3 includes the results and comparisons with the standard that were made in 2003.

2. Quality Assurance/Quality Control

Laboratory personnel conduct biota sampling according to written, standardized QA/QC procedures and protocols. These procedures and protocols are identified in the overall QAPP for the Foodstuffs and Nonfoodstuffs Monitoring Project (Foodstuffs-QAPP); and, more specifically in the following procedures:

- "Produce Sampling," RRES-MAQ-701, and
- "Facility Soil and Vegetation Sampling," RRES-MAQ-711.

Paragon Analytics, Inc., analyzed the samples for tritium; plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; and uranium. Also, for Dual Axis Radiographic Hydrodynamic Test facility (DARHT) samples, Paragon Analytics, Inc., analyzed the samples for silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, and

thallium. (**Note:** Prior evaluations of metals at Area G have showed no elements of concern.) Paragon Analytics met all QA/QC requirements.

Radionuclide results are reported on a per gram ash basis. To convert units to a wet weight basis for dose assessments, multiply the media results in a per gram ash basis by the appropriate ash/dry and dry/wet weight ratios provided in Fresquez and Ferenbaugh (1999). These ratios are also presented in the data tables of this chapter.

3. Institutional Monitoring

a. Monitoring Network. Vegetation sampling locations correspond to soil sampling locations described in Chapter 7. Team members collect these samples from 4 regional background locations, 10 perimeter locations, and at 12 locations within the LANL boundary (Figure 7-1). This year we collected composite samples of unwashed understory (grasses and forbs) vegetation.

b. Radionuclide Analytical Results. The detailed data are in Table S8-7. Most radionuclide concentrations in understory samples from on-site and perimeter stations were nondetectable or within RSRLs. The very few detections that were above RSRLs included plutonium-239,240 in understory vegetation at TA-21, which correlates well with the soils data (Table 7-1). These data, however, were still very low, and the difference in concentrations between sites was very small.

4. Facility Monitoring

a. Monitoring Network. The two main facilities where biota monitoring takes place are the Laboratory's principal low-level radioactive waste disposal site (Area G) (Lopez 2002) (Figure 7-4) and the Laboratory's principal explosive test facility (DARHT) (Nyhan et al. 2001a) (Figure 7-5). 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 baseline statistical reference levels (BSRLs). BSRLs are the concentrations of radionuclides and trace elements in biota in the vicinity of the DARHT facility (1996–1999) before the operation phase (2000 and after). The Mitigation Action Plan for the DARHT facility at LANL mandated the establishment of baseline (preoperational) concentrations for potential environmental contaminants resulting from DARHT operations (DOE 1996). Laboratory personnel calculated these concentrations of radionuclides and trace elements from the mean DARHT facility sample concentration plus two standard deviations. (**Note:** Previous evaluations of BSRLs with RSRLs show no statistically significant differences between the two, and the use of BSRLs at DARHT is for compliance reasons.)

b. Radionuclide Analytical Results for Area G (TA-54).

Vegetation. A complete description of the site and sampling methodology can be found in Fresquez et al. (2004a). In general, unwashed overstory (trees) and understory (grass and forb) vegetation samples were collected at nine locations within and around the perimeter of Area G (Figure 7-7). These samples were analyzed for tritium, plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; and total uranium. Most radionuclides in/on plants were within RSRLs. The exceptions were tritium in overstory and some understory vegetation, particularly in the southwestern portion of Area G. Also, there was some foliar contamination from americium-241 and plutonium isotopes in/on a few plant samples—the highest concentrations occurring in the northern sections of Area G. These results are consistent with results from studies in previous years (Nyhan et al. 2000, Nyhan et al. 2001b).

A transect study using tree branch tips collected at various distances (approximately 10, 50, 100, 150, and 200 m) from the perimeter of Area G in seven directions showed that tritium concentrations in trees collected nearest the perimeter boundary (10 to 16 m) around Area G were higher than the RSRL. From there, most transects showed decreasing concentrations with distance and at around 90 m were similar to RSRLs (Fresquez et al. 2003).

Small Mammals *(Lars Soholt)***.** Nine samples of ash from small mammals captured in or near Area G were submitted for analysis in 2003; one of these was from animals captured in a reference area west of Area G. In general, the results were consistent with results from previous years (Biggs et al. 1995 and 1997, Bennett et al. 1996b and 1998, Bennett et al. 2002). Higher levels of the actinides and tritium were found in the on-site samples than in the off-site sample. Most of the on-site samples exceeded

RSRLs for one or more radionuclides. With one exception, the results were within the ranges of values found in previous years. One sample from on-site exhibited unusually high levels of plutonium-238 (99 pCi/g ash); plutonium-239,240 (301 pCi/g ash); cesium-137 (31 pCi/g ash); americium-241 (13 pCi/g ash); and strontium-90 (19 pCi/g ash). This sample was from animals collected in area 7a, above disposal trenches located in the southeastern portion of the site (Figure 7-7). There is no apparent reason why this particular sample exhibited such high values. We will try to capture animals from this area in 2004 to see if these unusually high values reoccur. As in the past, animals captured near the tritium disposal shafts exhibited elevated levels of tritium, but we found nothing unusually high.

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

Vegetation. A complete description of the DARHT site and sampling methodology can be found in a report by Fresquez et al. (2004b). In general, unwashed overstory and understory vegetation were collected at four locations around the DARHT facility. All samples were analyzed for concentrations of tritium, plutonium-238; plutonium-239,240; strontium-90; americium-241; cesium-137; total uranium; silver; arsenic; barium; beryllium; cadmium; chromium; copper; mercury; nickel; lead; antimony; selenium; and thallium. These results were compared with BSRL data established for a four-year-long preoperational period before DARHT operations (Fresquez et al. 2001). Most radionuclides, with the exception of uranium, and trace elements, with the exception of copper and selenium, in vegetation were below BSRL values. The differences, however, were small in every case and are of no concern.

C. References

Anderson 2002: T. A. Anderson, "Ecological Risk Assessment of Perchlorate on Fish, Amphibians and Mammals in the Lake Belton and Lake Waco Watersheds," Interim Progress Report, the Institute for Environmental and Human Health, Texas Tech University, Lubbock, Texas (September 2002).

Anderson and Wu 2002: T. A. Anderson and T. H. Wu, "Extraction, Cleanup, and Analysis of the Perchlorate Anion in Tissue Samples," *Bull. Environ. Contam. Toxicol*. **68**:684–691 (2002).

Bennett et al. 1996a: K. Bennett, J. Biggs, and P. R. Fresquez, "Radionuclide Contaminant Analysis of Small Mammals, Plants and Sediments within Mortandad Canyon, 1994," Los Alamos National Laboratory report LA-13104-MS (1996).

Bennett et al. 1996b: K. Bennett, J. Biggs, and P. Fresquez, "Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1995," Los Alamos National Laboratory report LA-13242-MS (1996).

Bennett et al. 1998: K. D. Bennett, J. R. Biggs, and P. R. Fresquez, "Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1997 (With Cumulative Summary for 1994–1997)," Los Alamos National Laboratory report LA-13517-MS (1998).

Bennett et al. 2002: K. D. Bennett, R. J. Robinson, and P. R. Fresquez, "Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area-54, 1998 (With Cumulative Summary for 1994–1998)," Los Alamos National Laboratory report LA-13874-MS (2002).

Biggs et al. 1995: J. Biggs, K. Bennett, and P. Fresquez, "Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1994," Los Alamos National Laboratory report LA-13015-MS (1995).

Biggs et al. 1997: J. R. Biggs, K. D. Bennett, and P. R. Fresquez, "Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1996 (With Cumulative Summary for 1994–1996)," Los Alamos National Laboratory report LA-13345-MS (1997).

Booher et al. 1998: J. L. Booher, P. R. Fresquez, L. F. Carter, B. M. Gallaher, and M. A. Mullen, "Radionuclide Concentrations in Bed Sediment and Fish Tissue within the Rio Grande Drainage Basin," Los Alamos National Laboratory report LA-13366 (1998).

Bousek 1996: J. Bousek, "An Analysis of Copper, Zinc, and Mercury Concentrations in Fish Species in Santa Rosa Reservoir, New Mexico," M.S. Thesis, New Mexico Institute of Mining and Technology, Socorro, New Mexico (1996).

Carini and Lombi 1997: F. Carini and E. Lombi, "Foliar and Soil Uptake of Cs and Sr by Grape Vines," *The Science of the Total Environment* **207**:157–164 (November 1997).

Corely et al. 1981: J. P. Corely, D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, and D. A. Waite, "A Guide for Environmental Radiological Surveillance at US Department of Energy Installations," Department of Energy report DOE/EP-0023 (1981).

DOE 1991: US Department of Energy, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," US Department of Energy report DOE/EH-0173T (January 1991).

DOE 1993: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (1993).

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

DOE 2002: US Department of Energy, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," US Department of Energy Standard DOE-STD-1153-2002 (July 2002).

DOE 2003: US Department of Energy, "Environmental Protection Program," US Department of Energy Order 450.1 (2003).

Fresquez and Ferenbaugh 1999: P. R. Fresquez and J. K. Ferenbaugh, "Moisture Conversion Rations for the Foodstuffs and Biota Environmental Surveillance Programs at Los Alamos National Laboratory: 1999 (Revision 1)," Los Alamos National Laboratory document LA-UR-99-253 (1999).

Fresquez et al. 1994: P. R. Fresquez, D. R. Armstrong, and J. G. Salazar, "Radionuclide Concentrations in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory: 1981 to 1993," Los Alamos National Laboratory report LA-12818-MS (1994).

Fresquez et al. 1995: P. R. Fresquez, D. R. Armstrong, and J. G. Salazar, "Radionuclide Concentrations in Elk that Winter on Los Alamos National Laboratory Lands," Los Alamos National Laboratory report LA-12795-MS (1995).

Fresquez et al. 1996: P. R. Fresquez, D. R. Armstrong, and L. Naranjo, Jr., "Radionuclide and Heavy Metal Concentrations in Soil, Vegetation, and Fish Collected around and within Tsicoma Lake in Santa Clara Canyon," Los Alamos National Laboratory report LA-13144-MS (1996).

Fresquez et al. 1998a: P. R. Fresquez, D. R. Armstrong, and L. Naranjo, Jr., "Radionuclides and Heavy Metals in Rainbow Trout from Tsichomo, Nana Ka, Wen Povi, and Pin De Lakes in Santa Clara Canyon," Los Alamos National Laboratory report LA-13441-MS (1998).

Fresquez et al. 1998b: P. R. Fresquez, D. R. Armstrong, and M. A. Mullen, "Radionuclides and Radioactivity in Soils Collected from within and around Los Alamos National Laboratory: 1974–1996," *Journal of Environmental Science and Health A* **33** (2), 263–278 (1998).

Fresquez et al. 1999a: P. R. Fresquez, D. H. Kraig, M. A. Mullen, and L. Naranjo, Jr., "Radionuclides and Trace Elements in Fish Collected Upstream and Downstream of Los Alamos National Laboratory and the Doses to Humans from the Consumption of Muscle and Bone," *Journal of Environmental Science and Health B* **34** (5), 885–900 (1999).

Fresquez et al. 1999b: P. R. Fresquez, J. D. Huchton, and M. A. Mullen, "Trace Elements, with Special Reference to Mercury, in Fish Collected Upstream and Downstream of Los Alamos National Laboratory," Los Alamos National Laboratory report LA-13658-MS (1999).

Fresquez et al. 1999c: P. R. Fresquez, J. R. Biggs, K. D. Bennett, D. H. Kraig, and M. A. Mullen, "Radionuclides in Elk and Deer from Los Alamos National Laboratory and Doses to Humans from the Ingestion of Muscle and Bone," *Journal of Environmental Science and Health Part B*, B **34** (5): 901–916 (1999).

Fresquez et al. 2001: P. R. Fresquez, J. W. Nyhan, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, and Vegetation around the DARHT Facility," in Nyhan et al., "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001), pp. 48–76.

Fresquez et al. 2002: P. R. Fresquez, G. J. Gonzales, J. Nyhan, T. Haarmann, L. Soholt, and B. Gallaher, "Soil, Foodstuffs, and Associated Biota," in "Environmental Surveillance at Los Alamos during 2001," Los Alamos National Laboratory report LA-13979-ENV (2002), pp. 419–521.

Fresquez et al. 2003: P. R. Fresquez, L. Vasquez-Tator, and E. A. Lopez, "Tritium Concentrations in Vegetation as a Function of Distance from a Low-Level Waste Site at Los Alamos National Laboratory," Los Alamos National Laboratory report LA-14091-MS (2003).

Fresquez et al. 2004a: P. R. Fresquez, J. W. Nyhan, and E. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive Waste Disposal Area G during the 2003 Growing Season," Los Alamos National Laboratory report LA-14108-PR (2004).

Fresquez et al. 2004b: P. R. Fresquez, J. W. Nyhan, and E. L. Taylor, "Concentrations of Radionuclides and Trace Elements in Soils and Vegetation around the DARHT Facility during 2003," Los Alamos National Laboratory report LA-14099-PR (2004).

Kang et al. 2003: T. Kang, P. K. Dasgupta, and T. A. Anderson, "Determination of Trace Perchlorate in High-Salinity Water Samples by Ion Chromatography with On-Line Preconcentration and Preelution," *Anal. Chem.* **75**:701–706 (2003).

Keith 1991: L. H. Keith, *Environmental Sampling and Analysis: A Practical Guide* (CRC Press, Inc., Baca Raton, Fl., 1991).

LANL 2003: Los Alamos National Laboratory, "Los Alamos National Laboratory Perchlorate Issues: A Summary of Laboratory Information as of August 2003," Los Alamos National Laboratory document LA-UR 03-5710 (2003).

Lopez 2002: E. Lopez, "MDA G and L Environmental Monitoring Plan for FY 2002," Los Alamos National Laboratory document LA-UR-02-6128 (2002).

Martinez 1999: P. Martinez, Environmental Engineer Specialist, Air Quality Bureau, New Mexico Environment Department (September 22, 1999), personal communication.

Menzel, 1965: R. G. Menzel, "Soil-Plant Relationships of Radioactive Elements," *Health Phys*. **11**, 1325–1332 (1965).

Nelson and Wicker 1969: W. C. Nelson and F. W. Wicker, "Cesium-137 in Some Colorado Game Fish, 1965–66," in Symposium on Radioecology, US Atomic Energy Commission report CONF-670503 (1969).

NMDA 1993 New Mexico Department of Health, "Fish Consumption Guidelines due to Mercury Contamination," NM Department of Health, NM Environment Department, NM Department of Game and Fish (1993).

NMED 1999: New Mexico Environment Department, "A White Paper on Mercury," New Mexico Environment Department, Surface Water Quality Bureau, Santa Fe, NM (1999).

Nyhan et al. 2000: J. W. Nyhan, P. R. Fresquez, W. R. Velasquez, and E. A. Lopez, "Radionuclide Concentrations in Soils and Vegetation at Low-Level Radioactive-Waste Disposal Area G during the 1999 Growing Season," Los Alamos National Laboratory report LA-13771-PR (2000).

Nyhan et al. 2001a: J. W. Nyhan, P. R. Fresquez, K. D. Bennett, J. R. Biggs, T. K. Haarmann, D. C. Keller, and H. T. Haagenstad, "Baseline Concentrations of Radionuclides and Trace Elements in Soils, Sediments, Vegetation, Small Mammals, Birds, and Bees around the DARHT Facility: Construction Phase (1996 through 1999)," Los Alamos National Laboratory report LA-13808-MS (2001).

Nyhan et al. 2001b: J. W. Nyhan, P. R. Fresquez, W. R. Velasquez, and E. A. Lopez, "Radionuclide Concentrations in Soils at Low-Level Radioactive Waste Disposal Area G during the 2000 Growing Season," Los Alamos National Laboratory report LA-13864-PR (2001).

PNNL 2002: Pacific Northwest National Laboratory, "Hanford Site Environmental Report for Calendar Year 2001," PNNL report 13910 (2002).

Seel et al. 1995: J. F. Seel, F. W. Whicker, and D. C. Adriano, "Uptake of 137Cs in Vegetable Crops Grown on a Contaminated Lakebed," *Health Physics* **68**:793–799 (1995).

Smith et al. 2001: P. N. Smith, C. W. Theodorakis, T. A. Anderson, R. J. Kendall, "Preliminary Assessment of Perchlorate in Ecological Receptors at the Longhorn Army Ammunition Plant, Karnack, Texas," *Ecotoxicology*, **10**:305–313 (2001).

Torres 1998: P. Torres, "Metal Accumulation in Various Fish Species from Conchas Lake and Santa Rosa Lake in East Central New Mexico," M.S. Thesis, New Mexico Institute of Mining and Technology, Socorro, NM (1998).

Whicker and Schultz 1982: W. F. Whicker and V. Schultz, *Radioecology: Nuclear Energy and the Environment* (CRC Press, Inc., Boca Raton, Florida, 1982).

Whicker et al. 1972: W. F. Whicker, W. C. Nelson, and A. F. Gallegos, "Fallout Cs-137 and Sr-90 in Trout from Mountain Lakes in Colorado," *Health Phys.* **23**, 517–527 (1972).

Yanicak 2001: S. Yanicak, "Cochiti Reservoir Fish Tissue Sampling Results Dioxin/Furan and Mercury and Abiquiu Reservoir Fish Tissue PCB Sampling Results—1999 and 2000," State of New Mexico Environment Department DOE Oversight Bureau letter to Joe Vozella (April 12, 2001).

8. Foodstuffs and Biota Monitoring

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 5400.1, "General Environmental Program;" 5400.5, "Radiation Protection of the Public and the Environment;" and 231.1, "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 DOE dose factors from DOE 1988a and DOE 1988b. The dose factors DOE 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 (RPS) for the public (NCRP 1987). Table A-1 lists currently applicable RPSs, now referred to as public dose limits (PDLs), for operations at the Laboratory. DOE's comprehensive PDL 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 PDLs and the DOE dose factors 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 as shown in Table A-4. This table shows the number of analytes included in each analytical suite. The specific compounds analyzed in each suite are listed in Tables A-5 through A-8.

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

	Effective 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 (annual EDE[e])
Nonstochastic Effects	
Lens of eye	15 rem (annual EDE[e])
Extremity	50 rem (annual EDE[e])
Skin of the whole body	50 rem (annual EDE[e])
Organ or tissue	50 rem (annual EDE[e])
Unborn Child	
Entire gestation period	0.5 rem (annual EDE[e])

[a]As used by DOE, effective dose equivalent (EDE) includes both the EDE from external radiation and the committed EDE to individual tissues from ingestion and inhalation during the calendar year.

[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 (PDL) 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]Annual EDE is the EDE received in a year.

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 ICRP30 (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	Annual	$\mu g/m^3$	60		
Particulates	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.

Table A-4. Organic Analytical Methods

Test	SW-846 Method	Number of Compounds
Volatiles	624, 8260B	68
Semivolatiles	625, 8270C	69
PCB[a]	608, 8082, 8081	8
HE[b]	8330	14

[a]Polychlorinated biphenyls.
[b]High explosives.

Table A-5. Volatile Organic Compounds

Analytes	Limit of Quantitation Water (µg/L)
1,1,1,2-Tetrachloroethane	1
1,1,1-Trichloroethane	1
1,1,2,2-Tetrachloroethane	1
1,1,2-Trichloroethane	1
1,1-Dichloroethane	1
1,1-Dichloroethylene	1
1,1-Dichloropropene	1
1,2,3-Trichloropropane	1
1,2,4-Trimethylbenzene	1
1,2-Dibromo-3-chloropropane	1
1,2-Dibromoethane	1
1,2-Dichlorobenzene	1
1,2-Dichloroethane	1
1,2-Dichloropropane	1
1,3,5-Trimethylbenzene	1
1,3-Dichlorobenzene	1
1,3-Dichloropropane	1
1,4-Dichlorobenzene	1
2,2-Dichloropropane	1
2-Butanone	5
2-Chloroethylvinyl ether	5
2-Chlorotoluene	1
2-Hexanone	5
4-Chlorotoluene	1
4-Isopropyltoluene	1
4-Methyl-2-pentanone	5
Acetone	5
Acrolein	10
Acrylonitrile	10
Benzene	1
Bromobenzene	1
Bromochloromethane	1
Bromodichloromethane	1
Bromoform	1
Bromomethane	1

Table A-5. (Cont.)

Analytes	Limit of Quantitation Water (µg/L)
Carbon disulfide	5
Carbon tetrachloride	1
Chlorobenzene	1
Chloroethane	1
Chloroform	1
Chloromethane	1
cis-1,3-Dichloropropylene	1
Dibromochloromethane	1
Dibromomethane	1
Dichlorodifluoromethane	1
Ethylbenzene	1
Hexachlorobutadiene	1
Iodomethane	5
Isopropylbenzene	1
m,p-Xylenes	2
Methylene chloride	5
Naphthalene	1
n-Butylbenzene	1
n-Propylbenzene	1
o-Xylene	1
sec-Butylbenzene	1
Styrene	1
tert-Butylbenzene	1
Tetrachloroethylene	1
Toluene	1
Toluene-d8	1
trans-1,2-Dichloroethylene	1
trans-1,3-Dichloropropylene	1
Trichloroethylene	1
Trichlorofluoromethane	1
Trichlorotrifluoroethane	5
Vinyl chloride	1
Xylenes (total)	3

Table A-6. Semivolatile Organic Compounds

Analytes	Limit of Quantitation Water (µg/L)	Sediments (mg/kg)
1,2,4-Trichlorobenzene	10	0.33
1,2-Dichlorobenzene	10	0.33
1,2-Diphenylhydrazine	10	0.33
1,3-Dichlorobenzene	10	0.33
1,4-Dichlorobenzene	10	0.33
2,4,5-Trichlorophenol	10	0.33
2,4,6-Trichlorophenol	10	0.33
2,4-Dichlorophenol	10	0.33
2,4-Dimethylphenol	10	0.33
2,4-Dinitrophenol	20	0.67
2,4-Dinitrotoluene	10	0.33
2,6-Dinitrotoluene	10	0.33
2-Chloronaphthalene	1	0.03
2-Chlorophenol	10	0.33
2-Methyl-4,6-dinitrophenol	10	0.33
2-Methylnaphthalene	1	0.03
2-Nitrophenol	10	0.33
2-Picoline	10	0.33
3,3'-Dichlorobenzidine	10	0.33
4-Bromophenylphenylether	10	0.33
4-Chloro-3-methylphenol	10	0.33
4-Chloroaniline	10	0.33
4-Chlorophenylphenylether	10	0.33
4-Nitrophenol	10	0.33
Acenaphthene	1	0.03
Acenaphthylene	1	0.03
Aniline	10	0.33
Anthracene	1	0.03
Benzidine	50	1.67
Benzo(a)anthracene	1	0.03
Benzo(a)pyrene	1	0.03
Benzo(b)fluoranthene	1	0.03
Benzo(ghi)perylene	1	0.03
Benzo(k)fluoranthene	1	0.03
Benzoic acid	20	0.67
Benzyl alcohol	10	0.33
bis(2-Chloroethoxy)methane	10	0.33
bis(2-Chloroethyl) ether	10	0.33
bis(2-Chloroisopropyl)ether	10	0.33
bis(2-Ethylhexyl)phthalate	10	0.03
Butylbenzylphthalate	10	0.33
Chrysene	1	0.03
Dibenzo(a,h)anthracene	1	0.03
Dibenzofuran	10	0.33

Table A-6. Semivolatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation Water (µg/L)	Sediments (mg/kg)
Diethylphthalate	10	0.33
Dimethylphthalate	10	0.33
Di-n-butylphthalate	10	0.33
Di-n-octylphthalate	10	0.33
Fluoranthene	1	0.03
Fluorene	1	0.03
Hexachlorobenzene	10	0.33
Hexachlorobutadiene	10	0.33
Hexachlorocyclopentadiene	10	0.33
Hexachloroethane	10	0.33
Indeno(1,2,3-cd)pyrene	1	0.03
Isophorone	10	0.33
m-Nitroaniline	10	0.33
Naphthalene	1	0.03
Nitrobenzene	10	0.33
N-Methyl-N-nitrosomethylamine	10	0.33
N-Nitrosodiphenylamine	10	0.07
N-Nitrosodipropylamine	10	0.33
o-Nitroaniline	10	0.33
p-(Dimethylamino)azobenzene	10	0.33
Pentachlorophenol	10	0.33
Phenanthrene	1	0.03
Phenol	10	0.33
Pyrene	1	0.03
Pyridine	10	0.33

Table A-7. Polychlorinated Biphenyls

Analytes	Limit of Quantitation Water (µg/L)	Sediments (mg/kg)
Aroclor 1016	0.5	0.003
Aroclor 1221	0.5	0.003
Aroclor 1232	0.5	0.003
Aroclor 1242	0.5	0.003
Aroclor 1248	0.5	0.003
Aroclor 1254	0.5	0.003
Aroclor 1260	0.5	0.003
Aroclor 1262	0.5	0.003

Table A-8. High-Explosives Compounds

Analytes	Limit of Quantitation Water (µg/L	Sediments (mg/kg)
1,3,5-Trinitrobenzene	0.105	0.08
2,4,6-Trinitrotoluene	0.105	0.08
2,4-Dinitrotoluene	0.105	0.08
2,6-Dinitrotoluene	0.105	0.08
2-Amino-4,6-dinitrotoluene	0.105	0.08
4-Amino-2,6-dinitrotoluene	0.105	0.08
HMX	0.105	0.08
Nitrobenzene	0.105	0.08
RDX	0.105	0.08
Tetryl	0.105	0.08
m-Dinitrobenzene	0.105	0.08
m-Nitrotoluene	0.105	0.08
o-Nitrotoluene	0.105	0.08
p-Nitrotoluene	0.105	0.08

References

DOE 1988a: US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0071 (July 1988).

DOE 1988b: US Department of Energy, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0070 (July 1988).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

EPA 1989a: US Environmental Protection Agency, "40CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," Federal Register 54, 51 653-51 715 (December 15, 1989).

EPA 1989b: US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," Code of Federal Regulations, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

ESH-17 2000: Air Quality Group, "Quality Assurance Project Plan for the Rad-NESHAP Compliance Project," Air Quality Group Document ESH-17-RN, R1 (January 2000).

ICRP 1988: International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, and 3, and their supplements, Annals of the ICRP 2(3/4) -8(4) (1979-1982), and Publication 30, Part 4, 19(4) (1988).

NCRP 1987: National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

NMEIB 1995: New Mexico Environmental Improvement Board, "New Mexico Drinking Water Regulations," (as amended through January 1995).

NMWQCC 1995: New Mexico Water Quality Control Commission, "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," Section 3-101.K (as amended through January 23, 1995).

Appendix 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:

where

c^{i} = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples a station or group comprises.

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)

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

$PM_{2.5}$	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
<	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," Batelle 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, is located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor will be transferred to the institution for placement into the decontamination and decommissioning (D&D) program beginning in 2006.

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 being constructed. 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 SNM in various configurations below critical.

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: This site is divided into five facility management units. 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: This TA contains two facility management units. 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 (R&D) 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 R&D 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.

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 Johnson Controls Northern New Mexico.

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 of 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.airquality.lanl.gov/pdf/ESR/LA-14162-ENV.pdf provides access to *Environmental Surveillance at Los Alamos during 2003*.

http://www.airquality.lanl.gov/ESRIndex2003.htm provides access to supplemental data tables for 2003.

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.esh.lanl.gov/~AirQuality 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.
dose	A term denoting the quantity of radiation energy absorbed.
EDE	Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious

genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100-mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to $100 \times 0.12 = 12$ mrem.

CEDE: committed effective dose equivalent

TEDE: total effective dose equivalent

maximum individual dose The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.

population dose The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)

whole body dose A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).

EA Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.

effluent A liquid waste discharged to the environment.

EIS Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

emission A gaseous waste discharged to the environment.

environmental compliance The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.

environmental monitoring The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.

environmental surveillance	The sampling of contaminants in air, water, sediments, soils, foodstuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.
EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
exposure	A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)
external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.

hazardous waste constituent — The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.

HSWA — Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.

hydrology — The science dealing with the properties, distribution, and circulation of natural water systems.

internal radiation — Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.

ionizing radiation — Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.

- long-lived isotope - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
- short-lived isotope - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

MCL — Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.

MEI — Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.

mixed waste	Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).
mrem	Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.
NEPA	National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.
NESHAP	National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.
nonhazardous waste	Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.
NPDES	National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.
nuclide	A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content—or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.
outfall	The location where wastewater is released from a point source into a receiving body of water.
PCB	Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. 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-permeablity 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.

ACD	air curtain destructor
AIRNET	Air Monitoring Network
AOC	area of concern
AST	above-ground storage tank
BCG	Biota Concentration Guides
BMP	best management practices
BSRL	baseline statistical reference level
CAA	Clean Air Act
CEI	Compliance Evaluation Inspection
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic foot per second
CGP	Construction General Permit
CMR	Chemistry and Metallurgy Research (LANL building)
CO	compliance order
COE	Army Corps of Engineers
CWA	Clean Water Act
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
D&D	decontamination and decommissioning
DI	deionized
DMR	Discharge Monitoring Report
DOE	Department of Energy
DRO	diesel-range atomic compound
DU	depleted uranium
EA	Environmental Assessment
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EMS	Environmental Management System
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERA	Environmental Resource Associates
ESA	Engineering Sciences and Applications Group (LANL)
ES&H	environment, safety, & health
ESP	Environmental Surveillance Program (LANL)
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FY	fiscal year
GIS	Geographic Information System
GMAP	gaseous mixed air activation products
HAP	hazardous air pollutants

HAZWOPER	hazardous waste operations (training class)
HE	high-explosive
HEWTF	High-Explosive Wastewater Treatment Facility
HMX	cyclotetramethylenetetra nitramine
HPAL	Health Physics Analysis Laboratory (LANL)
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
IC	ion chromtograhy
ISM	Integrated Safety Management (LANL)
IWM	Integrated Work Management
LASO	Los Alamos Site Office (DOE)
LANSCE	Los Alamos Neutron Science Center (TA-53)
LANL	Los Alamos National Laboratory (or the Laboratory)
LC/MS/MS	liquid chromatography/mass spectrometry/mass spectrometry
MAPEP	Mixed-Analyte Performance Evaluation Program
MCL	maximum contaminant level
MDA	minimum detectable activity
MDL	method detection limit
MEI	maximally exposed individual
MOX	Mixed Oxides fuels
MRL	minimum risk level
MSGP	Multi-Sector General Permit
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEWNET	Neighborhood Environmental Watch Network
NHPA	National Historic Preservation Act
NMAC	New Mexico Administrative Code
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMED-DOB	New Mexico DOE Oversight Bureau
NMOCD	New Mexico Oil Conservation Division
NMWQCC	New Mexico Water Quality Control Commission
NNSA	US National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
ODS	ozone depleting substance
PAH	polycyclic aromtic hydrocarbon
PBT	persistent, bioaccumulative, and toxic

PCB	polychlorinated biphenyls
PE	performance evaluation
PDL	public dose limit
PERC	perchloroethylene
PM	particulate matter
ppb	parts per billion
ppm	parts per million
PQL	practical quantitation limit
PRS	potential release site
psig	pounds per square inch gauge
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
RadNESHAP	NESHAP for Radionuclides
RCRA	Resource Conservation and Recovery Act
RDX	research department explosive (cyclonite)
RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
ROD	record of decision
RPD	relative percent difference
RRES	Risk Reduction and Environmental Stewardship Division (LANL)
RRES-ECO	Ecology Group (LANL)
RRES-EP	Environmental Protection Program (LANL)
RRES-GPP	Groundwater Protection Plan
RRES-MAQ	Meteorology and Air Quality Group (LANL)
RRES-RS	Remediation Services Group (LANL)
RRES-SWRC	Solid Waste Regulatory Compliance Group (LANL)
RRES-WQH	Water Quality and Hydrology Group (LANL)
RSRL	regional statistical reference level
SA	supplement assessment
SAL	screening action level
SCC	Strategic Computing Complex
SDWA	Safe Drinking Water Act
SODAR	sonic detection and ranging
SOW	statement of work
SPCC	Spill Prevention Control and Countermeasures
SR	State Road
STP	site treatment plan
SVOC	semivolatile organic compound
SWEIS	site-wide environmental impact statement
SWPP	Storm Water Prevention Plan

SWMU	solid waste management unit
SWWS	Sanitary Wastewater Systems Plant (LANL)
TA	Technical Area
TCE	trichloroethylene
TEOM	tapered-element oscillating microbalance
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TRC	total residual chlorine
TSCA	Toxic Substances Control Act
TSP	total suspended particulate matter
TTHM	total trihalomethane
UC	University of California
UC	University of California
UST	underground storage tank
VAP	vaporous activation products
VOC	volatile organic compound
WGO	Waste Generation Overview
WIPP	Waste Isolation Pilot Plant

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	Phosphaeus	P
Calcium	Ca	Phosphate (as Phosphous)	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	Stronium	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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